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Field evaluation of methoxyfenozide and chromafenozide, ecdysone agonists against cotton leaf worm, sugar beet moth and preservation their predators

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Abstract:

Due to the significant economic losses of the sugar beet crop caused by the cotton leaf worm *Spodoptera* sp. (*littoralis* and *exigua*) and the sugar beet moth *Scrobipalpa ocellatella* (Boys.) (Lepidoptera : Gelechiidae), as well as the desire to reduce the use of traditional insecticides for their harms, this study was conducted during seasons; 2017/2018 and 2018/2019 at shenno village, Kafr El-Sheikh Governorate .The aim was to evaluate alternatives to traditional insecticides represented by five ecdysone agonists. It also assesses its role in maintaining the presence of arthropod predators associated with these pests in the field. Results showed that the tested ecdysone agonists and the tested insecticides were similar in reducing the number of *Spodoptera* sp. larvae. The all tested insecticides induced above 92% reduction in *Spodoptera* sp. larvae number in the both study seasons. As for the arthropod predators associated with *Spodoptera* sp., the maximum overall mean reduction was 31.59% and 11.57% during the first and second seasons respectively Compared to traditional insecticides (99.38% and 98.68% in 2017/2018 and 2018/2019 seasons respectively). Ascendancy reducing the number of *S. ocellatella* larvae, overall mean of reductions to all tested insecticides took the same trend. They caused above 87% reduction in *S. ocellatella* larvae numbers. Concerning the arthropod predators numbers associated with *S. ocellatella,* the maximum overall mean of reduction caused by the tested ecdysone agonists were 12.41% and 14.40% in the first and second seasons respectively. While, that recorded when using traditional insecticides 99.20%in 2017/2018 season and 99.54% in 2018/2019.

Introduction

Sugar beet *Beta vulgaris* L. (Family : Chenopodiaceae) attacks by several insect species beginning from seed germination up to harvest (Abo–Saied, 1998; Bazazo, 2005; Saleh *et al*.,2009; Bazazo, 2010; El–Dessouki, 2014; Bazazo *et al*., 2016; Khalifa 2018 and El-Dessouki, 2019). These insect pests proved to reduce the crop quality (Sugar Percent) and quantity (roots weight per feddan) (Shalaby, 2001; Bazazo, 2010; Shalaby *et al.*, 2011; Rashed, 2017 and Abbas, 2018). Lepidopteran pests of sugar beet cause severe yield reduction in most growing areas of the world (Jafari *et al.*, 2009). The cotton leaf worms, *Spodoptera littoralis* Boisd and *Spodoptera exigua* Hub. (Lepidoptera: Noctuidae) and the beet moth Scrobipalpa *ocellatella* (Boys.) (Lepidoptera: Gelechiidae) are destructive insects and causing high economic losses to sugar beet crop in Egypt.

Severe infestation of sugar beet with *S. cellatella* larvae was caused significant reductions of 38.20 and 52.40% in root weight and sugar percentages, respectively (Abo-Saied,1987). Bassyouny *et al*. (1991) found that the younger plants were highly infested with cotton leaf worms, the greater damage was caused in both sugar beet leaves and roots, consequently a considerable reduction in sugar percentages. Also, Mesbah (2000) concluded that one larva of *S.littoralis* consumed 183.6 cm^2 of sugar beet leaf tissues throughout the entire larval stage, Causing large bare batches. All the farmers spray the conventional insecticides in controlling these insects. But, the intensive use of conventional insecticides led to several important drastic problems, i.e. environmental pollution, sedtruction of the natural enemies and incidence insect resistance to these insecticides (Awad *et al*., 2014).

Over the past four decades, efforts have been made to develop novel insecticides with selective properties that are designed to act on specific biochemical sites or physiological processes of the target pest. Insect Growth regulators (IERs) are bio-rational insecticides with novel modes of action which disrupt the physiology and development of the target pest, such compounds tend to be selective and generally less toxic to natural enemies than conventional insecticides (Gurr *et al*., 1999). Ecdysone agonists are one of the most important groups of IGRs, and widely used against many lepidopteran pests. Methoxfenozide and Chromafenozide are important members of ecdysone agonist they highly specific to lepidopteran pests all over the world (Pineda *et al.*, 2009). They were reported to be safer for natural enemies than conventional products (Schneider *et al.*, 2008). They favorable eco-toxicological profile and short period of persistence in the environment mad their good choice for integrated pest management (IPM) programs in various crops (Pineda *et al.*, 2006).

Therefore, the current study was conducted for field evaluation of the five ecdysone agonists efficiency (methoxyfenozide and chromafenozide) in reducing the number of cotton leaf worm and sugar beet moth larvae. In addition to assess their role in maintaining the presence of the associated predators compared to conventional ones.

Materials and methods

The current study was conducted during two successive seasons; 2017/2018 and 2018/2019. Farida cultivar was planted at Shenno village, Kafr El-Sheikh Governorate. The early plantation was sown on 5^{th} August and the late plantation was sown on 30^{th} October in both seasons. Five ecdyson agonists and five traditional comparison insecticides are listed in Table (1) were used. Each treatment was replicated four times (10 x 4 = 40 plots) in randomized block design. Each plot was measured $42m^2$, in additional to four plots as control. The experimental plots were separated from each other by untreated belts to avoid spray drift. Each sample was consisted of 10 plants/plot (40 plants/ treatment). The primary examination was done before treatment. The treatments were applied on 5th September at the early plantation and on 10th March at the late plantation against *Spodoptera* sp. and *S. ocellatella* larvae, respectively in both seasons. Knapsac sprayer (20 L Volume) was used in applying the treatments. Number of *Spodoptera* sp and *S. ocellatella* larvae was simultaneously counted at the early and the late plantations respectively. The associated arthropod predators were distinguished and accounted. The visual examination was done three, seven and 10 days after tested ecdysone agonists application. While it was achieved one, seven and 10 days after traditional tested insecticides application according to Anonymous (2019). Also, arthropod fauna of predators was sampled using visual examination and sweep net. In each replicate, ten single strokes were made at diagonal direction (Kandil *et al*., 1991). The Reduction in the *Spodoptera* sp., *S. ocellatella* larvae and associated arthropod predators number were calculated by Henderson and Tilton formula (1955).

Differences between mean numbers of the *Spodoptera* sp. and *S. ocellatella* larvae after the tenth day of treatment were analyzed using Duncan test (1955).

Table (1): List of the tested insecticides and their rats per feddan.

Insecticide		Category	Rate
Common name	**Trade name**		
Methoxyfenozide	Raner 24% Sc	Ecdysone agonist	75 cm^3 /fed.
Methoxyfenozide	Abhold 36% Ec	Ecdysone agonist	125 cm^3 /fed.
Chromafenozide	Ferto 5% Sc	Ecdysone agonist	400 cm^3 /fed.
Methoxyfenozide	Xtreme 36% Ec	Ecdysone agonist	125 cm^3 /fed.
Methoxyfenozide	Methobiet 24% SC	Ecdysone agonist	75 cm^3 /fed.
Chlorpyrifos	Dora 48% EC	Conventional	1L./fed.
Carbosulfan	Marshal 20% Ec	Conventional	250 cm^3 /fed.
Chlorfenapyr	Fanty plus 36% EC	Conventional	90 cm^3 /fed.
Methomyl	Diracomel 90% Sp	Conventional	300 gm /fed.
Pyridalyl	Pelo 5% Ec	Conventional	100 cm^3 /fed.

Results and discussion

1. Effects on *Spodoptera* sp. larvae and their associated arthropod predators:

Data shown in Table (2) indicate that the reduction percentages for the five ecdysone agonists insecticides; raner, abhold, ferto, xtreme and methobiet in *Spodoptera* sp. larvae number were close. High reduction percentages were achieved after the third, seventh and tenth days of treatment. Overall mean of reduction percentages in *Spodoptera* sp. larvae number were 92.04, 93.29, 94.01, 93.78 and 94.12%, respectively in 2017/2018 season. As well in 2018/2019 season, over all mean of reduction percentages were 95.87, 95.93, 95.53, 94.34 and 95.70%, respectively. Concerning the conventional insecticides, dora, marshal, fanty plus, diracomel and pelo recorded high reduction percentages after the first, seventh and tenth days of treatment. Overall mean of reduction percentages was 97.15, 95.61, 95.44, 95.30 and 95.61%, respectively in 2017/2018 season. Also, it was 95.34, 96.09, 97.56, 97.38 and 97.76%, respectively in 2018/2019 season.

Overall mean of reductions to the all tested insecticides ranged between

92.04 – 97.15% in the first season and 94.34 – 97.76% in the second season. This means that the all tested insecticides induced above > 92% reduction in *Spodoptera* sp. larvae number.

The arthropod predators associated with *Spodoptera* sp were true spiders, formicidae, *Chrysoperla carnea* (Stephens). Data in Table (3) reveal that the treatment of five ecdysone agonists insecticides resulted in a low decrease in reduction percentages in the number of predators. The mean number of predators ranged between 8.25 to 9.75 and 7.80 to 11.75 individuals /10 plants during seasons 2017/2018 and 2018/2019 respectively. The overall mean reduction percentages were ranged between 23.16 to 31.59% and 10.84 to 11.57% during the first and second seasons respectively. While the treatment with conventional insecticides led to a high reduction in the number of predators. The mean number of predators ranged between 0.00 to 0.75 individuals /10 plants in the two study seasons. The overall mean reduction percentages were ranged between 95.59 to 99.38% and 96.72 to 98.68% in 2017/2018 and 2018/2019 seasons respectively. After the tenth day of treatment, the effect of the tested ecdyson agonists and the tested traditional insecticides differed significantly in the mean number of predators during the two successive seasons.

Table (2): Reduction percentages in *Spodoptera* sp. larvae number during 2017/2018 and 2018/2019 seasons.

Season 2017/2018										
Compound	**Before spray**	**After one day**		**After 3 days**		**After 7 days**		After 10 days		Overall mean of reduction
	M	**M.**	**% Red**	**M.**	**% Red**	**M.**	**% Red**	M.	% Red	
Raner	25.25	-	-	2.5	92.15	3.25	91.7	3.75	92.28	92.04
Abhold	26.25	-	-	2.25	93.2	3	92.63	3	94.06	93.29
Ferto	25.75	-	-	2	93.84	2.5	93.74	2.75	94.45	94.01
Xtreme	26	-	-	1.75	94.66	2.75	93.18	3.25	93.5	93.78
Methobiet	25.5	-	-	2	93.78	2.5	93.68	2.5	94.9	94.12
Dora	26.25	0.25	99.11	-	-	1.5	96.31	2	96.04	97.15
Marshal	26.25	1.25	95.56	-	-	1.75	95.73	2.25	95.54	95.61
Fanty plus	26.5	1	96.48	-	-	1.75	95.74	3	94.11	95.44
Diracomel	25	0.75	97.2	-	-	1.75	95.48	3.25	93.24	95.3
Pleo	25.25	0.75	97.23	-	-	1.75	96.8	3.5	92.8	95.61
Control	26.75	28.75	-	33.75	-	41.5	-	51.5	-	-
Season 2018/2019										
Compound	**Before spray**	**After one day**		**After 3 days**		**After 7 days**		After 10 days		Overall mean of reduction
	M	**M.**	**% Red**	**M.**	**% Red**	**M.**	**% Red**	M.	% Red	
Raner	21.5	-	-	0.75	97.59	1.75	95.44	2.25	94.58	95.87
Abhold	21.75	-	-	0.75	97.62	1.5	96.13	2.5	94.05	95.93
Ferto	22.25	-	-	1	96.89	2	94.96	2.25	94.76	95.53
Xtreme	22.5	-	-	1.25	96.16	2.5	93.78	3	93.1	94.34
Methobiet	21.25	-	-	1.25	95.94	1.5	96.04	2	95.12	95.7
Dora	22.75	1	96.04	-	-	1.75	95.69	2.5	94.31	95.34
Marshal	22.25	0.5	97.97	-	-	2	94.96	2	95.34	96.09
Fanty plus	22	0	100	-	-	1.25	96.81	1.75	95.88	97.56
Diracomel	22	0	100	-	-	1	97.45	2.25	94.7	97.38
Pleo	21.75	0	100	-	-	0.75	98.06	2	95.24	97.76
Control	22.25	24.75	-	32.25	-	39.75	-	43	-	-

Table (3): Reduction percentages in arthropod predators number associated with *Spodoptera* sp. during 2017/2018 and 2018/2019 seasons.

Compound	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction
Season 2017/2018										
	M	M.	% Red	M.	% Red	M.	% Red	M.*	% Red	
Raner	10	-	-	9	23.12	8.75	31	8.25a	40.65	31.59
Abhold	9.75	-	-	9.75	14.58	9.5	23.17	9.25a	31.75	23.16
Ferto	10	-	-	9.5	18.85	9.5	25.09	9.25a	35.72	26.55
Xtreme	9.25	-	-	9	16.89	9	23.28	8.75a	31.95	24
Methobiet	9.5	-	-	9.25	16.83	9.25	23.22	9.25a	29.96	23.33
Dora	10.25	0	100	-	-	0.5	96.15	0.75b	90.64	95.59
Marshal	9.75	0	100	-	-	0.25	97.97	0.50b	96.31	98.09
Fanty plus	9.75	0	100	-	-	0	100	0.25b	98.15	99.38
Diracomel	9.5	0	100	-	-	0.25	97.92	0.75b	94.32	97.41
Pleo	9	0	100	-	-	0	100	0.50b	96	98.66
Control	10.25	11.25	-	12	-	13	-	14.25	-	-
Season 2018/2019										
Compound	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction
	M	M.	% Red	M.	% Red	M.	% Red	M.*	% Red	
Raner	12.25	-	0	12	7.8	11.75	11.45	11.75a	14.73	11.32
Abhold	12	-	0	11.75	7.84	11.5	11.53	11.50a	14.81	11.39
Ferto	11.75	-	0	11	11.88	11.5	9.65	11.50a	13	11.51
Xtreme	11.75	-	0	11.5	7.88	11.25	11.62	11.25a	13.04	10.84
Methobiet	11.5	-	0	11	9.97	11	11.7	11.25a	13.04	11.57
Dora	11	0	100	-	-	0.25	97.9	0.50b	95.95	97.95
Marshal	11.25	0	100	-	-	0	100	0.50b	96.04	98.68
Fanty plus	11.25	0	100	-	-	0	100	0.57b	94.07	98.02
Diracomel	12	0	100	-	-	0.25	98.07	0.50b	96.29	98.12
Pleo	11.5	0	100	-	-	0.5	95.98	0.75b	94.2	96.72
Control	12	12.5	-	12.75	-	13	-	13.5	-	-

The Duncan test at level of 5% probability was applied, the mean followed by the same letter do not differ significantly.

2. Effects on *Scrobipalpa ocellatella* larvae and their associated arthropod predators:

Concerning the relation between the number of *S. ocellatella* larvae and the ten tested insecticides was shown in the Table (4). The tested ecdyson agonists caused a considerable decrease in the number of larvae during 2017/2018 and 2018/2019 seasons. The minimum overall mean reduction percentages were 89.25and 88.76% in the first and second seasons respectively. While the maximum overall mean reduction percentages were 90.86 and 92.08% in the first and second seasons respectively. About traditional insecticides recorded the minimum overall mean reduction percentages which were 89.89 in 2017/2018 season and 87.71% in 2018/2019 season. As for the maximum records were 91.23% in the first season and 88.18% in the second season. In the two seasons of the study, effects of the tested ecdyson agonists were like those of the traditional insecticides in reducing the number of sugar beet moth larvae. Overall mean of reductions to all tested insecticides ranged between (89.25 – 91.23%) for the first season and (87.71 – 92.08%) for the second season, this means that all tested insecticides caused above > 87% reduction in *S. ocellatella* larvae numbers.

On the other hand, the arthropod predators associated with *S. ocellatella* were true spiders, formicidae, and

Coccenilla undecimpunctata (L.). Results in Table (5) clarify that the tested ecdysone agonists were caused overall mean of reduction percentages (ranged between 8.30 to 12.47%) in these predators' numbers less than that recorded when using traditional insecticides (ranged between 98.36 to 99.20%) in 2017/2018 season. The results of the second season took the same trend as the previous season. The lowest and highest overall mean of reduction percentages were 7.97 and 14.3% respectively in case of the tested ecdyson agonists treatment. Whereas the traditional insecticides treatment achieved 98.11 and 99.54% as the lowest and highest records respectively. Statistical analysis showed significant differences between the average numbers of predators after the tenth day of the treatment in the both study seasons.

In conclusion, the current study presented that the tested ecdyson agonists have converged with conventional insecticides in their highly reduced impact on the tested insect pests' larvae numbers. As for its effect in reducing the number of predators, it is minimal compared to traditional insecticides. This means its safe effect on natural enemies and their survival under field conditions.

These results are agreement with Sparks (2001) who reported that the diacylhydrazines are novel class of IGRs which in the Lepidoptera function as ecdysone agonists which disrupting the molting process by mimicking the action of 20 – Hydroxy ecdysone. As well as good selectivity towards beneficial insects. Smagghe *et al*. (2003) reported that the compound methoxyfenozide was the newest member of this new group of moulting hormone accelerating IGRs to reach the marketplace against Lepidoptera. Yanagi and Kawagishiu (2006) demonstrated that Toxic effects of chromafenozides against lepidopteran larvae mainly via digestion. The treated larvae stopped the feeding within 10 – 12 hr. after treatment to toxic doses of the agent and inducing the molting process. A treated larva slipped its head out of the old head capsule prematurely to attempt to molt. Furthermore, several authors i.e. Gurr *et al*. (1999), Moulton *et.al*.(2002), , Pineda *et al.* (2006), Schneider *et al.* (2008), Pineda *et al.* (2009), Shahout *et al*. (2011) and Rani *et al.* (2018) concluded that ecdysone agonists (methoxyfenozide and chromafenozide) are promising insecticides with high efficacy against various lepidopteran insects, at the same time almost non-toxic to pollinators, predators, parasitoids, mammals and has minimum impact on the environment. Consequently, it would be an ideal agent for integrated pest management (IPM).

Table (4): Reduction percentages in *Scrobipalpa ocellatella* larvae number during 2017/2018 and 2018/2019 seasons.

Season 2017/2018

Compound	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction
	M	M.	% Red	M.	% Red	M.	% Red	M.	% Red	
Raner	19.75	-	-	4.75	80.8	2.5	91.3	1.5	95.65	89.25
Abhold	19.75	-	-	4.5	81.81	2.75	90.43	1.5	95.65	89.29
Ferto	20	-	-	4.5	82.04	2.25	92.27	1.25	96.42	89.57
Xtreme	20	-	-	4.25	83.04	2	93.13	1.25	96.42	90.86
Methobiet	19.5	-	-	4.25	82.6	2.25	92.07	1.5	95.59	90.08
Dora	19.5	4.25	80.65	-	-	2	92.95	1.25	96.33	89.97
Marshal	19.25	4.25	80.4	-	-	1.75	93.75	1.5	95.53	89.89
Fanty plus	19.25	4.25	80.4	-	-	1.75	93.75	1.5	95.53	89.89
Diracomel	20.25	4	82.46	-	-	1.75	94.06	1	97.17	91.23
Pleo	19	4	81.31	-	-	1.5	94.57	1	96.98	90.95
Control	19.75	22.25	-	24.75	-	28.75	-	34.5	-	-

Season 2017/2018

Compound	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction
	M	M.	% Red	M.	% Red	M.	% Red	M.	% Red	
Raner	17.5	-	-	4.75	81.05	2.5	98.66	1.25	96.55	92.08
Abhold	17.25	-	-	5	79.77	2.75	90.71	1.5	95.8	88.76
Ferto	17.25	-	-	4.75	80.78	2.75	90.71	1.25	96.5	89.33
Xtreme	16.75	-	-	4.75	80.78	2.75	90.43	1.25	96.4	89.2
Methobiet	16.75	-	-	4.5	81.25	2.5	91.3	1.25	96.4	89.65
Dora	17.75	4.75	76.36	-	-	2.75	90.97	1.5	95.8	87.71
Marshal	17	4.5	76.66	-	-	2.5	91.43	1.5	95.74	87.94
Fanty plus	17	4.5	76.66	-	-	2.5	91.43	1.5	95.74	87.94
Diracomel	16.5	4.5	75.95	-	-	2.5	91.17	1.25	96.34	87.82
Pleo	17	4.5	76.66	-	-	2.5	91.43	1.25	96.45	88.18
Control	16.75	19	-	24	-	28.75	-	34.75	-	-

Table (5): Reduction percentages in arthropod predators number associated with *Scrobipalpa ocellatella* during 2017/2018 and 2018/2019 seasons.

Season 2017/2018

Compound	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction
	M	M.	% Red	M.	% Red	M.	% Red	M.*	% Red	
Raner	19.75	-	-	19	7.31	18	14.28	18.00a	15.29	12.29
Abhold	19.75	-	-	19	7.31	19	9.52	19.50a	8.23	8.35
Ferto	20	-	-	19.5	6.06	19.5	8.3	19.25a	10.54	8.3
Xtreme	20	-	-	18.75	9.67	19	10.65	19.00a	11.7	10.67
Methobiet	19.5	-	-	18	11.06	18	13.18	18.25a	13.01	12.41
Dora	19.5	0	100	-	-	0	100	0.59b	97.61	99.2
Marshal	19.25	0	100	-	-	0.25	98.77	0.75b	96.37	98.38
Fanty plus	19.25	0	100	-	-	0	100	0.75b	96.37	98.79
Diracomel	20.25	0	100	-	-	0.25	98.83	0.75b	96.55	98.46
Pleo	19	0	100	-	-	0.25	98.76	0.75b	96.33	98.36
Control	19.75	20	-	20.5	-	21	-	21.25	-	-

Season 2018/2019

Compound	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction
	M	M.	% Red	M.	% Red	M.	% Red	M.*	% Red	
Raner	17.5	-	-	16	12.48	12.25	12.37	16.25a	13.59	12.81
Abhold	17.25	-	-	16.25	59.83	16.5	9.73	16.50a	10.99	10.18
Ferto	17.25	-	-	15	16.77	16	12.47	16.00a	13.68	14.3
Xtreme	16.75	-	-	16.25	7.14	16.25	8.45	16.50a	8.33	7.97
Methobiet	16.75	-	-	14	2	15	15.49	15.00a	16.66	11.38
Dora	17.75	0	100	-	-	0.25	98.68	0.50b	97.37	98.68
Marshal	17	0	100	-	-	0.25	98.61	0.50b	97.26	98.62
Fanty plus	17	0	100	-	-	0.25	98.61	0.50b	97.26	98.62
Diracomel	16.5	0	100	-	-	0.25	98.57	0.75b	95.77	98.11
Pleo	17	0	100	-	-	0	100	0.25b	98.63	99.54
Control	16.75	17	-	17.5	-	17.75	-	18	-	-

The Duncan test at level of 5% probability was applied, the mean followed by the same letter do not differ significantly.

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