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Efficacy of some novel pesticides on tortoise beetles, *Cassida vittata* Vill. and predators associated with sugar beet

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Abstract
Tortoise beetles, *Cassida vittate*, Vill., Coleoptera: Chrysomelidae is a dangerous sugar beet pest in Egypt that reduces output of both quantitative and qualitative traits. As a result, the farmers rush to apply pesticides to suppress this insect regardless of the economic threshold level. With the increased consciousness about the hazards of traditional chemicals in agriculture, a remarkable decrease in the use of pesticides and an increase in the use of biorational pesticides (insect growth regulators and biocide) were noticed. Biorational pesticides, known as "third-generation pesticides" are made from synthetic or natural compounds that effectively control insect pests, with no risk to the environment or farm animals. The current study was carried out in western Nubariyah, El- Beheira Governorate (Sugar beet area) during 2020/2021 and 2021/2022 seasons to evaluate the effect of three biorational pesticides (Hexaflumuron, Methoxyfenozide and Emamectin benzoate) compared with two traditional pesticides (Chlorpyrifos and Profenofos as organophosphates) against larvae and adults of *C. vittata* and their side effect on arthropod related predators. Concerning reduction percentage, the obtained results revealed that Chlorpyrifos and Profenofos were more toxicity pesticides against *C. vittata* population in both stages, while chitin synthesis inhibitors (hexaflumuron) and ecdysone agonists (methoxyfenozide) exhibited intermediate toxicity to target this insect. On the other hand, biocide pesticide (Emamectin benzoate) showed the lowest toxic effect. Moreover, the toxic effect of the used pesticides on the two insect stages (larvae and adults) was slightly similar with respect to the number of insects in various frequent inspection times after spraying and the reduction percentages. The results also indicated that the pesticides were the lowest toxic on the thirds day after spraying, then the efficiency of the lethal pesticides effect gradually increased until 21 days after spraying the pesticides in both stages (larvae and adult) of tortoise beetles. Further, data of the average overall inspection showed that reduction percentage for insect growth inhibitors, IGRs (hexaflumuron and methoxyfenozide) and biocide pesticides were safer for the studied total predators, *Coccinella undecimpunctata* (Linneus), *Coccinella septempunctata* (Reiche), *Scymnus interruptus* (Goeze), *Paederus alfierii* (Koch), *Orius* sp. and *Chrysoperla carnea* (Stephens) as compared to the traditional pesticides (Chlorpyrifos and Profenofos).
Under conditions of the present study, the use of insect growth regulators and biocides pesticides (third-generation pesticides) that affect the hormonal regulation of molting and developmental processes in insects as one of integrated pest management (IPM) can be recommended for sugar beet pests, especially *C. vittata* considered safer for the biotic and abiotic conditions.

Keywords: biorational insecticides, insect growth regulators, biocide, tortoise beetles, sugar beet

Introduction

Sugar beet was introduced to Egypt in 1982 as complementary source for white sugar production beside sugarcane, where the first beet sugar factory was established. Nowadays, sugar beet became the first sugar crop, where nine beet sugar factories have been established and produce 1 million and 835 thousand tons of sugar represents 67.7% of the total domestic sugar production in 2021. Sugar beet area was expanded from 16 thousand feddans in 1882 to nearly 700 thousand in 2021, where it became an essential winter crop sown during September to November. In this regard, sugar beet is subjected to the attack by insect pests from sowing up to harvesting. Injury to the plants directly causes a great damage as feeders or indirectly as vectors of certain virus diseases, which negatively reflected on both root and sugar yields.
Tortoise beetles, *Cassida vittata* Vill., Coleoptera: Chrysomelidae is a dangerous sugar beet pest that reduces output in both quantitative and qualitative ways, where both stages of tortoise beetle larvae and adults cause rounded feeding holes on leaves, resulting in a distinctive “shot-hole” feeding appearance. In severe infestation, the leaves are ragged and could be entirely ruptured [1-5]. According to [6, 8], the severe infestation of this insect in sugar beet causes a considerable loss in root weight and sugar content of 40% and 56.20%, respectively. As a result, farmers rush to apply insecticides to suppress this insect regardless of the economic threshold level.
Despite efforts to persuade growers to use the integrated pest control against this insect, which combine all possible measures in time and space-based techniques (agro-technical, mechanical, biological, and so on), chemical treatments remain dominant. Conventional pesticides are often employed to reduce the insect population in order to avoid economic loss. Casida, [9], noticed that organophosphate compounds (OPs) are principally neurotoxicants that work by damaging the nervous systems of target species by inhibiting the activity of acetylcholinesterase enzyme (AChE), which breaks down the neurotransmitter acetylcholine (ACh) within the central nervous system (CNS) synaptic cleft or at neuromuscular in the peripheral nervous system (PNS) [10-11]. Yang, [12] mentioned that organophosphate compounds cause tremors, lacrimation, bradycardia and even death. Also, [13] found Profenofos was the most efficient compound against larvae and adults of *C. vittata*. Anter [5] observed that chlorpyrifos

was the most effective chemical against larvae and adults of tortoise beetles. Most conventional pesticides are neurotoxic chemicals that have an array of harmful impacts on human health, environmental pollution [14-16], non-target beneficial organisms [17] and the development of pesticide-resistant biotypes of insects [18].
Recently, a new generation of pesticides (biorational insecticides) has gained interest in pest management and potential non-conventional alternatives. Biorational pesticides are a phrase coined from two words, "biological" and "rational," which refers to pesticides that are synthetic or natural substances that are effective against the targeted pest but are less harmful to natural enemies [19, 20]. Biorational pesticides, sometimes are known as "third-generation pesticides", made from natural sources and pose little or no risk to the environment or beneficial animals. The microbial pesticide *Bacillus thuringiensis* (Kurstaki), neonicotinoids, avermectins, phenlpyrazoles, spinosyns, pyrroles, oxadiazines, and numerous classes of insect growth regulators are examples of biorational pesticides [21]. Insect growth regulators (IGRs) have novel modes of action that disrupt the physiology and development of the target pest. Based on their method of action, IGRs are divided into two categories: chitin synthesis inhibitors (CSIs) and chemicals that interfere with insect hormone function. Chitin synthesis inhibitors include benzyl phenyl urea (Hexaflumuron), which prevents insects from molting by inhibiting chitin production [22]. Ecdysteroid agonist (methoxyfenozide) is a chemical that interferes with the activity of insect hormones, where its functions as a potent agonist, or mimic, of the insect molting hormone, 20-hydroxyecdysone (20E).
Khalil and Abd El-Naby, [23] clarified that the Avermectin group is a type of natural product made up of a large macrocyclic lactone ring derived from the metabolites of the Gram-positive bacterium *Streptomyces avermectinius.* Emamectin benzoate, a derivative of abamectin was classified as the second generation of avermectins [24]. It is a biological insecticide containing a mixture of the benzoic acid salt of two structurally complicated heterocyclic compounds: emamectin $B1_a$ (> 90%) and emamectin $B1_b$ (<10%). Its main physiological mode of action is to stimulate the release of the neurotransmitter γ-aminobutyric acid (GABA), thus causing a continuous flow of chloride ions into muscle cells resulting in a suppression of contraction and paralysis [25].

Materials and Methods

1. Field experiments

Two field experiments were carried out in calcareous soil characterized with its high content of calcium carbonate in western Nubariyah, El-Beheira Governorate (Sugar beet area). Sugar beet (*Beta vulgaris* var. *saccharifera*), multigerm Pyramids variety, was sown in mid-October in both 2020/2021 and 2021/2022 seasons. Five pesticides plus untreated checks (control), were randomly applied in three replicates in a Randomized Complete Block Design (RCBD) in both seasons. Plot area was 21 m^2, which consisted of 5 rows of 7 m long and 60 cm width, with 20 cm spacing between within hills. The other agricultural practices (land preparation, irrigation, mechanical weed control and fertilization) were adopted as recommended.

2. The tested pesticides

The used pesticide and their rates are presented in Table (1).

Table 1: Trade name, common name, chemical group, category and rate of pesticides use/fed in 2020/2021 and 2021/2022 seasons

Trade name	Common name	Chemical Group	Category	Rate/fed
Raner 26% SC	Methoxyfenozide	Diacylhydrazine	Ecdysone agonists	75 cm^3
Consult 10% EC	Hexaflumuron	Benzoylurea	Chitin synthesis inhibitors	200 cm^3
Emamex 5% EC	Emamectin benzoate	Avermectin	Biocide	150 g
Cord 72% EC	Profenofos	Organophosphorus	Conventional	750 cm^3
Truefos 48% EC	Chlorpyrifos	Organophosphorus	Conventional	1000 cm^3

The five pesticides were tested against sugar beet tortoise beetles, *Cassida vittata* (larvae and adults) and total predators; *Coccinella undecimpunctata*, Linnaeus; *Coccinella septempunctata*, Linnaeus; *Scymnus interruptus*, Goeze; *Paederus alfierii*, Koch; *Orius* sp. and *Chrysoperla carnea*, Stephens.
The pesticides were sprayed by a knapsack sprayer (20 liter) at the time when the population of *C. vittata* was the highest during March in the two seasons. To prevent contamination by pesticide drift, two rows of sugar beet were grown as borders without treatments. The number of larvae and adults of tortoise beetles and total predators was counted visually and recorded before spraying and after 3, 5, 7, 14 and 21 days from pesticides application for five plants per treatment for each replicate. The reduction percentage was calculated according to [26] equation:

$$\text{Reduction \%} = 1 - \left\{ \frac{\text{Insect No in control before spray}}{\text{Insect No in control after spray}} \times \frac{\text{Insect No in treatment after spray}}{\text{Insect No in treatment before spray}} \right\} \times 100$$

Analysis of variance was computed by using MSTAT statistical package (MSTAT-c) for in both seasons according to [27]. Treatment means were compared using LSD at a 5% level of probability.

Results and Discussion

Number and reduction percentage in *Cassida vittata* larvae and adults:

The results Tables 2 and 3 clarified that the number of larvae and adults per five plants for each replicate before any pesticide application ranged from 20.33 to 34.67 larvae and 14.00 to 21.33 adults, in the first season. In the second one, they ranged from 23.67 to 30.33 larvae and 11.67 to 18.33 adults. The population density of *C. vittata* was suppressed by using the studied pesticides in comparison to the control. Most pesticide treatments significantly decreased the population of *C. vittata*.
The overall average after 3, 5, 7, 14 and 21 days from pesticides application (Table 2) cleared that the severest pesticide on the larvae of tortoise beetles was Truefos 48% EC, which recorded the highest reduction % (93.91 and 95.33 %) and the lowest number of larvae (3.07 and 1.93/5 plants), in the 1st and 2nd season, respectively. Moreover, Truefos 48% EC showed a significant superiority over the

other pesticides, recording 29.67, 17.75, 5.14 and 12.78 % higher values of reduction % of *C. vittata* larvae, over that recorded by Emamex 5% EC, Raner 26% SC, Cord 72% EC and Consult 10% EC, in the 1st season, corresponding to 31.40, 20.11, 5.68 and 13.13 %, in the 2nd season, successively.

On the other hand, Emamex 5% EC as biocide pesticide was the lowest in reducing the average number of larvae (15.67 and 13.33/ 5 plants) with significant differences caused the less reduction of 64.24% and 63.93% than control in the first and second seasons, respectively. Whereas, the intermediate effect on beetles larvae for the rest of the pesticides was arranged in descending order as the following: Cord 72% EC > Consult 10% EC > Raner 26% SC in both seasons, respectively.

Table 2: Efficacy of some novel pesticides on the average number and reduction percentage in *Cassida vittata* larvae infesting sugar beet in 2020/2021 and 2021/2022 seasons

Season	Pesticide treatments	Recommended rate/feddan	Average No. of larvae before spray	Aver. number (No.) of larvae/5 plants\replicate and reduction percentage (Red.%) after pesticides application: 3 days		5 days		7 days		14 days		21 days		Overall Average	
				No.	Red.%	No.	Red.%	No.	Red.%	No.	Red.%	No.	Red.%	No.	Red. %
2020/2021	Emamex 5% EC	150 g	29.00	14.67	56.15	15.33	61.39	15.67	66.86	16.00	67.69	16.67	69.11	15.67	64.24
	Truefos 48% EC	1000 cm^3	34.67	4.00	90.00	3.33	92.99	3.00	94.69	2.67	95.49	2.33	96.39	3.07	93.91
	Raner 26% SC	75 cm^3	20.33	6.33	73.01	6.67	76.04	8.00	75.86	7.67	77.90	8.33	77.98	7.40	76.16
	Cord 72% EC	750 cm^3	32.33	4.00	83.02	6.00	86.45	5.33	89.89	4.67	91.15	4.00	93.35	5.27	88.77
	Consult 10% EC	200 cm^3	26.00	5.67	81.10	6.33	82.22	8.33	80.35	8.00	81.98	9.67	80.02	7.60	81.13
	Control	-	21.67	25.00	-	29.67	-	35.33	-	37.00	-	40.33	-	33.47	-
	LSD at 5%		4.31	4.29		3.65		4.29		4.29		3.51		4.06	
2021/2022	Emamex 5% EC	150 g	25.67	12.33	58.34	12.67	62.60	13.00	64.60	13.67	67.23	15.00	66.87	13.33	63.93
	Truefos 48% EC	1000 cm^3	30.33	2.67	92.36	2.33	94.18	2.00	95.39	1.67	96.61	1.00	98.13	1.93	95.33
	Raner 26% SC	75 cm^3	23.67	7.33	73.14	8.00	74.39	8.67	74.39	9.33	75.74	9.00	78.44	8.47	75.22
	Cord 72% EC	750 cm^3	27.00	5.00	83.94	4.33	87.85	4.00	89.64	3.33	92.41	2.67	94.39	3.87	89.65
	Consult 10% EC	200 cm^3	29.33	6.67	80.28	7.33	81.06	7.33	82.53	8.00	83.22	8.33	83.90	7.53	82.20
	Control	-	24.00	27.67	-	31.67	-	34.33	-	39.00	-	42.33	-	35.00	-
	LSD at 5%		3.76	3.76		2.64		3.82		3.41		4.54		3.49	

Table 3: Efficacy of some novel pesticides on the average number and reduction percentage in *Cassida vittata* adults infesting sugar beet in 2020/2021 and 2021/2022 seasons

Season	Pesticide treatments	Recommended rate/feddan	Average No. of adults before spray	Aver. number (No.) of adult insects/5 plants and reduction percentage (Red.%) after pesticides application: 3 days		5 days		7 days		14 days		21 days		Overall Average	
				No.	Red.%	No.	Red.%	No.	Red.%	No.	Red.%	No.	Red.%	No.	Red.%
2020/2021	Emamex 5% EC	150 g	15.33	7.33	56.09	8.00	59.96	8.33	65.02	9.33	64.49	10.00	67.67	8.60	62.65
	Truefos 48% EC	1000 cm^3	21.33	2.67	88.50	2.33	91.62	2.33	92.96	2.00	94.53	1.67	96.11	2.20	92.74
	Raner 26% SC	75 cm^3	17.67	5.33	67.10	6.67	71.03	7.00	74.50	7.67	74.68	8.67	75.68	7.07	72.60
	Cord 72% EC	750 cm^3	14.00	4.00	73.76	3.33	81.75	3.67	83.12	3.33	86.12	2.67	90.55	3.40	83.06
	Consult 10% EC	200 cm^3	16.00	4.00	77.04	4.67	77.60	5.33	78.55	5.67	79.32	6.33	80.39	5.20	78.58
	Control	-	18.67	20.33	-	24.33	-	29.00	-	32.00	-	37.67	-	28.67	-
	LSD at 5%		3.49	2.91		3.54		4.00		2.25		2.96		3.19	
2021 /2022	Emamex 5% EC	150 g	13.33	7.00	57.63	8.33	59.53	8.67	61.65	10.00	62.08	12.33	61.33	9.27	60.44
	Truefos 48% EC	1000 cm^3	18.33	2.00	91.20	2.00	92.93	1.67	94.63	1.67	95.40	1.33	96.97	1.73	94.23
	Raner 26% SC	75 cm^3	16.00	6.00	69.74	6.67	73.00	7.33	72.99	8.00	74.73	8.67	77.35	7.33	73.56
	Cord 72% EC	750 cm^3	11.67	3.67	74.63	4.33	75.97	3.67	81.46	3.00	87.01	2.00	92.84	3.80	82.38
	Consult 10% EC	200 cm^3	14.67	4.33	76.19	5.00	77.93	4.67	81.23	6.00	79.33	6.33	81.96	5.25	79.33
	Control	-	15.33	19.00	-	23.67	-	26.00	-	30.33	-	36.67	-	27.13	-
	LSD at 5%		3.49	3.02		2.78		3.58		3.16		3.19		3.20	

With respect to the effect of the five used pesticides, data illustrated that Truefos 48% EC had the highest toxicity against *Cassida vittata* adults (mature stage), where it caused a reduction percentage amounted to 30.09, 20.14, 9.68 and 14.16 % of *C. vittata* adults, over that recorded by Emamex 5% EC, Raner 26% SC, Cord 72% EC and Consult 10% EC, in the 1st season, corresponding to 33.79, 20.67, 11.85 and 14.90 %, in the 2nd one, respectively. On the other hand, Emamex 5% EC gave the lowest effect on beetles adults recorded a reduction percentage 62.65 and 60.44% in both seasons, counterside the number of the adults which significantly differed 8.60 and 9.27/ 5 plants in the two seasons. Furthermore, the other used pesticides are arranged in descending order as follows Cord 72 % EC, Consult 10 % EC and Raner 26% EC in both seasons.

Data tables (2 and 3) showed the percentage of reduction during five inspection days (3, 5, 7, 14 and 21 days) after pesticides application. Pesticides were less toxic on the third day after the application of the pesticides, then the efficiency of the lethal pesticides effect gradually increased until 21 days after spraying the pesticides in both stages (larvae and adults). And the organophosphorus pesticides recorded the highest percentage of reduction compared to the insect growth regulators and the biocide under studied. These results are in harmony with those of [4, 28] who mentioned that the percent population reduction varied depending on time passed after spraying of each insecticide.

The average over the five duplicate inspections, the two traditional pesticides Truefos 48% EC and Cord 72% EC showed more toxicity, where it recorded (93.91% and 88.77% reduction) of larvae and (92.74% and 83.06%) of adults, in the 1st season, corresponding to (95.33% and 89.65%) of larvae and (94.23% and 82.38%) of adults in the 2nd one, successively. On the other hand, both chitin synthesis inhibitors and ecdysone agonists (IGRs) pesticides showed intermediate toxicity to *C. vittata* numbers (Tables 3 and 4). For the first pesticide (Consult 10% EC) in 2020/2021 season, the reduction percentage was 81.13% and 78.58% for larvae and adults. While, the same pesticide in the 2021/2022 season the reduction percentage was 82.20% and 79.33% for larvae and adults, respectively. The second pesticide (Raner 26%

Table 4: Efficacy of some novel pesticides on average number and reduction percentage in total predators on sugar beet in 2020/2021 and 2021/2022 seasons

Season	Pesticide treatments	Recommended rate/feddan	Average No. of adults before spray	Aver. Number (No.) of adult insects/5 plants and reduction percentage (Red.%) after pesticides application										Overall Average	
				3 days		5 days		7 days		14 days		21 days			
				No.	Red.%	No.	Red.%	No.	Red.%	No.	Red.%	No.	Red.%	No.	Red.%
2020/2021	Emamex 5% EC	150 g	13.33	11.00	21.56	11.33	23.08	11.67	24.39	12.33	25.21	12.67	29.16	11.80	24.68
	Truefos 48% EC	1000 cm3	14.33	0.00	100.00	0.33	97.92	0.67	95.96	1.00	94.36ss	1.33	93.08	0.67	96.26
	Raner 26% SC	75 cm3	13.00	9.67	25.62	10.00	30.39	10.33	31.37	11.00	31.58	11.33	35.05	10.47	30.80
	Cord 72% EC	750 cm3	11.00	0.00	100.00	0.00	100.00	0.33	97.41	0.67	94.41	1.00	93.23	0.40	97.01
	Consult 10% EC	200 cm3	12.67	9.33	30.00	9.33	33.36	9.67	34.08	10.33	34.78	11.00	35.29	9.93	33.50
	Control	-	12.67	13.33	-	14.00	-	14.67	-	15.67	-	17.00	-	14.93	-
	LSD at 5%		N.S.	0.39		0.36		0.44		0.72		0.45		0.50	
2021/2022	Emamex 5% EC	150 g	14.00	12.33	24.53	12.33	28.57	12.67	30.39	13.00	35.20	13.00	40.74	12.67	31.89
	Truefos 48% EC	1000 cm3	13.67	0.00	100.00	0.33	98.04	0.67	96.23	1.33	93.21	1.67	92.20	0.80	95.94
	Raner 26% SC	75 cm3	11.00	9.00	29.89	9.33	31.21	9.33	34.76	10.00	36.56	10.67	38.10	9.67	34.10
	Cord 72% EC	750 cm3	12.33	0.00	100.00	0.00	100.00	0.33	97.94	0.67	96.21	1.33	93.12	0.47	97.45
	Consult 10% EC	200 cm3	10.00	7.67	34.28	8.00	35.12	8.33	35.92	8.67	39.50	9.00	42.57	8.33	37.48
	Control	-	10.00	11.67	-	12.33	-	13.00	-	14.33	-	15.67	-	13.40	-
	LSD at 5%		N.S.	0.41		0.39		0.57		0.56		0.44		0.46	

SC) reduction percentage was 76.16% and 72.60% for larvae and adults and the reduction percentage of tortoise beetle population (larvae and adults) was 75.22% and 73.56% in both seasons, sequentially. Furthermore, biocide (Emamex 5% EC) exhibited the lowest number of larvae and adults. The reduction percentage cleared in tables (2 and 3) which recorded 64.24% and 62.65% in the 1st season and 63.93% and 60.44% in the 2nd one for larvae and adults, respectively. Worth to such results are in harmony with those of other researchers. Profenofos was the most efficient pesticide against the immature stages of the tortoise beetle, *C. vittata*, according to [29, 30] who showed that Emamectin benzoate and hexaflumuron significantly reduced female moth fecundity, egg fertility and hatchability.

The author also added that the two biorational insecticides may be recommended to control American cotton bollworm, *Helicoverpa armigera* and are considered environmental friends. Anter, [5] suggested that Chlorpyrifos was the most effective chemical against *C. vittata* larvae and adults., while, Abamectin had moderate toxicity. Massoud, [31] illustrated that Profenofos recorded the highest general means reduction percentage against *P. mixta* than Emamectin benzoate.

Regarding the influence of tested pesticides (Raner 26% SC, Consult 10% EC, Emamex 5 % EC, Cord 72% EC, Truefos 48% EC) on the population of total predators; ladybird beetles (adults), rove beetles (larvae and adult), pirate bugs (adults) and green lacewing (larvae) are presented in table (4).

Data showed that the overall average percentage reduction (after 3, 5, 7, 14 and 21 days from treatment) of the total predators reach 26.68 and 31.89 % for Emamex 5% EC as a biocide, 30.80 and 34.10 % for Raner 26% SC as Ecdysone agonist pesticide and 33.50 and 37.48% for Consult 10% EC as chitin synthesis inhibitor for both seasons, respectively. Therefore, the obtained findings that the reduction percentage has obviously low impact on the number of the total predators which gives evidence that those three pesticides are more safety for the studied predators as compared to Cord 72% EC and Truefos 48% EC as conventional pesticides which cause a high percentage of reduction recording 97.01% and 96.26%, respectively in the first season, and 97.45 and 95.94% in the second season. Such effect gives evidence that biocide and IGRs pesticides were less toxic on *Cassida vittata* in two stages larvae and adults. These results are in agreement with those of [32- 34] who noticed the accompaniment of predators as compared with conventional pesticides (organophosphates and carbamate compounds) that give high toxicity to both the insect and predators. These findings are in accordance with those reviewed by [35] reported that IGRs caused lower effects against tested predators than Chlorfenapyr. Wang [36] indicated that Neonicotinoids, Avermectins, Pyrethroids and IGRs were less toxic, while, Phenylpyrazoles, Organophosphates and Carbamates were found slightly moderately or danger toxic to egg parasitoids, *Trichogramma evanescens*. With a risk period of fewer than 4 days, Emamectin benzoate was more safe for the growth of *Harmonia axyridis*, *Chrysoperla sinica*, *Snelleniua manilae* and *Telenomus remus* as reviewed by [37]. observed that the organophosphorus compound (Profenofos and Chlorfenapyr) has had the most toxicant effect on predators than tested IGRs, which could be attributed to their selective stomach insecticides.

Conclusion

Under conditions of the present study, the use of insect growth regulators and biocides pesticides (third-generation pesticides) that affect the hormonal regulation of molting and developmental processes in insects as one of integrated pest management (IPM) can be recommended for sugar beet pests, especially *C. vittata* considered safer for the biotic and abiotic conditions as compared to traditional pesticides.

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