Journal of Plant Protection and Pathology

Journal homepage: www.jppp.mans.edu.eg
Available online at: www.jppp.journals.ekb.eg

Role of Parasitoids, Conventional Insecticides and Ecdysone Agonists in Regulating Population of *Cassida vittata* Vill in Egyptian Sugar Beet Fields

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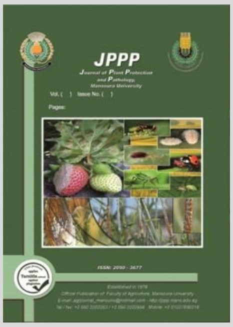

ABSTRACT

This study was carried out at the experimental farm of Sakha Agricultural Station, Kafr El-Sheikh Governorate for three successive seasons (2017/2018, 2018/2019 and 2019/2020). The study aimed to monitor seasonal abundance of *Cassida vittata* Vill. (Coleoptera: Chrysomelidae) and its hymenopterous parasitoids, *Monorthochaetaa nigra* Blood (Trichogrammatidae) and *Dinarmus laticeps* (Pteromalidae). Further, role of ecdysone agonists compounds in reducing *C. vittata* numbers and their adverse effect on these parasitoids in comparison with the conventional insecticides. Results proved that population density of *C. vittata* and its parasitoids gradually increased towards the end of the season resulting in highly positive significant correlations between this insect and its parasitoids. General egg-parasitoid of *M. nigra* to host ratio was 1:1.88 and 1:1.96, while it was 1:1.61 and 1:1.44 for larval-pupal parasitoid *D. laticeps* during 2018/2019 and 2017/2018 seasons, respectively. Lastly, ecdysone agonists were efficient against *C. vittata*, whereas it were almost safer to parasitoids than conventional insecticides. Thus, *C. vittata* parasitoids and ecdysone agonists may be used for integrated pest management programs for this serious insect.

***Keywords**: Cassida vittata, Monorthochaetaa nigra, Dinarmus laticeps, Ecdysone agonists, Beta vulgaris.*

INTRODUCTION

The sugar beet beetle, *Cassida vittata* Vill. (Coleoptera: Chrysomelidae) is one of the most important insect pests of sugar beet crop, *Beta vulgaris* L. which negatively affect the crop foliage and consequently reduce the crop productivity in Egypt (Ebieda, 1997; El-Mahalawy, 2011, Rashed, 2017 and Abbas, 2018). Its larvae and adults feed upon sugar beet leaves, causing significant defoliation to this crop (Maareg *et al.*, 2005; Abo El-Ftooh *et al.*, 2008; El- Dessouki *et al.*, 2014 and El-Dessouki, 2019). The high infestation of sugar beet with this insect causes significant reduction of 40% and 56.20% in root weight and sugar content, respectively (Abo- Saied, 1987). Therefore, the farmers hurry up to control this insect with spraying insecticides regardless the economic threshold level. The intensive use of conventional insecticides led to numerous important drastic problems, i.e. environmental pollution, destruction of the natural enemies and incidence insect resistance to these insecticides. Parasitoids are vital biological agents that used widely in controlling various insect pest species (Sampaio *et al*., 2010 and Kalyanasundaram and Jamala, 2016). Two parasitoid species were identified in Egyptian sugar beet fields: *Monorthochaeta nigra* Blood as an egg-parasitoid and *Tetrastichus* sp. as a pupal parasitoid (Abo-Aiana 1991; Awadalla, 1993; Bazazo, 2010 and Hawila, 2021). Up to our knowledge this is the first record of *D. Laticeps* in Kafr El-Sheikh Governorate sugar beet fields.

Ecdysone agonists (Methoxyfenozide and Chromafenozide) are novel and promising bioinsecticides with high efficiency against various insects, and almost non-toxicity to parasitoids and environment (Awad *et al.*, 2014). In fact, studies on the egg-parasitoid, *M. nigra* and the larval-pupal parasitoid, *D. laticeps* of *C. vittata* Vill. in Egypt are apparently few. As well, the effect of ecdysone agonists on *C. vittata* and its parasitoids was scarcely investigated. Therefore, the aim of the present investigation is to monitor the seasonal abundance of *C. vittata*, and its parasitoids *M. nigra* and *D. laticeps* and to compare the efficiency of certain ecdysone agonists with certain conventional insecticides on *C. vittata* and its two parasitoids in sugar beet fields.

MATERIALS AND METHODS

This study was carried out at the experimental Farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during 2017/2018 and 2018/2019 seasons. The experimental area was about (one feddan) planted with sugar beet variety Hussam on 15th October and 18th October during the two seasons of 2017/2018 and 2018/2019, respectively. Another sugar beet field that planted with the same variety on 15th October and 18th October during 2018/2019 and 2019/2020 seasons at the Experimental Farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, Egypt was used to evaluate the biological activity of some chemical compounds on *C. vittata* larvae and its parasitoids. Recommended agricultural practices were followed, but without insecticide application. This study was designed for the following items:

Seasonal abundance of *C. vittata* eggs and larvae:

Eggs and larvae of the sugar beet beetle, *C. vittata* were visually inspected and counted on randomly selected

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DOI: 10.21608/jppp.2021.193801

ten plants every five days, during 2017/2018 and 2018/2019 seasons.

Seasonal abundance of the egg and larval-pupal parasitoids:

To estimate the population of the egg and larval-pupal parasitoids of *C. vittata*, visually determined eggs and larvae of *C. vittata* on their parts of sugar beet leaves were collected by using scissors, and transferred to the laboratory. Eggs were separated in Petri-dishes (9 cm). Larvae of *C. vittata* were transferred to other Petri dishes (9 cm), containing filter papers. These dishes were kept under laboratory conditions (25 ± 2C^o, 60-70% R.H.). In case of larval-pupal parasitoid, the formed pupae of *C. vittata* were moved to other Petri-dishes and monitored till the emergence of adult parasitoids. The emerged parasitoids were inspected by binocular for preserving the individuals of these parasitoids in glass vials containing 70% alcohol and then these specimens were sent to the Plant Protection Research Institute, Giza – Cairo for identification.

Correlation coefficient between number of *C. vittata* stages and their associated parasitoids was determined during the first and second seasons using MINITAB® software program (ver. 16).

Biological activity of certain chemical compounds on *C. vittata* and its associated parasitoids:

This experiment was conducted at another sugar beet field that planted with Hussam variety on 15th October and 18th October during 2018/2019 and 2019/2020 seasons at the Experimental Farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, Egypt. Two ecdysone agonists and two conventional chemical compounds were applied. The used compounds and their rates were presented in Table (1) were applied. Each compound was replicated four times (4 compounds x 4 plots = 16 plots), each plot measured 42 m^2, in addition to another four plots as check. Treatments were distributed in completely randomized block design. Knapsack (20 L. volume) was used for spraying these compounds. Date of spraying was 10 April and 13 April in two seasons, respectively. The efficiency of the tested chemical compounds on the populations of *C. vittata* and its parasitoid were evaluated. In each inspection time, the numbers of *C. vittata* and its larval-pupal parasitoid were estimated before treatment, and after one, three, seven and ten days from spraying. Number of *C. vittata* larvae were visually recorded on ten plants for each compound in both treated and non-treated plots. Leaf samples having host larvae were collected from each plot and larvae of *C. vittata* were kept in Petri-dishes until parasitoid emergence. Population reduction of *C. vittata* larvae and its parasitoid due to the different treatments was calculated in comparison with untreated plots in each case. Reduction percent of *C. vittata* larvae and its parasitoids was estimated according to the formula of Henderson and Tilton (1955) as follows:

$$\text{Population reduction } \% = \left(1 - \frac{Ta \times Cb}{Tb \times Ca}\right) \times 100$$

where:

Ta: population in treated plots after treatment Ca: population in control after treatment

Tb: population in treated plots before treatment Cb: population in control before treatment

Table 1. Chemical compounds used against *C. vittata* and their rates.

Insecticide		Category	Rate /Fed /200L water.
Common name	**Trade name**		
Methoxyfenozide	Raner 24% Sc	Ecdysone agonists	75 cm^3
Chromafenozide	Raner 24%	Ecdysone agonists	400 m3
Chlopyrifos	Dora 48% Ec	Conventional	1000 cm3
Methomyl	Goldbein 90% SP	Conventional	300 gm

RESULTS AND DISCUSSION

Seasonal abundance of *C. vittata* eggs and larvae and their associated parasitoids:

In 2017/2018 season, the number of *C. vittata* eggs appeared on 10 March (eggs/ 10 plants), and the population density progressively increased to exhibit highly numbers on 5, 10, 15, 20, 25 April with 12, 18, 20, 26 and 30 eggs /10 plants (Table 2). While, the egg parasitoid *M. nigra* began to appear on 20 March and increased on the same previous dates with values; 3, 5, 6, 23, and 27 individuals, respectively. Concerning, the larvae of *C. vittata* were noticed on 10 March (one larvae /10 plants), and the population density gradually increased towards the end of the season to incidence highly numbers on 15, 20 and 25 April with 23.29 and 33 larvae/ 10 plants, respectively. Further, the larval-pupal parasitoid, *D. laticeps* population started to appear with 1 individual on 15 March then increased gradually to reach 18, 20 and 24 individuals on 15, 20 and 25 April, respectively.

In 2018/2019 season, the number of *C. vittata* eggs started to appear on 11 March (one egg /10 plants), and the population density gradually increased to exhibit high numbers on 6, 11, 16, 21 and 26 April with 8, 11, 11, 22 and 27 eggs/10 plants, respectively. In addition to the egg parasitoid of *C. vittata*, *M. nigra* population increased on the same previous dates with number; 4, 4, 8, 13 and 15 individuals, respectively. Whereas, the larvae of *C. vittata* recorded on 11 March (2 larvae /10 plants), and the population density gradually increased towards the end of the season to incidence highly numbers on 11, 16, 21 and 26 April with 24,27, 31 and 39 larvae /10 plants, respectively. As the larval-pupal parasitoid of *C. vittata*, *D. laticeps* populations increased on the same previous dates with values 7, 12, 18 and 26 individuals, respectively. Further, Tables (2 and 3) show that the general host ratio of parasitoid (*M. nigra)* was 1 : 1.88 and 1: 1.96 also, was 1: 1.61 and 1: 1.44 for the parasitoid, *D. laticeps* in the two seasons, respectively.

Abo-Aiana (1991) detected two peaks for *M. nigra* as an egg parasitoid of *C. vittata*, the first peak occurred in April, while the second one occurred in May. Awadalla (1993) reported that *M. nigra* is active in April and May. Youssef (1994) indicated that this parasitoid activity covered the duration from February to May. Lastly, Bazazo (2010) found the same parasitoid from March to May.

Table (4) show that the simple correlation coefficient values between C. vittata stages and their corresponding parasitoids during 2017/2018 and 2018/2019 seasons. Highly positive significant correlations between *C. vittata* eggs and the egg parasitoid, *M.* nigra were detected in the first and second season, respectively. The same correlation trend and it significant were obtained between *C. vittata* larvae and its larval-pupal parasitoid, *D. laticeps* in the two seasons.

Table 2. Seasonal abundance of *C. vittata* eggs and larvae and their associated parasitoids in sugar beet fields, during 2017/2018 season.

Sampling date	No. of eggs/10 plants	No. *M. nigra*	No. of larvae/10 plants	No. of *D. laticeps*
10 March	2	0	1	0
15	3	0	2	1
20	7	2	4	2
25	7	2	9	3
30	9	3	9	3
5 April	12	3	19	10
10	18	5	21	12
15	20	6	23	18
20	26	23	29	20
25	30	27	33	24
Total	134	71	150	93
General of parasitoid-host ratio	1 : 1.88		1 : 1.61	

Table 3. Seasonal abundance of *C. vittata* eggs and larvae and their associated parasitoids in sugar beet fields, during 2018/2019 season.

Sampling date	No. of eggs/10 plants	No. *M. nigra*	No. of larvae/10 plants	No. of *D.laticeps*
11 March	1	0	2	0
16	2	0	3	1
21	4	2	3	0
26	6	2	7	2
31	8	3	11	3
6 April	8	4	21	6
11	11	4	24	7
16	11	8	27	12
21	22	13	31	18
26	27	15	39	26
Total	100	51	108	75
General of parasitoid-host ratio	1:1.96		1:1.44	

Table 4. Correlation Coefficient (r) between eggs and larvae of *C. vittata* and associated parasitoids in sugar beet fields, during 2017/2018 and 2018/2019 seasons

Relationship	2017/2018		2018/2019	
	r	Probability level (P)	r	Probability level (P)
C. vittata egg × egg parasitoid *M. nigra*	0.90	< 0.01	0.98	< 0.01
C. vittata Larvae × larval-pupal parasitoid *D. laticeps*	0.98	< 0.01	0.93	< 0.01

Bazazo (2005 and 2010) reported that sugar beet ecosystem has enormous natural enemies (mainly, parasitoids) that should be wisely conserved to keep the insect pests under the economic threshold levels. Bazazo (2010) surveyed 38 parasitoid species, belonging to 20 families of Hymenoptera. Kalyanasundaram and Kamala (2016) indicated that natural enemies has recently gained much interest because of the problems encountered by use of pesticides and environmental concerns. Because sugar beet is a food crop, it is wise to avoid or minimize the use of insecticides. Parasitoids are an important biological tool used widely in agriculture for managing of various insect species. Clarke *et al.* (2019) concluded that parasitoids are among arthropods that are most widely used in biological control against crop pests and thus are a significant component of integrated pest management systems (IPM).

Biological activity of some conventional and ecdysone agonist chemical compounds on population of *C. vittata* and its parasitoids.

Tables (5 and 6) elucidate that ecdysone agonists; Raner 24% s and Ferto 5% sc were induced overall mean of reduction in *C. vittata* populations with 94.38 and 94.64%, respectively in 2018/2019 season, and 93.56 and 94.07%, respectively in 2019/2020 season. While, the conventional insecticides; Dora 48% Ec and Goldbein 90% sp were induced overall mean of reductions against the same insect with 97.12 and 96.82%, respectively in 2018/2019 season, and 95.75 and 92.76%, respectively in 2019/2020 season. Concerning the parasitoids results presented in table (7 and 8) clarify that ecdysone agonists; Raner 24% Sc and Ferto 5% Ec caused overall mean of reduction in parasitoids numbers with 11.90 and 13.46%, respectively in 2018/2019 season, and 13.86 and 13.06%, respectively in 2019/2020 season.

As for the conventional insecticides; Dora 48% E and Goldbein 90% Sp reduced the same parasitoids with 100 and 100%, respectively in both seasons. These results demonstrate that ecdysone agonists are efficient in reducing *C. vittata* larvae, and in the same time are almost safe to parasitoids in comparison with conventional insecticides. It would be an ideal agent for integrated pest management (IPM) against *C. vittata*. Sparks (2001) reported that the ecdysone agonists are novel class of IGRs, disrupting the molting process by mimicking the action of 20 Hydroxy ecdysone. Yanagi *et al.* (2006) demonstrated that 20-Hydroxy ecdysone one of the most active insect hormone- ecdysones, at every stage of the insect's growth to regulate molting. These results are in agreement with those of several authors; Ishaaya (2005), Pineda *et al*., (2009) and Rani *et al*., (2018). They concluded that ecdysone agonists are promising insecticides with high efficacy against various insects, at the same time almost non- toxic to parasitoids and have minimum effect on the environment.

Table 5. Reduction in *C. vittata* populations by certain conventional and ecdysone agonist chemical compounds on sugar beet plants during 2018/2019 season.

Compound	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction
	Mean	M.	Red%	M.	Red%	M.	Red%	M.	Red%	
Raner 24%	20.25	2.25	88.20	1.50	93.29	0.75	96.99	0.25	99.66	94.38
Ferto 5%	20.00	2.25	89.25	1.25	94.34	1.00	95.94	0.25	99.05	94.64
Dora 48%	21.50	1.25	94.44	0.75	96.84	0.50	98.11	0.25	99.21	97.12
Goldbein90%	21.50	1.50	93.3	1.00	95.7	0.25	99.05	0.25	99.21	96.82
Check	21.5	2.50	-	23.75	-	26.50	-	28.50	-	-

Table 6. Reduction in *C. vittata* numbers by some conventional and ecdysone agonist chemical compounds on sugar beet plants during 2019/2020 season.

Compound	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction
	Mean	M.	Red%	M.	Red%	M.	Red%	M.	Red%	
Raner 24%	15.00	2.00	87.71	1.25	92.79	1.00	94.92	0.25	98.84	93.56
Ferto 5%	15.25	1.75	89.43	1.25	92.91	0.75	96.25	0.50	97.72	94.07
Dora 48%	16.50	1.50	91.62	1.00	94.76	0.50	97.69	0.25	98.94	95.75
Goldbein90%	15.75	1.75	89.76	1.50	91.76	1.25	93.96	1.00	95.59	92.76
Check	17.5	19.00	-	20.25	-	23.00	-	25.25	-	-

Table 7. Reduction in parasitoid populations by some conventional and ecdysone agonist chemical compounds on sugar beet plants during 2018/2019

Compound	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction
	Mean	M.	Red%	M.	Red%	M.	Red%	M.	Red%	
Raner 24%	7.50	7.25	6.66	7.00	12.88	7.25	12.68	7.25	15.41	11.90a
Ferto 5%	7.50	7.00	9.88	7.00	12.88	7.00	15.69 100	7.25	15.41	13.46a
Dora 48%	7.25	0.00	100	0.00	100	0.00	100	0.00	100	100b
Goldbein90%	7.25	0.00	100	0.00	100	0.00		0.00	100	100b
Check	7.00	7.25	-	7.50	-	7.75	-	8.00	-	-

Table 8. Reduction in parasitoids populations by some conventional and ecdysone agonist chemical compounds on sugar beet plants during 2019/2020

Compound	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction
	Mean	M.	Red%	M.	Red%	M.	Red%	M.	Red%	
Raner 24%	6.25	6.00	7.42	5.50	5.50	6.00	13.60	6.00	16.38	13.86a
Ferto 5%	6.25	5.75	11.28	5.50	5.50	6.25	10.00	6.25	12.90	13.06a
Dora 48%	7.00	0.00	100	0.00	0.00	0.00	100	0.00	100	100b
Goldbein90%	7.00	0.00	100	0.00	0.00	0.00	100	0.00	100	100b
Check	6.75	7.00	-	7.25	-	7.50	-	7.75	-	-

ACKNOWLEDGEMENT

The authors wish to express his deep gratitude to all staff members of Sugar Crops Research Department, Sakha Agricultural Research Station for their support and help throughout the experimental period.

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دور الطفيليات وبعض المبيدات الحشرية ومنبهات سرعة الإنسلاخ في مكافحة خنفساء البنجر في حقول بنجر السكر في مصر

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أجريت هذه الدراسة بالمزرعة التجريبية بمحطة سخا الزراعية بمحافظة كفر الشيخ لمدة ثلاثة مواسم متتالية. ٢٠١٨/٢٠١٧ و ٢٠١٩/٢٠١٨ و ٢٠٢٠/٢٠١٩. هدفت الدراسة إلى رصد الوفرة الموسمية لحشرة خنفساء البنجر السلحفائية وطفيلياتها من رتبة غشائية الأجنحة وهما الطفيليين *Monorthochaeetaa nigra* Blood و *Dinarmus laticeps*. أيضا ، دور مبيدات الانسلاخ في تقليل أعداد خنفساء البنجر وتأثيرها الضار على هذه الطفيليات مقارنة بالمبيدات الحشرية التقليدية. أثبتت النتائج أن الكثافة العددية لخنفساء البنجر وطفيلياتها زادت تدريجياً في نهاية المواسم مع حدوث أعداداً عالية و إرتباط معنوي إيجابي بين هذه الحشرة وطفيلياتها. كما بلغ نسبة طفيل البيض *M. nigra* للعائل ١,٨٨:١و ١,٩٦:١في حين كان ١,٦١:١و ١,٤٤:١ لنسبة الطفيل اليرقي- العذري *D. laticeps* للعائل خلال الموسمين٢٠١٨/٢٠١٧ و ٢٠١٩/٢٠١٨ على التوالي. أخيرًا ، كانت مبيدات الانسلاخ فعالة ضد خنفساء البنجر في نفس الوقت كانت آمنة تقريبًا للطفيليات مقارنة بالمبيدات الحشرية التقليدية. وبالتالي ، يمكن إستخدام الطفيليات لخنفساء البنجر و مبيدات الانسلاخ في برنامج المكافحة المتكاملة للآفات (IPM) لهذه الافة الخطيرة.

كلمات مفتاحيه: خنفساء البنجر ـ الطفيل *Monorthochaeetaa nigra* ـ الطفيل *Dinarmus laticeps* ـ منبهات الانسلاخ ـ بنجر السكر.