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Effect of the flowering weed, *Euphorbia helioscopia* L. (Euphorbiacea) in enhancing the parasitism by the synovigenic parasitoid females of *Trissolcus basalis* (woll.) (Hymenoptera: Scelionidae) on *Nezara viridula* (L.) egg masses (Hemiptera: Pentatomidae) in sugar beet fields

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ABSTRACT

Numerous parasitoid species have been proved feeding on flowers nectar of plants that contains sugar, proteins, amino acids, lipids and many other organic and inorganic substances. Consequently, parasitism rates can be increased in the field by feeding on nectar. This investigation aimed to evaluate the effect of the flowering weed, *E. helioscopia* in raising parasitism rates of *Trissolcus bassalis* on *Nezara viridula* eggs during 2018/ 2019 and 2019/ 2020 at the experimental farm of Sakha Agricultural Research Station, Kafr El- Sheikh Governorate. Results elucidated that seasonal mean of *N. viridula* egg masses was higher in the third cultivation date (3.91 ± 0.30 and 4.24 ± 1.10) than the first (1.33 ± 0.10 and 1.08 ± 0.10) and second (2.24 ± 0.20 and 2.08 ± 0.20) dates during the first and second seasons, respectively. Further, numbers of *T. basalis* were higher in the third cultivation date (6.66 ± 2.10 and 4.91 ± 1.20) than the first (1.58 ± 0.10 and 1.41 ± 0.20) and second (4.00 ± 1.10 and 2.58 ± 0.10) dates during the first and second seasons, respectively. On the other side, the parasitized egg masses, emerged parasitoids and parasitism percentages were higher in weedy – plots in the first (4.85 ± 0.10, 23. 90 ± 2.10 and 92.83 ± 6.10) and second (4.47 ± 0.20, 19.94 ± 2.20 and 84.52 ± 5.10) seasons than the weed-free plots (1.56 ± 0.10, 5.33 ± 0.30 and 31.26 ± 4.10) in the two seasons, respectively. The information obtained here might be valuable in increasing our knowledge about the role of flower nectars in conservation of natural enemies, especially synovigenic females of insect parasitoids.

Keywords: *Euphorbia heliscopia, Trissolcus basalis, Nezara viridula*, Sugar beet, Egyptian.

1. Introduction

Sugar beet (*Beta vulgaris* L.) (Family: Chenopodiaceae) is considered one of the most important sugar crops worldwide. In Egypt, it is the second important sugar crop after sugar cane for sugar production till 2013. But, it is became the first source of sugar since 2013 till now (Hawila, 2021). The total cultivated area with sugar beet reached 650 thousand feddans in Egypt during 2020/ 2021, that produce more than 1.6 million tons of sugar (Anonymous, 2021).

Sugar beet is liable to attack by many destructive insect pests during the whole growing season. These insects cause significant reductions in sugar beet yield (Abou- El Kassem, 2010; El- Dessouki, 2019). The piercing-sucking insects such as *Nezara viridula* (L.) is considered among the economic insects of sugar beet plants (Nielson *et al*. 2011; Khalifa 2017 and 2018) causing direct damage by piercing and sucking the plant sap and indirect damage by transmission of many virus diseases (Hegazy *et al*., 2018).

The intensive use of insecticides led to several important drastic problems such as the environmental pollution, reduction of the natural enemies and incidence insect resistance to these insecticides (Awad *et al*., 2014).

Recently the parasitoids consider as a vital agent of biological control against sugar beet insects (Bazazo, 2010 and Hendawy and El- Fakharany, 2017). The egg parasitoid, *T. basalis* has proven

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effective against *N. viridula* eggs. (Mcpherson and Mcpherson, 2000, Tawfik, 2007, Bazazo, 2010 and Hawila, 2021). They recorded that the percentage of parasitism ranged between 40.1 to 100%.

Reproductive ecology in parasitoids has been of great interest because it is a major component of their life history as it relates to egg production and female fecundity (Price, 1973 and 1974; Quicke, 1997; Papaj, 2000). Nutrition is the single most important factor influencing egg production and female fecundity; the amount of resources available to the female from her own larval and adult feeding largely determines her reproductive potential (Godfray, 1994; Quicke, 1997; Thompson, 1999; Papaj, 2000; Rivero *et al*., 2001). Adult nutrition is also important in female reproduction. Adult parasitoids after eclosion generally require food to sustain foraging activity and to initiate and maintain oogenesis (Jervis and Kidd, 1986; Heimpel and Collier, 1996; Jervis *et al*., 1996; Thompson, 1999). Plant materials such as floral and extrafloral nectars, pollens etc. are widely used as adult food (Jervis *et al*. 1993, 1996; Thompson 1999).

Thus, the flowering weeds have frequently been cited as important food resources for adult parasitoids. Many of the relevant studies have proved the value of flowering weeds that supply dietary pollen and nectar, leading to increased longevity and fecundity in adult of parasitoids (Bugg and Wilsor, 1989). Further, Thorbek and Bilde (2004) in Germany, suggested that leaving some weeds without cutting in sugar beet fields lead to a significant increase in parasitoids density. In such concern, Wnuk and Wojciechowicz – Zytko (2007) showed that *Phacelia tanacetifolia* Benth is an important source of pollen and nectar for parasitoids in faba bean fields. One of the conservation biological control methods is habitat modification and improving the parasitoid: host ratio through enriching the field neighborhood with flowering plants. Because of all these reasons, the present study was conducted to examine the role of the flowering weeds in improving the efficiency of the synovigenic female parasitoids of *T. basalis* against *N. viridula* egg masses.

2. Materials and Methods

2.1. Seasonal numbers of *N. viridula* eggs and its parasitoid in the field

To record the seasonal density of *N. viridula* egg masses during 2018/ 2019 and 2019/ 2020 in the three plantations (Photo, 1). An area of about 2400 m^2 was divided into three replicates. Farida variety was sown in three different plantation dates (15^{th} August, 15^{th} September and 15^{th} October). All recommended cultural practices were done till harvest without insecticide spraying. Monthly samples of 10 plants/ replicate were chosen randomly and inspected in the field by the visual examination. The seasonal abundance of the parasitoid was recorded by using sweep-net (50 double strikes)/ replicate.

2.2. Role of the flowering weed, *E. helioscopia* in improving the efficiency of *T. basalis* parasitoid:

An additional area (2400 m^2) was selected and divided into two plots: the first plot was weedy-free and the second ones was weed free, except from those of *Euphorbia helioscopia* (Photo, 2). Bare zone (100 m^2) as a barrier was considered between the two plots. Farida variety was sown on 15^{th} October in the two seasons of the study. Egg masses were taken from the two areas, then were kept in petri dishes that provided with pieces of moistened cotton till hatching or parasitoid emergence. Egg masses were kept under laboratory conditions (27 ± 1C° and 70 ± 3% R.H).

The number of egg masses, parasitized eggs and parasitism percentages were recorded (Photo, 3). The parasitoids were identified at the Plant Protection Institute, Egypt. The samples were taken on 15^{th}, 20^{th} and 30^{th} March in the first season, and on 15^{th}, 20^{th} and 30^{th} April and 10^{th} May in the second season.

Photo. 1: Egg mass of *N. viridula*

Photo. 2: *E. helioscopia*.

Photo. 3: *T. basalis* adult.

2.3. Statistical analysis:

All statistical analysis was performed using analysis of variance (ANOVA) using "SPSS" computer software package. The treatment means were compared using Duncan multiple range test (Duncan, 1955).

3. Results and Discussion

3.1. Seasonal mean of *N. viridula* egg masses and its parasitoid, *T. basalis*:

Data in Table (1) and Fig. (1) show the mean number of *N. viridula* egg masses/ 10 plants during the first cultivation in 15th November was 0.33, that increased to 1.00 in December, 1.66 in January and 2.33 in February. The seasonal mean was 1.33 ± 0.10/ 10 plants. The second and third cultivations, the mean numbers increased towards the end of the season. Seasonal mean was 2.24 ± 0.20 and 3.91 ± 0.30, respectively. Statistical analysis proved that significant differences among the three cultivation. The highest mean was in third, second and first cultivations. Concerning, *T. basalis* parasitoid in Table (2) and Fig. (2) show that seasonal mean numbers were 1.58 ± 0.10, 4.00 ± 1.10 and 6.66 ± 2.10 in three cultivations, respectively during 2018/ 2019 season. In 2019/ 2020 season, the same trend was obtained Table (3 &4) and Fig. (3 & 4). These results indicate that the highest seasonal mean number of *T. basalis* parasitoids coincided with that of *N. viridula* egg masses during the three cultivations in two seasons.Similar results were obtained by Colazza and Bin (1995) in Italy, reported that the parasitoid, *T. basalis* an important agent in controlling *N. viridula* egg masses in the fields. In the USA, Jones (1995) indicated that *T. basalis* is significant element in reducing *N. viridula* populations. Also, Tawfik (2007) in Egypt, demonstrated that *T. basalis* parasitoid play a vital role in controlling *N. viridula* egg masses. In such concern, Khalifa (2017) noted that fortunately, sugar beet ecosystem has enormous parasitoids that should be wisely conserved to keep the insect pests beyond the economic threshold levels. In conclusion, the populations of this parasitoid increase with the increasing of *N. viridula* populations, this synchronization proves that the importance of this parasitoid in suppressing this insect pest.

Table 1: Seasonal average of N. viridula egg masses/ 10 plants in three cultivations during 2018/ 2019 season.

Date of sampling	Cultivations		
	1st	2nd	3rd
Nov. 15	0.33	0	0
Dec. 16	1.00	0	0
Jan. 15	1.66	1.33	0
Feb. 17	2.33	2.33	2.33
Mar. 18	0	2.66	3.00
Apr. 15	0	2.66	5.00
May 14	0	0	5.33
***Mean ± SE**	1.33 ± 0.10 a	2.24 ± 0.20 b	3.91 ± 0.30 c

*Means followed by different letters are significantly differences at level 5% of probability.

Table 2: Seasonal average of *T. basalis* parasitoid/ 50 doubles strikes in three cultivations, 2018/ 2019 season.

Date of sampling	**Cultivations**		
	1st	2nd	3rd
Nov. 15	1.00	0	0
Dec. 16	1.33	0	0
Jan. 15	2.00	2.00	0
Feb. 17	2.00	3.00	3.00
Mar. 18	0	5.00	6.00
Apr. 15	0	6.33	7.33
May 14	0	0	10.33
***Mean ± SE**	1.58 ± 0.10 a	4.00 ± 1.10 b	6.66 ± 2.10 c

*Means followed by different letters are significantly differences at level 5% of probability.

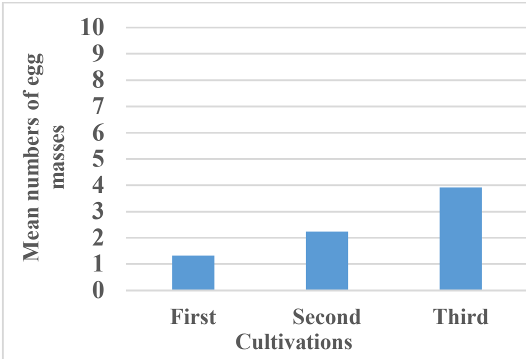

Fig. 1: Mean number of *N. viridula* egg masses in 2018/ 2019 season.

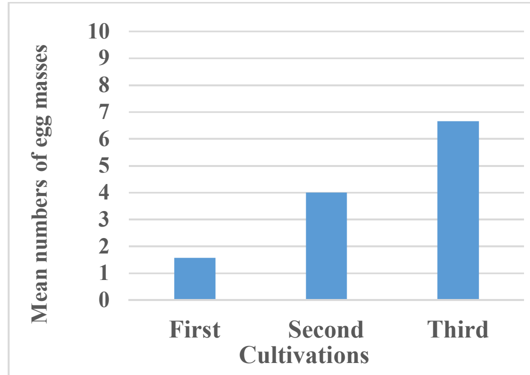

Fig. 2: Mean number of *T. basalis* parasitoid in 2018/ 2019 season.

Table 3: Seasonal average of *N. viridula* egg masses/ 10 plants in three cultivations throughout 2019/ 2020 season.

Date of sampling	Cultivations		
	1st	2nd	3rd
Nov. 14	0.33	0	0
Dec. 15	0.66	0	0
Jan. 14	1.33	1.33	0
Feb. 16	2.00	1.66	2.33
Mar. 19	0	2.33	3.00
Apr. 18	0	3.00	4.33
May 16	0	0	7.33
***Mean ± SE**	1.08 ± 0.10 a	2.08 ± 0.20 b	4.24 ± 1.10 c

*Means followed by different letters are significantly differences at level 5% of probability.

Table 4: Seasonal average of *T. basalis* parasitoid/ 50 doubles strikes in three cultivations, 2019/ 2020 season.

Date of sampling	Cultivations		
	1st	2nd	3rd
Nov. 14	0.66	0	0
Dec. 15	1.00	0	0
Jan. 14	1.66	0.66	0
Feb. 16	2.33	2.00	2.66
Mar. 19	0	3.66	4.00
Apr. 18	0	4.00	5.33
May 16	0	0	7.66
***Mean ± SE**	1.41 ± 0.20 a	2.58 ± 0.10 b	4.91 ± 1.20 c

*Means followed by different letters are significantly differences at level 5% of probability.

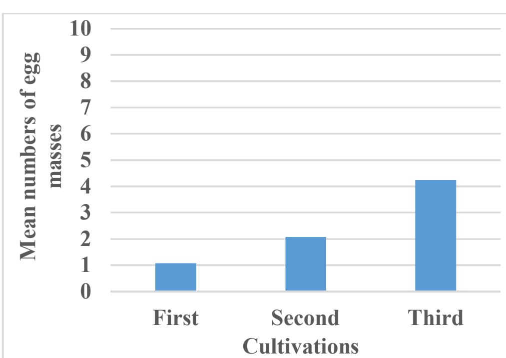

Fig. 3: Mean number of *N. viridula* egg masses during 2019/ 2020 season.

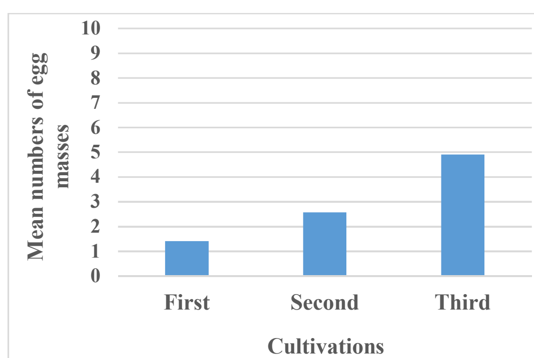

Fig. 4: Mean number of *T. basalis* parasitoid during 2019/ 2020 season.

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3.2. Comparing the parasitized masses, emerged parasitoids and parasitism percentages to weedy plots and weed- free ones:

Numerous field experiments show that access to nectar and pollen may be vital to parasitoid adults survival, reproduction, longevity and efficiency of parasitism (Harmon *et al*. 2000; Rebek *et al*. 2005 and Pontin *et al*. 2006). Jones (1995) reported that egg masses placed in the weeds had significantly higher rates of parasitism by *T. basalis* in orchard fields. Also, Fiedler and Landis (2007) showed that multiple studies have found increased parasitoids in the presence of flowering plants. In such concern, Winkler *et al* (2006) reported that parasitoids with access to nectar and hosts parasitized 96 times as many hosts as those with access to hosts only. Lastly, Jevis *et al*. (1993) recorded that numerous parasitoid species have been reported feeding on a broad range of flowers.

The results show that the importance of the flowering weed, *E. helioscopia* in increasing efficiency of parasitism to *T. basalis*, consequently reducing *N. viridula* populations.

Data in tables (5 & 6) and Figures (5 & 6) clarify that statistical analysis demonstrate incidence significant differences between weedy plots and weed- free ones in mean of parasitized egg masses, emerged parasitoids and parasitism percentages throughout the two seasons.

The values were 4.85 ± 0.10, 23.90 ± 2.10 and 92.83 ± 6.10, respectively. The corresponding values were 1.56 ± 0.10, 4.47 ± 0.20 and 29.87 ± 3.10 in weed- free plots during 2018/ 2019. In 2019/ 2020 season, the same findings were recorded. The values were 4.47 ± 0.20, 19.94 ± 2.20 and 84.52 ± 5.10, respectively in weedy plots. Whilst, the corresponding values were 1.56 ± 0.10, 5.33 ± 0.30 and 31.26 ± 4.10 in weed- free ones.

Table 5: Seasonal mean of parasitized egg masses, emerged parasitoids and parasitism percentages in weedy plots and weed- free ones during 2018/ 2019 season.

Mean of egg masses	Weedy plots			Weed- free plots		
	Mean of parasitized egg masses	Mean of emerged parasitoids	Parasitism percentages (%)	Mean of parasitized egg masses	Mean of emerged parasitoids	Parasitism percentages (%)
2.00	1.66	16.66	83.33	0.66	3.33	3.33
3.00	2.66	20.66	88.88	0.66	3.66	22.22
4.00	3.66	24.33	91.66	1.00	4.33	25.00
5.00	5.00	26.00	100.00	1.66	4.66	33.33
6.00	5.66	26.33	94.44	2.00	4.66	33.33
7.00	6.66	26.66	95.23	2.00	5.33	28.57
9.00	8.66	26.66	96.29	3.00	5.33	33.33
***Mean ± SE**	4.85 ± 0.10 a	23.90 ± 2.10 a	92.83 ± 6.10 a	1.56 ± 0.10 b	4.47 ± 0.20 b	29.87 ± 3.10 b

*Means followed by different letters are significantly differences at level 5% of probability.

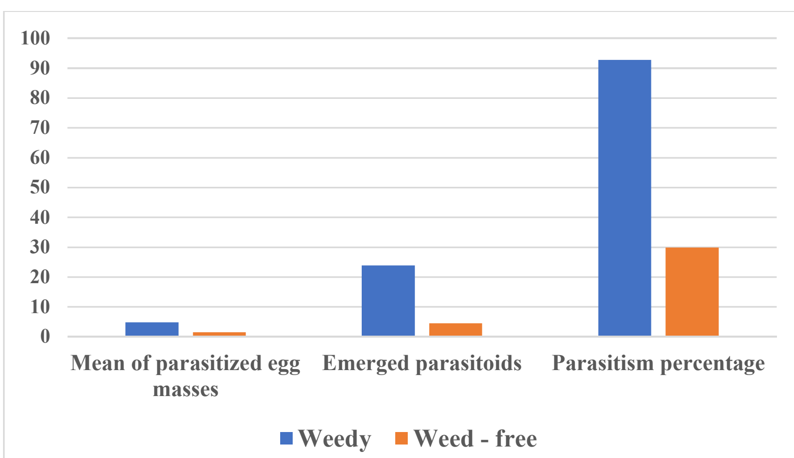

Fig. 5: Mean of parasitized egg masses, emerged parasitoids and parasitism percentages, 2018/ 2019.

Table 6: Seasonal mean of parasitized egg masses, emerged parasitoids and parasitism percentages in weedy plots and weed- free ones throughout 2019/ 2020 season.

Mean of egg masses	Weedy plots			Weed- free plots		
	Mean of parasitized egg masses	Mean of emerged parasitoids	Parasitism percentages (%)	Mean of parasitized egg masses	Mean of emerged parasitoids	Parasitism percentages (%)
1.66	1.33	16.66	80.00	0.66	4.33	40.00
2.33	1.66	17.66	71.42	0.66	4.33	28.57
4.33	3.33	20.33	76.92	1.33	4.66	30.67
4.66	4.00	21.00	85.71	1.33	5.33	28.57
6.33	6.33	17.33	100.00	2.00	6.00	31.57
7.33	7.00	23.33	95.45	2.00	6.00	27.27
9.33	7.66	23.33	82.14	3.00	6.66	32.14
***Mean± SE**	4.47 ± 0.20 a	19.94 ± 2.20 a	84.52 ± 5.10 a	1.56 ± 0.10 b	5.33 ± 0.30 b	31.26 ± 4.10 b

*Means followed by different letters are significantly differences at level 5% of probability.

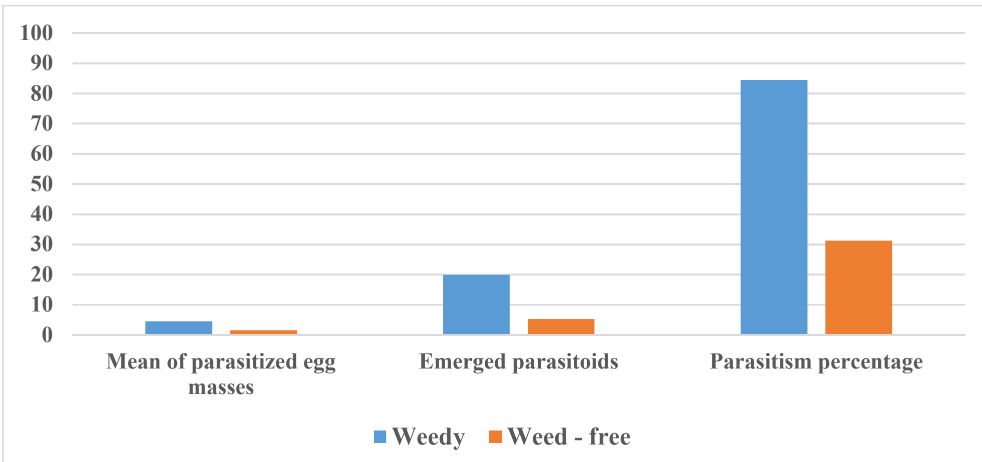

Fig. 6: Mean of parasitized egg masses, emerged parasitoids and parasitism percentages, 2019/ 2020.

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