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Impactful Role of Biocide, (Biossiana)® and *Aphidius matricariae* Haliday (Hymenoptera: Aphidiidae) *Parasitoid* in Biocontrolling *Myzus persicae* (Sulzer) (Homoptera: Aphididae) in Egyptian Sugar Beet Fields

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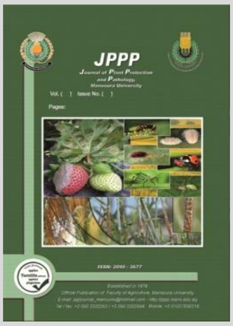

ABSTRACT

Studies was performed at the Experimental Farm of Sakha Agricultural Research Station and Laboratory of Sugar Crops Research Department, Sakha – Kafr El- Sheikh Governorate throughout 2021/2022 and 2022/2023 seasons. The results revealed that parasitism efficiency- during the whole season- of *A. matricariae* parasitoid on *M. persicae (nymph+adults)* was 53.42,43.29 and 68.49% in the three cultivations, respectively during 2021/2022, 60.00, 54.43 and 56.84% in three cultivations, respectively during 2022/2023. In addition to, average of reductions in *M.persicae* populations was 72.28, 72.03 and 64.09% to Ematrade, , Basudin and Biocide (Biossiana) respectively in 2021/2022 season. While, in 2022/2023 season the average of reductions was 68.23,69.96 and 63.34%, respectively. On the other hand, average of reductions in *A. matricariae* parasitoid numbers was 84.36,85.50 and 29.32 to the same previous insecticide, respectively in 2021/2022 season. Whereas, in 2022/2023 season the average of reductions was 82.53,81.09 and 26.93% , respectively. In conclusion, these results proved that the biocide, Biossiana induced a good reduction in *M. persicae* populations during the two seasons. At the same time, biocide induced a lower reduction in *A. matricariae* parasitiod numbers as compared to conventional insecticides. Thus, the integration between Biossiana and *A. matricariae* parasitoid are very efficient tools for *M.persiae* IPM in Egyptian sugar beet fields.

Keywords: Impactful. *Aphidius matricariae. Myzus persicae.* Egyptian sugar beet.

INTRODUCTION

Sugar beet (Chenopodiaceae: *Beta vulgaris L.)* is rated one of the most vital sugar crops worldwide .In Egypt, it is the first important sugar crop before sugar cane for sugar production (Hawila , 2021). Egypt cultivates about 650000 feddans of beets to produce 1.8 million tons of sugar in 2023 (Anonymous ,2023). Sugar beet crop infests by many destructive insect pests during the whole season, from seedlings stage to maturing stage. These insects cause considerable economic losses in roots and sugar percentages of this crop (El-Rawy and Shalaby, 2011, El-Dessouki 2014, Ahmadi *etal.*, 2017 and El-Dessouki , 2019). *Myzus persicae (*Sulzer) (Homoptera: Aphidiidae) is consider among the economic pests of sugar beet crop yield (Khalifa, 2017 and 2018) causing direct damage by piercing and sucking the plant sap and indirect damage by transmission of numerous virus diseases (Al- Habshy *etal*. 2014). Aphids are the most important pests that adversely affect crop yield and quality. There are different of agriculturally important species in the subfamily Aphidinae such as *M. persicae* (Blackman and Eastop,2008). Also, *M. persicae* infestation not only weakens the plant, but also transmits more than 100 viral or phytoplasma diseases that end up with the plant death , if efficient control methods are not applied (Van Emden *etal,*1969) . *M.persicae* is classified a serious pest causing damages in different crops, both directly and indirectly i.e, stunting, leaf curling, yellowing premature death of leaves, twisting of growing shoots, injecting toxic salivary secretions during feeding, secreting honeydew, which cause the growth of sooty molds on the leaf surface (Van Emden and Harrington 2007) in Egyptian sugar beet fields, Sherief *etal.* (2013) indicated *M. persicae* recorded one peak of abundance in 2nd week of February (2945 indiv./50 plants), and in 3rd week of February (3089/50 plants) during 2008/2009 and 2009/2010 , respectively. Moreover, Al-Habshy *etal*. (2014) mentioned seasonal abundance of *M.persicae* recorded two peaks for *M.persicae.* The first one was occurred at 2nd week of December with 275 and 316 insects/ sample for the two seasons, respectively. While, the second one was observed at 4th week of January represented by 417 and 548 indiv. / sample for the two seasons, respectively. In such concern, El-Dessouki (2014) reported that aphid populations were very high on the plants of Mid-Nov. plantation, followed by Mid-Oct and finally by Mid- Aug. In another study, Khalifa (2017) reported that the averages of population density of aphids were 8.00,10.00 and 10.00 nymphs and adults/ 25 sugar beet plants in first, second and third plantations, respectively. In Europe, Albittar *et al.* (2016) reported that *M. persicae* on sugar beet crop is responsible for an annual loss of 2 million tones. Also, *M. persicae* affect plant growth and the storage of sugar directly by sucking plant sap and indirectly by transmitting plant viruses. The beet yellow virus and the beet mild yellow virus can cause yield losses of up to 50% and 35%, respectively .Fortunately, aphids have a great number of

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various natural enemies known over the world. Parasitoids an important tool in controlling aphids on different crop plants (Alikhani *et al*.,2013)

A. matricariae is the most effective factor of *M.persicae* (Wick,1992).Mature females may live between 15 to 17 days, parasitizing more that 200 aphids also killing aphids when host-feeding. Females' host -feed in order to obtain nutrition. Also, *A.matricariae* is a unique species of parasitoid wasp crucial to the control and management of more than 40 types of destructive aphids, mainly *M.persicae* (Cloyd,2023). Excessive use of insecticides has pernicious impact on parasitoids and may result in the environmental hazardousness (Mansour *etal.*2023). Bio-insecticides is safety to parasitoids (Zhao *etal*, 2016). Thus, this experiment was done for investigating the vital role of biocide (Biossiana) and *A.matricariae* parasitoid in suppressing *M. persicae* populations.

MATERIALS AND METHODS

1- Recording the parasitism efficiency of *A. matricariae* parasitoid on *M. persicae* during 2021/2022 and 2022/2023:

This trail is carried out at the Experimental Farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during 2021/2022 and 2022/2023 seasons. The Diamond variety of sugar beet was grown on 15th August, 15th September and 15th October in two seasons, respectively. Every 15 plants /15 days were inspected by visual examination to the three cultivations. Injured leaves with aphids (nymph + adults*)* were cut by small scissors, then these leaves were enclosed into paper bags, and transported to laboratory of sugar crops Research department, Sakha. These injuried leaves are posit into Petri dishes (9 cm²) under laboratory conditions (25±2°c and 60-70%RH). Emerged parasitoids were counted and preserved in vials containing alchol 70% till identification. Also, parasitism percentages and Parasitism efficiency by the following formula three cultivations throughout the two seasons.

$$\text{Parasitism percentages} = \frac{\text{No. of parasitoid populations}}{\text{No. of aphid populations}} \times 100$$

$$\text{Parasitism efficiency} = \frac{\text{Total numbers of parasitoid during the season}}{\text{Total numbers of aphid during the season}} \times 100$$

The parasitoid individuals were taxnomied by Insect Identification Unit (IIU), Plant Protection Research Institute, Agricultral Research Center.

2- Evaluation of certain conventional insecticides and the biocide (Biossiana) on *M. persicae* and its associated parasitoid, *A.matricariae* during 2021/2022 and 2022/2023:

In another field, this experiment was performed in 2021/2022 and 2022/2023 seasons. The field cultivated with Diamond variety on 15 September during the two seasons. Three insecticides in Table (1) were applied. Every insecticide (168m²) divided into 4 replicates, each replicate (42m²), also the check treatment (168m²) shared out 4 replicates, each replicate (42 m²). Completely Randomized Block Design was layout. 40 plants, were examined through visual inspection before spraying and 40 plants after spraying for 3, 7 and 10 days for each insecticide as well as check plots. Knap sac sprayer (20L.) was used in spraying these insecticides. Date of spraying was 10 and 15 March during the two seasons, respectively. the individuals of parasitoid were counted by sweep net method (50 double strikes each replicate). While, the populations of *M. persicae* were counted through visual examination method in the field.

To calculate the percentage of reductions, (Henderson and Tilton, 1955) was using as follow:

$$\text{Reduction\%} = 1 - \left(\frac{\text{Mean number in control before}}{\text{Mean number in treatment after}} x \frac{\text{Mean number in treatment after}}{\text{Mean number in control before}}\right) x\, 100$$

Statistical analysis are done by analysis of variance (ANOVA) technique by means were package. The treatment means were compared using Duncan multiple range test Duncan (1955).

Table 1. List of certain insecticides sprayed on sugar beet plants against *M. persicae* populations during 2021/2022 and 2022/2023.

Trade name	Chemical class	Common name	Rate/ Feddan
Ematrade® 35% SC	Neonicotinoids	Imidacloprid	300 ml
Basudin® 60% EC	Organophosphate	Diazinon	100 ml
Biossiana®	Beauveria,bassiana (1×10^8 CFU/gm)	Biocide	500 gm

RESULTS AND DISCUSSION

1- Monitorning the parasitism percentages to *A. matricariae* parasitoid on *M.persicae* :

Data in Table (2) showed that parasitism percentages of *A.matricariae* on *M. persicae* populations ranging between 16.66 to 66.66% for first cultivation, 27.27 to 75.0% for second cultivation and 30.0 to 93.02% for third cultivation. Moreover, parasitism efficiency throughout the whole season was 53.42, 43.29. and 68.49% at three cultivations, respectively in 2021/2022 season. In 2022/2023 season, data in Table (3) indicated that parasitism percentages of *A.matricariae* on *M. persicae* individuals ranging between 33.33 to 81.81% for first cultivation, 16.66 to 85.0% for second cultivation and 18.18 to 78.04 % to third cultivation. Also, parasitism efficiency during the season was 60.00, 54.43 and 56.84% to the three cultivations, respectively in 2022/2023 season. No parasitoid individual was detected on 15 November, 2021 and on 14 November, 2022 during the seasons, respectively. These results demonstrated that this parasitoid is active during the two seasons. There are a numerous number of papers on the efficacy of aphid parasitoids (Rakhshani *etal.*2012) *A.matricariae* is an effective biological control agent against aphid populations (Tahriri *etal*. 2007). It has been recorded that *A. matricariae* has more than 50 aphid species as its hosts (Farahani *et al*., 2016). *M. persicae* has been known as one of the preferred hosts to *A matricariae* parasitoid (Tazerouni *etal*. 2016). Due to the deleterious effects of conventional insecticides on *A. matricariae* populations and environment, the use of biocides would be a safe and suitable method in *M. persicae* controlling (Mehran and Saeid,2019)

In such concern, El-Hussieni *etal.* (2003) reported that utilization of aphid parasitoids in biocontrol has given excellent results in many countries of the world. *A. matricariae* in the widely distributed aphidiid in almost all the

Mediterranean countries, and has a wide range of hosts in agroecosystems. In conclusion, these findings demonstrated that the biocide, Biossiana is safe method for *A. matricariae* parasitoid populations, while it has very acceptable mortality on *M. persicae* individuals. Therefore, integration of Biossiana with *A. matricariae* could be recommended for achieving successful control of *M. persicae* in sugar beet fields.

Table 2. Parasitism efficiency to *A. matricariae* parasitoid on *M.persicae* in three cultivations , 2021/2022 season.

Date	First			Second			Third		
of investigation	No. aphids	No. parasitoid	% parasitoid	No. aphids	No. parasitoid	% parasitoid	No. aphids	No. parasitoid	% parasitoid
15/11	2	0	0.00	-	-	-	-	-	-
30/11	6	1	16.66	-	-	-	-	-	-
15/12	8	4	50.0	7	2	28.57	-	-	-
30/12	13	6	46.15	11	4	36.36	-	-	-
15/1	21	13	61.90	22	6	27.27	10	3	30.0
30/1	14	9	64.28	13	5	38.46	12	4	33.33
15/2	9	6	66.66	8	6	75.0	8	4	50.0
28/2	-	-	-	10	7	70.0	7	5	71.42
15/3	-	-	-	26	18	69.23	29	18	62.06
30/3	-	-	-	-	-	-	37	26	70.27
15/4	-	-	-	-	-	-	43	40	93.02
Parasitism efficiency	73	39	53.42	97	42	43.29	146	100	68.49

Table 3. Parasitism efficiency of *A. matricariae* parasitoid on *M.persicae* in three cultivations , 2022/2023 seasons

Date	First			Second			Third		
of investigation	No. aphids	No. parasitoid	% parasitoid	No. aphids	No. parasitoid	% parasitoid	No. aphids	No. parasitoid	% parasitoid
14/11	0	0	0.00	-	-	-	-	-	-
29/11	3	1	33.33	-	-	-	-	-	-
14/12	6	2	33.33	6	1	16.66	-	-	-
29/12	14	7	50.0	10	3	30.0	-	-	-
14/1	19	12	63.15	18	9	50.0	11	2	18.18
29/1	11	9	81.81	11	4	36.36	10	2	20.0
14/2	7	5	71.42	6	4	66.66	9	4	44.44
27/2	-	-	-	8	5	62.5	9	7	77.77
16/3	-	-	-	20	17	85.0	30	16	53.33
31/3	-	-	-	-	-	-	36	20	55.55
16/4	-	-	-	-	-	-	41	32	78.04
Parasitism efficiency	60	36	60.00	79	43	54.43	146	83	56.84

2- Efficacy of certain conventional insecticides in reducing *M. persicae* numbers and its associated parasitoid, *A. matricariae* as compared to biocide (Biossiana)

In 2021/2022 season, Table (4) indicate that average of reduction in *M. persicae* numbers was 72.28. 72.03% and 64.09% to Ematrade, Basudin and Biossiana insecticides, respectively. Reduction in this insect population increased from 56.13% after three days post spraying to 86.49% after ten days post spraying for Ematrade. While, Basudin insecticide increased from 53.96% to 88.49%. Also, Biossiana insecticide increased from 39.71% to 85.11%. In another side, Table (5) show that average of reductions in *A. matricariae* parasitoid populations was 84.36, 85.50 and 29.32% to the same previous insecticides, respectively. Reduction in this parasitoid increased from 79.53% for after three days post spraying to 88.67% after 10 days post spraying for Ematrade. As, Basudin insecticide increased from 78.87% to 90.64%. Moreover, Biossiana increased from 15.80% to 42.0%. In 2022/2023 season, Table (6) clarify that average of reductions in *M. persicae* numbers was 68.23,69.96 and 63.34% to Ematrade, Basudin and Biossiana insecticides, respectively. Reduction in this insect numbers increased from 49.95 to 86.35% for Ematrade . Basudin insecticide increased from 55.45% to 85.83%. Also, Biossiana insecticide increased from 41.04% to 83.73%. In such concern, Table (7) demonstrate that average of reduction in *A. matricariae* parasitoid individuals was 82.53, 81.09 and 26.93% for the same previous insecticides, respectively. In addition to, reduction in this parasitoid increased from 73.39% after three days post- spraying to 89.28% after 10 days post treatment for Ematrade insecticide. Whilst, Basudin insecticide increased from 71.10 to 89.65%. Also, Biossiana from 13.79 to 38.88% after 10 days. post-spraying. Kachhawa (2017) reported that growth rate of biocides industry has been forecasted in the next 10 years at 10-15 percent per annum in contrast to 2-3 per cent for conventional insecticides. Main advantages of these biocides are their specificity to target pests, safety to parasitoids. Also, do not cause ill effects on environment and human health and can be used against insects which develop resistance to the conventional insecticides, and they fit as ideal components in IPM. Abd El-Gawad (2007) reported that the conventional insecticides were the most effective against sugar beet insects with a highly suppressive effect on natural enemies. Also, Wu *etal.(*2014) showed that bio-pesticides are advised to be included in IPM programs with selected insecticides groups. Moreover, Fergani and Yehia (2020) revealed that biocides are Premium alternative to conventional insecticides offering eco-friendly control agent with minimal residue, and no hazardous to associated natural enemies. Moreover, El Khateeb *etal*. (2021) reported integration of other practices, such as use of resistant varieties, plant extracts, inter-cropping, natural enemies and entomopathogenic micro-organisms are favorable to suppress insect pest overrun and promote environmental protection. In another study, Zhao *etal.* (2016) indicated that bio-insecticides is safety to non-targeted beneficial organisms, enhancing conservation biological control of insect pests by reducing negative impact on beneficial insects such as parasitoids in agricultural ecosystems. Also, El- Agamy *etal.* (2021) noted that use of synthetic chemical pesticides is a main pest control practice, the frequent use or overuse often causes development of pesticide resistance, leading to the outbreak or resurgence of insects. In addition to, Fergani *etal*. (2022) demonstrated that although the traditional insecticides have a very strong effect on sugar beet insect, they dramatically affect then natural enemies. So, biocides I considered in control programs as a safe alternative to kill sugar beet insects. On the other hand, Bass *et al.* (2019) clarified those farmers use a great of conventional insecticides against *M. persicae*. Overuse of insecticides has led to the development of aphid's resistance, decrement of the aphid's parasitoids. Thus, biological control (Biocides + parasitoids) is a major component in IPM program of aphids.

Table 4. Average of reductions in *M. persicae* Populations due to certain insecticides spraying, 2021/2022.

Insecticides	Before spray	After spray/ day						Average*
		3		7		10		
	M.	M.	Red	M.	Red	M.	Red	
Ematrade	11.50	5.25	56.13	3.75	74.22	2.25	86.49	72.28[a]
Basudin	12.0	5.75	53.96	4.0	73.65	2.0	88.49	72.03[a]
Biossiana	12.75	8.0	39.71	5.25	67.45	2.75	85.11	64.09[b]
Check	12.25	12.75	-	15.5	-	17.75	-	-

Table 5. Average of reductions in *A. matricariae* populations due to same insecticides spraying, 2021/2022.

Insecticides	Before spray	After spray/ day						Average*
		3		7		10		
	M.	M.	Red	M.	Red	M.	Red	
Ematrade	8.00	1.75	79.53	1.5	84.89	1.25	88.67	84.36[a]
Basudin	7.75	1.75	78.87	1.25	87.0	1.0	90.64	85.50[a]
Biossiana	7.5	6.75	15.80	6.5	30.18	6.0	42.0	29.32[b]
Check	7.25	7.75	-	9.0	-	10.0	-	-

Table 6. Average of reductions in *M. persicae* numbers due to certain insecticides spraying, 2022/2023.

Insecticides	Before spray	After spray/ day						Average*
		3		7		10		
	M.	M.	Red	M.	Red	M.	Red	
Ematrade	14.75	7.75	49.95	5.75	68.39	2.75	86.35	68.23[a]
Basudin	15.5	7.25	55.45	6.0	68.61	3.0	85.83	69.96[a]
Biossiana	15.75	9.75	41.04	6.75	65.25	3.5	83.73	63.34[b]
Check	15.0	15.75	-	18.5	-	20.5	-	-

Table 7. Average of reductions in *A. matricariae* numbers due to certain insecticides spraying, 2022/2023.

Insecticides	Before spray	After spray/ day						Average*
		3		7		10		
	M.	M.	Red	M.	Red	M.	Red	
Ematrade	7.0	2.0	73.39	1.25	84.93	1.0	89.28	82.53[a]
Basudin	7.25	2.25	71.10	1.5	82.54	1.0	89.65	81.09[a]
Biossiana	6.75	6.25	13.79	5.75	28.12	5.5	38.88	26.93[b]
Check	6.75	7.25	-	8.0	-	9.0	-	-

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الدور الفعال للمبيد الحيوي بيوسيانا والطفيل *Aphidius matricariae* في المكافحة الحيوية لمن الخوخ الأخضر في حقول بنجر السكر المصرية

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الملخص

أنجزت الدراسة الحالية في المزرعة البحثية لمحطة البحوث الزراعية وكذلك معمل قسم بحوث المحاصيل السكرية بسخا – محافظة كفرالشيخ خلال موسمي ٢٠٢١ / ٢٠٢٢ و٢٠٢٢ / ٢٠٢٣ .ولقد أوضحت النتائج ما يلي: كانت كفاءة الطفيل *A. matricariae* ضد العائل مـنّ الخوخ الأخضر هي ٥٣,٤٢ ، ٤٣,٢٩ و ٦٨,٤٩ % للثلاث عروات على التوالي خلال موسم ٢٠٢١ / ٢٠٢٢، بينما كانت النسب هي ٦٠,٠٠ ، ٥٤,٤٣ و ٥٦,٨٤ % للثلاث عروات على التوالي خلال موسم ٢٠٢٢ / ٢٠٢٣. كان المتوسط العام لانخفاض تعداد من الخوخ الأخضر هو ٧٢,٢٨ ، ٧٢,٠٣ و ٦٤,٠٩ % للمبيدات ايماتريد، باسودين والمبيد الحيوي بيوسيانا على التوالي خلال ٢٠٢١ / ٢٠٢٢. بينما كانت النسب هي ٦٨,٢٣ ، ٦٩,٩٦ و ٦٣,٣٤ % للثلاث مبيدات السابقة على التوالي خلال موسم ٢٠٢٢ / ٢٠٢٣. ومن ناحية أخرى كان المتوسط العام لانخفاض تعداد الطفيل *A. matricariae* هو ٨٤,٣٦، ٨٥,٥٠ و ٢٩,٣٢ للثلاث مبيدات على التوالي خلال موسم ٢٠٢١ / ٢٠٢٢ بينما كانت النسب للموسم الثاني ٢٠٢٢ / ٢٠٢٣ هي ٨٢,٥٣ ، ٨١,٠٩ و ٢٦,٩٣ % للثلاث مبيدات على التوالي. وفي النهاية ، أوضحت هذه النتائج أن المبيد الحيوي أحدث انخفاضاً بنسب مقبولة جداً خلال الموسمين لمن الخوخ الأخضر، وفي نفس الوقت حافظ على تعداد الطفيل بنسبة كبيرة وذلك بالمقارنة بالمبيدات التقليدية . لذلك، فإن التكامل بين المبيد الحيوي والطفيل السابق يعتبرا من الأدوات الفعالة جداً في برنامج المكافحة المتكاملة لمن الخوخ الأخضر في حقول بنجر السكر المصرية.