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Ecological studies on the cotton mealybug *Phenacoccus solenopsis* (Hemiptera: Pseudocccidae) on maize in Upper Egypt

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Abstract

Maize crop is one of the food crops that played an important role in the Egyptian economy. it's important came from its several uses, whether as a food for man or as animal feed. Recently, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudocccidae) recorded infesting maize crop, *Zea Mays* L. across Egypt. This paper covers the population fluctuations of *P. solenopsis* and its associated parasitoid, *Aenasius arizonensis* (Girault) (Hymenoptera: *Encyrtidae*) during two successive growing seasons of summer 2019 and 2020 in two varieties of maize plantation (White corn and yellow singular Hybrid 168) in Albalina, Sohag Governorate, Egypt. The results obtained clarified that *P. solenopsis* and its associated parasitoid have three peaks of abundance in both years in the selected maize verities. The correlation of the abiotic factors (Daily mean temperature and relative humidity) and biotic factors (Parasitoid and the plant age of maize varieties) with the population fluctuation of the cotton mealybug were studied.

Introduction

Maize crop is one of the food crops that played an important role in Egyptian economy. it's important came from its several uses, whether as a food for man or as animal feed. Recently, maize crop noticed infesting with the newly introduced pest in Egypt the cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera:Pseudocccidae). Since 2005, the cotton mealybug *P. solenopsis* has emerged as a serious pest of cotton in Pakistan and India. It spread rapidly and has been reported from 173 species in 45 plant families and from 26 countries in different ecological zones. Most of these hosts belongs to the families: Malvaceae, Solanaceae, Asteraceae, Euphorbiaceae, Amaranthaceae and Cucurbitaceae. Economical damage was observed on cotton, brinjal, okra, tomato, sesame, sunflower and china rose and reached plant death in severe conditions (Arif *et al.*, 2009; Abbas *et al.*, 2010; Fallahzadeh *et al.*, 2014 and Badr *et al.*, 2020). It was recorded for the first time in Egypt in September, 2009 by (Abd-Rabou *et al.*, 2010) infesting *Hibiscus* sp., from that time the pest was spreading rapidly across Egypt and recorded from different host plants. In tomato plant it was recorded for the first time by (Ibrahim *et al*., 2015). After that it was recorded from 29 new host plants from them corn plantation by Attia, and Abdel Aziz (2015) and Abdel- Razzik *et al*. (2015). Abd El-Wareth (2016) recorded the pest for the first time from several host plant at Fayoum Governorate from them, maize. (Beshr *et al.* , 2016) submitted 20 host plants infested by the pest 8 of them new host in Egypt (Moharum *et al.,* 2017) recorded the pest from 18 host plants belonging to 11 families at Dakahlia Governorate. Ecological studies were conducted on the pest at Sharkia Governorate on Eggplants by (Nabil, 2017). The annual generations with biology and thermal development of the *P. solenopsis* was carried out by Shehata (2017) on okra leaves. The impact of weather factors on the population density of *P. solenopsis* and its natural enemy were studied by (Nabil and Hegab, 2019) on okra plants.

The aim of this study is to estimate the population fluctuation of the cotton mealybug *P. solenopsis* and its parasitoid, *Aenasius arizonensis* (Girault) (Hymenoptera: *Encyrtidae*) in maize as an economic important crop in Egypt for better controlling this endemic pest. As well as, estimate the effect of selected biotic and abiotic factor affecting its population at Albalina, Sohag Governorate, Egypt during two successive years of 2019/2020.

Materials and methods

1. Population fluctuations of the cotton mealybugs *Phenacoccus solenopsis*:

In order to study the population fluctuations of the cotton mealybug *P. solenopsis*, an experiment carried out during two successive growing seasons of summer 2019 and 2020, in a chosen private area of one Fadden to every variety of maize plant (White corn and yellow singular Hybrid 168) *Zea mays* L. in Albalina, Sohag governorate, Egypt. The experimental plots received the standard cultivation practices of that area, including organic and mineral fertilization and mechanical control to remove weeds. No insecticides were applied during the period of the experiment. Sample content of 15 cm leaves from twenty-five plants were chosen randomly having similar size, shape and height from all directions of each tree in two weeks' intervals.

The cuttings leaves were put in cloth bags and transferred to the laboratory in order to classify and count the existing individuals by using stereoscopic binocular microscope. The upper and lower surface of the leaves were examined. All stages of the insect as well as parasitized stages of the inspected insects were counted and recorded. Cutting leaves with the counted insects were then confined in glass jars and kept in the laboratory for securing and emerging parasitoids. During the two successive years of the experiment the endoparasitoid, *A. arizonensis* was recorded infesting the cotton mealybug.

2.Effect of biotic and abiotic factors on the abundance of *Phenacoccus solenopsis* :

Weather factors (Abiotic factors) as maximum and minimum temperature as well as relative humidity were considered from the http//: www: Weather underground.eg. The week maximum and minimum temperatures as well as relative humidity were calculated. Plant phenology emulating plant nutritional value dynamics over the growing season was considered as plant age (X) (biotic factors). This relation was presented by polynomial equation of third degree ($Y= a +b1x + b2x2 + b3x3$). Multiple regressions were conducted for weather factors combined as well as the plant age as described.

3. Statistical analysis

The obtained determination factor (R2) of expected value (E.V.%) percentage was used to explain the effect of testing factors. Correlation and regression were used in SAS program to analysis the obtained date (SAS Institute, 1998).

Results and discussion

1. Population fluctuations of the cotton mealybug *Phenacoccus solenopsis* Tinsley on corn *Zea mays* Varity , white corn and yellow singular Hybrid 168).

1.1. Seasonal activity of *Phenacoccus solenopsis* in white corn varity:

Population fluctuations of the cotton mealybug, on maize crop white corn Varity was estimated during summer 2019 and 2020 in Albalina, Sohag Governorate. The seasonal activity of *P. solenopsis* as total number of nymphs and adults from the fourth directions (West, north, east and south) were illustrated for the both years of study of 2019 and 2020 in (Figure 1 A and B) and (Figure 2 A and B).

In this experiment samples collected from 22nd of May to 25th of September. In first year of study 2019 the total number of infestations by mature and immature stages of the cotton mealybugs recorded few numbers in 19th of June. After that the population increased rapidly recorded its first peak in 31st of July, second peak reached its maximum in 21st of August and the third peak of abundance existed in 18th of September 2019 (Figure 1 A and B). Data obtained during the second year of study, 2020 clarified that, the population of the studied stages take the same trend as first year of 2019. We noticed that cotton mealybug nymphs achieved three peaks in 24th of July, 14th of August and 11th of September 2020, respectively (Figure 2 A). Whereas, adults achieved its three population fluctuation abundance peak in 31st of July, 21st of August and 18th of September 2020 (Figure 2 B). The obtained data showed that, the population of *P. solenopsis* was in general high in the second year than the first year on white corn.

1.2. Seasonal activity of *Phenacoccus solenopsis* in yellow singular Hybrid 168 corn:

Population fluctuations of the cotton mealybug, on maize crop yellow singular Hybrid 168 was estimated during summer 2019 and 2020 in Albalina, Sohag governorate, Egypt. The seasonal activity of *P. solenopsis* as total number of nymphs and adults from the fourth directions (West, north, east and south) were illustrated for the both years of study of 2019 and 2020 in (Figure 3 A and B) and (Figure 4 A and B).

In this experiment samples collected from 22nd of May to 25th of September 2020. In the first year of study 2019 the total number of infestations by mature and immature stages of the cotton mealybugs recorded few numbers in 26th of June. After that the population increased rabidly to record the insect first peak in 31st of July, second peak reached in 21st of August and the third peak of abundance existed in 18th of September 2019 (Figure 3 A).

While the obtained results indicated that adult individuals recorded few numbers in 26th of June. Accordingly, the population increased to record the first peak of abundance in 31st of July, the second peak in 28th of August and the third peak in 18th of September 2019 (Figure 3B) respectively.In the second year of study, 2020 the seasonal population fluctuation of the pest takes the same trend. We noticed that the nymphs achieved three peaks in 17th of July, 14th of August and 11th of September 2020, respectively (Figure 3A). whereas, adult of *P. solenopsis* reached three peaks of abundance respectively in 17th of July, 14th of August and 11th of September 2020 (Figure 2B). The population of *P. solenopsis* on yellow singular Hybrid 168 corn was in general the same in both years of study.

2. Population fluctuations of the primary parasitoid; *Aenasius arizonensis*, of *Phenacoccus solenopsis* on *Zea mays* varity , white corn and yellow singular Hybrid 168.

Population fluctuations of the primary parasitoid; *A. arizonensis* is a solitary, endoparasitoid emerged from its host, the adult stage of the cotton mealybug, on maize crop white corn and yellow singular Hybrid 168 was estimated during summer 2019 and 2020 in Albalina, Sohag governorate, Egypt.

2.1.Seasonal activity of the endoparasitoid of *Phenacoccus solenopsis*, *Aenasius arizonensis* infesting white corn varity:

The seasonal activity of *A. arizonensis* from the fourth direction (West, north, east and south) (Figure 1C) and (Figure 2C) were illustrated for the years of study. In both years of study 2019 and 2020 the first appearance for the parasitoid was in 3rd of July. Subsequently, the population of *A. arizonensis* increased rapidly to record first peak in 31st of July, and its second peak in 21st of August and finally its third peak in 18th of September 2019 (Figure 1C).

In the second year of the study *A. arizonensis* achieved two peaks in 17th of July and 18th of September 2020, respectively (Figure 2C). The obtained results showed that, the population of *A. arizonensis* was in general high in the first year comparing with second year on white corn.

2.2. Seasonal activity of the endoparasitoid of *Phenacoccus solenopsis*, *Aenasius arizonensis* infesting yellow singular Hybrid 168:

The seasonal activity of the parasitoid individual of *A. arizonensis* from the fourth direction (West, north, east and south) (Figure 3C) and (Figure 4C) were illustrated for 2019 and 2020. In both years of study 2019 and 2020 the first appearance for the parasitoid was in 3rd of July and 10th of July, respectively. Consequently, the population of *A. arizonensis* in 2019 increased to record its first peak in 31st of July, second peak reached its maximum in 21st of August and finally the third peak was in 18th of September 2019 (Figure 3C). In the second year of study the *A. arizonensis* achieved three peaks in 17th of July, 21st of August and 18th of September 2020, respectively (Figure 4C). The population of *A. arizonensis* was in general high in the first year than the second year on yellow singular Hybrid 168. Fand and Suroshe (2015) reported that, about 28 species of natural enemies including 12 predators and 16 multiple parasitoids of *P. solenopsis* have been reported throughout its range, but only the encyrtid species *Aenasius bambawalei* Hayat has been instrumental in controlling *P. solenopsis* natural population in a range 30- 60%.

3. Effect of biotic and abiotic factors on the abundance of *Phenacoccus solenopsis* in white corn:

The total nymph and adult population of *P. solenopsis* on white corn insignificantly correlated with maximum and minimum temperature in both year of study, while with RH.% was significant on first year and insignificant on second year. Whereas, multiple regression between total nymph population and weather factor was (E.V.%) 51.70 and 7.24% on both year of study on white corn. Whereas, multiple regression between total adult population and weather factor was (E.V.%) 56.39 and 9.99% on both year of study on white corn (Table 1). Multiple regression between total nymph population and the parasitoid *A. arizonensis* was (E.V.%) 85.17 and

75.92% on both year of study on white corn. While, between total adult population and the parasitoid *A. arizonensis* was (E.V.%) 91.81 and 79.86% on both year of study on white corn. Data obtained suggested that, plant age of white corn was affected on population fluctuation of *P. solenopsis* nymphs and adult females by 60.83 and 34.77% and 63.08 and 34.58%, respectively . The common effect of weather factor, parasitoid and plant age effect on nymphs and adult population fluctuations recorded 87.81 and 85.59 % and 93.99 and 87.33%, respectively (Table 1).

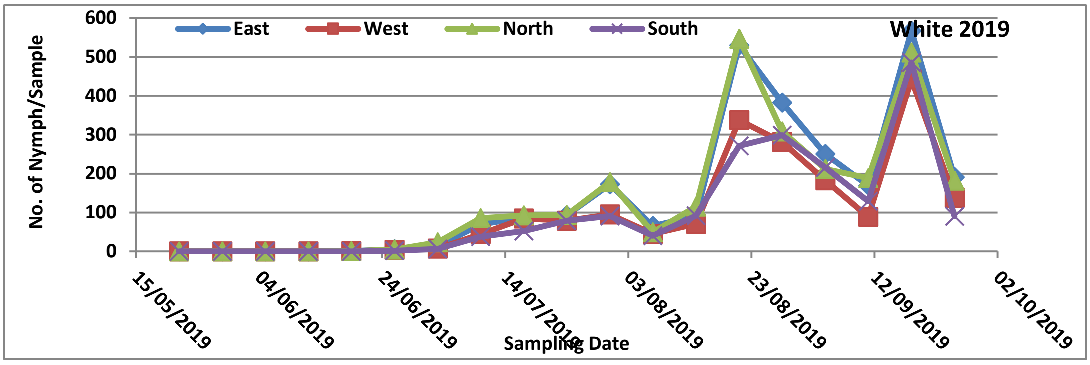
4. Effect of biotic and abiotic factors on the abundance of *Phenacoccus solenopsis* in yellow singular Hybrid 168 corn:

The total nymphs and adult population of *P. solenopsis* on yellow singular Hybrid 168 corn insignificantly correlated with maximum and minimum temperature in both years of study, while with RH.% it was correlated significantly in both years of study. Whereas, multiple regression between total nymph population and weather factor was (E.V.%) 55.05 and 17.80% in both years of study on yellow singular Hybrid 168 corn. Whereas, multiple regression between total adult population and weather factor was (E.V.%) 62.52 and 13.04% in both years of study on yellow singular Hybrid 168 (Table 2).

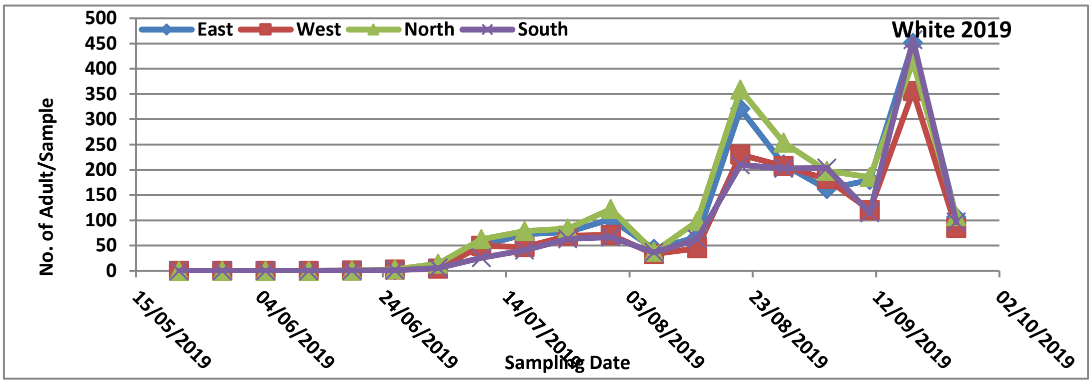
Multiple regression between total nymphs' population and biotic factor as the parasitoid *A. arizonensis* was (E.V.%) 92.26 and 95.73% in both years of the study on yellow singular Hybrid 168 corn. While, between total adult's population and the parasitoid *A. arizonensis* it was (E.V.%) 87.43 and 91.24% on both year of study on yellow singular Hybrid 168 (Table 2). The plant age of white corn was affected on population fluctuation *of P. solenopsis* nymphs and adult females by 75.63 and 44.11% and 68.87 and 40.17%, respectively.The common effect of weather factor, parasitoid and plant age effect on nymphs and adult population fluctuations recorded 97.35 and 97.05% and 95.42 and 92.25%, respectively (Table 2).Data obtained indicated that, there were insignificant correlation with maximum and minimum temperature. That is agree with (Singh and Kumar, 2012) who stated that the mealybug population was showing positive correlation with higher temperature.

The plant age of maize had higher effective on population fluctuation of *P. solenopsis* than weather factor this result similar to (Moharum *et. al.*,2018) they reported that the plant age of tomato in summer and winter season were affected on nymph and adult female by (90.33 and 84.80%), (81.93 and 71.54%) at Ismailia and (89.95% and 80.45%), (90.18 and 89.95%) at Kafr El-Sheikh.

It can be concluded that the cotton mealybug, *P. solenopsis* and the associated parasitoid, *A. arizonensis* has three annual Population fluctuations in the two maize crop verities, white corn and yellow singular Hybrid 168 corn in two successive years 2019/2020 in Albalina, Sohag governorate, Egypt. In white corn the common effect of weather factor, parasitoid and plant age effect on nymphs and adult population fluctuations recorded 87.81 and 85.59% and 93.99 and87.33%, respectively, while in yellow singular Hybrid 168 recorded 97.35 and 97.05% and 95.42 and 92.25%, respectively.



(A)



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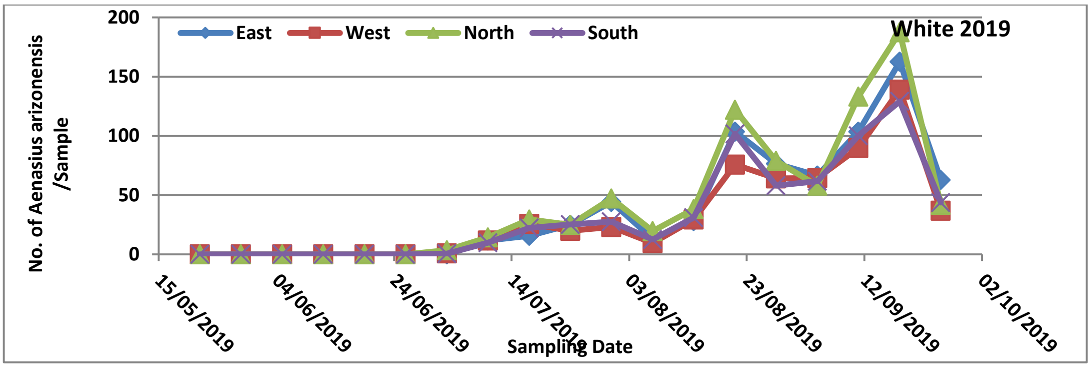
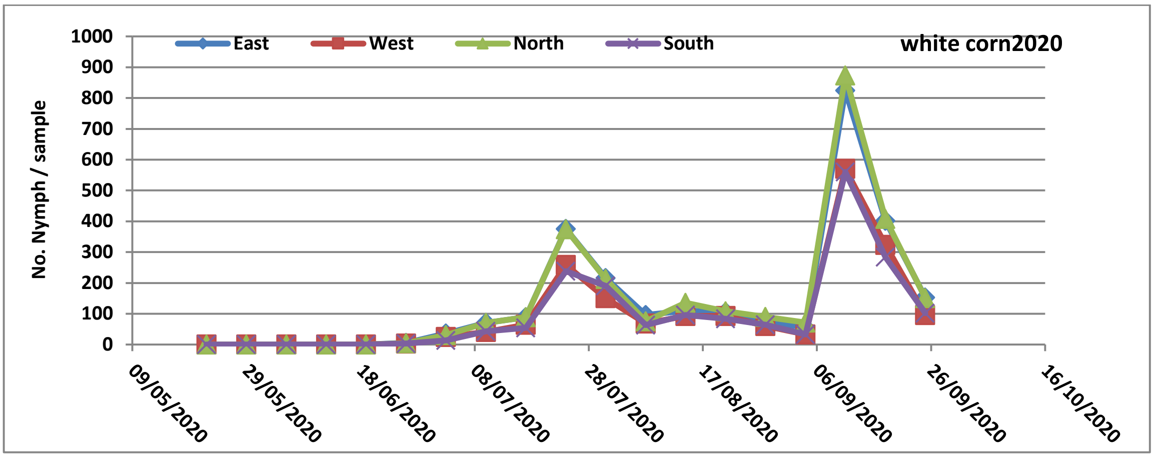


(C)

Figure (1 A, B and C): Population fluctuations of *Phenacoccus solenopsis* during the summer season of 2019 infesting white maize varity, compared with the number of parasitoid individuals of *Aenasius arizonensis* in Albalina, Egypt.



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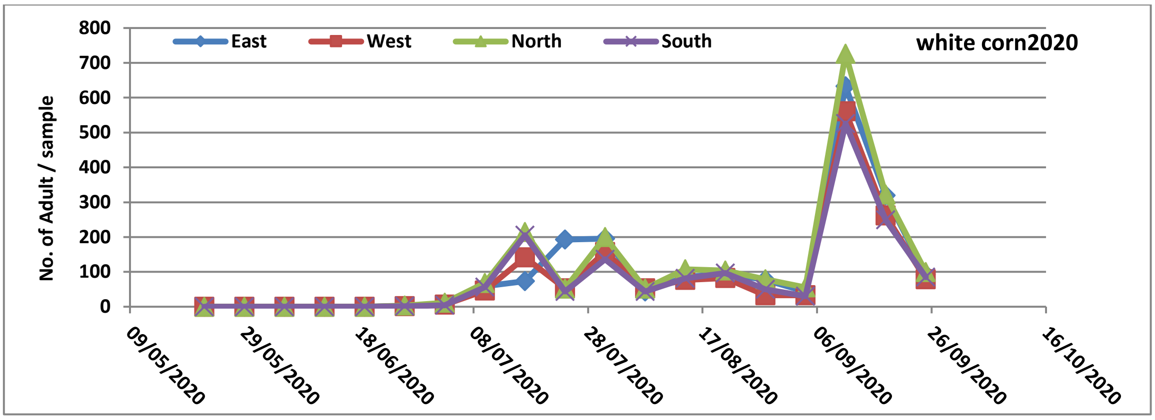

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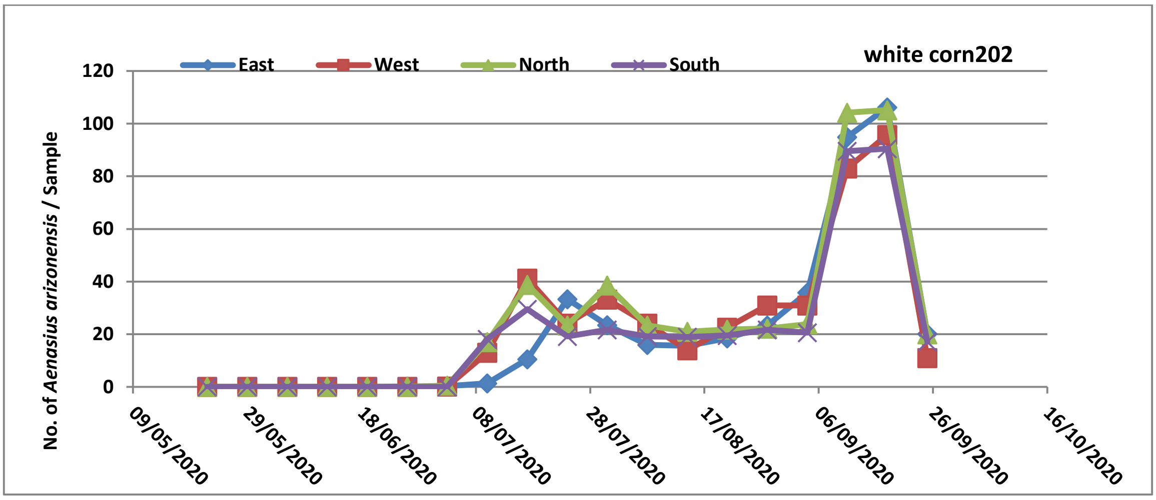
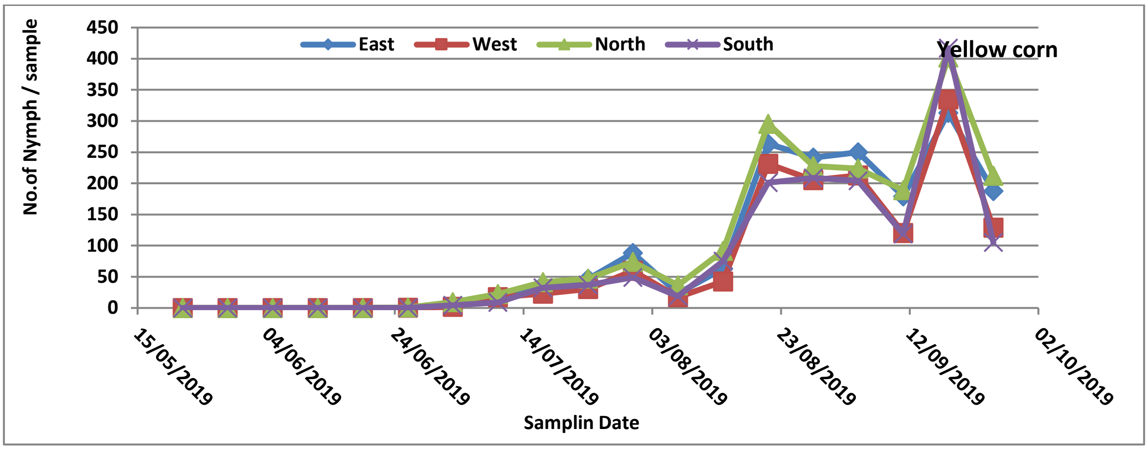
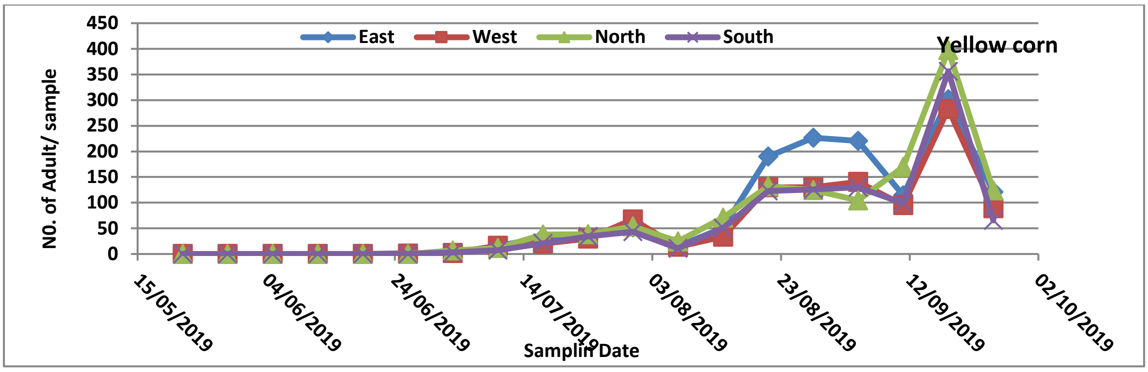


(C)

Figure (2 A, B and C): Population fluctuations of *Phenacoccus solenopsis* during the summer season of 2020 infesting white mazie varity, compared with the number of parasitoid individuals of *Aenasius arizonensis* in Albalina, Egypt.



(A)



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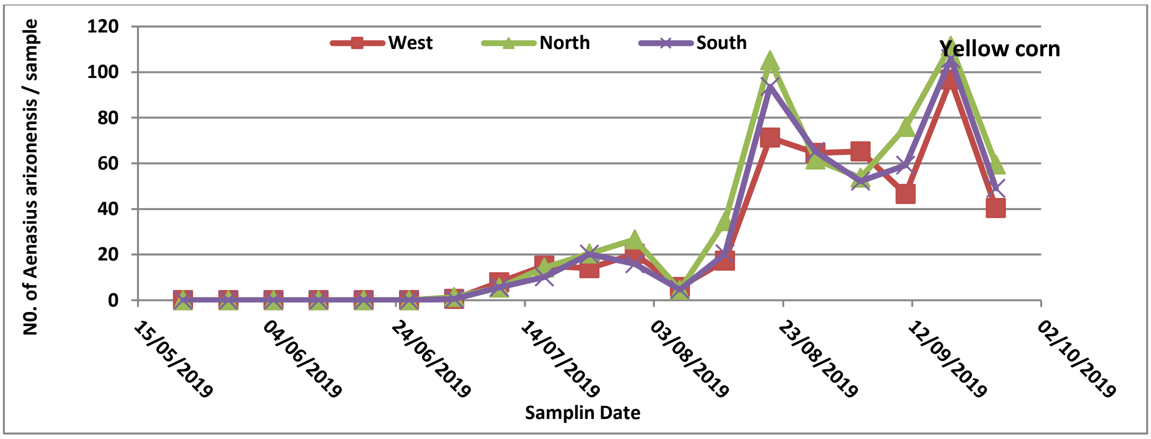
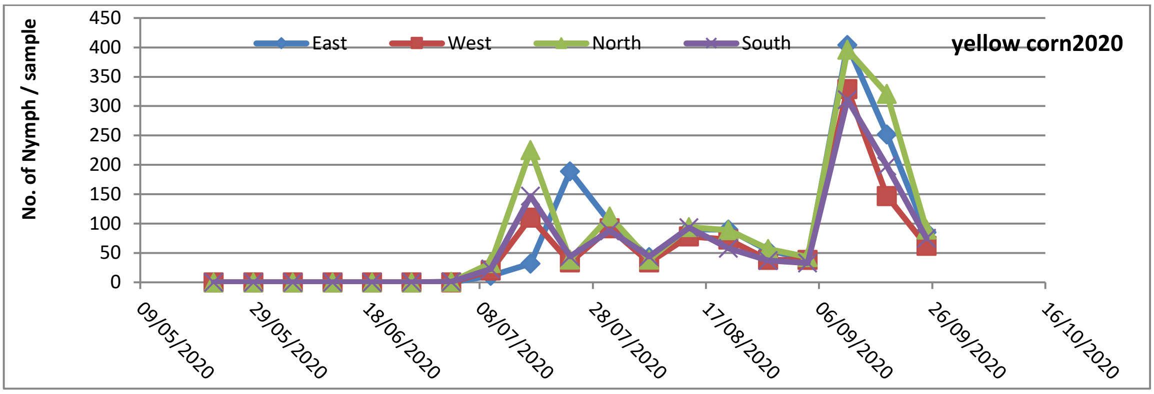
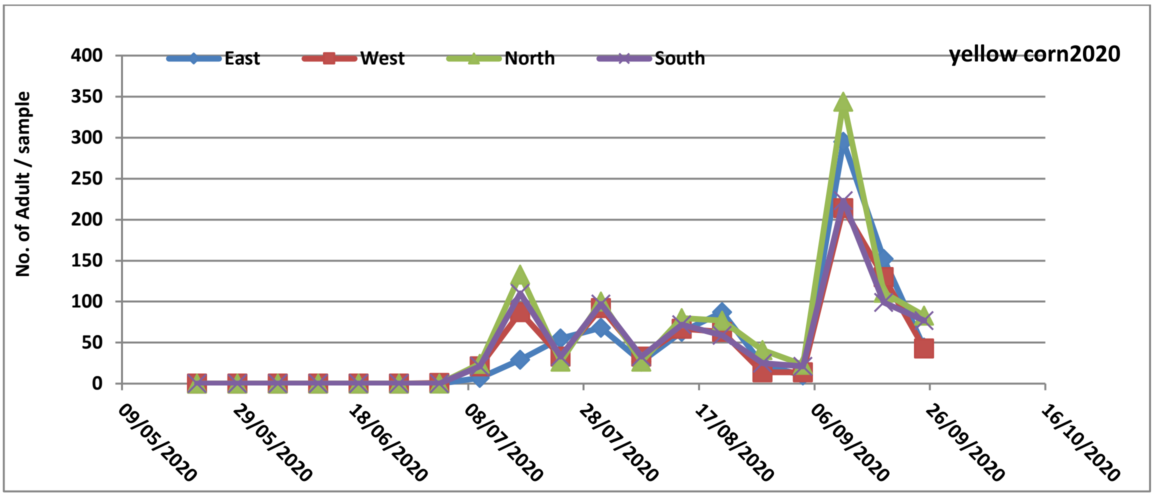


(C)

Figure (3 A, B and C): Population fluctuations of *Phenacoccus solenopsis* during the summer season 2019 of yellow mazie, compared with the number of parasitoid individuals *Aenasius arizonensis* in Albalina, Egypt.



(A)



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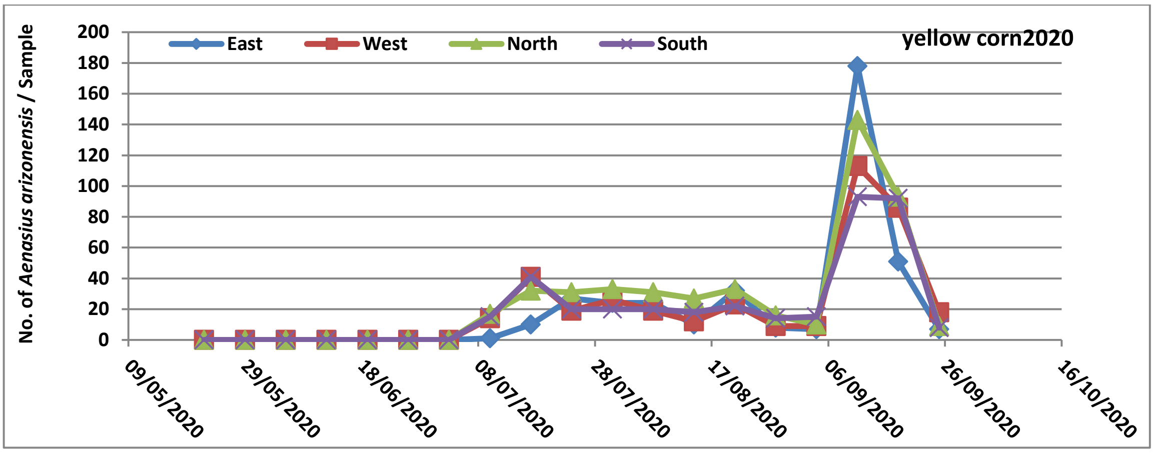

(C)

Figure (4 A, B and C): Population fluctuations of *Phenacoccus solenopsis* Tinsley during the summer season 2020 of yellow mazie, compared with the number of parasitoid individuals *Aenasius arizonensis* in Albalina, Egypt.

Table (1): The simple correlation (r) and regression coefficients (b) and multiple regressions (F and E.V.%) between the different stages of *Phenacoccus solenopsis* and biotic and abiotic factors on white corn.

Factor			Simple correlation and regression			Multiple regression	
			r	B	P	F	E.V.%
2019	Nymph	T. Max.	-0.06	-21.56	0.8146	5.35	51.70
		T. Min.	-0.31	-71.75	0.1971		
		RH.%	0.52	51.11	0.0223		
		Aenasius arizonensis	0.92	3.08	0.0001	97.63	85.17
		Age plant				7.76	60.83
		All above				11.32	87.81
	Adult	T. Max.	-0.09	-24.65	0.7280	6.47	56.39
		T. Min.	-0.35	-62.51	0.1424		
		RH.%	0.53	40.19	0.0194		
		Aenasius arizonensis	0.96	2.46	0.0001	190.51	91.81
		Age plant				8.54	63.08
		All above				24.59	93.99
2020	Nymph	T. Max.	-0.23	-102.98	0.3454	0.39	7.24
		T. Min.	-0.07	-12.65	0.7684		
		RH.%	0.22	24.48	0.3605		
		Aenasius arizonensis	0.87	5.33	0.0001	53.60	75.92
		Age plant				2.66	34.77
		All above				9.34	85.59
	Adult	T. Max.	-0.26	-97.75	0.2806	0.56	9.99
		T. Min.	-0.12	-18.07	0.6130		
		RH.%	0.25	22.80	0.3051		
		Aenasius arizonensis	0.89	4.56	0.0097	67.40	79.86
		Age plant				2.64	34.58
		All above				10.8	87.33

T. Max.: Maximum temperature T. Min.: Minimum temperature RH.%: Percent relative humidity.

Table (2):The simple correlation (r) and regression coefficients (b) and multiple regressions (F and E.V.%) between the different stages of *Phenacoccus solenopsis* and biotic and abiotic factors on yellow singular Hybrid 168.

Year	Stage	Factor	Simple correlation and regression			Multiple regression	
			r	**b**	**P**	**F**	**E.V.%**
2019	Nymph	T. Max.	-0.18	-49.77	0.4614		
		T. Min.	-0.37	-64.03	0.1154	6.12	55.05
		RH.%	0.54	38.91	0.0181		
		Aenasius arizonensis	0.98	3.17	0.0001	341.54	95.26
		Age plant				15.52	75.63
		All above				57.87	97.35
	Adult	T. Max.	-0.17	-37.21	0.4851		
		T. Min.	-0.45	-60.28	0.0557	8.34	62.52
		RH.%	0.51	29.42	0.0245		
		Aenasius arizonensis	0.94	2.40	0.0001	118.22	87.43
		Age plant				11.06	68.87
		All above				32.76	95.42
2020	Nymph	T. Max.	-0.30	-71.23	0.2108		
		T. Min.	-0.23	-20.76	0.3534	1.08	17.80
		RH.%	0.31	17.99	0.1964		
		Aenasius arizonensis	0.98	2.74	0.0001	380.78	95.73
		Age plant				3.95	44.11
		All above				51.72	97.05
	Adult	T. Max.	-0.26	-44.45	0.2767		
		T. Min.	-0.12	-7.61	0.6370	0.75	13.04
		RH.%	0.31	12.94	0.1929		
		Aenasiusarizonensis	0.96	1.91	0.0001	177.12	91.24
		Age plant				3.36	40.17
		All above				18.70	92.25

T. Max.: Maximum temperature T. Min.: Minimum temperature RH.%: Percent relative humidity.

References

Abbas, G.; Arif, M. J.; Ashfaq M.; Aslam, M. and Shafqat, S. (2010): Host Plants Distribution and Overwintering of Cotton Mealybug (*Phenacoccus solenopsis*; Hemiptera: Pseudococcidae). Int.J. Agric. Biol., 12(3):421–425.

Abd El-Wareth, H. M. (2016): The first record of the cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: pseudococcidae) as A new Insect Pest on Tomato, Peper, Eggplant, Maize Plants and Population Density at Fayoum Governorate in Egypt. Egypt.

Acad. J. Biolog. Sci., 9(3): 41–48 .

Abdel- Razzik, K. I.; Attia, A. R. and Abdel Aziz, M. (2015): Newly host plants of cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera : Pseudococcidae in Egypt. Egypt Acad. Biolog. Sci., 8(3):31-33.

Abd-Rabou S.; Germain J. F. and Malausa T. (2010): *Phenacoccus parvus* Morrison and *P. solenopsis* Tinsley, two new mealybugs in Egypt (Hemiptera: Pseudococcidae). Bulletin of Entomological Society of France, 115 (4): 509–510.

Arif, M. I.; Rafiq, M. and Ghaffar, A. (2009): Host plants of cotton mealybug (*Phenacoccus solenopsis*): a new menace to cotton agro-ecosystem of Punjab, Pakistan. Int. J. Agric. Biol., 11: 163–167.

Attia, A.R. and Abdel Aziz, M. (2015): Newly host plants of cotton mealybug Phenacoccus solenopsis Tinsley (Hemiptera: Pseudococcidae) in Egypt. Egypt. Acad. J. Biol. Sci. A Entomol., 8: 31-33

Badr, S. A.; Abdel-Razak, S. I. ; Moharum; F. A. and Mohamed, G.H. (2020): Cotton Mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Coccomorpha: Pseudococcidae) associated with various crops and ornamental plants from Egypt and its economic threat on Egyptian agriculture. J. Entomol., 17 (3): 93-102.

Beshr, S.M.; Badr, S.A. ; Ahmad, A.A. and Mohamed, G.H. (2016): New record of host plants of invasive mealybug *Phenacoccus solenopsis* Tinsley (Tinsley, 1898), (Hemiptera: Pseudococcidae) in Alexandria and Behaira Governorates. J. Entomol., 13: 155-160.

Fallahzadeh, M.; Japoshvili, G.; Abdimaleki, R. and Saghaei, N. (2014): New records of Tetracneminae (Hymenoptera, Chalcidoidea, Encyrtidae) from Iran. Turkish Journal of Zoology, 38: 515-518.

Fand, B. and Suroshe, S.S. (2015): The invasive mealybug *Phenacoccus solenopsis* Tinsley, athreat to tropical and subtropical agricultural and horticultural production systems –a review. Crop protection, 69: 34-43.

Ibrahim, S. S.; Moharum, F. A. and Abd El-Ghany, N. M. (2015): The cotton mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) as a new insect pest on tomato plants in Egypt. J. of Plant Protection Research, 55 (1): 48–51.

Moharum, F. A.; Abd El-Mageed, S. A. M. and El-Baradey, W. M.M. (2018): Ecological studies on the cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) on tomato at Ismailia and Kafr el-sheikh Governorates in Egypt**.** Egy. J. Plant Pro. Res., 6 (1): 32-47.

Moharum, F.A.; Mohamed, G.H. and Abo Hatab, E.E. (2017): Survey of cotton mealybug *Phenacoccus solenopsis* Tinsley (Sternorrhyncha: Pseudococcidae) on host plants in Dakahlia Governorate, Egypt. Bulltein of the Entomological Society of Egypt, 63-70.

Nabil, H.A. and Hegab, M.A.M. (2019): Impact of some weather factors on the population density of *Phenacoccus solenopsis* tinsley and its natural enemies. Egypt. Acad. J. Biol. Sci., 12: 99-108.

Nabil, H.A., (2017): Ecological studies on cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Sternorrhyncha: Coccoidea: Pseudococcidae) on Eggplant at Sharkia Governorate, Egypt. Egypt. Acad. J. Biol. Sci. A. Entomol., 10: 195-206.

SAS Institute (1998): SAS user's guide. Statistics SAS Institute, Cary, N.C.

Shehata, I.E. (2017): On the biology and thermal developmental requirements of the cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) in Egypt. Arch. Phytopathol. Plant Prot., 50: 613-628.

Singh, A. and Kumar, D. (2012): Population dynamics, biology of mealybug *Phenacoccus solenopsis* (Tinsley) and its natural enemies in Vadodara, Gujarat. Recent Research in Science and Technology, 4(11): 22-27.