

TRITROPHIC INTERACTIONS AMONG EGYPTIAN WHEAT PLANT, CEREAL APHIDS AND NATURAL ENEMIES

El-Heneidy, A.H. and Salwa S. Abdel-Samad

Plant Protection Research Institute, Agricultural Research Center, Giza, Egypt.

(Received, October 25, 2001; November 17, 2001)

ABSTRACT

An evaluation of the tritrophic interactions among wheat plant, key aphids, and their natural enemies, mainly parasitoids and predators, in wheat fields was studied at three different agro-ecosystems in Egypt during the three seasons 1997/98 - 1999/2000. Rate of aphids' infestation, number of predators and percentages of parasitism were estimated in the three sites. *Rhopalosiphum padi* L., *R. maidis* Fitch., and *Schizaphis graminum* Rond. were the most abundant aphid species found on wheat plants during the study. Aphids' infestation season in wheat fields lasted from early January up to the end of April. Highest infestation rates; 35, 23 and 29 % were recorded at Sohag, Beni-Suef and Sharkia Governorates, respectively between mid-February and mid-March, during booting and heading wheat plant growth stages, in season 1999/2000. Highest numbers of predators; 31 and 21 individuals / 100 wheat plants were recorded by mid-March in Upper- and Middle-Egypt, respectively, in season 1999/2000. Highest percentages of parasitism; 26, 18 and 23 %, were estimated during the period between mid-February and mid-March at Sohag, Beni-Suef and Sharkia, respectively. This period coincided with the highest infestation period of aphids in each location. Generally, Sohag was the highest in all the studied parameters among the three locations.

Key Words:- Tritrophic interactions, wheat plant, aphids, natural enemies, wheat fields, Egypt.

INTRODUCTION

Cereal aphids' problem has arisen independently in various areas of the world, and their adverse impact may be almost perennial or may vary over the years. The interactions among the three major trophic levels (plants, herbivores, and natural enemies associated) can be quite complex. Much research has focused on the relationships between plants and pests (Maxwell and Jennings, 1980) and between pests and natural enemies (Burgess, 1981). Recently, a greater understanding of the need for integration of these systems has occurred (Price, 1986 Van Emden, 1986 and Ibrahim *et al.* 1991).

Aphids have been the subjects of much research on ecological relationships and population management. Many workers have contributed to the understanding of host-aphid relationships, and much has been done towards developing aphid-resistant plants (Auclair, 1989; ICARDA, 1996). There are, however, few reports on the tritrophic aspects of aphid

ecology, and more information in this area is vital. However, aphid-resistant cultivars may negatively impact the third trophic level (Price, 1986; van Emden, 1986). Therefore, it is important to recognize both positive and negative interactions that occur between the two primary components of a management system, plant cultivars and natural enemies, when developing integrated pest management systems.

The objective of this study was to evaluate the tritrophic interactions among a recommended commercial wheat variety (Sakha 69), key cereal aphids, and their natural enemies, mainly parasitoids and predators, in three different agro-ecosystems in Egypt.

MATERIALS AND METHODS

The study was carried out in wheat fields located at three Agricultural Research Stations; Shandaweel (Sohag Governorate, represented Upper Egypt), Seds (Beni-Suef Governorate, represented Middle Egypt) and Zagazig

(Sharkia Governorate, represented Lower Egypt (the Delta)) for the three growing seasons; 1997/98 - 1999/2000. An experimental area of one feddan, cultivated (between 15 - 25 November) with the recommended commercial wheat variety (Sakha 69), in each location was chosen annually for sampling. Samples were taken weekly from the three sites, started from early January (mostly during wheat plant tillering stage) through the end of April (mostly ripening stage), annually except for season 1998/99, when sampling was started one month later, early February. Experimental plots received regular cultural practices. No insecticides were used throughout the three seasons of the study. Surrounding crops were Egyptian clover, faba bean and vegetables.

Aphids Infestation

Rate of infested wheat plants was estimated weekly throughout the three seasons by examining 100 randomized wheat plants / location under field conditions, giving the following relative categories (El-Heneidy 1994):

N = No infestation

L = Light infestation (scattered nymph colonies, <10 individuals/colony present on leaves).

M = Moderate infestation (relatively bigger colonies 10-25 individuals/colony present on leaves and/or stem).

S = Severe infestation (dense numbers of colonies, accompanied by winged forms infesting leaves and stem, honeydew may present).

Natural Enemies

Weekly direct counts of predatory species found associated with the aphids on the above-examined 100 wheat plants / location were also undertaken in the three sites.

Samples of infested plants were collected weekly and transferred to the laboratory for estimating percentage of parasitism by dissecting 100 randomized living aphids /

location as well as for identifying emerged parasitoid species.

Meteorological data, including daily temperature and relative humidity in the three working sites, were recorded (Fig. 1). Data were statistically analyzed using ANOVA.

RESULTS AND DISCUSSION

Target Pest

Aphid Species Incidence

Wheat plants in the experimental fields were liable to be infested mainly by three key cereal aphid species, *Rhopalosiphum padi* L., *R. maidis* Fitch., and *Schizaphis graminum* Rond. Seasonal infestation period of different species was recorded as follows; from early January to end of April for *R. padi*, from late January to mid-April for *S. graminum*, and from early February to mid-April for *R. maidis*. It is noteworthy to mention that the species, *Sitobion avenae* Fab. which usually occurs late in the season was observed in very low numbers during the three seasons of the study and only in the Delta. This result differed than the findings of Ibrahim and Afifi, 1991 who recorded *S. avenae* early in February on wheat plants at Giza Governorate. Generally, *R. padi* dominated the other species of aphids in the wheat fields at the three working sites. According to Ibrahim 1991b and El-Heneidy, 1994, the active period of cereal aphids in wheat fields in Egypt usually starts from the late-tillering growth stage (mostly during January) and continued through the stem elongation, booting, heading and ends during the ripening stage (mostly during April).

Rate of Infestation

The results of the plant infestation ratings of the three seasons and the three sites are averaged in Table 1 and Fig. 2. Generally, aphids' infestation started earlier at Sohag (Upper Egypt) and few weeks later at Middle Egypt and Delta. According to the four relative categories of aphid infestation, highest

infestation period lasted from mid - February to mid - March. It reached the peaks of 35 % by mid-February at Sohag and 23 & 29 % by early and mid-March at Beni-Suef and Sharkia Governorates, respectively. These periods were more or less during the booting and heading wheat plant growth stages. These results agreed with the findings of Ibrahim, 1990 a,b,c, El-Heneidy, 1994, Hafez, 1994 and Abdel-Rahman *et al*, 2000. Ibrahim, 1990 a,b,c reported also that the population of cereal aphid species varied according to the susceptibility of different wheat varieties. Generally, highest rates of infestation were recorded at Sohag (an average of 13.2 %) while the lowest were found at Beni-Suef (an average of 7.1 %) (Table 1 and Fig. 2). Rates of infestation in season 1998/99 were relatively lower than those of 1997/98 and 1999/2000, while the highest rates were recorded in season 1999/2000, particularly, at Sohag (15.7 %). Statistical analyses showed significant differences in the rates of infestation among the three seasons at both Sohag and Sharkia while the differences were highly significant at Beni-Suef.

Natural Enemies

Predators and parasitoids were the bio-control agents taken in consideration during the study. Few individuals of aphids were found diseased by the fungus, *Entomophthora* sp., particularly at Zagazig and Seds during March.

Predators

Aphidiphagous predatory species surveyed and counted stage(s) in the experimental wheat fields associated with cereal aphids were:

Coleoptera - Coccinellidae: *Coccinella undecempunctata* L. and *Scymnus interruptus* L. (larvae and adults) - Staphilinidae:

Paederus alfieri (Koch.) (adults),

Diptera - Syrphidae: *Syrphus* spp. (larvae),

Hemiptera - Anthocoridae: *Orius* spp. nymphs and adults),

Neuroptera - Chrysopidae: *Chrysoperla carnea* Steph. (larvae), and

Acrina - True spiders (several species).

Seasonal occurrence of these species and their total numbers in the three locations are averaged in table 1 and fig.2. Among the seasons, highest average numbers of predators were counted in season 99/2000 and during March, by mid-March in Upper and Middle-Egypt (31 and 21 individuals / 100 plant, respectively), and by the end of March (32 individuals) at Sharkia (the Delta). These results varied slightly with the findings of Ghanem and El-Adl, 1983, Hafez, 1994 and El-Heneidy, 1994, who reported that the peak numbers of predators in wheat fields occurred during April, which is later than the highest infestation period of cereal aphids in wheat fields in Egypt (usually March). Such change in the peaks of the predators' numbers towards the highest period of aphids' population might be due to the recent wise-use of insecticides in wheat fields in Egypt. El-Heneidy *et al*, 1991 stated that a sharp decline (40 - 48 %) occurred in the number of predators presented in the wheat fields following pesticide applications. Highest average numbers of predators were recorded at Sohag and Sharkia Governorates (12.3 and 11.4 individuals / 100 plants, respectively) while the lowest was found at Beni-Suef Governorate (7.7 individuals / 100 plants). Coccinellids and true spiders were the most abundant predatory species found associated with aphids in wheat fields.

Parasitism

Parasitoid species are mostly specific on a single or certain group of insect hosts. The following list reveals hymenopterous primary and secondary parasitoids emerged from the key cereal aphids in wheat fields in Egypt during the study:

Primary parasitoids

Aphidiidae: *Aphidius matricariae* Haliday, *A. colemani* Viereck, *Diaeretiella rapae* M'Intosh, *Praon necans* Mackauer, *Ephedrus persicae* Haliday, and *Trioxys* sp.

Aphelinidae: *Aphelinus* sp.

Secondary parasitoids

Cynipidae: *Alloxysta* (= *Charips*) sp. and other cynipids.

Chalcididae: chalcids and pteromalids (*Asaphes* and *Pachyneuron*).

Encyrtidae: *Aphidencyrthus* sp.

Megaspilidae: *Dendrocerus* (formerly *Lygocerus*) sp.

Most of the surveyed parasitoid species were recorded in the three working sites (El-Heneidy *et al.*, 2001). Highest percentages of parasitism, 26, 18 and 23 % were estimated during the period lasted from mid-February to mid-March at Sohag, Beni-Suef and Sharkia Governorates, respectively to coincide more or less with the highest infestation period in each location (Table 1 and Fig.2). Average percentage of parasitism was almost equal at both Sharkia and Beni-Suef Governorates (6.3 and 6 %, respectively), although the rates of infestation in the two locations were significantly different, while the highest % parasitism was found at Sohag Governorate (7.8 %). These results agreed with the findings of Ibrahim, 1990a,b, c, El-Heneidy, 1994, Hafez, 1994 and Abdel-Rahman *et al.*, 2000. Highest percentage of parasitism (10.1 %) was estimated at Sohag season 99/2000. Ibrahim, 1990 a,b, c recorded 69 % parasitism on cereal aphids at Giza during 1997/98 and 1998/99 growing seasons. El-Heneidy *et al.*, 1991 stated that a sharp decline (66 %) in the percentages of parasitism occurred in the wheat fields following pesticide applications.

Generally, it could be concluded that Sohag (Upper Egypt) was the highest among the three locations in all the studied parameters; rate of infestation, % parasitism and number of predators followed by Sharkia (the Delta). There were seasonal differences in the occurrence of the particular species of the natural enemy complex. The predators, true spiders and *C. carnea* and the parasitoids, *A. matricariae*, *D. rapae* and *P. necans* characterized early season while the others tended to be the last to act. At the end of the

season when the plants became dry, these indigenous aphids departed, the natural enemies concentrated to the remnants of the aphid population.

Resistant wheat varieties with high levels of antibiosis affected growth and reproduction of both the aphid and the parasitoid (Ibrahim, 1990a,b, c and Reed *et al.*, 1991). Therefore, the use of any management strategy that tends to decrease the efficacy of natural enemies should be taken in consideration.

Statistical analyses of the three calculated parameters, rate of infestation, % parasitism and no. of predators among the three locations, Sohag, Beni-Suef and Sharkia in the three seasons showed relatively some significant differences.

Rate of infestation among the three Governorates in the three seasons was highly significant (= 0.01). It was also significant, highly significant and significant among the three seasons at Sohag (= 0.04), at Beni-Suef (= 0.006) and at Sharkia (= 0.05), respectively.

% parasitism was highly significant (= 0.01) among the three Governorates in season 1998/99.

Significant differences were also obtained between the temperature and the rate of infestation at Sohag in season 1997/98 (= 0.05) and between the temperature and the no. of predators at Beni-Suef in season 1997/98 (= 0.04) and at Sharkia in seasons 1997/98 and 1998/99 (= 0.02).

Differences in all other analyses were insignificant.

Acknowledgement

This study was supported in part by the Agricultural Technology Utilization and Transfer (ATUT), ARC, Egypt and USAID through the IPM wheat project (ATUT W 16). Thanks are due to all the ATUT project management and staff for their continuous sincere helps.

Table (1) : Monthly means of percentages of infested wheat plants, parasitism ant total numbers of predators /100 plants in wheat fields at three agro-ecosystems during the growing seasons 1997/98 - 1999/2000

Month	Location/Season	% Infested Plants				% Parasitism				No. Predators/100 Plants			
		1997/98	1998/99	1999/2000	1997/98	1998/99	1999/2000	1997/98	1998/99	1999/2000	1997/98	1998/99	1999/2000
January	Sohag	6.3	-	9.5	1.8	-	2	2.8	-	9.5	0	-	9.5
	Beni-Suef	0.5	-	5.5	1.5	-	1.5	0.5	-	3	-	-	3
	Sharkia	1.3	-	8.5	0	-	1	1.5	-	5	-	-	5
February	Sohag	26.5	9.8	20.3	8.5	8.3	12.3	15	10.5	17	-	-	17
	Beni-Suef	6.3	4.8	16.3	7.3	8.3	7.8	8.3	6	8.3	-	-	8.3
	Sharkia	13.8	6.5	21.3	4.5	6.5	11	9.8	10	9.5	-	-	9.5
March	Sohag	19.6	16.5	26.5	7.5	12.8	21.3	16.5	19.5	27	-	-	27
	Beni-Suef	9	9.5	16.3	10.3	7.3	12	11.3	12.3	18.3	-	-	18.3
	Sharkia	16	15.3	19.3	7.8	9.3	14.3	13	19	23.5	-	-	23.5
April	Sohag	3.8	2.8	6.3	3.3	3.3	4.8	6	5	7.3	-	-	7.3
	Beni-Suef	2	2.3	7	3	3.5	2.5	7	4	4	-	-	4
	Sharkia	5.8	5.5	9.8	4.2	3.5	7.3	8.8	12.5	10.8	-	-	10.8
General	Sohag	14.1a	9.7a	15.7a	5.3	8.1a	10.1	10.1	11.7	15.2	-	-	15.2
Mean	Beni-Suef	4.5b	5.5b	11.3b	5.5	6.4b	6	6.8	7.8	8.4	-	-	8.4
	Sharkia	9.2c	9.1a	14.7c	4.1	6.4b	8.4	8.3	13.8	12.2	-	-	12.2

Defferent letters mean significance

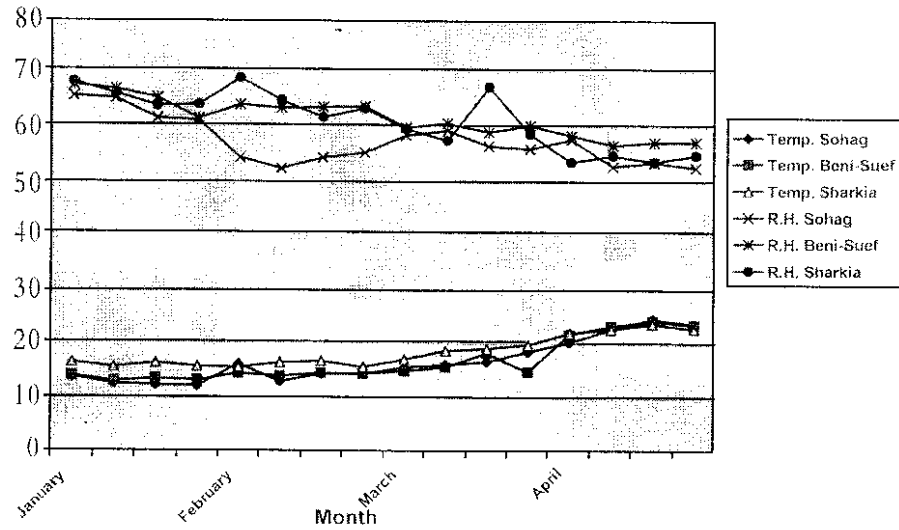


Fig. 1: 3-year weekly means of temperature °C and relative humidity % in three Egyptian governorates.

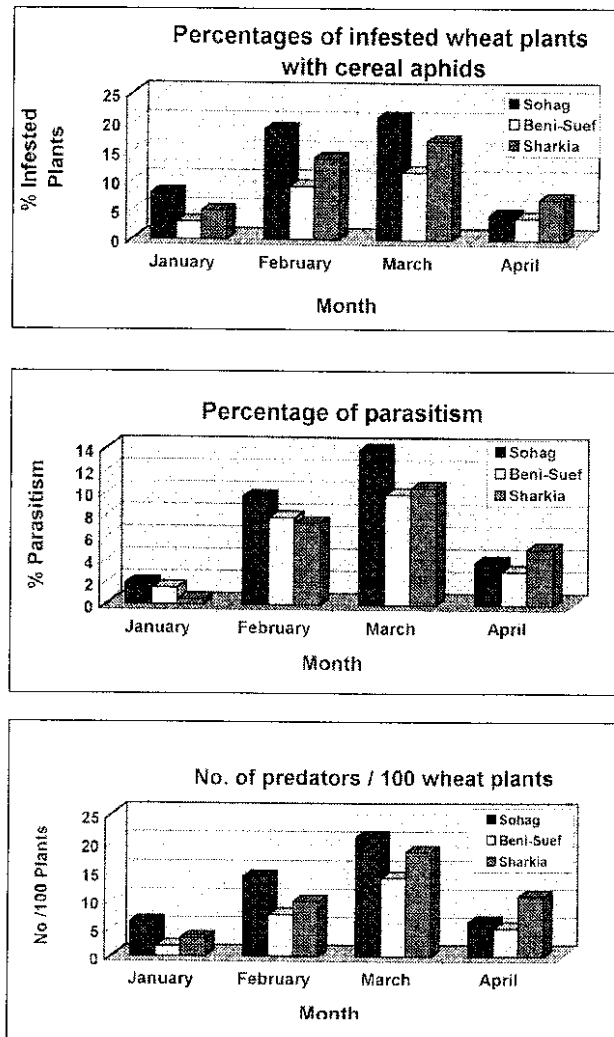


Fig.(2): 3-year (1997/98 - 1999/2000) monthly means of percentages of infested wheat plants and parasitism, and numbers of predators /100 plants in wheat fields in three agro-ecosystems in Egypt.

REFERENCES

- Abdel-Rahman, M. A., M. A. Nasser and A. M. Ali. 2000. Incidence of hymenopterous parasitoids attacking cereal aphids in wheat fields in Upper Egypt. *Ass. J. Agric. Sci.*, 31: 317-328.
- Auclair, J. L. 1989. Host plant resistance. In "Aphids, Their Biology, Natural Enemies and Control" (A. K. Minks and P. Harrewijn, Eds.), Vol. C, pp. 225-265. Elsevier, Amsterdam.
- Burges, J. D. (Ed.) 1981. "Microbial Control of Pests and Plant Diseases 1970 - 1980." Academic Press, New York / London.
- El-Heneidy, A. H. 1994. Efficacy of aphidophagous insects against aphids at wheat fields in Egypt. *Egypt. J. Biol. Pest Control* 4(2): 113-123.
- El-Heneidy, A. H., Y. H. Fayad and M. A. Shoab. 1991. Influence of insecticidal application on aphid populations and their natural enemies in wheat fields in Egypt. *Egypt. J. Biol. Pest Control* 1(2): 79-85.
- El-Heneidy, A. H., D. Gonzalez, P. Stary, Dalia Adly and M. A. El-Khawas. 2001. A survey of primary and secondary parasitoid species of cereal aphids in Egypt. *Egypt. J. Biol. Pest Control*. (in press)
- Ghanem, A. A. and M. A. El-Adl. 1983. Aphids infesting wheat and the effect of predators in suppressing their population in the field, at Mansoura district. *Egypt. J. Agric. Sci. Mansoura University*, 8(4): 958-968.
- Hafez, A.A. 1994. Increasing the role of bio-control agents against cereal aphids infesting wheat in Qalubia-Egypt. *Egypt. J. Biol. Pest Control* 4(2): 57-71.
- Ibrahim, A.M.A. 1990a. Population dynamics of bird-cherry aphid, *Rhopalosiphum padi* L. (Hom.: Aphididae) and its primary parasitoids and hyperparasitoids association on wheat in Egypt. *Bull. Soc. ent. Egypte*, 69, 137-147.
- Ibrahim, A.M.A. 1990b. Corn leaf aphid, *Rhopalosiphum maidis* (F.) (Hom.: Aphididae) on wheat and associated primary parasitoids and hyperparasitoids. *Bull. Soc. ent. Egypte*, 69, 149-157.
- Ibrahim, A.M.A. 1990c. Population dynamics of the green bug, *Schizaphis graminum* (Rond.) (Hom.: Aphididae) and its primary parasitoids and hyperparasitoids association on wheat in Egypt. *Egypt. J. Appl. Sci.* 5(7), 501-513.
- Ibrahim, A.M.A. and Amal, I. Affi. 1991a. Seasonal fluctuation of English grain aphid, *Sitobion avenae* (Fab.) (Hom.: Aphididae) on wheat and its primary parasitoids and hyperparasitoids in Giza Governorate, Egypt. *Bull. Fac. of Agric. Univ. of Cairo*, Vol. 42, No.1: 167-182.
- Ibrahim, A.M.A. and Amal, I. Affi. 1991b. The relationship between the cereal aphids and aphidophagous syrphids, coccinellids and chrysopids on wheat and barley in Egypt. *Bull. Fac. of Agric., Univ. of Cairo*, Vol. 42, No. 1: 151 - 166.
- ICARDA 1996. Annual report of the Nile Valley project
- Maxwell, F. G., and Jennings, P. R. (Eds.) 1980. "Breeding Plants Resistant to Insects." Wiley, New York.
- Price, P. W. 1986. Ecological aspects of host plant resistance and biological control: Interactions among three trophic levels. In "Interactions of Plant Resistance and Parasitoids and Predators of Insects" (D. J. Boethel and R. D. Eikenbary, Eds), pp. 138-150. Ellis Horwood Ltd., Chichester.
- Reed, D. K., Webster, J. A., Jones, B. G. and Burd, J. D. 1991. Tritrophic relationships of Russian wheat aphid (Homoptera: Aphididae), a hymenopterous parasitoid (*Diaeretiella rapae* McIntosh), and resistant and susceptible small grains. *Biological control* 1, 35-41.
- Van Emden, H.F. 1986. The interaction of plant resistance and natural enemies: Effects on populations of sucking insects. In "Interactions of Plant Resistance and Parasitoids and Predators of Insects" (D. J. Boethel and R. D. Eikenbary, Eds), pp. 138-150. Ellis Horwood Ltd., Chichester.