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Field assessment of neonicotinoids against three aphid species and their natural enemies on wheat crop in Ismailia, Egypt

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SUMMARY

Aphids are the most important pests on wheat in Egypt and worldwide. Field trials were conducted to assess the efficacy of the neonicotinoid insecticides imidacloprid (Nufidor 60% FS; at the doses of 2.1, 1.05 and 0.525 g a.i./kg of seeds) and thiamethoxam (Cruiser 70% WS; at the rates of 14.4, 7.2 and 3.6 g a.i./kg of seeds) as seed treatments, and thiamethoxam (Actara 25% WG; at the rates of 0.1, 0.05 and 0.025 g a.i./l) as foliar application, against three wheat aphids: bird cherry oat aphid, *Rhopalosiphum padi* (L.), greenbug, *Schizaphis graminum* (Rondani), and corn leaf aphid, *Rhopalosiphum maidis* (Fitch). Their effects on the aphids' natural enemies: lacewings, *Chrysoperla carnea* Stephens, ladybird beetles, *Coccinella* spp., and syrphid flies *Syrphus* spp. were assessed as well. The trials were conducted on the farm of the Faculty of Agriculture, Suez Canal University, Ismailia Governorate, during 2013/14 and 2014/15 seasons. Our results showed significant differences between the tested insecticides at all concentrations and clearly indicated that the recommended doses of all insecticides were more efficient against aphids on wheat plants than half- and quarter-doses. Also, the data revealed significant differences between the two seed treatments at all doses before and after foliar application, as compared to the control at all time intervals of inspection regarding the mean number of aphids on wheat plants, from the 3rd until 13th week after sowing, except in the 8th week after seed treatment before foliar application. The results clearly indicated that the weekly reduction of infestation and the general efficacy was higher at the recommended doses of Nufidor, Cruiser and Actara than the half and quarter doses in both seasons. Also, reduction in infestation decreased over the following weeks until the 8th week, when Actara insecticide was sprayed. Data revealed that there were no significant differences between treatments and control in the mean number of *Chrysoperla carnea* and *Syrphus* spp., while a significant difference in the mean number of coccinellids was observed on wheat plants treated with imidacloprid seed treatment before foliar application 6 and 7 weeks after sowing, and also after foliar application with thiamethoxam 9, 10, 11, 12 and 13 weeks after sowing. Regarding thiamethoxam seed treatment, significant differences were revealed in the ladybird population on wheat plants 3, 4, 7 and 8 weeks before foliar application, and only in the 10th week after spraying with thiamethoxam.

Keywords: Neonicotinoids; Foliar application; Seed treatment; Aphids; Predators: Wheat; Egypt

INTRODUCTION

Wheat plays an important role in the diet of Egyptians, while annual production of wheat (*Triticum aestivum* L.) is insufficient to cover Egyptian demand. Cereal aphids are serious pests that attack cereal crops in Egypt, particularly wheat, barley and maize (El-Hariry,1979; El-Heneidy, 1994), which causes a damage estimated at up to 23%, particularly in Upper Egypt, where the highest infestation intensity mostly occurs (Tantawi, 1985).

Direct damage that aphids cause to crops include: sap ingestion, desiccation of leaves, reduced germination potential and productivity, and finally plant death. Indirect damage is caused through stunting and premature plant death, reduction in photosynthesis, as well as sterilization of inflorescences, plentiful honeydew production, which may result in deformed leaves, and growth of sooty mold (Blackman & Eastop, 2000). Among economic pests, 29 aphid species infest wheat crops (Kuroli, 2000). Predominant species are the greenbug, *Schizaphis graminum* (Rondani) and bird cherry oat aphid, *Rhopalosiphum padi* (L.) (Bosque-Perez & Schotzko, 2000). In Egypt, El-Heneidy and Adly (2012) recorded 11 species of aphids on wheat, and the most dominant species were *Rhopalosiphum maidis*, *R. padi* and *S. graminum*.

Since 1990, a new class of synthetic chemicals, the neonicotinoids, has entered the pesticide market and its use has grown rapidly. The neonicotinoids have a systemic mode of action in the plant, which becomes toxic for insects sucking the circulating fluids or ingesting parts of it. They are effective in the control of a range of insect pests, including aphids. This group of insecticides is frequently applied to crops as seed treatments at sowing to protect seedlings (Magalhaes et al., 2009, Simon-Delso et al., 2014). However, the systemic nature of these insecticides means that they get into other parts of the plant including pollen and nectar; thus non-target species harvesting those parts of the plant, e.g. predators exposed through ingesting prey, will also be exposed, often for a long time due to the chemicals' persistence (Neumann, 2015). Conservation of natural enemies through using selective pesticides has been one of the main criterions for establishing an integrated pest management program (El-Zahi, 2012; Suhail et al., 2013). The aim of this study was to assess the efficacy of several neonicotinoid insecticides registered in Egypt for seed treatment and foliar application against wheat aphids, as well as their impact on aphid predators, in order to obtain research data for improving the management of their populations.

MATERIALS AND METHODS

Experimental design

Field experiments were conducted at the Experimental Farm, Faculty of Agriculture, Suez Canal University (SCU), Ismailia, Egypt, during two successive wheat growing seasons of 2013/14 and 2014/15. Seeds of the wheat cultivar Gemiza 9 used in this study were acquired from the Agronomy Department, Faculty of Agriculture, SCU. The experiment was laid out in a randomized complete block design with seven treatments including a control and four replicates of each. An area of about 0.168 ha was prepared and divided into plots; each plot was about 4 m long and 1.8 m in width, four-rows in each plot, spacing between rows ≈ 45 cm. Treated wheat seeds were sown by drilling in hills and the spacing between hills in the same row was ≈ 20 cm. All agronomic practices were conventionally practiced over the different growth stages of wheat plants in all treatments throughout both growing seasons as required. Control treatments were also conducted using untreated seeds.

Insecticides used

The neonicotinoid insecticides used in this study were imidacloprid (Nufidor 60 FS; Cairo Chemicals) and thiamethoxam (Cruiser 70WS and Actara 25 WG; Syngenta), both registered for use in wheat fields in Egypt. The recommended rate (RR), ½ of the RR, and ¼ of the RR of the insecticides were prepared as follows: 14.4, 7.2 and 3.6 g a.i./kg of seeds for Cruiser 70 WS; 2.1, 1.05 and 0.525 g a.i./kg of seeds for Nufidor 60 FS; and 0.1, 0.05 and 0.025 g a.i./l for Actara 25 WG.

Treatments

Seed treatments with Nufidor 60 FS and Cruiser70 WS, followed by foliar application with Actara 25 WG (eighth week after sowing) were tested in these trials. Solutions of each tested concentration of Nufidor 60 FS were freshly prepared and applied directly to one kg of seeds. Treated seeds were left for three hours to dry out and then sown. The tested concentrations of Cruiser 70 WS were directly mixed with wet seeds using big plastic bags to ensure seed coating. A single foliar treatment with Actara 25 WG at its tested concentrations was performed by a backpack sprayer in a broadcast application on wheat plants. The insecticides were applied on 15 January 2015, when wheat plants were about 2 months old.

Effect on aphids and their natural enemies

Field observation started 3 weeks after sowing and continued up to 13 weeks after sowing. Weekly samples of 10 plants of each replicate were examined and aphids (*R. padi*, *R. maidis* and *S. graminum*) and their predators, ladybird beetles *Coccinella*spp, lacewings *Chrysoperla carnea* Stephens and syrphid flies *Syrphus* spp., were counted. The percent reduction in insect infestation was calculated for the seasons 2013/14 and 2014/15 according to a modified version of Abbott's formula (Abbott, 1925):

$$\text{Reduction (\%)} = 1 - \frac{Tn}{Cn} \times 100$$

where: n = the number of insects, T = treatment, C = control

Statistical analysis

Aphid and predator counts were subjected to an analysis of variance (ANOVA) and the means were separated by LSD test at $P \leq 0.05$. (SAS Institute, 2004).

RESULTS

Effects of insecticides on aphid infestation

Data presented in Tables 1 and 2 show the effects of three concentrations (RR, ½ RR, and ¼ RR) of the tested insecticides applied as seed treatment prior to sowing (Nufidor 60 FS and Cruiser 70 WS), and foliar treatment (Actara25 WG) in the 8th week after sowing, on the mean number of aphids recorded weekly on wheat plants starting from the 3rd through 13th week of plantation. Data showed significant differences between the tested insecticides at all concentrations and clearly indicated that the recommended doses of all insecticides were more effective against aphids on wheat plants than the half and quarter doses. The data showed that the mean number of aphids increased gradually with time after seed treatment, reaching a maximum by the 9th week, just before foliar application with Actara. One week after spraying, the number of aphids declined to zero in both seasons, such as in plots with the recommended rates (RR) of Nufidor and Cruiser, and then increased gradually until the inspection in the 13th week after sowing. These data revealed significant differences in the mean number of aphids on wheat plants between the two seed treatments at all doses before and after foliar application, compared to control plots, at all time intervals of inspection from the 3rd until the 13th week after sowing, except in the 8th week after seed treatment, before foliar application.

Table 1. Mean number of aphids found weekly on wheat plants growing after seed treatments (Nufidor 60 FS and Cruiser 70 WS) and succeeding foliar application (Actara 25 WG) in the season 2013/14

Insecticides (seed treatments)	Mean number of aphids after (weeks)											
	3 w	4 w	5 w	6 w	7 w	8 w	Actara 25 WG (foliar)	9 w	10 w	11 w	12 w	13 w
Nufidor 60 FS (RR)	0.0 c	1.0 d	7.5 e	9.0 a	24.0 c	40.0 c	(RR)	0.0 d	2.5 e	17.5 d	56.0 d	78.5 d
Cruiser 70 WS (RR)	0.0 c	4.5 d	10.5 de	15.0 d	35.5 c	56.5 c	(RR)	0.0 d	3.5 e	25.0 d	72.0 d	84.0 d
Nufidor 60 FS (½ RR)	18.5 abc	4.5 d	27.5 cd	34.0 c	54.5 b	64.5 c	(½ RR)	4.5 cd	19.0 d	71.0 c	135.0 c	111.0 c
Cruiser 70 WS (½ RR)	4.4 bc	7.5 d	42.0 bc	55.0 b	99.5 a	93.0 b	(½ RR)	9.0 cd	22.0 d	53.0 c	92.5 d	119.0 c
Nufidor 60 FS (¼ RR)	39.0 ab	21.0 c	55.0 ab	78.0 a	98.0 a	127.0 a	(¼ RR)	19.5 c	46.5 c	76.5 c	167.5 bc	205.0 b
Cruiser 70 WS (¼ RR)	23.0 abc	44.5 b	57.0 ab	85.5 a	112.0 a	135.5 a	(¼ RR)	34.5 b	78.0 b	112.0 b	180.0 b	255.5 a
Control	45.0 a	58.0 a	67.0 a	40.5 c	102.0 a	57.0 c		98.5 a	139.0 a	212.5 a	245.0 a	264. 5 a
P	0.3620	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000
F	2.811	32.972	14.791	44.479	39.575	16.124		49.867	89.650	68.697	25.039	80.475
LSD	32.207	11.534	17.944	12.939	16.894	27.328		14.663	15.352	23.504	39.569	26.283

RR = Recommended rate, (½ RR) = Half of recommended rate, (¼ RR) = Quarter of recommended rate
Means marked by the same letters (column wise) are not significantly different (ANOVA, LSD; $P \leq 0.05$)

Table 2. Mean number of aphids found weekly on wheat plants growing after seed treatments (Nufidor 60 FS and Cruiser 70 WS) and succeeding foliar application (Actara 25 WG) in the season 2014/15

Insecticides (seed treatments)	Mean number of aphids after (weeks)											
	3 w	4 w	5 w	6 w	7 w	8 w	Actara 25 WG (foliar)	9 w	10 w	11 w	12 w	13 w
Nufidor 60 FS (RR)	0.0 d	3.0 d	6.0 c	7.0 d	18.0 c	38.0 c	(RR)	0.0 d	1.5 d	13.5 e	26.0 e	57.5 e
Cruiser 70 WS (RR)	0.5 d	2.0 d	8.0 c	11.5 d	28.5 c	42.5 c	(RR)	0.0 d	2.5 d	18.5 e	32.5 de	67.5 de
Nufidor 60 FS (½ RR)	3.5 d	5.0 d	11.0 c	25.5 c	47.5 b	47.5 c	(½ RR)	2.5 cd	8.5 d	30.0 de	57.5 cd	87.5 d
Cruiser 70 WS (½ RR)	4.5 d	6.0 cd	30.0 b	42.0 b	79.0 a	75.0 b	(½ RR)	7.0 cd	16.5 d	39.5 d	77.5 c	90.0 d
Nufidor 60 FS (¼ RR)	14.0 c	14.0 c	42.5 a	65.0 a	90.0 a	93.5 a	(¼ RR)	14.5 c	35.0 c	60.0 c	150.0 b	181.5 c
Cruiser 70 WS (¼ RR)	23.0 b	37.5 b	45.0 a	72.5 a	75.0 a	103.5 a	(¼ RR)	34.5 b	70.0 b	90.0 b	147.0 b	210.0 b
Control	45.0 a	47.5 a	51.0 a	36.0 b	73.5 a	45.0 c		95.0 a	105.0 a	162.5 a	202.5 a	265.0 a
P	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		0.0000	0.0000	0.0000	0.0000	0.0000
F	59.888	41.698	23.432	73.393	25.790	37.164		60.112	56.869	79.508	56.527	93.545
LSD	17.952	8.404	11.645	8.578	15.983	12.947		13.062	15.389	17.351	26.508	24.673

RR = Recommended rate, (½ RR) = Half of recommended rate, (¼ RR) = Quarter of recommended rate
Means marked by the same letters (column wise) are not significantly different (ANOVA, LSD; P ≤ 0.05)

Table 3. Reduction of aphid infestation and average efficacy of the tested insecticides in wheat growing after seed treatments (Nufidor 60 FS and Cruiser 70 WS) and succeeding foliar application (Actara 25 WG) in the season 2013/14

Insecticides (seed treatments)	Reduction of infestation (%) after (weeks)												
	3 w	4 w	5 w	6 w	7 w	8 w	Actara 25 WG (foliar)	9 w	10 w	11 w	12 w	13 w	Average efficacy (%)
Nufidor 60 FS (RR)	100	98.28	88.81	77.50	76.47	29.82	(RR)	100	98.20	91.76	77.14	70.32	82.57
Cruiser 70 WS (RR)	100	92.24	84.33	62.50	65.20	0.88	(RR)	100	97.48	88.24	70.61	68.24	75.42
Nufidor 60 FS (½ RR)	58.89	92.24	58.96	15.00	46.57	0	(½ RR)	95.43	86.33	66.59	44.90	58.03	56.63
Cruiser 70 WS (½ RR)	90.22	87.07	37.31	0	2.45	0	(½ RR)	90.86	84.17	75.06	62.24	55.01	53.12
Nufidor 60 FS (¼ RR)	13.33	63.79	17.91	0	3.92	0	(¼ RR)	80.20	66.55	64.00	31.63	22.50	32.98
Cruiser 70 WS (¼ RR)	48.89	23.28	14.93	0	0	0	(¼ RR)	64.97	43.88	47.29	26.53	3.40	24.83

RR = Recommended rate, (½ RR) = Half of recommended rate, (¼ RR) = Quarter of recommended rate

Data in Tables 3 and 4 show reductions in infestation percentage (efficacy) over the eleven weeks after sowing and average efficacy in both seasons 2013/14 and 2014/15. The results showed that the infestation reduction and general efficacy were approximate in both experimental seasons but the weekly reduction of infestation and general efficacy were higher at the recommended doses of Nufidor 60 FS, Cruiser 70 WS and Actara 25 WG than the half and quarter doses in both seasons. Also, reduced infestation further decreased over the following weeks until the 8th week, when Actara insecticide was sprayed. Thereafter, the reduction of infestation percentage increased in the 9th week and decreased gradually by the 13th week.

Data presented in Tables 5 and 6 for the 2013/14 season show the impact of seed treatment at sowing, followed by foliar application, of the recommended rates

Table 4. Reduction of aphid infestation and average efficacy of the tested insecticides in wheat growing after seed treatments (Nufidor 60 FS and Cruiser 70 WS) and succeeding foliar application (Actara 25 WG) the season 2014/15

Insecticides (seed treatments)	Reduction of infestation (%) after (weeks)												Average efficacy (%)
	3 w	4 w	5 w	6 w	7 w	8 w	Actara 25 WG (foliar)	9 w	10 w	11 w	12 w	13 w	
Nufidor 60 FS (RR)	100	93.68	88.24	80.56	75.51	15.56	(RR)	100	98.57	91.69	87.16	78.30	82.66
Cruiser 70 WS (RR)	98.89	95.79	84.31	68.06	61.22	5.56	(RR)	100	97.62	88.62	83.95	74.63	78.05
Nufidor 60 FS (½ RR)	92.22	89.47	78.43	29.17	35.37	0	(½ RR)	97.37	91.90	81.54	71.60	66.98	66.73
Cruiser 70 WS (½ RR)	90.00	87.37	41.18	0	0	0	(½ RR)	92.63	84.29	75.69	61.73	66.04	54.44
Nufidor 60 FS (¼ RR)	68.89	70.53	16.67	0	0	0	(¼ RR)	84.74	66.67	63.08	25.93	31.70	38.92
Cruiser 70 WS (¼ RR)	48.89	21.05	11.76	0	0	0	(¼ RR)	63.68	33.33	44.62	27.41	20.75	24.68

RR = Recommended rate, (½ RR) = Half of recommended rate, (¼ RR) = Quarter of recommended rate

Table 5. Impact of seed treatment followed by foliar application (Nufidor 60 FS + Actara25 WG) on the mean number of predatory insects associated with aphids on wheat crop in the season 2013/14

Predatory insects	Nufidor 60 FS (RR) + Actara 25 WG (RR) Mean number of predatory insects after (weeks)										
	3 w	4 w	5 w	6 w	7 w	8 w	9 w	10 w	11 w	12 w	13 w
Coccinella spp.											
Treatment	34.50	34.25	33.00	28.25	24.75	34.50	12.00	10.50	24.25	26.50	26.50
Control	36.75	48.00	47.75	56.75	44.75	50.25	32.75	32.25	47.75	43.25	41.00
P	0.7341	0.1722	0.1681	0.0117	0.0180	0.0706	0.0008	0.0035	0.0011	0.0278	0.0429
F	0.127	2.401	2.457	12.766	10.401	4.819	39.516	21.688	34.606	8.339	6.553
LSD	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Chrysopa carnea											
Treatment	2.75	2.75	4.25	4.25	6.00	4.00	4.00	4.25	4.25	1.75	2.25
Control	3.00	3.50	3.50	4.50	3.75	3.50	5.25	4.50	3.75	4.00	3.75
P	0.8291	0.6394	0.4372	0.9001	0.0718	0.7049	0.4175	0.8701	0.7748	0.0117	0.3053
F	0.051	0.243	0.692	0.017	4.765	0.158	0.758	0.029	0.090	12.790	1.256
LSD	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Syrphus spp.											
Treatment	1.25	2.00	1.75	2.25	1.00	2.00	1.00	1.50	1.75	2.50	3.00
Control	2.25	2.00	2.25	2.50	3.50	2.00	1.50	1.50	2.00	2.50	2.00
P	0.3040	1	0.5945	0.8439	0.0667	1	0.6891	1	0.8555	1	0.4454
F	1.263	0	0.316	0.042	5	0	0.176	0	0.036	0	0.667
LSD	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Means marked by the same letters (column wise) are not significantly different (ANOVA,LSD; P ≤ 0.05)

of the tested insecticides (because most Egyptian farmers use the recommended or higher doses, rather than lower doses against insect pests). Data revealed no significant differences between treatments with insecticides and control regarding the mean number of *Chrysoperla carnea* and *Syrphus* spp. However, significant differences were detected in the mean number of coccinellids on wheat plants treated with imidacloprid seed application, before foliar application, during the 6th and 7th weeks after sowing, and also after foliar application with thiamethoxam at the intervals of 9, 10, 11, 12 and 13 weeks after sowing. Regarding thiamethoxam seed treatment, there were significant differences in coccinellid populations on wheat plants 3, 4, 7 and 8 weeks after sowing, before foliar application, and only in the 10th week after spraying with thiamethoxam.

Table 6. Impact of seed treatment followed by foliar application (Cruiser 70 WS+Actara25 WG) on the mean number of predatory insects associated with aphids on wheat crop in the season 2013/14

Natural enemies	Cruiser 70 WS (RR) + Actara 25 WG (RR)										
	Mean number of predatory insects after (weeks)										
	3 w	4 w	5 w	6 w	7 w	8 w	9 w	10 w	11 w	12 w	13 w
Coccinella spp.											
Treatment	36.75 b	31.75 b	26.25	39.75	37.25 b	24.50 b	40.25	22.25 b	42.50	19.50	25.50
Control	56.50 a	50.50 a	41.75	38.00	53.00 a	35.75 a	51.00	42.75 a	49.50	30.00	33.75
P	0.0193	0.0139	0.1053	0.7906	0.0310	0.0468	0.2262	0.0126	0.3442	0.0801	0.0745
F	10.050	11.792	3.633	0.077	7.859	6.231	1.818	12.376	1.054	4.425	4.647
LSD	15.24	13.36	ns	ns	13.74	11.02	ns	14.25	ns	ns	ns
Chrysoperla carnea											
Treatment	1.50	1.25	3.50	4.00	2.00	1.50	2.50	2.50	3.25	4.25	1.75
Control	1.75	1.50	3.00	3.00	2.75	1.75	3.00	1.25	5.25	4.25	1.50
P	0.8519	0.8090	0.5847	0.1980	0.5490	0.8090	0.6480	0.2534	0.2493	1	0.8439
F	0.038	0.064	0.333	0.750	0.403	0.064	0.231	1.596	1.627	0	0.042
LSD	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Syrphus spp.											
Treatment	1.00	1.25	1.75	2.00	2.00	2.50	2.25	3.00	2.50	0.75	1.50
Control	1.50	1.25	2.00	1.75	2.00	2.75	2.25	3.25	2.25	1.75	1.50
P	0.6480	1	0.6202	0.8160	1	0.8701	1	0.8394	0.8439	0.2528	1
F	0.231	0	0.273	0.059	0	0.029	0	0.045	0.042	1.600	0
LSD	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Means marked by the same letters (column wise) are not significantly different (ANOVA, LSD; P ≤ 0.05)

Table 7. Impact of seed treatment followed by foliar application (Nufidor 60 FS + Actara25 WG) on the mean number of predatory insects associated with aphids on wheat crop in the season 2014/15

Predatory insects	Nufidor 60 FS (RR) + Actara25 WG (RR)										
	Mean number of predatory insects after (weeks)										
	3 w	4 w	5 w	6 w	7 w	8 w	9 w	10 w	11 w	12 w	13 w
Coccinella spp.											
Treatment	35.25	34.50	31.00	28.25	32.75	32.75	23.25	25.75	30.00	31.75	30.50
Control	38.00	42.75	41.50	44.25	43.00	43.00	30.25	29.75	42.75	41.00	37.00
P	0.5029	0.0298	0.1002	0.0430	0.882	0.0882	0.0447	0.2305	0.0298	0.2877	0.1489
F	0.508	8.027	3.769	6.534	4.136	4.136	6.426	1.780	8.036	1.360	2.270
LSD	ns	7.125	ns	15.305	ns	ns	6.756	ns	11.015	ns	ns
Chrysopa carnea											
Treatment	1.00	2.50	2.50	3.00	4.50	3.00	4.00	2.50	2.75	4.25	4.25
Control	2.25	2.50	2.75	3.00	4.75	3.00	4.75	3.75	2.75	4.75	5.25
P	0.0941	1	0.8619	1	0.8090	1	0.5891	0.3171	1	0.6754	0.4127
F	3.947	0	0.038	0	0.064	0	0.325	1.190	0	0.194	0.774
LSD	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Syrphus spp.											
Treatment	0.75	1.25	2.50	2.50	3.00	1.50	2.00	2.00	2.00	2.75	3.5
Control	1.00	1.50	3.00	3.50	4.75	2.00	2.50	3.00	2.75	2.75	3.00
P	0.7049	0.7663	0.5370	0.2070	0.0584	0.5847	0.6891	0.4198	0.3559	1	0.6891
F	0.158	0.097	0.428	2	5.444	0.333	0.176	0.750	1	0	0.176
LSD	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Means marked by the same letters (column wise) are not significantly different (ANOVA,LSD; P ≤ 0.05)

Table 8. Impact of seed treatment followed by foliar application (Cruiser 70 WS+Actara25 WG) on the mean number of predatory insects associated with aphids on wheat crop in the 2013/14 season

Natural enemies		Cruiser 70 WS (RR) + Actara 25 WG (RR)										
		Mean number of predatory insects after (weeks)										
		3 w	4 w	5 w	6 w	7 w	8 w	9 w	10 w	11 w	12 w	13 w
Coccinella spp.												
Treatment		28.00	32.00	31.75	20.50	27.00	20.25	27.50	27.25	30.00	29.50	25.00
Control		47.00	45.00	41.75	33.00	40.50	23.25	38.50	35.25	34.50	37.50	38.75
	P	0.0023	0.0489	0.0879	0.0629	0.0468	0.5676	0.2341	0.2037	0.4772	0.3577	0.0629
	F	25.482	6	4.145	5.193	6.231	0.365	1.749	2.034	0.574	0.992	5.192
	LSD	9.2098	12.986	ns	ns	13.233	ns	ns	ns	ns	ns	ns
Chrysoperla carnea												
Treatment		0.75	1.00	2.50	2.25	2.75	2.25	2.00	2.25	3.00	2.50	1.50
Control		0.50	0.75	2.75	2.25	2.50	3.25	1.75	2.75	3.25	3.50	2.75
	P	0.6704	0.7049	0.7304	1	0.8231	0.3822	0.6202	0.5504	0.7796	0.2070	0.1210
	F	0.200	0.158	0.	0	0.054	0.889	0.086	0.400	0.086	2.000	3.261
	LSD	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Syrphus spp.												
Treatment		1.25	0.75	2.00	1.25	1.75	2.00	2.25	2.25	2.75	1.50	1.00
Control		1.75	1.50	1.25	1.00	2.75	3.25	1.50	2.25	2.75	2.25	1.75
	P	0.4881	0.3202	0.2782	0.7502	0.2528	0.1936	0.3202	1	1	0.5801	0.1682
	F	0.545	1.174	1.421	0.111	1.600	2.143	1.174	0	0	0.342	2.454
	LSD	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Means marked by the same letters (column wise) are not significantly different (ANOVA, LSD; P ≤ 0.05)

Also, data in Tables 7 and 8 for the 2014/15 season revealed that the tested insecticides had no significant differences between treatments and control in the mean number of *Chrysoperla carnea* and *Syrphus* spp. On the other hand, significant differences in the mean number of coccinellids were observed on wheat plants treated with Nufidor (imidacloprid) as seed application before foliar treatment at the intervals of 4 and 6 weeks after sowing, and in the 9th week after foliar application of Actara (thiamethoxam). Moreover, significant differences in the mean number of coccinellids was observed on wheat plants treated with Cruiser seed application before foliar application 3, 4 and 7 weeks after sowing, while differences were insignificant in coccinellid populations on wheat plants after the foliar application of Actara (thiamethoxam).

DISCUSSION

Neonicotinoid insecticides move through plants after seed treatment as the seeds germinate, and provide aphid control over 4 to 15 weeks, depending on the rate of application, environmental conditions, type of treated plants and type of experiment (laboratory, greenhouse or field) (Zidan, 2012). Only early-season aphids of wheat were inspected in this study. Management of other wheat aphids that occur later in the season and fall outside the activity spectrum of neonicotinoid insecticide seed treatment may have a different spectrum of alternative treatments. Therefore, foliar neonicotinoid application is considered one of the most important treatments to manage wheat aphids, either using it alone (on plants not exposed to neonicotinoid insecticidal seed treatments) or in combination (on plants previously treated with a neonicotinoid insecticide at seed stage).

In the current study, insecticide seed treatments and foliar application 8 weeks after sowing during 2013/14 and 2014/15 seasons led to significant reductions in infestation rates and decreases in wheat aphid population. These results are in agreement with data reported by Harvey et al. (1996), who found that imidacioprid seed treatment controlled corn leaf aphids and greenbugs (Homoptera: Aphididae) for 3 to 4 weeks after sowing but not for 7 weeks. Mahmoud and Osman (2015) reported that treatment of canola (*Brassica napus* L.) seeds with neonicotinoid insecticides, followed by a foliar application with salicylic acid, was not effective in managing the cabbage aphid, *Brevicoryne brassicae* L. in the late growing season from 15th to 21st week.

Torres and Ruberson (2004) showed that thiamethoxam and imidacloprid provided significant control of whitefly, compared to untreated plots, for a duration of up to 40 days.

Neonicotinoid seed treatments showed positive effects on wheat aphid populations and reduction of infestation until 8 weeks from sowing. But, when the foliar neonicotinoid insecticide was applied 8 weeks after seed treatments the effect was significant in terms of reduction of aphid population. The results showed that the efficiency of the tested insecticides, regarding the percent reduction of aphid infestation on wheat plants, decreased with decreasing application rates of the insecticides. Likewise their efficiency decreased with increasing time intervals of inspection after seed treatment, as well as after foliar application.

The current study revealed no significant differences between insecticide treatments and control in the mean number of *Chrysoperla carnea*, *Syrphus* spp. and Coccinella spp. The side effects of neonicotinoid insecticides when applied as drenches, granules or growth media on natural enemies have shown less toxicity to a variety of predators and parasitioids (Mensah, 2002; Ahmed et al., 2014).

In conclusion, neonicotinoid seed treatment provides excellent control at the early stage of infestation by aphids. Conversely, their management in the later stage of infestation is moderate or relatively weak. Neonicotinoid seed treatments and foliar application of neonicotinoid insecticides offer different but potentially compatible approaches to suppressing aphid populations and reducing their infestation rates. The efficacy of managing aphids increases when neonicotinoid seed treatments and foliar application of neonicotinoid insecticides are used in combination. Undoubtfully, natural enemies play an important role in regulating the host population; therefore, using neonicotinoid insecticides in IPM programs for aphids may offer the best control of pest populations while preserving the natural enemies that also control pests.

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Ocenjivanje efikasnosti neonikotinoida protiv tri vrste biljnih vaši i njihovih prirodnih neprijatelja u poljskim ogledima u pšenici u Ismailiji, Egipat

REZIME

Biljne vaši su najvažniji štetni organizmi u usevima pšenice u Egiptu, kao i širom sveta. Postavljeni su poljski ogledi kako bi se ocenila efikasnost neonikotinoidnih insekticida imidakloprida (Nufidor 60% FS; u dozama primene od 2.1, 1.05 i 0.525 g a.m./kg semena) i tiametoksama (Cruiser 70% WS; u dozama 14.4, 7.2 i 3.6 g a.m./kg semena) kao semenskih tretmana, kao i tiametoksama (Actara 25% WG; u dozama 0.1, 0.05 i 0.025 g a.m./l) primenjenog folijarno protiv tri vrste biljnih vaši: sremzine lisne vaši *Rhopalosiphum padi* (L.), zelene vaši *Schizaphis graminum* (Rondani) i lisne vaši *Rhopalosiphum maidis* (Fitch). Proučavan je i njihov uticaj na prirodne neprijatelje biljnih vaši: zlatooke kukce *Chrysoperla carnea* Stephens, bubamare *Coccinella* spp. i osolike muve *Syrphus* spp. Ogledi su izvedeni na poljima Poljoprivrednog fakulteta Univerziteta Suez Canal, Ismailia, tokom sezona 2013/14 i 2014/15. Rezultati su pokazali značajne razlike između ispitivanih insekticida pri svim koncentracijama, kao i da su preporučene doze svih insekticida bile efikasnije od polovine i četvrtine doza u suzbijanju biljnih vaši na pšenici. Takođe, podaci su pokazali značajne razlike između dva tretmana semena pri svim dozama pre i nakon folijarne primene, u poređenju sa kontrolom, u svim intervalima ocenjivanja prosečnog broja biljnih vaši na biljkama pšenice, od treće do trinaeste nedelje nakon setve, osim osam nedelja nakon tretmana semena, a pre folijarne aplikacije. Rezultati su jasno pokazali da su nedeljna redukcija zaraženosti, kao i opšta efikasnost, bile veće pri preporučenim dozama preparata Nufidor, Cruiser i Actara nego pri polovini i četvrtini doze tokom obe sezone. Takođe, smanjenje infestacije opadalo je do osme nedelje, kada je insekticid Actara primenjen raspršivanjem. Podaci su pokazali da nije bilo značajne razlike između tretmana i kontrole u pogledu prosečnog broja jedinki *Chrysoperla carnea* i *Syrphus* spp., dok je u prosečnom broju bubamara bilo razlike na pšenici treatiranoj imidaklopridom pre folijarnog tretmana 6 i 7 nedelja nakon setve, kao i nakon folijarnog tretmana tiametoksamom 9, 10, 11, 12 i 13 nedelja nakon setve. Što se tiče semenskog tretmana tiametoksamom, značajne razlike su otkrivene kod populacije bubamara na pšenici 3, 4, 7 i 8 nedelja pre folijarnog tretmana i samo u desetoj nedelji nakon zaprašivanja tiametoksamom.

Ključne reči: Neonikotinoidi; Folijarna primena; Tretman semena; Biljne vaši; Predatori; Pšenica; Egipat