Entomologica, Bari, 41 (2008-2009): 195-217

MAHMOUD M.M. SOLIMAN[1] - EUSTACHIO TARASCO[2]

Toxic effects of four biopesticides (Mycotal, Vertalec, Vertemic and Neem Azal-T/S) on *Bemisia tabaci* (Gennadius) and *Aphis gossypii* (Glover) on cucumber and tomato plants in greenhouses in Egypt

ABSTRACT

Laboratory bioassays and field trials were performed to evaluate and compare the efficacy of 4 biopesticides, Mycotal, Vertalec, Vertemic and NeemAzal-T/S, against *Bemisia tabaci* (immature stages and adults) and *Aphis gossypii* on cucumber and tomato plants in greenhouses in Egypt. All these biopesticides reduced significantly whitefly and aphid populations. In laboratory bioassays Vertemic caused the highest toxic effect against whitefly and aphid, while in field experiments good results were obtained with all the compounds especially at high concentrations. The higher the concentration of these products the more severe was the effect. The data of this study suggest that these biopesticides are really useful alternative products to be used in IPM of tomato and cucumber crops.

Key words: whitefly, aphid, *Verticillium lecanii*, Abamectin, Azadirachtin.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) and tomato (*Solanum lycopersicum* L.) plants are considered two of the most important vegetable crops in Egypt. They are attacked by many insect species including whitefly, *Bemisia tabaci*, (Gennadius, 1889) (Rhynchota: Aleyrodidae) and *Aphis gossypii* Glover, 1877 (Rhynchota: Aphididae).

The sweetpotato whitefly, *Bemisia tabaci* is an important pest on a variety of crops, causing direct damage (such as physiological disorders and reduction of plant development) and transmits more than 70 different plant viruses (BERLINGER & DAHAN, 1987; BROWN *et al.*, 1989). *B. tabaci* comprises sibling species and/or biotypes which causes great economical damage to field and greenhouse crops, reaching up to 100 % of losses (BACCI *et al.*, 2007) in subtropical and tropical regions (OLIVEIRA *et al.*, 2001). *B. tabaci* is also important within a social context for increasing levels of

---

Dattiloscritto accettato il 15 luglio 2009

[1] Plant Protection Department, Faculty of Agriculture, South Valley University, Egypt

[2] DiBCA, Faculty of Agriculture, University of Bari, Italy

unemployment in some rural areas (BACCI *et al.*, 2007). Infestation by *B. tabaci* modifies the vegetative and reproductive development of the injured plant and causes direct damage by sucking the plant sap and injecting toxins. The latter causes physiological changes including leaf silvering in cucurbits (COSTA *et al.* , 1993) irregular ripening of tomatoes (SCHUSTE *et al.*, 1990), foliar disorders in ornamentals (TSAI *et al.*, 1997) and white streaking on *Brassica* species (BROWN *et al.*, 1992). *B. tabaci* also causes indirect damage by excretion of honeydew (BROWN *et al.*, 1995); the growth of sooty mould on honeydew decreases photosynthesis and damages harvestable parts (LIU, 2000).

In Egypt, aphids are considered among the most serious pests of different plants as well as all over the world. Many species are common as major pests attacking economic crop plants. In addition, some species are playing a great role as a vector of certain plant virus diseases (AHMED *et al.*, 2007). The cotton or melon aphid, *Aphis gossypii*, is a polyphagous species widely distributed in tropical, subtropical and temperate regions (LECLANT & DEGUINE, 1994). This aphid is a pest of cotton, cucurbits and citrus, and in temperate zones principally attacks vegetables in fields and greenhouses (BLACKMAN & EASTOP, 1985). *A. gossypii* causes direct damage, inducing pant deformation and indirect damage caused either by honeydew or by transmission of viruses (KING *et al.*, 1987; SLOSSER *et al.*, 1989; GONZALES *et al.*, 1992). The cotton aphid is the vector of 76 virus diseases in a very large range of plants (CHAN *et al.*, 1991).

In recent years, however, *A. gossypii* has emerged as one of the main aphid species on citrus, cotton, cucurbits, and greenhouse-grown vegetables (SATAR *et al.*, 1999). The cotton aphid is currently becoming more important pest because of increased insecticide tolerance and destruction of natural enemies through the use of chemical pesticides in cotton and vegetable plantations (GHABEISH *et al.*, 2008). The cotton aphid is an increasing problem in glasshouse vegetables. Presently it can only be controlled by non-selective chemicals, which inhibits the use of biological control of other pests in the glasshouse.

Synthetic chemical insecticides have played important and beneficial roles in the control of agricultural pests and the reduction of insect borne diseases for nearly 50 years. Their use will remain essential for many more years. Nonetheless, insecticides also pose real hazards. Some leave undesirable residues in food, water and environment. Low doses of many insecticides are toxic to humans and other animals, and some insecticides are suspected to be carcinogens. An effective way to delay resistance to insecticides and still maintain insect population densities below the economic threshold is to reduce the use of pesticides with the integration of other control strategies (TABASHNIK, 1986). As a result, many researchers and farmers are seeking less hazardous alternatives to conventional synthetic insecticides.

Microbial insecticides are composed of microscopic living organisms (viruses, bacteria, fungi, protozoa or nematode-bacteria complexes) or the toxins produced by these organisms. They are formulated to be applied as conventional insecticidal sprays, dusts or granules. Each product's specific properties determine the ways in which it can be used most effectively. The fungal pathogens will be suitable for greenhouse crops (KANAGARANTNAM *et al.*, 2008; SANTIAGO-ÁLVAREZ *et al.*, 2006). The organisms already used on whitefly and aphids are likely to be commercially available. These include the two fungal pathogens, *Verticillium lecanii* (Zimmerm.) Viegas and *Paecilomyces fumosoroseus* (Wize) Brown & Smith. Other natural enemies are available overseas for growers to use.

Abamectin, as Spinosad, are microbial derived biorational pesticides used against insect pests of several orders worldwide. Abamectin acts through ingestion and contact and kills the insects through targeting the nervous system by a persistent activation of acetylcholine receptors (THOMPSON *et al.*, 2000; COWLES *et al.*, 2000; TJOSVOLD & CHANEY, 2001). Similarly, Spinosad also target insects by affecting the function of nerve fibers.

Azadirachtin (product Neem Azal-T/S), a steroid-like tetranortriterpenoid derived from neem trees, *Azadirachta indica* A. Juss. (family Meliaceae), is a strong antifeedent, repellent and growth-regulating compound for a variety of phytophagous insects, including whiteflies (COUDRIET *et al.*, 1985; SCHMUTTERER, 1990). It delays or prevents molting; reduces growth, development, and oviposition; and can cause significant mortality, particularly in immature stages (COUDRIET *et al.*, 1985; FLINT & SPARKS, 1989; PRABHAKER *et al.*, 1989; SCHMUTTERER, 1990; LIU & STANSLY, 1995; MITCHELL *et al.*, 2004).

The present study aimed to provide and evaluations of the effectiveness of 4 alternative products that are available for use in insect pest management: Mycotal, Vertalec, Vertemic and NeemAzal-T/S.

MATERIALS AND METHODS

PRODUCTS

- Mycotal and Vertalec are a wettable powders based on the spores of a specific strain of *Verticillum lecanii*. The products contain 10^{10} spores/gram and the spray solution 10^7 spores/ml (VAN DER PAS *et al.*, 1995). Each compound was applied at the rates 4g/lt (4X10^7 spores/ml), 3g/lt (3X10^7 spores/ml), 2g/lt (2X10^7 spores/ml) and 1g/lt (1X 10^7 spores/ml) (Table 1).

- Abamectin (Vertemic 1.8% EC) is a mixture of avermectins containing about 80% avermectin B1a and 20 % avermectin B1b; B1a and B1b have very similar biological and toxicological properties. The avermectins are insecticidal and anthelmintic compounds derived from various laboratory broths fermented by the soil bacterium *Streptomyces avermitilis* and Abamectin is a natural fermentation product of this bacterium. No recommended dose rates for abamectin against whiteflies and aphids were available but dose rates chosen were 1–4 ml/lt (Table 1) water based on recommended rate of 1– 4 ml of abamectin for *Plutella xylostella* (L.), *Helicoverpa armigera* (Hübner) and *Spodoptera* spp. on brassicaceous crops (KUMAR & POEHLING, 2007). Vertemic was applied at rates of 6 ml/lt and 4 ml/lt water (Table 1)

- NeemAzal-T/S 1% consists of 4 % NeemAzal-T/S i.e. 1% Azadirachtin A (10g/L) and 3% other neem substances. It contains about 51% plant oil. The product is now registered in Germany as commercial insecticide for the control of greenhouse and some field pests. It was applied at the rates of 10 ml/lt and 5 ml/lt water (Table 1).

Three sprays were applied with one week intervals for all these compounds.

INSECTS

Table 1 - Bioinsecticide products: rates of application in lab bioassays

Concentrations	Mycotal against *B. tabaci* on cucumber and tomato plants	
	g/liter (a.i)	Dilution
M 1	4 g	4 X 10^7
M 2	3 g	3 X 10^7
M 3	2 g	2 X 10^7
M 4	1 g	1 X 10^7
	Vertalec against *A. gossypii* on cucumber and tomato plants	
	g/liter (a.i)	Dilution
V 1	4 g	4 X 10^7
V 2	3 g	3 X 10^7
V 3	2 g	2 X 10^7
V 4	1 g	1 X 10^7
	Abamectin (Vertemic) on cucumber and tomato plants	
	g/liter (a.i)	Dilution
A 1	0.108 ml / liter	6 ml / liter
A 2	0.072 ml / liter	4 ml / liter
	Neem – Azal T/S on cucumber and tomato plants	
	g/liter (a.i)	Dilution
N 1	0.05 g/liter	5 ml / liter
N 2	0.1 g / liter	10 ml / liter

- *Bemisia tabaci*. Infested cucumber and tomato leaves with immature stage of *B. tabaci* were taken from an agricultural greenhouse and transferred to the laboratory.

- *Aphis gossypii*. The stock culture of cotton aphid was collected from infested cotton seedling leaves in the laboratory. *A. gossypii* was reared in a controlled climate room at 20±2 ºC and 60±5 % R.H. Pots of cotton seedlings cultivated in soil were placed in center of the cage (measured 80X60X60 cm). A continuous light source of (60 watt) fluorescent was provided. Large numbers of *A. gossypii* were placed on leaf of the cotton seedling and then left to reproduce. This strain was reared for several generations in the laboratory according to NORMAN & SUTTON (1967).

BIOASSAYS

- *Bemisia tabaci*. Laboratory bioassay experiments were carried out to evaluate the relative toxicity of Mycotal, Vertalec, Abamectin and Neem Azal-T/S against immature stages of *B. tabaci* by using a leaf-dipping method (PARK *et al.*, 2002). Emulsions of treatments were prepared by mixing a few drops of Triton-X on water. Serials of concentrations for each of the tested products were prepared. Infested plant leaves with immature stages of *B. tabaci* were dipped into the treatment solution for 10s. Twenty five leaves were used for each concentration (5 leaves per replicate). Control leaves were dipped in distilled water and Triton-X only. Both treated and untreated leaves were left for dryness, and then kept in incubator. Counts of mortality of whitefly were carried out after 2 days for treatment with Abamectin and Neem Azal T/S and after 7 days for the treatment with Mycotal and Vertalec.

- *Aphis gossypii*. Toxicity of the tested compound was investigated against *A. gossypii* using residue film technique as described by IWUALA *et al.* (1981). Different concentrations of the compounds by mixing a few drops of Triton-X on water. A known volume of all tested concentrations was evenly spread at the bottom of Petri-dish surface 7 cm in diameter and kept until dryness. Five concentrations for each treatment were used and each one was replicated five times. After complete film dryness, the number of adults were placed in each of the treated Petri dishes, covered and incubated at 20±2 ºC, and the percentage mortality was calculated after 24 h. for the Abamectin and Neem Azal T/S and after 7 days for the Mycotal and Vertalec. Control was prepared with water and Triton-X only. Corrected mortality counts according to formula (ABBOTT, 1925), then submitted to probit analysis using FINNEY (1971):

$$\text{Relative toxicity} = \frac{LC_{50}\ \text{of the most active treatment}}{LC_{50}\ \text{of certain treatment}} \times 100$$

Field trials

The efficiency of these compounds were tested in cucumber and tomato crops in commercial greenhouses at the farm of Faculty of Agriculture in Qena, Egypt. The greenhouse temperature ranged between 28ºC to 30ºC in daytime and between 20ºC to 22ºC at night. The experiment was carried out during November 2007–January 2008. The experimental area was divided according to complete randomized block design including 5 replicates for each treatment.

All insecticides were sprayed 3 times at weekly intervals with a knapsack sprayer. Samples of 10 leaves each were taken at random from each replicate representing different levels of the plants. They were examined in greenhouses in early morning to estimate the living adults of whitefly and then taken to laboratory to calculate the alive number of immature stages with the aid of binocular microscope. All counts of treatments and control were recorded shortly before spraying and at 3 and 7 days after each spray. Percent reduction in infestation of immature and adult stages of whitefly and apterous adults of aphid for each treatment were calculated according to Henderson & Tiliton (1955) formula.

Statistical analysis and Toxicity lines

Differences between the percentages of host mortality were evaluated by analysis of variance (Statistica, 1999). Means were separated using Tukey's test-comparison procedure (significance level, $p < 0.05$).

RESULTS AND DISCUSSION

Laboratory bioassays. Toxicity of tested compounds against *B. tabaci* and *A. gossypii*. Results concerning the toxic effect of entomopathogenic fungi products, Mycotal and Vertalec, on different stages of *B. tabaci* and *A. gossypii* are shown in Fig. 1. Data clarify that the tested substances caused toxic effects on all the tested insect. Results indicate that the LC_{50} entomopathogenic fungi products, were 7.299 gm/L and 7.936gm/L for Mycotal and Vertalec respectively.

Results concerning the toxic effect of Abamectin and Neem Azal T/S on different stages of *B. tabaci* and *A. gossypii* are shown in Fig. 2. The bioinsecticide Abamectin was the most toxic to whitefly and aphids. The LC_{50} of the tested compounds were 2.873 ml/L, 3.152 ml/L and 10.921 and 12.50 ml/L for *B. tabaci* and *A. gossypii*, respectively.

Field evaluation

Effects of different concentrations of Mycotal and Vertalec on *B. tabaci* and *A. gossypii* on cucumber and tomato plants:

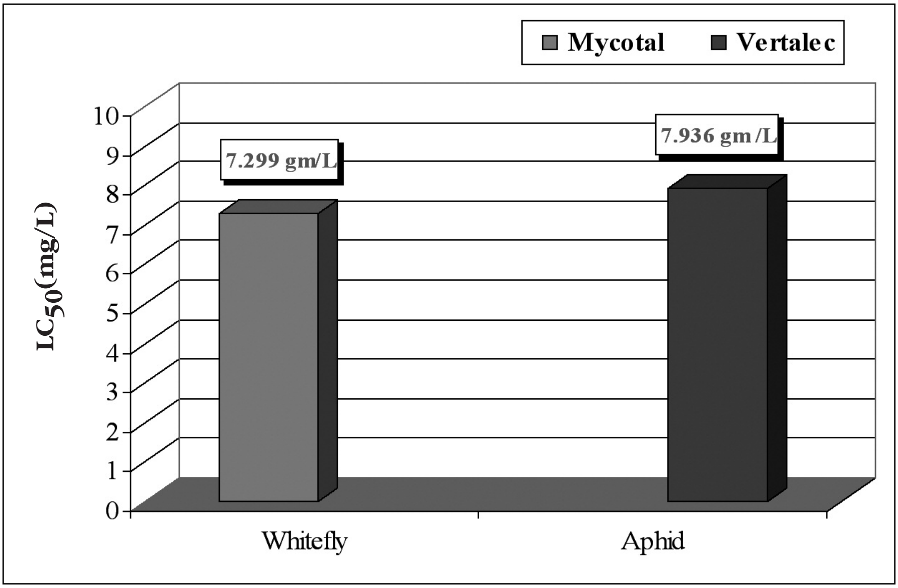


Fig. 1 - Toxicity of Mycotal against *B. tabaci* and Vertalec against *Aphis gossypii*.

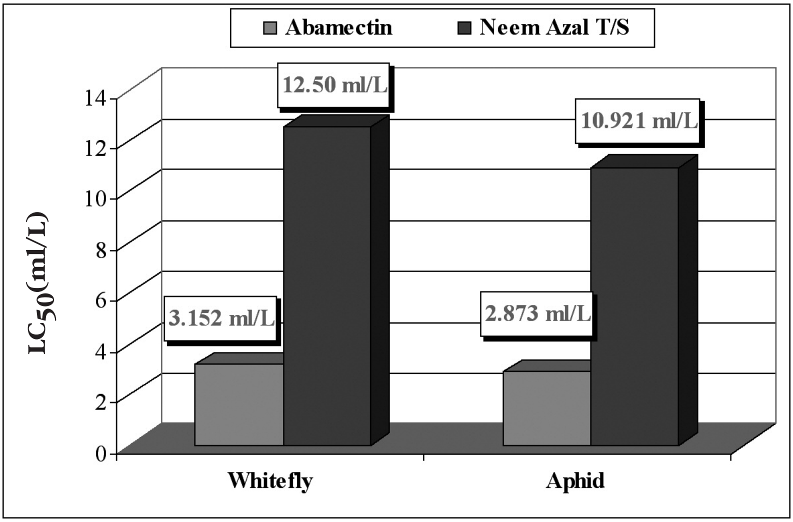


Fig. 2 - Toxicity of Vertimec and Neem Azal T/S against *B. tabaci* and *A. gossypii*.

Results are set out in Figs. 3, 4, 5, 6, 7, 8, 9 and 10 and Tables 2, 3 and 4. Data presented in Figs. 3 and 4 showed the mean mortality percentages of adult and immature stages respectively of *B. tabaci* in cucumber plants after treated with different concentrations of Mycotal. Results indicated that there were significant differences between the control and the concentrations of Mycotal ($F=187.45$; $df=1.39$, $P<0.005$) and also significant differences occurred between the high (M1, M2) and low (M3, M4) concentrations and their toxic effects against whitefly stages ($F=7.0$; $df=1.21$). Data presented in Fig. 5 showed also the mean mortality percentages of *A. gossypii* in cucumber plants after treated with different concentrations of Vertalec; in this case there were no significant differences among concentrations ($F=2.0$; $df=1.18$).

Data presented in Figs. 6 and 7 showed the mean mortality percentages of *B. tabaci*, adult and immature stages respectively, in tomato plants after treated with different concentrations of Mycotal. Results indicated that there were significant differences between the control and the concentrations of Mycotal ($F=222.44$, $df=1,15$, $P<0.005$) and also significant differences occurred between the low and high concentrations and their toxic effects against whitefly stages ($F=6.3$; $df=1.28$). Data presented in Fig. 8 showed also, the mean mortality percentages of *A. gossypii* in tomato plants after treated with different concentrations of Vertalec and no significant differences among concentrations occurred ($F=2.4$; $df=1.19$). Data in Figs. 9 and 10 showed the mortality percentages of whitefly stages and aphid in cucumber and tomato plants respectively treated three times with Mycotal and Vertalec as a comparison between 4 concentrations, after 7 days post treatment.

Data concerning percentages of reduction in infestation of immature and adult stages of whitefly in cucumber and tomato plants after 4 concentrations of Mycotal and Vertalec are set out in Tables 2, 3 and 4. The first spray was started when the mean number of 29.16 adults and 12.62 immature in cucumber plants and 37.8 adults 18.04 immature in Tomato plants, respectively. Results indicated that there were differences between the control and insecticides treatments and also, differences occurred between the different sprays and treatments. Results in Table 2 elucidate the percentage reduction in the population of *B. tabaci* during the period of three successive applications with 4 concentrations of Mycotal in cucumber plants. After the first spray M1 highly reduced the immature stages of *B. tabaci* 3 days after spraying followed by M2. Their respective percentages of reduction were 61.51 and 47.68 %. Seven days after application all concentrations of Mycotal caused more than 50 % reduction of the immature stages. Their respective percentages of reduction were 74.56, 65.15, 53.78 and 50.10 % for M1, M2, M3 and M4, respectively. The second spray was started at the seventh day of the first spray. The results showed that the four concentrations of Mycotal tested caused considerable reduction in population density of *B. tabaci* ranged between 58.27, 71.47 % and 59.28, 78.29 % at 7^{th} days after the second spray for adult and immature stages, respectively. The alive number of adult and immature stages of whitefly decreased after seven days of third spray with the concentrations of Mycotal. It were presented 81.19, 78.74, 77.02 and 65.90 % in immature stages and 86.73, 81.86, 80.39 and 77.50 % in adult infestations by using M 1, M 2, M 3 and M 4, respectively.

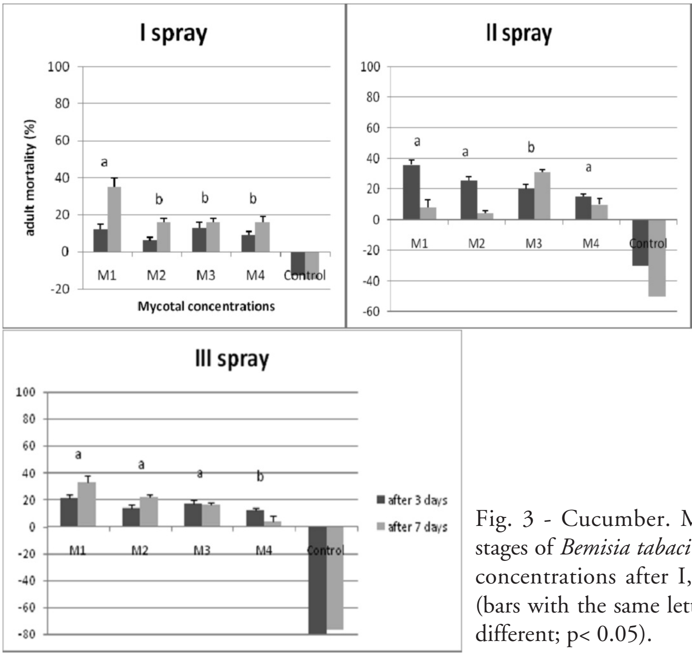


Fig. 3 - Cucumber. Mortality (%) of adult stages of *Bemisia tabaci* with Mycotal different concentrations after I, II and III treatments (bars with the same letter are not significantly different; p< 0.05).

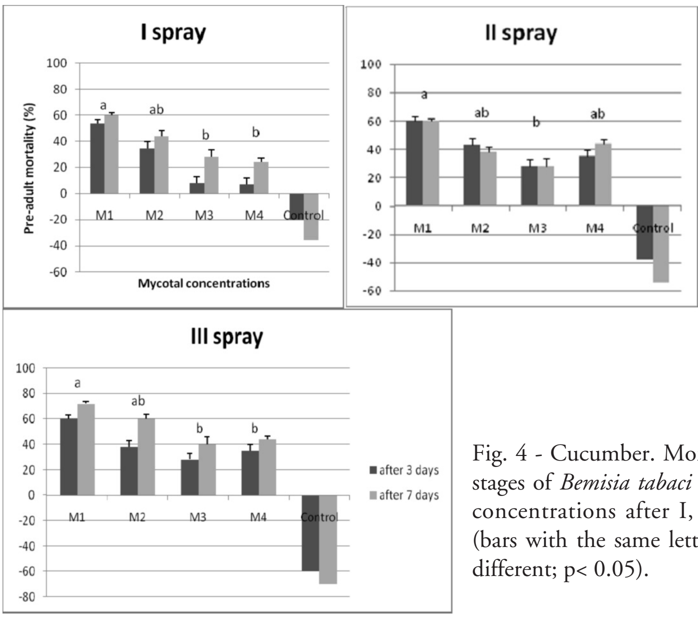
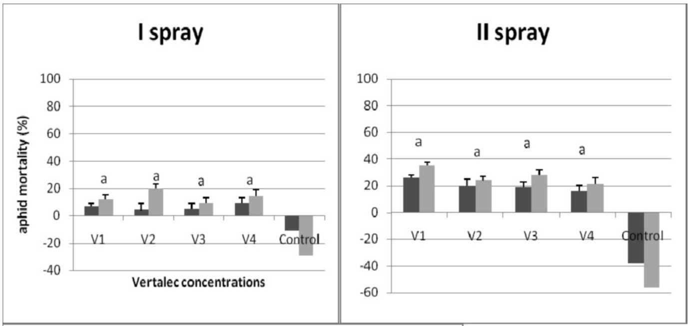


Fig. 4 - Cucumber. Mortality (%) of pre-adult stages of *Bemisia tabaci* with Mycotal different concentrations after I, II and III treatments (bars with the same letter are not significantly different; p< 0.05).



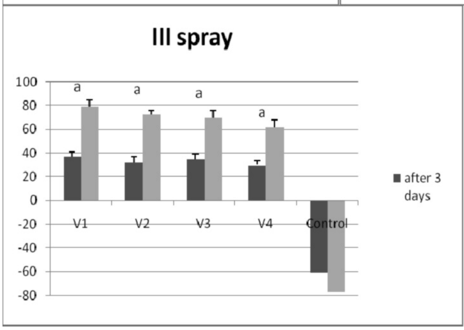
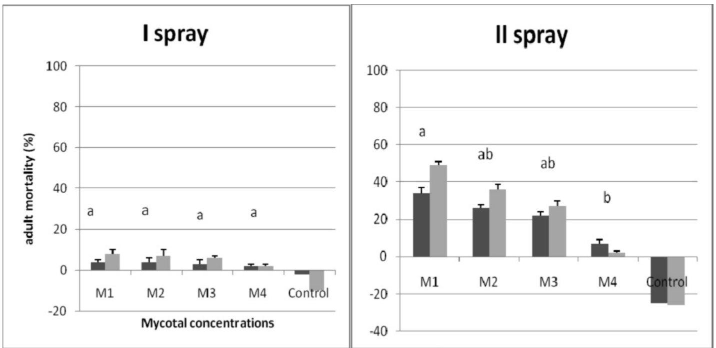


Fig. 5 - Cucumber. Mortality (%) of aphid with Vertalec different concentrations after I, II and III treatments (bars with the same letter are not significantly different; $p < 0.05$).



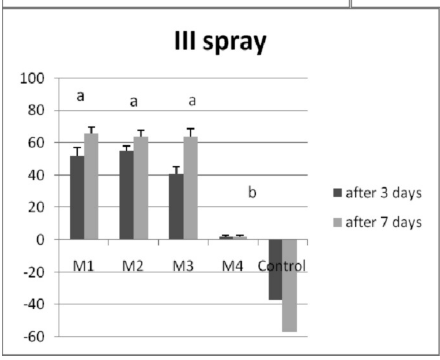


Fig. 6 - Tomato. Mortality (%) of adult stages of *Bemisia tabaci* with Mycotal different concentrations after I,II and III treatments (bars with the same letter are not significantly different; $p < 0.05$).

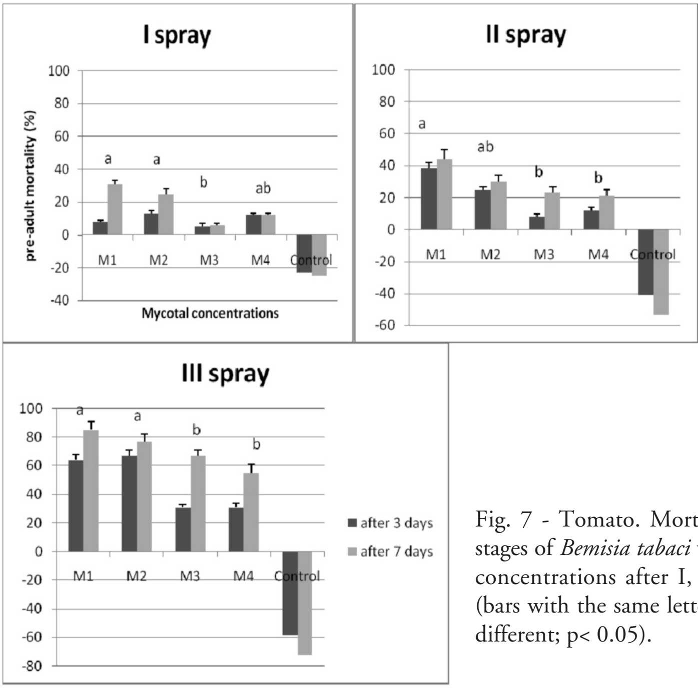


Fig. 7 - Tomato. Mortality (%) of pre-adult stages of *Bemisia tabaci* with Mycotal different concentrations after I, II and III treatments (bars with the same letter are not significantly different; p< 0.05).

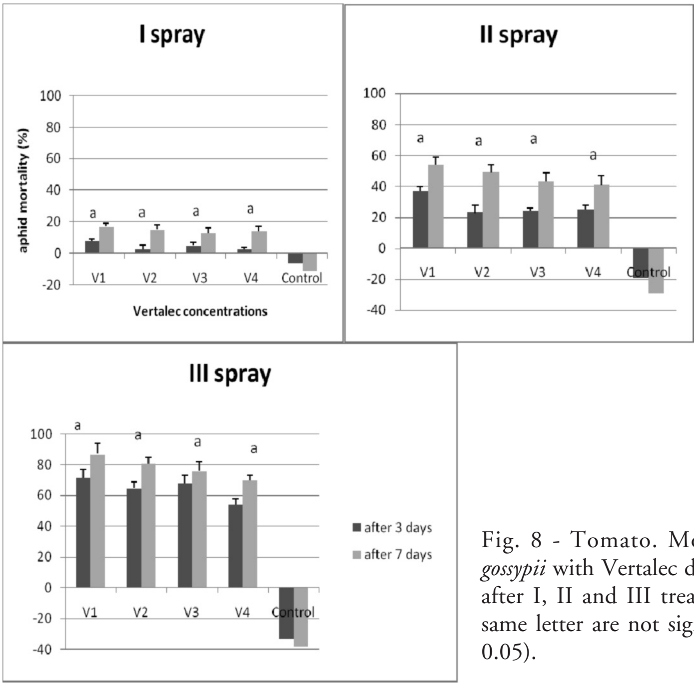


Fig. 8 - Tomato. Mortality (%) of *Aphis gossypii* with Vertalec different concentrations after I, II and III treatments (bars with the same letter are not significantly different; p< 0.05).

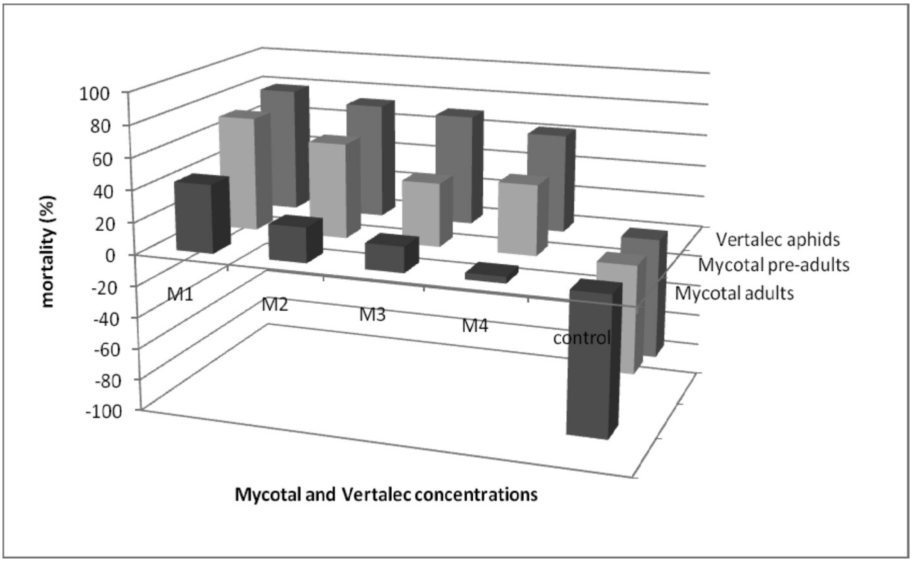


Fig. 9 - Mortality (%) of whitefly stages and aphid on cucumber plants treated 3 times with Mycotal and Vertalec as a comparison between 4 concentrations, after 7 days post treatment.

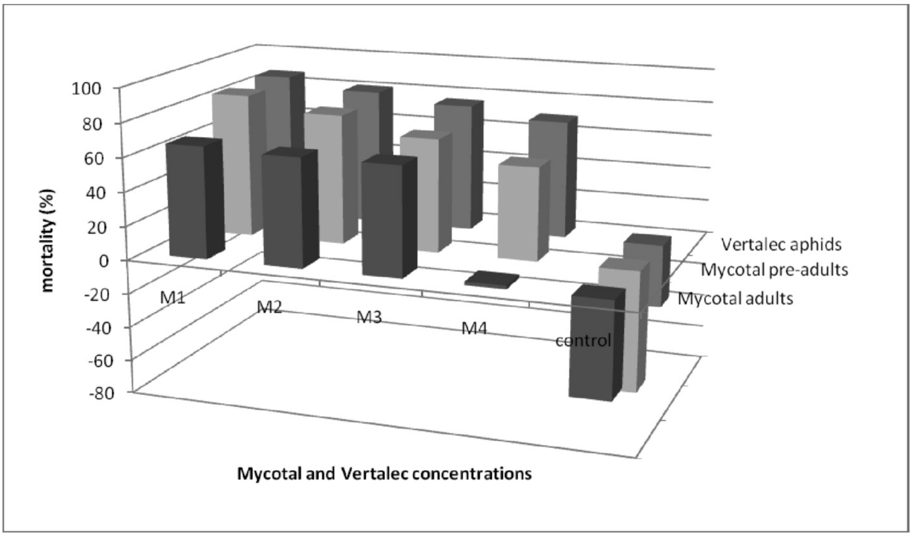


Fig. 10 - Mortality (%) of whitefly stages and aphid on tomato plants treated 3 times with Mycotal and Vertalec as a comparison between 4 concentrations, after 7 days post treatment.

Table 2 - The percentages reduction of *B. tabaci* post spraying with Mycotal on cucumber plants

Compound	No. treatment		Adult stages				Pre-adult stages			
			Mycotal concentrations				Mycotal concentrations			
		Period	M 1	M 2	M 3	M 4	M 1	M 2	M 3	M 4
Mycotal	First spray	3 days	23.15	19.39	19.36	17.29	61.51	47.68	25.71	23.22
		7 days	44.48	27.34	27.34	26.75	74.56	65.15	53.78	50.10
		Mean	**33.82**	**23.37**	**23.35**	**22.02**	**68.04**	**56.42**	**39.75**	**36.66**
	Second spray	3 days	30.50	30.23	25.62	19.73	77.37	68.53	60.89	58.65
		7 days	71.47	70.08	68.34	58.27	78.29	70.56	61.37	59.28
		Mean	**50.99**	**50.16**	**46.98**	**39.00**	**77.83**	**69.55**	**61.13**	**58.96**
	Third spray	3 days	73.10	67.70	55.09	53.27	80.91	72.76	67.91	60.61
		7 days	86.73	81.86	80.39	77.50	81.19	78.74	77.02	65.90
		Mean	**79.92**	**74.78**	**67.74**	**65.39**	**81.05**	**75.75**	**72.47**	**63.23**
	General mean		**54.90**	**49.44**	**46.02**	**42.14**	**75.64**	**67.24**	**57.78**	**52.95**

Table 3 - The percentages reduction of *B. tabaci* post spraying with Mycotal on tomato plants

Compound	No. treatment		Adult stage				Pre-adult stage			
			Mycotal concentrations				Mycotal concentrations			
		Period	M 1	M 2	M 3	M 4	M 1	M 2	M 3	M 4
Mycotal	First spray	3 days	6.67	5.35	4.22	2.65	31.43	26.28	20.11	19.45
		7 days	15.22	14.52	13.94	8.59	45.51	40.34	39.74	27.94
		Mean	**10.95**	**9.94**	**9.08**	**5.62**	**38.47**	**33.31**	**29.93**	**23.70**
	Second spray	3 days	47.33	41.19	37.78	24.13	56.23	48.40	36.01	35.41
		7 days	58.26	48.32	42.24	24.53	63.07	55.70	51.26	48.50
		Mean	**52.97**	**44.76**	**40.01**	**24.33**	**59.65**	**52.05**	**43.64**	**41.96**
	Third spray	3 days	65.30	64.61	57.04	27.62	83.60	73.27	57.30	56.46
		7 days	77.89	77.35	76.40	36.28	91.44	87.75	81.01	73.30
		Mean	**71.60**	**70.98**	**66.72**	**31.95**	**87.52**	**80.51**	**69.16**	**64.88**
	General mean		**45.17**	**41.89**	**38.63**	**20.63**	**61.88**	**55.29**	**47.58**	**43.51**

Data in Table 3 showed the percentages reduction in populations of whitefly stages after treatment with different concentrations of Mycotal in tomato plants. As regard the mean of percentage reduction in adult and immature stages of *B. tabaci* after 7 days of the third pray, it is evident that M 1, M 2, M 3 and M 4 gave considerable effects against *B. tabaci*. In term of figures, percentages of reduction of immature stages were 87.52, 80.51, 69.16 and 64.88 %, respectively. The corresponding values to adult stages were 71.60, 70.98, 66.72 and 31.95 %, respectively.

Table 4 - The percentages reduction of *Aphis gossypii* post spraying with Vertalec product on cucumber and tomato plants

Compound	No. treatment	Period	Cucumber plants Vertalec concentrations V 1	V 2	V 3	V 4
Cucumber plants	First spray	3 days	16.07	12.80	11.05	11.00
		7 days	37.34	30.59	28.31	22.53
		Mean	**26.71**	**21.70**	**19.68**	**16.77**
	Second spray	3 days	45.23	40.68	37.13	35.52
		7 days	56.19	50.53	48.08	46.38
		Mean	**50.71**	**45.61**	**42.61**	**40.95**
	Third spray	3 days	61.31	57.16	53.56	50.46
		7 days	87.70	84.92	81.50	77.30
		Mean	74.51	71.04	67.53	63.88
	General mean		**50.64**	**46.12**	**43.27**	**40.53**
Tomato plants	First spray	3 days	12.96	11.88	10.45	8.76
		7 days	26.27	23.87	23.39	22.30
		Mean	**19.62**	**17.88**	**16.92**	**15.53**
	Second spray	3 days	47.09	36.16	36.02	35.39
		7 days	64.26	61.09	55.60	55.10
		Mean	**55.68**	**48.63**	**45.81**	**45.25**
	Third spray	3 days	78.84	75.12	69.17	65.64
		7 days	88.73	85.96	82.74	78.68
		Mean	**83.97**	**72.15**	**75.96**	**72.16**
	General mean		**53.09**	**46.22**	**46.23**	**44.25**

Results in Table 4 indicated that 4 concentrations of Vertalec caused moderate reduction after seven days of the second spray in cucumber plants. The percent reduction in infestation were 37.34, 30.59, 28.31 and 22.53 % for V1, V2, V3 and V4, respectively. Results indicated that all concentrations of Vertalec caused reduction of infestations in the aphis after the third spray. The corresponding values were 87.70, 84.92, 81.50 and 77.30 %, for V1, V2, V3 and V4, respectively. Data also, showed that the first concentration of Vertalec was the most effective on *A. gossypii* after seven

Table 5 - The percentages reduction of whitefly insect, *B. tabaci* stages post spraying with Vertemic and Neem Azal T/S product on Cucumber and Tomato plants.

Crop	No. treatment		Adult stages				Pre-adult stages			
			Abamectin		Neem Azal		Abamectin		Neem Azal	
		Period	A1	A 2	N 1	N 2	A1	A 2	N 1	N 2
Cucumber	First spray	3 days	47.96	31.58	19.36	10.71	15.13	12.34	9.91	8.46
		7 days	52.25	39.20	25.24	12.53	33.95	20.02	17.80	12.94
		Mean	**50.11**	**35.39**	**22.30**	**11.62**	**24.54**	**16.18**	**13.86**	**10.70**
	Second spray	3 days	64.05	51.87	34.87	25.63	37.85	21.73	22.21	18.69
		7 days	72.66	58.71	43.35	30.60	48.46	29.52	30.30	20.46
		Mean	**68.36**	**55.29**	**39.11**	**28.12**	**43.16**	**25.63**	**26.26**	**19.58**
	Third spray	3 days	83.66	73.26	62.12	49.90	66.80	54.12	60.21	27.82
		7 days	93.40	82.96	74.72	65.38	86.22	62.54	77.04	47.60
		Mean	**88.53**	**78.11**	**68.42**	**57.64**	**76.51**	**59.83**	**68.63**	**37.71**
	General mean		**69.00**	**56.26**	**43.28**	**32.46**	**48.07**	**33.88**	**36.25**	**22.66**
Tomato	First spray	3 days	50.11	37.64	26.09	14.55	29.63	13.67	11.01	10.98
		7 days	57.07	40.95	31.34	14.69	43.78	24.02	20.98	20.94
		Mean	**53.59**	**39.30**	**28.72**	**14.62**	**36.71**	**18.85**	**16.00**	**15.96**
	Second spray	3 days	62.09	45.97	36.76	23.01	50.67	24.97	25.76	25.31
		7 days	71.73	57.34	50.19	35.26	61.65	31.44	32.44	31.08
		Mean	**66.91**	**51.66**	**43.48**	**29.14**	**56.16**	**28.21**	**29.10**	**28.20**
	Third spray	3 days	78.85	67.14	64.41	50.90	67.08	37.94	39.91	34.30
		7 days	90.48	80.02	76.55	75.57	83.96	60.24	73.03	48.22
		Mean	**84.87**	**73.58**	**70.48**	**63.24**	**75.52**	**49.10**	**56.47**	**41.26**
	General mean		**68.46**	**54.85**	**47.56**	**35.67**	**56.13**	**32.05**	**33.86**	**28.47**

days of application in tomato plants which gave 87.70 % reduction in the aphid populations. Regarding to the mean percent reduction in infestations for the Vertalec concentrations, V1, V2, V3 and V4 were 88.73, 85.96, 82.74 and 78.68 %, respectively.

Effects of different concentrations of Vertimec and Neem Azal T/S on *B. tabaci* and *A. gossypii*:

Mortality rates of adult and pre-adult stages of *B. tabaci* and *A. gossypii* on cucumber and tomato plants at the various concentrations are shown in Figs. 11-18. There were statistically differences in the mortalities of *B. tabaci* stages caused by the 2 bioinsecticides (F=7.3, df=1.21, P<0.005), concentrations (F=6.9, df=1.12) and the two-way interaction (insecticides-concentrations) (F=5.4, df=1.21). Abamectin increased the mortality of *B. tabaci* populations compared with Neem Azal T/S on

Table 6 - The percentages reduction of *Aphis gossypii* post spraying with Vertemic and Neem Azal T/S products on cucumber and tomato plants.

	No. Sprays		Vertemic		Neem Azal	
		Period	A1	A 2	N 1	N 2
Cucumber	First spray	3 days	18.76	15.52	20.70	20.52
		7 days	30.62	24.30	28.27	25.87
		Mean	**24.69**	**19.91**	**24.49**	**23.20**
	Second spray	3 days	41.27	32.48	36.27	32.47
		7 days	47.24	36.52	39.23	33.64
		Mean	**44.26**	**34.50**	**37.75**	**30.06**
	Third spray	3 days	57.05	40.70	42.40	34.02
		7 days	81.10	46.28	47.70	36.76
		Mean	**69.08**	**43.49**	**45.05**	**35.39**
	General mean		**46.01**	**32.63**	**35.76**	**29.55**
Tomato	First spray	3 days	18.71	11.30	18.26	11.30
		7 days	35.46	27.00	30.20	25.07
		Mean	**27.09**	**19.15**	**24.23**	**18.19**
	Second spray	3 days	44.71	30.91	31.40	30.30
		7 days	49.46	35.85	36.67	33.76
		Mean	**47.09**	**33.38**	**34.04**	**32.03**
	Third spray	3 days	65.93	40.42	60.59	38.93
		7 days	89.78	70.19	71.00	40.53
		Mean	**77.86**	**55.31**	**65.80**	**39.73**
	General mean		**50.68**	**35.95**	**41.36**	**29.98**

cucumber plants (Table 5). Results indicate that 93.40 and 82.96 %, 74.72 and 65.38 % as initial kill of *B. tabaci* adult and pre-adult stages and 86.22 and 62.54 % and 77.04 and 47.60 % for two concentrations of Abamectin (A1, A 2) and (N 1, N 2) after 7 days of the third spray on cucumber plants, respectively. As regards, the mean of reduction percent in whitefly, *B. tabaci* pre-adult and adult stages in tomato plants after the 7 days of the third spray it is evident that the first concentration of Abamectin (A1) was the most effective on the adult and pre-adult stages of *B. tabaci* causing 90.48 and 83.96 % reduction, respectively (Table 5).

The results presented in Table 6 indicated the effects of Vertemic and Neem Azal T/S concentrations on *A. gossypii* in cucumber and tomato plants. For tomato the

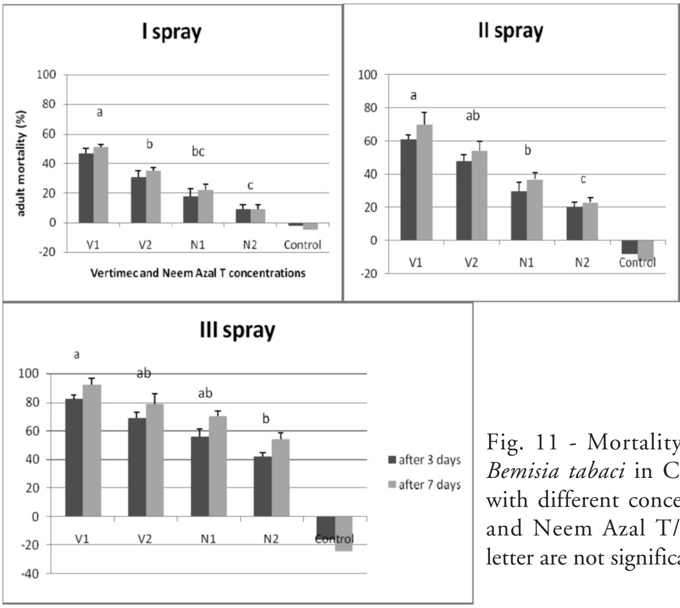


Fig. 11 - Mortality (%) of adult stage of *Bemisia tabaci* in Cucumber plants treated with different concentrations of Abamectin and Neem Azal T/S (bars with the same letter are not significantly different; p< 0.05).

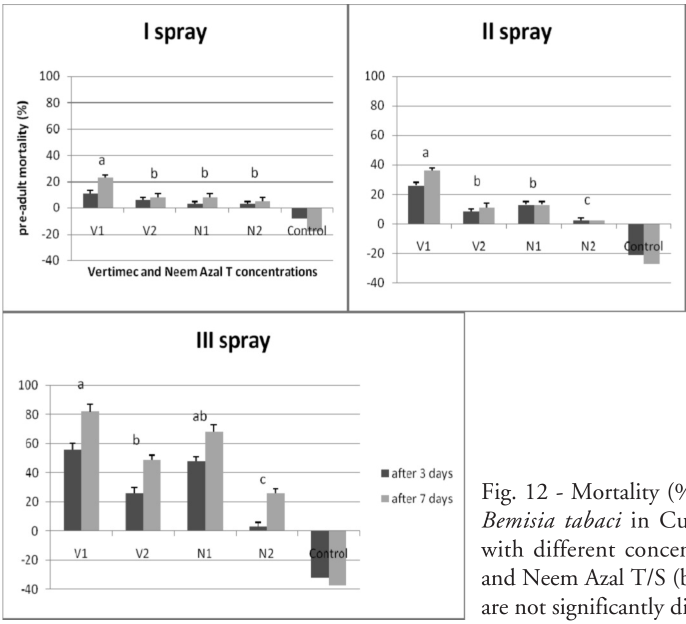


Fig. 12 - Mortality (%) of pre-adult stages of *Bemisia tabaci* in Cucumber plants treated with different concentrations of Abamectin and Neem Azal T/S (bars with the same letter are not significantly different; p< 0.05).

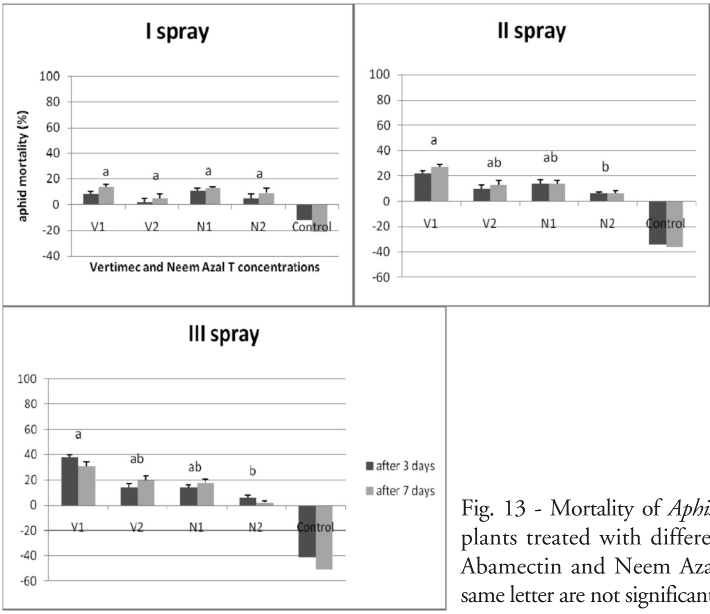


Fig. 13 - Mortality of *Aphis gossypii* in cucumber plants treated with different concentrations of Abamectin and Neem Azal T/S (bars with the same letter are not significantly different; p< 0.05).

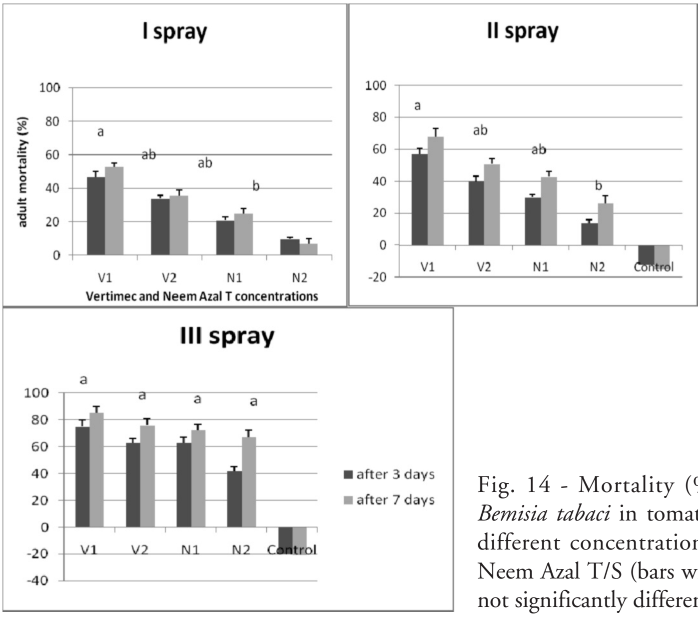


Fig. 14 - Mortality (%) of adult stage of *Bemisia tabaci* in tomato plants treated with different concentrations of Abamectin and Neem Azal T/S (bars with the same letter are not significantly different; p< 0.05).

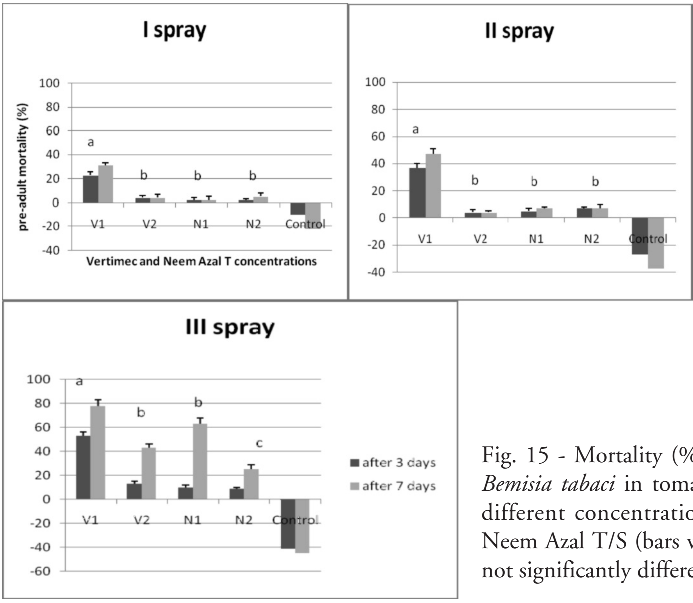


Fig. 15 - Mortality (%) of pre-adult stage of *Bemisia tabaci* in tomato plants treated with different concentrations of Abamectin and Neem Azal T/S (bars with the same letter are not significantly different; p< 0.05).

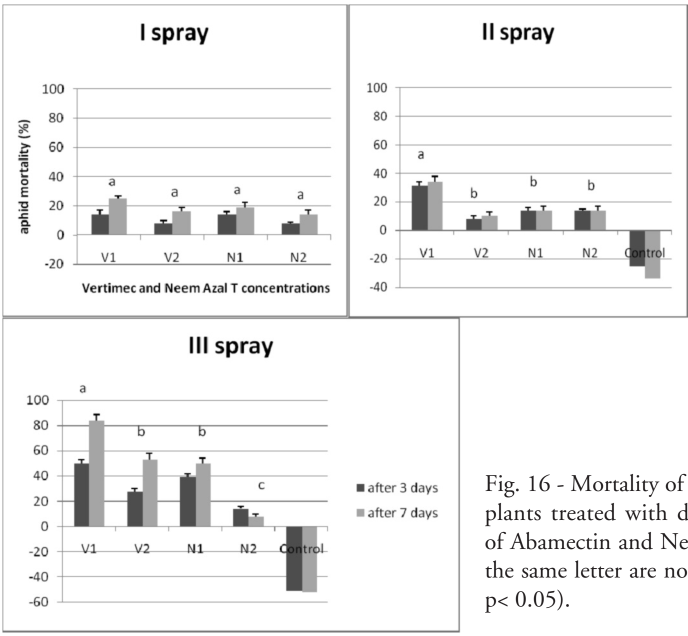


Fig. 16 - Mortality of *Aphis gossypii* in tomato plants treated with different concentrations of Abamectin and Neem Azal T/S (bars with the same letter are not significantly different; p< 0.05).

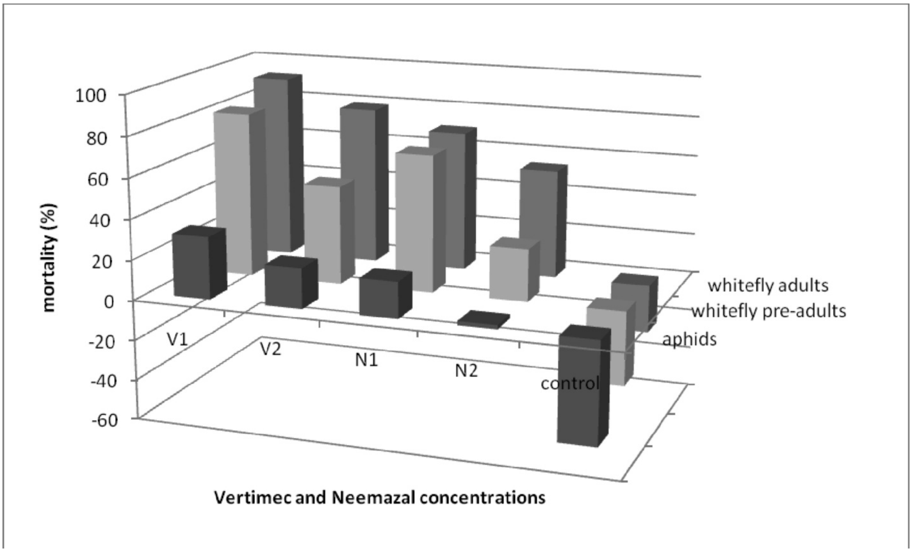


Fig. 17 - Mortality (%) of whitefly stages and aphid in cucumber plants treated 3 times with Abamectin and Neem Azal T/S as a comparison between 2 concentrations for each, after 7 days post treatment.

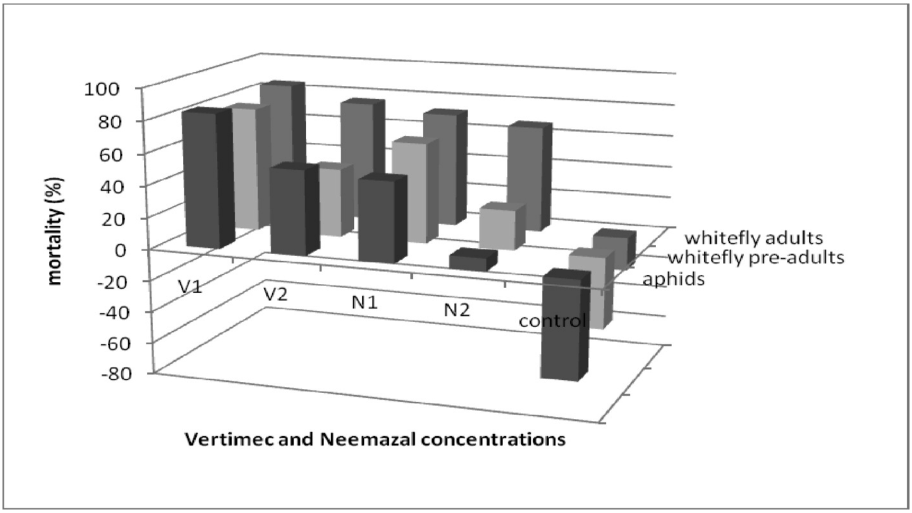


Fig. 18 - Mortality (%) of whitefly stages and aphid in tomato plants treated three times with Abamectin and Neem Azal T/S as a comparison between 2 concentrations for each, after 7 days post treatment.

highest percent reductions in infestations were 89.78, 70.19, 71.00 and 40.53% for Abamectin (A1, A2) and Neem Azal T/S (N1, N2), respectively; for cucumber the maximum values of mortality (%) were 81.10, 46.28, 47.70 and 36.76 % for Abamectin (A1, A2) and Neem Azal T/S (N1, N2), respectively.

In conclusion the laboratory bioassays and field trials carried out in this research have shown the efficacy of Mycotal, Vertalec, Vertemic and NeemAzal-T/S9, against *Bemisia tabaci* (immature stages and adults) and *Aphis gossypii* on cucumber and tomato plants inside greenhouses in Egypt. All these biopesticides reduced significantly whitefly and aphid populations and their use may contribute to the development of sustainable production systems through a reduction in the use of chemical insecticides and, consequently, a reduction of chemical residues on produce and insecticide resistance.

RIASSUNTO

TOSSICITÀ DI QUATTRO BIOINSETTICIDI (MYCOTAL, VERTALEC, VERTEMIC E NEEM AZAL-T/S) SU *BEMISIA TABACI* (GENNADIUS) E *APHIS GOSSYPII* (GLOVER) IN COLTURE PROTETTE DI ZUCCHINO E POMODORO IN EGITTO

Effetti tossici di 4 biopesticidi, Mycotal, Vertalec, Vertemic e Neem Azal–T/S su *Bemisia tabaci* (Gennadius) e *Aphis gossypii* (Glover) in coltivazioni sotto serra di cetriolo e pomodoro in Egitto. In questo studio sono stati effettuati esperimenti di laboratorio e di campo per valutare l'efficacia di 4 bioinsetticidi, Mycotal, Vertalec, Vertemic e NeemAzal-T/S9, nei confronti di *Bemisia tabaci* (stadi giovanili e adulti) e *Aphis gossypii* su coltivazioni in serra di cetriolo e pomodoro in Egitto. Tutti i prodotti testati hanno avuto un effetto tossico su *B. tabaci* e *Aphis gossypii* riducendone le popolazioni in maniera significativa. Nei biosaggi di laboratorio il Vertimec ha evidenziato l'effetto tossico maggiore, mentre negli esperimenti di campo sono stati ottenuti buoni risultati (% di mortalità) da tutti i prodotti, soprattutto quando utilizzati alle dosi più elevate. Più alte le concentrazioni delle sospensioni bioinsetticide, maggiore l'effetto tossico ottenuto. Questi dati mostrano l'efficacia di questi prodotti e confermano il loro potenziale utilizzo nelle strategie di controllo integrato delle coltivazione di cetriolo e pomodoro in serra.

Parole chiave: aleirodidi, afidi, *Verticillium lecanii*, Abamectina, Azadiractina.

REFERENCES

ABBOTT W.S., 1925 - A method for computing the effectiveness of an insecticide. J. Econ. Entomol., 18: 265-267.

AHMED A.A.I., GESRAHA M.A., ZEBITZ C.P.W., 2007 - Bioactivity of Two Neem Products on *Aphis fabae.* Journal of Applied Sciences Research, 3 (5): 392-398.

BACCI L., CRESPO A.L.B., GALVAN T.L., PEREIRA E.J.G., PICANCO M.C., SILVA G.A., CHEDIAK M., 2007 - Toxicity of insecticides to the sweetpotato whitefly (Hemiptera: Aleyrodidae) and its natural enemies. Pest Manag. Sci., 63: 699-706.

BERLINGER M.J., DAHAN R., 1987 - Breeding for resistance to virus transmission by whiteflies in tomato. Insect Sci. Appl. 8, 783-784.

BLACKMAN R.L. EASTOP, V.F., 1985 - Aphids on the world's crops: an identification guide. Chichester, A Wiley-Interscience Publication, 465.

BROWN J.K., COSTA H.S., LAEMMLEN F., 1992 - First report of whitefly associated squash silver leaf disorder of *Cucurbita* in Arizona and of white streaking disorder of *Brassica* species in Arizona and California. *Plant Dis* 76:426.

BROWN J.K., FROHLICH D.R., ROSELL R.C., 1995 - The sweetpotato or silver leaf whiteflies: biotypes of *Bemisia tabaci* or a species complex? *Annu Rev Entomol* 40:511-534.

BROWN J.K., CAMPODONICO O.P., NELSON M.R., 1989 - A whitefly transmitted geminivirus from peppers with tiger disease. Plant Dis. 73: 610.

CHAN C.K., FORBES A.R., RAWORTH D.A., 1991 - Aphid-transmitted viruses and their vectors of the world. Agric. Canada Res. Branch. Tech. Bull., 3E: 216.

COSTA H.S., ULLMAN D.E., JOHNSON M.W. AND TABASHNIK B.E., 1993 - Antibiotic oxytetracycline interferes with *Bemisia tabaci* (Homoptera: Aleyrodidae) oviposition, development, and ability to induce squash silverleaf. Ann. Entomol. Soc. Am., 86: 740-748.

COUDRIET D.L., PRABHAKER N., MEYERDIRK D.E., 1985 - Sweetpotato whitefly (Homoptera: Aleyrodidae), effects of neem-seed extract on oviposition and immature stages. Environ. Entomol., 14: 776-779.

COWLES R.S., COWLES E.A. MCDERMOTT A.M., RAMOUTAR D., 2000 - Inert formulation ingredients with activity: toxicity of trisiloxane surfactant solutions to two spotted mites. J. Econ. Entomol., 93: 180 -188.

FERREIRA L.T., 1998 - A vidos MFD Mosca-branca: Presença indesej avel no Brasil. Biotec. Cienc. Desenvolv., 4: 2-26.

FINNEY D.J., 1971 - Probit analysis, 3rd ed. Cambridge, UK: Cambridge University Press.

FLINT, H. M. AND N. J. SPARKS, 1989 - Effect of azadirachtin from the neem tree on immature sweetpotato whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae) and other selected pest species on cotton. J. Agric. Entomol. 6:1989. 211-215.

GHABEISH, I. SALEH A. AND AL-ZYOUD F., 2008 - *Dicyphus tamaninii*: Establishment and efficiency in the control of *Aphis gossypii* on greenhouse cucumber. Journal of Food, Agriculture & Environment Vol. 6 (3&4): 346-349.

GONZALEZ R.A., GOLDMAN G.E., NATWICK E.T., ROSENBERG H.R., GRIESHOP J.I., SUTTER S.R., 1992 - Whitefly invasion in Imperial Valley costs growers, workers millions in losses. Calif. Agr., 46: 7- 8.

HENDERSON C.F., TILITON E.W., 1955 - Test with acaricides against the brown wheat mites. J. Econ. Entomol. 48:157-161.

IWUALA MOE, OSISOGU IUW, AGBAKWURU EOP., 1981 - Dennettia oil, a potential insecticide: Tests with adult and nymphs of *Periplanta american* and *Zonocerus variegatus.* J. Econ. Entomol., 74:249 - 252

KANAGARATNAM P., HALL R.A. AND BURGES H.D., 2008 - Control of glasshouse whitefly, *Trialeurodes vaporariorum*, by an 'aphid' strain of the fungus *Verticillium lecanii*. Annals of Applied Biology 100 (2): 213-219.

KING E. G., PHILLIPS, J.R., HEAD, R.B., 1987 - 40th Annual conference report on cotton insect research and control. Proceedings, Beltwide Cotton Production and Research Conferences. National Cotton Council of America, Memphis, TN, pp. 171-193.

KUMAR P., POEHLING H-M., 2007 - Effects of Azadirachtin, Abamectin, and Spinosad on Sweetpotato Whitefly (Homoptera: Aleyrodidae) on Tomato Plants Under Laboratory and Greenhouse Conditions in the Humid Tropics. Jo. Econ. Entomol., 100 (2): 411- 420.

LECLANT F., DEGUINE, J.P. (1994) - Aphids (Hemiptera: Aphididae). In Matthew, G.A., Tunstall, J.P. (Eds) Insect Pests of Cotton. Wallingford UK, CAB International. 285-323.

LIU T., 2000 - Population dynamics of *Bemisia argentifolii* (Homoptera: Aleyrodidae) on spring collard and relationship to yield in the Lower Rio Grande Valley of Texas. J. Econ.

Entomol. 93: 750-756.

LIU T.X., STANSLY P.A. , 1995 - Deposition and bioassay of insecticides applied by leaf dip and spray tower against *Bemisia argentifolii* nymphs (Homoptera: Aleyrodidae). Pestic. Sci. 44:1. 317-322. Cross Ref, CSA.

MITCHELL P.L., GUPTA R. SINGH A.K. AND KUMAR P., 2004 - Behavioral and developmental effects of neem extracts on *Clavigralla scutellaris* (Hemiptera: Heteroptera: Coreidae) and its egg parasitoid, *Gryon fulviventre* (Hymenoptera: Scelionidae). J. Econ. Entomol., 97: 916 -923.

NORMAN PA, SUTTON R.A., 1967 - Host plants for laboratory rearing of melon aphid. J. Econ. Entomol., 60(5): 1205-1207.

OLIVEIRA MRV, HENNEBERRY TJ AND ANDERSON P., 2001 - History, current status, and collaborative research projects for *Bemisia tabaci*. Crop Prot 20: 709 -723.

PARK SB, LEE ES, CHOI SW, JEONG YC, SONG C, CHO YK., 2002 - Insecticidal and acaricidal activity of pipernonaline and piperoctadecalidine derived from dried fruits of *Piper longum* L. Crop Protect. 21(4): 249 - 241.

PRABHAKER N., TOSCANO N.C., COUDRIET D.L., 1989 - Susceptibility of the immature and adult stage of the sweetpotato whitefly (Homoptera: Aleyrodidae) to selected insecticides. J. Econ. Entomol. 82: 983 - 988.

SATAR S., KERSTING U., UYGUN N., 1999 - Development and Fecundity of Aphis Gossypii Glover (Homoptera: Aphididae) on Three Malvaceae Hosts. Tr. J. of Agriculture and Forestry, 23: 637-643

SANTIAGO-ÁLVAREZ C., MARANHÃO E.A.A., MARANHÃO E.H.A., QUESADA-MORAGA E., 2006 - Host plant influences pathogenicity of *Beauveria bassiana* to *Bemisia tabaci* and its sporulation on killed cadavers. BioControl, 51: 519-532.

SCHMUTTERER, H., 1990 - Properties and potential of natural pesticides from neem tree, *Azadirachta indica*. Annu. Rev. Entomol., 35: 271-297. CrossRef, Medline

SCHUSTE D.J., MUELLER T.F., KRING J.B., PRICE J.F., 1990 - Relationship of the sweetpotato whitefly to new tomato fruit disorder in Florida. Hort. Science 25:1618-1620.

SLOSSER J. E., PINCHAK, W.E. AND RUMMEL, D.R., 1989 - A review of known and potential factors affecting the population dynamics of the cotton aphid. Southwest Entomology 36: 302-313

TABASHNIK B.E., 1986 - Computer simulation as a tool for pesticide resistance management. In Pesticide resistance, strategies and tactics for management. National Research Council, National Academy Press, Washington, DC. pp: 194-206

THOMPSON G.D., DUTTON R. AND T.C. SPARKS, 2000 - Spinosad-a case study: an example from a natural products discovery program. Pest Manag. Sci. 56: 696-702.

TJOSVOLD, S.A. AND CHANEYW.E., 2001 - Evaluation of reduced risk and other biorational miticides on the control of spider mites, *Tetranychus urticae*. Acta Hortic. 547: 93 - 96.

TSAI MC, LIU C.S. AND SU H.J., 1997 - Poinsettia leaf curl, a new disease caused by a geminivirus. J Phytopathol 145:347-350.

VAN DER PAS R.K., RAVENSBERG W.J., DEN BRAVER A.C., VAN BUIJSEN, MALAIS M., 1995 - A comparison between Mycotal (*Verticillum lecanii*) and *Aschersonia aleyrodis* for the control of whitefly. IOBC/WPRS/EPRS Meeting Poznan, Poland Aug. 27- Sept. 1: 71-75.