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Field Efficiency of Humic Substances, Boric Acid and some Novel Insecticides against *Aphis gossypii* Glover and *Bemisia tabaci* (Gennadius) on Cotton Plants

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ABSTRACT

Nutritive acids improve the plant growth via increasing its carbohydrates content and nutrients uptake, and enhance the plant resistance to biotic and a biotic stress factors. Accordingly, field experiments were conducted at Sakha Agricultural Research Station, Kafr EL-Sheikh Governorate, Egypt during seasons 2016 and 2017 to evaluate the insecticidal activity of the nutritive acids (boric acid, humic acid and fulvic acid), pymetrozine, dinotefuran and thiamethoxam against *Aphis gossypii* Glover and *Bemisia tabaci* (Gennadius) on cotton plants under the field conditions. The toxicity of the binary mixtures of the nutritive acids with the tested insecticides against the two insects was evaluated as well. The tested compounds were applied at their field recommended rates. Pymetrozine, dinotefuran and thiamethoxam applied separately exhibited high efficiency against *A. gossypii* (causing 90.10 – 97.48% reduction), *B. tabaci* adults (recording 88.07 – 94.68% reduction) and *B. tabaci* immature stages (producing 87.29 – 92.43% reduction). Boric acid, humic acid and fulvic acid resulted in a considerable toxicity to both *A. gossypii* (31.60 – 55.21% reduction) and *B. tabaci* adults (29.51 – 43.70% reduction) and immature stages (22.46 – 37.94% reduction). Among the tested nutritive acids, humic acid proved to be the most potent against *A. gossypii*, while fulvic acid was the most effective on *B. tabaci*. Binary mixtures of the nutritive acids with the tested insecticides resulted in insignificant changes in the insecticides activity against the two pests. These results suggest that boric acid, humic acid and fulvic acid could be effectively used to improve the cotton plant growth (as recommended) and, at the same time, to control *A. gossypii* and *B. tabaci*. Further studies are required to clarify the mode of action through which the nutritive acids cause their insecticidal activity against sucking insects on cotton plants.

Keywords: Cotton, *Aphis gossypii*, *Bemisia tabaci*, boric acid, humic acid, fulvic acid, novel insecticides.

INTRODUCTION

Cotton plants are liable to infestation with many phytophaguos pests such as cotton aphid, *Aphis gossypii* Glover and whitefly, *Bemisia tabaci* (Gennadius) causing severe damages. Heavy infestations of cotton aphid in the early season cause stunt and retard cotton seedling growth and development due to direct feeding. Late season infestations of *A. gossypii* and *B. tabaci* result in decreases in fiber quality because of stickiness and development of black sooty mold associated with honey dew dropped on the open bolls (Blackman and Eastop, 1984; Forlow and Henneberry, 2001). Moreover, different biotypes of *B. tabaci* can transmit more than 90 types of plant virus (Jorge and Mendoza 1995; Hunter and Polston, 2001). In many agricultural systems worldwide, it well documented that *A. gossypii* and *B. tabaci* have acquired resistance to organophosphates, carbamates and pyrethroids (Horowitz *et al.*, 1998; Li *et al*., 2001). To combat development of resistance, scientists and workers in the field of insect control are seeking alternatives that are effective against the pest and safe to humans and biodiversity. Thiamethoxam and dinotefuran are belonging to neonicotinoid chemical group and interfere with the nicotinic acetylcholine receptors; therefore, they have specific activity against the insects' nervous system (Maienfish *et al*., 2001). Pymetrozine is a systemic insecticide, highly effective and specific against sucking pests (Fluckiger *et al*., 1992). It doesn't poison the treated insects directly, but stops their feeding rapidly without return. Hence, pymetrozine could be considered a promising chemical control agent in IPM programs due to its high degree of selectivity, low mammalian toxicity and safety to birds, fishes and non-targeted arthropods.

The organic acids (humic acid and fulvic acid) are excellent foliar carriers and activators (Vaughan and Malcolm, 1985). Foliar application of humic acid and fulvic acid in combinations with trace elements and other plant nutrients improves the growth of plant foliage, roots and fruits via increasing the carbohydrate content of leaves, and stems (Chen and Aviad, 1990; Pettit, 2004). Furthermore, humic substances enhance the plant resistance to environmental stress factors and pathogens attacks (Jackson, 1993), Boric acid, the inorganic nutritive acid, has been used alone and in combinations with many insecticides to control insect pests (Caroline, 2004; Malik *et al*., 2012). This study aimed to evaluate the efficiency of nutritive acids (boric acid, humic acid and fulvic acid), pymetrozine, dinotefuran and thiamethoxam separately and the binary mixtures of the nutritive acids with the insecticides against *Aphis gossypii* Glover and *Bemisia tabaci* (Gennadius) on cotton plants under the field conditions.

MATERIALS AND METHODS

Chemicals used

- Dinotefuran (Oshin 20% SC, Mitsui Chemicals Agro., Inc., Japan) at rate of 250 mg AI/L.
- Thiamethoxam (Actara 25% WG, Syngenta Agrosciences, Switzerland) at rate of 350 mg AI/ L.
- Pymetrozine (Chess 50% WG, Syngenta Agrosciences, Switzerland) at rate of 400 mg AI/ L.
- Boric acid 17% (H_3BO_3) at rate of 255.1 mg AI/L.
- Humic acid 40% at rate of 2000 mg AI/L.
- Fulvic acid 70% at rate of 3496 mg AI/L.

Experiment design and sampling

The experiments were carried out at the farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, Egypt. An area of 4000 m^2 was sown with cotton seeds ver. Giza 92 on April 15, 2016 and April 21, 2017 seasons and divided into plots (replications) each of 84m^2. All recommended agricultural practices were followed all through the season without any insecticidal treatments up to the start of the experiments. The treatments were distributed in this area in a Complete Randomized Block Design with four replications. The tested compounds: Pymetrozine, dinotefuran, thiamethoxam, boric acid, humic acid and fulvic acid were sprayed separately and in binary mixtures of nutritive acids with the insecticides. The treatments were sprayed once on August 1, 2016 and August 6, 2017 by a knapsack sprayer (CP_3). The final volume of spray solution represented 200 L/ feddan. Samples of 25 cotton leaves were collected at random in the early morning from both diagonals of the inner square area of each experimental plot. The leaves were sampled immediately before spray and 2, 5, 8, 11 and 14 days after spray. The upper and lower surfaces of the leaves were inspected carefully in the field using lens (8X) for the numbers of the cotton aphid and whitefly adult stage. The inspected leaves were transmitted to the laboratory where binocular microscope was utilized to count the nymphs and pupa of *B. tabaci*. The reduction percentages were calculated using the equation of Henderson and Tilton (1955).

Statistical analysis

Mean population of each insect per cotton leaf for all treatments were calculated and subjected to one-way analysis of variance (ANOVA). Duncan's multiple range test (Duncan, 1955) was used to determine significant differences (P = 0.05) between treatments using CoStat system for Windows, Version 6.311.

RESULTS AND DISCUSSION

The nutritive acids (boric acid, humic acid and fulvic acid), thiamethoxam, dinotefuran and pymetrozine separately and the binary mixtures of the nutritive acids with the insecticides were tested for their insecticidal activity against both of *Aphis gossypii* Glover and *Bemisia tabaci* (Genn.) on cotton plants under the field conditions and the obtained results are discussed in the following lines.

Effectiveness against *Aphis gossypii*

It is noticed from data presented in Tables 1 and 2 that the population density of *A. gossypii* before spray ranged from 10.50 to 22.31 insects per cotton leaf in season 2016 and from 23.80 to 49.80 insects per cotton leaf in season 2017. Accordingly, the equation of Henderson and Tilton (1955) was used to calculate the corrected percent reduction occurred in *A. gossypii* infestation as a result of application of the tested compounds in relation to the untreated check. When the tested insecticides were applied separately in season 2016, dinotefuran was the most effective against *A. gossypii* recording 96.30 % mean of reduction in aphid population (Table 1), followed by thiamethoxam (94.40%) and pymetrozine (90.10%) without significant differences among them. The tested nutritive acids (boric acid, humic acid and fulvic acid) did not produce any toxicity against aphids up to two days post application causing zero% reduction.

Table 1. Efficiency of different treatments against *Aphis gossypii* on cotton plants under field condition during season 2016

Treatment	Conc. (Mg AI/ L^{-1})	Mean population per cotton leaf and percent reduction of *A. gossypii* during season 2016						Mean
		Pre-spray	Post spray at indicated days					
			2	5	8	11	14	
Thiamethoxam	350	15.80	2.80 (83.80)	0.50 (96.73)	0.20 (98.75)	0.30 (97.76)	0.70 (94.98)	0.90 (94.40ab)
Dinotefuran	250	10.50	1.30 (88.68)	0.30 (97.05)	0.10 (99.06)	0.10 (98.88)	0.20 (97.84)	0.40 (96.30a)
Pymetrozine	400	11.80	3.02 (76.76)	0.70 (93.88)	1.10 (90.76)	0.80 (92.00)	0.30 (97.12)	1.18 (90.10abc)
Boric acid	255.1	12.31	14.92 (0.00)	9.62 (19.42)	8.43 (32.31)	5.32 (49.16)	4.10 (62.27)	8.46 (32.63e)
Humic acid	2000	13.60	15.10 (0.00)	8.03 (39.27)	7.32 (46.80)	5.04 (56.62)	3.81 (68.37)	7.84 (42.21d)
Fulvic acid	3496	11.50	13.70 (0.00)	7.20 (35.36)	6.21 (46.57)	4.71 (51.78)	3.92 (61.61)	7.14 (39.06d)
Thiamethoxam + Boric acid	350 + 255.1	17.03	8.32 (55.38)	1.30 (92.11)	0.90 (94.75)	0.70 (95.14)	0.50 (96.67)	2.34 (86.81c)
Thiamethoxam + Humic acid	350 + 2000	17.81	7.10 (63.55)	0.90 (94.78)	0.50 (97.22)	0.30 (98.01)	0.10 (99.36)	1.78 (90.58abc)
Thiamethoxam + Fulvic acid	350 + 3496	20.50	9.60 (57.20)	2.20 (88.92)	1.90 (90.81)	1.51 (91.37)	1.10 (93.92)	3.26 (84.44c)
Dinotefuran + Boric acid	250 + 255.1	17.12	1.20 (93.59)	0.80 (95.17)	0.30 (98.26)	0.60 (95.86)	0.70 (95.37)	0.72 (95.65ab)
Dinotefuran + Humic acid	250 + 2000	15.20	1.50 (90.98)	1.10 (92.53)	0.60 (96.09)	0.30 (97.67)	0.10 (99.26)	0.72 (95.31ab)
Dinotefuran + Fulvic acid	250 + 3496	16.50	1.70 (90.58)	0.60 (96.25)	0.20 (98.80)	0.20 (98.57)	0.10 (99.31)	0.56 (96.70a)
Pymetrozine + Boric acid	400 + 255.1	19.31	6.03 (71.59)	0.60 (96.79)	0.50 (97.43)	0.70 (95.72)	0.30 (98.24)	1.62 (91.95abc)
Pymetrozine + Humic acid	400 + 2000	13.30	5.30 (63.58)	0.90 (93.01)	1.30 (90.31)	0.90 (92.02)	0.40 (96.59)	1.76 (87.10bc)
Pymetrozine + Fulvic acid	400 + 3496	21.02	10.90 (52.99)	0.70 (96.56)	0.80 (96.22)	0.20 (98.87)	0.10 (99.46)	2.54 (88.82abc)
Control	—	22.31	24.40	21.61	22.52	18.91	19.70	21.43

Figures in parentheses refer to the percentages of reduction in *A. gossypii* population comparing to the check.

In the same column, means followed by the same letters are not significantly differed, p = 0.05 by Duncan (1955).

But, their activity increased gradually with time progress starting from the 5th day post application up to the end of the experiments recording a weak mean of percent reduction ranged from 32.63- 42.21%. Humic acid was the most effective nutritive acid against *A. gossypii* with 42.21% mean of reduction. With respect to the binary mixtures of thiamethoxam, dinotefuran and pymetrozine with boric acid, humic acid and fulvic acid, slight and insignificant decreases were found in the activity of the mixtures comparing to the insecticides applied alone. The binary mixtures of the three nutritive acids with dinotefuran, thiamethoxam or pymetrozine resulted in 95.31- 96.70%, 84.44- 90.58% and 87.10- 91.95% mean of reduction in *A. gossypii* populations, respectively. The obtained results in season 2017 emphasized that of season 2016 and displayed in the same trend of effect (Table 2). Where, dinotefuran, thiamethoxam and pymetrozine applied alone were highly effective against *A. gossypii* producing 97.48, 95.54 and 92.85% mean of reduction. Application of the nutritive acids alone resulted in a feeble effect on aphid infestation translated in 31.60- 55.21% mean of reduction, and humic acid was the most potent (causing 55.21% reduction) comparing to boric acid and fulvic acid in season 2017.

Treatment of plants with nutritive acids generally improves the plant growth via increasing the carbohydrates content of the leaves and stems (Chen and Aviad, 1990). Moreover, humic substance can enhance the resistance of plants to environmental stress factors and insect attacks (Jackson, 1993). Because of the relatively small size of fulvic molecules, they can readily enter plant roots, stems and leaves; as they enter these plant parts they carry trace minerals from plant surfaces into plant tissues, also transport trace minerals directly to metabolic sites in plant cells resulting in an enhancement of plant defense against biotic and a biotic stress (Pettit, 2004). Some of the previous studies demonstrated the toxicity of nutritive acids against herbivorous insects. Malik *et al*., 2012 found that boric acid was effective against *Tribolium castaneum*, and showed a synergistic effect when it was applied in combinations with cypermethrin and *Azadirachta indica*. Mohamadi *et al*. (2016) reported that application of humic fertilizer enhanced tomato resistance to *Tuta absoluta*, and this was related to growth promotion and enhancement of nutrient uptake of plant due to addition of humic substance. Also, Caroline (2004) reported that boric acid and borates suppressed the populations of *A. gossypii*, *Thrips tabaci*, mites, algae and fungi.

Table 2. Efficiency of different treatments against *Aphis gossypii* on cotton plants under field condition during season 2017

Treatment	Conc. (Mg AI/ L^{-1})	Mean population per cotton leaf and percent reduction of *A. gossypii* immature stages during season 2017						Mean
		Pre-spray	Post spray at indicated days					
			2	5	8	11	14	
Thiamethoxam	350	28.90	5.62 (86.07)	0.34 (98.86)	0.02 (99.94)	0.94 (96.56)	0.88 (96.29)	1.56 (95.54a)
Dinotefuran	250	29.80	3.00 (92.79)	1.26 (95.90)	0.05 (99.85)	0.28 (99.01)	0.04 (99.84)	0.93 (97.48a)
Pymetrozine	400	30.50	8.22 (81.22)	1.54 (95.10)	0.84 (97.57)	1.72 (94.03)	0.92 (96.32)	2.65 (92.85ab)
Boric acid	255.1	29.62	60.20 (0.00)	24.26 (20.53)	24.50 (26.97)	17.76 (36.51)	6.32 (73.97)	26.61 (31.60e)
Humic acid	2000	26.70	70.20 (0.00)	16.16 (41.32)	9.30 (69.27)	3.16 (87.48)	4.82 (78.00)	20.73 (55.21d)
Fulvic acid	3496	31.63	56.74 (0.00)	22.48 (31.02)	18.82 (47.45)	16.54 (44.62)	14.12 (45.53)	25.74 (33.72e)
Thiamethoxam + Boric acid	350 + 255.1	23.80	13.32 (59.92)	0.22 (99.10)	0.04 (99.85)	0.16 (99.29)	0.02 (99.90)	2.75 (91.61b)
Thiamethoxam + Humic acid	350 + 2000	49.80	23.05 (66.85)	5.32 (89.64)	3.80 (93.27)	2.82 (94.01)	2.62 (93.59)	7.52 (87.47bc)
Thiamethoxam + Fulvic acid	350 + 3496	35.40	19.74 (60.07)	0.38 (98.96)	0.98 (97.56)	2.54 (92.41)	0.66 (97.73)	4.86 (89.35b)
Dinotefuran + Boric acid	250 + 255.1	34.30	1.62 (96.62)	0.08 (99.17)	0.02 (99.95)	0.20 (99.38)	0.02 (99.93)	0.39 (99.01a)
Dinotefuran + Humic acid	250 + 2000	34.11	2.62 (94.50)	0.10 (99.72)	0.01 (99.98)	0.06 (99.81)	0.01 (99.98)	0.56 (98.80a)
Dinotefuran + Fulvic acid	250 + 3496	37.10	8.36 (83.86)	0.18 (99.53)	0.02 (99.95)	0.06 (99.83)	0.01 (99.97)	1.73 (96.63a)
Pymetrozine + Boric acid	400 + 255.1	32.36	13.96 (69.11)	0.40 (98.80)	0.43 (98.83)	0.76 (97.51)	0.22 (99.17)	3.15 (92.68ab)
Pymetrozine + Humic acid	400 + 2000	30.60	16.10 (62.32)	0.42 (98.67)	0.62 (99.25)	0.84 (97.10)	0.20 (99.20)	3.56 (91.31b)
Pymetrozine + Fulvic acid	400 + 3496	32.80	19.86 (56.64)	0.12 (99.65)	0.10 (99.73)	0.74 (97.61)	0.16 (99.41)	4.20 (90.61b)
Control	—	25.50	35.60	26.30	28.90	24.10	20.92	27.16

Figures in parentheses refer to the percentages of reduction in *A. gossypii* population comparing to the check.
In the same column, means followed by the same letters are not significantly differed, p = 0.05 by Duncan (1955).

The obtained results are in harmony with that of Sechser *et al*. (2002) when reported that Pymetrozine reduced the populations of aphid immediately after its application. Abd-Ella (2013) found that acetamiprid, imidacloprid, thiamethoxam and dinotefuran caused significant reductions in aphid infestation at 1,7,15 and 21days post treatment.

Also, Barrania and Abou-Taleb (2014) showed that thiamethoxam, imidacloprid and acetamiprid exhibited highest reductions in aphid populations on cotton. Pymetrozine was the highest effective against *A. gossypii* on cucumber plants in greenhouse, followed by azadirachtin, flufenoxuron, while buprofezin had the least activity (Makaremini *et al*., 2014). Abou Shaisha (2016) found that thiamethoxam, pymetrozine and acetamiprid were the most effective against *A. gossypii* and *Aphis craccivora* (Koch).

Effectiveness against *Bemisia tabaci*

The insecticidal activities of the nutritive acids (boric acid, humic acid and fulvic acid) either applied alone or in binary mixtures with thiamethoxam, dinotefuran and pymetrozine against *B. tabaci* infesting cotton plants are discussed in Tables 3-6. The results of Tables 3 and 4 indicated that the nutritive acids induced feeble efficacy against adults of *B. tabaci* recording 29.51, 33.64 and 43.70% mean of reduction in 2016 and 35.01, 42.28 and 43.48% mean of reduction in 2017 for boric acid, humic acid and fulvic acid, respectively. It is noticed that fulvic acid was the most efficient nutritive acid against *B. tabaci* adults. Thiamethoxam, dinotefuran and pymetrozine exhibited high efficiency against *B. tabaci* adults ranged from 89.53– 93.51% and from 88.07– 94.68% mean of reduction in 2016 and 2017, respectively. Insignificant increases occurred in the activities of the tested insecticides when they were applied in binary mixtures with boric acid, humic acid and fulvic acid causing from 90.94– 94.77% mean of reduction in 2016 and from 93.48– 98.73% mean of reduction in 2017. Similarly, the tested boric acid, humic acid and fulvic acid demonstrated weak effect on *B. tabaci* immature stages (Tables 5 and 6) where they gave 22.46, 26.66 and 31.68% mean of reduction in 2016 and 28.12, 37.45 and 37.94% mean of reduction in 2017, respectively, and fulvic acid was the most potent nutritive acid on *B. tabaci* immature stages. The three tested insecticides proved to be the most effective against *B. tabaci* immature stages resulting in from 87.29- 91.74% and from 88.81- 92.43% mean of reduction in 2016 and 2017, respectively.

Table 3. Efficiency of different treatments against adults of *Bemisia tabaci* infesting cotton plants under field condition during season 2016

Treatment	Conc. (Mg AI/ L^{-1})	Mean population per cotton leaf and percent reduction of *B. tabaci* adults during season 2016						Mean
		Pre-spray	Post spray at indicated days					
			2	5	8	11	14	
Thiamethoxam	350	14.0	2.30 (84.72)	1.89 (88.93)	1.37 (92.66)	1.50 (91.64)	1.72 (89.68)	1.76 (89.53b)
Dinotefuran	250	17.5	2.50 (86.71)	1.50 (92.97)	1.09 (95.33)	0.81 (96.39)	0.80 (96.16)	1.34 (93.51a)
Pymetrozine	400	14.8	1.80 (88.69)	1.39 (92.30)	1.00 (94.93)	0.72 (96.21)	0.91 (94.84)	1.16 (93.39a)
Boric acid	255.1	16.40	14.20 (19.48)	13.89 (30.55)	13.40 (38.72)	13.00 (38.17)	15.50 (20.16)	13.99 (29.51e)
Humic acid	2000	15.50	12.35 (25.90)	12.00 (36.52)	11.30 (45.32)	12.10 (39.11)	14.51 (21.37)	12.45 (33.64d)
Fulvic acid	3496	15.90	13.02 (23.84)	11.90 (38.63)	12.00 (43.40)	11.80 (42.11)	14.10 (25.51)	12.56 (43.70c)
Thiamethoxam + Boric acid	350 + 255.1	19.00	2.90 (85.05)	2.00 (91.37)	1.70 (93.29)	1.74 (92.86)	1.78 (92.13)	2.02 (90.94ab)
Thiamethoxam + Humic acid	350 + 2000	17.80	2.50 (86.71)	1.93 (91.11)	1.70 (92.84)	1.41 (93.82)	1.35 (93.45)	1.78 (91.59ab)
Thiamethoxam + Fulvic acid	350 + 3496	17.30	1.90 (89.79)	1.69 (90.23)	1.34 (94.19)	1.00 (95.49)	1.10 (94.66)	1.41 (92.87ab)
Dinotefuran + Boric acid	250 + 255.1	16.40	1.62 (90.81)	1.19 (94.05)	1.00 (95.43)	1.20 (94.29)	1.31 (95.36)	1.26 (93.99a)
Dinotefuran + Humic acid	250 + 2000	17.20	1.50 (91.89)	1.14 (94.57)	0.93 (95.94)	0.81 (96.33)	0.95 (95.12)	1.07 (94.77a)
Dinotefuran + Fulvic acid	250 + 3496	15.50	1.30 (92.20)	1.08 (94.29)	0.71 (96.56)	0.98 (95.07)	1.00 (94.58)	1.01 (94.54a)
Pymetrozine + Boric acid	400 + 255.1	18.00	1.75 (90.95)	1.63 (92.57)	0.89 (96.29)	0.80 (96.53)	1.10 (94.87)	1.23 (94.24a)
Pymetrozine + Humic acid	400 + 2000	14.00	1.99 (86.78)	1.58 (90.75)	0.60 (96.77)	0.43 (97.60)	0.65 (96.10)	1.05 (93.60a)
Pymetrozine + Fulvic acid	400 + 3496	16.30	1.65 (90.59)	1.50 (92.45)	0.90 (95.86)	0.33 (98.42)	0.67 (96.55)	1.01 (94.77a)
Control	—	15.30	16.50	18.50	20.20	19.60	18.30	18.62

Figures in parentheses refer to the percentages of reduction in *B. tabaci* population comparing to the check.
In the same column, means followed by the same letters are not significantly differed, p = 0.05 by Duncan (1955).

Combining of the nutritive acids with the tested insecticides in binary mixtures did not produce significant changes in the insecticides activity. Although boric acid, humic acid and fulvic acid are well documented as plant nutrients and effective control agents against pathogens, few data are available on their activity as toxic components to the herbivorous pests. Caroline (2004) studied the mode of action of some nutritive acids against economic pests, and stated that boric acid and sodium tetraborate are used to kill wood-boring beetles, ants, mealybugs, mites, aphids and scale insects by act as stomach poisons and break down the cuticle of the treated pests via absorption of the cuticle waxes causing pests to dry out and die. Some of the previous investigations demonstrated the effectiveness of the nutritive acids against pests attacking the vegetable plants. Application of vermicompost which contains high concentration of humic acid to vegetable plants resulted in significant decrease in the infestations of green peach aphid *Myzus persica*, citrus mealybug *Planococcus citri* and two-spotted spider mite *Tetranycus urtica* (Arancon *et al*, 2005; Edwards *et al*., 2010). Boric acid was more effective against *Tetranycus urtica* than against *A. gossypii* and *Thrips tabaci* on strawberry plants causing 66.67, 32.88 and 29.33% reduction in the populations of the three pests, respectively (Habashy *et al*., 2010). Also, Yildirim and Unay (2011) reported that application of fulvic acid resulted in significant negative impact on *Liromiza trifolii* infesting tomato plants under greenhouse conditions and increased the yield. Our results concerning the high efficacy of thiamethoxam, dinotefuran and pymetrozine against *B. tabaci* are in parallel with that of Castle and Prabhaker (2013) who mentioned that dinotefuran, thiamethoxam, imidacloprid and acetamiprid possessed high efficiency against *B. tabaci*. Pymetrozine exhibited the superior activity comparing to the botanical insecticides toward *B. tabaci* infestations (Barati *et al.*, 2013). Smith *et al.* (2016) concluded that dinotefuran was more effective (LC_{50} ranged from 0.043 – 3.350 mg L^{-1}) than thiamethoxam (LC_{50} ranged from 0.965 – 24.430 mg L^{-1}) against field populations of *B. tabaci* prevailing in south Florida. Further studies are required to clarify the mode of action by which the nutritive acids cause their insecticidal activity against sucking insects on cotton plants.

Table 4. Efficiency of different treatments against adults of *Bemisia tabaci* infesting cotton plants under field condition during season 2017

Treatment	Conc. (Mg AI/ L^{-1})	Mean population per cotton leaf and percent reduction of *B. tabaci* adults during season 2017						Mean
		Pre-spray	Post spray at indicated days					
			2	5	8	11	14	
Thiamethoxam	350	20.73	4.36 (81.07)	2.98 (87.21)	2.20 (91.41)	2.30 (91.79)	2.71 (88.87)	2.91 (88.07c)
Dinotefuran	250	13.70	1.46 (90.41)	1.24 (91.94)	0.54 (96.81)	0.62 (96.65)	0.40 (97.52)	0.85 (94.67ab)
Pymetrozine	400	15.40	2.10 (87.73)	0.94 (94.34)	0.72 (96.21)	0.56 (97.31)	0.40 (97.79)	0.94 (94.68ab)
Boric acid	255.1	20.03	16.20 (27.21)	14.40 (36.02)	16.00 (35.30)	13.90 (48.64)	17.00 (27.86)	15.50 (35.01e)
Humic acid	2000	20.12	14.90 (33.35)	12.80 (43.38)	13.51 (45.61)	11.90 (56.23)	15.90 (32.83)	13.81 (42.28d)
Fulvic acid	3496	20.92	15.87 (31.73)	13.40 (48.95)	12.95 (49.88)	12.12 (57.13)	17.30 (29.71)	13.73 (43.48d)
Thiamethoxam + Boric acid	350 + 255.1	20.40	2.16 (90.47)	1.46 (93.63)	2.00 (92.06)	1.49 (94.60)	0.81 (96.63)	1.58 (93.48b)
Thiamethoxam + Humic acid	350 + 2000	14.30	0.70 (95.59)	0.54 (96.64)	0.52 (97.05)	0.36 (98.14)	0.24 (98.57)	0.47 (97.20ab)
Thiamethoxam + Fulvic acid	350 + 3496	20.65	2.42 (89.45)	1.46 (90.91)	1.32 (94.82)	0.80 (97.13)	0.52 (97.86)	1.30 (94.03ab)
Dinotefuran + Boric acid	250 + 255.1	19.30	0.46 (97.85)	0.36 (98.34)	0.54 (97.73)	0.68 (97.39)	0.56 (97.53)	0.52 (97.77ab)
Dinotefuran + Humic acid	250 + 2000	20.40	0.50 (97.79)	0.68 (97.00)	0.64 (97.45)	0.62 (97.75)	0.54 (97.75)	0.60 (97.55ab)
Dinotefuran + Fulvic acid	250 + 3496	19.80	0.80 (96.36)	0.68 (96.94)	0.32 (98.69)	0.18 (99.33)	0.50 (97.85)	0.50 (97.83ab)
Pymetrozine + Boric acid	400 + 255.1	19.80	0.39 (98.22)	0.44 (98.00)	0.30 (98.77)	0.20 (99.25)	0.14 (99.40)	0.29 (98.73a)
Pymetrozine + Humic acid	400 + 2000	18.75	2.14 (89.73)	1.32 (93.73)	0.90 (96.11)	0.46 (98.18)	0.92 (95.83)	1.15 (94.61ab)
Pymetrozine + Fulvic acid	400 + 3496	19.00	1.60 (92.42)	1.46 (93.16)	1.26 (94.63)	0.32 (98.75)	0.24 (98.75)	0.98 (95.54 ab)
Control	—	17.10	18.93	19.02	20.98	22.90	19.90	20.35

Figures in parentheses refer to the percentages of reduction in *B. tabaci* population comparing to the check.
In the same column, means followed by the same letters are not significantly differed, p = 0.05 by Duncan (1955).

Table 5. Efficiency of different treatments against immature stages of *Bemisia tabaci* infesting cotton plants under field condition during season 2016

Treatment	Conc. (Mg AI/ L^{-1})	Mean population per cotton leaf and percent reduction of *B. tabaci* immature stages during season 2016						Mean
		Pre-spray	Post spray at indicated days					
			2	5	8	11	14	
Thiamethoxam	350	20.50	4.12 (80.91)	2.93 (85.71)	1.85 (91.80)	0.98 (89.17)	1.90 (88.88)	2.36 (87.29b)
Dinotefuran	250	18.50	2.55 (86.91)	1.53 (91.73)	0.59 (96.17)	0.85 (94.03)	1.56 (89.88)	1.42 (91.74ab)
Pymetrozine	400	18.00	2.43 (87.18)	1.35 (92.50)	0.75 (95.00)	1.00 (92.78)	1.70 (88.67)	1.45 (91.23ab)
Boric acid	255.1	17.20	16.00 (11.62)	13.00 (24.42)	10.10 (29.53)	9.20 (30.47)	12.00 (16.28)	12.06 (22.46e)
Humic acid	2000	18.30	15.90 (17.46)	12.10 (33.88)	11.00 (27.87)	9.00 (36.07)	12.50 (18.03)	12.10 (26.66d)
Fulvic acid	3496	17.30	14.00 (23.12)	10.92 (36.88)	8.50 (41.04)	8.00 (39.88)	11.90 (17.46)	10.66 (31.68c)
Thiamethoxam + Boric acid	350 + 255.1	16.80	1.98 (88.60)	1.25 (92.56)	0.43 (96.93)	0.75 (94.20)	1.32 (90.57)	1.15 (92.61ab)
Thiamethoxam + Humic acid	350 + 2000	15.70	1.48 (91.04)	1.25 (92.04)	0.64 (95.11)	1.02 (91.55)	1.60 (89.81)	1.19 (91.91ab)
Thiamethoxam + Fulvic acid	350 + 3496	17.50	1.73 (90.61)	1.40 (92.00)	0.40 (97.26)	0.97 (92.79)	1.90 (86.97)	1.28 (91.93ab)
Dinotefuran + Boric acid	250 + 255.1	17.80	1.53 (91.83)	1.09 (93.88)	0.65 (95.62)	1.20 (91.24)	2.00 (86.52)	1.29 (91.82ab)
Dinotefuran + Humic acid	250 + 2000	19.80	1.40 (93.28)	0.89 (95.51)	0.39 (97.64)	1.00 (93.43)	1.92 (88.36)	1.12 (93.64a)
Dinotefuran + Fulvic acid	250 + 3496	16.30	1.29 (92.48)	0.75 (95.40)	0.30 (97.79)	0.93 (94.29)	1.80 (86.75)	1.01 (93.29a)
Pymetrozine + Boric acid	400 + 255.1	20.30	1.56 (92.70)	1.05 (94.83)	0.65 (96.16)	1.06 (93.21)	2.10 (87.59)	1.35 (92.90ab)
Pymetrozine + Humic acid	400 + 2000	18.80	1.21 (93.89)	0.4 (95.00)	0.54 (97.13)	1.20 (91.70)	2.30 (85.32)	1.24 (92.61ab)
Pymetrozine + Fulvic acid	400 + 3496	16.50	1.15 (93.38)	0.82 (95.03)	0.44 (96.80)	0.85 (93.30)	1.70 (87.64)	0.99 (93.23 a)
Control	—	18.30	19.30	17.00	15.90	13.90	15.40	16.30

Figures in parentheses refer to the percentages of reduction in *B. tabaci* population comparing to the check.
In the same column, means followed by the same letters are not significantly differed, p = 0.05 by Duncan (1955).

Table 6. Efficiency of different treatments against immature stages of *Bemisia tabaci* infesting cotton plants under field condition during season 2017

Treatment	Conc. (Mg AI/ L^{-1})	Mean population per cotton leaf and percent reduction of *B. tabaci* immature stages during season 2017						Mean
		Pre-spray	Post spray at indicated days					
			2	5	8	11	14	
Thiamethoxam	350	18.20	3.96 (83.24)	2.40 (89.71)	1.62 (93.32)	2.49 (89.33)	2.70 (88.43)	2.63 (88.81b)
Dinotefuran	250	19.70	4.72 (81.55)	2.36 (91.98)	1.45 (94.48)	1.30 (94.85)	1.90 (92.48)	2.35 (91.07ab)
Pymetrozine	400	20.22	2.63 (89.98)	2.08 (92.08)	1.52 (94.36)	1.60 (93.83)	2.10 (91.90)	1.99 (92.43ab)
Boric acid	255.1	15.82	14.90 (27.48)	14.20 (29.99)	13.50 (35.99)	15.00 (26.04)	16.00 (21.11)	15.92 (28.12d)
Humic acid	2000	18.65	16.24 (32.95)	15.00 (37.27)	13.10 (47.32)	14.50 (39.36)	16.65 (30.36)	15.10 (37.45c)
Fulvic acid	3496	20.62	18.00 (32.78)	16.30 (38.34)	14.00 (49.08)	16.20 (38.72)	18.30 (30.78)	16.56 (37.94c)
Thiamethoxam + Boric acid	350 + 255.1	15.45	2.00 (90.03)	1.45 (92.68)	1.25 (93.93)	1.41 (92.88)	1.62 (91.82)	1.55 (92.27ab)
Thiamethoxam + Humic acid	350 + 2000	14.80	1.59 (91.73)	1.31 (93.10)	0.98 (95.03)	1.40 (92.62)	2.00 (89.46)	1.46 (92.39ab)
Thiamethoxam + Fulvic acid	350 + 3496	19.57	2.98 (88.63)	2.30 (90.83)	1.51 (94.21)	2.00 (92.02)	2.49 (90.08)	2.26 (91.15ab)
Dinotefuran + Boric acid	250 + 255.1	18.22	1.98 (91.63)	1.49 (93.62)	1.09 (95.51)	1.50 (93.58)	2.50 (89.30)	1.71 (92.73ab)
Dinotefuran + Humic acid	250 + 2000	16.45	2.88 (86.52)	1.95 (90.75)	1.31 (94.03)	1.25 (94.07)	1.40 (93.36)	1.76 (91.75ab)
Dinotefuran + Fulvic acid	250 + 3496	14.85	3.00 (84.44)	2.13 (88.81)	1.22 (93.84)	1.00 (94.74)	1.56 (91.80)	1.78 (90.73ab)
Pymetrozine + Boric acid	400 + 255.1	13.72	2.56 (85.63)	1.42 (91.93)	1.00 (94.53)	0.80 (95.45)	1.37 (92.21)	1.43 (91.95ab)
Pymetrozine + Humic acid	400 + 2000	16.65	2.41 (88.85)	1.30 (93.91)	1.10 (95.05)	0.72 (96.76)	1.65 (92.27)	1.44 (93.37a)
Pymetrozine + Fulvic acid	400 + 3496	15.75	2.30 (88.76)	1.20 (94.06)	0.99 (95.29)	0.63 (96.88)	1.91 (90.54)	1.41 (93.11a)
Control	—	14.00	18.25	17.98	18.78	18.06	17.90	18.19

Figures in parentheses refer to the percentages of reduction in *B. tabaci* population comparing to the check.
In the same column, means followed by the same letters are not significantly differed, p = 0.05 by Duncan (1955).

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الفاعلية الحقلية لمواد الهيومك وحمض البوريك وبعض المبيدات الحديثة ضد من القطن والذبابة البيضاء على نباتات القطن

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تحسن الأحماض المغذية من نمو النبات من خلال زيادة محتوى النبات من المواد الكربوهيدراتية و إمتصاصه للعناصر المغذية ، كما تحسن من مقاومة النبات للعوامل الحية وغير الحية المناوئة. أجريت تجارب حقلية في محطة البحوث الزراعية بسخا، كفر الشيخ، مصر خلال موسمى ٢٠١٦، ٢٠١٧ لتقييم الفاعلية الإبادية للأحماض المغذية (البوريك ، الهيومك، الفولفك) ومبيدات البيمتروزين ، الداينوتفيوران ، الثياميثوكثام ضد من القطن و الذبابة البيضاء على القطن تحت الظروف الحقلية. كذلك تم تقييم سمية المخاليط المزدوجة من الأحماض المغذية مع المبيدات المختبرة ضد الحشرتين المذكورتين. تم تطبيق المركبات المختبرة بالمعدلات الحقلية الموصى بها. أثبتت مبيدات البيمتروزين ، الداينوتفيوران ، الثياميثوكثام فاعلية عالية ضد من القطن (مسببة ٩٠.١٠ ــ ٩٧.٤٨ % خفض في التعداد) و الحشرة الكاملة للذبابة البيضاء (مسجلة ٨٨.٠٧ ــ ٩٤.٦٨ خفض في التعداد) والأطوار غير الكاملة للذبابة البيضاء (منتجة ٨٧.٢٩ ــ ٩٢.٤٣ % خفض في التعداد). نتج عن تطبيق أحماض البوريك والهيموك و الفولفك سمية يعتد بها ضد من القطن حيث بلغت نسبة الخفض ٣١.٦٠ ــ ٥٥.٢١ %بينما بلغت نسبة الخفض في الحشرة الكاملة للذبابة البيضاء ٢٩.٥١ ــ ٤٣.٧٠ % وفي الأطوار غير الكاملة ٢٢.٤٦ ــ ٣٧.٩٤. بينت النتائج أن حامض الهيومك هو الأكثر فاعلية ضد من القطن من بين الأحماض المغذية المختبرة، بينما كان حامض الفولفك هو الأكثر فاعلية ضد الذبابة البيضاء. نتج عن تطبيق المخاليط المزدوجة من الأحماض المغذية مع المبيدات المختبرة تغيرات غير معنوية في فاعلية المبيدات ضد كلا الآفتين. من النتائج المتحصل عليها تقترح هذه الدراسة أنه يمكن بكفاءة إستخدام حامض الهيومك و البوريك و الفولفك في تحسين نمو نبات القطن (كما هو موصى به) وفي نفس الوقت في مكافحة المن والذبابة البيضاء.

كلمات مفتاحية: القطن، من القطن، الذبابة البيضاء، حامض البوريك، حامض الهيومك، حامض الفولفك، المبيدات الحديثة.