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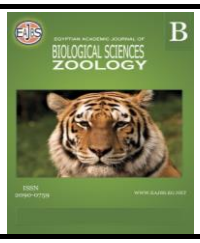

Field Comparison Between Tow Natural Compounds and A Common Acaricide On Two-Spotted Spider Mite, *Tetranychus urticae* And Three of Its Natural Enemies by Using Certain Ground Spraying Equipment on Soybean Crop in Egypt.

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ABSTRACT

Field experiments were carried on soybean variety (Giza 111) during two successive seasons 2019 and 2020. Two natural compounds were tested, Humic acid, Chitosan Nano-particles (C.N.Ps) and a common acaricide, Abamectin, of recommended dose rates and one treatment left without spraying as control by using Economy Micron ULVA sprayer (15L./fed.) and Hydraulic sprayer (Matabi) (56 L/Fed.). Data indicated that all tested compounds induced significant negative influenced on *Tetranychus urticae* adult females' survival. Abamectin and humic acid revealed successful results followed by the C.N.Ps. Results showed that C.N.Ps have lower toxicity on *T. urticae* but it safer on all movable stages of *Amblyseius californicus*, *Orius insidiosus*, and *Scolothrips sexmaculatus*, the natural enemies associated. It could be recommended that using those compounds with LV spraying equipment with not less than (15 L. /Fed.). A satisfactory spray coverage was obtained on soybean plants. The droplets spectrum ranging from 150-170 µm (VMD). A sufficient number ranging from 18-199 N/cm². The data showed that the Economy Micron ULVA sprayer was the best equipment to control. *Tetranychus urticae* on soybean according to the homogeneity of the droplet spectrum. The rate of performance of Hand-held Hydraulic sprayer (Matabi) (56 L. /Fed.), Economy Micron ULVA (15 L. /Fed.) were 3.55 Fed. /day, 3.30 Fed. /day, respectively. Data also revealed that lost spray-on ground for Ulva sprayer was lower than Matabi sprayer with 35%.

INTRODUCTION

Soybean (*Glycine max* L.) is a common leguminous crop used in a wide world of food-derived. There are many different insects infesting soybean it in Egypt, some of them are detrimental, while others are beneficial. Serious yield production and quality reductions will result when pests' outbreaks occur and don't be managed. The two-spotted spider mite, *Tetranychus urticae* (Koch) (Acari: Tetranychidae) is an extremely polyphagous species and a serious pest of a wide range of economically important crops, including soybean. (Alakhdar *et al.*, 2015).

High reproductive ability and short life cycle of *T. urticae* promotes the rapid development of resistance against some acaricides after a few applications. Resistance has been recorded for compounds in several countries, extraction of new chemicals and the

judicious use of acaricides from various forms of action are currently the best approach. It is important to test the efficacy of new alternatives on both the pests and their natural enemies to determine if outbreaks are likely to occur and to define potential mechanisms of material selectivity.

Abamectin is currently used to control several pests in many crops. Recently, intensive Abamectin applications have been used to control *T. urticae*, some growers have observed low efficacy, and shortened abamectin effect, indicating a potential resistance development problem (Sato *et al.,* 2005). Humic acid (HA) is a natural soil-based material and a bio-product of organic matter decomposition that has been widely used in the production of various crops. Direct effects of HA on plant growth have been well defined in field experiments; these effects include increased absorption and root growth of macronutrients and micronutrients. (Xu, *et al.,* 2015; Baldotto *et al.,* 2010 and Ekin 2019). Chitosan Nano-Particles (C.N.Ps) is a new natural material that was derived from chitin. It may serve as a good alternative for broad-spectrum and highly persistent pesticides. C.N.Ps has the potential for biological control of several pests with a slight effect on some associated natural enemies (Alakhdar, 2020).

The world global attention was directed to the minimization of spraying volumes and the control costs which may be happened by using cheap and effective insecticides or using developmental ground spraying technique with low application costs per feddan, the efficiency of different ground sprayers in the spray coverage due to arrangement of the nozzles, Low- volume, spraying, and rate of application was studied (Magdoline *et. al*., 1992; Hindy, 1992 and 1997). Maintaining sprayers for pesticide application of excellent state of repairing and proper working in order to reduce their harmful effects on human health and environment Dokic *et al.* (2018).

This work aimed to determine the best compound and the best equipment controlling *Tetranychus urticae* on soybean with the least hazard to *Amblyseius californicus*, *Orius insidiosus,* and *Scolothrips sexmaculatus*, the natural enemies of this pests with conservation of agricultural environment.

MATERIALS AND METHODS

The Tested Compounds:-

a-Abamectin:- Gold® 1.8% E.C**.** 12% weight\volume,86.2% solvent., rate dose 160 cm^3/fed.

b-Humic No.1: 12% humic acid/ 3% folic acid/ 4%potassium oxide/ 4% fifth Phosphorus oxide/ 0.5% iron/ 0.2% zinc/ 0.1% Manganese/ 0.1% Born, rate dose 60cm^3/fed. Obtained from the Central Laboratory of Organic Agriculture/ Agricultural Research Center 128 cm /L.

c-Nano-Chitosan Particles: Chitosan was purchased from the Oxford lab. India. Chitosan Nano-Particles were prepared according to Gan *et al.* (2005) at NAQAA Nanotechnology-Network-Giza-Egypt. The used concentration was the LC_{90} (133.33 ppm), recommended for *T. urticae* by one of the authors ; (Alakhdar 2020).

Spraying Equipment Tested on Soybean:-

Two ground application equipment were selected to perform the scope of this work as follows:

1. Economy Micron ULVA sprayer, Spraying volume (15L./fed.), the U.K. made.
2. Hand-held Hydraulic sprayer (Matabi), Spraying volume (56 L./fed.), Espine made.

The tested equipment calibrated with water and represented according to the technical categorization mentioned in Table (1). Calculations of productivity and rate of performance were recorded as described by Hindy (1992).

Table 1: Techno-Operational data of certain ground sprayers applied to the soybean field during seasons (2019-2020).

Equipment	Economy Micron ULVA sprayer	Hand-held Hydraulic sprayer (Matabi)
Type of atomization	Centrifugal (Rotary Spinning disc)	Hydraulic
Nozzle type	One restrirector	Hollow cone nozzle 80°
Pump type	-	Manual Hydraulic pump
Number of nozzles	1	1
Pressure (bar)	-	5
Spray tank (L.)	1+10	20
Rate of application (L/fed.)	15	56
Working speed (Km/h.)	2.4	2.4
Swath width (m.)	1	1.5
Flow rate (L/min.)	0.150	0.8
Spray height (m.)	0.5	0.5
Type of Spraying	Target in all sprayers	
Productivity * (fed./h.)	0.571	0.86
Rate of performance* (fed./day)	3.3	3.55

***Number of spraying hours=8 hours daily. *Number of workers=2**
*** Calculations of productivity and rate of performance after Hindy (1992).**

Execution of Field Experiments:-

1- Arrangements of the Experiments:

Field experiments were carried out during two successive seasons 2019 and 2020 in 15 th June in a private field at Aga district, Dakahlia governorate. The soybean cultivated variety (Giza 111) planted in the 1st week of May in the two seasons, the experiments were done under local meteorological conditions of 38°C average temperature, 65 % average RH, and 2 m/sec. as an average wind velocity during spraying operations. The selected area of 14 Karats = 0.58 feddan (2450 m^2) was split into 6 plots and a control plot. The area of each plot was 350 m^2, three rows of soybean plants between treatments were not sprayed as barrier zones to avoid drift spray between treatments, spraying operations have not been done with compounds before the execution of the field experiment. Abamectin, Humic acid were sprayed with recommended dose rate, while the suggested by one of the authers Lc_{90} (133.3) ppm of Chitosan Nano-Particles (C.N.Ps) for *T. urticae* was applied, (Alakhdar 2020). All treatments sprayed as target spraying technique with two mentioned sprayers, except one treatment left separated without spraying as a control, in opposite to wind direction.

2-Bioassay Procedure:-

The experimental design was a randomized complete block (RCBD) with three replications. When the infection was confirmed with *T. urticae*, a pre-spray sample was taken and the treatment was carried out with the all tested compounds. Ten leaves were taken from each replicate and the number of adult females of *Tetranychus urticae* (Koch) (Acari: Tetranychidae), and all movable stages (adults and immatures) of the associated predators, *Amblyseius californicus* (Mc Gregor) (Acari: Phytoseiidae) and Predatory thrips *Scolothrips sexmaculatus*, (Pergande) (Thysanoptera: Thripidae) and minute pirate bug *Orius insidiosus* (Say), (Hemiptera: Anthocoridae), were counted before treatment and after three, seven and 14 days post-treatment by the aid of a stereomicroscope.

3-Calibration and Performance Adjustment of The Tested Equipment:

a- Collection of Spray Coverage of Droplets on Soybean Plants:

Before spraying each soybean field treatment, a sampling line was constructed of five-wire holders fixed in a diagonal line at each treatment to collect the lost spray between plants; each wire holder top has a fixed with water-sensitive paper (Novartis Cards ®) on it. Also,

each five soybean plants, of about 70 cm length, the water-sensitive paper cards were put at upper and lower levels of plants in each treatment; to collect the droplets deposit on soybean leaves, were designed according to the method described by Hindy (1989). After spraying, all cards were collected and transferred carefully to the laboratory for measuring and calculating the average number of droplets/cm² and its average droplet sizes (VMD) µm in all treatments.

b-Determination of Spray Droplets Distribution and Its Sizes:

Number and size of blue spots (deposited droplets) on each water sensitive cards (Novartis cards) measured with a special scaled monocular Japanese lens (Strüben)® (15X).The volume mean diameter (VMD) µm and an average number of droplets in one square centimeter (N/cm²) were estimated according to Hindy (1992), the spread factor of water-sensitive paper was 2.2.

c-Phytotoxic Effect:-

Determined by recording any colure change, leaf curling, or flaming up to 8 days after spraying, according to Badr *et al*. (1995).

Calculation and Data Analysis:

a.Reduction percentages in the average populations of *T. urticae* and its predators were calculated according Henderson and Tilton (1955) at two seasons.

.**b.** Obtained data were analyzed by using Proc ANOVA in SAS (Anonymous. 2003). Means separation was conducted using LSD in the same statistical program.

RESULTS

Field evaluation of two natural compounds, Humic acid and Chitosan Nano-Particles against adult females of the two-spotted spider mite, *T. urticae* and all movable stages (adults and immatures) of three of its associated predators *A.californicus*, *O. insidiosus* and *S. sexmaculatus* to compare their efficiency with a commonly used pesticide Abamectin, by using two ground spraying equipment, Micron ULVA sprayer (15L./fed.) and Hydraulic sprayer (Matabi). Data showed mortality percentages differ from the three compounds after three, seven, and 14 days after spraying Tables (2-6).

Table 2: The relation between droplets distribution obtained by the tested ground spraying equipment and the corresponding mortality on soybean plants during seasons (2019-2020) at Dakahlia.

Insecticide and dose rate	Tested sprayer	Upper level		Lower level		% Mortality General mean *			
		N /cm²	VMDµm	N /cm²	VMDµm	*T*	*A*	*O*	*S*
Abamectin (160 gm/ fed.)	Ulva	180	155	160	156	91	100	100	100
	Matabi	163	160	150	165	83.5	98.3	93	97.7
Humic acid (60cm³/ fed.)	Ulva	195	150	170	150	78	100	100	100
	Matabi	170	158	160	160	77.5	91.9	80.3	94.4
C.N.Ps. (133.33 ppm)	Ulva	170	160	148	165	80	37.7	52.1	54.2
	Matabi	159	167	149	169	71.2	50.6	50.2	57.5

VMD = Volume Mean Diameter. N / cm² = Number of droplets per square centimeter. *Average of two seasons, T= *T. urticae*, A= *A.californicus*, O= *O. insidiosus* and S= *S. sexmaculatus*.

Efficacy of Abamectin Against Spider Mite *T. urticae* and Its Associated Predators *A.californicus*, *O. insidiosus* and *S. sexmaculatus*, on Soybean:

The highest reduction in the population of *T. urticae* adult females occurred by Economy Micron ULVA sprayer (15 L/fed.). The average droplet sizes were 155 and 162 and average N/cm² were 170 and 156 for Economy Micron ULVA sprayer and Hydraulic sprayer (Matabi) during the two seasons (2019 and 2020), respectively. The mean mortality

percentages after three days of treatments with the recommended dose were 84.9 and 70.5 % with general mean reduction percentages 91 and 83.5 % for Economy Micron ULVA sprayer and Hydraulic sprayer (Matabi) during the two seasons (2019 and 2020), respectively.

For *A.californicus* adults and immatures, the mean mortality percentages after three days of treatment were 100 and 95% while the mean reduction percentages were 100 and 98.3% for the rest infestation, gotten for recommended dose sprayed with Economy Micron ULVA sprayer and Hydraulic sprayer (Matabi) during the two seasons, respectively. The mean mortality percentages of *O. insidiosus* nymphs and adults of the two seasons (2019 and 2020) after three days of treatment by using abamectin formulation were 100 and 79.1% reduction % of two seasons were 100 and 93% for recommended dose sprayed with Economy Micron ULVA sprayer, and Hydraulic sprayer (Matabi), respectively. The mean mortality percentages of *S. sexmaculatus* nymphs and adults after three days of treatment by using abamectin formulation were 100 and 93 % reduction percentages of two seasons were 100 and 97.7 % for recommended dose sprayed with Economy Micron ULVA sprayer and Hydraulic sprayer (Matabi) during the two seasons, respectively.

Efficacy of Humic Acid Against Spider Mite *T. urticae* and Its Associated Predators *A.californicus, O. insidiosus* and *S. sexmaculatus,* on Soybean:

The highest reduction in the population of *T. urticae* adult females and all movable stages of its associated predators was occurred by Economy Micron ULVA sprayer (15 L/fed.) .The average droplet sizes were 150 and 159 and average N/cm^2 were 182 and 165 for Economy Micron ULVA sprayer and Hydraulic sprayer (Matabi) during the two seasons (2019 and 2020), respectively. After three days of treatments, the mean mortality percentages for *T. urticae* were 61.6 and 52% for recommended dose sprayed with Economy Micron ULVA sprayer (15 L/fed.) and Hydraulic sprayer (Matabi), respectively. *A.californicus* showed mean reduction percentages of two seasons 100 and 91.9 % for recommended dose sprayed with Economy Micron ULVA sprayer and Hydraulic sprayer (Matabi), respectively. The mean mortality percentages of *O. insidiosus* by using humic acid formulation were 100 and 68.3 % and the general mean reduction percentages of two seasons were 100 and 80.3 % for the recommended dose. The mean mortality percentages of *S. sexmaculatus* were 100 and 90.2 % for recommended dose sprayed with Economy Micron ULVA sprayer and Hydraulic sprayer (Matabi), respectively.

Efficiency of Chitosan Nano-Particles (C.N.Ps) Against Spider Mite *T. urticae* and Its Associated Predators *A.californicus, O. insidiosus* and *S. sexmaculatus,* on Soybean:

The efficiency of C.N.Ps as mortality percentages after three, seven, and 14 days of spraying was presented in tables (2-6). The highest reduction in the population of *T. urticae* adult females was occurred by Economy Micron ULVA sprayer (15 L/fed.). The average droplet sizes were 162 and 168 and average N/cm^2 were 159 and 154 for Economy Micron ULVA sprayer and Hydraulic sprayer (Matabi) during the two seasons (2019 and 2020), respectively. The mean mortality percentages after three days of the two seasons (2019 and 2020) were 53.3 and 50%, and the general mean reduction percentages of two seasons 80 and 71.2 % with Motorized Economy Micron ULVA sprayer and Hydraulic sprayer (Matabi), respectively. The mean mortality percentages of all movable stages of *A.californicus, O. insidiosus* and *S. sexmaculatus* were 25.3 & 33.9 %, 29.7 & 28.9 % and 42.2 and 45 % after three days of treatment with recommended dose of C.N.Ps sprayed with Economy Micron ULVA sprayer and Hydraulic sprayer (Matabi), respectively.

There was a significant difference between both the distribution percentages of droplets numbers/cm^2 (LSD=9.15 between levels and 7.47 between tools, and 9.15 between compounds). Differences between droplet sizes VMD (LSD=2.67 between levels, 2.18 between tools, and 2.76 between compounds). Between reduction percentages (LSD=2.7472 for tools, 3.3646 for compounds) for *T. urticae* and (LSD=5.2831 for tools, 6.4704 for

compounds) for *A.californicus*, (LSD=4.5937 for tools, 5.6261 for compounds), for *O. insidiosus* and (LSD=2.5204 for tools, 3.0869 for compounds) for *S. sexmaculatus*.

Table 3: Reduction Percentages of *Tetranychus urticae* adult females affected by certain compounds sprayed with two ground equipment during the two seasons (2019-2020) after three, seven, and 14 days of treatments.

Equipment / Treatments	% Reduction after spraying															
	2019															
	3th				7th				14h				General mean			
	Micron ULVA (15L/fed).		Matabi (56 L/fed.)		Micron ULVA (15L/fed).		Matabi (56 L/fed.)		Micron ULVA (15L/fed).		Matabi (56 L/fed.)		Micron ULVA (15L/fed).		Matabi (56 L/fed.)	
	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %
Abamectin (160 gm/ fed.)	52	61	23	56	38	78	8	89	17	94.2	7	94	36	78	13	80
Humic acid (60cm³/ fed.)	44	85	29	73	38	90	20	87	3	99	9	96	28	91	19	85
C.N.Ps. (133.33 ppm)	63	52	18	54	39	77	12	79	24	91.5	8	90	42	74	13	74
Untreated control	119	_	125	_	153	_	160	_	256	_	267	_	176	_	184	_
2020																
	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %
Abamectin (160 gm/ fed.)	49	62.2	17	48.1	35	79	7	83.7	16	94.3	5	93	33	78	10	75
Humic acid (60cm³/ fed.)	34	84.7	25	67.9	29	90	17	83.3	5	99	9	95	23	91	17	82
C.N.Ps. (133.33 ppm)	54	55.1	15	46.5	34	78	11	70	21	91.9	7	89	36	86	11	68.4
Untreated control	111	_	120	_	145	_	157	_	240	_	268	_	165	_	182	_

C= Count of life adult females after treatments. R= % Reduction of adult females.

Table 4: Reduction Percentages of *Amblyseius californicu*s adults and immatures affected by certain compounds sprayed with certain ground equipment during the (2019- 2020) after three, seven, and 14 days of treatments.

Equipment / Treatments	% Reduction after spraying															
	2019															
	3th				7th				14h				General mean			
	Micron ULVA (15L/fed).		Matabi (56 L/fed.)		Micron ULVA (15L/fed).		Matabi (56 L/fed.)		Micron ULVA (15L/fed).		Matabi (56 L/fed.)		Micron ULVA (15L/fed).		Matabi (56 L/fed.)	
	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %
Humic No.1 (60 cm³/fed)	0	100	8	80.5	0	100	2	95.6	_	_	0	100	0	100	3.3	92
Abamectin (160cm3/fed)	0	100	2	95.8	0	100	0	100	_	_	_	_	0	100	1	98.6
C.N.Ps. (133.33 ppm)	61	20.5	56	17.9	59	23.1	27	64.7	55	45.2	25	71.6	58	29.6	36	51.4
Untreated control	55	_	58	_	62	_	65	_	72	_	75	_	63	_	66	_
2020																
	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %
Humic No.1 (60 cm³/fed)	0	100	9	79.3	_	_	2	96	_	_	0	100	0	100	4	91.8
Abamectin (160cm3/fed)	0	100	3	94.1	_	_	0	100	_	_	_	_	0	100	1	98
C.N.Ps. (133.33 ppm)	56	30	32	49.9	54	46	45	42	50	61.5	42	57.4	53	45.8	45	49.8
Untreated control	40	_	46	_	50	_	56	_	65	_	71	_	52	_	58	_

C= Count of life adults and immatures after treatments. R= % Reduction of adults and immatures .

Table 5: Reduction Percentages of *Orius insidiosus* nymphs and adults affected by certain compounds sprayed with certain ground equipment during the season (2019- 2020) after three, seven, and 14 days of treatments.

Equipment / Treatments	% Reduction after spraying															
	2019															
	3th				7th				14h				General mean			
	Micron ULVA (15L/fed).		Matabi (56 L/fed.)		Micron ULVA (15L/fed).		Matabi (56 L/fed.)		Micron ULVA (15L/fed).		Matabi (56 L/fed.)		Micron ULVA (15L/fed).		Matabi (56 L/fed.)	
	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %
Humic No.1 (60 cm³/fed)	0	100	10	69.1	0	100	20	57.5	0	100	0	100	0	100	10	75.5
Abamectin (160cm3/fed)	0	100	5	80.7	0	100	0	100	0	100	0	100	0	100	1.5	93.6
C.N.Ps. (133.33 ppm)	18	33	21	29.4	17	57.5	20	53.8	16	69.23	19	65.7	17	53.2	20	49.6
Untreated control	20	_	22	_	30	_	32	_	39	_	41	_	28	_	30	_
2020																
	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %
Humic No.1 (60 cm³/fed)	0	100	10	67.4	0	100	6	87.5	0	100	0	100	0	100	5	85
Abamectin (160cm3/fed)	0	100	6	77.5	0	100	0	100	0	100	0	100	0	100	2	92.5
C.N.Ps. (133.33 ppm)	23	26.4	21	28.4	22	57.7	20	56.4	20	69	19	67.6	22	51	20	50.8
Untreated control	15	_	16	_	25	_	25	_	31	_	32	_	24	_	25	_

C= Count of life nymphs and adults after treatments. R= % Reduction of nymphs and adults.

Table 6: Reduction Percentages of *Scolothrips sexmaculatus* nymphs and adults affected by certain compounds sprayed with certain ground equipment during the season (2019- 2020) after three, seven and 14 days of treatments.

Equipment / Treatments	% Reduction after spraying															
	2019															
	3th				7th				14h				General mean			
	Micron ULVA (15L/fed).		Matabi (56 L/fed.)		Micron ULVA (15L/fed).		Matabi (56 L/fed.)		Micron ULVA (15L/fed).		Matabi (56 L/fed.)		Micron ULVA (15L/fed).		Matabi (56 L/fed.)	
	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %
Humic No.1 (60 cm³/fed)	0	100	8	91	_	_	5	96	_	_	0	100	0	100	4.3	95.7
Abamectin (160cm3/fed)	0	100	6	94	_	_	0	100	_	_	0	100	0	100	2	98
C.N.Ps. (133.33 ppm)	56	47	48	44	64	57.3	47	60.5	52	76.7	46	72	54	60.3	47	58.8
Untreated control	70	_	75	_	100	_	105	_	149	_	154	_	106	_	111	_
2020																
	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %	C	R %
Humic No.1 (60 cm³/fed)	0	100	9	89.3	0	100	4	90	0	100	0	100	0	100	4	93.1
Abamectin (160cm3/fed)	0	100	8	91.9	0	100	0	100	0	100	0	100	0	100	3	97.3
C.N.Ps. (133.33 ppm)	47	37.3	42	46	45	48	48	58.4	44	58.8	61	64	45	48	38	56.1
Untreated control	45	_	63	_	52	_	93	_	64	_	138	_	95	_	98	_

C= Count of life nymphs and adults after treatments. R= % Reduction of nymphs and adults.

Relationship Between Lost Spray on The Ground and The Bioresidual Activity of Compounds Used:

Data in table (7) showed that there was a negative correlation between lost spray-on ground equipment and the efficacy activity of compounds used. The mean lost spray produced from Economy Micron ULVA sprayer spray volume (15 L\fed.) was 4.47% and the mean spray lost produced from Hydraulic sprayer (Matabi) spray volume (56L\ fed.) was 15.24 %, we extracted that the smaller spray volume the lesser spray lost.

a-Lost Spray of Economy Micron ULVA Sprayer:

Data in Table (7) showed that the lost spray percentages were 5.8, 4.7 and 5.9% from the total spray volumes, while the general mean in reduction percentages were 91, 78 and 80% for *T. urticae*; 100, 100 and 37.7 % for *A.californicus*; 100, 100 and 52.1 % for *O. insidiosus* and 100, 100 and 54.2 % on *S. sexmaculatus*, for Abamectin, Humic acid, Chitosan Nanoparticles (C.N.Ps), respectively during the two seasons 2019 and 2020.

b-Lost Spray of Hydraulic Sprayer (Matabi):

Data in Table (7) showed that the lost spray percentages were 15.2, 14.5 and16 % from the total spray volumes in the case of Abamectin, Humic acid, and Chitosan Nanoparticles (C.N.Ps), respectively. The general mean of reduction percentages of the two seasons (2019-2020) were 83.5, 77.5 and 71.2% for *T. urticae* adult females, 98.3, 91.1 and 50.6% for *A.californicus*; 93, 80.3 and 50.2% for *O. insidiosus* and 97.7, 94.4 and 57.5 % *S. sexmaculatus* at total recommended doses for the same compounds, respectively.

Table 7: Lost spray-on ground, as produced by low volume ground spraying equipment, against *T. urticae* adult females during seasons (2019-2020).

Insecticide and dose rate	Tested sprayer and spray volume (L / fed.)	*N / cm^2 of total spray droplets	N / cm^2 roplets lost on ground)	Volume mean diameter VMD (on ground)	% N/cm^2 (ground) ——— x 100 N/Cm^2 (Plants+ground)	% Mortality General mean *
Abamectin (160 gm/ fed.)	Ulva (15)	361	21	169	5.8	91
	Matabi(56)	369	56	169	15.2	83.5
Humic acid (60 cm^3/ fed.)	Ulva (15)	383	18	161	4.7	78
	Matabi (56)	385	56	169	14.5	77.5
C.N.Ps. (133.33 ppm)	Ulva (15)	338	20	170	5.9	80
	Matabi (56)	367	59	165	16	71.2

N /cm^2 = Number of droplets per square centimeter. * On soybean and lost spray on ground. *Average of two seasons.

Rate of Performance fed./day of Sprayers Used on Soybean:

The rate of performance of Hand-held Hydraulic sprayer (Matabi) (56 L./Fed.), Economy Micron ULVA (15L./Fed.) was 3.55 Fed./day,3.30 Fed./day, respectively.

Relations Between Spray Quality and The General Reduction Percentages of Two Seasons of Certain Insecticides Applied on Soybean Season:

Data in Table (8) showed that Abamectin, Humic acid followed by Chitosan Nano-Particles, respectively. Using two ground spraying equipment and varied spraying volumes depending on the sprayer used. Data indicated that all the tested spraying equipment gave satisfactory coverage on soybean crop i.e. more than 50 droplets/ cm^2, and droplet sizes ranged from 150 to 170 μm (VMD). The difference in the mortality percentage was due to the different modes of action of the compounds insecticides and the degree of homogeneity of droplets spectrum in the case of Economy micron Ulva is higher than handheld Hydraulic (Matabi) sprayer.

Table 8: Relationship between field spray quality (homogeneity) of certain equipment in 2019 and 2020 seasons against *T. urticae* at Dakahlia Governorate.

Equipment	Economy Micron Ulva (15L./Fed.)			Hand-held hydraulic Matabi (56L./Fed.)		
Treatments	Abamectin	Humic acid	Chitosan nanoparticles	Abamectin	Humic acid	Chitosan nanoparticles
	S.Q	S.Q	S.Q	S.Q	S.Q	S.Q
Upper Level	0.86	0.77	0.94	0.98	0.93	1.05
Lower Level	0.98	0.88	1.1	1.1	1	1.1

S.Q = spray quality. = VMD/N/cm^2= Spray quality (degree of homogeneity).
The spray height is constant ~ 0.5 meters in all treatments.
VMD= Volume mean diameter, N/cm^2= Number of droplets/cm^{-2}

The Following Remarks and Results Were Obtained:

-There was no phytotoxic effect on soybean leaves after treatments with three compounds, no change in the leaves color, no leaf curling or flaming up phenomena occurred, plants sprayed with C.N.Ps. recovered and showed better growth than the mite-infested plants.

-Insecticides treated plants revealed the lowest soybean yield loss in comparison with untreated plots; their application reduced the incidence of two-spotted spider mite *T. urticae* adult females infestation on soybean and decreased the percent loss of soybean yield in all treatments and with all sprayers.

- Plants treated with C.N.Ps. showed increases in the number of associated natural enemies after treatments, therefore, C.N.Ps. may help in sustainable agricultural programs.

DISCUSSION

The field experiment was carried out on an infested area with two-spotted spider mite, *T. urticae*, some of its enemies (*A.californicus*, O. *insidiosus*, and S. *sexmaculatus*) were naturally found. For evaluation of the field performance of Low-Volume spraying machines; Economy Micron Ulva (15L. /Fed.) and Hydraulic sprayer (Matabi) (56 L. /fed.); to spray Abamectin, Humic acid, Chitosan Nano-Particles, with the full recommended dose. A satisfactory coverage was obtained on soybean, the droplets spectrum was obtained in field experiment was agreed with the optimum droplet sizes which mentioned by Himel (1969), (Himel *et. al.*, 1969) in the optimum droplet size to control cotton leafworm in cotton fields by ground equipment. Abamectin and Humic acid revealed the best bio-efficacy results with the two equipment followed by the Chitosan nanoparticles, and these results agreed with Hindy *et al.* (2004), Genidy *et al.* (2005) which recommended KZ oil and Pyriproxyfen followed by Agerin by using low volume spraying because of reducing the time lost in the process filling the machines, improve the homogeneity of the spray solution on the plant leaves and saving the lost spray on the ground, these results also in agreement with Bakr *et al*. (2014*)* recommendation by using Profenofos followed by Pyriproxyfen and Spinosad with Agromondo motorized knapsack sprayer (20L/fed.) and Morsy *et al.* (2015) whom recommended using Carbosolvan, Acetamiprid and Deltamethrin with low volume machines not less than (15 L/fed.), also Dar (2016) recommendation whenever using Lufenuron followed by Spinosad in controlling cotton leafworm on Clover with low volume machines. Abamectin, Humic acid, and Chitosan Nanoparticles (C.N.Ps), respectively revealed successful results in controlling *T. urticae* adult females. Also, Chitosan nanoparticles have lower toxicity and more safe on *A.californicus*, O. *insidiosus*, and S. *sexmaculatus* , the natural enemies existed, these results were in agreement with Alakhdar(2020) evaluated the effect of the Lc_{90} value of C.N.Ps. on *T. urticae* under field conditions on Green beans (*Phaseolus vulgaris* L.). It was found to be potent against *T. urticae*, as it caused 94.35,

93.33, and 90.73% reduction percentages for *T. urticae* at 133.33 ppm after three, seven and 14 days of treatment, respectively. The mortality percentage of Chitosan Nano-Particles tested against the predatory mites *A. californicus* were 17.5, after three days of treatment. Moreover, another nanomaterial was evaluated against *T. urticae* and *T. cinnabarinus* and their natural predators, *Orius insidiosus*, *Phytoseiulus persimilis*, and *Stethorus punctillum*. Silica Nano-Particles showed mortality percentages of *T. urticae* adults 32.5, 35, 67.5, and 85% at the concentrations of 50, 100, 200, and 400 ppm, respectively, under laboratory conditions, after 7 days post-treatment. Alakhdar and Elsamahy (2016) also reported that the mortality percentages were 32.5, 35, and 97.5% for *O. insidiosus*, *P. persimilis*, and *S. punctillum* after the same time of treatment, respectively. Tabozada (2013) who reviewed that Thiamethoxam has more indirect toxicity than Thiaclopride on *Chrysoperla carnea* nymphs and affected the predation capacity on *Tuta absoluta* larvae. Also, Dar (2016) who reported that Profenofos was more toxic to *Chrysoprla carnea* nymphs than other insecticides.

Also, Economy Micron Ulva revealed the lowest spray volume and the lowest percentages of lost spraying between plants about 4.47 % and Hydraulic sprayer (Matabi), spray lost about 15.25 %, these results were agreed with Hindy *et al.* (1997), Dar *et al.* (2019), Dar *et al*. (2020) who mentioned that there was a positive correlation relationship between the rate of application and lost spray-on ground. The data showed that Economy Micron ULVA was the best equipment to control *Tetranychus urticae* on Soybean according to the homogeneity of droplet spectrum, this in agreement with Dobson (2001) who illustrated the typical values for spray quality (homogeneity)=more than 2.5 (very poor) for hydraulic nozzle whereas =1.2 for a spinning disc, respectively.

Conclusion

It could be concluded that, using Abamectin, Humic acid, respectively followed by Chitosan Nano-Particles with low volume (LV) ground spraying equipment with not less than (15 L./fed.) by using recommended doses which revealed successful management against *T. urticae* on soybean under our local conditions and make a lesser harm to natural enemies to protect the natural equilibrium of the environment. We hope that in farther work we must use 3\4 or 1\2 recommended dose in order to keep the natural enemies in their natural counts.

There was a negative complete correlation between droplet sizes and the mean of mortality of *T. urticae* adult females, *A.californicus* adults, and immatures while there was a positive complete correlation between N/cm² and the mean mortality of T. *urticae* adult females, *A.californicus* immatures and adults, *O. insidiosus* nymphs and adults, *S. sexmaculatus* nymphs and adults in all treatments.

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ARABIC SUMMARY

مقارنة حقلية بين مركبين طبيعيين و مبيد اكاروسى على العنكبوت ذو النقطتين وثلاثة من اعدائه الحيوية باستخدام الات رش ارضية معينة على فول الصويا فى مصر

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معهد بحوث وقاية النباتات – مركز البحوث الزراعية– الدقي – الجيزة

يهدف هذا البحث الي تقييم التأثير القاتل لإثنان من المواد الطبيعية و هما حمض الهيومك و النانو شيتوزان مقارنة بمبيد أكاروسي معتمد أبامكتين (جولد) على العنكبوت الاحمر ذي البقعين *Tetranychus urticae* وثلاثة من أعدائه الحيوية وهم المفترس الاكاروسي *Phytoseiulus persimilis* , خنفساء الاوريوس *Orius insidiosus* والتربس المفترس *Scolothrips sexmaculatus* على نبات فول الصويا أثناء موسمى الزراعة 2019و 2020. أجريت التجارب الحقلية في مساحة 14 قيراط على الصنف صنف (جيزة 111) في منتصف شهر يونيو في أجا محافظة الدقهلية. تم تقسيم المنطقة المختارة الى 6 قطع معاملة و الكنترول. و تم رش المركبات بالجرعة الموصى بها من قبل وزارة الزراعة للمبيد الأكاروسى أبامكتين والمغذى النباتى حمض الهيوميك والجرعة المميتة 90% (LC_{90}) ل النانو شيتوزان . كما تم رش كل معاملة باستخدام آلتين رش و هما الرشاشة ميكرون اولفا الاقتصادية (15 لتر\فدان) و الرشاشة اليدوية ميتابى الهيدوليكية (56 لتر\فدان). أوضحت النتائج أن جميع المركبات حققت نسب خفض على الطور البالغ (الانثي) من العنكبوت الاحمر بآلتى الرش. و كان أكثر المركبات كفاءة أبامكتين يليه حمض الهيوميك مع تأثير سلبي على الاعداء الحيوية. بينما كان النانو شيتوزان أكثرهم أمانا على جميع الأطوار المتحركة من الأعداء الحيوية مع نسب خفض متوسطة للأفه و من ذلك يمكن التوصية بإدراج هذه المركبات في برامج المكافحة المتكاملة للعنكبوت الأحر ذي البقعتين بإستخدام معدات أرضية ذات حجوم رش قليلة التي لا تقل عن (15 لتر\فدان) للحصول على نتائج مكافحة مرضية مع تغطية مرضية من قطيرات الرش على نباتات فول الصويا وتراوح مدى طيف الرش بين 150 و170 ميكرون لاحجام القطيرات ومن 18 الى 199 قطيرة فى السم المربع مع تحقيق وفرة فى كميات المياة اللازمة للفدان 0حيثما أوضحت النتائج أنه كلما قل معدل التطبيق للآلة قل الفاقد من الرش على الأرض بين النباتات. كما حققت الرشاشة ميتابى الهيدوليكية أعلى معدل كفاءة تشغيل يومى بمقدار3,55 فدان\يوم بينما حققت الرشاشة ميكرون أولفا الاقتصادية أقل معدل كفاءة تشغيل يومى بمقدار3,3 فدان فى اليوم.