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EFFICACY OF SPINOSAD AND MINERAL OIL AGAINST THE WHITEFLY *BEMESIA TABACI* (GENNADIUS) (HOMOPTERA: ALEYRODIDAE) INFESTING CANTALOUPE *CUCUMIS MELO* L. IN THE FIELD.

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ABSTRACT

Field experiments were carried out to evaluate the efficacy of foliar application of spinosad and mineral oil applied alone or in mixtures against *B. tabaci* on cantaloupe. All experiments were conducted at The Agriculture Research Station, Etay El Baroud, El-Beheira Governorate, Egypt, during the growing seasons of cantaloupe in 2004 and 2005. The commercial cultivar of the crop used in this study was the cantaloupe variety Shahed El-Dokky.

Foliar application of spinosad (Tracer 24% SC) at the higher rate of 30 ml/100 liters of water was more effective against *B. tabaci* immature, adults and egg deposition on cantaloupe than at the lower rate of 20 ml/100 liters of water. In the growing seasons (2004 and 2005), application of spinosad 30 ml applied singly or combined with 1 L mineral oil 95% EC caused 45.62% and 57.79 % reduction in adult population of *B. tabaci*, respectively. Spinosad 20 ml combined with the mineral oil provided next better control against *B. tabaci* causing 51.18 % reduction in the adult population. Spinosad 20 ml/100 L alone achieved 40.65 % reduction in *B. tabaci* population. The single application of mineral oil causing 52.09 % reduction in *B. tabaci* adult population.

Foliar spray of mixture of spinosad 30 ml and the mineral oil provided the best efficacy inducing 59.86% reduction in immature population. Application of the mineral oil alone caused 57.24% reduction in *B. tabaci* immature population while spinosad 20 ml + the mineral oil induced 50.30 % in *B. tabaci* immature population.

The highest mean percentage reduction in the number of eggs laid by *B. tabaci* in 2004-2005 (57.02 %) was obtained by foliar spray of spinosad 30 ml mixed with the mineral oil followed by the mineral oil alone (54.84 % reduction).

This study revealed that, there were no compatibility problems in insecticide performance by combining spinosad with the mineral oil on the plant, and it is clear from the obtained results in the present study that mixtures of spinosad and the mineral oil gave superior white fly control.

Key words: spinosad, mineral oil, *Bemesia tabaci.*

INTRODUCTION

The sweet potato whitefly, *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae) is one of the most serious economic agricultural pests worldwide (Byrne and Bellows 1991) and Egypt (El-Khayat *et al.* 1994). To reduce losses caused by *B. tabaci,* numerous chemical insecticides were applied in agronomic cropping systems. These treatments have resulted in development of resistance to various groups of conventional insecticides after only few applications (Georghiou 1983; Sawicki and Denholm 1987; Herron and Rophail 1998; Gorman *et al.* 2001).

Cantaloupe, *Cucumis melo* L. is one of the cucurbits and considered an important tasty nutrition fruit, which add lots of vitamin A and C to human diet, and is grown in large area in Egypt mainly during summer. The realization of optimal yield of vegetable crops including potatoes and cantaloupe is often constrained by a number of serious pests and virus diseases vectored by them.

Certain chemicals derived either from plants or from certain microorganisms, or biopesticides, have been promoted in recent years. These include spinosad and neonicotinoids.

Spinosad is a bionaturnal pesticide and classified as a reduced risk insecticide (Ishaaya *et al.* 2001). The active ingredient is derived from aerobic fermentation of the naturally occurring soil dwelling bacterium *Saccharopolyspora spinosa*, a rare actinomycete (Sparks *et al.* 1998). It is used on crops against insect pests with high selectivity concerning mammals or wildlife (Kadam et al. 2006; Ramesh and Ukey 2006 a, b). It is used to control several insect pests including *B. tabaci* (Ochou and Martin 2003; Aslam *et al.* 2003; Prabhat and Poehling 2007). Despite its activity against insects following application, in green house and field applications its residual activity sharply declined within few days (Prabhat and Poehling 2007. Persistence of spinosad was comparably high in the laboratory, but in the green house a faster decline of activity was evident by increased egg deposition, egg hatch and reduced rates of immature mortality

The use of mineral oils or surfactants in combination with rapidly decomposing pesticides extends their foliar residual toxicity, especially to phytophagous insects under green house and field conditions (Dybas 1989; Horowitz *et al.* 1997). Mineral oils applied alone efficiently controlled whitefly populations and can be used as an alternative in integrated pest management (Gonzalez- Acosta et al. 2006). Horowitz *et al.* (1997) in field trials have demonstrated considerable control of *B. tabaci* populations using mixtures of abamectin plus mineral oils. This may be used in alteration with other effective novel compounds in insecticide resistance management strategies especially when whiteflies are present in the field.

The present study aimed to investigate the efficacy of spinosad and mineral oils applied alone or in mixtures against *Bemisia tabaci* on cantaloupe.

MATERIALS AND METHODS

All experiments were conducted at The Agriculture Research Station, Etay El Baroud, El-Beheira Governorate, Egypt, during the growing seasons of cantaloupe in 2004 and 2005. The commercial cultivars of the cantaloupe variety Shahed El-Dokky. Row spacing, plant spacing and seasonal maintenance procedures were conducted following the local agronomic practices. Cantaloupe was planted on 3 April 2004 and 2005 in rows 120 cm wide and 6.5 m long 30 cm between hills, and 40 cm between plants.

Treatment regimens. Spinosed (Tracer 24% SC) and KZ oil mineral oil (95% EC) were applied alone or in mixtures against *B. tabaci* on cantaloupe during the summer growing seasons of 2004-2005. The study was conducted in a field of cantaloupe plots that was 756 m^2. Experimental design was a randomized block with three replicates and 6 treatments. Three plots received no insecticides served as control. The plots were sprayed with Tracer (spinosad) alone at a rate of 120 ml and 80 ml. AI/Feddan. KZ oil was applied alone at a standard rate of 4 Liters AI/Feddan. Mixture of both compounds was used at the rate of 30 ml Tracer + 1 L KZ oil, 20 ml Tracer + 1 L KZ oil/ 100 L water. The plots were sprayed on 17 April 2004 and 19 April 2005 (2 weeks after planting); with knap sack motorized sprayer 20 liters capacity (Coogle Peger Comp. UK). Estimates of *B. tabaci* populations on 25 randomly selected leaved per plot (25/ replicate) 3 replicates were done on days 0, 1, 3, 5 and 7 for adults and 2, 5 and 7 days for eggs and immature after insecticide applications.

Table 1 : Mean number of *Bemisia tabaci* adults infesting cantaloupe treated with foliar spray of spinosad and the mineral oil applied alone or in mixtures during 2004 growing seasons .

Treatment	Rate / 100 liters of water (*)	Mean ± SE no. of *B. tabaci* adults / 25 leaves				
		Pretreatment mean numbers (±SE)	Mean numbers (±SE) after spraying:			
			1 day	3 day	5 day	7 day
Spinosad alone	30 ml	138.67 ± 26.45	68.67 ± 6.99 bc	81.00 ± 7.03 bc	96.00 ± 3.79 b	110.00± 9.55 bc
	20 ml	136.00 ± 14.19	78.67 ± 5.37 b	87.33 ± 8.42 b	102.00 ± 17.49 b	115.00 ± 14.12 b
Spinosad + Mineral oil	30 ml + 1 liter	140.67 ± 21.45	47.00 ± 16.67 bc	58.00 ± 10.45 bc	85.33 ± 3.85 b	82.00 ± 9.55 bc
	20 ml + 1 liter	102.33 ± 7.32	48.33 ± 6.85 bc	55.00 ± 7.10 c	66.33 ± 3.76 b	78.67 ± 5.55 c
Mineral oil alone	1 liter	134.00 ± 13.76	37.33 ± 9.95 c	60.67 ± 10.43 bc	98.67 ± 16.76 b	116.33 ± 5.24 b
Control	...	**138.67 ± 25.34**	**146.33 ± 12.56 a**	**147.33 ± 12.56 a**	**169.67 ±13.89 a**	**182.67 ± 15.88 a**
	F		12.18	9.02	13.33	14.52
	LSD		33.06	36.05	29.38	32.27

Means in the same column followed by the same letters are not significantly different (P =0.05) (Duncan Multiple rang test in SAS). SC: Soluble concentration. EC: Emulsfiable concentrate. (*) As recommended by the Ministry of Agriculture

The population of *B. tabaci* was monitored on 25 randomly selected cantaloupe leaves per 8 plots. Adults of *B. tabaci* were counted on the lower surfaces of leaves in the field. The 25 leaf sample unit was individually placed in paper bags and transferred to the laboratory. In the laboratory, the number of *B. tabaci* eggs and immature stages (nymphs and pupae) in the samples were counted separately using a binuclear microscope (30X) in one viewing area of the objective (1 $inch^2$). Collections of leaves were made at sunrise between (7and 9 a.m.) and before the activity of whitefly adults.

Statistical analysis

Percentage reduction of *B. tabaci* populations was calculated from the pooled data for all replicates according to Abbott's formula (1925). Data for each application were analyzed as a 1-way analysis of variance (ANOVA) using Duncan Multiple *F* test (P= 0.05) to distinguish treatment mean differences "SAS Institute 1995". Initial reduction was calculated one day after treatment of adults and two days after treatment for eggs and immature of *B. tabaci*. Data for each application were analyzed as a 1-way analysis of variance (ANOVA) using Duncan Multiple *F* test (P= 0.05) to distinguish treatment mean differences (SAS Institute 1995)

RESULTS

Spinosad (Tracer 24% SC), applied as foliar treatment, singly or in combination with the mineral oil (KZ oil 95% EC) protected cantaloupe from *B. tabaci* infestation. There were no compatibility problems in insecticide performance by combining spinosad with the mineral oil on the plant.

In 2004 and 2005, the pretreatment *B. tabaci* population in the control plots reached 138.67 ± 25.34, 172.00 ± 10.23 respectively (table 1, 2). Foliar application of Tracer alone at the higher rate of 30 ml/100 liters significantly (F = 2.09; LSD = 14.4; p = 0.05) reduced the population of whitefly adults relative to the untreated control by 53.07, 45.02, 43.42 and 39.80 % 1, 3, 5, and 7 days after application respectively (table 3). In 2005, comparable significant (F = 2.46; LSD = 12.88; p = 0.05) reductions of adult population were obtained by application of Tracer alone at the rate of 30 ml/ 100 liters of water (53.26, 46.07, 43.87, 40.39 %, 1, 3, 5 and 7 days after application) respectively (table 4).

Tracer at the rate of 20 ml/ 100 liters of water was relatively less effective against adults inducing 45.18, 39.56, 38.70, 35.81 percentage reduction 1,3,5,7 days after application in 2004. Similar results were observed in 2005. In 2004, application of the mineral oil at the rate of 1 litre/100 liters of water

Table 2 : Mean number of *Bemisia tabaci* adults infesting cantaloupe treated with foliar spray of spinosad and the mineral oil applied alone or in mixtures during 2005 growing seasons .

Treatment	Rate / 100 liters of water (*)	Pretreatment mean numbers (± SE)	Mean numbers (± SE) of adults / 25 leaves after spraying			
			1 day	3 day	5 day	7 day
Spinosad alone	30 ml	160.00 ± 22.63	79.14 ± 7.85 b	99.67 ± 4.34 b	90.33 ± 12.72 b	98.33 ± 8.85 b
	20 ml	146.00 ± 18.74	81.33 ± 11.00 b	96.67± 7.70 b	89.29 ± 4.26 b	95.30 ± 14.33 b
Spinosad + Mineral oil	30 ml + 1 liter	165.33 ± 15.66	55.03 ± 12.62 b	71.33 ± 2.73 bc	81.33 ± 6.39 b	95.00 ± 21.82 b
	20 ml + 1 liter	157.67 ± 6.70	56.39 ± 10.05 b	74.67 ± 18.04 bc	82.04 ± 8.03 b	93.32 ± 5.61 b
Mineral oil alone	1 liter	135.33 ± 10.18	48.33 ± 13.36 b	63.67 ± 4.67 c	82.00 ± 24.57 b	74.67 ± 8.10 b
Control	...	**172.00 ± 10.23**	**182.00 ± 7.10 a**	**198.67 ± 8.36 a**	**173.00 ± 8.51 a**	**177.33 ± 5.18 a**
	F		8.88	8.71	29.96	22.37
	LSD		37.35	38.96	28.18	32.57

Means in the same column followed by the same letters are not significantly different (P =0.05) (Duncan Multiple rang test in SAS). SC: Soluble concentration. EC: Emulsfiable concentrate. (*) As recommended by the Ministry of Agriculture

Table 3 : Efficacy of foliar applications of spinosad (Tracer 4% SC) and the mineral oil (KZ oil 95% EC) applied alone or in mixtures against *Bemisia tabaci* adults on cantaloupe during 2004.

Treatment	Rate / 100 liters of water (*)	Mean % reduction				Total Mean % reduction
		Days after spraying				
		1 day	3 day	5 day	7 day	
Spinosad alone	30 ml	53.07	45.02	43.42	39.80	**45.33 AB**
	20 ml	45.18	39..56	38.70	35.81	**39.81 B**
Spinosad + mineral oil	30 ml + 1 liter	68.34	61.2	50.42	55.75	**58.93 A**
	20 ml + 1 liter	55.24	49.41	47.02	41.64	**48.33 AB**
Mineral oil alone	1 liter	73.60	57.39	39.82	34.1	**51.23 AB**
F =	2.09	*LSD* =	14.403			

Means in the same column followed by the same letters are not significantly different ($P = 0.05$) (Duncan Multiple rang test in SAS). SC: Soluble concentration. EC: Emulsfiable concentrate. (*) As recommended by The Ministry of Agriculture.

Table 4 : Efficacy of foliar applications of spinosad (Tracer 4% SC) and the mineral oil (KZ oil 95% EC) applied alone or in mixtures against *Bemisia tabaci* adults on cantaloupe during 2005.

	Rate / 100 liters of water (*)	Mean % reduction				Total Mean
		Days after spraying				
		1 day	3 day	5 day	7 day	% reduction
Spinosad alone	30 ml	53.26	46.07	43.87	40.39	**45.90 AB**
	20 ml	47.35	42.68	39.2	36.70	**41.48 B**
Spinosad + Mineral oil	30 ml + 1 liter	68.54	62.65	51.09	44.27	**56.64 A**
	20 ml + 1 liter	66.20	59.00	48.3	42.59	**54.02 AB**
Mineral oil alone	1 liter	66.25	59.27	39.76	46.48	**52.94 A**
F =	2.46	*LSD* =	12.884			

Means in the same column followed by the same letters are not significantly different ($P = 0.05$) (Duncan Multiple rang test in SAS). SC: Soluble concentration. EC: Emulsfiable concentrate. (*) As recommended by The Ministry of Agriculture.

effectively suppressed *B. tabaci* population by 73.60, 57.39, 39.82, 34.1%, 1, 3, 5 and 7 days after treatment respectively. In 2005, reductions in the populations of adults by 66.25, 59.27, 39.76 and 46.48% were detected 1, 3, 5 and 7 days after treatment respectively. Foliar application of mixtures of Tracer and the mineral oil appeared to improve the efficacy of Tracer against adults than single application of the insecticide. In 2004, Tracer at the rate of 30 ml + IL /100 L of water combined with the mineral oil reduced adult population by 68.34 and 61.20% on day 1 and day 3 post application respectively. However, this combination was less effective on day 5 and day 7 (50.42 and 55.75% respectively). Similar results were obtained in 2005. Foliar application of a mixture of Tracer at the rate of 20 ml + IL /100 L of water with the mineral oil was less effective inducing 55.24, 49.41, 47.02 and 41.64% reduction in adult population on 1,3,5 and 7 days post application respectively. Comparable reductions of adult populations were observed in 2005 using this combination. In 2004 and 2005, application of Tracer at the higher rate of 30+ IL /100 L ml alone caused 45.62 mean percentage reduction of adults which was comparable to that of mixture of Tracer and mineral oil (57.79 %reduction). Tracer at the rate of 20 ml/ 100 L combined with the mineral oil provided next better control causing 51.18 % reduction in the adult population. Spinosad 20 ml/100 L alone achieved 40.65 % reduction in *adult* population.

The numbers of *B. tabaci* immature in all treatment plots were significantly decreased than the immature numbers in the control plots in 2004 and 2005 (table 5, 6). Whereas, immature population in all treatment plots (Tracer, mineral oil, and their mixture) were not significantly different in most cases.

In 2004 and 2005, compared with the control, the field relevant rate of Tracer alone at the higher rate of 30 ml/100 L of water led to significant decrease in immature numbers on cantaloupe. Moderate efficacy was observed on day 2 and 5 post-treatment (44.96 and 43.15% reduction) respectively. However, on day 7 post- treatment, the activity of Tracer applied alone decreased and induced 39.50 % reduction in immature populations. Comparable results were obtained in 2005. The efficacy of Tracer applied alone at the lower rate of 20 ml/100 L of water was less effective than that at the higher rate applied in 2004, where reductions of 39.35, 39.33 and 32.52 % on day 2, 5 and 7 respectively were achieved. In 2005, Tracer reduced immature populations by 37.42, 35.48 and 32.30 % on days 2, 5 and 7 respectively (Table 7, 8). Application of the mineral oil alone significantly reduced immature population as compared to the control (60.06, 57.56 and 54.18% reduction, 2, 5 and 7 days post application) respectively in 2004. Similar results were observed in 2005. Mixtures of Tracer and mineral

Table 5: Mean number of *Bemisia tabaci* immature on cantaloupe treated with foliar spray of spinosad (Tracer 24% SC) and the mineral oil (KZ oil 95%EC) applied alone or in mixtures during 2004 growing seasons .

Treatment	Rate / 100 liters of water (*)	Mean number (± SE) of adults / 25 leaves of *B. tabaci* immature / 25 inch^2			
		Pretreatment	Days after spraying		
			2 days	5 days	7 days
Spinosad alone	30 ml	82.33 ± 9.27	143.67 ± 5.24 bc	158.67 ± 6.34 bc	183.32 ± 10.28 bc
	20 ml	82.00 ± 11.80	157.67 ± 7.68 b	168.67 ± 21.82 b	203.67 ± 17.73 b
Spinosad + Mineral oil	30 ml + 1 liter	84.00 ± 9.66	103.33 ± 7.13 d	113.33 ± 12.25 c	135.00± 8.90 c
	20 ml + 1 liter	78.00 ± 7.78	119.67 ± 5.46 cd	128.67 ± 13.97 bc	160.00 ± 9.30 bc
Mineral oil alone	1 liter	79.00 ± 6.57	100.02 ± 6.09 d	113.67 ± 5.85 c	133.22 ± 9.54 c
Control	...	**80.33 ± 4.67**	**254.67 ± 14.19 a**	**272.33 ± 26.62 a**	**295.67 ± 26.47 a**
	F		12.31	7.62	19.52
	LSD		32.66	42.97	25.17

Means in the same column followed by the same letters are not significantly different (P = 0.05) (Duncan Multiple rang test in SAS). SC: Soluble concentration. EC: Emulsfiable concentrate. (*) As recommended by the ministry of Agriculture

Table 6: Mean number of *Bemisia tabaci* immature on cantaloupe treated with foliar spray of spinosad (Tracer 24% SC) and the mineral oil (KZ oil 95%EC) applied alone or in mixtures during 2005 growing seasons .

Treatment	Rate / 100 liters of water (*)	Mean number (± SE) of immature / 25 inch^2			
		0 day	Days after spraying		
			2 days	5 days	7 days
Spinosad alone	30 ml	103.67 ± 6.34	127.00 ± 20.13 b	160.33 ± 23.17 b	173.67 ± 18.50 b
	20 ml	96.00 ± 22.94	132.33 ± 17.40 b	157.67 ± 10.35 b	177.33 ± 16.78 b
Spinosad + Mineral oil	30 ml + 1 liter	105.00 ± 20.06	89.00 ± 9.01 c	106.00 ± 6.51 c	116.00 ± 27.62 c
	20 ml + 1 liter	96.67 ± 4.41	101.33 ± 6.18 bc	120.33 ± 9.22 bc	129.00 ± 8.20 bc
Mineral oil alone	1 liter	105.67 ± 6.18	90.00 ± 17.95 bc	119.67 ± 6.70 bc	130.33 ± 14.44 bc
Control	...	**116.67 ± 5.90**	**257.00 ± 18.70 a**	**297.00 ± 13.07 a**	**318.33 ± 7.23 a**
	F		15.42	19.53	32.7
	LSD		33.84	34.40	26.37

Means in the same column followea by the same letters are not significantly different ($P = 0.05$) (Duncan Multiple rang test in SAS). SC: Soluble concentration. EC: Emulsfiable concentrate. (*) As recommended by the ministry of Agriculture oil decreased immature population levels throughout the experiment largely than Tracer alone. Tracer at the higher rate mixed with the mineral oil resulted in 61.20, 60.20 and 56.34 % reduction, 2, 5 and 7 days post application. Tracer at the lower rate mixed with the mineral oil was significantly less effective ($F = 24.22$; $LSD = 6.05$; $p = 0.05$) and resulted in 51.61, 51.34 and 44.27 % reduction, 2, 5 and 7 days post application in 2004 and in 2005 ($F = 56.02$; $LSD = 4.54$; $p = 0.05$).

Foliar spray of mixture of Tracer at the higher rate and the mineral oil provided the best efficacy inducing 59.86% reduction in immature population. Application of the mineral oil alone caused 57.24% reduction in immature population while Tracer at the lower rate mixed with the mineral oil induced 50.30 % in immature population.

In 2004 and 2005, the ovipositional pattern of *B. tabaci* showed a decrease in egg laying on cantaloupe sprayed with Tracer alone at the higher rate (Table 9, 10). Tracer alone at the higher rate caused significant reduction ($F = 8.94$; $LSD = 13,93$; $p = 0.05$), 45.39 and 42.56 % in the numbers of eggs deposited on treated plants 2 and 5 days post application respectively. However, on day 7 post-treatment the activity of Tracer decreased inducing 22.90 % reduction in the number of eggs deposited on the plant. Similar results were obtained in 2005 (Table 11, 12). Reduction in the number of eggs on cantaloupe sprayed with Tracer alone at the lower rate was much less effective than that reported on cantaloupe sprayed with spinosad at the higher rate. In 2004, the numbers of eggs were significantly reduced by 27.03, 24.63 and 19.41% on days 2, 5 and 7 the post treatment respectively ($F = 8.94$; $LSD = 13, 93$; $p = 0.05$). Similar reductions in the numbers of eggs were observed in 2005. In 2004, application of the mineral oil alone reduced the numbers of eggs on the leaves by 57.05, 56.40, and 47.71 % on days 2, 5 and 7-post treatment respectively. Meanwhile, addition of the mineral oil to Tracer at the higher rate induced 62.30, 59.00 and 44.6 % reduction in the numbers of eggs 2, 5 and 7 days post- treatment respectively. Reduction the numbers of eggs deposited on cantaloupe sprayed with mixture of Tracer at the lower rate and the mineral oil induced 42.87, 40.74 and 40.60 % reduction in egg numbers 2, 5 and 7 days post treatment. Similar results were obtained in 2005. In most cases, the numbers of eggs deposited by *B. tabaci* in all treatment plots (Tracer, mineral oil and their mixtures) were not significantly different. The highest mean percentage reduction in the number of eggs laid by *B. tabaci in* 2004-2005 (57.02 %) was obtained by foliar spray of Tracer at the higher rate mixed with the mineral oil followed by the mineral oil (54.84 % reduction).

In general, *B. tabaci* adult population on cantaloupe sprayed with Tracer alone at the higher rate was the most reduced life stage than either the immature or eggs in

Table 7: Efficacy of foliar application of spinosad (Tracer 24% SC) and the mineral oil (KZ oil 95% EC) applied alone or in mixtures against *Bemisia tabaci* immature on cantaloupe during 2004 growing seasons .

Treatment	Rate / 100 liters of water (*)	Mean % reduction after spraying			Total mean % reduction
		2 day	5 day	7 day	
Spinosad alone	30 ml	44.96	43.15	39.5	**42.54 C**
	20 ml	39.35	39.33	32.52	**37.07 C**
Spinosad + mineral oil	30 ml + 1 liter	61.20	60.20	56.34	**59.25 A**
	20 ml + 1 liter	51.61	51.34	44.27	**49.07 B**
Mineral oil alone	1 liter	60.06	57.56	54.18	**57.27 A**
F =	24.22	*LSD* =	6.05		

Means in the same column followed by the same letters are not significantly different ($P = 0.05$) (Duncan Multiple rang test in SAS). SC: Soluble concentration. EC: Emulsfiable concentrate. (*) As recommended by The Ministry of Agriculture.

Table 9: Mean number of *Bemisia tabaci* eggs on cantaloupe treated with foliar spray of spinosad (Tracer 24% SC) and the mineral oil (KZ oil 95%EC) applied alone or in mixtures during 2004 growing seasons.

Treatment	Rate / 100 liters of water (*)	Mean number (± SE) of eggs / 25 $inch^2$			
		Pretreatment	Days after spraying		
			2 days	5 days	7 days
Spinosad alone	30 ml	140.67 ± 6.37	89.00 ± 6.57 c	103.33 ± 7.13 bc	160.67 ± 13.26 bc
	20 ml	138.00 ± 5.69	116.67 ± 7.32 b	133.00 ± 11.28 b	164.67 ± 9.54 b
Spinosad + Mineral oil	30 ml + 1 liter	137.33 ± 18.12	60.00 ± 10.98 d	72.00 ± 8.73 c	112.67 ± 7.63 cd
	20 ml + 1 liter	139.00 ± 8.01	92.00 ± 7.01 bc	105.33 ± 9.63 bc	122.33 ± 9.42 bc
Mineral oil olne	1 liter	144.67 ± 11.79	72.00 ± 10.45 d	80.67 ± 24.66 c	112.00 ± 8.51 d
Control	...	**138.67 ± 14.90**	**160.67 ± 5.05 a**	**177.33 ± 14.64 a**	**205.33 ± 13.76 a**
	F		16.06	13.49	49.18
	LSD		46.63	50.33	25.3

Means in the same column followed by the same letters are not significantly different (P =0.05) (Duncan Multiple rang test in SAS). SC: Soluble concentration. EC: Emulsfiable concentrate. (*) As recommended by the Ministry of Agriculture
Planting date on 3 April 2005. Date of spray (19 / 4 / 2005).

Table 8: Efficacy of foliar application of spinosad (Tracer 24% SC) and the mineral oil (KZ oil 95% EC) applied alone or in mixtures against *Bemisia tabaci* immature on cantaloupe during 2005 growing seasons .

Treatment	Rate / 100 liters of water (*)	Mean % reduction after spraying			Total mean % reduction
		2 day	5 day	7 day	
Spinosad alone	30 ml	44.39	39.25	38.6	**40.75 C**
	20 ml	37.42	35.48	32.3	**35.07 D**
Spinosad + mineral oil	30 ml + 1 liter	61.52	60.34	59.51	**60.46 A**
	20 ml + 1 liter	52.41	51.10	51.09	**51.53 B**
Mineral oil alone	1 liter	61.34	55.51	54.79	**57.21 A**
F =	56.02	***LSD*** =	4.542		

Means in the same column followed by the same letters are not significantly different (*P* = 0.05) (Duncan Multiple rang test in SAS). SC: Soluble concentration. EC: Emulsfiable concentrate. (*) As recommended by The Ministry of Agriculture.

Table 10: Mean number of *Bemisia tabaci* eggs on cantaloupe treated with foliar spray of spinosad (Tracer 24% SC) and the mineral oil (KZ oil 95%EC) applied alone or in mixtures during growing seasons.

Treatment	Rate / 100 liters of water (*)	Mean number (± SE) of eggs / 25 $inch^2$			
		Pretreatment	Days after spraying		
			2 days	5 days	7 days
Spinosad alone	30 ml	169.33 ± 12.21	99.00 ± 9.08 c	105.00 ± 6.09 bc	143.33 ± 8.18 bc
	20 *ml*	158.67 ± 9.18	126.67 ± 6.99 b	134.00 ± 17.23 b	161.33 ± 15.98 b
Spinosad + Mineral oil	30 ml + 1 liter	176.00 ± 25.61	66.00 ± 8.40 d	69.00 ± 8.03 c	124.00 ± 18.54 cd
	20 ml + 1 liter	165.33 ± 15.01	106.33 ± 7.36 cd	105.33 ± 5.85 bc	150.67 ± 12.68 bc
Mineral oil alone	1 liter	158.67 ± 8.85	68.00 ± 7.01 d	76.00 ± 11,55 c	103.33 ± 6.18 d
Control	...	**180.00 ± 6.67**	**198.67 ± 11.62 a**	**204.33 ± 13.55 a**	**229.33 ± 7.32 a**
	F		19.74	30.34	16.20
	LSD		52.03	39.47	48.65

Means in the same column followed by the same letters are not significantly different (P =0.05) (Duncan Multiple rang test in SAS). SC: Soluble concentration. EC: Emulsfiable concentrate. (*) As recommended by the Ministry of Agriculture
Planting date on 3 April 2005. Date of spray (19 / 4 / 2005).

Table 11: Efficacy of foliar application of spinosad and the mineral oil applied alone or in mixtures against *Bemisia tabaci* eggs on cantaloupe during 2004 growing seasons.

Treatment	Rate / 100 liters of water (*)	Mean % reduction Days after spraying 2 day	 5 day	 7 day	Total Mean % reduction
Spinosad alone	30 ml	45.39	42.56	22.9	**36.95 CD**
	20 ml	27.03	24.63	19.41	**23.69 D**
Spinosad + mineral oil	30 ml + 1 liter	62.30	59	44.60	**55.30 A**
	20 ml + 1 liter	42.87	40.74	40.6	**41.40 BC**
Mineral oil alone	1 liter	57.05	56.4	47.71	**54.72 AB**
F =	8.94	*LSD* =	13.927		

Means in the same column followed by the same letters are not significantly different (*P* =0.05) (Duncan Multiple rang test in SAS). SC: Soluble concentration. EC: Emulsfiable concentrate. (*) as recommended by The Ministry of Agriculture.

2004-2005. Immature population on cantaloupe sprayed with mixture of Tracer at the higher rate and mineral oil and the mineral oil alone was the most reduced life stage than either the adult or eggs in 2004-2005 (table 13).

DISCUSSION

Chemical control is the primary method to control *B. tabaci*. However, management with pesticides is difficult for several reasons. Penetration of insecticides after foliar treatments can be inhibited by the waxy shelters protecting the nymph and pupa stages (Byrne *et al.* 1990), and all feeding stages colonize the abaxial surface of leaves and spraying from the top of the canopy resulted in incomplete coverage. Shortly after settling of adults, all stages of *B. tabaci* are presented on the plant (Byrne *et al.* 1990; Byrne and Bellows 1991). Therefore, control strategies not targeting all stages would be inefficient. Moreover, the short and multiple life cycle with high reproductive rates, favors fast selection of resistant *Bemisia* biotypes to different classes of insecticides (Byrne *et al.* 2003). Alternatively, certain chemicals either derived from plants or from certain microorganisms have been promoted in recent years. In the present study the efficacy of reduced risk effect spinosad and the mineral oil was assessed for controlling natural populations of *B. tabaci.*

A sound integrated pest management program in cantaloupe field should strive to minimize insecticide application whenever possible, and if chemical control is necessary, include the use of reduced risk or IPM- compatible products. Perhaps the most promising results of this insecticide trial were the identification of spinosad and mineral oil as effective materials for *B. tabaci* conrol. In the present study, foliar application of spinosad alone (Tracer 24% SC) which is classified as reduced risk or IPM- compatible product (Ishaaya *et al.* 2001), at the higher rate of 30 ml/100 liters, was efficacious against populations of whitefly immature that attack cantaloupe in Egypt. In addition, spinosad deterred settling of adults on the crop and consequently reduced egg deposition. Meanwhile, spinosad at the lower rate of 20 ml/ 100 liters of water was relatively less effective. In addition to the very low mammalian toxicity spinosad, it also appears to have little negative impact on most beneficial insects (Anonymous 1998; Eger Jr. 1998). For example, when *Orius insidiosus* (Say), *Geocoris punctipes* (Say), *Hippodamia convergens* Guerin-Meneville and *Chrysoperla carnea* Stephens were exposed to ten insecticides, spinosad was less toxic than all other insecticides tested on all species (Elzen *et al.* 1998). Duffle *et al.* (1997) reported that in field trial in cotton and soybean, of 17 insecticides or insecticide mixture applied, following a single application, spinosad has the least adverse effect on

Table 12: Efficacy of foliar application of spinosad and the mineral oil applied alone or in mixtures against *Bemisia tabaci* eggs on cantaloupe during 2005 growing seasons.

Treatments	Rate / 100 liters of water (*)	Mean % reduction			Total Mean % reduction
		Days after spraying			
		2 day	5 day	7 day	
Spinosad alone	30 ml	47.03	45.37	33.6	**42.00 CB**
	20 ml	27.7	25.6	20.19	**24.50 D**
Spinosad + mineral oil	30 ml + 1 liter	66.02	65.46	44.7	**58.73 A**
	20 ml + 1 liter	41.73	43.88	28.47	**38.03 CD**
Mineral oil alone	1 liter	61.17	57.81	48.88	**55.95 AB**
F =		**8.88** ***LSD*** =	**14.758**		

Means in the same column followed by the same letters are not significantly different (*P* =0.05) (Duncan Multiple rang test in SAS). SC: Soluble concentration. EC: Emulsfiable concentrate. (*) as recommended by The Ministry of Agriculture.

population of *Geocoris* sp on cotton. In addition, following two applications, numbers of coccinellids were similar between spinosad and untreated areas.

The present results are in accordance with the findings of Salgado *et al.* (1997) who reported that the insecticide Tracer has a high efficacy on target insects. Tracer is biologically based insect control product with many favorable characters. The organism *Saccharopolyspora spinosa,* a bacterium produces the secondary metabolite spinosad, which is the active ingredient in Tracer (Sparks *et al.* 1998; Thompson *et al.* 1996). Spinosad (Tracer) seems to act on acetylcholine (Ishaaya *et al.* 2001).

Ochou and Martin (2003) assessed the activity spectrum of spinosad against sucking pests including *B. tabaci.* They suggested that spinosad could be used in appropriate resistance management programs for either alone or reinforced in mixture by other insecticides. Johnson *et al.* (1997) reported that Tracer has been effective in controlling pyrethroid-resistant tobacco budworms. Similarly, (Prabhat and Poehling 2007) reported that Spinosad caused heavy mortality of the three nymph stages of *B. tabaci* with the first instars being most susceptible. However, the authors suggested that the persistence of spinosad was comparably high in the laboratory, but in the green house, a faster decline of activity was evident by increased egg deposition, egg hatch and reduced rates of immature mortality. On the other hand, Aslam *et al.* (2003) found that the efficacy of Tracer 240 SC (Spinosad) was less effective at recommended dose against *B. tabaci* and Ulaganathan and Gupta (2004) recorded that spinosad failed to control sucking pests of cotton. Ramesh and Ukey (2006b) also reported that spinosad a 0.005% was less effective against *B. tabaci* in tomato field than imidacloprid. Prabhat and Poehling (2007) observed that spinosad (success) did not reduce adult *B. tabaci* settling on tomato.

During the past decade there has been a shift from single product applications towards increasingly tank mixes containing up to five products. In many cases, use of multiple active ingredients within products, multiple products within tank mixes, and repeated applications of products or mixtures has led to the use of smaller quantities of individual active ingredients.

In the current study application of the mineral oil at the rate of 1 liter/100 liters of water effectively suppressed *B. tabaci* population during cantaloupe growing seasons of 2004 and 2005. In addition, mixtures of spinosad and the mineral oil appeared to improve the efficacy of spinosad against *B. tabaci* adult settling, ovipostion and immature than single application of spinosad. Overall, the data suggest that the mineral oil and spinosad work additively to reduce *B. tabaci.* Horowitz *et al.* (1997) showed that addition of ultra fine mineral oil increased the residual potency of abamectin. They assumed that the mineral oil enhances the

Table 13: The field efficacy of spinosad (Tracer 24% SC) and the mineral oil (KZ oil 95%EC) applied alone or in mixtures against B. tabaci life stages.

Treatment	Rate / 100 kg (*)	Mean % reduction in 2004-2005		
		Adult	Immature	Egg
Spinosad alone	30 ml	45.62	41.65	39.48
	20 ml	40.65	36.07	24.10
Spinosad + Mineral oil	30 ml + 1 litre	57.79	59.86	57.02
	20 ml + 1 litre	51.18	50.30	39.72
Mineral oil alone	1 litre	52.09	57.24	54.84

translaminar activity of insecticide. Cloyd *et al.* (2007) reported that tank mixtures of acetamiprid, bifenazate, buprofezin and chlorfenapyr exhibited no antagonistic activity resulting in >75% mortality in nymphs of *B. argentifoii* under green house conditions.

There have been numerous researches done with oils on pests that can affect crops, particularly white flies. Sieburth *et al.* (1998) evaluated the horticultural Sun Spray for effects on nymphs of the silver white fly and showed that among nymphs, pupae, and crawlers emerging from treated egg approximately 50% to 75% were killed outright. When Sun Spray was compared with a broad-spectrum pyrethroid for residual toxicity, Sun Spray as a dip proved to be at least as effective as pyrethroid for the control of *B. argentifolli* on tomatoes under greenhouse and laboratory conditions (Liu and Stansly 1995). Mineral oils were effective against *B. tabaci* on cotton (Rao *et al.* 1990a, b), on tomato (Abdel-Megeed *et al.* 1998) and on egg plant (Negm 2001; Gonzalez-Acosta *et al.* 2006).

Repellent effects of horticultural oils have been reported in many studies (Larew and Locke 1990; Liu and Stansly 1995 and Xie and Isman 1995). Weissling *et al.* (1997) found that oils significantly reduced winter form oviposition rate of pear psylla, *Cacopsylla pyricola* (L). Similarly, mineral oils or oil combined with insecticides has toxic and repellent effects against *B. tabaci* in cucurbit field (Hesler and Plap 1986; El- Lissy and Antilla 1993; Liu and Stansly 2000). In heavy infested cucumber plots, Butler and Henneberry (1991) reported that mineral oils and vegetable oils applied with a mist blower reduced number of *B. tabaci* adults. On tomatoes, Liu and Stansly (2000) reported that mineral oil alone or in combination have good potentials for controlling *B. argentifolii.* Shawir (2000) mentioned that KZ oil showed moderate toxicity. Negm (2001) found that KZ oil application against *B. tabaci* immature stages in all canopy levels (upper, middle, lower and whole plant) of the treated aubergine resulted in 83.6, 81.4, 75.0 and 78.3 reduction percentages respectively. Vegetable oil residues (peanut, cottonseed, castor, soybean and sunflower) were toxic to immature stages, adults and affected settling and oviposition of *B. tabaci* (Fenigstein *et al.* 2001). Gonzalez-Acosta *et al.* (2006) reported that the mineral oils (Saf-T and Nu Film) efficiently controlled white fly populations infesting egg plant (*Solanum melongena*) and can be used as an alternative in integrated pest management.

On the other hand, Rizk *et al.* (1999) found that none of the tested mineral oils (CAPL.1; CAPL. 2) succeeded against adult of white fly. In their study, they used KZ oil 95% EC at lower rate (3 L / Feddan 3 L / 400 L water) and different concentration of (4 L /400 L water).

The present study demonstrated that the mineral oil was compatible with spinosad insecticide and improved effectiveness of the insecticide applications. Thus, it is possible to decrease the use of spinosad, which will minimize the losses by evaporation and drift. At the same time, it allows for a better penetration of the active ingredients through the insect cuticle and the plant structure. By improving the spray coverage and penetration, spinosad could control *B. tabaci.* Moreover, mineral oil could also improve the efficiency of spinosad and considerably reduce the costs of control.

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