FIELD EFFICIENCY OF THE NOVEL BIOCIDE SPINOSAD SINGULAR, MIXED WITH DIFFERENT GROUPS OF INSECTICIDES AND COMPARED WITH OTHER BIOCIDE IN SEQUENCE EXPERIMENT ON COTTON LEAFWORM *SPODOPTERA LITTORALIS* (BOISD.)

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INTRODUCTION

There are many insects causing reductions in cotton production. The cotton leafworm, *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae), is responsible for the greatest part of this loss and it threatens several economically important crops such as cotton, corn, peanuts, vegetables and soybean. Synthetic insecticides are often a part of management programs to control lepidopterous pests (Gurkan 2004). In last few years, Ministry of Agriculture in Egypt did not recommend using conventional insecticides during the egg masses period so as to conserve the natural enemy populations (Raslan 2002). The environmental hazards of conventional insecticides necessitate the use of other new mode of action of insecticides that are effective, safer for human and ecosystem. Spinosad is an extract of the fermentation broth of the soil actinomycete bacterium, *Saccharopolyspora spinosa* Martz & Yao, containing a naturally occurring mixture of two macrocyclic lactones, spinosyn A and spinosyn D. It shows exceptional activity against Lepidoptera, Thysanoptera, Diptera and Coleoptera, and is selective to many beneficials and nontarget insects (Dutton *et al.*, 2003) . Due to this unique mode of action, Spinosad is valued in resistance management programmes. Spinosad and Methoxyfenozide represent an important choice to be used in integrated pest management where *S. littoralis* is a major pest (Pineda *et al.*, 2006) . The objective of this research was to evaluate the field efficiency of one novel biocide (Spinosad) singular alone and mixed with different groups of insecticides and also comparing this novel biocide with another biocide (*Bacillus thuringiensis*) in sequence experiments against cotton leafworm *S. littoralis*.

MATERIAL AND METHODS

Tested Insecticides

1- Spinosad (Spintor® 24% S.C.) 50 cm / feddan (1 feddan = 4200m^2) as Microbial insecticides (macrocyclic lactone insecticides, *Saccharopolyspora spinosa* Martz & Yao).

2- Chlorpyrifos (Dursban® 48 %E.C.) 1000 cm / feddan as Organophosphorus insecticide.

3- Methomyl (Lannate® 90 %W.P) 300 gm / feddan as Carbamate insecticide.

4- Beta-cyfluthrin (Bulldock®12.5 % S.C.) 150 cm / feddan as Synthetic pyrethroid insecticides.

5- Chlorfluazuron (Atabron® 5% E.C.) 400 cm / feddan as insect growth regulator.

6- Methoxyfenozide (Runner® 24% S.C.) 200 cm / feddan as insect growth regulator.

7- Manf 6 (Manf 6®) 300 cm / feddan as plant extract .

8- *Bacillus thuringiensis* subsp. *kurstaki* Berliner (Agerin® 6.5 % WP)Contain 32000 IU/mg 500 gm / feddan as Biocide.

Experimental design

The experiments were conducted at Aga district , Dakahlia Governorate to evaluate the field efficiency of one novel biocide (Spinosad) singular and mixed with different groups of insecticides and compared this novel biocide compound with another biocide (Agerin) in sequence experiments against cotton leafworm *S. littoralis*. The fields were cultivated with Giza 86 cotton variety on April 15, 2005 and the normal agricultural practices were applied. The experimental area was divided into plots of 42 m^2 each and the treatments were arranged in randomized complete blocks with four replicates each. Plots were isolated from each other by unplanted corridors (1 m width) that separated replicates. Applications of the insecticides were on June 7 and 15, 2005. A motor sprayer was used. The volume of spray solution was 40 liters /feddan. Treatments included one novel biocide (Spinosad) singular alone or mixed with six insecticides belonging to different five groups and compared with the biocide Agerin (Bt) in sequence experiments (two application with 7 days intervals with single continuous or alternating system) on cotton leafworm. The number of larvae of the cotton leafworm was recorded on 25 plants at random from the inside rows of each plot before the first spray and on 2,5,7,11 and 14 days after the first spray . Percent reduction in infestation was estimated using Henderson and Tilton, (1955) equation to determine the effect of the tested insecticides.

RESULTS AND DISCUSSION

Singular and mixture experiments

Data in Table (1) demonstrate the comparison of the field efficiency of Spinosad singular or with different groups of insecticides on cotton leafworm *S. littoralis* (Boisd.). The initial effect (two days after spraying), Beta-cyfluthrin was superior in activity giving 88.24% reduction in infestation followed by Methomyl and Methoxyfenozide giving 78.80 and 78.15 %, respectively while Chlorpyrifos , Spinosad and Chorfluazuron were moderately effective (61.24, 58.70 and 44.24%, respectively) whereas Mnf-6 gave negligible effect 1.34 % reduction . Concerning the mean of residual effect percentage for the tested insecticides, Chorfluazuron showed the longest residual effect which gave 98.33% followed by Methoxyfenozide, Beta-cyfluthrin, Methomyl, Chlorpyrifos, Spinosad and Mnf-6 with values 93.34, 90.03, 87.25, 82.61, 75.95 and 53.29 %,respectively . The general mean of reduction percentage of the tested insecticides were arranged in a descending order as follows: Beta-cyfluthrin, Methoxyfenozide, Methomyl, Chlorpyrifos, Chorfluazuron, Spinosad and Mnf-6 giving 89.14, 85.74, 83.02, 71.93, 71.29, 67.32 and 27.31%, respectively.

Field efficiency of Spinosad on cotton leafworm when mixed with different groups of insecticides was illustrated in Table (1), the addition of Spinosad to the tested insecticides increased both initial and residual activity than that obtained when tested singular. The most pronounced initial effect was achieved when Spinosad was mixed with Methoxyfenozide resulting in 97.39% reduction followed by Spinosad when mixed with Mnf-6, Chorfluazuron, Chlorpyrifos, Methomyl and Beta-cyfluthrin, with values ranging between 94.13 and 86.43 %. Regarding the residual effect, addition of the tested insecticides to Spinosad led to raising the activity of this compound than that obtained when tested singular. The highest residual activity was noticed when Spinosad mixed with Chlorpyrifos resulting 93.08% reduction, while the lowest residual effect was obtained with the mixture of Spinosad + Methomyl with value of 77.69% reduction in pest numbers. The efficiency of the tested mixtures can be arranged according to the general mean of reduction percentage in a descending order as follows: Spinosad + Chlorpyrifos, Spinosad + Chorfluazuron, Spinosad + Mnf-6, Spinosad + Methoxyfenozide, Spinosad + Methomyl and Spinosad + Beta-cyfluthrin, they were 93.06, 90.85, 88.09, 87.84, 85.34 and 83.81%, respectively.

Comparison between Spinosad and B.t in sequence experiments

Data presented in Table (2) show that Spinosad surpassed B.t when used in one application or in two applications with the single continuous system and alternating system. The initial effect (after two days from the first application) Spinosad gave reduction in infestation that ranged between 50.51 and 76.36 % while B.t gave a range of 15.21 and 36.40%.

Concerning the comparison between Spinosad and B.t in sequence experiments (two applications with 7 days intervals) the resulted general mean of reduction percentage in (Table 2) revealed that the single continuous system of Spinosad (Spinosad - Spinosad) gave 84.60 % reduction of *S. littoralis* infestation while the single continuous system of B.t (B.t - B.t) induced 66.67 % reduction.

Regarding the alternating system, the general mean of reduction percentage was arranged in a descending order as follows: (Spinosad – Chorfluazuron), (Spinosad – Methoxyfenozide), (B.t - Methoxyfenozide) and (B.t - Chorfluazuron) being 76.37, 74.53, 55.01 and 53.67 %, respectively.

The pressure of insecticide selection causes a resistance problem in the control of lepidopterous pest. The time until the development of resistance depends on a number of factors, including the frequency and nature of resistance genes, pest management strategies, and the relative fitness of the resistant strains relative to the wild type (which is still sensitive to the insecticide in question). To prevent this cycle, there is a need for different insecticides having different modes of action. Spinosad is a naturally derived biorational insecticide with an environmentally favourable toxicity profile (Bond *et al.*, 2004). The development of resistance to organophosphates, carbamates, and pyrethroids needs the development of new insecticides to help ease the resistance problem . In order to minimize the negative effects of the chemicals on the environment and natural enemies in the management of pests, the natural insecticides could be integrated into IPM programmes, Spinosad was very effective in the control of *S. littoralis* (Aydin and Gurkan, 2006). Pineda *et al.*, (2004) reported that Spinosad and Methoxyfenozide are potentially potent compounds for control of *S. littoralis* . Kerns and Tellez, (1998) found that, neither Success (Spinosad) nor Proclaim (Emamectin benzoate) seemed to benefit greatly from the addition of Musting (Zeta-cypermethrin). However, from observations in commercial fields, the addition of a pyrethroid to Spinosad when applied by air to large framed plants may enhance looper control. In other investigation for the same researchers, Kerns and Tellez, (1999) cited that, when a low rate of Warrior (pyrethroid) was mixed with the low rate of Success (Spinosad), control across all the species (cabbage looper, Heliothis and beet armyworm) was good, and was statistically similar to the higher rate of Success. In tank-Mix test, Greene and Capps, (2001) found that at four days after the first application, Denim + Baythroid

TABLE (I)

Field efficiency of one novel biocide singular and mixed with different groups of insecticides against cotton leafworm

Treatments	Rate of Application /feddan	Count /100 Leaves Pre-Spray	Number and % reduction after spraying											General mean of % Reduction
			Initial effect after 2 days		Residual effect								Mean of % Residual effect	
					5		7		11		14			
		N	N	%R	N	%R	N	%R	N	%R	N	%R		
Singular														
Spinosad	50 ml	1084	44	58.70	0	100.00	0	100.00	0	100.00	4280	3.78	75.95	67.32
Chlorpyrifos	1000 ml	420	16	61.24	8	47.39	0	100.00	0	100.00	292	83.06	82.61	71.93
Methomyl	300 gm	1920	40	78.80	0	100.00	0	100.00	0	100.00	4020	48.98	87.25	83.02
Beta-cyfluthrin	150 ml	2768	32	88.24	0	100.00	4	97.46	0	100.00	4240	62.67	90.03	89.14
Chlorfluazuron	400 ml	876	48	44.24	0	100.00	0	100.00	0	100.00	240	93.32	98.33	71.29
Methoxyfenozide	200 ml	1304	28	78.15	5	89.41	0	100.00	0	100.00	860	83.93	93.34	85.74
Manf-6	300 ml	2104	204	1.34	76	0.24	0	100.00	0	100.00	7520	12.90	53.29	27.31
Mixed														
Spinosad + Chlorpyrifos	50ml+1000ml	1755	12	93.04	0	100.00	0	100.00	0	100.00	1993	72.33	93.08	93.06
Spinosad + Methomyl	50ml+300gm	1600	11	93.00	0	100.00	0	100.00	0	100.00	5860	10.75	77.69	85.34
Spinosad + Beta-cyfluthrin	50ml+150ml	1200	16	86.43	0	100.00	0	100.00	0	100.00	3707	24.72	81.18	83.81
Spinosad + Chlorfluazuron	50ml+400ml	2240	13	94.10	0	100.00	0	100.00	0	100.00	4560	50.39	87.60	90.85
Spinosad + Methoxyfenozide	50ml+200 ml	1560	4	97.39	0	100.00	0	100.00	0	100.00	5560	13.14	78.29	87.84
Spinosad + Manf-6	50ml+300 ml	2600	15	94.13	0	100.00	0	100.00	0	100.00	7663	28.18	82.05	88.09
Control		2320	228		84		132		600		9520			

N . Number of larvae.
%R . Reduction Percentage.

TABLE (II)

Field efficiency of one novel biocide and compared with other biocide in sequence experiment against cotton leafworm

Treatments		Count / 100 leaves Pre-Spray	Number and % reduction after spraying											General mean of % Reduction
			Initial effect after 2 days		Residual effect								Mean of % Residual effect	
					5		7		11		14			
		N	N	%R	N	%R	N	%R	N	%R	N	%R		
One application:-														
Spinosad (50 ml/fed.)		904	21	76.36	0	100.00	0	100.00	0	100.00	1408	62.04	90.51	83.44
B.t (500 gm/fed.)		128	8	36.40	0	100.00	0	100.00	5	87.92	432	17.75	76.42	56.41
Chlorfluazuron (400 ml/fed.)		876	35	59.35	0	100.00	0	100.00	0	100.00	75	97.91	99.48	79.41
Methoxyfenozide (200 ml/fed.)		1304	34	73.47	0	100.00	0	100.00	0	100.00	80	98.51	99.63	86.55
Two application with 7days intervals:-														
1st application	**2nd application**													
Spinosad(50 ml/fed.)	Spinosad(50 ml/fed.)	905	25	71.89	0	100.00	0	100.00	0	100.00	400	89.23	97.31	84.60
B.t (500 gm/fed.)	B.t (500 gm/fed.)	128	8	36.40	0	100.00	0	100.00	0	100.00	80	84.77	96.94	66.67
Spinosad(50 ml/fed.)	Chlorfluazuron(400 ml/fed.)	344	15	55.63	0	100.00	0	100.00	0	100.00	165	88.31	97.10	76.37
Spinosad(50 ml/fed.)	Methoxyfenozide(200 ml/fed.)	1028	50	50.51	0	100.00	0	100.00	0	100.00	244	94.27	98.57	74.53
B.t (500 gm/fed.)	Chlorfluazuron(400 ml/fed.)	192	16	15.21	0	100.00	0	100.00	0	100.00	248	68.52	92.13	53.67
B.t (500 gm/fed.)	Methoxyfenozide(200 ml/fed.)	52	4	21.73	0	100.00	0	100.00	0	100.00	100	53.14	88.29	55.01
Control		2320	228		84		132		600		9520			

N Number of larvae.

%R Reduction Percentage.

provided good control of mixed populations of budworm (55%) and bollworm (45%), while Steward + Asana, Lannate + Baythroid, and Spinosad + Baythroid provided significant control . All tank-mixed insecticides provided adequate control of Heliothines following the second application at three days, with Spinosad, Denim, and Steward (all with Baythroid) all providing the best control. Schneider *et al.*, (2002) cited that Spinosad and Methoxyfenozide could be considered safe for parasitoids. Unfortunately, little information is available concerning the activity of Spinosad in sequence experiment. The unique mode of action may reduce the probability of being cross-resistant to other cholinesterase inhibitor insecticides (Liu *et al.*, 1999) , so to conserve this product in ICM programmes, it is essential that it is used carefully within well planned resistance management strategies (Dutton *et al.*, 2003) . Our trials addressed the effectiveness of these new biocides when compared with existing insecticides but their effectiveness needs evaluation over time

SUMMARY

The objective of this research was to evaluate the field efficiency of one novel biocide (Spinosad) singular and mixed with different groups of insecticides and comparing this novel biocide with *Bacillus thuringiensis* in sequence experiments against cotton leafworm *Spodoptera littoralis* (Boisd.). Spinosad gave moderately initial and residual effects 58.70 and 75.95 % when tested singular, whereas the most pronounced initial effect was achieved when Spinosad was mixed with Methoxyfenozide giving 97.39% reduction. Regarding the residual effect, addition of tested insecticides to Spinosad induced raising in the activity of this compound than that obtained when tested singular .The highest residual activity was noticed when Spinosad was mixed with Chlorpyrifos resulting in 93.08% reduction. Spinosad surpassed B.t. when used in one application or in two applications with the single continuous system and alternating system. For the initial effect (after two days from the first application), Spinosad gave reduction in infestation ranging between 50.51 and 76.36 % while for B.t. it ranged between 15.21 and 36.40 %. Comparing Spinosad with B.t. in sequence experiments (two application with 7 days intervals), the single continuous system of Spinosad (Spinosad - Spinosad) gave 84.60 % while (B.t - B.t) induced 66.67 % reduction in infestation according to the general mean of reduction percentage. Regarding the alternating system, the general mean of reduction percentage in pest infestation was arranged in a descending order as follows: (Spinosad – Chorfluazuron), (Spinosad – Methoxyfenozide), (B.t - Methoxyfenozide) and (B.t - Chorfluazuron) being 76.37, 74.53, 55.01 and 53.67 %, respectively.

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