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Efficacy of Spinosad, Lufenuron and Malathion against olive fruit fly, *Bactrocera oleae* (Gmelin) (Diptera: Tephritidae)

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ABSTRACT

Spinosad, Lufenuron and Malathion were evaluated in controlling olive fruit fly, *Bactrocera oleae* (Gmelin) under field conditions by using partial bait spray and killing bags during fruiting seasons of 2008 and 2009. The obtained results showed that the percentages of *B. oleae* populations and fruit infestation were obviously low in treated plots with Lufenuron, Spinosad and Malathion, respectively in comparison with control plot which were relatively high. The mean reduction percentages in *B. oleae* population in treated plots with Lufenuron, Spinosad and Malathion were 86.2±8.2, 77.3±3.0 and 71.3±11.2% during 2008 season and 74.8±10.1, 71.9±9.4 and 70.2±7.2% during 2009 season, respectively. While, the mean reduction percentages in fruit infestation by *B. oleae* larvae in treated plots with Lufenuron, Spinosad and Malathion were 77.5±6.5 & 73.1±5.1, 76.9±5.2 & 71.5±5.1 and 70.8±6.8 & 64.9±6.2% during 2008 & 2009 seasons, respectively.

Keywords: *Bactrocera oleae*, Spinosad, Lufenuron, Malathion, partial bait spray.

INTRODUCTION

Olive (*Olea europaea* L.) like most fruit tree crops is usually attacked by two or three key pests. The olive fruit fly, *Bactrocera oleae* (Gmelin) is the key pest damaging olive in the world (Rice, 2000) as well as in Egypt (Eid, 2003). It is native to the Mediterranean countries which has 98% of the world's cultivated olive trees (Montiel and Jones, 2002). The larvae are monophagous and feed exclusively on mature or young olive fruits as they develop in June through August (Phillips and Rice, 2001) with economic losses (reach up 15 to 40%) of the olive crop (Mazomenos *et al.*, 2002 and Haniotakis, 2003). While feeding, greatly increase the free fatty acid level (acidity) of the olive oil (Athar, 2005).

The bait application technique (BAT) consists of protein hydrolyzate/ insecticide bait sprays, it is applied directly on the trunk and foliage of the fruit trees on regular 10-15 day rounds and kills both males and female flies (Manrakhan and Price, 1999). Protein hydrolyzate mixed with organophosphorous insecticides bait sprays have been used for many years against the olive fly (Nadel, 1966; Manousis and Moore, 1987). Usually three to five treatments may be required, especially in years favorable to the pest (Mazomenos *et al.*, 2002).

Tephritid fruit flies are currently controlled in Mexico and Central America by area wide applications of baits containing malathion or a naturally-derived insecticide spinosad, GF-120 (Ruiz *et al.*, 2008). GF-120 bait is based on hydrolyzed maize protein, ammonium acetate and 0.02% spinosad (Moreno and Mangan, 2003). Arial applications of GF-120 are now being performed over large areas of fruit orchards in

Central America and in fruit-growing areas of the United States, including Hawaii (Enkerlin, 2005).

Lufenuron is the most used and field tested chitin synthesis inhibitor against Medfly, *Ceratitis capitata* (Wied.). This compound showed good potential in the control of the Medfly populations. Lufenuron can interrupt Medfly reproduction and prevent the hatching of eggs (Liquido *et al.*, 1991; Casaña-Giner *et al.*, 1999 and Licudine *et al.*, 2001).

It is necessary to find alternative safety insecticides to reduce the heavy doses of organophosphorous insecticides which had been used in the past. Therefore, the present study aimed to evaluate Lufenuron (insect growth regulator) and Spinosad (bio-insecticide) in comparison with Malathion (organophosphorous) in partial bait spray technique and killing bags against the olive fruit fly.

MATERIAL AND METHODS

Tested Insecticides:

Spinosad-baised, GF-120 (Conserve 0.24% CB) as a microbial insecticide (macrocyclic lactone insecticides, *Saccharopolyspora spinosa* Martz & Yao), Lufenuron (Match 5% EC) as an insect growth regulator, and Malathion (Malatox 57% EC) as an organophosphorus insecticide were evaluated in controlling olive fruit fly, *Bactrocera oleae* (Gmelin) under field conditions.

Experimental design:

The experiments were conducted at Aga district, Dakahlia Governorate during the two successive years 2008 (from the 5th of July till the 30th of August) and 2009 (from the 4th of July till the 29th of August) through the fruit ripening period to evaluate the field efficacy of the previously mentioned insecticides against *B. oleae*. The experimental area divided into four plots (three tested insecticides and control) of about 1/2 feddan each.

Partial bait spray and killing bags (Saafan *et al*., 1992) were used in these experiments. The commercial insecticides were used. However, the mixture of Conserve: water was 1.00: 19.00; while the mixture of Match: buminal: water was 0.32: 1.60: 18.08, respectively and the mixture of Malatox: buminal: water was 0.35: 1.60: 18.05, respectively. Knap sprayer used to spray trees trunks with the chemical dilutions (100 ml / tree). In addition, 20 killing bags were impregnated with the same mixture. The impregnated killing bags were distributed all over the plot area. The tested insecticides were sprayed for four times on regular every two weeks, while the killing bags were re-impregnated weekly.

Also, five modified Nadel traps (Hanafy *et al*., 2001) powered with an aqueous solution consists of 5.0% food attractant (buminal) and 0.5% malathion 57% were hanged on the trees of each plot at height of about two meters in shady and airy place for monitoring *B. oleae* population. Traps were hanged before the first spray by one week to evaluate the population level before treatment. The traps were inspected weekly along the tested period (9 weeks) with renewal of their solution. Captured adults of *B. oleae* were counted and recorded.

Fruit samples were investigated visually every week by investigating 250 random fruits from five trees [50 fruits / tree; 10 fruits / direction (north, south, east, west and center)] for every plot to estimate the infestation percentage. Fruit samples were investigated before the first spray to evaluate the infestation percentage before treatment.

Reduction percentages in both population and infestation were estimated according to Henderson-Tilton's formula (1955). In addition to the regression analysis was done.

RESULTS

The fluctuations of *Bactrocera oleae* (Gmelin) adults in the treated and untreated plots during 2008 and 2009 seasons were illustrated in Figure (1).

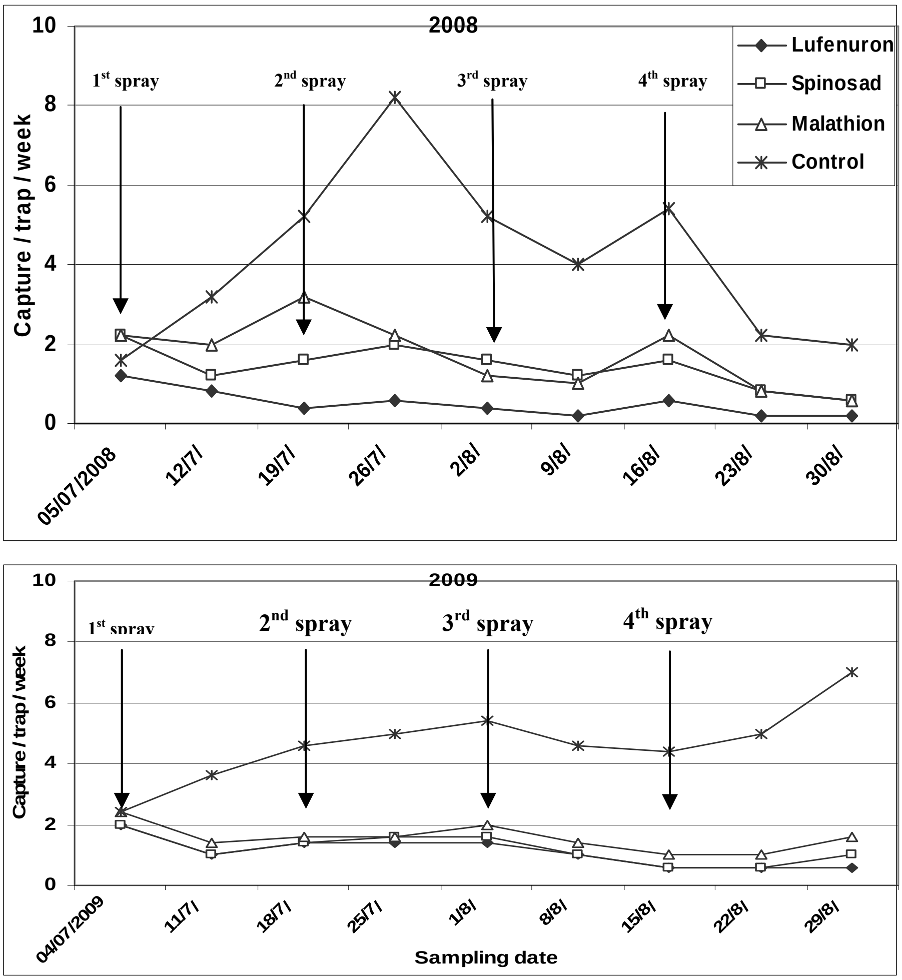

Fig.1: Fluctuations in numbers of *B. oleae* adults in Lufenuron, Spinosad and Malathion treated plots as well as in control plot during 2008 and 2009 seasons.

Capture/trap/week in the four plots was approximately the same at the beginning of experiment (pre treatment); however, it was 1.2, 2.2, 2.2 and 1.6 (during 2008) & 2.0, 2.0, 2.4 and 2.4 adults (during 2009) in Lufenuron, Spinosad, Malathion and control plots, respectively. After that, *B. oleae* populations in the treated plots decreased gradually till the end of the experiment; however, capture/trap/week reached 0.2, 0.6 and 0.6 (during 2008) & 0.6, 1.0 and 1.6 adults (during 2009) in the treated plots with Lufenuron, Spinosad and Malathion, respectively. On the contrary, *B. oleae* population increased in the control plot; however, the capture/trap/week reached 8.2 (at the 26th of July 2008) and 7.0 (at the 29th of August 2009).

Table (1) shows the weekly reduction percentages of *B. oleae* population in treated plots in comparison with control plots during the two studied seasons.

As shown in this Table, the mean reduction percentages in treated plots with Lufenuron, Spinosad and Malathion were 86.2±8.2, 77.3±3.0 and 71.3±11.2% during 2008 season and were 74.8±10.1, 71.9±9.4 and 70.2±7.2% during 2009 season, respectively. The mean reduction percentages of *B. oleae* population caused by Lufenuron, Spinosad and Malathion all over the two seasons were 80.5±8.1, 74.6±3.8 and 70.8±0.8%, respectively.

Table 1: Reduction percentages of *B. oleae* population using modified Nadel traps in Lufenuron, Spinosad and Malathion treated plots during 2008 and 2009 seasons.

Treatment	Season	Reduction % of population after spraying (weekly)								Mean of reduction	General mean of two seasons
		1st spray		2nd spray		3rd spray		4th spray			
		1st	2nd	3rd	4th	5th	6th	7th	8th		
Lufenuron	2008	66.7	89.7	90.2	89.7	93.3	85.2	87.9	86.7	86.2±8.2	80.5±8.1
	2009	66.7	63.5	66.4	68.9	73.9	83.6	85.6	89.7	74.8±10.1	
Spinosad	2008	72.7	77.6	82.3	77.6	78.2	78.5	73.6	78.2	77.3±3.0	74.6±3.8
	2009	66.7	63.5	61.6	64.4	73.9	83.6	74.8	86.3	71.9±9.4	
Malathion	2008	54.6	55.2	80.5	83.2	81.8	70.4	73.5	70.9	71.3±11.2	70.8±0.8
	2009	61.1	65.2	68.0	63.0	69.6	77.3	80.0	77.1	70.2±7.2	

At the beginning of experiment (pre treatment), infestation percentages during the first season were 9.2, 14.8, 20.8 and 10.0% in Lufenuron, Spinosad, Malathion and control plots, respectively, while during the second season, these percentages were 16.8, 20.8, 21.6 and 13.2%, respectively (Figure, 2). After that, infestation percentages by *B. oleae* larvae in the treated plots decreased gradually till the end of the experiment; however, it reached 2.4, 4.8 and 9.2% (during 2008) & 4.8, 7.2 and 9.2% (during 2009) in the treated plots with Lufenuron, Spinosad and Malathion, respectively. Infestation percentages in the control plot was obviously high; however, it reached 29.2% (at the 26th of July 2008) and 32.8% (at the 25th of July 2009).

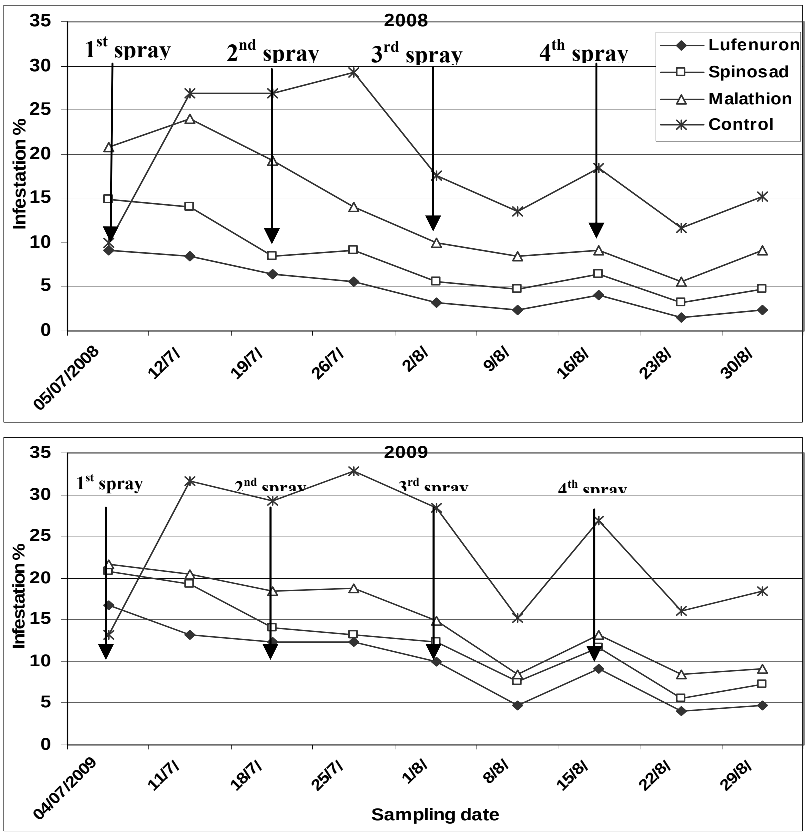

Fig. (2). Fluctuations in infestation percentages by *B. oleae* in Lufenuron, Spinosad and Malathion treated plots as well as in control plot during 2008 and 2009 seasons.

As shown in Table (2), the mean reduction percentages of infestation by *B. oleae* larvae in treated plots with Lufenuron, Spinosad and Malathion were 77.5±6.5 & 73.1±5.1, 76.9±5.2 & 71.5±5.1 and 70.8±6.8 & 64.9±6.2% during 2008 & 2009 seasons, respectively. The mean reduction percentages caused by Lufenuron, Spinosad and Malathion all over the two seasons were 75.3±3.1, 74.2±3.8 and 67.9±4.2%, respectively.

Table (2). Reduction percentages of infestation by *B. oleae* in Lufenuron, Spinosad and Malathion treated plots during 2008 and 2009 seasons.

Treatment	Season	Reduction % of infestation after spraying (weekly)								Mean of reduction	General mean of two seasons
		1st spray		2nd spray		3rd spray		4th spray			
		1st	2nd	3rd	4th	5th	6th	7th	8th		
Lufenuron	**2008**	65.9	70.0	79.2	80.2	80.8	76.4	85.0	82.8	**77.5±6.5**	**75.3±3.1**
	2009	67.2	66.6	70.3	72.3	75.2	73.0	80.3	79.5	**73.1±5.1**	
Spinosad	**2008**	64.7	78.8	78.7	80.5	76.2	76.5	81.4	78.7	**76.9±5.2**	**74.2±3.8**
	2009	61.4	69.6	74.5	72.3	68.3	72.5	77.8	75.2	**71.5±5.1**	
Malathion	**2008**	57.0	65.5	77.0	72.7	70.3	76.0	77.0	71.0	**70.8±6.8**	**67.9±4.2**
	2009	60.5	61.5	65.0	68.3	66.2	70.0	68.0	69.4	**64.9±6.2**	

Figure (3) shows the captured *B. oleae* adults / trap / week and infestation percentages by larvae against time in Lufenuron, Spinosad, Malathion and control plots during 2008 and 2009 fruiting seasons. As shown in this Figure, the rate of daily reduction in *B. oleae* population was high in treated plots in comparison with control plots; however, b-regression was -0.014*, -0.020*, -0.031* and -0.012^{ns} (during the first season) and was -0.021**, -0.018*, -0.014^{ns} and 0.052* (during the second season) in Lufenuron, Spinosad, Malathion and control plots, respectively.

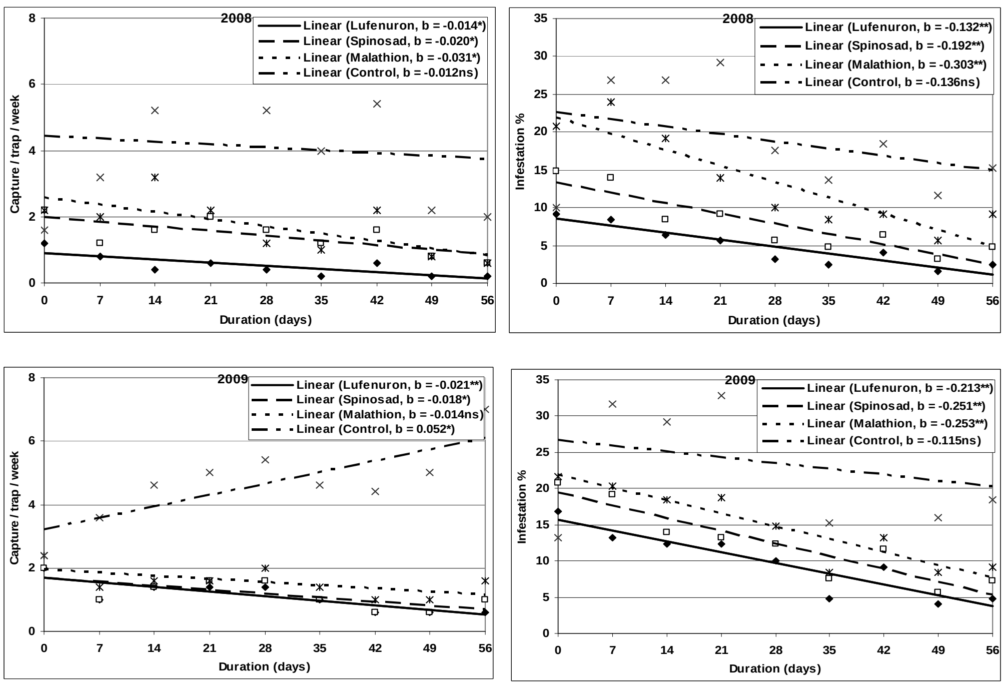

Figure (3). Captured *B. oleae* adults / trap / week and infestation percentages against time in Lufenuron, Spinosad, Malathion and control plots during 2008 and 2009 seasons.

Also, the rate of daily reduction in infestation percentages by *B. oleae* larvae was high in treated plots with Lufenuron (b = -0.132** and -0.213**), Spinosad (b = -

0.192** and -0.251**) and Malathion (b = -0.303** and -0.253**) in comparison with control plot (b = -0.136^{ns} and -0.115^{ns}) during the first and second seasons (Figure, 3).

As a conclusion, Lufenuron was the most effective treatment on *B. oleae* followed by Spinosad and Malathion treatments, respectively.

DISCUSSIONS

This study aimed at verifying whether Lufenuron and Spinosad could be used instead of conventional agrochemicals for olive fruit fly, *Bactrocera oleae* (Gmelin) in olive orchards. The obtained results showed clearly that Lufenuron is the most effective insecticide on *B. oleae* in comparison with Spinosad and Malathion. Similar conclusion was obtained by El Moubariki (2005) who indicated that the system Match Medfly in small plot trials showed an efficacy comparable to the conventional chemical control in Morocco. He added that the rates of Medfly captures and the mean number of pupae produced by punctured fruits were greater in the control field than in the treated area.Also,Bachrouch *et al.* (2008) reported that the Lufenuron bait station technique could be involved as an appropriate strategy for the control of the Medfly in Tunisia. However, Lufenuron acts to stop eggs hatching and not to stop female flies from stinging fruits, it is possible that the larval population in the fruits decrease. Also, in Spain using the insect growth regulator (Lufenuron) under two application methods spraying and hanging traps showed a high reduction of Medfly population (Liquido *et al.*, 1991). Furthermore, Castillo *et al.* (2000) showed that the Lufenuron used as chemosterilizing agent at a dose of 1,000 ppm against *C. capitata* leaded to an important sterilizing activity as hatching inhibitors.

The present work revealed that Spinosad had the second rank against *B. oleae* followed by Malathion. Similar results obtained by Braham *et al.* (2007) (in Tunisia) and El-Aw *et al.* (2008) who reported that Spinosad was more efficient than Malathion in controlling *C. capitata* and *Bactrocera zonata* Saunders. Also, Rice (2000) mentioned that control of olive fly for the immediate future will rely upon protein hydrolysate bait sprays containing Spinosad insecticide.

Vargas and Prokopy (2006) and Vargas *et al.* (2008) suggest that Spinosad is a promising substitute for organophosphate insecticides in protein bait sprays for control of *B. dorsalis* and *B. cucurbitae* in Hawaii and California. They added that Spinosad bait sprays may be a viable alternative to Malathion that could be integrated with sterile fly releases.

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ARABIC SUMMARY

فعالية كل من ليوفينرون وسبينوساد وملاثيون ضد ذبابة ثمار الزيتون *actrocera oleae* Gmelin (Diptera:Tephritidae)

سامح أحمد مصطفى ـ أحمد السيد عبد المجيد ـ مصطفى مهران المتولي ـ نبيل محمد غانم
معهد بحوث وقاية النباتات – مركز البحوث الزراعية – وزارة الزراعة

في هذه الدراسة تم تقييم ثلاثة أنواع من المبيدات تتبع ثلاثة مجاميع مختلفة ليوفينرون وسبينوساد وملاثيون وذلك في مكافحة ذبابة ثمار الزيتون بحقول الزيتون باستخدام طريقة الرش الجزئي والحزم القاتلة خلال موسمي ٢٠٠٨ و ٢٠٠٩ . وأوضحت النتائج ان تعداد الآفة ونسب الإصابة بها كان منخفضاً بدرجة ملحوظة في المناطق المعاملة بكل من ليوفينرون وسبينوساد وملاثيون على التوالي وذلك مقارنة بمنطقة المقارنة والتي كان بها التعداد ونسب الإصابة مرتفعين . وقد بلغ متوسط نسب الخفض في تعداد الآفة على مدار الموسم الأول ٨٦.٢±٨.٢ ، ٧٧.٣±٣.٠ و ٧١.٣±١١.٢% وذلك بالمناطق المعاملة بـ ليوفينرون وسبينوساد وملاثيون على التوالي ، بينما في الموسم الثاني بلغت هذه النسب ٧٤.٨±١٠.١ ، ٧١.٩±٩.٤ و ٧٠.٢±٧.٢% على التوالي . كما بلغ متوسط نسب الخفض في نسبة الإصابة بالثمار على مدار الموسم الأول ٧٧.٥±٦.٥ ، ٧٦.٩±٥.٢ و ٧٠.٨±٦.٨% وذلك بالمناطق المعاملة بـ ليوفينرون وسبينوساد وملاثيون على التوالي ، بينما في الموسم الثاني بلغت هذه النسب ٧٣.١±٥.١ ، ٧١.٥±٥.١ و ٦٤.٩±٦.٢% على التوالي .