Field Persistence of Some Novel Insecticides Residues on Cotton Plants and Their Latent Effects against *Spodoptera littoralis* (Boisduval)

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ABSTRACT

New insecticides that exhibited high compatibility with environment components are very promising substitutes for control of the economic insects. Simi-field experiments were conducted on profenofos and four novel insecticides viz., spinosad, emamectin-benzoate, pyridalyl and indoxacarb to investigate their efficiency and the field persistence of their residues against 4th instar larvae of the cotton leaf worm, *Spodoptera littoralis* (Boisd.), field strain via determination of Lt_{50} values. The recommended rates of these insecticides were sprayed on the foliage of cotton plants, var. Giza 86, in the field. Also, latent effects after feeding of larvae on sprayed leaves for 24 h were studied under laboratory conditions. Pyridalyl and emamectin-benzoate had significantly the most persistent residual activity with Lt_{50} values of 6.74 and 5.51days, respectively. Whereas, indoxacarb, spinosad and profenofos displayed inferior persistence periods translated in Lt_{50} values of 0.72, 1.33 and 1.55 days, respectively. The high efficiency of pyridalyl and emamectin-benzoate decreased gradually after spray causing 100, 100, 95, 87, and 72% larval mortality for pyridalyl and 100, 92, 88, 66, and 41% larval mortality for emamectin-benzoate after 0, 1, 2, 4, and 6 days of spray, respectively. Two days post spray, the toxic effect of profenofos declined sharply recording 94, 60, 45, 30, and 10% larval mortality after 0, 1, 2, 4, and 6 days of application, respectively. As the time after spray extended, the latent effects of the tested insecticides on survived larvae and consequent stages significantly decreased. Pyridalyl and emamectin-benzoate resulted in the superior latent effects even at the 6th day of spray; causing larval duration of 20.1 & 19.6 days, 20.4 & 42.6% normal pupae and 26.7 & 55.2% normal adult emergence, respectively comparing to the other treatments. These results indicated that novel insecticides had the potentiality to be promising substitutes of conventional toxicants for *S. littoralis* control under field conditions.

Key words: Cotton, *Spodoptera littoralis*, Novel insecticides, Field persistence, Residual activity, Latent effects.

INTRODUCTION

The Egyptian cotton leafworm, *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae) is one of the most destructive and economic pests of cotton, vegetables, ornamentals and other field crops. This pest is widely distributed throughout Africa, Mediterranean Europe and several parts of Asia (Azab *et al*., 2001). Caterpillars of *S. littoralis* are very polyphagous and can feed on approximately 90 economically important plant species belonging to 40 families (Brown and Dewhurst, 1975). Application of chemical insecticides to control *S. littoralis* is unavoidable procedure especially when outbreak occurs or its population density exceeds the economic threshold. Over the past 25 years, the intensive and unwise application of broad-spectrum insecticides against *S. littoralis* led to development of its resistance to many registered toxicants for its control and caused serious problems in environment components and natural balance between pests and their natural enemies (Smagghe *et al*., 1999; Abo-Elghar *et al*., 2005; Aydin and Gürkan, 2006).

Scientists and growers are seeking alternative materials that are effective against *S. littoralis*, safe to untargeted organisms and environment components and compatible with integrated pest management practices. In this respect, using new types of insecticides that originated from natural agents or disrupt the physiological processes of the targeted pests could be useful as alternatives for conventional insecticides (Thompson *et al*., 2000; Smagghe *et al*., 2003; Pineda *et al*., 2007). Several investigations indicated that, novel insecticides including Oxadiazines, Avermectins, Spinosyns, and Pyridalyl which characterized with their new and/or unique modes of action; have the potential for crop protection against economic pests and low toxicity to environment components and natural enemies (Foster *et al*., 2003, Michaud and Grant, 2003; Sakamoto *et al*., 2005).

Insecticides persistence on sprayed foliages depends upon many factors: physiochemical properties of the insecticide and additive materials, chemistry (pH and hardness) of the spray water, environmental factors and surface chemistry of the sprayed plants (McDonald *et al*., 1998; Argentine *et al*., 2002; Abdu-Allah, 2010). Moreover, under the same weathering conditions, the persistence period of the insecticide residues on plant foliage significantly differs based on the kind of sprayed plant (Holland *et al*., 1984; McDonald *et al*., 1998) and the targeted insect (Ishaaya *et al*., 2002). Cotton growers are seeking insecticide residues to be effective against targeted pests for longest periods as possible to avoid treatments reiteration. The objective of this study was to determine the residues persistence periods (Lt_{50}) and latent effects (larval duration, pupation percentages and percentages of adult emergence) of profenofos and four

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novel insecticides i.e. spinosad, emamectin-benzoate, pyridalyl and indoxacarb against field strain of *S. littoralis* under semi-field conditions.

MATERIALS AND METHODS

2.1. Tested insecticides:

The field recommended rates of the following insecticides were tested against 4th instar larvae of *S. littoralis* using commercial formulation of each.

- Spinosyn insecticide, spinosad (Tracer, SC 24%), obtained from Dow AgroSciences Co. and was applied at 60 mg AI / L.
- Oxadiazine insecticide, indoxacarb (Steward, EC 15%), provided from Du Pont Co. and was applied at 39 mg AI /L.
- The novel insecticide, pyridalyl (Pleo, EC 50%), supplied from Sumitomo Chemical Co. and was applied at 250 mg AI /L.
- Avermectin derivative insecticide, emamectin-benzoate (Proclaim, SG 5%), obtained from Syngenta Co. and was applied at 15 mg AI /L.
- Organophosphate insecticide, profenofos (Adwiprof, EC 72%), supplied from Adwia Co. and was applied at 2700 mg AI /L.

2.2. Insect rearing:

Egg masses of *S. littoralis* field strain were collected from cotton fields of Kafr El- Sheikh Region, which did not receive any insecticidal treatments before egg masses collection. The egg masses were transferred to the laboratory and maintained under conditions of 25 ± 2°C, 65 ± 5 RH and 14:10, L: D, photoperiod even developed into 4th instar larvae; then used in the test. The larvae were fed on fresh leaves of castor bean, *Ricinus communis*, as described by El-Defrawi *et al*. (1964).

2.3. Application of the tested insecticides:

Application of the tested insecticides was conducted at Sakha Agricultural Research Station farm, where an area of 2100 m^2 was selected to be sown on 8th of April, 2012 with cotton seeds var. Giza 86; received all good recommended agricultural practices without any insecticidal treatments. This area was divided into plots each of 42 m^2. Six treatments, the five tested insecticides and the check, were designed in this area. Four plots (replications) were made for each treatment. The treatments were arranged in a randomized complete block design. Application of tested insecticides was done on 6th of July, 2012 under field conditions of 35 ± 2°C at day, 75 ± 5 RH and 14:10, L: D, photoperiod. Irrigation water was used in diluting of the tested insecticides at their field recommended rates, and the final volume of spray solution represented 476 liters per hectare. Knapsack sprayer (CP_3) equipped with one nozzle was used. Unplanted belts (3 m width) were left as barriers between plots to avoid contamination with drifts.

2.4. Laboratory experiments:

The experiments were performed under laboratory conditions of 25 ± 2°C, 70 ± 5 RH and 14:10, L: D, photoperiod. Five *S. littoralis* 4th instar larvae were put in a 500 ml plastic pot and covered with a clean piece of muslin cloth, representing one replication. Ten replications were made for each treatment at each date of feeding. The sprayed cotton leaves were picked up immediately after one h from spray (zero time), and then after 1, 2, 4, and 6 days post spray and transferred directly to the laboratory for feeing the selected larvae. After 24 h of feeding on treated leaves, the survived larvae were transmitted to new and clean 500 ml plastic pots and were fed on untreated cotton leaves till pupation. Number of dead larvae and percentage of mortality were recorded 48 h post treatment. The larva was considered dead if no movement was observed when it was touched with a small brush. Larval duration, percentages of normal and deformed pupae, and percentages of normal and malformed adult emergence were estimated.

2.5. Statistical analysis:

Mortality percentages were corrected for mortality in control using the formula of Abbott (1925) and analyzed by probit analysis (Finney, 1971) using POLO- PC software (Le Ora Software, 1987) for time-mortality regression lines. Differences were considered significant based upon non-overlapping of 95% fiducial limits. Percentages of corrected mortality, pupation and adult emergence were subjected to one-way ANOVA by SPSS 13.0 (SPSS, 2004). Duncan's Multiple Range Test (DMRT) was used to determine significant differences between larval duration means ($P<0.05$) by CoStat system for Windows, Version 6.311, Berkeley, CA, USA, CoStat Program (2006).

RESULTS AND DISCUSSIONS

The field recommended rates of profenofos and other four novel insecticides viz., spinosad, emamectin-benzoate, pyridalyl and indoxacarb were sprayed on cotton foliage under field conditions to study the persistence of their residues against 4th instar larvae of *S. littoralis* via determination of Lt_{50} when the larvae were fed for 24 h on treated leaves under laboratory conditions. Efficiency of the foregoing insecticides and their latent effect (larval duration, pupation and adult emergence) on treated larvae were studied as well.

3.1. Field persistence of the tested insecticides residues and their efficiency against *S. littoralis*:

Persistence of the tested insecticides residues on cotton foliage under field conditions, expressed in Lt_{50}s, and the corresponding fidutial limits and slope values are presented in Table 1. Pyridalyl had significantly the superior persistent residual activity against *S. littoralis* 4th instar larvae with Lt_{50} value of 6.74 days, followed by emamectin-benzoate with Lt_{50} value of 5.51 days. On the contrary, indoxacarb showed significantly the shortest persistence period translated in Lt_{50} value of 0.72 day only, preceded by spinosad and profenofos with Lt_{50} values of 1.33 and 1.55 days, respectively. This may be explained by either the diversity in cotton foliage capability for adsorption of different tested insecticides into epicuticular waxes and deeper leaf tissues or the degradation factors which act versus the persistence of insecticide residue on cotton foliage. Moreover, the persistence period of an insecticide residue, under the same weathering conditions, differs based on the used concentration, the sprayed plant and the targeted insect. When spinosad was applied against neonate of *Spodoptera exigua*; it had half-life of 10-20 days on kiwifruit foliage comparing to 7 days on cotton foliage (McDonald *et al*., 1998). El-Barkey *et al*. (2008) found that spinetoram (compound of the same family of spinosad) had short persistence period on cotton under field conditions against *S. littoralis* larvae. Gupta *et al*. (2009) reported that, the half-life time of indoxacarb at 70 and 140 g AI/ ha on okra fruit was 0.58 and 1.02 days, respectively.

Efficiency of the tested insecticides against *S. littoralis* is summarized in Table 2. Pyridalyl proved to be the most effective against 4th instar larvae ; its efficiency decreased gradually after spray causing 100, 100, 95, 87, and 72% larval mortality after 0, 1, 2, 4, and 6 days of application, respectively. Similarly, emamectin-benzoate displayed the same direction of effect resulting in 100, 92, 88, 66, and 41% larval mortality at the same times after application.

Table 1. Persistence of the tested insecticides residues (Lethal time, Lt_{50}) on cotton foliage under field conditions against 4th instar larvae of *Spodoptera littoralis* field strain

Insecticide	Conc.* mgAI/L	Lt_{50} (days)	95%Fidutial limits	Slope	X^2
Spinosad	60	1.33	1.00 - 1.72	1.04 ± 0.111	0.145
Emamectin-benzoate	15	5.51	4.48 – 7.35	1.73 ± 0.222	7.221
Pyridalyl	250	6.74	5.11 - 8.23	0.93±0.154	3.989
Indoxacarb	39	0.72	0.46 – 1.02	0.79 ± 0.102	7.243
Profenofos	2700	1.55	1.24 – 1.91	1.35 ± 0.129	0.221

*The used field recommended rate expressed in mg A.I. per L

Table 2. Corrected mortality percentage and duration of survived 4th instar larvae of *Spodoptera littoralis* field strain after feeding for 24 h on cotton leaves treated with various insecticides

Treatment	Conc. mg AI per L.	%Mortality(%M) and larval duration(LD) at indicated days after spray:									
		Zero time		1 day		2 days		4 days		6 days	
		%M± SD	LD days	%M± SD	LD days	%M± SD	LD days	%M± SD	LD days	%M± SD	LD days
Spinosad	60	86 ± 2.35	18.6[a]	54 ± 3.25	18.8[a]	43 ± 2.57	19.1[b]	32 ± 2.13	17.5[b]	24 ± 1.78	16.0[c]
Emamectin-benzoate	15	100	–	92 ± 1.02	–	88 ± 2.01	21.2[a]	66 ± 3.12	21.5[a]	41 ± 2.11	19.6[a]
Pyridalyl	250	100	–	100	–	95 ± 0.87	–	87 ± 1.11	20.6[a]	72 ± 1.58	20.1[a]
Indoxacarb	39	65 ± 2.56	19.5[a]	58 ± 3.78	19.7[a]	35 ± 2.31	20.6[a]	26 ± 2.45	20.7[a]	14 ± 1.99	18.2[b]
Profenofos	2700	94 ± 1.25	–	60 ± 4.12	15.2[b]	45 ± 3.45	15.0[c]	30 ± 2.98	15.6[c]	10 ± 3.41	15.1[c]
Control	——	0.0	14.6[b]	0.0	14.3[b]	0.0	14.0[c]	0.0	14.6[c]	0.0	14.5[c]

- No survived larvae to complete larval stage.

Within a column, means followed by the same letter are not significantly different using DMRT (P<0.05).

%Mortality was estimated 48 h after treatment.

Table 3. Pupation percentage of survived 4th instar larvae of *Spodoptera littoralis* field strain after feeding for 24 h on cotton leaves treated with various insecticides

Treatment	Conc. mgAI per L.	%Pupation ± SD at indicated days after spray:									
		Zero time		1 day		2 days		4 days		6 days	
		%nor. pupae	%def. pupae	%nor. pupae	%def. pupae	%nor. pupae	%def. pupae	%nor. pupae	%def. pupae	%nor. pupae	%def. pupae
Spinosad	60	39.8 ± 2.3	5.5± 0.65	58.9 ± 3.1	4.3± 0.12	73.1 ± 3.6	3.5± 0.21	79.9 ± 2.9	3.8 ± 0.19	85.7 ± 4.5	3.2± 0.05
Emamectin-benzoate	15	–	–	–	–	37.3 ± 2.5	15.6± 1.25	38.4 ± 2.6	13.9± 1.12	42.6 ± 1.5	10.3± 1.22
Pyridalyl	250	–	–	–	–	–	–	12.2 ± 1.1	10.7± 1.36	20.4 ± 2.4	12.9± 1.87
Indoxacarb	39	26.4 ± 3.4	20.3± 1.23	45.7 ± 1.5	16.8± 1.5	49.2 ± 2.8	10.9± 0.28	61.5 ± 3.2	8.4± 0.89	73.3 ± 4.2	5.4 ± 0.45
Profenofos	2700	–	–	72.4 ± 3.4	5.6± 1.1	76.8 ± 2.9	4.9 ± 0.36	85.2 ± 4.1	3.4± 0.67	90.4 ± 3.4	3.1± 0.57
Control	—	96.2 ± 1.6	2.3± 0.12	97.1 ± 1.1	1.8± 0.31	96.8 ± 1.4	1.3± 0.05	97.5 ± 1.2	1.2± 0.09	96.3 ± 1.7	2.1 ± 0.32

- No survived larvae to develop into pupae.
Percentage of normal pupae (%nor. pupae) and deformed pupae (%def. pupae) were calculated based on the number of survived larvae 48 h after treatment.

Table 4. Adult emergence percentage of survived 4th instar larvae of *Spodoptera littoralis* field strain after feeding for 24 h on cotton leaves treated with various insecticides

Treatment	Conc. mg AI per L.	%Adult emergence ± SD at indicated days after spray:									
		Zero time		1 day		2 days		4 days		6 days	
		%nor. adults	%malf. adults	%nor. adults	%malf. adults	%nor. adults	%malf. adults	%nor. adults	%malf. adults	%nor. adults	%malf. adults
Spinosad	60	52.1 ± 2.9	10.6± 0.89	64.3 ± 2.6	6.7± 0.55	79.5 ± 3.5	5.2± 0.12	87.1 ± 4.2	3.3± 0.32	93.3 ± 4.6	2.6± 0.23
Emamectin-benzoate	15	–	–	–	–	35.9 ± 2.1	17.7± 1.4	39.8 ± 2.7	15.4± 2.21	55.2 ± 2.6	12.3± 0.54
Pyridalyl	250	–	–	–	–	–	–	21.3 ± 1.6	13.8± 0.98	26.7 ± 2.4	14.2± 1.45
Indoxacarb	39	55.3 ± 2.8	14.7± 1.05	61.4 ± 3.1	12.2± 0.52	72.6 ± 4.6	10.4± 0.91	76.3 ± 3.4	7.5± 0.75	81.4 ± 4.5	5.6± 0.12
Profenofos	2700	–	–	72.1 ± 2.9	5.2± 0.11	80.5 ± 3.6	3.4± 0.44	85.7 ± 3.1	3.1± 0.31	95.2 ± 2.4	2.4± 0.33
Control	—	97.2 ± 1.5	1.4± 0.22	98.3 ± 1.4	1.8± 0.06	97.7 ± 1.5	2.2± 0.32	97.9 ± 0.9	1.2± 0.91	97.5 ± 1.5	0.9± 1.11

- No survived larvae to develop into adults.
Percentage of normal adults (%nor. adults) and malformed adults (%malf. adults) were calculated based on the total number of pupae (normal and deformed).

These results substantiated the abovementioned high persistence of pyridalyl and emamectin-benzoate residues on cotton foliage and their unique and/or new modes of action which translated in low insect resistance. This may be due to pyridalyl and emamectin-benzoate both are not frequently used against *S. littoralis* in Egypt and relatively new compounds in the Egyptian market of insecticides.

On the other hand, the efficiency of the conventional insecticide, profenofos, declined sharply and significantly 2 days post spray recording 94, 60, 45, 30, and 10% larval mortality after 0, 1, 2, 4, and 6 days of application, respectively. In this respect, indoxacarb and spinosad exhibited the inferior activity at the beginning of the experiment; then decreased gradually till the experiment end. Cook *et al*. (2004) found that pyridalyl and emamectin-benzoate controlled *S. exigua* infestation up to 10 days after treatment of cotton field-

plants compared to untreated control. Emamectin-benzoate proved to be more efficient than spinosad and indoxacarb against *S. litura* larvae (Ahmad *et al*., 2006). The field recommended rate of methylamine avermectin (compound of the same group of emamectin-benzoate) caused 100, 93.6, 81.7, 68.4, and 51.6% mortality of *S. littoralis* 2nd instar larvae after 0, 1, 2, 4, and 7 days of spraying cotton foliage, respectively under field conditions (Dahi *et al*., 2009). Moreover, Abdu-Allah (2010) stated that after spraying of cotton field-plants, the efficiency of emamectin-benzoate against 4th instar larvae of *S. littoralis* decreased gradually and significantly recording 98.00, 70.00, 36.67, and 0.00% mortality after 0, 3, 6, and 10 days of application, respectively.

3.2. Latent effects of the tested insecticides on *S. littoralis*:

Most of previous studies about the efficiency of novel insecticides on lepidopteran pests had been conducted on larval stages and little has been published about their latent effects on pupae and adults. In this study, data presented in Table 2 indicated that emamectin-benzoate significantly prolonged the larval duration (21.5 days) comparing to control treatment (14.6 days) when the larvae were fed on sprayed leaves after 4 days of application; followed by indoxacarb (20.7 days), pyridalyl (20.6 days) and spinosad (17.5 days).While, profenofos did not cause significant change in larval duration (15.6 days). As the time after spray extended, the effect of all tested compounds on larval duration declined. Similar results were found by Abdel-Rahim *et al*. (2009); they mentioned that pyridalyl significantly prolonged larval duration (18.0 days) of *S. littoralis* field strain, followed by spinosad (12.5 days) and methylamine avermectin (12.3days) comparing to control (8.8 days) when these compounds were applied at their LC_{50} values against 4th instar larvae.

As criteria of latent effects, percentages of normal pupae, deformed pupae, normal adults and malformed adults were studied and the obtained data are discussed in Tables 3 and 4. It is noticed that, no survived larvae to develop into pupae in treatments which were fed on sprayed leaves with pyridalyl, emamectin-benzoate and profenofos after 2 days, 1 day, and zero time of spray, respectively. It is also remarkable that, the negative effect of the tested insecticides on percentages of pupation and adult emergence decreased as the time after spray increased. Larvae which were fed on indoxacarb-treated leaves after zero time and one day of spray significantly produced the least percentage of normal pupae (26.4 and 45.7%) and the highest percentage of deformed pupae (20.3 and 16.8%), but this effect subsequently dropped. After 6 days of spray, pyridalyl and emamectin-benzoate demonstrated the highest persistent negative effect on pupation causing 20.4 & 42.6% normal pupae and 12.9 & 10.3% deformed pupae, respectively comparing to the other treatments. The conventional insecticide, profenofos, had feeble effect on normal pupation. The same direction of act was observed regarding latent effect on adult emergence (Table 4). When the larvae were fed on sprayed leaves after 6 days of application, pyridalyl and emamectin-benzoate significantly resulted in the highest percentage of malformed adults (14.2 and 12.3%) and the lowest percentage of normal adults (26.7 and 55.2%), respectively comparing to all other tested insecticides and the control. Abdel-Rahim *et al*. (2009) stated that pyridalyl and spinosad at their LC_{50} values against 4th instar of *S. littoralis* field strain resulted in 60.7 & 68.3% normal pupae and 74 & 72% normal adults. Also, they reported that the percentages of deformed pupae and malformed adults were the highest with pyridalyl application (10.8 and 22.0%) comparing to spinosad application (2.2 and 3.3%), respectively. Osman and Mahmoud (2009) found that spinosad at its recommended rate against 3rd instar larvae of *S. littoralis* susceptible strain resulted in 33.3% pupation, 13.3% adult emergence and 6.6% malformed adults.

CONCLUSION

The obtained results of this study revealed that the novel insecticides, pyridalyl and emamectin-benzoate, had high persistent residues on cotton plants under field conditions. In addition, they demonstrated the superior effectiveness against the cotton leaf worm, *Spodoptera littoralis*, for the longest periods post application causing high initial and latent effects comparing to the conventional insecticides. Moreover, many previous studies clarified that pyridalyl and emamectin-benzoate exhibited low toxicity to natural enemies and environment components. Thus, these novel insecticides represent an important choice for use in Integrated Pest Management programs as substitutes of conventional insecticides to control the cotton leaf worm, particularly under field conditions.

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الملخص العربي

الثبات الحقلي لمتبقيات بعض المبيدات الحديثة على نبات القطن وتأثيراتها المتأخرة علي دودة ورق القطن (Boisduval) *Spodoptera littoralis*

الزاهي صابر الزاهي

تعتبر المبيدات الحديثة التي أظهرت توافقا مع المكونات البيئية من البدائل الواعدة في مكافحة الحشرات الاقتصادية. أجريت تجارب نصف حقلية على بروفينوفوس وأربعة مبيدات جديدة أخرى هي اسبينوساد، ايمامكتين بنزوات، بيريدااليل، اندوكساكارب لدراسة فعاليتها والثبات الحقلي لمتبقياتها ضد العمر اليرقي الرابع للسلالة الحقلية من دودة ورق القطن المصرية *Spodoptera littoralis* من خلال تقدير قيم الزمن اللازم لقتل 50% من تعداد اليرقات المعاملة (Lt_{50}) بهذه المركبات. تم رش المعدلات الموصي بها من هذه المركبات على نباتات القطن في الحقل. وكذلك تم دراسة التأثيرات المتأخرة لهذه المبيدات بعد تغذية اليرقات على الأوراق المعاملة لمدة 24 ساعة في المعمل. أثبتت النتائج أن متبقيات بيريدااليل و ايمامكتين بنزوات كانت الأعلى ثباتا بعد الرش مسجلة قيم Lt_{50} 6.74، 5.51 يوم على الترتيب. بينما كانت متبقيات اندوكساكارب، اسبينوساد، بروفينوفوس هي الأقل ثباتا مسجلة قيم Lt_{50} هي 0.72، 1.33، 1.55 يوم على الترتيب.

انخفضت الفعالية الكبيرة لـ بيريدااليل و ايمامكتين بنزوات تدريجيا بعد الرش مسببة 100،100, 95، 72،87 % موت لليرقات في حالة بيريدااليل و100، 92، 88 ، 66، 41% موت لليرقات في حالة ايمامكتين بنزوات بعد صفر، 1، 2، 4، 6 يوم بعد الرش على الترتيب. انخفض التأثير السام لمركب بروفينوفوس بشدة بعد يومين من الرش مسجلا 94، 60، 45، 30، 10% موت بعد صفر ،1 ،2 ،4 ،6 يوم بعد الرش على الترتيب. أوضحت النتائج كذلك أنه كلما امتد الوقت بعد الرش، كلما انخفض التأثير المتأخر للمركبات علي اليرقات معنويا. نتج عن المعاملة بـ بيريدااليل و ايمامكتين بنزوات أعلى تأثير متأخر حتى بعد 6 يوم من الرش مسببة 20.1، 19.6 يوم كطول للعمر اليرقي & 20.4، 42.6% عذارى طبيعية & 26.7، 55.2% فراشات طبيعية على الترتيب ، مقارنة بالمعاملات الأخرى.