Comparative Curative and Preventive Ovicidal Effectiveness of Certain Selected IGRs and Insecticides Against The Cotton Leafworm and Sweetpotato White Fly

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Abstract: Six insect growth inhibitors (IGIs) and regulators (IGRs) were tested in the laboratory for their curative and preventive ovicidal properties on the cotton leaf worm, *Spodoptera littoralis* (Boisd.) and sweet potato white fly, *Bemisia tabaci* (Genn.).Both emamectin benzoate and chlorpyrifos exhibited remarkably high curative ovicidal effectiveness against *S.littoralis* 24 hrs old eggs whereas each of the IGIs lufenuron and chlorfluazuron recorded moderate curative ovicidal activity. Likeswise, each of emamectin benzoate ,lufenuron and profenfos acts as excellent preventive ovicidal products with an LC_{50} of 0.23, 1.47 and 1.6 ppm, respectively.As for whitefly, emamectin benzoate, lufenuron and chlorfluazuron act as effectively curative direct ovicides with LC_{50} values of 0.78, 6.35 and 15.89 ppm compared ovicidal effect with LC_{50} 24.02, 7.93 and 15.69 ppm for the same compounds, respectively.On the other hand each of emamectin benzoate, lufenuran and chlorfluazuron exhibited distinguished high preventive effect on reducing fecundity of both pests indirectly, recording and EC50 values of 0.1, 1.06 and 1.33 ppm for, *S.littoralis* compared with 0.59, 11.55 and 28.84ppm against *B. tabaci* for the same IGRs, respectively. In general profenfos exhibited the least curative and preventive ovicidal effect against both pests. However only four of the tested compounds possessed the highest translaminar activity, recording 83.06, 82.67, 81.77 and 74.88% for emamectin benzoate, profenfos, chlorpyrifos and buprofezin, respectively.
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1. Introduction:

The sweet potato whitefly *Bemisia tabaci* (Genn.) and the cotton leafworm *Spodoptera littoralis* (Boisd.) are cosmopolitan pests of many field and vegetable crops including cotton. The sweet potato whitefly, ***B. tabaci*** infestation lowers crop quality and value by direct feeding on cotton leaves sap, excretion of honeydew and transmission of over 100 plant viruses (Jones, 2003). The cotton leafworm ***Spodoptera littoralis*** (Boisd.), has its importance as one of the destructive phytophagous lepidopterous pests in Egypt where it causes various ravages not only for cotton plants bout also for other field crops and vegetables (Hosny *et al.*, 1986).

Recently due to the situation of intensive use of broad-spectrum insecticides in cotton fields, both pests have developed high level of resistance to conventional insecticides, i.e, *S.littoralis* (Ishaaya *et al.*, 1995, Ghoneim, *et al.*, 2002) and *B. tabaci* (Prabhaker *et al.*, 1988, Dittrich *et al.*, 1990). **D**uring the last three decades, intensive search has been carried out for evaluating insecticides with novel mode of action against both pests and with minimum environmental risks (Ishaaya, 1990).**T**hese insecticides include the chitin synthesis inhibitors, benzoylphenyl ureas, such as chlorfluazuron, teflubenzuron and leufenuron which are considerably more potent than the parent compound diflubenzuron on various agricultural pests (Ishaaya, 1992). However such as acylureas derivatives are selective insecticides acting on various orders by inhibiting chitin formation (Ishaaya and Casida, 1974), thereby causing abnormal indoctuicul deposition and an abortive moulting. They influence a physiological process such as ecdyson and pupation. These compounds may also have biological efficacy, causing sterilization of adults as well as mortality of egg stage (Wang *et al.*, 1994; Hassanein, 2004). As for the environmental toxicity, the IGRs are considered to have little human (mammalian) toxicity, because humans do not make chitin and do not make or use the insect hormones in moulting (Schmutterer, 1985). Generally from the practical point of view the use of IGR compounds in insect control have been tested successfully against several insect species (Pineda *et al.*, 2007; Wang and Tian, 2009).

Recently, the insect growth regulator, buprofezin was thought likely to be a useful insecticide for controlling *B. tabaci* (Ellsworth *et al.*,

1997; El-Kady and Devine, 2003). However it is slow acting and has little effect on the adults and eggs. **S**everal attempts were made to use the ECR as target site for discovery and development of new and environmentally safe insecticides, i.e, the ecdystriod agonist insecticides. Ecdystroid agonist are one of the most recent developed groups of IGRs that mimic the moulting hormones, resulting in premature moulting (Dhadialla *et al.,* 1998). **M**ethoxyfenozide (RH-2485) is a newest IGR which is the most potent member of the Molt Accelerating Compound (MACs) against Lepidoptera (Smagghe *et al.,* 2003).

Our objective in the present study was to evaluate the curative and preventive ovicidal effectiveness of six IGRs and two conventional insecticides on ***B.tabaci***, **and *spodoptera littoralis*** in addition to studying the translaminar of the tested pesticides against ***Bemicia tabaci*** (Genn.) adults.

2.Materials and Methods

1. Insecticides and their rates used :

Five IGRs were tested for their ovicidal effectiveness. They included diflubenzuron (Dimilin 48%. SC), at concentration (9.3-148.8) ppm, chlorfluazuron (Atabron 5% EC), at concentration (3.1-50) ppm lufenuron (Match 5% EC) , at concentration (1.25-20) ppm, buprofezin (Applaud 25%SC) . at concentration (23.4-375) ppm. One IGR product, ecdyson agonist namely methoxyfenozide (Runner 24%SC) at concentration (7.5-120)ppm and one semi synthetic derivative of abamectin named methylamineavermectin (Radical 5%EC) at concentration (0.15-2.5) ppm in addition to two organophosphates, chlorpyrifos-ethyl (Dursban 48% EC) at concentration (75-1200) ppm and profenfos (Selecron 72% EC) ppm at concentration (84.3-1350) ppm were tested for comparison.

2. Laboratory cultur of the tested insects.

2.1. The sweetpotato whitefly ***Bemsi tabaci*** (Genn.) adults were collected from Gharbia Governorate cotton fields that exposed previously to the official control program of Ministry of Agriculture and Soil Reclamation. The strain was reared in the laboratory on untreated cotton seedlings for two generations, according to Coudriet *et al.* (1985) with some minor modifications, in standard room conditioned at 26±1ºC temperature, 70±5% R.H, and photoperiod of 16: 8 (L:D) without exposure to insecticides to obtain homogeneity.

2.2. The cotton leafworm *S.littoralis* (Boisd.), egg masses were collected from cotton fields and transmitted to laboratory for hatching and larvae were fed on untreated castor bean leaves for one generation for more homogeneity according to El-Defrawi *et al.* (1964) in a standard room conditioned at 25±2ºc and 55±5% R.H., without exposure to insecticides until testing.

3- Ovicidal experiments:

3.1. Preventive ovicidal effectiveness.

In preventive testing of ***S.littoralis***, three glass jars (1.1b/each) were internally treated (coated) for each concentration/ insecticide. Also, tafla ***Nerium oleander*** leaves were dipped in the same concentrations and after natural dryness were introduced in treated jars(2 females+1 male/jar) for egg deposition. Also, three glass jars and tafla leaves were treated with water to serve as control. After 48h exposure, the number of deposited eggs for each replicate and concentration was counted.

In case of whitefly ***B. tabaci***, cotton seeds variety Giza 89 was cultivate in plastic pots containing mixture of sand: clay: beetmos (1:1: 1) when cotton plants reached 4-5 true leaves it were sprayed with the tested concentration/ insecticide and were left for natural dryness. About 50 adults of whitefly were confined in clip on cage on the underside of treated cotton leaves for 24 hrs for eggs deposition. Also, three cotton pots were sprayed with water to serve as control. In all treatments adults were removed after 24hrs and the number of deposited eggs was recorded.

In both insect pests, the reduction percent in total number of deposited eggs (fecundity) relative to control in each concentration/ insecticide was calculated and used in computing EC_{50} values. However once all the eggs in the control expeirment had hatched out, the eggs in insecticide treatments was observed under binocular and the rate of un hatched was noted for each concentration/ to be used in computing LC_{50}value, representing indirect ovicidal effectiveness on fertility.

3.2. Curative ovicidal effectiveness

For investigating the direct curative ovicidal effectiveness on cotton leafworm eggs newly deposited egg - masses 24 hrs age were obtained from the mass- reared colony. Three replicates each of 5 egg -mass were dipped for 20 sec. in different concentrations of each insecticide and were left for natural dryness before putting in Petri dish until hatch. The area of egg - masses in treated and untreated (control) was measured and converted to number which was used to calculate percent un hatch . Control replicates completely hatched.

As for the direct ovicidal effect on eggs of whitefly, about 50 adults were confined in clip on cage on the underside of untreated leaves of potted cotton. After oviposition for 24 hrs adults were removed by and aspirator and number of deposited eggs were counted and the infested plants were sprayed with different concentrations of each tested insecticide. Then the treated plants were isolated with cylinder glass and covered with musiline and rubber

band. All pots were maintained under standard room conditions of 26±1ºc, 70±5% R.H. and photoperiod, 16: 8 (L: D) until hatch. Number of unhatched eggs was recorded and were used to calculate ovicidal LC_{50} values.

4. Translaminar activity:

Two groups of potted cotton plants were used: in the first the plants in three replicates were sprayed with the tested concentrations of each insecticide until the run-off and wetting both sides of the leaves. In the second group the upper side only of the leaves was carefully treated with the tested concentrations. Using painting brush. After natural dryness, in both cases about 50-60 unsexed whitefly adults were confined in clip-on cage on the under side of leaves using for each conc./insecticide three replicates in addition to control. Adult mortality were recorded after 24h. Translaminar activity was calculated according to Radwan and Zidan (2003) equation where: Translaminar activity% = (LC_{50} when both leaf surfaces were treated/ LC_{50} when only upper surface was treated) × 100.

5. Analysis of results:

Estimates of LC_{50} or EC_{50} values and their confidence limits in addition to slope (b) regression lines was obtained by profit – analysis (Finney, 1971) where EC_{50} represent relationship between the concentration and the number of deposited eggs (fecundity) while LC_{50} values represents the un hatched eggs (ovicidal effect). In addition the toxicity index (T.1) was calculated according to Sun (1950).

3. Results and Discussion

1. Cotton leaf worm *S. littoralis* (Boisd).

1.1. Curative ovicidal effectiveness

The data obtained in (Table 1) show that the curative ovicidal effectiveness of emamectin benzoate (LC_{50} = 0.28 p.p.m) was Ca. 3 times less effective than its preventive ovicidal effectiveness(LC_{50}=0.01 ppm). As for other pesticides tested it was obvious that chlorpyrifos-E came next recording less curative ovicidal effect (LC_{50} = 0.57 ppm). However, three insecticides showed moderate curative ovicidal effect where LC_{50} values reached 4.35, 8.83 and 10.14 ppm for lufenuron, chlorfluazuron and diflubenzuron, respectively. On the other hand, remarkably low curative ovicidal effect expressed as LC_{50} of 28.11, 78.71 and 80.76 ppm were recorded for buprofezin, methoxyfenozide and profenfos, respectively.

In laboratory tests, El-Ghareeb (1988) found that the curative ovicidal activity (LC_{50}) for chlorfluazuron and diflubenzuron were 2000 and 3.7 ppm respectively, when *S. littoralis* egg masses were dipped in solution of the IGRs. Later on Emam and Degheele (1993) studied the effect of adding adjuvant on curative ovicidal activity when evaluating various benzoylphenyl urease at 10 ppm. They found that diflubenzuron and chlorfluazuron had no ovicidal activity against *S. littoralis* eggs at 23 degrees °C and low activity at higher degree of 30C. Addition of 0.3% of adjuvant Atplus 411F to chlorfluazuron resulted in greater ovicidal activity, however, egg hatch being 60-70 with chlorfluazuron and diflubenzuron, compared to 98% with no treatment (control).

Table (1): Curative ovicidal effectivness of several insecticides by dipping 0-24 h old eggs of *S.littoralis* in different concentrations of insecticides diluted in water.

Insecticides	Conc. tested range ppm	Slope ± SE	LC_{50} ppm	(95% F.L.)
Chlorpyrifos-E	75 – 1200	0.69 ± 0.27	0.57	0.16-0.92
Profenfos	84.3 – 1350	1.58 ± 0.21	80.76	32.77 – 126.24
Lufenuron	1.25 – 20	2.86 ± 0.85	4.35	0.58 – 22.57
Difluben zuron	9.3 – 148.8	1.65 ± 0.75	10.14	6.13-13.08
Methoxyfenzide	7.5 – 12	1.89 ± 0.39	78.71	39.46 – 957.2
Buprofezin	23.4 – 375	2.47 ± 0.47	28.11	9.56 – 43.3
Chlorfluazuron	3.1 – 50	3.05 ± 0.72	8.83	3.40 – 19.04
Emamectin benzoate	0.15 – 2.5	1.28 ± 0.86	0.28	0.23 – 0.32

Conc. range includes 1/16 RFR, 1/8, 1/4, 1/2 and recommended field rate LC_{50}=50% lethality concentration.

1.2. Preventive ovicidal effectiveness:

In preventive application (Table 2) namely, when cotton leafworm ***S. littoralis*** adults were subjected to insecticides-treated leaves and eggs were laid directly on insecticide residues, five of the six, IGRs and 1GIs tested had a considerably preventive ovicidal effectiveness in reducing fecundity in the tested concentrations range, recording EC_{50} values of 0.1, 1.06, 1.5, 1.3, and 2.5 ppm for emamectin benzoate (Radical), lufenuron (Match), buprofezin (Apploud), chlorfluazuron (Atabron), respectively. Only methoxyfenozide (Runner) showed low

preventive ovicidal effectiveness recording EC_{50} of 10.7 ppm. However, Emamectin. Benzuate showed the best preventive ovicidal effect with 50% reduction in fecundity at (EC_{50}) of 0.103 ppm. On the other hand both organophosphates tested showed poor preventive ovicidal effect recording EC_{50} of 39.79 ppm and 116.01 ppm for chlorpyrifos-E(Dursban) and profenfos (Selecron), respectively.

As for the indirect effectiveness on fertility of eggs deposited after exposure of adults to insecticide-treated leaves, the data indicate that emamectin benzoate, and lufenuron were still the best ovicides products showing high percent of unhatched eggs and recording LC_{50} values of 0.23 and 1.47 ppm, respectively whereas methoxyfenozide (12.79 ppm) and chlorfluazuron (14.65 ppm) exhibited moderate effect.

On contrary, diflubenzuron, buprofezin and chlorpyrifos exhibited remarkably poor ovicidal performance, recording 133.74, 775.05 and 487.31 ppm, respectively, whereas profenfos (571.97 ppm) was significantly the least effective one.

In primary screen bioassay carried out by Ascher and Nemmy (1990) for ovicidal activity against *S. littoralis* 1 day old eggs at 100 mg a.i/litre, chlorpyrifos gave 100% mortality whereas protenfos exhibited > 90% mortality.

Likewise, El-Dahan *et al.* (1990) found that chlorpyrifos was active at all the concentrations tested (400, 800 and 1600 p.p.m.) against ***S. littoralis*** eggs of all ages whereas the growth regulator chlorfluazuron was weakly active as ovicide. The present finding are in agreement with Emam and Degheele (1993) who found that diflubenzuron and chlorfluazuron had low ovicidal activity against ***S. littoralis*** at 30C, whereas addition of adjuvant Atplus 411F resulted in 60-70% egg hatch with chlorfluazuron and diflubenzuron compared to 98% for the control.

Pineda *et al.* (2000) found that more than 90% mortality occurred for the neonate larvae that hatched from 24h eggs treated with methoxyfenozide dissolved in acetone or distilled water at 0.1-1.5 mg/a.i./lit.

Later on Pineda et al. (2004) reported that direct dipping of cotton leafworm, ***S. littoralis*** 0-24 h old eggs in methoxyfenozide diluted in water, no ovicidal activity was recorded and vice versa occurred when insecticide was diluted in acetone.

Feeding ***Spodoptera littoralis*** adults on 10% honey solution containing 3, 1.5 or 0.75 ppm chlorfluazuron indicated that the hatch ability of eggs deposited by treated moths being reduced by 24.8, 22.2 and 16.6%, for the different concentrations of the insecticides tested, respectively. Also, the laminated exochorion of the egg shell was shown to be affected by the IGR (Hegazy, 1991).

Reduction in fecundity may be due to disfunction of maturation of an insect egg which depend on the materials that are synthesized by the ovary in suit which includes protein, lipids and carbohydrates all of which required for embryonic structure (Shaurub *et al.*, 1998).

In 2009 Pineda *et al.,* found that oral exposure of ***S. littoralis*** adults to Methoxyfenozide significantly affected fecundity and fertility. They found that adult fecundity was more affected when moths were treated by ingestion than when treated topically with a mean number eggs laid per female of 343+89 and 932+79, respectively.

Under field conditions, Charmillot *et al.* (2001) found that using diflubenzuron, chlorfluazuron and lufenuron, however, the first application of the season, at the beginning of codling moth *Cydia pomonella* L flight, should be very early, not only because these products are better ovicides than larvicides but also because they are noticeably more effective in preventive application than on eggs which have already laid (curative ovicidal effect), even fresh ones.

Earlier several studies indicated indirect latent effects on fecundity and fertility of early treatment of immature (larval) stages.

Emam and Degheele (1993) found that treating 4th instar larvae of ***S. littoralis*** with sublethal doses of chlorfluazuron and diflubenzuron induced decrease in adult emergence from 80% in control to 14 and 23%, respectively, also viability of deposited eggs and progeny formation was reduced. For explanation, Sallam (1999) indicated that Ovicidal activity of the tested 1GR, flufenoxuron in eggs deposited by *S. littorals* that outcome from treating 2^{nd} or 4^{th} instar larvae could be due to disturbance in cuticle formation of the embryo (Sallam, 1999), developed embryos were enabled to perforate the surrounding vitelline membrane, it could be due to a weakened chitinous mouth parts that was insufficiently rigid to affect hatching. Like wise El-Aw (2003) studied the sublethal effect of Proclaim (emamectin benzoate) when ***S. litteralis*** 4^{th} instar larvae were fed on castor bean leaves treated with the LC_{25} value. The author found that fecundity and egg hatchability were reduced for the resulted adults.

Again Sammour *et al.* (2008) found that ***Spodoptera littoralis*** adults obtained from exposing 5^{th} instar larvae to chlorfluazuron and leufenuron treatments resulted in a very low percentage of fecundity which ranged between (33.3 to 53.4%). They added that egg hatchability was also significantly reduced, it ranged between (44.5 to 61.7%) for chlorfluazuron and (59.7 to 73%) for lufenuron compared to (94.7%) for control.

They also found that females produced for treated larva deposited less number of eggs represent about 60% reduction compared to control. These results are in agreement with Moursy and Salem (1995).

Table (2): Preventive direct and indirect effects of ovicidal of insecticides on *S. littoralis* fecundity and adult, expressed as percent reduction than control in no. of eggs deposited after exposure to treated cotton leaves.

Insecticides	Conc. tested range ppm	Slope ± SE	EC^{1}_{50} ppm	(95% F.L.)	Slope ± SE	LC_{50}^{2} ppm	(95% F.L.)
Chlorpyrifos-E	75 – 1200	1.22 ± 0.11	39.79	23.01 – 56.20	0.44 ± 0.2	478.31	443.89-.542.00
Profenfos	84.3 – 1350	1.92 ± 0.42	116.87	105.07-128.30	0.13 ± 0.64	571.97	404.92-987.59
Lufenuron	1.25 – 20	2.41 ± 0.70	1.06	.99-2.12	2.41 ± 0.70	1.47	0.67-384
Difluben zuron	9.3 – 148.8	0.76 ± 0.06	2.58	1.77 – 3.44	0.76 ± 0.06	133.74	100.54 – 195.22
Methoxyfenzide	7.5 – 120	1.18 ± 0.08	10.72	9.67 – 11.88	1.54 ± 0.58	12.79	10.53-16.20
Buprofezin	23.4 – 375	0.48 ± 0.33	1.51	0.81-4.02	0.48 ± 0.32	775.05	690.15-814.09
Chlorfluazuron	3.1 – 50	1.45 ± 0.09	1.33	1.11 – 1.53	1.45 ± 0.09	14.65	12.70 – 17.45
Emamectin benzoate	0.15 – 2.5	1.69 ± 0.37	0.10	0.01-1.03	1.64 ± 0.37	0.23	0.01-2.01

1- EC_{50}= concentration that induced 50% reduction than control in number of eggs deposited after adult exposure to treated cotton leaves.
2- LC_{50} = Concentration that induced 50% non hatched eggs.

2. Sweetpotato whitefly *B. tabaci* (Genn.)

2.1. Curative ovicidal effectiveness:

In curative application (Table 3) when 1 day old eggs of ***B. tabaci*** (Genn) field strain, deposited on the underside of cotton leaves, and the eggs were sprayed directly with different concentrations of the tested insecticides, all the IGIs and IGRs showed a noticeable ovicidal effect ranging between moderate and high effectiveness. However, emamectin benzoate came first recording LC_{50} value of 0.78 ppm whereas lufenuron, chlorfluazuron, methoxyfenozide, diflubenzuron, and buprofezin exhibited moderate ovicidal effect recording 6.35, 24.37, 35.74, 65.47 and 77.13 ppm for the prementioned IGRs, respectively. On contrary, both organophosphates chlorpyrifos and profenfos showed relatively poor curative ovicidal effect, recording LC_{50} values of 243.61 and 573.53 ppm respectively.

Table (3): Curative ovicidal effectiveness of several insecticides by spraying 0-24h old eggs of *B. tabaci* by concentrations of insecticides diluted in water.

Insecticides	Conc. tested range ppm	Slope ± SE	LC_{50} ppm	(95% F.L.)
Chlorpyrifos-E	75 – 1200	.96 ± 0.19	243.61	152.73 – 363.52
Profenfos	84.3 – 1350	0.87 ± 0.42	573.53	434.08-610.40
Lufenuron	1.25 – 20	.80 ± 0.09	6.35	5.37 – 9.73
Difluben zuron	9.3 – 148.8	0.57 ± 0.20	65.47	39.22 – 145.14
Methoxyfenzide	7.5 – 120	0.52 ± 0.19	35.74	21.07 – 62.97
Buprofezin	23.4 – 375	1.34 ± 0.17	77.13	55.42 –29.68
Chlorfluazuron	3.1 – 50	0.92 ± 0.09	24.37	20.48 – 29.32
Emamectin benzoate	0.15 – 2.5	1.06 ± 0.27	0.78	0.52 – 1.93

LC 50 = 50% lethality concentration.

2.2. Preventive ovicidal effectiveness:

In preventive application (Table 4), exposure of ***B. tabaci*** (Genn.) adults to residues of various concentrations of the tested insecticides on cotton leaves ranging from 1350 ppm for profenfos to 2.5 ppm for emamectin benzoate and their dilutions, exhibited remarkable direct preventive effect on adult fecundity and oviposition rate. However, a strong reduction in fecundity or progeny formation, expressed as reduction in number of deposited eggs was obtained as well as inhibition in egg hatchabilit Estimated concentration for 50% reduction in adult

fecundity (EC_{50}) reached 197.37 and 121.44 ppm for the tradit th ional insecticides profenfos (Selecron) and chlorpyrifos (Dursban) while it was 118.43., 106.44, and 103.21 ppm for buprofezin (Apploud), methoxyfenozid (Runner) and diflubenzuron (Dimilin) respectively. However, remarkably lower concentration of 28.84 ppm, 11.55 ppm and 0.59 ppm was exhibited as EC_{50} values for chlorfluazuron (Atabron), lufenuron (Match) and emamectis benzoate (Radical), respectively, indicating the high potential effect of these three compounds in reducing fecundity as preventive effectiveness.

The present findings are in agreement with Yasui *et al.* (1985, 1987) who found that buprofezin as 1GR suppresses chitin formation as do benzoylphenyl ureas compounds and act on oviposition and egg fertility. Likewise Ishaaya *et al.*(1988) found that buprofezin sprayed on cotton seedlings under greenhouse conditions suppressed embryogensis and progeny formation of the sweetpotato whitefly ***B. tabaci*** (Genn.). However, the effect on egg production seems to result from the inhibition of biochemical processes leading to prostaglandin. Also, Beevi and Balasubramanian (1991) found that mean fecundity of ***B. tabaci*** females was significantly reduced when adults was exposed to cotton seedlings treated with the 1GR buprofezin at 1000 ppm however, at 50 to 500 ppm the oviposition period was extended with a considerable increase in mean fecundity. Overall mean percentage hatch dropped gradually from 25.8 to 12.9 as the concentration increased from 50 to 1000 ppm compared to 96.9% in the control.

As for the inhibition in fertility expressed as ovicidal effect, similar trend in percent reduction was obtained for ***B. tabaci*** egg hatch (fertility) where the calculated LC_{50} values (effective concentration for 50% egg unhatch) were 7.93, 15.69, and 24.02 ppm for lufenuron (Match), chlorfluazuron (Atabron), and emamectin benzoate (Radical), respectively. However chlorpyrifos-E (Dursban) was the least effective and exhibited $LC_{50}$of 1371.59 ppm, and was followed by profenfos (Selecron) recording 523.85 ppm. Other tested insecticides showed moderate ovicidal effect where LC_{50} values ranged between 120.24 and 239.16 ppm.

Treatment or exposure of adult stage of several other dipteran species (Rup and Chopra 1985) with chitin synthesis inhibitors resulted in the absorption of the IGR by the developing egg consequently, a reduction in egg production or hatch. However, ovicidal activity of the tested CSI in the present study could be due to the disturbance in cuticle formation of the embryo (Sallam, 1999), developed embryos were enabled to perforate the surrounding vitelline membrane, it could be due to a weakened chitinous mouth parts that was insufficiently rigid to affect hatching.

Table (4): Preventive direct and indirect effects of ovicidal of insecticides on *B.tabaci* fecundity and adults expressed as percent reduction than control in no. of eggs deposited after exposure to treated cotton leaves.

Insecticides	Conc. tested range ppm	Slope ± SE	EC^{1}_{50} ppm	(95% F.L.)	Slope ± SE	LC^{2}_{50} ppm	(95% F.L.)
Chlorpyrifos-E	75 – 1200	1.16± 0.23	121.44	40.22 – 238.9	0.99 ± 0.18	1371.59	717.1 – 4854.2
Profenfos	84.3 – 1350	1.45 ± 0.22	197.37	115.8 – 319.5	1.64 ± 0.37	523.85	258.0 – 4357.5
Lufenuron	1.25 – 20	0.73 ± 0.08	11.55	8.70 – 15.8	1.45 ± 0.16	7.93	6.41 – 10.39
Difluben zuron	9.3 – 148.8	0.48 ± 0.08	103.21	64.35 – 217.5	0.75 ± 0.11	120.24	76.28 – 249.3
Methoxyfenzide	7.5 – 120	1.62 ± 0.27	106.44	70.0 – 227.3	1.24 ± 0.16	177.8	133.31 – 272.2
Buprofezin	23.4 – 375	1.95 ± 0.45	118.43	94.16-161.07	0.69 ± 0.10	239.16	125.91 – 327.0
Chlorfluazuron	3.1 – 50	0.66 ± 0.08	28.84	20.49 – 46.78	0.95 ± 0.26	15.69	5.83 – 60.7
Emamectin benzuate	0.15 – 2.5	0.77 ± 0.08	0.59	0.45 – 0.79	0.65 ± 0.21	24.01	5.36 – 143.78

1- EC_{50}= concentration that induced 50% reduction than control in number of eggs deposited after adult exposure to treated cotton leaves.
2- Conc. range includes 1/16 F.R, 1/8, 1/4, 1/2 and recommended field rate.
LC_{50}= concentration that induced 50% nonhatched egg

3. Translaminary activity

Translaminar activity may have important practical implications under field conditions for controlling whitefly ***B. tabaci*** (Genn.) present on the lower surface of the leaves. In most field sprays, insufficient of insecticide solution reach the lower surfaces of the leaves where whitefly eggs and immature stages are present.

Data in Table (5) demonstrate the translaminar activity of 6 IGRs compared with two

organophosphates. It is obvious that only two out of the six 1GRs exhibited in general high translaminar activity almostly closely to the organophosphates. The highest translaminar activity was recorded for emamectin benzoate (83.06%) and buprofezin (74.88%) compared with 82.67% for profenfos and 81.77% for chlorpyrifos. Other 1GRs possessed relatively moderate translaminar activity reached 43.43, 36.38, 33.38 and 24.62% for diflubenzuron, methoxyfenozide, chlorfluazuron and lufenuron, respectively. However, comparison on the basis of toxicity index revealed that emamectin benzoate was the most toxic one (T.1 = 100) against ***B. tabaci*** (Genn.) whereas chlorpyrifos was the least toxic (T.1. = 0.20) one.

In general, the data recorded here (Table 5) had showed that the translaminar activity varied considerably among different pesticides tested. However, one of the factors influencing translaminar is due to the mobility of different compounds which was affected and/or related to either quantitative and differences in plant cuticle waxes (Price, 1979; Baker, 1980; Ishaaya and Horowitz, 1995) or chemical components of insecticides itself such as active material and solvent mainly in addition to additive components such as surfactants, oils, synergists and inorganic salts. However, the lower translaminar activity may result from a difference in the wax level and/or in epiculticular structure of plant leaves (Ishaaya and Horowitz, 1995) . In this respect, later on Bucholz and Nauen (2001) studied the leaf systemic properties and found that the trnaslaminar activity could be due to plant-specific barier properties caused by different types of cuticle.

In previous study, Cock *et al.* (1990) found that less than 4% of the initial deposit of buprofezin that penetrated into the cotton leaves was sufficient to produce a moderate translaminar effect. They added that such moderate bioactivity could be due to that anpreciable (35%) fraction of buprofezin was absorbed to the leaf wax or to inert residues of the formulation.Valle *et al.* (2002) found that no presence of translaminar effect was detected when soybean leaves with 1st nymphs of ***B. tabaci*** were treated in the upper surface with buprofezin where no suppression of adult emergence occurred.

Table (5): Relative short-term translaminar activity of several insecticides on adults of *B.tabaci* on cotton seedlings under laboratory conditions.

Insecticides	a Treated surface	Slope ± SE	LC50 (95% F.L) ppm	T.l.	b Relative translaminar activity%
Chlorpyrifos-E	Both Upper	0.83 ± 0.52 0.86 ± 0.53	0.99 (0.52 – 1.56) 1.20	100	83.06
Profenfos	Both Upper	1.75 ± 0.49 0.53 ± 0.90	483.2 (393.2 – 589.7) 590.9 (411.80-833.71)	0.20	81.77
Lufenuron	Both Upper	1.47 ± 0.39 0.89 ± 1.10	394.6 (231.8 – 556.7) 477.3 (336.39-661.41)	0.25	82.67
Difluben zuron	Both Upper	1.17 ± 0.38 0.64 ± 0.52	49.36 (17.84 – 77.9) 113.64) (66.51-211.77)	2.02	43.43
Methoxyfenzide	Both Upper	0.59 ± 0.32 1.55 ± 0.52	25.25(20.13-63.70) 69.41 (46.19-101.77)	3.95	36.38
Buprofezin	Both Upper	1.29 ± 0.32 0.61 ± 0.46	6.12 (3.80 – 8.78) 24.86(16.23-44.11)	16.31	24.62
Chlorfluazuron	Both Upper	0.73 ± 0.19 2.55 ± 0.23	74.98 (42.8 – 155.57) 100.12 (90.38–258.1)	1.33	74.88
Emamectin benzuate	Both Upper	0.74 ± 0.26 1.37 ± 0.57	6.27 (0.57-11.66) 18.8 (17.97-172.4)	15.89	33.38

a- In both cases of treatments, adults under clip-on cages were exposed and fed on the lower surfaces of cotton leaves.
b- Translaminar activity %= (LC_{50} when both surfaces were treated/ LC_{50} when upper surface was treated) × 100.

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