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Effect of formulation types on the efficacy of indoxacarb against cotton leafworm *Spodoptera littoralis* (Lepidoptera: Noctuidae)

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Abstract:

The primary objectives of formulation technology are to optimize the biological activity of the pesticide and to give a product which is safe for use. The present study aimed to determine the more formulation type which had more the effect on the efficiency of indoxacarb against cotton leafworm *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae). Three formulation types of Indoxacarb; emulsifiable concentrate (EC), suspension concentrate (SC) and water dispersible granule (WG) were prepared in four concentrations and evaluated against 3rd instar larvae of cotton leafworm *S. littoralis*. Also, the physicochemical properties of the spray solution of these formulation types were determined. The results indicated that the EC was more formulation type effect on the efficiency of indoxacarb where the mortality percentage increased with it compared with other both formulation types. Also the medium lethal concentration was less with EC compared with SC and WG. The physicochemical properties of the spray solution illustrated that the values of surface tension and pH of ECwere less than SC and WG. On the other hand, the viscosity and conductivity values were more with EC than SC and WG. In conclusion, the formulation type may be increase the efficiency of the active ingredient. In this study EC concentrate was more effective on the efficiency of indoxacarb than SC and WG.

Introduction

For an insecticide to be effectively used in the control of insects, it must first be prepared into a form suitable for a particular application method. This preparation of an insecticide is called a formulation and involves the addition of various chemical solvents or diluents to improve the effectiveness or physical properties of the insecticide. The formulation improves the properties of a chemical for handling, storage, application and may substantially influence effectiveness and safety (Burges, 1998). Any given active ingredient can often be purchased in more than one formulation, for example, the active ingredient indoxacarb is available as an emulsifiable concentrate (EC), a suspension concentrate (SC) and a water dispersible granule (WG) thus, the same active ingredient is available in three different products. Indoxacarb is anoxadiazine pesticide developed by Du Pont Ltd., New Zealand that acts against lepidopteran larvae. Its main mode of action is via blocking of neuronal sodium channels. The use of insecticides such as indoxacarb insecticides plays an important role in controlling the Egyptian cotton leafworm in Egypt and will likely continue to be used until a more biological system with minimum environmental risks based management could be developed. The cotton leafworm, *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae) is a destructive prolific and highly polyphagous insect in Egypt that causes various ravages not only for cotton plants but also for other field crops and vegetables. It is considered to be a major pest of great economic importance in many countries since it attacks a multitude of host plants (Lobna *et al.,* 2013 and Heidi *et al.*, 2015). The aim of this study was to investigate the effect of three different formulation types on increasing the effectiveness of indoxacarb against cotton leafworm, *S. littoralis* under laboratory conditions.

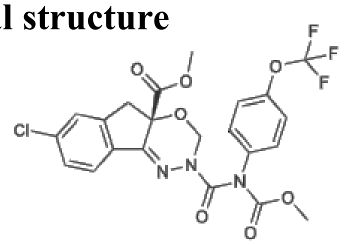
Materials and methods

1. Tested pesticide used:

Indoxacarb:

Indoxacarb is an oxadiazine pesticide developed by Du Pont Ltd., New Zealand that acts against lepidopteran larvae. Its main mode of action is via blocking of neuronal sodium channels.

Chemical structure



IUPAC name: Methyl7-chloro-2,5-dihydro-2-[[(methoxycarbonyl)[4(trifluoromethoxy)phenyl] amino]carbonyl] indeno[1,2-e][1,3,4]oxadiazine-4a(3*H*)-carboxylate

2. Indoxacarb formulation types used:

2.1. EC: Emulsifiable concentrate

2.2. SC: Suspension concentrate = Flowable concentrate

2.3. WG: Water Dispersible Granule

3. Insect pest used:

The laboratory strain of cotton leafworm *S. littoralis* was obtained from Plant Protection Research Institute, Agricultural Research center, Giza, Egypt to bioassay test. It was reared on castor oil leaves in laboratory under constant conditions of 27 ± 2°C, photoperiod of 14 hrs light and 10 hrs dark and 65 ± 5 % RH.

4. Bioassay tests:

Three formulation types of indoxacarb (emulsifiable concentrate, suspension concentrate and water dispersible granule) as well as control, were evaluated against cotton leafworm *S. littoralis* by leaf-dip bioassay method using castor oil leaves as described by Tabashnik *et al.* (1991). Four concentrations were prepared from each formulation type of indoxacarb (15, 30, 50 and 100 ppm). Castor oil leaves were first washed with distilled water then dipped in pesticide solution of different concentrations for 30 sec. and then air-dried. Five replicates were used for each concentration. Then leaves were placed individually into plastic cups (replicate). Twenty individuals of third instar larvae of *S. littoralis* were placed in each prepared plastic cups. Each cup was tightly covered with a piece of fine cotton cloth by means of a rubber band. Larvae were allowed to feed for 48 hrs on treated leaves. Larval mortality was recorded after 48 hrs post treatment. The mortality percentages were corrected by Abbott's formula (Abbott, 1925). Results were illustrated graphically as log/probit regression lines. Median lethal concentration (LC_{50}), slope values and 95 % fiducially limits were estimated by Finney's probit analysis method (Finney, 1971). Also, the toxicity index was calculated according to Sun's equation (1950).

5. Spray solution properties at field dilution rate:

The physicochemical properties for the spray solution of the three formulations were determined according to the following standard methods:

5.1. Surface tension: It was determined by using Du-Nouytensiometer for solutions containing 0.5 % (W/V) surfactant according to **ASTM D-1331 (2001).**

5.2. Viscosity: It was determined by using Brook field viscometer Model DVII+ Pro, where centipoise is the unit of measurement according to **ASTM D-2196 (2005).**

5.3. Electrical Conductivity: It was determined by using Cole-Parmer PH/Conductivity meter 1484-44, where µmhos is the unit of electrical conductivity measurements according to **Dobrat and Martijn (1995).**

5.4. PH: It was determined by using Cole-Parmer PH conductivity meter 1484-44 according to **Dobrat and Martijn (1995).**

Results and discussion

The efficiency of three formulation types (EC, SC, WG) of indoxacarb was evaluated on the third instar larvae of laboratory strain of cotton leafworm *S. littoralis* under laboratory condition. As shown in Table (1) the highest mortality percentage was with the treatment by EC followed by SC and the lowest mortality percentage was with the treatment by WG formulation type.

Based on the LC_{50} values of the tested formulation types, the present results indicated that all the tested formulation have larvicidal activities against 3^{th} instar larvae of *S. littoralis*. As shown in Table (2), EC formulation of indoxacarb proved to be the most toxic formulation compared with other tested formulations, the corresponding LC_{50} value was 9.66 ppm followed by SC, where the corresponding LC_{50} value was 24 ppm then WG, LC_{50} value was 51.84 ppm. These results indicated that the EC formulation type was more effective on the efficiency of indoxacarb against *S. littoralis* compared with the SC and WG formulations.

It was reported that the physicochemical properties of the spray solution of the pesticide formulation determine strongly the efficiency of the pesticides. The increase in viscosity and electrical conductivity could result in an increase in the pesticide efficiency as stated by Tawfik and EL-Sisi (1987) and Richardson (1974). The three formulations under study showed high and relative viscosity and conductivity values. But the emulsifiable concentrate (EC) formulation showed the lowest surface tension followed by the suspension concentrate (SC) and the water dispersible granule (WG) formulation, indicating the greater larvicidal efficiency according to Osipow (1964) who stated that the decrease in surface tension of the spray solution can result in an improved wet-ability and spreading on the treated surface with a consequence increase in the pesticide activity (Table, 3). Also, the pH of spray solution (level of acidity) plays an important role in the stability and effectiveness of pesticides. The lower pH in the spray solution leads to prevent degradation of pesticide active ingredients caused by the high pH spray solution (Tawfik and EL-Sisi, 1987). In the present study, EC formulation was lowest in pH value compared with other both formulations. Another explanation for the higher efficiency of the EC formulation compared to the SC and the WG is the solvent used for the preparation of each formulation, EC formulation contain an organic solvent while the other two formulations contains an aqueous solvent. In spite of the latter formulations were environmentally friendly than the other former one.

Table (1): Effect of three formulation types from indoxacarb, emulsifiable concentrate (EC), suspension concentrate (SC) and water dispersible granule (WG) on the mortality % of cotton leafworm *Spodoptera littoralis* under laboratory condition.

Indoxacarb conc.	15 ppm			30 ppm			50 ppm			100 ppm		
Formulation types	EC	SC	WG	EC	SC	WG	EC	SC	WG	EC	SC	WG
Mortality % corrected by Abbot's formula	6٢	31	13	89	58	23	96	79	45	96	93	82

Table (2): Susceptibility of the 3rd instar larvae of the cotton leafworm *Spodoptera littoralis* to three formulation types, emulsifiable concentrate (EC), suspension concentrate (SC) and water dispersible granule (WG), from indoxacarb.

Formulation type	LC_{50} ppm	Confidence limits 95%		Slope ± SE	Toxicity index %
		Lower (ppm)	Upper (ppm)		
EC	9.66	3.00	15.09	2.15 ± 0.54	100
SC	24.00	16.65	30.82	2.35 ± 0.47	40.25
WG	51.84	43.44	63.35	3.61 ± 0.58	18.63

Table (3): Physicochemical properties of the spray solution of the tested three formulations emulsifiable concentrate (EC), suspension concentrate (SC) and water dispersible granule (WG) at field dilution rate.

Physical properties and formulation	Surface tension Dyne/cm	Viscosity Cm/poise	Conductivity µ mohs	PH
EC	31.5	9.87	495	6.31
SC	42	8.87	363	7.80
WG	47.6	8.18	296	8.25

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