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Interactions Between Insects and Certain Pest Control Factors in an Aquatic Ecosystem

I. Toxicity of Five Herbicides Used in Rice Fields to Different Stages of *Culex pipiens* L.

Introduction

Rice fields represent a unique type of man-made agroecosystems with a wide variety of interacting biotic and abiotic factors. From the entomological point of view, a rice field is a common ground of interest for both those concerned with plant protection and those involved in medical entomology and public health problems. In addition to rice plants, weeds, algae, phytophagous insects, mosquitoes and mosquito predators, snails and sometimes certain species of fish as well as many microorganisms, rice fields receive several other components such as organic and inorganic fertilizers, fungicides, insecticides, herbicides etc. These "added elements" having been applied to the field soonly become integral part of this environment with all the manifestations of the possible interactions and interdependent relationships. The present work constitutes the first part of a wider multidisciplinary research programme aiming at investigating the inter-relationships that might occur between the naturally existing and the artificially added components in this agroecosystem.

Although it is agreed that interaction of herbicides with insects is of greatest significance to IPM (Robert, 1982), little is known about the effect of herbicides used for weed control in rice fields on the mosquito populations in these habitats. However, there are contradicting reports on the impact of various herbicide compounds and formulations on the invertebrate, and sometimes vertebrate fauna in the aquatic environments. Reports of Hooper (1985), Hilsenhoff (1966) and Smith and Isom (1967) indicate no harmful effects of 2,4-D and disquate on the bottom feeding invertebrates. Pimentel (1971) mentioned that damselfly nymphs and water beetles increased by at least 100% after the application of atrazine to a water body. In view of Robert (1982) herbicides in general are much less toxic to insects.

On the other hand, the harmfulness of herbicides of various chemical groups to aquatic fauna, including insects, were reported by Walker (1963 and 1965), Newman and Way (1966), McCraren et al. (1969), Frank (1971), Muirhead-Thomson (1971), Pimentel (1971) and Schaefer et al. (1983).

In the present work, five herbicides currently used for weed control in rice fields in Egypt, i.e. Ordram, Ronstar, Machete, Stomb 330 E and Rifit 550 EC were tested in the laboratory for their possible insecticidal activity against *Culex pipiens*.

Materials and Methods

The tested herbicides

– Ordram (Molinate), and organic carbothioate compound with the structure: S-ethyl hexahydro-1 H-azephine-1-carbothioate;

– Ronstar (oxadiazon), an oxadiazole compound with the structure: 2-tert-butyl-4-(2,4-dichloro-5-isopropyl-oxyphenyl)-1,3,4,-oxadiazolin-5-one;

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– Machete (Butachlor, Butanex, Lambast) an acetamide compound with the structure: N-(butoxymethyl)-2-chloro-N-(2,6-diethylphenyl)-acetamide;

– Stomb 330 E (Herbadox, Prowl), a dinitroaniline compound with the chemical structure N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitro benzenamine; and

– Rifit 550 EC, an acetamide compound with the following structure: 2-chloro-2,6-diethyl-(N-(2-propoxyethylacetanilide).

Test insect: A laboratory colony of *Culex pipiens* L.; was maintained using the Rearing technique described by ABOU-BAKR (1984).

Toxicity tests

The recommended field rate of each of the tested herbicides was used as a basal concentration (R); higher and lower concentrations were tested when necessary. It is estimated that one feddan of rice plants may contain approximately 800000 liters of irrigation water. Meanwhile, the rates recommended for field application of Ordram, Ronstar, Machete, Stomb and Rifit are 2500, 750, 2000, 700 and 700 cc/feddan, respectively. These field rates could be transformed in terms of numbers of milliliters/one liter of water (or ppm) to be equivalent to 0.003 (3 ppm), 0.0009 (0.9 ppm), 0.003 (3 ppm), 0.01 (10 ppm) and 0.01 ml/L (10 ppm), respectively. Egg rafts, L_2, L_4, and pupae of *C. pipiens* were exposed to different dilutions (in dechlorinated tap water) of the rested compounds. In each dilution 100 individuals in 4 replicates were tested. As for the adults, only Stomb 330 E and Rifit 550 EC were tested. Small fenestrated plastic cages (8.5 cm diameter, 9 cm high) was used for this purpose. Tested compounds were mixed with 10% sugar and pieces of cotton wool were saturated with the mixture and offered to adult mosquitoes. Experiments were carried out under a temperature of 25 °C, ranged between 24 and 27 °C. In all cases mortality readings were recorded for 3 successive days.

Results and Discussion

Effect on egg rafts

All the tested herbicides did not interfere with egg hatching when similar ten egg rafts of *C. pipiens* were placed in water containing concentrations equivalent to the recommended rates of each herbicide. There was no noticeable reduction in hatchability in comparison with the egg rafts kept in dech. tap water as untreated control (data not included in the tables).

Effect on larvae

Second and fourth-instar larvae of *C. pipiens* were exposed to five different concentrations of each tested herbicide.

Ordram and Machete caused no mortality among either L_2 or L_4 of *C. pipiens* when mosquito larvae were exposed to 3 ppm, a concentration corresponding to the field application rate 0.003 ml/L (R) (Table 1). Doubling the dosage to 2R resulted in no mortality with the exception of 4% death recorded among L_4 treated with Machete after 3 days of exposure. At higher concentrations, i.e. 10 ppm and 20 ppm which are equivalent to 4R and 8R, respectively, noticeable mortalities were observed. However, L_2 appeared less susceptible to the high concentrations of Ordram than L_4. The mortality reached 46% after 3 days among L_2 treated with 20 ppm while the same dosage caused 60% mortality

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Table 1:
Mortality % among L_2, L_4 and pupae of *Culex pipiens* exposed to Ordram and Machete in different concentrations for three successive days. Concentrations equivalent to the recommended field rates are marked as (R)

Tested mosquito stage	herbicide concentrations	Mortality %					
		Ordram			Machete		
		1 d	2 d	3 d	1 d	2 d	3 d
L_2	20 ppm (8 R)	0	12	46	28	42	68
	10 ppm (4 R)	0	2	4	20	30	44
	6 ppm (2 R)	0	0	0	0	0	0
	3 ppm (R)	0	0	0	0	0	0
	Control	0	0	0	0	0	0
L_4	20 ppm	14	26	60	32	48	64
	10 ppm	12	14	18	20	36	40
	6 ppm (2 R)	0	0	0	0	0	0
	3 ppm (R)	0	0	0	0	0	0
	Control	0	0	0	0	0	0
Pupa	20 ppm	0	0	0	6	6	6
	10 ppm	0	0	0	0	0	0
	6 ppm (2 R)	0	0	0	0	0	0
	Control	0	0	0	0	0	0

among L_4 after an equal period. As for Machete, there were no big differences between susceptibility of the both tested larval instars, with mortality reaching 68% and 64% on the third day among L_2 and L_4 when treated with a concentration of 20 ppm which is equivalent to 8-fold the application rate.

Similarly, Ronstar did not cause any mortality among L_2 and L_4 of *C. pipiens* when used at a concentration of 0.9 ppm. Increasing the herbicidal material to a rate of 8 ppm (=8 R) caused initial mortality of 44% among L_2. However, this mortality did not change during the following two days. On contrary to what was reported for Ordram, fourth-instar larvae of *C. pipiens* showed less resistance than those of the second instar when treated with high concentrations of Ordram (Table 2).

On the other hand, Stomb 330 EC and Rifit 550 EC demonstrated considerable larvicidal activity against both 2nd and 4th instar larvae of *C. pipiens* 24 hrs after treatment with concentrations equivalent to applied field rates (10 ppm). Data presented in Table 3 obviously show that the recorded mortalities were proportional to the concentrations used. The exposure of L_2 to 10 ppm of Stomb 330 E resulted in 44.9% mortality after 24 hrs, increased to 66.2% after three days in the same treatment which, in turn, caused 22.2 and 24.4% mortality among L_4 on the 1st and 3rd day, respectively. Stomb 330 E showed stronger insecticidal power than Rifit 550 EC when used in similar concentrations. A concentration of 10 ppm of this compounds killed 20% of L_2 on the 1st day increased to 34% on the 3rd day. The same concentration killed 18.2 and 54.4% of the treated L_4 on the 1st and 3rd day, respectively. Increasing the concentrations of the herbicides caused higher mortalities among treated larvae. Very high concentration (80 ppm) of these two compounds caused 100% death within only one hour in both L_2 and L_4 Table 3). Moreover,

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the two tested compounds seemed to keep their larvicidal action even in lower concentrations ($\equiv \frac{1}{2}$R) with relatively less mortality in Rifit than in Stomb in the case of L_2, but vice versa in the case of L_4.

Table 2:

Mortality % among L_2, L_4 and pupae of *C. pipiens* exposed to Ronstar in different concentrations for three successive days. Concentrations equivalent to the recommended field rates are marked (R)

Tested mosquito stages	concentrations	Mortality %		
		1 d	2 d	3 d
L_2	8 ppm	44	44	44
	4 ppm	12	22	40
	2 ppm	0	0	0
	0.9 ppm (R)	0	0	0
	Control	0	0	0
L_4	8 ppm	20	26	26
	4 ppm	10	12	12
	2 ppm	0	0	0
	0.9 ppm (R)	0	0	0
	Control	0	0	0
Pupa	8 ppm	0	0	0
	4 ppm	0	0	0
	20 ppm	0	0	0
	Control	0	0	0

Table 3:

Corrected mortality % among L_2, L_4, pupae and adults of *C. pipiens* exposed to Stomb 330 E and Rifit 550 EC in different concentrations for three successive days. Concentrations equivalent to the recommended rate are marked as (R)

Tested mosquito stage	concentrations	Mortality %							
		Stomb 330 E				Rifit 550 EC			
		1 h	1 d	2 d	3 d	1 h	1 d	2 d	3 d
L_2	80 ppm	100				100			
	40 ppm	78	84.1	88.1	90.1	0	100		
	20 ppm	0	69.6	80.2	86.7	0	42.0	76.0	86.0
	10 ppm (R)	0	44.9	66.2	66.2	0	20.0	30.0	34.0
	5 ppm ($\frac{1}{2}$R)	0	28.6	45.6	57.8	0	10.0	14.0	18.0
L_4	80 ppm	100				100			
	40 ppm	0	26.7	60.7	76.7	0	100		
	20 ppm	0	13.3	27.3	35.3	0	55.12	77.1	89.1
	10 ppm (R)	0	22.2	24.4	24.4	0	18.2	38.4	54.4
	5 ppm ($\frac{1}{2}$R)	0	2.2	8.8	8.2	0	10.2	16.2	20.2
Pupa	10 ppm (R)	0	6.0	10.1	12.2	0	4.0	6.3	6.3
Adult	10 ppm (R)	0	0	20.0	20.0	0	0	0	20.0

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Effect on pupae

No mortality was recorded among pupae of *C. pipiens* exposed to concentrations up to 4-fold the application rates of Ordram, Machete and Ronstar for 3 successive days (Tables 1 and 2). In one exeption, a concentration of 20 ppm of Machete, that equals 8 times the applied rate, cuased 6% mortality among the treated pupae one day after exposure. No increase in mortality was ovserved during the next two days (Table 1). However, R concentrations of both Stomb and Rifit caused noticeable mortality among treated pupa (Table 3): Stomb killed 6, 10.1 and 12.2% of pupa exposed to 10 ppm on the 1st, 2nd and 3rd days, respectively. Rifit seemed tobe less active in terms of pupicidal power; its R concentration killed 4 and 6.3% of the treated pupae on the 1st and 2nd days, respectively. No increase in this mortality was observed on the 3rd day. Results of the effect of the tested herbicides on mosquito pupae came in the same trend of their effect on the larvae.

Effects on adults

Newly-emerged adults of *C. pipiens* were tested against the herbicides which proved to have obvious insecticidal action against larvae and pupae of the same species when used at the regular dosages, i.e. Stomb 330 E and Rifit 550 EC. Mosquito adults were allowed to feed upon sugar solution mixed with 10 ppm of each of the two herbicides. No mortality was recorded in the case of Stomb one day after treatment. One day later, there was 20% mortality among treated adults. In the case of Rifit, similar result was obtained but after three days of exposure.

In conclusion, the obtained results indicate that the tested herbicides could be classified into two groups in terms of their insecticidal activity against mosquito when used at the field recommended dosages:

1) Mosquito-non-killing compounds, which include Ordram, Machete and Ronstar, and
2) Mosquito-killing compounds, which include Stomb 330 E and Rifit 550 EC.

Accordingly, when applied for weed control in rice fields or any other aquatic habitat, the two latter compounds will act as double.purpose pesticides; they will kill the target weeds and, at the same time, help in suppressing mosquito populations in the place. For the first glance, it is economically good to hit two birds with one stone. But from the ecological point of view it is necessary to go beyond this point. The impact of such chemicals on the other associated fauna, especially mosquito aquatic predators should be examined.

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Zusammenfassung

Fünf kommerzielle Herbizide, die für die Unkrautbekämpfung in Reisfeldern Ägyptens eingesetzt sind, werden im Laboratorium auf ihre Aktivität als Insektizid an verschiedenen Entwicklungsstadien von *Culex pipiens* getestet. Stomb 330 E und Rifit 550 EC zeigen deutliche Wirkung in Konzentrationen, die den Applikationsraten auf dem Feld entsprechen. Ordram, Machete und Ronstar beeinflussen die Mosquitos in diesen normalen Raten nicht.

Abstract

Five herbicides commercially used for weed control in rice fields in Egypt were tested in the laboratory for their insecticidal activity against different stages of mosquito, *Culex pipiens*. Two compounds, i.e.

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Stomb 330 E and Rifit 550 EC, demonstrated obvious larvicidal power when used at concentrations equivalent to field application rates. On the other hand, the other 3 compounds tested, i.e. Ordram, Machete and Ronstar did not affect mosquitoes when tested at normal rates.

Резюме

Пять кеммерческие гербициды, которыхиспольэйют для борьбы со сорняками на рисобых полях Эгиптии, подвергались испытанию в лаборатории как инсектицид на свою активность е различных стадиях развития *Cylex pipiens*. Штомб 330 Е и Рифит 550 ЕС демонстрируют заметное действие в концентрациях, которые соответствуют норме обработки на поле. Ордрам, Махете и Ронстар не влияют на москиты в этих нормальных нормах.

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