OCCURRENCE OF PROPANIL RESISTANCE IN *ECHINOCHLOA COLONA* IN CENTRAL AMERICA[5]

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Resumen: Se realizó un muestreo en las principales áreas productoras de arroz en centroamérica para determinar la presencia de poblaciones de *Echinochloa colona* resistentes al herbicida propanil. Se recolectó semilla en Costa Rica, El Salvador, Guatemala, Nicaragua y Panamá. Poblaciones selectas de *E. colona* se asperjaron con propanil a dosis crecientes hasta un máximo de 22.4 kg/ha en condiciones de invernadero en el CATIE, Costa Rica, para determinar su respuesta al herbicida y calcular el valor de RC_{50}. Las poblaciones analizadas variaron ampliamente en su respuesta al propanil, algunas fueron hasta 70 veces más resistentes que la población testigo (susceptible), dependiendo de las condiciones locales de crecimiento y de la presión de selección por el herbicida a que habían sido sometidas en el campo. La resistencia a propanil es bastante común en *E. colona* en centroamérica.

Introduction

The annual grass junglerice (*Echinochloa colona*) is a principal weed of rice throughout the tropics. Propanil, a relatively inexpensive, contact, post-emergence herbicide, has been traditionally used to control this weed. However, continued reliance on this herbicide led to the evolution of resistance. In Latin America, propanil resistance has been confirmed in Costa Rica and Colombia (Garro *et al.*, 1991, Fischer *et al.*, 1993).

Propanil resistance also occurred in the related species barnyardgrass (*E. crus-galli*) in Greece (Giannopolitis & Vassiliou, 1989) and Arkansas, USA (Smith *et al.*, 1992). The loss of this control option due to resistance in the weed flora has serious implications to farmers who depend on chemical weed control. The potential also exists for *Echinochloa spp.* to evolve resistance to alternative herbicides used in rice such as the case of a population of *E. colona* already resistant to propanil which was found to be resistant to the grass-herbicide fenoxaprop-ethyl in rice fields in Costa Rica (Caseley *et al.*, 1995).

The biochemical and physiological mechanism of resistance has been identified as an increased capability of *E. colona* to metabolize propanil in the same manner rice avoids phytotoxic damage (Leah *et al.*, 1994, 1995).

The existence, extent and severity of herbicide resistance is largely ignored in Latin America. Even in rice, where farmers now begin to recognize resistance as a problem, no specific actions are being taken by most growers to deal with or prevent the build up of resistance.

The objective of the bioassay studies reported here was to survey the extent of propanil resistance in *E. colona* populations in the main rice producing areas of Central America.

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Materials and methods

Collection of *E. colona* seed

E. colona seed samples were collected in the principal rice-growing areas in Panama, Costa Rica, Nicaragua, El Salvador and Guatemala. Fully mature seed was harvested by hand and taken to CATIE, Turrialba, Costa Rica, where they were coded and stored at room temperature until planting. Recent herbicide use history of sampled rice fields was obtained when it was possible.

Bioassays

Seeds were soaked in tap water for 24 hours with at least two water changes before they were placed in petri dishes containing filter paper (Whatman No. 2) moistened with water for germination at room temperature. Four seedlings (one-leaf growth stage) were transplanted in plastic pots with 260 g of soil supplemented with 2 g of 10-30-10 fertilizer and placed in a greenhouse with reduced light conditions. After this adaptation period, plants were transferred to a fully-exposed screenhouse until they reached the three-leaf stage.

One day before the application, plants were thinned to three per pot and sorted in a complete randomized block design with four replications. Propanil (Stam M4 AC 48% EC, Rohm and Hass) was applied at increasing doses (0, 0.35, 0.7, 1.4, 2.8, 5.6, 11.2 and 22.4 kg/ha) to individual pots in a spray booth (R & D Sprayers, Opelousas, Louisiana, USA) equipped with a Teejet 8001VS nozzle at 2.06 Bars, delivering 200 l/ha. Plants remained in the screenhouse for two more weeks until harvesting. Propanil phytotoxicity on *E. colona* was assessed visually at 8 and 15 days after treatment (DAT) and by harvesting the aerial part of the plants at 15 DAT to determine both fresh and dry weights. Two weeks after initial harvesting, clipped plants that resprouted were counted and weighted. Results shown in this paper are based only on fresh weight determinations.

GR_{50} (propanil rate required to reduce fresh weight by 50%) values were calculated for each *E. colona* population from regression equations. The resistance index (RI) was calculated as the ratio of the GR_{50} of the selected population over the GR_{50} of the most susceptible one (P2).

Results and discussion

Response to propanil varied considerably among *E. colona* populations from Central American countries and even within the same rice-growing region (Table 1). In general, there seems to be a relation between the rice-production history and the resistance level; however, some of the weed management practices at specific farms apparently have delayed resistance evolution even after many years of rice monoculture.

For example, susceptible populations from El Salvador were found at small farms (less than 3 ha) where agronomic practices are performed using family labor; fields are planted only once a year and hand weeding is practiced up to three times per crop cycle. Evidently, hand weeding decreases the selection pressure imposed by propanil in these fields.

Table 1. Response of selected *E. colona* biotypes from Central America to propanil.

Code	Country	Province or Department	Years of	Cycles/ rice[1]	GR_{50} year	RI[2]
CR39	Costa Rica	Guanacaste	NA	2	0.25	1.25
CR14	Costa Rica	Puntarenas	0	0	0.73	3.65
CR29	Costa Rica	Puntarenas	NA	1	1.16	5.80
CR5	Costa Rica	Puntarenas	15	1	1.55	7.75
CR16	Costa Rica	Puntarenas	NA	1	7.92	39.60
ES35	El Salvador	Ahuachapán	NA	NA	0.20	1.00
ES9	El Salvador	La Libertad	1	1	0.30	1.50
ES18	El Salvador	Sonsonate	15	1	0.35	1.75
ES3	El Salvador	Ahuachapán	15	1	0.50	2.50
ES8	El Salvador	La Libertad	5	1	0.69	3.45
ES6	El Salvador	La Libertad	2	1	0.70	3.50
ES7	El Salvador	Sonsonate	15	1	0.70	3.50
ES4	El Salvador	Chalatenango	10	1	1.50	7.50
ES5	El Salvador	Ahuachapán	15	1	1.50	7.50
ES28	El Salvador	Ahuachapán	26	1	2.80	14.00
ES30	El Salvador	La Libertad	NA	NA	8.68	43.40
G2	Guatemala	Chiquimula	25	1	0.33	1.65
G5	Guatemala	Chiquimula	25	1	0.42	2.10
G5	Guatemala	Chiquimula	25	1	0.42	2.10
G6	Guatemala	Chiquimula	NA	1	0.45	2.25
G1	Guatemala	Chiquimula	40	1	1.13	5.65
G3	Guatemala	Chiquimula	6	1	1.85	9.25
N21	Nicaragua	Matagalpa	0	0	0.24	1.20
N14	Nicaragua	Matagalpa	NA	2	0.45	2.25
N8	Nicaragua	Boaco	NA	2	0.47	2.35
N17	Nicaragua	Matagalpa	NA	2	0.85	4.25
N15	Nicaragua	Matagalpa	NA	2	1.70	8.50
N19	Nicaragua	Matagalpa	NA	NA	1.80	9.00
N10	Nicaragua	Boaco	NA	2	1.90	9.50
N7	Nicaragua	Granada	8	2	3.20	16.00
N5	Nicaragua	Granada	20	2	3.60	18.00

N1	Nicaragua	Granada	NA	2	3.62	18.10
N2	Nicaragua	Granada	5	2	3.62	18.10
N4	Nicaragua	Boaco	NA	2	4.25	21.25
N25	Nicaragua	Matagalpa	20	2	5.20	26.00
N3	Nicaragua	Granada	10	2	8.14	40.70
N12	Nicaragua	Granada	NA	2	8.14	40.70
N28	Nicaragua	Matagalpa	NA	2	9.58	47.90
N13	Nicaragua	Granada	NA	2	14.07	70.35
N11	Nicaragua	Managua	NA	NA	14.23	71.15
P2	Panamá	Coclé	NA	2	0.20	1.00
P6	Panamá	Herrera	16	2	5.40	27.00

[1] NA: Information not available, 0= Area not cultivate (field edge)

[2] RI: Resistance index

The highest resistance levels were found in Nicaragua. In the Granada (Malacatoya) area, farms are bigger, with long history of rice production and usually planted twice a year since there is irrigation available. Propanil has been used for more than 25 years and farm size does not allow for hand weeding. Susceptible populations from Nicaragua were those from farms where soil is puddled and the water table from irrigation helps in controlling weed seedlings. If propanil is used, it is commonly tank mixed with other herbicides. Additionally, in recent years some growers have shifted to the use of systemic grass killers such as fenoxaprop-ethyl.

Most of the *E. colona* populations from Guatemala are still fairly susceptible. Farmers in the Chiquimula area, where seed was collected, resemble those small growers from El Salvador, since they supplement chemical weed control with hand weeding.

The situation in Costa Rica was partially documented previously (Garro *et al.*, 1991). Only a few populations are included in this study, with varying degrees of resistance but it is well known that propanil resistance is very common in dryland-rice producing areas (Valverde, B. E., unpublished).

Only two populations from Panama are included. P2 from Penonomé was collected at a field edge and was used as a control for calculating the resistance indices; P6 from Chitré exhibited a high resistance level.

Results presented here indicate that propanil resistance is common among *E. colona* populations in the main rice growing areas in Central America and that differing degrees of resistance occur depending on local growing conditions and herbicide selection pressure.

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