

# Propanil Resistance in Smallflower Umbrella Sedge (*Cyperus difformis* L.): a New Challenge to Rice Growers in California

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## Introduction

Smallflower umbrella sedge (*Cyperus difformis* L.) is a major weed of California rice that is typically treated in post-emergence with propanil due to resistance to ALS-inhibitors<sup>1</sup>. However, growers have recently experienced poor *C. difformis* control with any of the available propanil formulations, suggesting resistance to this PSII inhibiting herbicide may have evolved in some populations.

## Objectives

Confirming the presence of resistance, quantifying its level, and exploring a metabolic basis for it were the objectives of the present work.

## Materials and Methods

**C. difformis** populations from 8 growers' fields with suspected propanil resistance, and from fields with known sulfonylurea-resistance (SM) and a susceptible control biotype (HR) were grown in pots in a greenhouse under average 24-30 °C, 16-h daylength and 900 μmol m<sup>-2</sup> s<sup>-1</sup> PPFD; plants were thinned to 5 per pot (58 cm<sup>2</sup>).

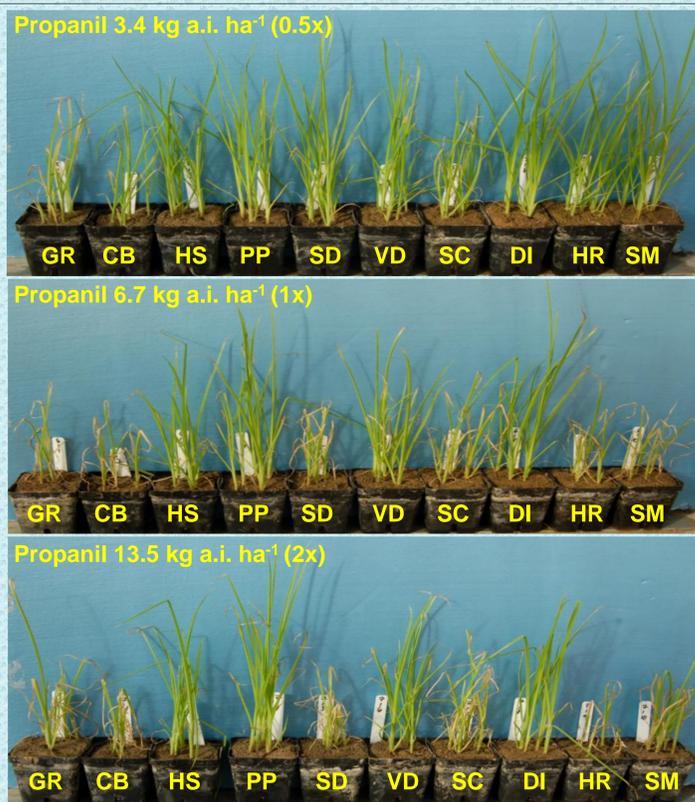
**Propanil resistance screening.** Plants from all populations were sprayed at either the 3-4 (run 1) or 2-3 leaf stage (run 2) with 0.5x, 1x and 2x of a high field rate (x = 6.7 kg ai ha<sup>-1</sup>) of propanil using a cabinet track sprayer with a 8001-EVS nozzle delivering 374 L ha<sup>-1</sup>.

**Whole-plant dose-response** was conducted in Spring, 2012 with PP and HR, which were the most resistant (R) and susceptible (S) populations in the previous test.

- Plants at the 2-3 leaf stage were treated with 8 propanil rates (0 to 8x, for x = 6.73kg ai ha<sup>-1</sup>).
- The insecticides malathion (1.0 kg a.i. ha<sup>-1</sup>) and carbaryl (1.8 kg a.i. ha<sup>-1</sup>) were applied individually to different sets of plants 1 day prior to the propanil treatments to explore possible aryl-acylamidase or P450-driven metabolism as the mechanism of resistance<sup>2</sup>.

**Evaluations:** Fresh weight was measured 14-17 days after herbicide application and the number of surviving plants/pot was counted. Experiments were repeated.

**Data Analysis:** Fresh weights were expressed as percent of the average untreated control for each population. and treatment means (resistance screening) were compared using Fisher's protected LSD (α = 0.05). Dose-response data were fit with a three-parameter log-logistic equation using the R statistical program (<http://www.R-project.org>).



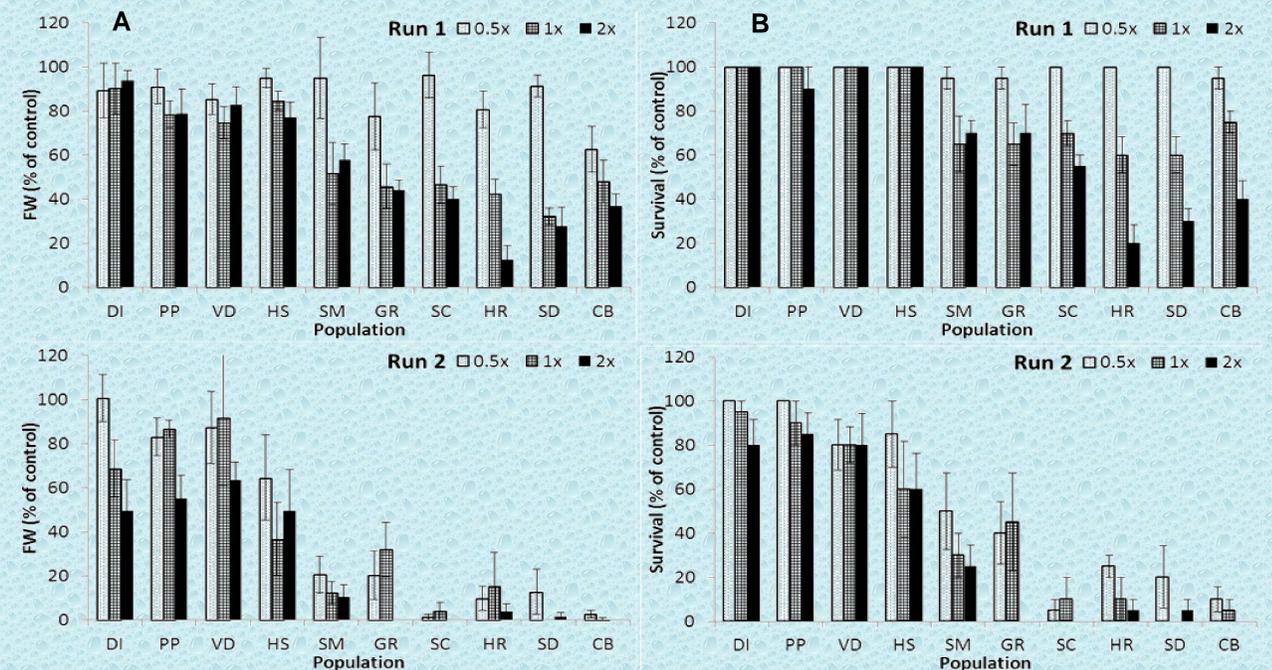
**Fig. 1.** Effects of propanil on *C. difformis* populations, (GR, CB, HS, PP, SD, VD, SC, DI, HR, and SM) 17 days after treatment.

**Table 1.** Resistance levels calculated by log-logistic analysis of propanil dose responses (Fig. 3);  $ED_{50}$  and  $ED_{20}$  are propanil rates for 50% and 20% fresh weight reductions, respectively. R/S are  $I_{50}$  and  $I_{20}$  ratios of R to S plants.

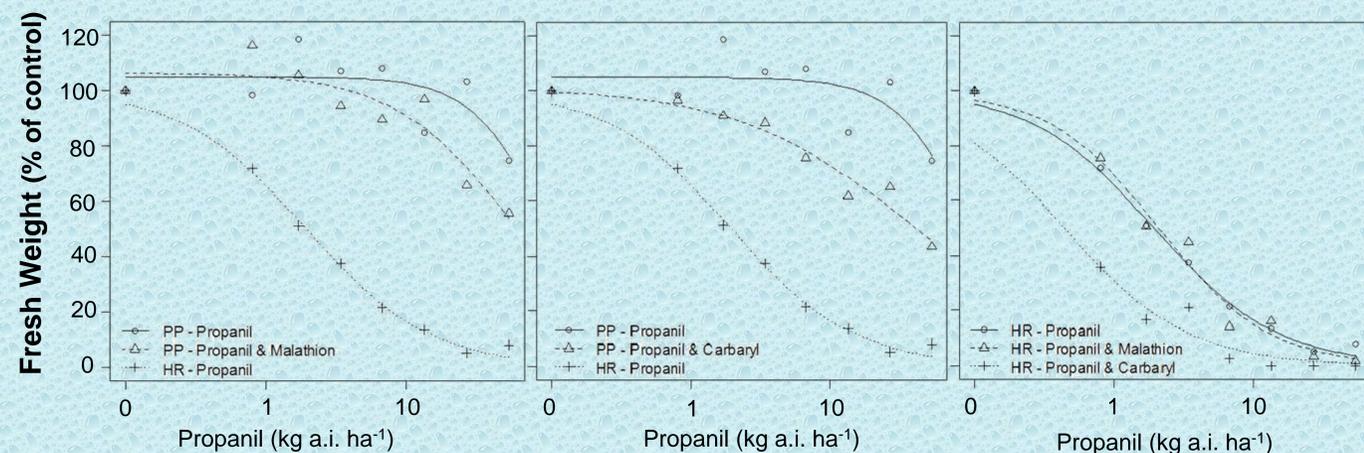
Population	Treatment	$ED_{50}$ (kg a.i. ha <sup>-1</sup> ± SE)	R/S	$ED_{20}$ (kg a.i. ha <sup>-1</sup> ± SE)	R/S
PP (R)	Propanil	> 54	>> 28.4	42.5 ± 13.3	88.5
HR (S)	Propanil	1.9 ± 0.5		0.5 ± 0.2	
PP (R)	Propanil + malathion	n.a.	n.a.	14.4 ± 5.8	30.0
HR (S)	malathion	n.a.	n.a.	0.6 ± 0.2	
PP (R)	Propanil + carbaryl	n.a.	n.a.	5.2 ± 2.3	10.9
HR (S)	carbaryl	n.a.	n.a.	0.1 ± 0.1	

n.a.: the  $ED_{50}$  value falls in a region beyond the range of observations, because it is greater than the highest propanil tested; R/S thus cannot be calculated

## Results



**Fig. 2.** Fresh weight (A) and survival (B) of ten *C. difformis* populations subjected to 0.5x, 1x and 2x propanil (x = 6.7 kg a.i. ha<sup>-1</sup>). Columns represent averages of 4 replicates expressed as a fraction of the untreated control, and bars are standard errors.



**Fig. 3.** Dose response of populations PP (R) and HR (S) to propanil, with and without malathion or carbaryl. Symbols are averages (n = 6 replicates); lines correspond to three-parameter log-logistic equations fitted to the data.

## Conclusions

- Four *C. difformis* populations (DI, PP, VD and HS) were resistant to propanil, making it the first such case outside the *Poaceae* family, and the first case of *C. difformis* resistance to mechanisms of action other than ALS inhibition<sup>1</sup>.
- Carbaryl and malathion reduced the resistance level ( $ED_{20}$ ) of the R population PP, suggesting a contribution of enhanced metabolism towards the mechanism of resistance. The  $ED_{20}$  was more reduced by the addition of carbaryl than by malathion, thus the stronger resistance mitigation by carbaryl suggests enhanced aryl-acylamidase activity could be more relevant than P450 metabolism as a mechanism of resistance<sup>3,4</sup>. The S population (HR) had much lower  $ED_{20}$  and  $ED_{50}$  values than PP (R) in all cases (table 1).
- Current research is aimed at further clarifying the mechanisms of propanil resistance in *Cyperus difformis* L.

## References

- Heap, I. 2012. The international Survey of Herbicide Resistant Weeds. [www.weedscience.com](http://www.weedscience.com)
- Norsworthy, J.K., R.E. Talbert and R.E. Hoagland. 1999. Chlorophyll fluorescence evaluation of agrochemical interactions with propanil on propanil-resistant barnyardgrass (*Echinochloa crus-galli*). *Weed Sci.* 47:13-19.
- Leah, J.M., J.C. Caseley, C.R. Riches and B. Valverde. 1994. Association between elevated activity of aryl acylamidase and propanil resistance in jungle rice, *Echinochloa colona*. *Pestic. Sci.* 42:281-289.
- Preston, C. 2004. Herbicide resistance in weeds endowed by enhanced detoxification: complications for management. *Weed Sci.* 52:448-453.