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[1]. 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 ºC, 16-h daylength and 900 µmol m^{-2} s^{-1} PPFD; plants were thinned to 5 per pot (58 cm^2).

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^{-1}) of propanil using a cabinet track sprayer with a 8001-EVS nozzle delivering 374 L ha^{-1}.

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^{-1}).
- The insecticides malathion (1.0 kg a.i. ha^{-1}) and carbaryl (1.8 kg a.i. ha^{-1}) 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[2].

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).

Results

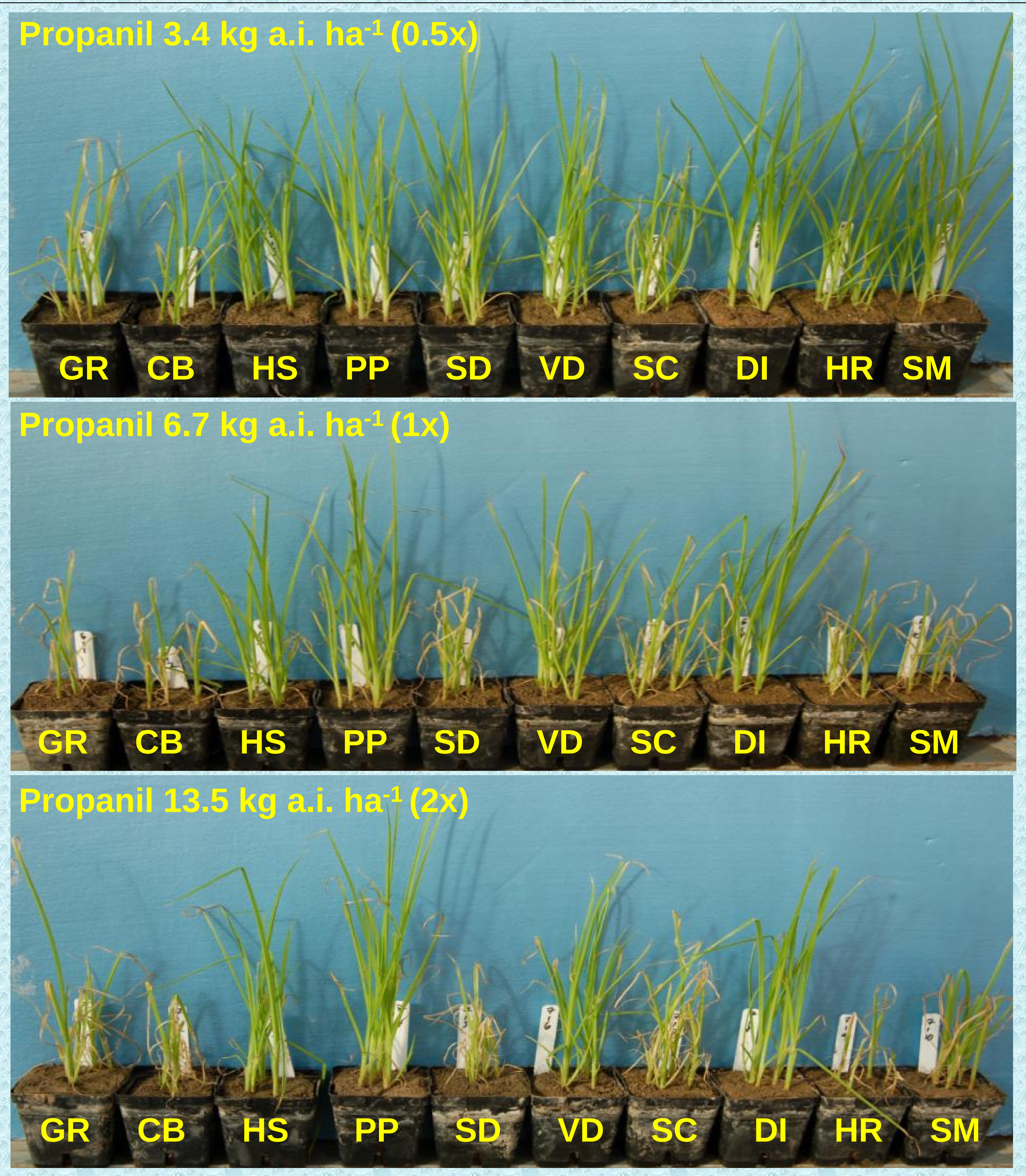

Fig. 1. Effects of propanil on *C. difformis* populations, (GR, CB, HS, PP, SD, VD, SC, DI, HR, and SM) 17 days after treatment.

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

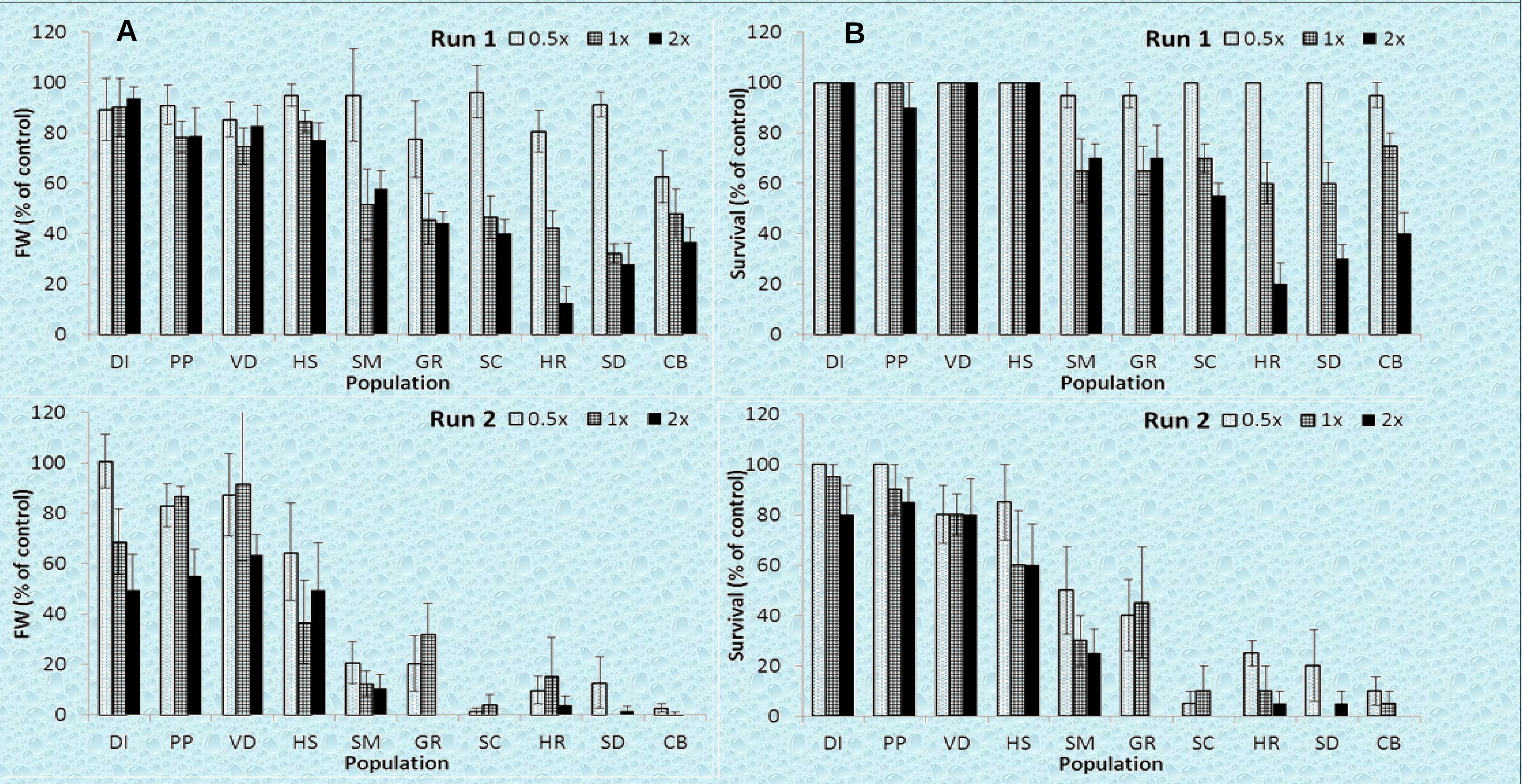

Fig. 2. Fresh weight (A) and survival (B) of ten *C. difformis* populations subjected to 0.5x, 1x and 2x propanil (x = 6.7 kg a.i. ha^{-1}). Columns represent averages of 4 replicates expressed as a fraction of the untreated control, and bars are standard errors.

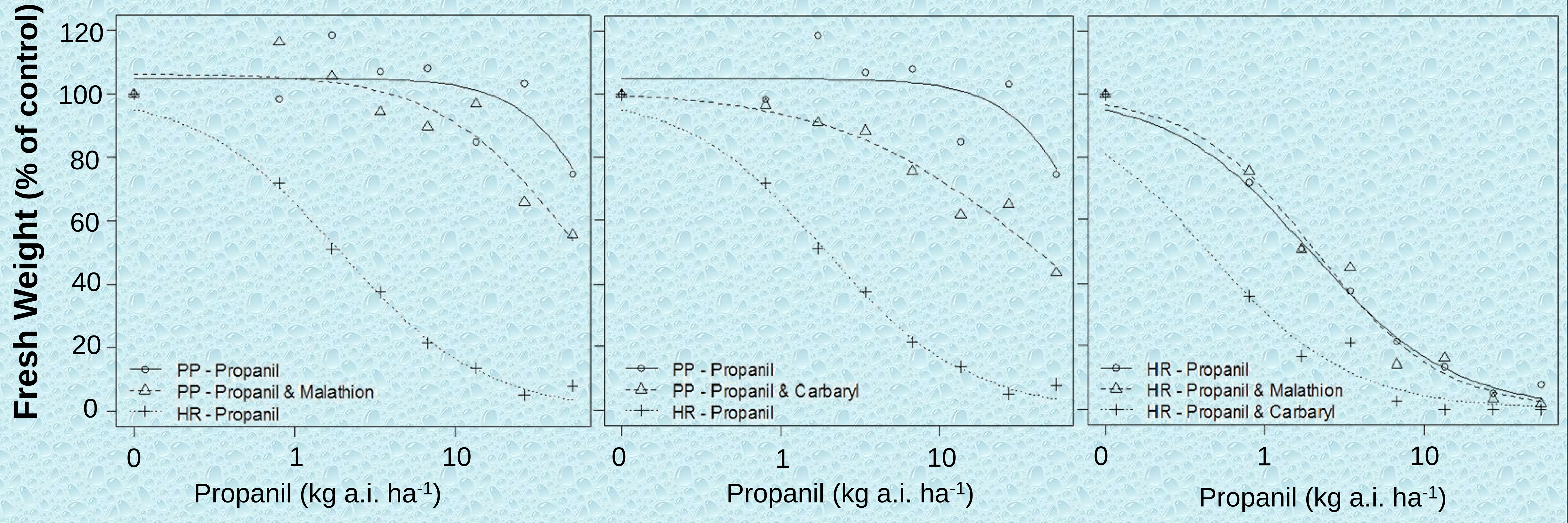

Fig. 3. Dose response of populations PP (R) and HR (S) to propanil, with and without malathion or carbaryl. Symbols are averages (n = 6 replicates); lines correspond to three-parameter log-logistic equations fitted to the data.

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[1].
- 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[3,4]. 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

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