HERBICIDE CROSS-RESISTANCE IN A POPULATION OF ANNUAL RYEGRASS, *LOLIUM RIGIDUM*

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Summary. Successive applications of herbicides to annual ryegrass, *Lolium rigidum*, have led to the selection of herbicide resistant biotypes. Resistant biotypes have cross-resistance to many herbicides with different modes and sites of action. There are now no selective herbicides for use in cereal crops, and few for legume crops, for the control of the resistant biotypes. Spraytopping is very effective in reducing seed production of resistant and susceptible biotypes and will be a useful tool in the integrated control of herbicide resistant ryegrass.

INTRODUCTION

Annual ryegrass is a widespread and important grass weed. It vigorously competes with both cereal and legume crops, reducing their yields (3, 4). Prior to the introduction of satisfactory control by selective grass herbicides, ryegrass infestations steadily increased with increasing cropping frequency. The successive application of grass herbicides to ryegrass populations has selected resistant individuals which existed in normal ryegrass populations at very low frequencies. A farmer generally becomes aware of poor ryegrass control when 30% or more of the population is resistant.

In 1980 a producer at Naracoorte, S.A., reported that a population of annual ryegrass on his property was no longer controlled by diclofop-methyl. The population was in an area devoted to medic seed production during the previous four years, and had been sprayed frequently with diclofop-methyl. Prior to this the dinitroaniline herbicides trifluralin and benfluralin had been used extensively. A population from an adjacent unsprayed area was, in contrast, controlled by diclofop-methyl (2).

The herbicide resistant (R) biotype of annual ryegrass has been shown to be cross-resistant to a range of grass herbicides (1). Herbicide resistant annual ryegrass has now been detected on many properties in W.A., S.A., Vic. and N.S.W.

This paper reports cross-resistance of annual ryegrass to a wide range of herbicides and a practical method of controlling the resistant ryegrass.

METHODS

Plant material. The resistant (R) population from Naracoorte (S.A.) has been treated with benfluralin in 1969, trifluralin from 1970 to 1977, and with diclofop-methyl annually from 1977 to 1980. The susceptible population came from screenings of a 1979 oat crop in an adjacent paddock which had never been sprayed with diclofop-methyl. The resistant population after two years field exposure to sethoxydim is designated "resistant (+S)". A susceptible population of annual ryegrass from the Waite Institute never sprayed with herbicides is designated "Waite susceptible".

Studies of cross-resistance. Cross resistance was studied using one pre-emergence herbicide trifluralin) and eight post-emergence herbicides (diclofop-methyl, fluazifop, chlorsulfuron, CGA 131-036, alloxydim, haloxyfop,

glyphosate and carbetamide) on five replicates. Herbicide rates are given in g a.i./ha in Figs. 1 and 2.

Trifluralin was mixed with sand at rates which were calculated on the basis of a 5 cm deep incorporation layer. Ten seeds were placed 2 cm deep into the treated sand in pots in a glasshouse.

For the post-emergence herbicides seeds were sown in 12 cm diameter pots, containing a 16 cm deep layer of potting soil and maintained in a glasshouse. Seedlings were thinned to leave 10 seedlings of a uniform size per pot. Treatments were applied 20 days after sowing, when the plants were at the three leaf stage. An experimental pot sprayer with an output of 125 L/ha was used to apply all treatments. Agral^{R} 60 was added to all solutions at 0.2% (v/v). Surviving plants and shoot dry weight were recorded 40 days after treatment. Percentage survival is presented as it indicates most of the important features.

Spraytopping trial. This trial was conducted on a property near Naracoorte, S.A. The resistant population infested an irrigated seed crop of subterranean clover. The producer had attempted to control the ryegrass with sethoxydim in June at 224 g a.i./ha and in July at 374 g/ha. Ryegrass samples tested from this paddock were found to be herbicide resistant.

A susceptible ryegrass population, 2 km from the resistant population, dominated in a less vigorous clover stand. This population had not been sprayed with herbicides since 1975 and samples tested from this population were found to be susceptible to herbicides.

Treatments were applied on 13 November 1986 at the peak of flowering in both populations. Paraquat and glyphosate were applied to 4 replicates using an experimental plot sprayer with an output of 125 L/ha. Agral^{R} 60 was added to all solutions at 0.2% (v/v). The treatments were 0, 0.5, 1.0 and 2.0 times the recommended rate of paraquat and glyphosate. All plots were harvested 5 weeks after treatment when the unsprayed plots had dired. Samples of heads were taken from three 0.1 m^2 quadrats in each replicate. Samples were threshed, sieved and viewed over a light table to allow collection and counting of all seeds which had developed any endosperm.

RESULTS AND DISCUSSION

The selection of resistant individuals and the development of resistant populations as a result of repeated applications of trifluralin and diclofop-methyl was predictable, but the cross-resistance of these biotypes to several grass herbicides with different modes of action was unexpected. The R biotype used in this study had never been exposed to fluazifop, chlorsulfuron, CGA 131-036, alloxydim or haloxyfop, yet these chemicals were ineffective for controlling it (Figs 1 and 2c).

Resistance is quantitative rather than qualitative (Fig. 2c). The original R biotype was resistant to haloxyfop, but its resistance increased following two years exposure to sethoxydim. This increase is a good demonstration of the development of cross-resistance as resistance to a third herbicide increased following exposure to two others.

The response of the R and S biotypes to glyphosate or carbetamide did not differ (Figs. 2a and 3b).

Spraytopping strongly reduced seed set in both R and S biotypes (Table 1),

more so within R, the heads of which were more erect in vigorous irrigated clover crop and thus presented a better target than the prostrate S. The tendency to higher seed weights in the R biotype is also likely to be due to irrigation earlier in the year. With increasing rates of both paraquat and glyphosate, the number of seeds/m^2 as well as the individual seed weights decreased.

Table 1. Control of herbicide resistant and susceptible annual ryegrass in pasture by spraytopping with paraquat and glyphosate

Herbicide and rate (g/ha)	Susceptible		Resistant	
	Seed prod. (seeds/m^2)	Seed wt. (mg/seed)	Seed prod. (seeds/m^2)	Seed wt. (mg/seed)
No treatment	35,075	1.88	45,185	2.92
Paraquat				
50	280	1.50	177	2.31
100	236	1.36	9	1.78
200	105	1.08	2	1.37
Glyphosate				
81	630	1.66	111	2.27
162	273	1.45	10	1.44
324	139	1.31	1	0.90
l.s.d.[a]	1.92	0.14	3.88	0.64

[a] Seed production values were analysed as logarithims so the numbers given are geometric means. To establish significant differences, multiply or divide the values by the l.s.d.

When a producer has to deal with a herbicide resistant biotype, increasing the rate of herbicide will aggravate the problem by selecting even greater resistance. Other selective grass herbicides will in general give similar results, so an integrated control program, which is not solely reliant on chemicals, is necessary. Some control measures should be directed towards reducing seed set in the year before cropping using non-selective herbicides such as spraytopping with either paraquat or glyphosate (Table 1). The producers that are more at risk of selecting a herbicide resistant ryegrass biotype are those who crop continuously and therefore do not have the opportunity to use spraytopping. The appearance of herbicide resistant ryegrass on these properties may force producers to restructure their cropping rotations.

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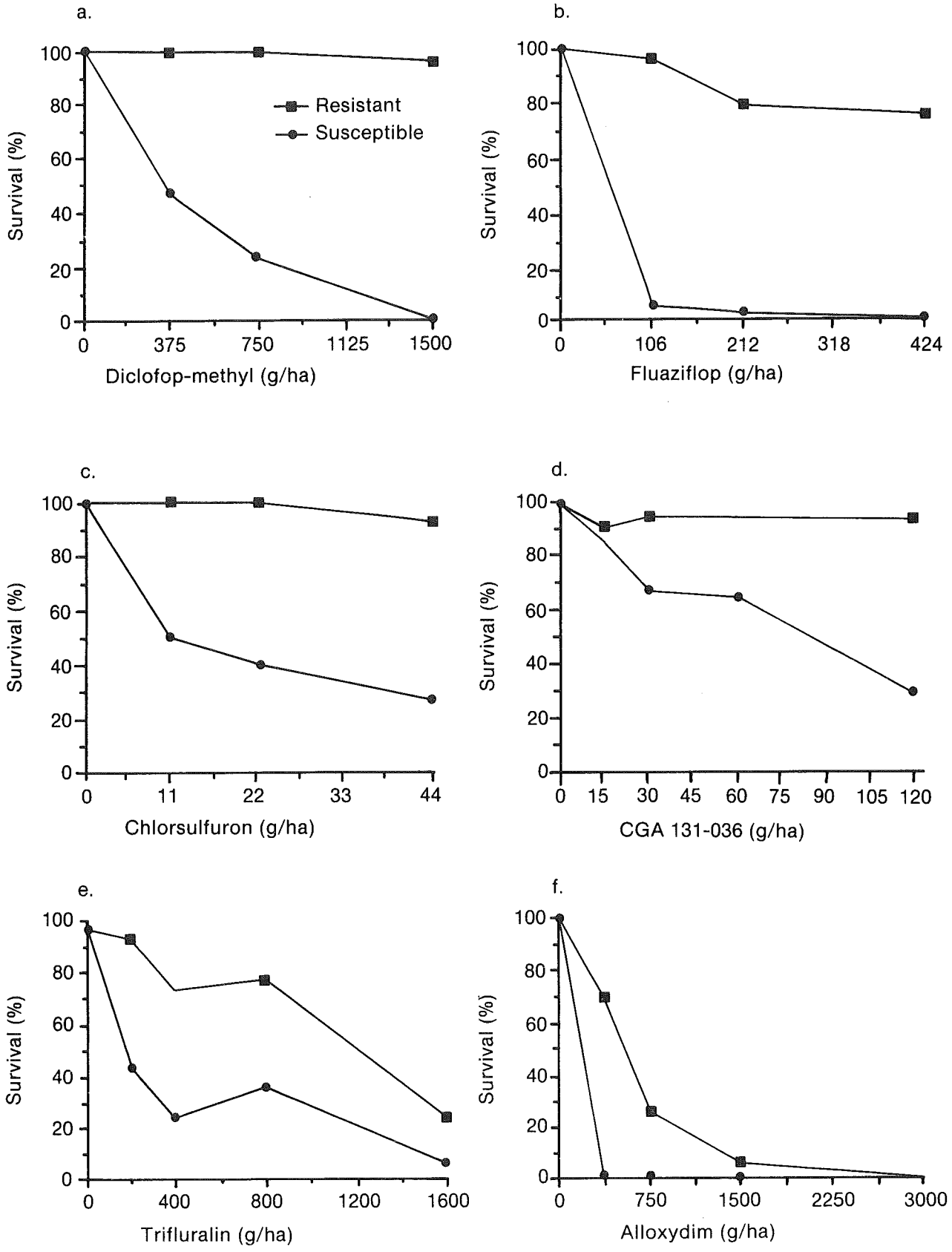

Figure 1. The survival (%) of herbicide resistant and susceptible annual ryegrass biotypes six weeks after herbicide application. Trifluralin was applied pre-emergence to the ryegrass. The other herbicides were applied post-emergence at the 2-3 leaf stage.

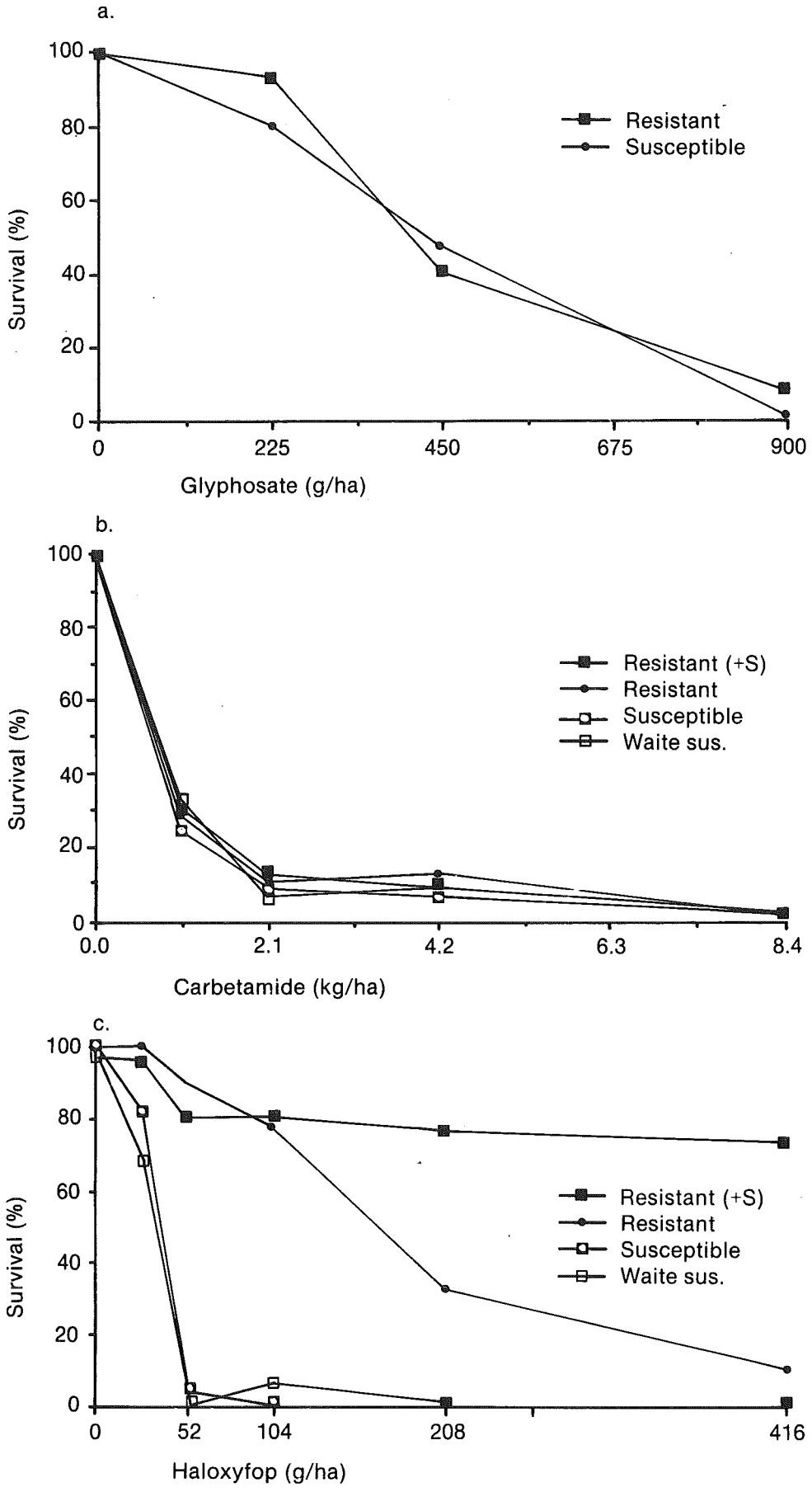

Figure 2. The survival (%) of herbicide resistant and susceptible annual ryegrass biotypes six weeks after herbicide application.