The inheritance of herbicide resistance in *Avena sterilis ssp. ludoviciana*, biotype SAS 1.

Andrew R. Barr[a], Ali M. Mansooji[b], Joseph A.M. Holtum[b] and Stephen B. Powles[b]
[a] S.A.D.A., Northfield Research Laboratories, S.A. 5085.
[b] Dept. Crop Protection, University of Adelaide, S.A. 5064.

Summary
Reciprocal crosses were made between cultivated oat (*Avena sativa* L.) cultivars 'Echidna' and 'Mortlock' and a biotype of wild oats (*A. sterilis ssp. ludoviciana*, biotype SAS 1) highly resistant to all aryloxyphenoxypropionate graminicides currently registered.

F_1 plants probed with fenoxaprop exhibited intermediate resistance responses whereas F_2 plants probed with fenoxaprop or fluazifop segregated to give responses in a ratio close to 1 resistant :2 intermediate :1 susceptible.

It is concluded firstly, that inheritance of resistance in SAS 1 fits models expected for a partially-dominant, nuclear-encoded single gene and secondly, resistance can be transferred to cultivated oats.

Introduction

Cultivated oats and wild oats are predominantly self-pollinated, closely-related hexaploid *Avena* spp that are normally sensitive to aryloxyphenoxypropionate (APP) and cyclohexanedione (CHD) graminicides. A consequence of this sensitivity is that APP and CHD herbicides cannot be used in oat crops.

Resistance to the APP graminicides has been detected in wild oat, both *A. fatua* and *A. sterilis*, from W.A., S.A., Vic. and N.S.W. (Holtum, unpub.). *A. sterilis*, biotype SAS 1, collected from Bordertown, South Australia, exhibits extreme resistance to the APP graminicides and a low level of resistance to CHD graminicides (2).

Crosses between SAS 1 and oat cultivars 'Echidna' and 'Mortlock' were performed to (1) test whether resistance could be transferred to cultivated oat breeding lines and (2) determine the inheritance of resistance in SAS 1.

Materials and methods

Reciprocal crosses were made in a glasshouse using the approach method between *A. sativa* cv. Echidna (classed susceptible to APP herbicides), cv. Mortlock (classed moderately susceptible to APP herbicides) and SAS 1. Parental, F1 and F2 seed was dehulled, pricked and placed on filter paper wetted with a 0.2 % solution of KNO_3 at 2°C. Germinated seedlings were transferred to soil and were treated with herbicide when most plants were at the two leaf stage.

Assessments of resistance were made 14 days after spraying. Plants were classed as alive or dead. Those in the alive class were designated resistant if they exhibited no symptoms of herbicide injury or intermediate if they exhibited leaf tip necrosis, leaf death and reduced growth rate but were still alive after 14 days.

Results

Expression of herbicide resistance in F_1 and F_2 plants was probed with fenoxaprop (300 or 600 g a.i which is equavalent to 5 or 10 L ha^{-1}) or fluazifop (550 g or 2.5 L ha^{-1}) (Tables 1 and 2).

Table 1. Responses of parents, F_1 and F_2 plants of reciprocal crosses of Mortlock and SAS 1 to graminicides

genotype or population	fenoxaprop rate 5 L ha^{-1}			10 L ha^{-1}			fluazifop rate 2.5 L ha^{-1}		
	res	int	susc	res	int	susc	res	int	susc
cv Mortlock	0	0	50	0	0	50	0	0	50
SAS 1	50	0	0	50	0	0	50	0	0
Mortlock/SAS 1 F_1	0	1	1	0	3	0	not determined		
SAS 1/ Mortlock F_1	0	3	0	0	2	1	not determined		
pooled F_1	0	4	1	0	5	1	not determined		
Mortlock/SAS 1 F_2	14	24	12	11	24	15	34	43	36
SAS 1/ Mortlock F_2	16	24	10	15	27	8	not determined		
pooled F_2	30	48	22	26	51	23	34	43	36

Table 3. Responses of parents, F_1 and F2 plants of reciprocal crosses of Echidna and SAS 1 to graminicides

genotype or population	fenoxaprop rate 5 L ha^{-1}			10 L ha^{-1}			fluazifop rate 2.5 L ha^{-1}		
	res	int	susc	res	int	susc	res	int	susc
cv Echidna	0	0	50	0	0	50	0	0	50
SAS 1	50	0	0	50	0	0	50	0	0
Echidna/SAS 1 F_1	0	5	1	0	0	2	not determined		
SAS 1/ Echidna F_1	0	2	1	0	0	5	not determined		
pooled F_1	0	7	1	0	0	7	not determined		
Échidna/SAS 1 F_2	10	18	13	10	15	14	33	90	37
SAS 1/ Echidna F_2	F_1 plants produced no viable seed								
pooled F_2	10	18	13	10	15	14	33	90	37

The qualitative herbicide responses of F_2 progeny were compared with segregation ratios expected for single gene transmission (Table 3).

Table 5. Fit of observations (pooled values for reciprocal crosses if available) for F_2 progeny to one gene models of inheritance using a X^2 test

treatment	Mortlock x SAS 1		Echidna x SAS 1	
	alive[1]:dead 3:1	res:int:susc 1:2:1	alive:dead 3:1	res:int:susc 1:2:1
fenoxaprop 5 L ha^{-1}	.4 <P	.4 <P	.3 <P	.6 <P
fenoxaprop 10 L ha^{-1}	.6 <P	.9 <P	.1 <P	.2 <P
fluazifop 2.5 L ha^{-1}	.1 <P	.01 <P <.025[1]	.5 <P	.2 <P

[1] the only hypothesis rejected at the 0.05 X^2 critical value

Discussion

For all crosses and for both herbicides, the performance of F_1 and F_2 plants indicates that resistance is conferred by a single dominant gene. Plants surviving herbicide application could be subdivided into 'resistant' and 'intermediate' (that is alive but damaged) classes. In most F_2 populations, the most appropriate model was 1 resistant : 2 intermediate : 1 susceptible. F_1 plants were usually classed as intermediate. Hence the simplest model is that resistance to the graminicides fenoxaprop and fluazifop in SAS 1 is coded by a single, nuclear-encoded, partially dominant gene.

SAS 1 contains a herbicide-insensitive target enzyme, acetyl coenzyme-A carboxylase (ACC; 2). Our hypothesis is that a single partially-dominant gene codes for this mutant. In maize and *Lolium multiflorum*, resistance to sethoxydim or diclofop endowed by ACC is inherited in a nuclear-encoded, partially-dominant single gene manner similar to that observed for SAS 1 (1, 3).

A more rigorous testing of this hypothesis is underway.

References

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