GENETIC VARIABILITY BETWEEN AND WITHIN POPULATIONS OF GREAT BROME, *BROMUS DIANDRUS* ROTH, TO CHLORSULFURON AND SIMAZINE COULD RESULT IN THE DEVELOPMENT OF HERBICIDE TOLERANCE

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Summary. Measurements of leaf growth detected significant variation in response to chlorsulfuron and simazine between progenies of plants selected at random from two adjacent populations of great brome, *Bromus diandrus* Roth, at Badgingarra, W.A. The mean responses of the two populations also differed significantly. Populations of great brome tolerant to chlorsulfuron and simazine could develop if either herbicide is applied repeatedly.

INTRODUCTION

Chlorsulfuron and simazine are used by farmers for weed control in wheat and lupins respectively. It is unknown how repeated use of these herbicides will affect the weed flora, particularly great brome which has become a serious weed in recent years.

The potential for the development of a biotype of a weed that is tolerant or resistant to a herbicide will depend on the presence of tolerance or resistance genes derived from mutation within the species, or the capacity of the species to acquire these genes through hybridization (4). Like other *Bromus* spp., great brome is believed to be a predominantly selfing annual with some outcrossing (9). In addition, it is an octaploid (2n = 56) and has awns for long-distance dispersal (3). Consequently, its populations are expected to be genetically variable (7).

This paper reports on variability between and within populations of great brome to chlorsulfuron and simazine. The test for herbicide responses was a simple, non-destructive measure of leaf length of seedlings that permited the selection of tolerant and sensitive individuals for subsequent studies of the genetics and physiology of tolerance.

METHODS

Two populations of great brome (BB and BC) were established from collections in adjacent paddocks at Badingarra Research Station, W.A. in 1985. Each population consisted of one hundred panicles (families) sampled at 1 m intervals along 8-10 transects (1). The paddocks had a variable history of cropping and herbicide treatments (Table 1).

A sandy soil from Lancelin, W.A. (pH 5.0 in $CaCl_2$) was sieved and air-dried. A complete nutrient solution and chlorsulfuron (Experiment 1) or simazine (Experiment 2) were applied to the soil surface of each pot to give, respectively, 40 and 500 ug/kg sand. When dry, the contents were thoroughly mixed in a cement mixer and the mixed soil was repotted into plastic cups (250 ml) at 300 g/cup.

The growth of seedling-leaves of 25 random families of each of the two populations were measured at root temperature of 15°C(± 3°C). Two seeds of great brome were sown 30 mm deep in each cup and thinned to one seedling per cup three days after emergence. Each family was represented by 10 cups (individuals) and cups were completely randomised with individuals nested within families within populations. Cups were placed in water baths in a glasshouse and watered as required to maintain field capacity. The final length of the lamina of the third leaf (LL3 for Experiment 1) and of the second leaf (LL2 for Experiment 2) were measured from the ligule to the leaf tip. Both leaf measurements were previously established to be sensitive measures of response to chlorsulfuron and simazine respectively (Kon and Blacklow, unpublished data).

Table 1. Crop and herbicide histories of the sites of collection of great brome from Badgingarra Research Station, W.A. in 1985

History	Populations[a]	
	BB	BC
Crops	Continuous cropping with cereal and lupins rotation since 1978	Volunteer subclover pastures since 1978 except for lupins in 1984
Herbicides:		
chlorsulfuron	1983	
simazine	1978, 1980, 1982, 1984	1984
diclofop-methyl	1981	
paraquat/diquat	1985	1983

[a] The populations were collected from two adjacent paddocks, about 100 m apart

RESULTS AND DISCUSSION

Significant differences in lamina length between the two Badgingarra populations following treatment with chlorsulfuron and simazine (Table 2) indicated there were differences between them in frequencies of genes controlling responses to these herbicides. However, the differences between the population means, although statistically significant, were not sufficiently large to suggest that these populations have developed herbicide tolerance. This is not surprising given that the sites of collection were only exposed to less than four years of any one herbicide which was also rotated with other herbicides of different modes of action (Table 1). Such practices, particularly the use of paraquat/diquat, could have delayed the appearance of tolerance in these populations.

An analysis of the variation between progenies of plants randomly selected from within each population also revealed significant differences between these families in their response to each herbicide (Figs. 1 and 2). Thus, it can be inferred that individual plants in these populations differed in respect of their genes that determined herbicide response. These populations could therefore still develop higher levels of tolerance under strong selection pressure associated with continuous application of a single herbicide. The development of tolerance to simazine could be more rapid than to chlorsulfuron due to the greater variability of the populations to simazine (Table 2).

Table 2. Analysis of the variation between and within populations of great brome from Badgingarra based on the lamina length of the third (LL3) and second (LL2) leaves of seedlings grown in 40 and 500 µg/kg soil of chlorsulfuron and simazine respectively.

Herbicide	Statistical significance[a]	C.V. (%)	Lamina length (mm)	
			BB	BC
Chlorsulfuron (LL3)				
Populations	***	98.5	89	82
Families within populations	***	17.5		
Individuals wihtin families		9.4		
Simazine (LL2)				
Populations	***	186.0	11	16
Families within population	***	141.1		
Individuals within families		77.9		

[a] *** Significant at P = 0.001.

The mode of inheritance of tolerance in great brome to these herbicides is presently unknown but we suspect it was polygenic because the distribution of tolerance was continuous (Figs. 1 and 2). Genetic variations in tolerance to chlorsulfuron and simazine, respectively, were interpreted as variations due to differences in metabolic breakdown by hydroxlation and glycoside conjugation (11), and N-dealkylation, glutathione conjugation and non-enzymatic hydroxylation (8). Resistance to chlorsulfuron in tabacco, and resistance to simazine in maize, were both controlled by a single, dominant gene in the nucleus (2, 5).

The selection pressures in our experiments were zero for chlorsulfuron (no mortality) and high for simazine (>99% mortality). However, in a chlorsulfuron environment, the tolerant genotypes may compete better with the sensitive ones; and may set more seeds assuming seedling vigour was correlated with fecundity. In a simazine environment, the survivors could mature and produce offsprings. For inbreeders such as great brome (9) in which some tolerant genotypes are already present, genetic shifts towards tolerance could be rapid (6). The inflow of new tolerance, or perhaps resistance genes, from other populations if possible through seed dispersal by machinery, human activities and stock movement, and thereafter, through occasional outcrossing supposing paternal inheritance in probable (10). Heritable herbicide resistance is likely to exist in most species and for most herbicides (4) and, by anology, this adds weight to the argument that great brome can develop tolerance and resistance also.

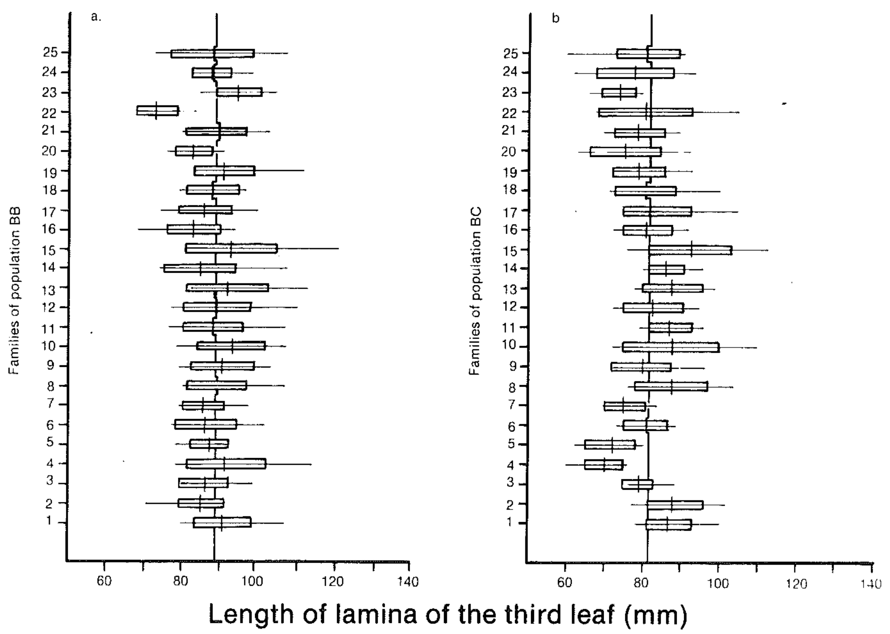

Figure 1. Variability in leaf growth of great brome when grown in soil containing 40 ug/kg of chlorsulfuron: (a) Badgingarra population BB, (b) Badgingarra population BC. The response of individuals within populations is represented by the range (horizontal line), standard deviation (box), and mean (vertical line). The population mean is shown by the continuous vertical line. Both populations were grown at a root temperature of 15°C.

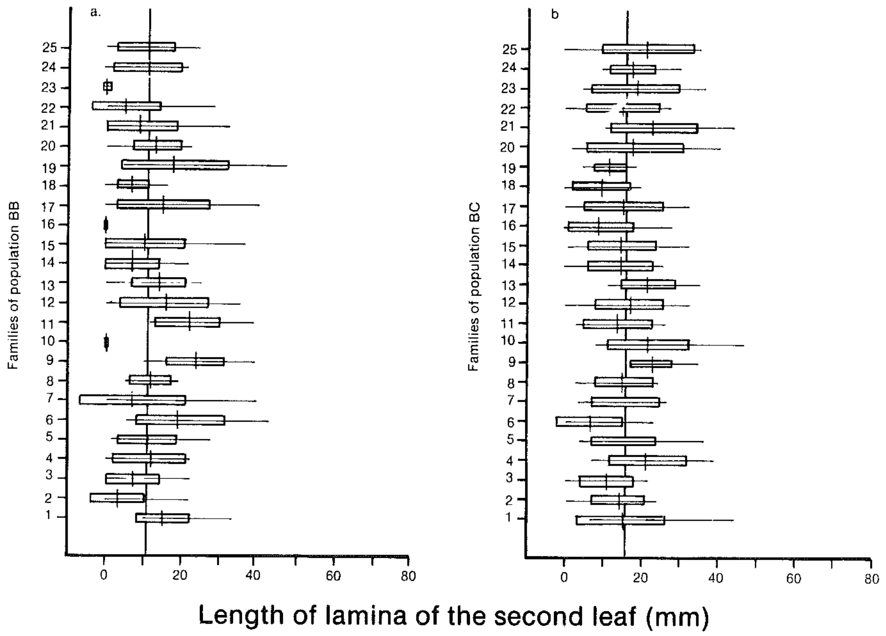

Figure 2. Variability in leaf growth of great brome when grown in soil containing 500 ug/kg of simazine: (a) Badgingarra population BB, (b) Badgingarra population BC. The response of individuals within populations is represented by the range (horizontal line), standard deviation (box) and mean (vertical line). The population mean is shown by the continuous vertical line. Both populations were grown at a root temperature of 15°C.

It is concluded that, if chlorsulfuron and simazine is repeatedly used, there is some potential for great brome populations to develop greater tlerance to these herbicides. Although our populations tested did not show convincing increase in tolerance to either herbicide, we envisage that the development of tolerance to simazine would be more rapid than to chlorsulfuron because of the stronger selection pressure exerted by simazine. Accurate prediction of the rate of appearance of herbicide tolerance using a simulation model (4) is currently not feasible because of insufficient data on the relationships between the selection pressure of the herbicides, and the fitness and phenotypic plasticity of great brome. However, we can state that if herbicide rotations and herbicide mixtures are not incorporated into a weed control programme, the appearance of herbicide tolerance could be accelerated (4).

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