DEVELOPMENT OF HERBICIDE RESISTANCE IN ANNUAL RYEGRASS IN THE CROPPING BELT OF WESTERN AUSTRALIA

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Summary. Annual ryegrass, *Lolium rigidum*, samples from the cropping belt of Western Australia were screened for herbicide resistance. In the wheat - pasture rotation, the relationship between the number of SU applications received in the field and the level of resistance determined in the glasshouse bioassay accounted for 67% of the variance in the data. The number of 'fop' (aryloxyphenoxypropionate) applications in the wheat - lupin rotation accounted for 49% of the variance. After repeated use of 'fops', some ryegrass populations had developed cross-resistance to the other chemical groups. There is an urgent need for farmers to adopt an integrated system of weed management where herbicides are just one of the tools to be used.

INTRODUCTION

Unlike crops, weeds are genetically variable species, some such as ryegrass more variable than others. This diversity allows weeds to evolve mechanisms to cope with selection pressures imposed on them by the environment. There are documented cases of weeds that have evolved resistance to high levels of SO_2 in polluted urban environments (1). In agricultural systems, practices such as summer fallowing have been shown to select for biotypes with longer seed dormancy allowing the weed seeds to carry over to the following crop (2). Herbicides are probably the strongest selection pressure that the weeds have to contend with, therefore it is not surprising that herbicide resistance is being reported in an increasing number of weeds (4).

For the last 10 years or so, farmers in Western Australia and other southern Australian states have relied heavily on selective herbicides for weed control. From 1980 to 1989, the total area of crop sprayed in Western Australia increased from 3.9 to 9.5 million ha, while the total area cropped during the same period remained relatively static around 5 million ha. On average, each cropped hectare in the State is sprayed twice a year for weed control.

In order to document the impact of this substantial herbicide use, extensive testing of ryegrass samples from Western Australian farms was carried out in 1991/92 with two main objectives:

(a) to determine the rate of development of resistance in ryegrass in the cropping belt; and
(b) to determine whether different rotations influenced the rate of resistance build-up.

MATERIALS AND METHODS

Ryegrass populations were tested for herbicide response in an air-conditioned glasshouse (18° day/12°C night). About 300 populations of ryegrass from different areas of the wheatbelt were tested for their herbicide resistance status. For most of these populations, information on herbicide usage in the field was available.

Seeds of ryegrass were imbibed in water for 24 h before they were transferred to a cabinet maintained at 4°C for 7 days. In earlier studies, this vernalisation process was found to promote uniform and synchronised emergence of ryegrass. Seeds were then taken to the glasshouse and sown in pots each containing about 1 kg of a loamy sand. Seeds were covered with the soil to a depth of about 10 mm and the pots were watered to field capacity. A balanced nutrient solution was applied to the pots at sowing and then 3 and 6 weeks after sowing. Pots were watered regularly as required to maintain the soil near field capacity.

Herbicides were sprayed with a sprayer calibrated to deliver a spray volume of 200 L/ha at a pressure of 200 kPa. A sulfonylurea (SU) herbicide, triasulfuron, was applied as a post-plant pre-emergence treatment at 12.5 and 25.0 g a.i./ha, the day after planting. Diclofop-methyl (aryloxyphenoxypropionate - 'fop') at 281.25 and 562.5 g a.i./ha and sethoxydim (cyclohexanedione - 'dim') at 47.25 and 94.5 g a.i./ha were sprayed at the Z12-13 stage of ryegrass. Herbicide rates used were half and full label rates registered for the control of ryegrass in Western Australia. A non-ionic wetting agent (BS1000) at 0.25% (vol./vol.) was added to both the post-emergence herbicide treatments.

The experiments were terminated 8 weeks after planting, by which time all the susceptible plants had died. At harvest, healthy plants were cut at the soil surface and shoot fresh weight was recorded. The shoot growth of ryegrass under any treatment was expressed as a percentage of the fresh weight of the unsprayed plants from the same sample.

The relationships between herbicide usage for the sampled paddocks and herbicide responsiveness in the glasshouse (relative shoot fresh weights) were determined by fitting a Gompertz curve to the data using GENSTAT.

RESULTS AND DISCUSSION

<u>Type of resistance</u>. Cross-resistance appeared quite frequently where farmers relied primarily on the 'fop' herbicides for weed control (Fig. 1). Out of the 51% populations that had 'fop' resistance, 42% had cross-resistance to either the SU's or the 'dims' or both 'dims' and SU's. This type of cross-resistance was very unpredictable and varied in its spectrum from paddock to paddock, even on the same farm with similar herbicide use patterns.

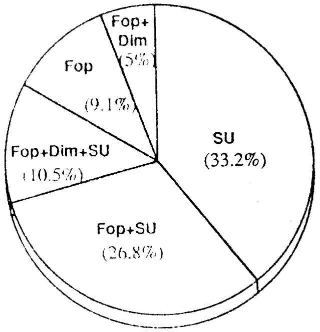

Figure 1. Types of resistance detected in ryegrass populations in Western Australia in 1992.

However, where resistance had developed through the use of the SU herbicides, it was specific to the ALS inhibiting herbicides and cross-resistance to the other herbicide groups was not detected. Because of the great genetic variability in ryegrass populations, several mechanisms of resistance and cross-resistance are known to exist (3).

Rate of resistance development.

'Fop' resistance As can be seen in Fig. 2 (a), 'fop' resistance could be detected in every ryegrass population that had received 6 or more applications of this herbicide group. A non-linear relationship between the number of herbicide applications and the level of resistance accounted for 49% of the variance in the data. Samples near the top limit of the confidence intervals of the means developed resistance with as few as 4 applications. The rate of resistance development by ryegrass in the wheat - lupin and wheat - pasture rotations was quite similar.

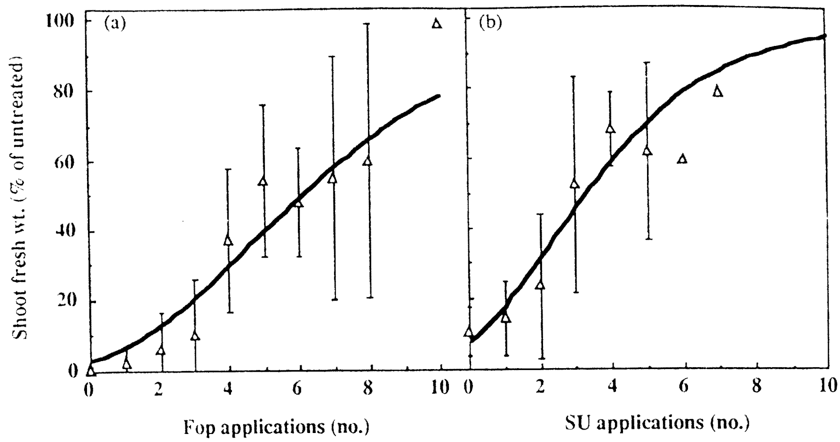

Figure 2. Rate of development of resistance to (a) the 'fop' group of herbicides in the wheat - lupin rotation. A Gompertz curve fitted through these data points accounted for 49% of the variance (n=123); and (b) the SU herbicides in wheat - pasture rotation. The Gompertz response surface accounted for 67% of the variance (n=66). Vertical bars represent confidence intervals around the mean (P=0.05).

SU resistance. SU resistance was found to be developing on Western Australian farms at an alarming rate (Fig. 2 b). Invariably it took only 4 applications of the SU's for ryegrass to develop resistance. Due to grazing by sheep and a lower frequency of herbicide use, the wheat - pasture rotation was considered to be relatively safe from herbicide resistance. Our results clearly show that the rate of development of resistance to highly effective and residual herbicides, such as the SU's, is not delayed by pasture rotations as currently used by the vast majority of farmers in Western Australia.

As described earlier (Fig. 1), some of the samples from wheat - lupin rotation with 'fop' history showed cross-resistance to the SU herbicides. This affected the fit of the Gompertz curve, because even at zero SU applications, some ryegrass populations had a fairly high level of SU resistance (up to 40%). However, by taking out samples that had received 3 or more 'fop' applications, where cross-resistance could have developed, this problem was overcome and the relationship accounted for 52% of the variance.

The relationship between the number of herbicide applications received in the field and the level of resistance determined in the glasshouse bioassay was more variable for the 'fop' herbicides as compared to the SU's (Fig. 2). This means that management factors which delay the development of resistance are more likely to be found for 'fops' than for SU's.

The herbicide revolution in weed control technology has been accompanied by an intensification of crop production throughout southern Australia. Over the last 4-5 years matters have been made worse by the decline in wool prices which has seen further shortening of rotations to include more frequent cropping (i.e. lower sheep numbers). There has also been a swing towards early sowing to achieve higher grain yields. Such factors have further increased farmers' reliance on selective herbicides for weed control. The consequences of over-reliance on selective herbicides are now apparent in Western Australia and some of the other southern Australian states where an ever increasing number of herbicide resistant ryegrass populations are being added to the tally each year.

Farmers are now being urged to correct the imbalance that has existed in the favour of herbicides over the last 10-15 years. Herbicides should be regarded just as one of the tools in an integrated weed management kit. At present this tool is quickly getting blunted by resistance and over-use. There are no new herbicides on the horizon and, even if there were, resistance to them could also develop at a rate similar to that we have documented for the 'fop', 'dim' and SU herbicides. Due to the high level of fitness of the resistant-types, it is not enough just to have pastures in the rotations. What is more important is to effectively control the weeds in pastures with options including grazing, spray-topping, and mechanical topping, that cannot be used in the cropping phase. In continuous cropping systems, there needs to be a greater emphasis on non-chemical methods of weed control and their integration with the selective herbicides.

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