Interpreting variable data from herbicide tolerance trials on pulse cultivars for on-farm applicability.

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Abstract

Symptoms of crop damage and resultant grain yield loss in pulses from herbicides applied for the selective control for broadleaf weeds can vary widely across seasons and environments and among cultivars of a particular species. This paper, using examples from field pea herbicide tolerance experiments in south-eastern Australia, demonstrates this variability for the field pea cultivars, Kaspa, Parafield and Sturt in response to application of the herbicide metribuzin. We then explore methods of interpreting and presenting this variable data, presenting a graphical alternative to current tabular methods, to allow effective and timely on-farm management decisions.

Keywords

Field pea, herbicide tolerance, crop damage, metribuzin, pulse.

Introduction

Pulses generally compete poorly with weeds and yield reductions in excess of 50% due to competition have been recorded in literature (Saxena and Wassimi 1980; Felton 2002; Al Thahabi *et al.*, 1994; Boerboom & Young 1995). To control broadleaf weeds a range of selective herbicides are commonly used in southern Australia. However, many of these herbicides can induce crop damage that may lead to grain yield loss. The severity of crop damage is generally dependant on the rate of herbicide used, pulse cultivar, sowing depth and environmental conditions such as soil type and moisture content or rainfall intensity following herbicide application.

Breeding programs are continually developing new cultivars with agronomic and yield improvements. These new cultivars are evaluated under a range of environmental conditions ensuring diverse adaptation, but agronomic management (e.g. herbicide choice and application) generally remains consistent across trial sites. For example, in the national field pea breeding program, the herbicide metribuzin is applied at label rates post-sowing pre-emergent to control broadleaf weeds. This means that new cultivars are only selected for adaptation to this herbicide management practice. It has been observed that pulse cultivars can vary widely in their response to herbicide application (McMurray 2006; Lockley *et al.,* 2006). Therefore it is essential that potential new cultivars are evaluated for adaptation to the range of commonly used herbicides in the regions that they will be most commonly grown.

The efficacy of herbicides is often related to soil type (e.g. texture and pH) and the timing of application. For example, herbicides with the active ingredient simazine need to be applied at lower rates on sandy soils compared with heavy textured soils for optimal efficacy. To be effective, rainfall or irrigation within 2 to 3 weeks of application of simazine is required (Syngenta 2003). Many of the Group B herbicides have greater persistence in high pH soils (Kotoula Syka *et al.,* 1993). Therefore evaluation for adaptation to herbicides needs to occur on a range of soil types through several cropping seasons to achieve reliable results which can be used by growers to make useful management decisions.

In this study, methods of interpreting and presenting variable responses to herbicides in a way that allows growers to make effective and timely management decisions are explored utilising data from herbicide tolerance trials in south eastern Australia.

Methods

Experimental design

Data for this paper was sourced from trials sown at several sites across South Australia and Victoria from 2002-2005 comparing the response of cultivars of field pea to various broadleaf herbicide treatments at recommended and double recommended rates (Table 1 and 2). These trials did not aim to assess the relative efficacy of these chemicals to control weeds. Not all cultivars and herbicides compared are shown in this paper, however, the herbicide treatments selected were representative of the variation that can occur in herbicide tolerance trials. In all experiments, treatments were replicated 3 or 4 times in randomised split-plot designs. All cultivars of field pea were sown to achieve a targeted plant density of 40-50 plants/m^2. Seed was inoculated with rhizobium (except at Minlaton, SA) and sown with suitable rates of fertilizer for each cropping region. Herbicide treatments were applied with a water rate of 125 L/ha at SA sites and 100 L/ha at Vic. sites. No in-crop herbicides were applied other than the herbicide treatments indicated, however, prior to sowing, weeds were controlled using a pre-sowing knockdown herbicide (plus trifluralin at reduced rates in some years), as required. Fungicides and insecticides were applied as required to control insects and diseases.

Table 1. Region, location, years of trials and soil type of field experiment sites in south eastern Australia and crops which were included in herbicide tolerance experiments discussed in this paper at each site.

Region	Location	Years	Cultivars	Soil type
York Peninsula, SA	Minlaton 34?47’S 137?34’E	2002 - 2005	Kaspa, Parafield, Sturt	Calcareous grey sandy loam (pH 8.1 at 10cm)
Wimmera, Vic.	Kalkee 36?34’S 142?12’E	2003	Kaspa, Parafield, Sturt	Black cracking clay (pH 8.1 at 10cm, 8.7 at 60cm)
Southern Mallee, Vic.	Jil Jil	2003	Kaspa, Parafield, Sturt	Calcareous sandy loam (pH 8.2) over a calcareous medium clay at 40cm (pH 9.4)
	Birchip 35?59’S 142?52’E	2004	Kaspa, Sturt	Calcareous loam (pH 8.4) over a sodic, calcareous medium clay at 40cm (pH 9.5)

Measurements and analysis

Herbicide damage symptoms (1 – no damage, 9 – complete plant death) were scored when symptoms were apparent between 3 and 8 weeks after sowing. All experiments were harvested and grain yields recorded. Grain yields and herbicide damage scores were analysed for significant differences within each experiment location and year using ANOVA and a Spatial Nearest Neighbour analysis for SA sites.

Table 2. Active ingredients, recommended rates and timing of application of herbicides presented in this paper from herbicide tolerance trials.

Active ingredient of herbicide	Rate of application (gai/ha[1])	Application timing[2]
metribuzin	210	PSPE
metribuzin	210	PE
flumetsulam	19	PE

1. gai/ha – grams of active ingredient per hectare
2. PSPE – Post sowing pre-emergent, PE – Post emergent (3-4 nodes crop growth).

Results and Discussion

Variability across sites, seasons and between cultivars

The response of pulse cultivars to herbicide application varies from year to year and among sites. Table 3 summarises results for the chemical metribuzin applied post-sowing pre-emergent (PSPE) to field peas. When applied at recommended rates, generally there were few damage symptoms observed and no grain yield loss at all sites across years except for *cv* Sturt at Minlaton in 2002. When applied at double recommended rates all cultivars except Sturt showed no significant yield loss at all sites from 2003-2005, however, in 2002 all cultivars displayed crop damage and yield loss. Results in that season were most likely due to dry conditions during seeding and chemical application followed by substantial early rainfall events. Dry seasonal conditions and a shortened growing season followed across southern Australia giving damaged plants little opportunity to recover. In 2003, Sturt showed no damage symptoms at Kalkee, but grain yields were significantly reduced. In comparison, at both Minlaton and Jil Jil, visual damage was observed, but no yield loss was recorded at Minlaton (trials were not harvested at Jil Jil due to dry conditions). In 2004, visual damage and significant grain yield loss occurred at Minlaton, but not Birchip. Overall from this series of trials it is concluded that Sturt is more likely to suffer yield loss in response to the herbicide metribuzin than Kaspa or Parafield. These results demonstrate the importance of a series of trials over several seasons and locations to provide accurate timely data on potential risks associated with using a herbicide on a particular cultivar before widespread adoption by growers. Reliance on data from only one or few years and seasons could result in an incorrect conclusion that Sturt has similar tolerance to metribuzin as Kaspa and Parafield (e.g. Minlaton 2003 and 2005, Birchip 2004). In addition, visual herbicide damage scores did not provide an accurate indication of grain yield loss. For example, in 2003 Sturt showed significant damage at Minlaton, but no grain yield loss and no damage at Kalkee, but significant grain yield loss.

Table 3. The effect of metribuzin applied post sowing pre emergent at recommended (210 gai/ha) and double recommended (420 gai/ha) rates on visual damage score (VS; 1 – no damage, 9 – complete plant death) and grain yield relative to an untreated control (GY; %) of field peas at various sites from 2002-2005. Statistically significant (*P* < 0.05) yield losses have been shaded.

Site	Year	Parafield		Kaspa		Sturt	
		VS	GY	VS	GY	VS	GY

			metribuzin 210 gai/ha				
Minlaton	2002	2.3	105	1.7	95	2.3	92
	2003	2.3	114	1.0	117	2.3	110
	2004	1.0	113	1.0	105	1.4	102
	2005	1.0	108	1.0	97	1.9	108
Kalkee	2003	1.0	112	1.0	108	1.0	95
Jil Jil	2003	5.0	n/a[1]	1.5	n/a	1.5	n/a
Birchip	2004			1.0	95	1.0	93
			metribuzin 420 gai/ha				
Minlaton	2002	6.7	86	5.3	90	7.0	79
	2003	3.0	107	1.7	116	4.3	98
	2004	3.7	117	3.3	102	5.4	90
	2005	1.9	105	1.9	105	3.3	108
Kalkee	2003	1.0	118	1.0	120	1.0	84
Jil Jil	2003	6.5	n/a	6.0	n/a	8.0	n/a
Birchip	2004			1.0	125	1.0	100

1. Not harvested due to dry conditions

Summarising data to allow effective and timely management decisions

Presenting variable data accurately and concisely to growers and agronomists is essential to allow effective and timely on-farm management decisions. Current presentation of data is lengthy, does not include all available information and difficult to interpret and compare individual seasonal responses across a number of years of experiments. It is difficult to encompass all the required information (i.e. 1. Has yield loss occurred for a particular cultivar in response to a herbicide? 2. How often has that yield loss occurred and to what extent (maximum potential yield loss)? 3. Are yield losses consistent across environments or specific to a particular soil type, region or environmental condition? 4. Will application of the herbicide result in visual crop damage regardless of grain yield loss?) in a tabulated form. In response to these concerns we have developed a graphical representation allowing growers to make effective on-farm management decisions.

Figure 1 provides three important pieces of information that are currently not encompassed in the tabular presentations (Hussein *et al.*, 2005; Lockley *et al.*, 2006; McMurray, 2006): 1. Maximum grain yield loss, 2. Proportion of years in which damage occurred and 3. Visual damage from the herbicide application. From figure 1 it can be seen that Kaspa, is generally more tolerant to metribuzin applied PSPE and post sowing and flumetsulam that Sturt and Snowpeak. Kaspa suffers less yield loss and yield loss occurred in a lower proportion of seasons. In comparison, Sturt commonly has the highest mean grain yield loss, the highest maximum grain yield loss and the greatest proportion of years when grain yield loss occurred. The visual scores provide an indication that for all these chemicals visual damage will often be observed for all cultivars except metribuzin applied PSPE at recommended rates to Kaspa. From this figure a grower could effectively identify the relative tolerance of new cultivars to herbicide, assuming consistency in relative response across environments/soils, and the relative risk of using a particular herbicide on a cultivar. If yield losses were not consistent across environment, separate figures could be used to represent each environment. Alternatively, complex GxE analysis of the data is needed to further improve interpretation and presentation.

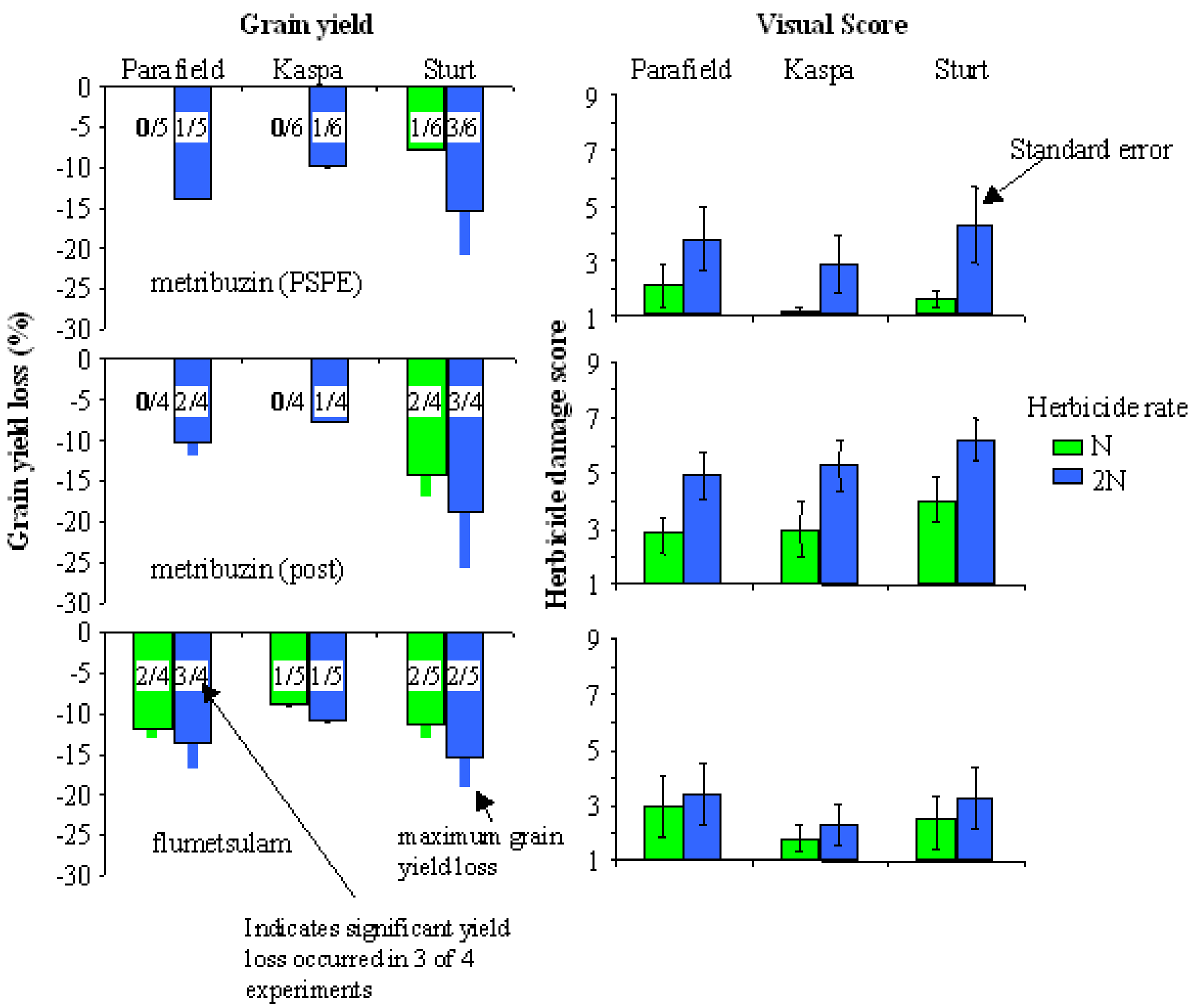

Figure 1. Mean and maximum grain yield loss, proportion of experiments when grain yield loss occurred and mean visual damage scores (1 - no damage, 9 - complete death) for the field pea

cultivars Parafield, Kaspa and Sturt, in response to various herbicides at recommended (N) and double recommended (2N) application rates at sites across south eastern Australia.

Conclusion

In pulses, symptoms of crop damage and resultant grain yield loss vary widely across seasons and environments and among cultivars of a particular species making interpretation and presentation difficult. Multiple sites and years of testing are required to generate information rapidly prior to the uptake of a cultivar by growers. Graphical, in comparison to tabular presentation allows incorporation of more data for growers to make effective on-farm management decisions.

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