Influence of sulphate of ammonia as an additive to glyphosate and SC-0224 on control of competition, and yield of sod-seeded wheat

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Summary

The effectiveness of sulphate of ammonia as an additive to glyphosate and SC-0224, herbicides with molecular similarities, was evaluated in terms of sward control and subsequent production of sod-seeded wheat at Orange, N.S.W. Herbicide rates ranged from 0 to 1.8 kg a.i. ha^{-1}. Ground cover of *T. subterraneum*, *L. perenne*, *E. plantagineum* and *Bromus* spp. was reduced by increasing application rate of both herbicides. Response by *T. subterraneum* and *L. perenne* to increasing herbicide rates was similar. Sulphate of ammonia improved the control of *E. plantagineum* at herbicide rates < 1.0 kg a.i. ha^{-1}. Both herbicides produced similar responses for total wheat DM and grain yield. Total wheat DM and grain yield increased with increasing herbicide rate and this effect was enhanced by sulphate of ammonia at herbicide rates < 0.61 kg a.i. ha^{-1}. Addition of sulphate of ammonia (1.25 kg ha^{-1}) at application rates of 0.25, 0.30, 0.36, 0.50 and 0.61 kg a.i. ha^{-1} glyphosate increased gross margins by \$36, \$50, \$46, \$11 and \$0 ha^{-1}, respectively. However its use would be considered only in situations where economic returns are uncertain; requiring a lower investment in knockdown herbicide and thus lower application rates.

Introduction

Confidence in glyphosate as a non-selective post-emergence herbicide with a broad spectrum of control and no residual soil activity (Franz 1985) has increased beyond the guarded optimism expressed when it was first introduced (Baird *et al*. 1971). Its effectiveness under a wide range of conditions has resulted in the development of chemicals with molecular similarities e.g. HOE-39866, SC-0224 and producing similar levels of competition control (Carlson and Burnside 1984; Wilson *et al*. 1985). These developments have prompted the evaluation of additives such as sulphuric acid and sulphate of ammonia to maintain efficacy at lower application rates (O'Sullivan *et al*. 1981, Buhler and Burnside 1983). The effect of sulphate of ammonia is widely documented (Turner 1985) though its effect has not been consistent (Suwannamek and Parker 1975).

Glyphosate is currently regarded as the most reliable knockdown herbicide for use before sod-seeding/direct-drilling operations in higher rainfall areas because of its ability to control perennial vegetation. With application rates of 0.72 kg a.i. ha^{-1} commonly required, competition control assumes a significant cost in any sod-seeding program. Consequently, the possibility of cheaper herbicides with a similar range of control as glyphosate or an increase in efficacy per herbicide unit is an attractive prospect.

This experiment aimed to compare the effectiveness of sulphate of ammonia as an additive to glyphosate and a glyphosate alternative, SC-0224, on control of *Trifolium subterraneum, Lolium perenne, Bromus* spp. and *Echium plantagineum* under sod-seeded conditions, and to show if this was beneficial to wheat growth and yield.

Materials and methods

The experiment was conducted at the Agricultural Research and Veterinary Centre, Orange, New South Wales (lat. 33°19'S; long. 149°05'E; elev. 922 m; aar 881 mm) during 1983. Initial botanical composition of the resident sward was assessed by point quadrat during 26 July and 3 August. Estimates were made using a standard 10-pin quadrat frame. Only the first touch by each pin was recorded. Percentage cover of the main pasture components were: *Lolium perenne* (47%), *Echium plantagineum* (26%), *Bromus* spp. (13%), *Trifolium subterraneum* (12%). Ground cover was complete and DM averaged 2 t ha^{-1}.

The isopropylamine salt of glyphosate (N-phosphonomethyl glycine) and SC-0224 (trimethylsulfonium carboxymethyl-aminomethylphosphonate) were evaluated in terms of competition control of vegetation and subsequent wheat DM production both in the presence and absence of a constant rate of sulphate of ammonia (1.25 kg ha^{-1}). Application rates for glyphosate and SC-0224 were 0 to 1.35 and 0 to 1.80 kg a.i. ha^{-1}, respectively. Chemicals were applied with a Chesterford mini-log sprayer onto plots 20 x 0.9 m in 310 L ha^{-1} water at 210 kPa using flat-fan spray nozzles (Allman No. 0). The half dosage distance was calculated to be 4.2 m at a walking speed of 1.1 m sec^{-1}. Calibration method followed that of Brunskill (1957) and Hartley *et al*. (1956), using 1% rhodamine red solution and Whatman filter papers spaced at intervals along the spray run. Papers were eluted in a standard volume of water and the concentration of the dye determined colourimetrically.

Herbicides were applied on 4 August, and wheat cv. Banks used as the bioassay, was sod-seeded at 175 kg ha^{-1} into the treated sward in two rows 32 cm apart on 16 August. Total wheat DM production per 10 cm of row was sampled at intervals of 0.5, 2.5, 4.5, 6.5, 8.5, 10.5, 14.5 and 18.5 m along each plot on 30 September and 13-15 March 1984, respectively. These distances were equivalent to application rates of 1.35, 1.01, 0.69, 0.52, 0.35, 0.27, 0.14, 0.06 - glyphosate; and 1.80, 1.34, 0.93, 0.69, 0.47, 0.36, 0.18, 0.09 kg a.i. ha^{-1} - SC-0224, respectively. Efficacy of herbicide application on ground cover was estimated from colour transparencies taken on 23 September at intervals along each plot in one replicate. These were originally taken to provide a visual record of weed control. Subsequently when we realised that the degree of weed control should be measured and analysed, we were able to use the transparencies.

Limited randomisation was achieved by randomly selecting which end of the main plot the control should be located and which direction the herbicide should be applied. There were four replications. Data were analysed by regression procedures after transformation to square root scale to normalize the variances. In Figure 2, a nonsymetric sigmoid response curve is most appropriate. This was approximated by deleting data from the two lowest application rates (these all had zero yields) and fitting an asymptotic function to the remaining data. The function used was to transform active ingredient onto a 0 (nil active ingredient) to 10 scale using $10 - 1/(0.1 + \text{kg a.i. ha}^{-1})$. This function fitted better than using a simple quadratic regression. All treatment differences and trends described are significant at the 5% level of probability or as indicated.

Results

The two herbicides did not differ in their effect on percent ground cover when application rate was expressed as kg a.i. ha^{-1}. Figure 1 presents the average of the two herbicides. Ground cover of the four major sward components *L. perenne, Bromus* spp., *E. plantagineum* and *T. subterraneum* declined with increasing herbicide rate. The regressions for *L. perenne* and *T. subterraneum* did not differ with sulphate of ammonia addition or from each other, and the average regression is presented (Figure 1). Percent ground cover of *L. perenne* and *T. subterraneum* decreased from 23% to 0% as herbicide application rates increased from 0.07 to 1.55 kg a.i. ha^{-1}. Ground cover of *E. plantagineum* declined as herbicide rate increased in the absence of sulphate of ammonia, but not in its presence. *Bromus* spp. showed a response pattern intermediate between *L. perenne*/ *T. subterraneum* and *E. plantagineum*. Although the slopes for *Bromus* spp. were not significantly different from each other, the slope with nil sulphate of ammonia was significantly different from zero, but in the presence of sulphate of ammonia it was not.

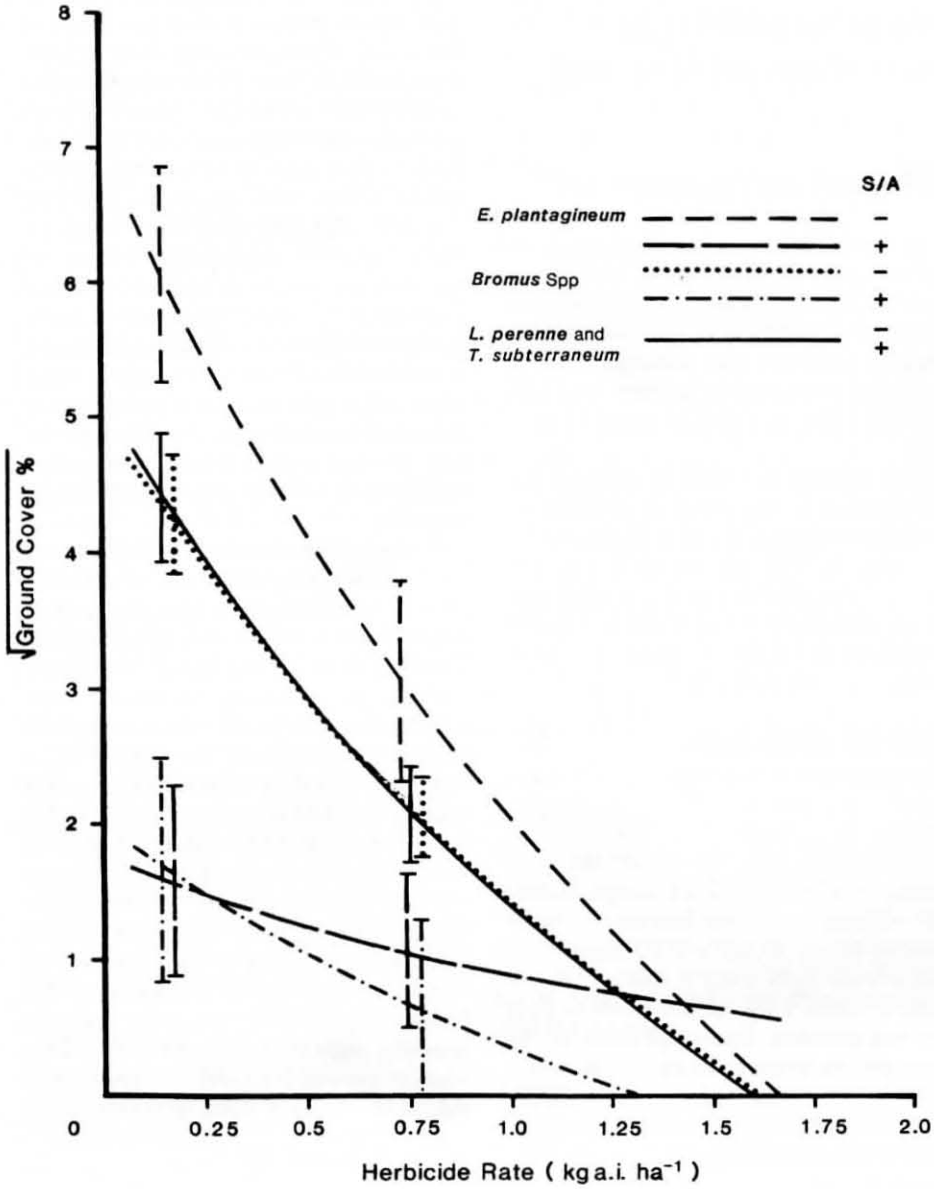

Figure 1. Effect of increasing rate of herbicide and sulphate of ammonia (S/A) applied at a constant rate (1.25 kg ha^{-1}) on percent ground cover of original sward components.

	S/A	Equation	r^2	s.d.
L. perenne plus *T. subterraneum*	±	y = 5.16 - 5.48Z	0.65	1.43
E. plantagineum	-	y = 7.02 - 7.22Z	0.73	1.69
"	+	y = 1.76 - 1.24Z	0.09	1.51
Bromus spp.	-	y = 5.08 - 5.38Z	0.87	0.77
"	+	y = 1.99 - 2.39Z	0.22	1.71

For the equations, Z = ln (1 + kg a.i. ha^{-1}). Standard errors are indicated by vertical lines. Each data point represents a single observation (*E. plantagineum, Bromus* spp.) and four observations (*L. perenne* and *T. subterraneum*).

In summary, the herbicides were more effective in the presence of sulphate of ammonia at rates < 1 kg a.i. ha^{-1} for *E. plantagineum*, and possibly for *Bromus* spp.

Wheat plant density six weeks after planting showed significant herbicide by rate interaction which we are unable to explain. In particular, SC-0224 with sulphate of ammonia resulted in decreasing plant numbers with increasing herbicide rate while the other treatments showed either no trend or an increase in plant numbers with increasing herbicide rate. The actual pattern of densities along the row was very variable and typically clumped. We suspect that local plant competition effects unrelated to treatments dominated the density counts and that the significant effect is not actually due to herbicide rate.

The effects of herbicide type (glyphosate and SC-0224) on total dry matter and grain yield did not differ significantly so the combined responses to herbicide rate are described. Both total yield and grain yield of wheat increased as herbicide rate increased up to 1.35 kg a.i. ha^{-1} (Fig. 2), with the responses being altered by the addition of sulphate of ammonia to the herbicides. At a constant rate of 1.25 kg ha^{-1}, sulphate of ammonia increased wheat production at herbicide application rates < 0.61 kg a.i. ha^{-1}, but suppressed yields at higher application rates. Zero DM production is predicted for application rates < 0.23 and < 0.14 kg a.i. ha^{-1} in the absence and presence of sulphate of ammonia, respectively. Similarly, zero grain yield is predicted at application rates < 0.25 and < 0.15 kg a.i. ha^{-1} (Fig. 2) respectively.

Discussion

The effectiveness of vegetation control of *L. perenne, T. subterraneum, Bromus* spp. and *E. plantagineum* increased with herbicide rate, and the application of sulphate of ammonia in conjunction with low rates of herbicide enhanced the level of control of *E. plantagineum* and to a lesser extent, *Bromus* spp. The greater effectiveness of sulphate of ammonia at lower rates of glyphosate has been previously noted, with the critical rate appearing to vary with the bioassay system used.

Total DM and grain yield increased with increasing application rate of herbicide. Predicted maximum total DM and grain yield (extrapolated) was 13.4 and 6.1 t ha^{-1}, respectively, as herbicide application rate approaches 2 kg a.i. ha^{-1}. Given reasonable seasonal conditions, these are possible maxima for sod-seeded wheat at Orange. The increase in wheat DM production by addition of sulphate of ammonia at herbicide rates < 0.72 kg a.i. ha^{-1} is in agreement with Blair (1975) and Turner and Loader (1980), but not with Heras (1978). While the increase in wheat DM production could be related to the greater effectiveness of sulphate of ammonia on *E. plantagineum*, it does not explain the yield suppression by sulphate of ammonia at herbicide rates > 0.61 kg a.i. ha^{-1}.

In dollar terms, how beneficial is the addition of sulphate of ammonia? With costings based on $41.67 kg a.i. for glyphosate and $100 t^{-1} for wheat grain, the addition of sulphate of ammonia to glyphosate at herbicide application rates (kg a.i. ha^{-1}) of 0.25, 0.30, 0.36, 0.50 and 0.61 resulted in an improved gross margin of $35.70, $49.70, $45.70, $10.70 and -$0.30 ha^{-1}, respectively. At the application rate where maximum response to sulphate of ammonia occurred (0.30 kg a.i. ha^{-1}), yield and gross margin is considerably lower (plus sulphate of ammonia, $53 ha^{-1}) than where higher rates of chemical are ap-

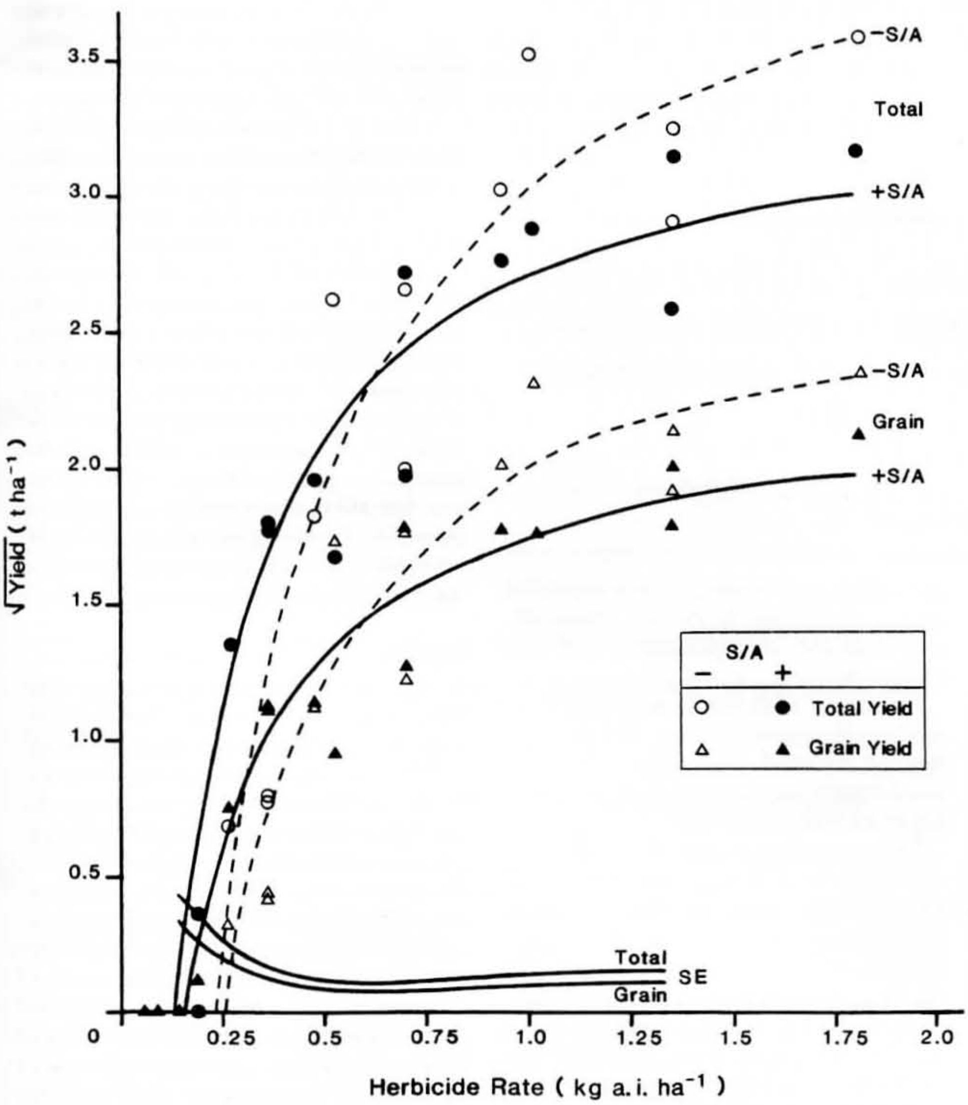

Figure 2. Effect of increasing rate of herbicide and a constant rate of sulphate of ammonia (1.25 kg ha^{-1}) on total yield and grain yield of wheat.

	S/A	Equation	r^2
Total yield	-	y = -10.15 + 1.45Z	0.71
"	+	y = -4.66 + 0.81Z	0.38
Grain yield	-	y = -7.25 + 1.02Z	0.69
"	+	y = -3.54 + 0.58Z	0.37

For the equations, $Z = 10 - 1/(0.1 + \text{kg a.i. ha}^{-1})$. Standard errors for total and grain yield are shown at base of figure. Each data point represents four observations.

plied (e.g. 0.75 kg a.i. ha minus sulphate of ammonia, \$275 ha^{-1}). Based on these results, sulphate of ammonia could be considered as an additive where the likelihood of economic crop yield is marginal or uncertain, and the initial outlay for chemical needs to be minimised.

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