OVERCOMING TRIFLURALIN ANTAGONISM OF GLYPHOSATE

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Summary Investigations into the cause of loss of glyphosate activity were carried out after reports of reduced glyphosate activity in trifluralin glyphosate tank mixes used in the 1995 cropping season. It was found that the antagonism increases as the ratio of trifluralin to glyphosate increases and at a ratio of 2:1 significant loss of glyphosate activity occurred. The antagonism was eliminated by the addition of ammonium sulphate at 2% of spray solution.

INTRODUCTION

In the 1995 cropping season wet weather delayed the sowing of winter crops and limited paddock preparation time. As a result there was insufficient time to apply pre- and post-emergent herbicides in separate operations. Consequently an off label tank mix of trifluralin and glyphosate was used widely in the Wimmera. Some herbicide sales representatives estimated that 30% of the trifluralin sold in the Wimmera last year was used in this tank mix. Most farmers were satisfied with the results from this tank mix, however there were some reports of reduced glyphosate activity.

It is well documented that glyphosate is commonly antagonized by cations and other herbicides. Nalewaja and Matysiak (1991) reported cation antagonism of glyphosate occurred with iron, zinc, calcium, magnesium, sodium and potassium. In contrast sulphate, phosphate, citrate and acetate anions were not antagonistic and that the anions of ammonium compounds were of primary importance in overcoming glyphosate antagonistic salts. Flint and Barrett (1989) reported antagonism of glyphosate by four forms of 2,4-D and two forms of dicamba, antagonism was more significant where glyphosate was at the lower rates and 2,4-D and dicamba were at the higher rates. Hydrick and Shaw (1994) investigated the effects of tank mix combinations of non-selective foliar and selective soil-applied herbicides on three weed species and reported antagonism was the most frequent interaction and usually occurred when the lower rates of non-selective foliar herbicides were used. When the rates of non-selective herbicide were increased antagonism was usually overcome. Wills and McWhorter (1995) reported salts of the monovalent cations ammonium, potassium, sodium and to a lesser degree, the anion phosphate, generally resulted in increased toxicity of glyphosate.

A series of experiments were conducted to isolate the factors effecting antagonism and to find a means of overcoming trifluralin antagonism of glyphosate.

MATERIALS AND METHODS

A series of bioassays was conducted to compare the phytotoxicity of various tank mixes of trifluralin and glyphosate. First an experiment assessed the effect of three ratios of trifluralin to glyphosate on activity of glyphosate. A second experiment assessed four spray additives for their ability to reduce antagonism. A final bioassay verified the results with dose response curves to measure the reduction of antagonism by ammonium sulphate.

Plants Oats (*Avena sativa* L. cv. Echidna) were grown in Debco® potting mix and supplied with adequate nutrients (1 plant per 10 cm diameter pot). Plants were grown in the glasshouse until they reached the 1.5 to 2-leaf stage (14 days). Uniform plants, one plant per replicate, were then selected for herbicide treatment, seven replicates per application rate. After herbicide application all plants were returned to the glasshouse and arranged in randomized blocks. Glyphosate activity was assessed by measuring plant fresh weight 14 days after herbicide application.

Herbicide application Herbicide was applied to plants using a laboratory track sprayer delivering 64 L ha^{-1} at 200 kPa via three Spraying Systems™ 11001 flat fan type nozzles. Nozzles were spaced 50 cm apart and 35 cm above the plants. The boom traversed the plants at 6 km h^{-1}.

Ratio experiment In the first experiment treatments were trifluralin plus glyphosate as tank mix ratios of 0:1, 1:2, 1:1 and 2:1. The trifluralin used was an EC (400 g a.i. L^{-1}) and the glyphosate was the isopropylamine salt (450 g a.i. L^{-1}). Rates for glyphosate were 66, 105, 150, 200, 300, 450, 600 and 1000 g a.i. ha^{-1}. All treatments had Chemwet 1000® added to the tank at 0.2% spray volume.

Spray additive experiment In a second experiment four spray additives (Table 1) were added to the tank mix to test their ability to eliminate antagonism. Results from the first experiment showed the greatest antagonism at a tank mix ratio of two trifluralin to one glyphosate, therefore this ratio was used in this experiment. Two tank mix rates were used: trifluralin at 120 and 600 g a.i. ha^{-1} with glyphosate at 60 and 300 g a.i. ha^{-1} respectively. All treatments had Chemwet 1000® added at 0.2%.

Experiment to measure effectiveness of Boost® A third experiment established dose response curves for glyphosate, trifluralin plus glyphosate and trifluralin plus glyphosate plus ammonium sulphate. Again a tank mix ratio of 2:1 trifluralin to glyphosate was used with glyphosate rates at 40, 60, 80, 100, 200, 400, and 800. Boost was added at 2% of spray volume. Chemwet 1000® was added to all treatments at 0.2% spray volume.

Statistical analysis Non-linear regression analysis was used to fit logistic dose response curve to the data in experiment 1 and 3 . The ED50 was calculated with a 95% least significant interval for comparison between treatments.

RESULTS AND DISCUSSION

Ratio experiment It was demonstrated that as the proportion of trifluralin was increased in the tank mixture the activity of glyphosate decreased. This concurs with the findings of Hydrick and Shaw (1994) when mixing imazaquin and metribuzin with glyphosate, as the proportion of these chemicals increased the activity of glyphosate decreased.

The efficacy of glyphosate was significantly reduced in glasshouse trials when trifluralin was added to the spray tank mixture at a ratio of 1:1 or 2:1 trifluralin to glyphosate on active ingredient. The tank mix ratio of 2:1 reduced glyphosate activity by 46%. The 1:2 ratio treatment was not significantly different from glyphosate sprayed alone (Figure 1).

Table 1. Additives used in experiment and amounts used for each treatment.

Additive	Amount
KH_2PO_4	2 parts to 1 glyphosate
KH_2PO_4	4 parts to 1 glyphosate
Li-700® 345 g L^{-1} soyal phospholipids 355 g L^{-1} proponoic acid	0.2% of spray water
Boost ® 500 g L^{-1} ammonium sulphate	2% of spray water
Flowright® 920 g L^{-1} blend of fatty triglycerides	1 part trifluralin to 3 parts Flowright mixed together before adding to tank.

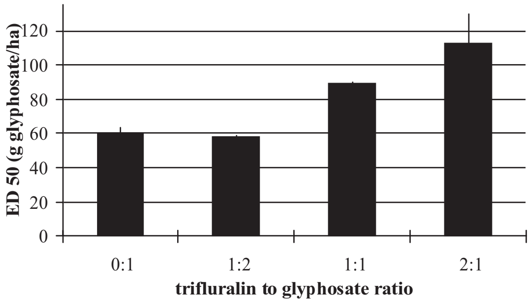

Figure 1. Activity of glyphosate on oats applied alone and when tank mixed with trifluralin at 1:2, 1:1 and 2:1 glyphosate:trifluralin (error bars = 95% least significant intervals).

These findings may explain why only some farmers reported loss of glyphosate activity. Growers preparing paddocks for canola or legumes could have used up to 945 g ha^{-1} trifluralin in the tank mix. Mixing this with the highest reccommended label rate of glyphosate 450 g ha^{-1} gives a ratio of 2:1. If lower rates of glyphosate were used, the ratio would increase resulting in greater antagonism and less activity.

Spray additive experiment The addition of ammonium sulphate to the trifluralin glyphosate tank mix appeared to eliminate the antagonism. Glyphosate applied alone reduced the fresh weight of oats by 96% (Table 2) when compared to the unsprayed controls. The addition of trifluralin to glyphosate at a 2:1 ratio reduced the fresh weight of oats by 52% of the unsprayed controls. When ammonium sulphate was added to the tank mix the fresh weight of oats was reduced to 96% of the unsprayed controls indicating a complete elimination of antagonism. Potassium dihydrogen orthophosphate at either concentration, Flowright® and Li-700® added to the tank mix reduced oat fresh weight by 71, 37 and 47% respectively when compared to the unsprayed controls.

Table 2. Oat fresh weight expressed as a percentage reduction of controls.

Treatment	% reduction oat fresh weight
Glyphosate	96
Tankmix (TM)	52
TM and KH_2PO_4 low rate	71
TM and KH_2PO_4 high rate	71
TM and Li-700®	47
TM and Flowright®	37
TM and Boost ®	96

The results presented in Table 2 are treatments sprayed at 600 g trifluralin plus 300 g glyphosate per hectare. The lower tank mix rate treatments showed a similar trend.

Effectiveness of ammonium sulphate experiment The third experiment was carried out to verify the results obtained in the previous experiment. A complete dose response curve was obtained for each treatment and the ED50 calculated for each curve.

The ED50 for glyphosate sprayed alone was 57 g ha^{-1} (Figure 3). which was significantly lower than the ED50 for trifluralin:glyphosate at 2:1 ratio which was 150 g ha^{-1}. Trifluralin:glyphosate at a 2:1 ratio with the addition of ammonium sulphate at 2% had an ED50 of 35 g ha^{-1} which was significantly lower than both other treatments.

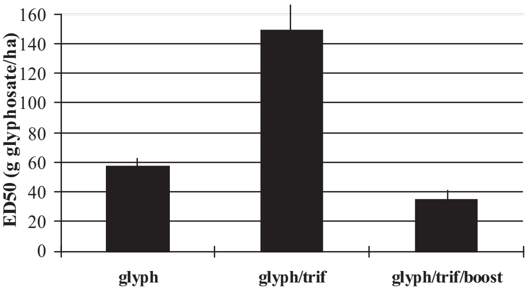

Figure 3. Activity of glyphosate on oats alone, tank mixed with trifluralin and the addition of ammonium sulphate to the tank mix (error bars = 95% least significant intervals).

It is concluded that ammonium sulphate effectively overcame trifluralin antagonism of glyphosate toxicity to oats. However, Nalewaja and Matysiak (1992) reported that the effectiveness of diammonium sulphate in overcoming calcium antagonism varied with species. Therefore further investigation would need to be carried out across a broader range of species before ammonium sulphate could be recommended to overcome antagonism in this tank mix. Such a recommendation would be useful in situations where canola and legume crop preparation are planned using tank mixes of trifluralin using low rates of glyphosate.

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