ALTERNATIVES TO FLUPROPANATE FOR THE CONTROL OF SERRATED TUSSOCK (*NASSELLA TRICHOTOMA* (NEES) HACK.)

M. H. Campbell[1], L. G. Miller[2] and D.L. Michalk[1]
[1] NSW Agriculture, Orange Agricultural Institute, Orange, NSW 2800
[2] Natural Resources and Environment, PO Box 103, Geelong, Vic. 3220

Abstract Of all the herbicides investigated in NSW, Victoria and South Africa between 1973 and 1999 only glyphosate presents a practical alternative to flupropanate for killing serrated tussock (*Nassella trichotoma* (Nees) Hack.). Effective rates varied between >5 to 1 kg a.i. ha^{-1}, depending on location which suggests that testing different rates on individual properties is necessary to ascertain the most effective rate for the many situations that exist. Glyphosate appeared to be effective at any time of the year provided that tussocks were not covered by seedheads or browned out by frosts or drought. The most serious disadvantage of glyphosate is its non- selectivity which precludes its application from aircraft where trees are present and emphasizes the need for accurate application from boom- and spot-spraying to spare useful associated pasture species.

INTRODUCTION

Research from 1973 to 1978 (Campbell *et al.* 1979) showed that flupropanate (Frenock®) was more effective than 2,2-DPA, the herbicide in use at that time, for killing serrated tussock (*Nassella trichotoma* (Nees) Arech.). Since then flupropanate has proved a reliable selective herbicide for treatment of serrated tussock in Australia, New Zealand and South Africa. Research for alternatives increased as the price of flupropanate increased over time and culminated in a full scale research project when flupropanate was withdrawn from sale in October 1998. This paper reviews the research done over the past 26 years on alternatives and provides an insight into future prospects for control.

MATERIALS AND METHODS

Testing alternatives to flupropanate was carried out in NSW, Victoria and South Africa in randomised and replicated small plot experiments from 1973 to 1999 (Campbell 1998a, Campbell *et al*. 1979, Miller 1995, Viljoen 1981). Herbicides were applied by hand-held sprayers in from 300 to 600 L ha^{-1} water at various times of the year. A surfactant was applied where necessary.

RESULTS AND DISCUSSION

Experiments in NSW showed the following herbicides to be less effective than flupropanate: quizalofop (0.2 kg a.i. ha^{-1}), fluazifop (0.4), clethodim (0.5), sethoxydim (0.6), imazapyr (0.4) and the sulfonylurea DPX-E9636 (60 g a.i. ha^{-1}) (Campbell and Vere 1995); atrazine (3.6), propaquizafop (0.4), hexazinone (1.0), rimsulfuron (0.l), imazapic (1.0) and Nontox® (2000 L ha^{-1} product) (Campbell unpublished data). Imazapyr killed serrated tussock but has a number of disadvantages which limit its use in practice. Glyphosate proved the most effective alternative to flupropanate and a full review of experiments involving this herbicide is presented in Campbell (1998a).

A pot experiment in Victoria in 1998 showed that imidazethypr (0.4) atrazine (0.8) and phenyl pyrazole (0.14) were ineffective but glyphosate (isopropylamine (1.08) and trimesium (0.4) salts), imazapyr (0.25), propaquizafop (0.12) SL-160 (0.1) AC299263 (0.048) and AC263222 (0.048) were effective (Melland and McLaren 1998). Results from this pot experiments need verification in the field because, although propaquizafop (0.12) proved effective in pots, it was ineffective (0.4) in field experiments in NSW (Campbell, unpublished data).

Field experiments in Victoria have shown simazine (0.8) to be ineffective (Orchard *et al.* private communication) but glyphosate (2.2) to be effective (Miller 1995).

Field experiments in South Africa showed that glyphosate (2.2, 2.9) was effective in respectively 7 and 9 months of the year (Viljoen 1981).

Therefore, of all the more recent readily available herbicides investigated glyphosate has proved the most effective alternative to flupropanate. Results from experiments using glyphosate have been confused; the following is an attempt to rationalize and summarize the results so far.

Rate of application Campbell and Gilmour (1979) found 5.0 kg a.i. ha^{-1} gave 77% kill when applied to mature tussock growing on rocky basalt soil in a high rainfall (850 mm $year^{-1}$; 1100 m altitude) area on the central tablelands of NSW. Viljoen (1981) found 2.9 kg a.i. ha^{-1} gave 86% kill of tussock growing on Clovelly Blinkklip soil in a moderate rainfall (686 mm $year^{-1}$; 1463 m altitude) area in South Africa. Miller 1995) found 2.2 kg a.i. ha^{-1} gave 91% kill of tussock growing on rocky basalt soil in a low rainfall (550 mm $year^{-1}$; 100 m altitude) area in Victoria. Applied to green leaf regrowth 12 months after burning, 1.4 kg a.i. ha^{-1} gave a satisfactory kill in Victoria (Miller personal communication) but not in NSW (Campbell 1996). Applied to serrated tussock growing in the shade of trees, 1.0 kg a.i. ha^{-1} gave a satisfactory kill in NSW (Campbell, unpublished data).

Therefore the minimum effective rate of glyphosate will vary between >5.0 to 1.0 kg a.i. ha^{-1} depending on environment and pre-treatment. In addition, morphological differences between serrated tussock from NSW and Victoria (Campbell 1998b) suggest that different ecotypes could exist which could exhibit differences in susceptibility to glyphosate. As it is not possible to conduct experiments in all environments in NSW and Victoria the most practical method of determining the minimum effective rate is for producers is to apply a range of rates on their properties over time to determine the most economical rate for their situation.

Time of application Campbell and Gilmour (1979) found no difference (P>0.05) in effect of glyphosate in NSW from application of 1, 3 and 5 kg a.i. ha^{-1} in each season of the year. Viljoen (1981) applied glyphosate at 0.7, 1.4, 2.2 and 2.9 kg a.i. ha^{-1} in each month of the year in South Africa and recorded commercially successful kills of serrated tussock in, respectively, 0, 2, 7 and 9 months. There appeared to be no response pattern in these results because the ineffective months at the 2.2 kg a.i. ha^{-1} rate were January, March, June, July and December. The January and December failures could be attributed to the seedheads preventing the herbicide from contacting the leaves while the other failures could be explained by rain soon after spraying (not recorded in the Paper) or some other environmental influence. Glyphosate was effective when applied in winter in Victoria to mature (Miller 1985) or pre-burnt (Miller personal communication) serrated tussock at, respectively, 2.2 and 1.4 kg a.i. ha^{-1}. Therefore glyphosate may be effective in killing serrated tussock at any time of the year provided the tussocks are not covered by seedheads and have a preponderance of green leaves. If tussock leaves are browned off by heavy frosts, drought or other factors it would be unwise to apply glyphosate. To reduce the effect on associated useful species glyphosate could be applied when native grasses are frosted off in winter, when introduced grasses, e.g., phalaris (*Phalaris aquatica* L.), are dormant in summer or before annuals germinate in autumn in response to the seasonal break.

Method of application

Aerial The greatest disadvantage of glyphosate is that it severely damages or kills trees if applied by aircraft at rates above 1.5 kg a.i. ha^{-1}. If trees are absent or so scattered that the pilot is able to avoid them then aerial application could be used if appropriate registration is achieved. However, small tussocks protected from the herbicide by large tussocks in a dense infestation will survive. If trees are absent glyphosate could be aerially applied in autumn after the seasonal break and followed one to two months later by the distribution of seed of an introduced pasture mixture based on phalaris and subterranean clover (*Trifolium subterraneum* L.).

Boom spraying and spot spraying Glyphosate can be applied using these methods but timing should be chosen to inflict least possible damage on associated useful species. For spot spraying, a guard on the nozzle of the sprayer, a restricted fan nozzle or low pressure could restrict distribution of the herbicide to the target tussocks.

Wiping Glyphosate (49% ai) can kill mature serrated tussock when applied with a wiper without damaging associated pasture but a high rate (1:3 glyphosate:water for a Rotowiper®) is necessary and the tussocks have to be wiped two ways. Different rates will be needed for different wipers. Wiping is only practical on relatively flat land with few obstructions. Because small plants will be missed, wiping will be necessary on an annual basis to remove plants as they attain wiping height.

Reducing seedhead production Low rates of glyphosate (0.25 to 0.50 kg a.i. ha^{-1}) will reduce seedhead production of serrated tussock by 91 to 99% provided they are applied in September or October before the seedheads begin to emerge (Campbell *et al.* 1998).

Seedling regeneration Because glyphosate does not have a residual effect similar to that of flupropanate seedling regeneration occurs, particularly where bare ground is plentiful after spraying. Burning before or after spraying results in massive seedling regeneration. To overcome this the area sprayed should be sown to introduced pasture species or the associated pasture surviving the glyphosate managed, by spelling and/or fertilizing, to provide maximum competition to the invading tussock seedlings.

Comparative costs Where glyphosate is effective between 1.5 and 3.0 kg a.i. ha^{-1} the cost for the herbicide will range from $A26 to $A52 ha^{-1} (recommended retail price June 1999) compared to $A70 ha^{-1} for flupropanate.

Registration At present glyphosate is not registered for application to serrated tussock. Permits have been approved in NSW for spot- and boom-spraying, wiping and for seedhead reduction but not for aerial spraying.

REFERENCES

Campbell, M.H. (1996). Effect of herbicides on burnt and unburnt serrated tussock. NSW Agriculture Pasture Notes 4, pp. 4-5.

Campbell, M.H. (1998a). Review of the effect of glyphosate on serrated tussock. NSW Agriculture Miscellaneous Publications, Orange Agricultural Institute, pp. 12.

Campbell, M.H. (1998b). Biological and ecological impact of serrated tussock on pastures in Australia. *Plant Protection Quarterly* 13, 80-6.

Campbell, M.H., Gilmour, A.R. and Vere, D.T. (1979). Effect of time and rate of application of herbicides on serrated tussock and improved species. 2. Tetrapion. *Australian Journal of Experimental Agriculture and Animal Husbandry* 19,476-80.

Campbell, M.H., Miller, L.G. and Nicol, H.I. (1998). Effect of herbicides on seedhead production and control of serrated tussock. *Plant Protection Quarterly* 13, 106-110.

Campbell, M.H. and Vere, D.T. (1995). *Nassella trichotoma* (Nees) Arech. In 'The Biology of Australian Weeds,' Vol. 1, eds R.H. Groves, R.C.H. Shepherd, and R.G. Richardson, pp. 189- 202. (R.G. and F.J. Richardson, Melbourne).

Melland, A. and McLaren, D. (1998). Efficacy of herbicides against serrated tussock in a pot trial. *Plant Protection Quarterly* 13, 102.

Miller, L. (1995). The use of Roundup® on serrated tussock. Proceedings 36th Conference, Grassland Society of Victoria, pp. 196-6.

Viljoen, B.D. (1981). Application of glyphosate on nassella at different times and rates. *Crop Production* 10, 206-8.