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HERBICIDAL CONTROL OF WOODY WEEDS IN CENTRAL QUEENSLAND
1. BRIGALOW (*ACACIA HARPOPHYLLA*)

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ABSTRACT

Triclopyr ester, hexazinone, carbamoylphosphonate, glyphosate and two formulations of 3,6-dichloropicolinic acid were compared with 2,4,5-T ester for brigalow (Acacia harpophylla) *regrowth control.*

Triclopyr ester (at 1 g·L^{-1} in 1000 L ha^{-1}) gave good control of regrowth less than 12 months old and was superior to 2,4,5-T ester on four year old regrowth (at 20 g L^{-1} in 50 L ha^{-1}). Water was an efficient carrier for misting of triclopyr ester but when 2,4,5-T ester was used, distillate was a more efficient carrier than water.

Hexazinone gave high mortality of brigalow regrowth when applied as an overall spray (2 g L^{-1} in 1000 L ha^{-1}) or as a spot application of the liquid formulation (1 g plant^{-1}). Clay pellets impregnated with hexazinone were ineffective on brigalow less than 12 months old. Reduced grass cover was evident after two growing seasons where 8 kg ha^{-1} of hexazinone had been applied as a ground application or as a spray.

Glyphosate at 1.8 to 7.2 g L^{-1} and carbamoylphosphonate at 1.2 to 4.8 g L^{-1} were ineffective as overall sprays when applied at 1000 L ha^{-1} in January–February to brigalow suckers less than 12 months old. Ester and amine formulations of 3,6-dichloropicolinic acid were effective at 4 g L^{-1} in 1000 L ha^{-1} on the same regrowth.

The possible roles of triclopyr ester and hexazinone in future brigalow regrowth control are discussed.

INTRODUCTION

The region dominated by brigalow (*A. harpophylla*) is one of the most important improved pasture and cropping zones in Queensland. Under the Fitzroy Basin Land Development Scheme, large properties were subdivided and the brigalow scrubs were cleared and sown to improved grass pasture (Johnson 1964). Most initial clearing has taken place and regrowth control is a major task presently facing the grazing industry in the area.

The type and amount of regrowth is largely determined by the type of original scrub, the soil moisture at the time of pulling and the timing of burning in relation to pulling (Johnson 1964). In a recent survey of pasture development in the northern brigalow region, Anderson *et al.* (1984) showed that approximately two-thirds of the pastures contained sufficient regrowth to cause immediate losses in productivity or future losses as the regrowth matures. Brigalow was by far the most important regrowth species even though the northern areas had a large component of other species present in the virgin communities.

There is a great potential for expansion of cropping in the brigalow region (Nix 1980), so many regrowth problems will be overcome through ploughing (Johnson and Back 1977a, Scanlan and Anderson 1981). However, significant areas are unsuitable for cultivation, principally because of gilgais, shallow soils or steep topography. Burning alone rarely reduces the density of brigalow suckers (Johnson and Back 1973) although when combined with spraying with 2,4,5-T ester, it can have an important role (Johnson and Back 1977b, c).

Chemical control of brigalow will continue to have an important role in maintenance of productive brigalow pastures. Initial screening of herbicides concentrated on the various formulations of 2,4-D and 2,4,5-T (Johnson 1964), while picloram was shown to be ineffective (McDonald 1970). As 2,4,5-T ester was effective and relatively economical, screening of further chemicals ceased.

The present controversy over the safety of 2,4,5-T has led to doubts about its continued use and availability. A number of promising herbicides have recently become commercially available. This paper presents results from five herbicide screening trials on brigalow regrowth of various ages and suggests possible roles for the more promising herbicides.

MATERIALS AND METHODS

Five field trials were established on Brigalow Research Station (24°50′S 149°48′E) which is situated about 30 km north-west of Theodore in Central Queensland. Trials 1, 2 and 3 were established in January–February 1980 on adjacent areas of a loamy surfaced duplex soil with some patches of deep cracking clays. The vegetation before clearing consisted of brigalow/Dawson gum (*Eucalyptus cambageana*). The trial area was stickraked approximately eight months before the treatments were applied.

Soil moisture was high at spraying and this, combined with the small size of the suckers, provided excellent conditions for brigalow control (Johnson 1976). Monthly rainfall records were maintained throughout the trial period (Table 1). Trials 4 and 5 were established during February 1981 on a deep cracking clay soil. The original vegetation was brigalow/belah (*Casuarina cristata*) and the area had been burnt about four years before the trial commenced. Suckers of this size are normally difficult to control by overall spraying or misting (Johnson 1976).

Observations were made on Trials 1 and 2 at 6, 12 and 24 months; on Trial 3 at 24 months; and on Trials 4 and 5 at 6 and 12 months. There were no significant differences between results at 12 and 24 months for Trials 1 and 2 and thus Trials 4 and 5 were terminated after 12 months.

Trial 1

Glyphosate (Round-up®), carbamoylphosphonate (Krenite Brush Control Agent®), hexazinone (Velpar® L) and the standard treatment of 2,4,5-T ester

(Farmco® T-80) were applied as overall high volume sprays. Hexazinone was also applied directly to the soil surface. Treatments applied are shown in Table 2.

The four contiguous replicates were pegged into 5 m × 5 m plots, with alternate plots used as guard plots. Plots with fewer than 10 brigalow suckers were discarded. The mean brigalow sucker number in remaining plots was 48 (19 000 per ha). Percentage cover in each plot was directly estimated. Treatments were applied to plots at random within blocks. Sprays were applied evenly over the plot at 1000 L ha^{-1} with a Solo Pneumatic Sprayer at 280 kP. A Du Pont Spotgun® was used to apply hexazinone to the soil surface near the base of each sucker clump.

Trial 2

Triclopyr ester (Garlon® 480), hexazinone, 3,6-dichloropicolinic acid as ester and amine formulations (Dowco® 290) and the standard treatment of 2,4,5-T ester were applied as overall high volume sprays to brigalow. Treatments are shown in Table 3.

Three contiguous replicates were divided into 5 m × 5 m plots and the number of brigalow suckers in each plot determined. Plots with fewer than 10 suckers were discarded. Ground cover was directly estimated for each plot. Treatments were allocated at random within each replicate. The herbicides were applied as per Trial 1.

Trial 3

Four observational plots were established to examine the effectiveness of pellets impregnated with 0.375 g hexazinone (Velpar Gridball®) for control of brigalow regrowth less than 12 months old. Four plots were set up and 25 pellets per plot were located on grid patterns of 1.5, 2, 3.5 and 5 metres. The number of suckers per plot was determined at the time of application and 24 months later. The mean initial sucker density was 20 000 ha^{-1}.

Trial 4

This misting trial examined the relative effectiveness of 2,4,5-T ester and triclopyr ester for the control of four year old brigalow regrowth, 1.5 m tall. Four carriers (distillate; water; 30% distillate–70% water and 10% distillate–90% water) were also used in factorial combination with the two herbicides and three rates of each herbicide (15, 20 and 30 g L^{-1} in 50 L ha^{-1}).

Plots were 10 m × 10 m with margins of 5 m to reduce the effects of spray drift. The number of plants and suckers in each plot was determined prior to treatment allocation. Blocking was carried out using initial numbers rather than position: plots with high sucker numbers were allocated to block 1 and those with lower numbers to block 2. Plots with less than 10 plants were discarded.

The treatments were applied in 50 L ha^{-1} of carrier and applied evenly to the plots with a Fontan R12-S misting machine.

Trial 5

Observational plots were established adjacent to Trial 4 to examine the effect of rate of ground applied hexazinone on the control of four year old brigalow regrowth, 1.5 m tall. Five plots (10 m × 10 m) were defined and the number of suckers within each plot counted. Mean sucker density was 8000 ha^{-1} located in 3000 clumps ha^{-1}. Hexazinone, at 0.25, 0.5, 1.0 and 1.5 g $plant^{-1}$, was applied with a Du Pont Spotgun® near the base of each sucker clump. Water was added to the 0.25 g and 0.5 g rates to make up the volume to 4 ml. This was done to prevent problems that may have arisen from applying small quantities of liquid. One plot was misted with 20 g L^{-1} 2,4,5-T ester in 50 L ha^{-1} of distillate.

RESULTS

The monthly rainfall data covering the experimental period are given in Table 1. Rainfall following the stickraking in April–May 1979 was sufficient to give rapid emergence of root suckers and good growth prior to spraying. Following treatment applications, growing conditions were satisfactory for both woody and herbaceous plant species during the summer periods and the winters were relatively dry.

TABLE 1

Monthly rainfall (mm) received at Brigalow Research Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1979	22	126	26	19	21	44	1	0	1	54	83	93	490
1980	176	216	105	2	42	5	32	0	0	54	7	50	689
1981	49	176	44	92	74	42	43	12	0	37	147	55	771
1982	118												
Long-term Mean	123	109	39	27	36	29	30	33	34	60	82	116	718

Trial 1

Hexazinone and the standard treatment of 2,4,5-T ester gave high mortality of brigalow (Table 2). Carbamoylphosphonate and glyphosate were ineffective at all rates both in terms of leaf kill and sucker death.

Carbamoylphosphonate and 2,4,5-T ester had no significant effect on percentage grass cover (Table 2). Hexazinone and glyphosate produced major reductions in grass cover three months after spraying. There were no significant differences between grass cover reduction at the three rates of glyphosate, at any sampling time. The grass recovery in plots sprayed with glyphosate was rapid and cover was not significantly different from the control plots, 16 months after spraying. Hexazinone caused a greater initial depression and a slower recovery than glyphosate. The 8 g L^{-1} rate of hexazinone and the ground applied hexazinone were the only treatments to have significantly less cover than the control plots ($p < 0.05$) at the final sampling.

TABLE 2

Leaf and sucker mortality of brigalow for herbicides applied as overall sprays (1000 L ha^{-1}) to regrowth less than 12 months old (Trial 1)

Herbicide	Rate (g L^{-1})	% Leaf death at 6 months	% Sucker death at 24 months	Grass cover % at 24 months
2,4,5-T ester	1	91	85	94
hexazinone	1 g per plant(a)	99	97	59
hexazinone	2	95	86	78
hexazinone	4	94	99	70
hexazinone	8	100	100	16
glyphosate	1.8	3	2	78
glyphosate	3.6	16	7	88
glyphosate	7.2	38	37	88
carbamoyl phosphonate	1.2	2	increase (1%)	83
carbamoyl phosphonate	2.4	3	increase (10%)	75
carbamoyl phosphonate	4.8	5	3	83
control	—	1	3	85
LSD ($p = 0.05$)	—	8	25	15

(a) 1 g of hexazinone L was applied to the ground at the base of each sucker clump. The approximate rate was 8 kg ha^{-1} of hexazinone.

Trial 2

All rates of triclopyr ester and the highest rate of both formulations of 3,6-dichloropicolinic acid gave initial leaf death and final sucker mortalities that were not significantly different ($P > 0.05$) from each other or from the standard treatment of

2,4,5-T ester (Table 3). The two formulations of 3,6-dichloropicolinic acid produced similar degrees of leaf and sucker mortality. Hexazinone at 1 g L^{-1} produced a high initial leaf death but gave a much lower sucker mortality rate than 2,4,5-T ester at 1 g L^{-1}.

Growth retardation in the plots receiving the lower rates of 3,6-dichloropicolinic acid and hexazinone was evidenced by the height reduction compared with the control plots. Regrowth less than 40 cm tall was from root suckers produced after treatments had killed the sprayed suckers.

Triclopyr ester, 3,6-dichloropicolinic acid and 2,4,5-T ester had no effect on grass cover at any stage. Hexazinone produced some grass leaf burn at all rates but did not kill any grass or prevent the establishment of grass seedlings.

TABLE 3

Leaf and sucker mortality and height of surviving brigalow following overall spraying (1000 L ha^{-1}) of brigalow regrowth less than 12 months old (Trial 2)

Herbicide	Rate (g L^{-1})	Leaf death % at 6 months	Sucker death % at 24 months	Height (cm) of surviving suckers at 24 months
2,4,5-T ester	1	95	84	15
triclopyr ester	0.5	88	76	30
triclopyr ester	1	94	82	33
triclopyr ester	4	100	95	20
amine of 3,6-dichloropicolinic acid	0.5	22	increase (8%)	83
amine of 3,6-dichloropicolinic acid	1	30	25	52
amine of 3,6-dichloropicolinic acid	4	90	87	20
ester of 3,6-dichloropicolinic acid	0.5	18	increase (7%)	55
ester of 3,6-dichloropicolinic acid	1	28	21	32
ester of 3,6-dichloropicolinic acid	4	89	82	28
hexazinone	0.25	40	increase (7%)	77
hexazinone	0.5	73	5	42
hexazinone	1	88	41	27
control		0	increase (9%)	90
LSD ($p = 0.05$)		17	24	16

Trial 3

Application of hexazinone in pellets appeared an inefficient means of controlling young brigalow regrowth (Table 4) with highest mortality of 57% at 1.5 kg ha^{-1} of hexazinone.

TABLE 4

The effect of spacing of pellets impregnated with hexazinone on control of brigalow regrowth less than 12 months old (Trial 3)

Grid Spacing (m)	Rate of hexazinone (kg ha^{-1})	No. of suckers per plot	Sucker death (%) at 24 months
1.5	1.5	115	57
2	1.0	310	28
3.5	0.3	290	14
5	0.15	570	6

Trial 4

Triclopyr ester killed significantly more ($p < 0.01$) four year old brigalow suckers (92%) than did 2,4,5-T ester (77%). There were no significant differences between rates of herbicides with means of 83%, 85% and 87% for 15, 20 and 30 g L^{-1}, respectively. Greater than 90% of original suckers were killed in all treatments except 2,4,5-T ester in water (74%). The lower values for total sucker number change are a result of root suckering, especially in the 2,4,5-T ester treatments.

Water was an inferior carrier to others for 2,4,5-T ester but there were no significant differences between the mortality produced by triclopyr ester with the various carriers (Table 5).

TABLE 5

Percentage reductions in total sucker number after misting four year old brigalow (Trial 4)

	Distillate	30% Distillate 70% water	10% Distillate 90% water	Water	LSD (p = 0.05)
2,4,5-T ester (a)	86.4	72.3	83.5	66.1	
triclopyr ester (a)	90.4	93.2	91.5	93.2	12.3

(a) Mean of 15, 20 and 30 g L^{-1} rates.

Trial 5

Hexazinone at 0.25 g $plant^{-1}$ killed 91% of four year old brigalow suckers, while rates of 0.5–1.5 g $plant^{-1}$ gave 98% control. This was superior to the degree of control achieved by 20 g L^{-1} of 2,4,5-T ester applied as misted spray in distillate (78%) at 50 L ha^{-1}.

DISCUSSION

Triclopyr ester and hexazinone were the most promising herbicides tested. High rates of 3,6-dichloropicolinic acid were effective but these products are not commercially available and would probably be too expensive for commercial usage at these rates. Carbamoylphosphonate was ineffective at the rates used. Glyphosate gave poor brigalow control even though the higher rates are effective on other woody species. It also resulted in grass death although this was important only in the first growing season.

Triclopyr ester was as effective as 2,4,5-T ester on brigalow regrowth less than 12 months old and was superior on four year old regrowth. It was equally effective as a misting application when applied in water or distillate, whereas 2,4,5-T ester in water showed a marked reduction in effectiveness. Thus triclopyr ester could replace 2,4,5-T ester for spraying brigalow. However triclopyr ester is about five times the price of 2,4,5-T ester and this will ensure that triclopyr ester will not replace 2,4,5-T ester while the latter is readily available. Should this situation change, triclopyr ester may find a limited role in brigalow control. It would not find a big usage in the commercial situation as ploughing would become a more attractive regrowth treatment (Scanlan and Anderson 1981) if the cost of chemical treatment becomes comparable with ploughing costs ($70–90 ha^{-1}).

The use of water as the carrier for 2,4,5-T ester aerial spraying, instead of distillate as at present, would lead to a 25% reduction in the total cost of treatment. However water was a poorer carrier than all others for 2,4,5-T in this study. McDonald (1970) indicated that water and 10% distillate/90% water emulsion was inferior to distillate alone as a carrier for 2,4,5-T ester. Back (1974) indicated that approximately 25% more herbicide should be used when using water, rather than distillate, as the carrier for tractor misting of brigalow. An important feature of using water as a carrier for 2,4,5-T ester is that results are less predictable than when distillate is used (Johnson and Back 1973b). Within this context it is important to note that all carriers were equally as effective for triclopyr.

Hexazinone was effective whether applied as an overall spray or as a ground application. At least 2 kg ha^{-1} of hexazinone (as an overall spray or as pellets) was required to give more than 80% kill of brigalow suckers less than 12 months old. By contrast, rates as low as 0.75 kg ha^{-1} gave over 90% kill of 4 year old brigalow suckers.

There are a number of possible reasons for this. The pellets were applied on a grid pattern and did not always occur within the root zone of small brigalow suckers. With overall sprays at low rates of hexazinone, it is possible that some herbicide was taken up by the grass or was otherwise "unavailable" for uptake by the brigalow suckers. By contrast the ground application on four year old suckers ensured that the hexazinone was present in a concentrated source within the root system of suckers. It is also possible that the root system of these suckers were sufficiently large to enable uptake from more than one spot. Thus pellets or ground application on a grid pattern may be more successful on larger regrowth even though there is a greater regrowth biomass.

The grass death caused by overall spraying of hexazinone excludes this method of application in pastures. There was little effect on grass at less than 1 kg ha^{-1} of hexazinone but brigalow mortality was poor. The high initial leaf death (88%) and the relatively poor sucker death at 24 months (41%) suggests that the hexazinone was not translocated to the root system.

Hexazinone may find a specific role in brigalow control because it offers a new method of application. Treating dense suckers with 2 kg ha^{-1} of hexazinone would cost about $150 ha^{-1}for chemical alone, making broadacre application uneconomical at present. However, hexazinone is very useful for killing brigalow regrowth along fencelines, around watering points or in scattered clumps. In these situations cost per hectare is not the determining factor—the ease and speed of treatment combined with the ability to apply the herbicide at any time of year makes ground treatment or pellet application very attractive.

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