factors may include a reduced root feeding area, restricted soil aeration or less obvious factors yet to be identified.

Although water table treatment significantly affected the Ca and P content of grasses, differences observed would not affect the performance of grazing ruminants. However, the high Mo level obtained in grasses grown on HWT plots could be important. A major mineral problem of cattle grazing organic soil pastures in south Florida has been a high Mo, low Cu complex (Cunha *et al.* 1964). Cattle grazing these pastures are commonly fed high Cu mineral supplement to prevent Cu deficiency caused by high Mo levels in forages. The above data suggest that problems related to high Mo levels may be more critical with forages grown under high water table conditions.

The results of this study support previous conclusions (Pate and Snyder 1978) that a high water table significantly reduces the yield of forage grasses grown on organic soil. The reduced yield is primarily related to a deficiency of N which under low water table conditions is adequately supplied by the oxidation and mineralization of organic matter. The results indicated that the reduction in forage yield caused by a high water table can be corrected with N fertilization of grasses adapted to high water tables. However, a high water table appears to cause certain chemical and morphological changes in the composition of grasses which are not corrected by N fertilization. The magnitude of these changes in leaf-stem composition and digestibility may affect the performance of grazing animals.

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REFERENCES

BARR, A. J., GOODNIGHT, J. H., SULL, J. P., and HELWIG, J. T. (1976) –A users guide to SAS-76. SAS Institute, Raleigh, North Carolina, pp. 127–144.

CUNHA, T. J., SHIRLEY, R. L., CHAPMAN, JR. H. L, AMMERMAN, C. B., DAVIS, G. K., KIRK, W. G., and HENTGES, JR. J. F. (1964) –Minerals for beef cattle in Florida. Florida Agricultural Experiment Station Bulletin 683.

DRIESSEN, P. M. and SOEPRAPTOHORDJO, M. (1974) –Soils for agricultural expansion in Indonesia. Bulletin 1. Soil Research Institute, Bogor, Indonesia. pp. 43–46.

MOORE, J. E. and MOTT, G. O. (1974) –Recovery of residual organic matter from *in vitro* digestion of forages. Journal of Dairy Science **57**: 1258–1259.

PATE, F. M. and SNYDER, G. H. (1978) –Effect of high water table in organic soil on yield and quality of forages grasses-lysimeter study. Soil Crop Science Society of Florida, Proceedings **38**: 72–75.

STEWART, E. H., BURT, E. O., and SMALLEY, R. R. (1965) –Subirrigation of turf. Proc., Turf-Grass Conf., Univ. Fla., Vol. XIII, p. 153–159.

TIE, Y. L. and KUCH, H. S. (1979) –A review of lowland organic soils of Sarawak. Technical Paper No. 4, Research Branch Department of Agriculture, Sarawak, Malaysia, pp. 7–8.

VAN BREEMEN, N. (1980) –Activity of wetland soils, including histosols, as a constraint to food production, p. 189–202. *In* Priorities for alleviating soil-related constraints to food production in the tropics. International Rice Research Institute, Los Banos, Philippines.

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HERBICIDAL CONTROL OF WOODY WEEDS IN CENTRAL QUEENSLAND
3. FALSE SANDALWOOD (*EREMOPHILA MITCHELLII*)

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ABSTRACT

Basal bark and foliar applications of triclopyr ester, 2,4,5-T ester and ground application of hexazinone were evaluated for the control of false sandalwood (Eremophila mitchellii).

Triclopyr ester and 2,4,5-T ester gave 93% and 95% kill, respectively, of false sandalwood when applied as a basal bark spray at 10 g L^{-1}. Misting treatments with triclopyr ester in water (10, 20 and 50 g L^{-1}) were ineffective.

Hexazinone applied on a grid pattern at rates of 4 and 8 kg ha^{-1} gave similar control to a basal bark spray of 2,4,5-T ester at 10 g L^{-1}. Individual treatment of false sandalwood with 1 g hexazinone resulted in greater than 95% kill of multi-stemmed plants up to 1.75 m tall.

INTRODUCTION

False sandalwood (*Eremophila mitchellii*) is a widespread native woody species in Queensland and New South Wales (Hodgkinson 1979) which was recognised early as having potential to be a woody weed problem (Anon. 1901). It is a common associate of poplar box (*Eucalyptus populnea*) (Beeston *et al.* 1980), brigalow (*Acacia harpophylla*) (Johnson 1964) and gidgee (*A. cambagei*) (Purcell 1966).

Following the development of these communities, false sandalwood can become a serious regrowth problem as existing plants are generally unaffected or untreated during development. Regrowth can occur from broken-off stumps after pulling the original vegetation or from seedling establishment, the latter being a more serious problem in areas with lower and more erratic rainfall (Beeston and Webb 1977).

A variety of control methods have been evaluated on false sandalwood. Good control is achieved with basal bark applications of 10 g L^{-1} of 2,4,5-T ester in distillate (Robertson 1965, Purcell 1966). The same herbicide will control small false sandalwood regrowth when applied as an overall spray (4 g L^{-1} 2,4,5-T ester in water) or as a misting application to small plants (10 g L^{-1} 2,4,5-T ester in oil-water emulsion) (Purcell 1966). Plants above 1 m in height are not controlled by misting with 2,4,5-T ester in distillate at rates of up to 150 g L^{-1} (Back 1977). Fire will control false sandalwood but the degree of control is dependent on fire intensity (Purcell 1964, Beeston and Webb 1977). Ploughing and stickraking are effective control measures although the former is generally restricted to cropping areas because of the high cost (Beeston and Webb 1977, Scanlan and Anderson 1981). Ringbarking or stem injection with herbicides are generally effective (Beeston and Webb 1977) but are not commonly used because of the high cost and the difficulty of treating the small stems of false sandalwood regrowth.

Chemical control methods that are suitable for large areas and/or have a low labour component are required to make the use of herbicides more attractive to the landholder. Two relatively new herbicides, hexazinone and triclopyr, have potential in this regard. The former is applied directly to the ground and is inexpensive to apply while the latter has been successfully used for control of brigalow by misting (Scanlan 1984). This paper reports the results of preliminary trials with these herbicides and evaluates their potential for commercial control of false sandalwood in pastures.

MATERIALS AND METHODS

The three trials reported here were established on Brigalow Research Station (30 km north-west of Theodore in Central Queensland) on a deep, loamy surfaced duplex soil. The original vegetation (before the area was pulled) consisted of brigalow/Dawson gum (*Eucalyptus cambageana*) with a range of other species being present but not frequent. These included pegunny (*Lysiphyllum hookeri*), silverleaf ironbark (*Eucalyptus melanophloia*), false sandalwood and poplar box. The regrowth of false sandalwood was approximately 10 years old. Trial 1 was established in January 1980, and Trials 2 and 3 in January-February 1981.

False sandalwood was the major regrowth species although there were some brigalow, limebush (*Eremocitrus glauca*) and poplar box present. The false sandalwood was about 2.5 m tall and had a density of 2700 plants ha^{-1} with an average of four stems per plant. Plants were actively growing at the commencement of each trial and soil moisture was moderate to high.

Rainfall data were collected for the complete experimental period. Observations on leaf kill and the number of totally defoliated plants were taken at various intervals. The number of dead plants was recorded at 24 months for Trial 1 and at 12 months for Trials 2 and 3.

Trial 1

This trial compared the effectiveness on false sandalwood of hexazinone (Velpar® L) applied to the soil surface on three grid patterns with the standard treatment of 2,4,5-T ester (Farmco® T-80) as a basal bark spray in distillate. Treatments are given in Table 2.

There were four replicates of four treatments plus control arranged as contiguous randomised blocks of 10 m × 10 m plots. The number of stems and plants of false sandalwood was determined before treatments were applied at random within replicates. The hexazinone was applied with a Du Pont Spotgun® set to deliver 1 g of hexazinone at the spacings shown in Table 2. The basal bark spray of 10 g L^{-1} 2,4,5-T ester in distillate was applied to the basal 30 cm of each stem using a knapsack sprayer.

Trial 2

The effectiveness of hexazinone applied on an individual plant basis was assessed by establishing five demonstration plots using various rates of hexazinone on various regrowth sizes. Table 3 gives the hexazinone rates and regrowth size and number within each area. The hexazinone was applied to the soil surface beneath the canopy of the false sandalwood.

Trial 3

This trial compared triclopyr ester (Garlon® 480) and 2,4,5-T ester for the control of false sandalwood. Triclopyr ester was applied in distillate as a basal bark spray and as a misting application with water (Table 4).

There were two replicates of seven treatments plus control which were applied at random within replicates. The number of false sandalwood plants within each plot was determined before treatments were applied.

RESULTS

Monthly rainfall data for the experimental period are given in Table 1. Good growing conditions were experienced prior to and during the experimental period. Excellent grass growth occurred following the control of the false sandalwood.

TABLE 1

Monthly rainfall data for 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

The 2 kg ha^{-1} rate of hexazinone produced significantly less ($P < 0.05$) leaf kill than all other treatments (Table 2), after six months. False sandalwood in all hexazinone treatments showed extensive new leaf growth during the first twelve months after treatment whereas the basal bark application of 2,4,5-T ester produced slightly higher defoliation as time proceeded.

TABLE 2

Leaf kill (%), plants totally defoliated (%) and mortality (%) of false sandalwood at 6, 12 and 24 months respectively, after ground application of hexazinone and basal bark application of 2,4,5-T ester in Trial 1

Herbicide	Rate (kg/ha)	Grid Spacing (m)	Leaf Kill (%) 6 months	Plants Defoliated (%) 12 months	Plant Mortality (%) 24 months	Stem Mortality (%) 24 months
Hexazinone	2	2.2	58	28	41	65
Hexazinone	4	1.6	91	55	78	91
Hexazinone	8	1.1	93	75	79	94
2,4,5-T ester(1)	(1)	(1)	92	87	85	94
LSD ($p = 0.05$)			10	22	14	8

(1) 2,4,5-T ester applied as a basal bark spray in distillate at a concentration of 10 g L^{-1}

The percentage of completely defoliated plants was very low in all hexazinone treatments (mean of 9%) after three months. The basal bark treatment had 80% of plants defoliated at the same stage. The hexazinone treatments showed an increase in the percentage of totally defoliated plants over the first twelve months with the 8 kg ha^{-1} rate being not significantly different ($p > 0.05$) from the basal bark treatment (Table 2). Mortality data show that 2 kg ha^{-1} of hexazinone gave poorer control than all other treatments which were not significantly different from each other ($p > 0.05$) in terms of either plant or stem mortality. In all cases, the stem mortality was higher than plant mortality with the biggest difference in the 2 kg ha^{-1} rate of hexazinone.

Four and 8 kg ha^{-1} of hexazinone killed all associated brigalow in all plots while the 2 kg ha^{-1} rate gave 80% mortality. Limebush (0.5 to 1.2 m tall) within a radius of 30 cm of the point of hexazinone application were killed: plants further away than this survived, mainly by producing root suckers. All poplar box (3 to 5 m tall) in the hexazinone treated plots were killed.

Trial 2

Hexazinone gave over 95% kill of false sandalwood (up to 1.75 m) when applied on an individual plant basis (Table 3). The exception was that plants more than 2 m tall treated with 1 g $plant^{-1}$ gave 82% kill. The plants that survived were multi-stemmed. Those stems closest to the point of application were killed but stems on the opposite side of the plant tended to survive even though some initially defoliated.

TABLE 3

The percentage mortality of false sandalwood plants treated with ground applied hexazinone in demonstration plots (Trial 2)

Rate(1) (g/plant)	Number of Plants Treated	Height (m)	% Kill at 12 months
0.5	26	1.25	96
1.0	28	1.25	100
1.0	15	1.75	100
1.0	44	2.50	82
2.0	25	1.25	100

(1) Only 1 application position for all rates.

Trial 3

Triclopyr ester (at 10 and 20 g L^{-1}) gave greater than 90% kill of false sandalwood when applied as a basal bark spray but was ineffective when applied as an overall misting treatment (Table 4). Both herbicides produced similar mortality at 10 g L^{-1} as a basal spray. All false sandalwood plants that died within the misting treatments were less than 1.5 m high. There were brigalow plants (1–2.5 m tall) in misted plots and all died.

TABLE 4

Leaf kill after 2 months and stem mortality of false sandalwood at 12 months after foliar and basal bark application of triclopyr ester (Trial 3).

Herbicide	Concentration ($g L^{-1}$)	Application Method	Carrier	Defoliation (2 months)	Stem Mortality (12 months)
Triclopyr ester	5	Basal Bark	Distillate	28	75
Triclopyr ester	10	Basal Bark	Distillate	95	93
Triclopyr ester	20	Basal Bark	Distillate	98	95
Triclopyr ester	10	Misting	Water	25	24
Triclopyr ester	20	Misting	Water	33	25
Triclopyr ester	50	Misting	Water	65	37
2,4,5-T ester	10	Basal Bark	Distillate	83	95
LSD ($p = 0.05$)				28	14

DISCUSSION

Triclopyr ester (at 10 and 20 g L^{-1} as a basal bark spray in distillate) and hexazinone (1 g $plant^{-1}$ ground applied) gave good control of false sandalwood up to 2.5 m tall. Misting of triclopyr and the grid application of hexazinone gave less reliable results. Both herbicides have given good control of brigalow and associated species (Scanlan 1984, Scanlan and Fossett 1984).

Hexazinone

The proximity of false sandalwood to the point of application of hexazinone influenced the rate of survival. When 1 g hexazinone was placed underneath the canopy, control was generally good, although some stems on the opposite side to the point of application survived. The grid pattern application was less effective as the average distance from the application point to the plants was greater than for individually treated plants. The highest survival of false sandalwood was noted among multi-stemmed plants greater than 2 m tall that had all or part of the plant more than 1 m from the nearest application point.

A result of this response is that grid application of hexazinone will give very high levels of control only when the application points are sufficiently close for each plant to have at least one placement under its canopy. This would obviously be an inefficient usage of the herbicide in dense regrowth. A more realistic approach would be to use the grid pattern to reduce dense false sandalwood stands to a level where the surviving plants could be treated individually.

The most likely role for hexazinone in the treatment of false sandalwood regrowth appears to be in areas of relatively low densities (200–300 ha^{-1}). At these densities, individual plant treatment would cost \$15–25 ha^{-1}. The rationale for this is that even at low densities mass establishment of false sandalwood seedlings can occur, given appropriate climatic conditions. There are extensive areas in the western regions of Queensland and New South Wales where this control technique may have a role despite the relatively low land values.

The high mortality of brigalow in all hexazinone treatments supports conclusions from other trials (Scanlan 1984). The ability of limebush to produce root suckers and the lack of foliage on regrowth make this species difficult to control by overall spraying techniques. Ground application of hexazinone may provide another avenue for control although observations made here suggest that high rates would be required.

Triclopyr

Triclopyr ester produced similar responses to those of 2,4,5-T ester when applied to false sandalwood: basal bark applications of both herbicides (at 10 g L^{-1}) gave greater than 85% mortality. The results for 2,4,5-T ester are similar to those reported by Robertson (1965) and Purcell (1966).

Misting false sandalwood with triclopyr ester in water proved ineffective at rates up to 50 g L^{-1}. Results from other misting trials on large false sandalwood (Back 1977) have also been disappointing with a maximum mortality of 38% at 150 g L^{-1} 2,4,5-T ester in distillate. Aerial applications of 0.75 kg ha^{-1} 2,4,5-T (for the control of brigalow) are ineffective on false sandalwood. There appears to be a problem with uptake and/or translocation of foliar applied herbicides as a smaller quantity of the same products gives good control when applied as a basal bark spray. Similar results have been reported for rubber vine (*Cryptostegia grandiflora*) (Harvey 1982).

Basal bark treatment of false sandalwood is not used extensively in the brigalow or gidgee regions of Queensland. Thus it is unlikely that triclopyr ester will play a major role in false sandalwood control, even if 2,4,5-T ester became unavailable. The main reasons for this situation are that suitable labour is often unavailable and the labour cost per unit area is high. Stickraking or pulling will continue to be the most widely used control measures although hexazinone will find some use in the control of false sandalwood.

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REFERENCES

ANON (1901)—Royal Commission to inquire into the condition of crown tenants, Western Division of N.S.W. (Government Printer, Sydney).
BACK, P. V. (1977)—Appendix 3: Screening of chemicals for control of *Eremophila mitchellii* using directed and non-directed misting techniques. *In* 'The ecology and control of *Eremophila mitchellii*' by G. R. Beeston and A. A. Webb. *Botany Branch Technical Bulletin No. 2.* (Queensland Department of Primary Industries, Brisbane).
BEETSON, G. R., WALKER, P. J., PURDIE, R. and PICKARD, J. (1980)—Plant communities of the poplar box (*Eucalyptus populnea*) lands of eastern Australia. *Australian Rangeland Journal* **2**: 1–16.
BEESTON, G. R. and WEBB, A. A. (1977)—The ecology and control of *Eremophila mitchellii. Botany Branch Technical Bulleton No. 2.* (Queensland Department of Primary Industries, Brisbane.)
HARVEY, G. J. (1982)—Studies on rubber vine (*Cryptostegia grandiflora*): IV. The effects of herbicide formulations, carrier, and placement on control of rubber vine: *Australian Weeds* **1**(3): 3–7.
HODGKINSON, K. C. (1979)—The shrubs of poplar box (*Eucalyptus populnea*) lands and their biology. *Australian Rangeland Journal* **1**: 280–295.
JOHNSON, R. W. (1964)—'Ecology and control of brigalow in Queensland'. (Queensland Department of Primary Industries, Brisbane).
PURCELL, D. L. (1964)—Gidyea to grass in the central west. *Queensland Agricultural Journal* **92**: 364–369.
PURCELL, D. L. (1966)—Sandalwood (*Eremophila mitchellii*) control in gidyea country. *Queensland Journal of Agricultural and Animal Science*. **23**: 387–395.
ROBERTSON, J. A. (1965)—Chemical control of *Eremophila mitchellii. Australian Journal of Experimental Agriculture and Animal Husbandry.* **5**: 299–304.
SCANLAN, J. C. (1984)—Herbicidal control of woody weeds in Central Queensland. I. Brigalow (*Acacia harpophylla*). Tropical Grasslands **18**: 26–32.
SCANLAN, J. C. and ANDERSON, E. R. (1981)—Use of the heavy duty blade plough for control of woody regrowth in Central Queensland. *Australian Weeds* **1**(2): 10–12.
SCANLAN, J. C. and FOSSETT, G W. (1984)—Herbicidal control of woody weeds in Central Queensland. II. Dawson gum (*Eucalyptus cambageana*), bitterbark (*Alstonia constricta*) and yellowwood (*Terminalia oblongata*) Tropical Grasslands **18**: 33–38.

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EVALUATION OF SOME *CENTROSEMA* SPECIES IN SMALL PLOTS IN NORTHERN AUSTRALIA

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ABSTRACT

Twenty-one accessions of five Centrosema *species were evaluated in cutting trials for 2–3 years at three sites (Katherine, Lansdown and Narayen Research Stations) in northern Australia, together with* Stylosanthes hamata *cv. Verano and* Macroptilium atropurpureum *cv. Siratro. At Katherine, several* C. pascuorum *accessions had herbage*