DISCUSSION

This experiment confirms results obtained during the breeding program at a single site (Clements *et al.* 1986), and shows that several bred lines of *C. pascuorum* have higher and more consistent herbage and seed yields than their parents during the first two years after sowing. Line 2/2 (recently released as cv. Cavalcade) was the best line both in this experiment and in the final stages of the breeding program (Clements *et al.* 1986). CPI 40060 and 55697, the parents of 2/2, were previously identified as the best of the small number of *C. pascuorum* accessions that had been introduced by 1976 (Clements *et al.* 1984, 1986).

In contrast to previous experience at Katherine (Clements *et al.* 1984), *C. pascuorum* lines did not yield as much herbage as *S. hamata* cv. Verano during the second growing season. This result was consistent at most sites (the Florina soil type at Katherine Experiment Farm was a possible exception) and was particularly obvious at Coastal Plains Research Station. There appears to be a trend for *C. pascuorum* to perform relatively worse on the poorer types of soil, and this needs further study. Burt *et al.* (1979) reported that in north-eastern Brazil, *C. pascuorum* was found mainly on the more fertile soils.

C. pascuorum is clearly worthy of attention from pasture agronomists in the Northern Territory and other areas having a similar climate. It is widely adapted in the Top End of the Northern Territory and has excellent seed production characteristics which should reduce seed costs and aid regeneration under grazing. Research on establishment, fertilizer requirements, grazing management, animal production and long-term persistence is needed.

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USE OF FIRE FOR SPELLING MONSOON TALLGRASS PASTURE GRAZED BY CATTLE

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ABSTRACT

Continuous grazing of preferred patches in set-stocked, unburnt pastures of native monsoon tallgrass results in the death of the perennial grass plants within several years. In paddocks of this pasture type at Katherine, N.T., in which half of each paddock was burnt in rotation each dry season, cattle strongly preferred to graze in those halves which had *been most recently burnt. The other halves of these paddocks were thus spelled in a complementary rotation. This spelling appeared to enable previously grazed patches of pasture to recover, and thus pasture degradation was arrested.*

Data from exclosures indicated that grazing early in the rainy season (but not thereafter) depressed the final yield of individual grass plants by about 60%. However the mean pasture yield was depressed by only about 10% because many plants were not grazed at all.

INTRODUCTION

Patch grazing by cattle is marked in monsoon tallgrass pastures (Norman 1960; Smith 1960; Mott 1986). Where the persistent re-grazing of particular patches continued for several years, the grass plants died (Mott 1986). The result at Katherine, N.T., is that the grazed patches become bare scalds within several years, due to the combination of hard-setting clay loam soils and an absence of natural invader species (Mott *et al.* 1979; Mott 1986). This phenomenon has been observed particularly in intensively-managed experiments, but it may become more widespread as the management of the northern cattle industry intensifies in response to the disease eradication programs for brucellosis and tuberculosis.

Burning is commonly practised in northern Australia, often to create fresher "green pick" early in the dry season. Many species of grazing animals, including cattle, are attracted to areas which have been recently burnt (for reviews, see West 1965; Grunow 1980; Tainton and Mentis 1984). Thus the controlled use of fire may be a way of controlling where cattle graze, and thus a way of spelling pasture and breaking the degradative cycle (Mott 1986).

In the Katherine district, experience shows that two year's accumulation of herbage growth is required to effect a clean burn. This permits an annual burning/spelling rotation. This paper reports an examination of the influence of an annual rotational burning regime on the grazing behaviour of cattle. The extent to which the cattle graze in that half of each paddock burnt during the previous dry season, and some observations of the consequence of this for pasture recovery, are discussed.

METHODS

Study site

This experiment was conducted at the Manbulloo experiment site, 50 km SW of Katherine, N.T. The climate is seasonally dry tropical: the mean annual rainfall at Katherine is 950 mm and rain falls mainly in the four months from December to March. The natural vegetation is a low open eucalypt savanna woodland with an understorey dominated by four perennial tallgrasses, *Themeda triandra* [formerly *T. australis*, Simon (1985)], *Chryspogon fallax*, *Sehima nervosum* and *Sorghum plumosum* (Mott and McDonald 1981).

Experimental design

Three 50 ha uncleared native pasture paddocks were each bisected by a central graded firebreak, with alternate halves of the paddocks burnt each July. Cattle grazing activity was followed during the rotational cycle July 1983–July 1985. The pastures had previously been grazed and managed with fire as detailed above for at least the preceding four years, when they were part of a cattle nutrition trial, with three animals per paddock and with different mineral supplementation regimes in each paddock (W. H. Winter, *personal communication*). During the present study, the stocking rate was increased 33% to four steers (3/4–7/8 Brahman × shorthorn) per paddock to accentuate the grazing effects. A low number (*c.* 20?) of kangaroos (probably *Macropus antilopinus*) were the principal other vertebrate grazers present, and grazing by them was not distinguished from grazing by cattle.

All cattle were fed a complete mineral supplement (including 4.5% non-protein nitrogen and 4% phosphorus) as a commercial block (I.C.I. Ultrapro 50). The supplement was fed adjacent to the water trough which was located in a corner of each paddock.

Measurements

Since it was not feasible to make direct, continuous observations of cattle activity, the paddocks were surveyed at approximately monthly intervals for evidence of cattle presence (dung, hoofprints) or grazing activity (defoliation, heavy grazing). To this end a sequence of 12 or 13 permanent grid lines 600 m long and *c*. 60 m apart, were laid out across each paddock. Each line was divided into 14 transects, each 40 m long and terminated by a 1 m^2 quadrat. The 20 m at each end of the grid line was not used to minimize the edge effect of the paddock fence and graded firebreak. The data were scored at approximately monthly intervals from November 1983 to June 1985.

(a) *Defoliation*

This was rated as the proportion of the current season's forage in the 1 m^2 quadrat estimated to have been removed by cattle grazing (0 = no grazing, 1 = trace ($<$ 5% defoliation), 2 = $>$ 5% and $<$ 25%, 3 = $>$ 25% and $<$ 50%, 4 = $>$ 50% and $<$ 75%, and 5 = $>$ 75%). The rating for each quadrat was substituted by the mean value of the range of percentage defoliation spanned by the rating (e.g. 62.5% for rating = 4) to obtain an estimated percentage defoliation. This is a simplified version of the "ocular estimation by plot" method of Pechanec and Pickford (1937). As well, the above-ground yield of these quadrats was measured non-destructively using the comparative yield technique (Haydock and Shaw 1975).

(b) *Heavy grazing*

This was defined as the removal by grazing of more than half of the estimated current season's forage production in the area within 0.5 m of the observer's footsteps as each transect line was paced. The frequency of heavy grazing was counted out of a maximum of 40 observations along each 40 m transect. Heavy grazing was recorded from March 1984.

(c) *Cattle dung*

The number of dung pats was counted within 1.5 m of the 40 m transect line (i.e. a 120 m^2 belt quadrat). Old and bleached dung was ignored, but the crumbly remains of dung recently broken down by dung beetles was included. Dung abundance is commonly used for surveying animal presence (e.g. for cattle: Julander 1955; Ares and Leon 1972).

(d) *Hoofprints*

The number of hoofprint trails (i.e. indicating the passage of at least one beast) or aggregations of hoofprints which crossed the 40 m transect line were recorded from February 1984.

Fenced exclosures

In August 1984, one month after burning but before the first rains, ten fenced exclosures were erected at random positions in the burnt halves of each of the three paddocks. A little post-burn regrowth on stored reserves had occurred in the previous month, most of which had been grazed off. The exclosures were used to examine the extent to which early grazing of the post-burn, rainy season growth depressed pasture yield. Each exclosure was 4 m $\times$ 4 m, and contained eight permanent 1 m^2 quadrats in a hollow square with a 0.5 m buffer inside the fence. Above-ground pasture yields were measured in these quadrats as part of the paddock surveys.

Data analysis

The grazing data were averaged for each half of each paddock, and subjected to an Analysis of Variance for a cross-over design with three replicates (Cochran and Cox 1957). The location of the supplement and water in one corner of each paddock, coupled with the tendency for the cattle to congregate along the common fenceline containing the watering point, confounded the grazing pattern attributable to the burning rotation. To overcome this, the data for the grid line in each paddock adjacent to the common fenceline were deleted.

To analyse the yield data, the burnt half of each paddock was divided into 10 discrete blocks, each block containing an exclosure and those (*c.* one tenth) of the unfenced quadrats close to it. The effect of exclosure on pasture yield was tested by a nested Analysis of Variance (blocks within paddocks). Quadrats which had evidence of grazing by cattle (i.e. defoliation score $\neq 0$) were excluded from the analysis.

Recovery of grazed patches

In December 1983, three heavily grazed patches about 5 m in diameter in each paddock were pegged with two permanent photopoints, and their recovery was monitored photographically at intervals over the ensuing two years. The boundaries of the patches were clearly defined by the contrast of the short grass of the patch with the tall, rank grass surrounding. The patches were located in those halves which had been burned in July 1982, and were thus unburnt during the 1983–4 season.

RESULTS

Area-selective grazing

Selection for post-burn pasture

All four indices of cattle activity reveal the same pattern (Fig. 1). The cattle preferred to graze in that half of each paddock which had been burnt during the previous dry season. This was statistically significant for at least one variable at each time (Table 1). Thus the stocking rate in the recently burnt half was much greater than that of the paddock as a whole, approaching twice the rate at the start of the rainy season, and conversely was less for the unburnt half. Some of the observed grazing may have been due to kangaroos—they, too, graze preferentially on short grass, sometimes in response to the effects of cattle grazing (Newsome 1971).

TABLE 1

The significance of the difference in the mean values of four measures of cattle grazing activity/presence between the recently burnt and recently unburnt halves of three paddocks in which the alternate halves were burnt in rotation in July.

Month	Percentage defoliation	Dung density	Hoofprint abundance	Frequency of heavy grazing
December[1,2]	*[3]	*	—[4]	—
January	*	NS	—	—
February	NS	NS	*	—
March	NS	NS	—	**
April	NS	NS	*	*
May	NS	NS	*	*
June	NS	NS	*	*

[1]The analysis is a cross-over design using two surveys twelve months apart for the time of year shown.
[2]Only two paddocks were surveyed in November 1983, so the November data were not analysed.
[3]Significance of the $F_{1,4}$ ratio from the Analysis of Variance for a cross-over design. *, $P < 0.05$; ** $P < 0.01$; NS, non-significant.
[4]no data, or rain interfered with hoofprint recording.

This area-preference was not absolute, however. There was a tendency for the cattle to increase the time they spent in the unburnt half as the season progressed, and the vegetation became more rank.

The four measures of cattle activity were each significantly correlated with each other ($P < 0.01$) on most occasions (quadrats pooled over paddocks, waterpoint gridlines excluded), except that the correlations between percent defoliation and dung abundance were significant only early in the rainy season.

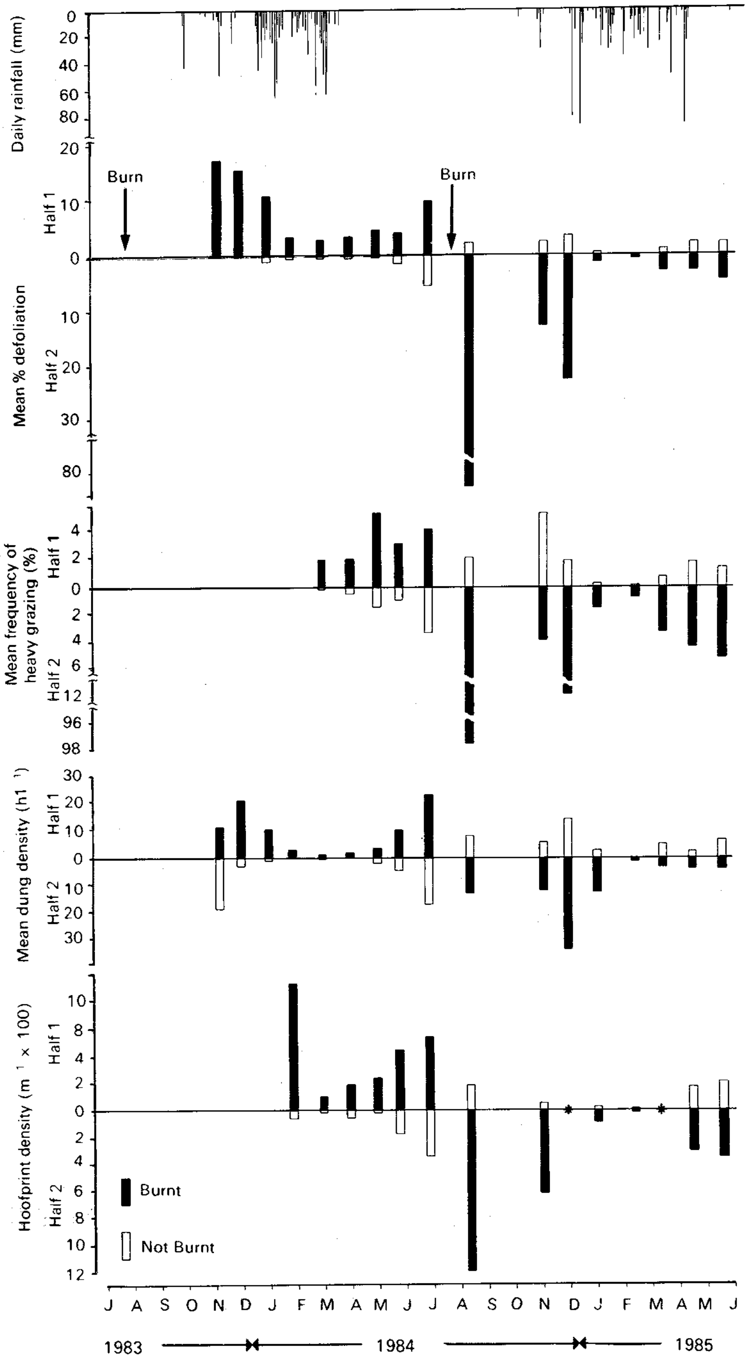

FIGURE 1

Mean values for four measures of cattle grazing activity/presence in the recently burnt and recently unburnt halves of the three paddocks, and daily rainfall for the period of measurement. Half 1 burnt in July 1983, half 2 burnt in July 1984. Asterisk indicates that rain interfered with hoofprint recording.

Temporal pattern

The temporal pattern in the defoliation values reveals how the cattle grazed these rotationally burnt paddocks. Most quadrats in the recently-burnt halves of the paddocks were grazed when growth was new and in short supply. This occurred during the late dry season when plants were growing from stored reserves (8.5 kg ha^{-1} dry matter yield in August 1984), or during the early part of the rainy season (50.7 kg ha^{-1} yield in November 1983 and 58.8 kg ha^{-1} in December 1984). This resulted in relatively high values of percentage defoliation and frequency of heavy grazing. (It should be noted that these values are nevertheless lower than might be expected, due to an artifact. When the post-burn growth is very short, defoliations of > 50% are rarely encountered because cattle cannot graze right to ground level.) As grass growth became more abundant after mid-December (Fig. 2), cattle were observed to graze a smaller and smaller total area, causing the mean percentage defoliation to fall (Fig. 1), until grass growth ceased in April–May. Pasture yields were then 1650 kg ha^{-1} (1983) and 1290 kg ha^{-1} (1984). Thereafter, the cattle began grazing new areas and extending old patches.

Suppression of pasture yield

The mean yield of unfenced quadrats with no obvious signs of grazing was always less than the yield of the fenced quadrats (Fig. 2). The absolute difference became greater, and statistically significant, as the season progressed, but the relative difference was always about 10% or less.

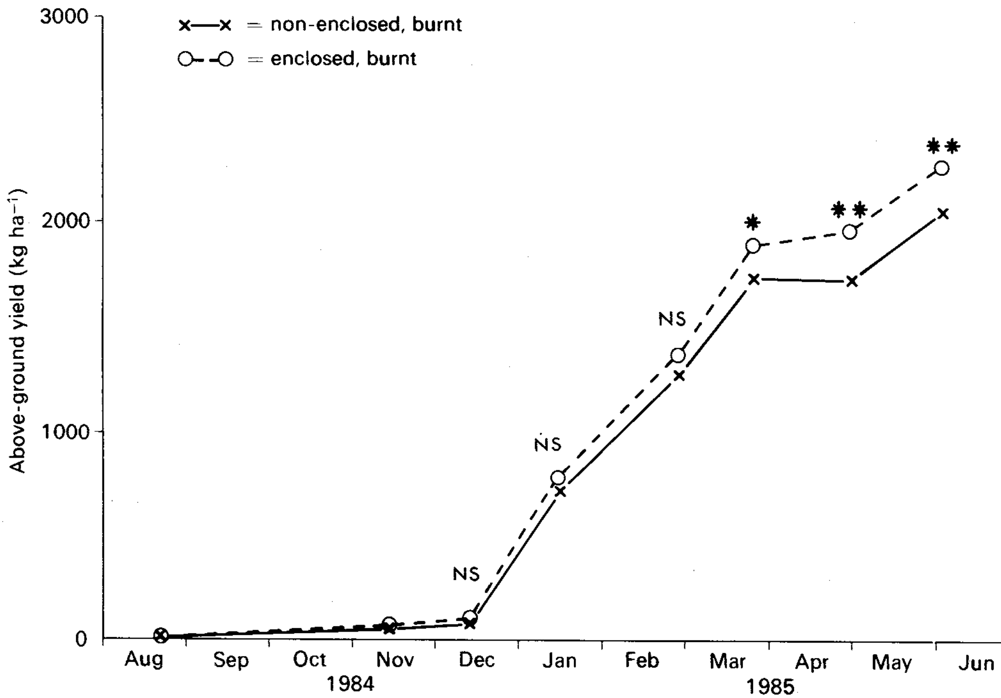

FIGURE 2

Above-ground dry matter production of fenced (– –) or unfenced (——) quadrats of monsoon tallgrass pasture burnt in July 1984 (averaged over three paddocks). The mean value for unfenced quadrats includes only those quadrats which were not obviously grazed at the time of each measurement. The significance of the difference between fenced and unfenced quadrats is shown: NS, non-significant; *, $P < 0.05$; **, $P < 0.01$.

By making some assumptions based on the results presented above, the defoliation data can be used to interpret this difference more discerningly. Firstly, of the quadrats heavily grazed (i.e. more than 50% defoliated) at the start of the rainy season (December 1984), some will have remained heavily grazed and comprised the grazed patches at the end of the rainy season (April/May) (proportions 0.01, 0.03 and 0.04 of the total quadrats in the three paddocks respectively). Secondly, the remainder of the initially-grazed quadrats will have been steadily released from grazing during the rainy season. Thirdly, assuming that the quadrats ungrazed at the start of the rainy season remained so thereafter, then the set of quadrats at the end of the rainy season which had no obvious evidence of being grazed (i.e. defoliation score = 0; the quadrats which provided the data in Figure 2) is made up of a proportion (p) of plants which were released from heavy grazing early in the season (p is obtained by subtracting the quadrats which remained grazed from the number grazed at the start of the season), and the rest ($1 - p$) which were never grazed. The relationship between the observed percentage reduction in mean yield (R) and p is:

$$R = \mathrm{r}\, p,$$

where r is the percentage reduction in yield of early-grazed quadrats.

I estimated the value of r by regressing R against p through the origin, using the values of R and p for each of the three paddocks for April 30, 1985. *The calculated value of % reduction in yield in early-grazed quadrats was 62%.*

Recovery of grazed patches

Of the nine closely grazed patches pegged for observation (selected from those present at the end of the 1983 dry season), eight were not grazed during the following 1983–4 rainy season, and the height and apparent biomass of the grasses in these patches was not noticeably different from that of the surrounding grassland. The one patch which remained grazed was in a part of a paddock, near a fenceline, in which the cattle congregated. When the pasture was burnt in July 1984, the eight ungrazed patches burned as cleanly as the surrounding grassland. In the 1984–5 rainy season when the cattle returned to graze those halves of the paddocks which contained the pegged patches, new patches were formed independently of the locations of the previous patches—of the eight pegged patches which had not been grazed in the 1983–4 rainy season, none was regrazed within the previous exact boundaries, but in one there were new patches formed adjacent to the slightly overlapping the old boundaries. The one patch grazed during the 1983–4 rainy season continued to be grazed. It is during the rainy season, particularly the early part, that grazing is most injurious to the grasses (Mott 1986). Thus it is significant for pasture recovery that most of the grasses in the former patches were spelled for two successive rainy seasons as the result of rotational burning.

DISCUSSION

This study shows that fire can be used to spell monsoon tallgrass pastures as cattle prefer to graze recently-burnt areas, at least under experimental conditions. There is evidence that this spelling permits previously grazed patches to recover, and that new patches formed when cattle return to graze after the next firing are located independently of the previous patch locations. This second point is consistent with Mott's (1986) results that there was no difference in the botanical composition of the patch and non-patch areas and that new patches could be created by mowing rank grass at random. These two points together explain why there has been little degradation over the eight years that the paddocks have been rotationally burnt. They also probably explain why patch degradation is not commonly observed in extensive rangeland paddocks in the Katherine district which are burnt virtually every year.

Climatic conditions affected the detail of the results obtained. No post-burn growth was produced in the remainder of the dry season (July–Oct) in 1983. Thus the animals would have had to forage in the unburnt half until the first rains, and the residual effect of this is the relatively high dung density in the unburnt half in November 1983 (Fig. 1). The values for % defoliation and heavy grazing of the burnt half for November 1984 appear anomalously low (Fig. 1), but there had been little grass growth by then, as judged by the exclosures (Fig. 2), so presumably the cattle also had to forage extensively in the unburnt half in November 1984 as well as in November 1983.

The % defoliation and heavy grazing data were more informative variables than dung and hoofprints. The values of the latter were more influenced by weather—rainfall stimulated dung beetle activity, which determined the amount and visibility of dung, and the timing and intensity of rainfall determined the number of hoofprints visible at any time. Also, hoofprints are measures only of animal presence, which is not necessarily grazing activity which the two former variables measure. Defoliation values, if obtained for the individual species in each quadrat, can be used to determine grazing preferences (Kruger and Edwards 1972). The frequency of heavy grazing is a measure of the proportion of the paddock being patch-grazed; being quick to score, a large sample size is readily obtained. It is probably for this reason that heavy grazing showed a significant burning effect on all occasions for which it was scored, whereas percentage defoliation, based on 40-fold fewer quadrats, was significant only early in the rainy season when grazing was most widespread throughout the burnt half.

The results for pasture yield indicate that the effect of grazing on fresh, post-burn growth at the start of the rainy season is very injurious to the perennial grass plants. This accords with the results of Tainton *et al.* (1977) and Mott (1986). Tainton *et al.* (1977), working in South Africa, measured total pasture yield over the summer growing season in Southern Tall Grass Veld pasture, which had been burnt in the dry season. They reported that yield was depressed by about 50% by a single clipping to 1 cm above the ground within the first two weeks of growth at the start of the rainy season. For single defoliations applied later in the rainy season, the yield depression was proportionately less. Their pasture, dominated by *Themeda triandra*, was similar physiognomically to the Katherine pasture of which *Themeda triandra* (formerly *australis*) is a major component. My estimate of the reduction in yield is very similar to their estimate of approximately 60% reduction. In my study here, plants may have been defoliated a number of times by cattle, rather than once (Tainton *et al.* 1977). Mott (1986), working at Manbulloo, showed that the effect of clipping at various times during one rainy season was measurable as a reduction in yield at the end of the following rainy season, with the greatest reduction (*c.* 60%) occurring in the plots clipped early in the rainy season.

Burning has frequently been used as a means of influencing animal distribution, but apparently not often expressly for the purpose of preventing pasture degradation (a notable exception being Duvall and Whitaker's (1964) study of cattle in Louisiana).

There are other methods for spelling pasture. However, the advantage of fire is that, in addition to its cheapness, it removes the old rank forage and creates a uniform, attractive pasture in formerly ungrazed areas. This redistributes the grazing animal and reduces pasture degradation due to persistent patch grazing. Spelling without burning is not likely to be very successful unless the old rank material is removed by some other means, like slashing. Fire can be used to burn a part or all of the paddock each year. However, burning the whole paddock is only feasible in systems where growth is sufficient to carry a fire each year. If burning has to be less frequent than yearly, then this may mean that the patches will be grazed for at least two consecutive years, which may be sufficient to damage the grasses in the patches (Pratt 1967; Mott 1986).

The disadvantage of burning is that it does not guarantee the spelling of adjacent unburnt areas, because cattle may continue to graze the unburnt areas because of other attractions (such as water points in this study, or favoured microhabitats (Duvall and Whitaker 1964). The experimental paddocks of this study were very uniform. It is important to know how well fire will work as a spelling tool in large paddocks (50–100 km^2) which are very heterogeneous.

Another advantage of burning in this seasonally-dry tropical environment is that it may improve animal production (Norman 1960). In the current study burning increased animal gain by nearly 20 kg $head^{-1}$ (W. H. Winter, *personal communication*). The benefits accrue specifically during the late dry season and early wet season when the animals concentrate their grazing on the recently burnt pasture. Pasture quality attributes such as a more nutritious forage (e.g. Norman 1960; Smith 1960; West 1965; Daubenmire 1968; Ash *et al.* 1982), and improved accessibility (Shaw and Bisset 1955; Stobbs 1973; Ash *et al.* 1982) are improved by burning.

Fire as a management tool has long been a controversial subject (West 1965; Egunjobi 1979), because of the possible damage to the environment through untimely burning and injudicious grazing. Heavy grazing of the fresh post-fire growth is damaging to the grass plants. Hence timing of the burn is very important in set-stocked systems—the earlier the burn, the longer the dry season growth is subjected to grazing. Late dry season fires are often intense, damaging the savanna trees and especially their juvenile forms (West 1965; Egunjobi 1979), and also the perennial grass plants if the rainy season growth has begun (Smith 1960). Since grazing pressure strongly determines fuel load and distribution, which in turn strongly influences fire intensity, there is clearly a tradeoff between the frequency and timing of burning on the one hand, and grazing management on the other, for the stability of both the understorey and woody components of the savanna system. We need to know more about this tradeoff before being confident that an intensified grazing management system incorporating fire will be ecologically sound.

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POTENTIAL OF *ALBIZIA LEBBECK (MIMOSACEAE)* AS A TROPICAL FODDER TREE A REVIEW OF LITERATURE

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ABSTRACT

Albizia lebbeck *(Indian siris), extensively grown as a shade tree in Queensland, has attributes which make it a potentially valuable species for pasture improvement. Literature on environmental requirements, establishment and production is reviewed. Indian siris is adapted to a wide range of environmental conditions, nodulates readily and its leaves provide a palatable, high-protein fodder. It is concluded that Indian siris can make an important contribution to plant and animal production from tropical pastures and could also be of special value in areas with salinity problems.*

INTRODUCTION

Various trees have been described as fodder trees. This implies that one or more components of such trees can be used directly as feed for domestic animals. It is likely that many of these trees could effectively improve the long term production of associated pasture species and thereby increase total pasture production. Balancing forage nutrient quality during the dormant season of grass, providing wildlife habitat and shelter for livestock, control of desert encroachment, maintaining soil fertility and stability and increasing soil nitrogen in the case of nitrogen fixing species are discussed as the advantages of fodder trees and shrubs by Glencross (1978) and McKell (1980). The fact that the climax vegetation in tropical and subtropical regions is often woodland or savannah-woodland, despite moderately high populations of herbivorous animals, suggests that a tree or shrub may have an ecological advantage over a fully herbaceous sward (Gray 1970). *Albizia lebbeck* (Indian siris), a well-known leguminous fodder tree with very palatable leaves (Negi 1977; Anonymous 1980a) is potentially one of the most suitable fodder trees for Queensland. While Indian siris is widely known in Queensland (Everist 1969), no commercial use of this fodder tree has yet been reported in this state. This paper reviews various aspects of the growth and the productivity of Indian siris, concluding with an assessment of its potential for wider use in Queensland.

BOTANY

Indian siris is native to tropical Asia and Africa, and possibly Cape York Peninsula in Queensland (Everist 1969; Anonymous 1979). *Albizia* is a large pantropical genus containing 150 species, mainly shrubs and trees, closely allied to and often mistaken for *Acacia* (Allen and Allen 1981). *Albizia lebbeck* is a moderate to large sized deciduous tree, which can reach a height of 30 m. Size and shape depend on locality. In the open the shape is spreading and low branching, but in dense forest the bole is straight. The foliage, markedly pale green when young and grey-green at maturity, consists of bipinnate leaves comprising 2–4 pairs of pinnae each 50–100 mm long and with 3–11 pairs of leaflets up to 50 mm long. Cream coloured flowers are