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Legume-based pasture options for the live cattle trade from the Australian semi-arid tropics

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Summary. The extensive beef industry in the Northern Territory has been based almost exclusively upon native grass pastures for over a century. The recent development of an export trade for live cattle of specific age, weight and type, has increased returns over chilled manufacturing beef exports and has resulted in a demand for improved pastures that can support rapid growth of young cattle. This paper compares the potential of native grass pastures, legume ley pastures and permanent sown grass–legume pastures, in a range of configurations, to meet the market demand. Results of farming systems and sown pasture management experiments conducted at the Katherine Research Station are presented. Data from these experiments and other sources are used to explore options appropriate to the new market. Particular attention has been given to the time required for weaner steers to reach export target weights of 290–300 kg/head and the flexibility of systems to seasonal and animal variability.

Permanent sown pastures are sustainable at stocking rates of about 2 steers/ha, but results indicate difficulty in maintaining legume dominance in the ley pastures, particularly if the cropping frequency is reduced. A proposal to use forage crops, rather than grain crops, to deplete soil nitrogen and reduce the incidence of weeds, is discussed.

We recommend that ley pastures be retained as part of the management system, despite management difficulties, as they provide higher productivity and greater flexibility for farmers to meet the market requirements.

Introduction

A stable cattle industry has developed in the semi-arid regions of the Northern Territory and the Kimberley region of Western Australia over the past hundred years (Winter *et al.* 1985). Cattle are concentrated on the restricted areas of relatively fertile clay soils where the native forages are of reasonable quality. In higher rainfall areas, where infertile red sesqui-oxidic soils predominate, the cattle industry is less well developed. Here, native grass pastures are of high nutritional value for only a very short time early in the growing season (Norman 1963), and, during the dry season, cattle normally lose a significant portion of weight gained in the wet season (McCown 1982). However, in some of these areas rainfall is sufficient for sown pastures and/or field crops, including the use of ley farming systems. Clearing and cropping is, however, restricted to that fraction of the area with suitable slope, soil depth, soil type and access—an area totalling 130–150 000 ha in the Katherine–Douglas Basin (Dilshad *et al.* 1996).

Ley farming has shown promise in experiments in the Katherine–Douglas Basin since the late 1970s (McCown *et al.* 1985). Over the past 10 years, as a result of the combined efforts of several innovative farmers and advisers from the Northern Territory Department of Primary Production and Fisheries, sown legume pastures and sorghum cropping have been combined effectively in what McCown (1993) claimed (perhaps rashly) might be the only new ley farming system in recent decades. In accordance with the history of such developments elsewhere, this has been driven by the opportunities for increased returns from the animal enterprise (Ruthenberg 1981; McCown *et al.* 1986; McCown 1993). In this case, the market incentive has been the export of young cattle from northern Australian ports for finishing elsewhere in south-east Asia.

Young, high grade Brahman cattle meeting strict weight and age specifications are required to capture this opportunity for much increased returns over the traditional export of chilled manufacturing beef. Consequently, a forage production system offering a higher plane of nutrition at relatively low costs is needed. Both research and practice have now shown that well-adapted sown pasture legumes are central to meeting these requirements and that these legumes can be provided either in continuously grazed sown legume–grass pastures or as legume ley pastures which are grazed only in the dry season.

This paper first reports an experimental evaluation of the ley pasture option at Katherine which aimed to establish the feasibility of a tropical ley farming system, including the productivity of crops and livestock, persistence and stability of the pasture phase, and potential trade-offs between the optimal operation of each component separately and the integration of both crop and livestock components. In this study, young cattle grazed native pastures in the wet season and croplands, containing legume ley pasture and crop residues, in the dry season. This is followed by a report of cattle performance on adjacent sown pastures during the same period. The paper concludes by comparing the performance of cattle on these systems and hypothetical variations in them in effectively turning off cattle for the live cattle export trade.

Materials and methods

Location and climate

The research was conducted in the northern part of the Northern Territory at the Katherine Research Station (132°E, 14°S), which has a mean annual rainfall of 950 mm, 94% of which falls in the 5 months between November and March. A more comprehensive physical geography of the region can be found in Williams *et al.* (1985).

Ley pasture experiment

Design. The experimental area consisted of 180 ha of native grass–*Eucalyptus* open woodland and 3.6 ha of cropping area. The native pasture area was typical of the region, consisting predominantly of perennial grasses, principally *Themeda triandra*, *Heteropogon contortus*, and *Sorghum plumosum*.

Within the cropping area, the intention was to establish a rotation of 1 year of cereal crop followed by 2 years of legume ley pasture. Results of the first 3 years of the sequence are reported here. The rotation was followed in three 1.2 ha paddocks, each of which was sown to one of 3 legume species: *Stylosanthes hamata* cv. Verano, *Alysicarpus vaginalis*, and *Centrosema pascuorum* CPI 55697, a parent line of the subsequently-released cultivar Cavalcade. Each paddock was divided into 3 equal areas, with a particular sequence of pasture and crop applied to each area as follows:

Area	1981–82	1982–83	1983–84
1	Maize	Ley year 1	Ley year 2
2	Ley year 1	Sorghum	Ley year 1
3	Ley year 1	Ley year 2	Maize

An early maturing sorghum variety was substituted for the intended maize crop in 1982–83 due to the very late incidence of acceptable planting conditions.

The legume blocks and native pasture treatments were not replicated. In the dry season, 12 steers (4 per paddock) were transferred from the native pasture block to cropland for a period of about 100 days. In each paddock they had access to two thirds of the area as dry legume (which had grown without grazing during the rainy season), and one third as crop residue following grain harvest. Six steers remained on native pasture at this time for comparison. Cattle in the croplands rejoined those on native pastures at the start of the wet season.

Pasture management and measurement. Legume pastures in each block were established initially with full cultivation and seeding rates >20 kg/ha, and thereafter regenerated naturally. The strategy for fertilisation of the cropped areas was to keep all nutrients, other than nitrogen, non-limiting [see McCown *et al.* (1986), for a more comprehensive report of experimental methods].

Pastures in the cropping area were sampled at 3 times. In late April, near the end of the wet season, the composition of the crop and ley pasture areas (including crop, weed and intercrop) was measured using the BOTANAL technique (Tothill *et al.* 1978). Pastures were sampled a second time at the start of the dry season when cattle were admitted, and a third time at the end of the dry season when cattle were removed. On these latter 2 occasions, ten 0.5 m^2 quadrats were harvested in each ley area of the 3 legume treatments.

The yield and composition of the native pastures were not measured. At the end of each wet season about 2 t/ha of forage was available, which was considered non-limiting for steer production. The pasture was managed by burning half of the area in alternate years during the dry season.

Cattle management and measurement. Block licks containing sodium, phosphorus, sulfur and urea were available to cattle on native pasture at all times; the same mix minus urea was available to animals grazing within the cropping area. Cattle were sprayed for tick control 6 times per annum. Cattle were returned from cropland to native pasture when sufficient rain (i.e. 30–40 mm) had fallen to produce grazable 'green pick' on the burned area.

At the start of each ley grazing period there were 4 animals in each of the 3 cropping area paddocks (two 1.5-year-old and two 2.5-year-old Brahman-cross steers) and 6 animals grazing native pasture (same age mixture). At the end of the ley grazing period the older animals in all treatments were replaced by yearlings which had previously grazed native pasture. Growth data for the ley pasture treatment animals during the subsequent wet season excludes these replacement stock.

Cattle were weighed without fasting on the occasions indicated in Figure 1. During the ley grazing period, observations were made on grazing behaviour for 1 day every 2 weeks. The observations were made with binoculars from a high tower and data on steer location and forage species eaten were recorded at 15 min intervals between 0730 and 1730 hours.

Sown pasture experiment

Treatments, pasture and animal measurements. Data for fully sown pastures are derived from treatments of a large experiment which were adjacent to the ley pasture

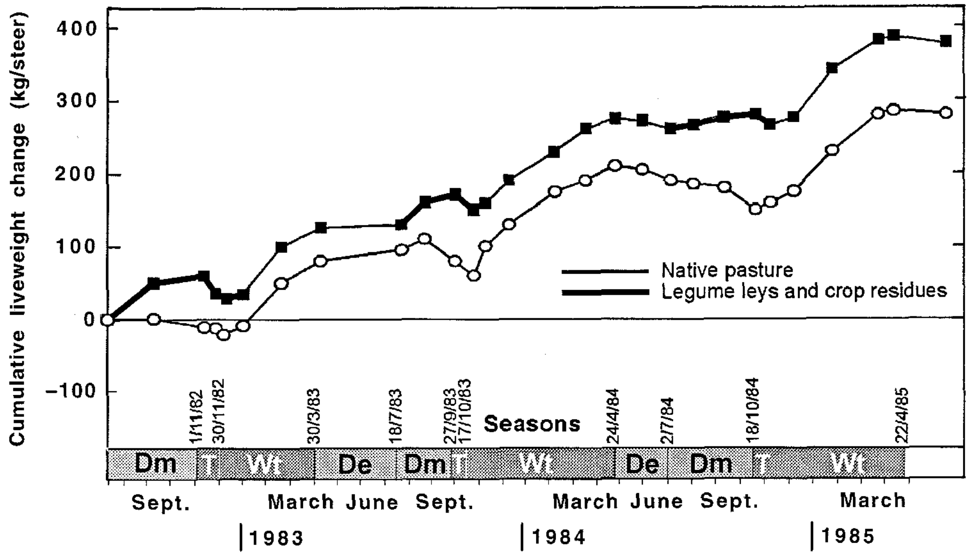

Figure 1. Cumulative trends of measured liveweight for cattle continuously on native grass pasture and for cattle on croplands in the main dry season and on native pasture the rest of the year. Seasons denoted as transition (T), wet (Wt), early dry (De) and main dry (Dm).

experiment, and for the same 3-year period. These pastures were sown in 1976 to a mixture of *Cenchrus ciliaris* (Biloela buffel), *Cenchrus setigeris* (Birdwood), *Urochloa mosambicensis* (Nixon sabi) and *S. hamata* cv. Verano. Superphosphate was applied at 300 kg/ha initially, 100 kg/ha annually for the next 3 years and thereafter at 50 kg/ha. Data on pasture composition and animal production for 2 stocking rates, 1.25 and 2.1 steers/ha, are presented here.

Pastures were grazed continuously with 4 Brahman-cross steers, half of which were replaced annually at the start of the dry season. They were provided with a NaCl supplement year-round and sprayed for tick control 6 times per year. The composition of the pastures was estimated at the end of the wet season (April–May) using the BOTANAL technique.

Results and discussion

Data reported upon here are from unreplicated treatments. The repeatability over time of outcomes and other published and unpublished data are drawn upon to best interpret the information.

Ley pasture experiment

Pasture production. Ley pasture dry matter available at the beginning of the main dry season ranged from 3.6 to 5.6 t/ha, comprised in most cases of more than 70% legume (Table 1). About 2 t/ha generally remained at the end of the period. The rate of dry matter disappearance in these pastures was 7.3, 9.2 and 8.6 kg/steer.day for the 3 years, respectively.

Botanical stability. With few exceptions, there were substantial changes in botanical composition of the ley pastures from the first to the second year. Data for the 2 crop sequences are presented in Table 2. With the exception of one of the *A. vaginalis* treatment years, annual grasses comprised less than 10% of pasture yield in the first year of the leys. While total pasture yields tended to be higher in the second year of the ley (data

Table 1. Dry matter yields and composition of croplands forage at the start and end of the grazing period

Data for the 1982 pasture are the means of 2 first-year leys, while 1983 and 1984 data are the means of 1 first-year and 1 second-year ley

	Initial forage DM (t/ha)	Proportion of legume (%)	Residual pasture (t/ha)
		1982	
S. hamata	5.0	93	1.7
A. vaginalis	3.6	90	1.6
C. pascuorum	5.2	81	2.1
Stover	1.5	—	—
		1983	
S. hamata	3.8	74	2.1
A. vaginalis	4.3	77	1.8
C. pascuorum	4.3	78	2.0
Stover	1.0	—	—
		1984	
S. hamata	5.6	67	2.0
A. vaginalis	5.2	48	2.0
C. pascuorum	5.6	79	2.9
Stover	1.0	—	—

Table 2. Composition (%) of ley pastures sown to *Stylosanthes hamata* cv. Verano, *Alysicarpus vaginalis* and *Centrosema pascuorum* in the first and second years in two crop–ley sequences

Values were recorded at peak yield; forbs other than the three legumes are not reported and account for the deviation of totals from 100%

Pasture species	Sequence C		Sequence A	
	Ley 1 (1981–82)	Ley 2 (1982–83)	Ley 1 (1982–83)	Ley 2 (1983–84)
	Stylosanthes treatment			
S. hamata	85	44	62	36
A. vaginalis	10	13	25	25
C. pascuorum	0	0	0	0
Grass	2	39	6	38
	Alysicarpus treatment			
S. hamata	10	39	0	2
A. vaginalis	85	32	77	12
C. pascuorum	1	0	0	0
Grass	0	29	22	85
	Centrosema treatment			
S. hamata	3	24	1	6
A. vaginalis	3	23	15	15
C. pascuorum	72	22	77	70
Grass	0	29	1	8

not shown), annual grasses generally increased dramatically in the *A. vaginalis* and Verano treatments. Over time *A. vaginalis* and Verano became more abundant in the other legume treatments.

The stability of annual legume pastures in the semi-arid tropics seems to be a function of the phosphorus status of the soils, grazing management and the extent of nitrogen accretion. Under conditions of low soil phosphorus availability, and with grazing during the wet season (when grass is grazed preferentially), *Stylosanthes* and *A. vaginalis* pastures in this environment have retained a high degree of purity for many years (Winter *et al.* 1989). However, under conditions of high phosphorus input, and grazing deferred until the dry season, annual grass invaded Townsville stylo (*S. humilis*) pastures after a few years in numerous locations throughout northern Australia (Gillard and Fisher 1978). Our hypothesis in this experiment was that legume composition could be kept high by: (i) using legume species that are more competitive than Townsville stylo, (ii) limiting ley pasture duration to only 2 years before depleting the available soil nitrogen levels with nitrophilous crops, and (iii) reducing weed populations by using pre-emergent herbicides in association with grain crops.

In this context, our results are inconclusive, although *C. pascuorum* appeared to be more competitive than the other legume species. It is possible that a mixture of all 3 legumes would be more robust and that light grazing early in the green season would reduce the competitiveness of the annual grasses.

Animal production. Trends in cumulative liveweight change of steers for the 3-year period are shown in Figure 1. The ley pasture data are the mean of the 3 legume species. Steers grazing continuously on native pasture gained an average 93 kg/annum, whereas those grazing within the cropping area during the dry season averaged 123 kg. In order to more precisely analyse treatment differences, each year in Figure 1 has been divided into 4 seasons: main dry (Dm), when there was no rain, and animals grazed within the cropping area or native pastures; transition (Tn), the period of high temperatures and erratic rainstorms, preceding the onset of the wet (Wt), the period of sustained rainfall; and early dry (De), the period without rain and when pastures deplete soil moisture and senesce.

Steers gained an average 456 g/day when grazing within the cropping area (at 3.3 steers/ha) during the 99 days of the main dry season—705 g/day more than those that remained on native pasture (at 0.03 steers/ha) (Table 3). Growth rates on the cropping area were similar to those on Townsville stylo at Katherine

Table 3. Rates of liveweight change of cattle grazing native pastures the entire year (average of three years), and native pastures in the wet and early dry seasons and legume leys in the dry season (average three years and the three legume treatments)

Season	Duration (days)	Continuous native pasture (g/steer.day)	(kg)	Native pasture + leys (g/steer.day)	(kg)
Early dry	90	−67		−171	
Main dry	99	−249		+456	
Transition	22	−393		−964	
Wet	159	+827		+733	
Full year	365		93		125

(Norman 1964, 1968; Norman and Stewart 1967), where steers gained 480–550 g/day over about 100 days during the early and main dry seasons. Lighter grazing pressure and grazing earlier in the season would probably give higher growth rates, up to 800 g/day, as indicated by results from Douglas–Daly (about 200 km north of Katherine) for steers grazing *C. pascuorum* cv. Cavalcade at 2.0 steers/ha for a 66-day period during the early dry season (D. Zuill unpublished data).

The nutritional contribution of stover in this experiment could not be assessed independently, but was probably modest due to yield and quality limitations (Austin *et al.* 1988). Although a significant proportion of the stover remained unconsumed at the end of each ley grazing period, the proportion of grazing time on maize stover declined from 13% at the outset to 2% by the end of the grazing period, and in 1983 time spent on sorghum stover declined with time from 15 to 9%.

Part of the advantage gained by steers in the cropping area during the main dry season was lost during the transition and wet seasons. In the first 2 years, steers remained on the legume leys during the transition season and weight loss was rapid (Fig. 1). This was presumably due to intake suppression as a result of moulding of legume herbage which, in its dry state, had supported modest weight gains (Norman 1967; McCown and Wall 1989). In the third year, weight loss was reduced as the steers were transferred to native pasture immediately after the first rainfall. Liveweight losses that occurred on the native pastures during the transition season can be attributed to reduction in gut fill in response to intake of green grass regrowth (Norman 1967; McLean *et al.* 1983). Compensatory gains of steers which had grazed native pastures continuously further reduced weight advantages accrued by steers in the croplands (Table 3, Fig. 1).

Liveweight gains of steers grazing the 3 different legumes treatments did not differ greatly, except in the main dry season in 1984, when weight gain on *A. vaginalis* was much less than on the other 2 legumes. This lower rate of gain was associated with the lowest legume content (48%) in the ley pasture during the experiment (Table 1). In 1982, when the purity of the sown species was high in all paddocks, growth rates differed by less than 3% between legume treatments. With the exception of the first year, the interpretation of differences in animal production between legume species was limited by the mixing of legume species and lack of within-year replication.

Sown pasture experiment

Pasture composition. Pasture composition did not vary much from year to year during the period 1982–84 (Table 4) but differences between stocking rates were consistent. The predominant annual grass was *Pennisetum pedicilatum* and the major weeds were *Sida acuta* and *Crotalaria spp*.

Table 4. Mean pasture composition (%) and yield at the end of the wet season for the two stocking rates
Values are the mean of three years (1982–84)

	Stocking rate (2.1 steers/ha)	Stocking rate (1.25 steers/ha)
Pasture species (%)		
Sown perennial grass	51	29
Annual grasses	11	39
Annual legume[A]	18	7
Broadleaf weeds	20	25
Dry matter on offer (t/ha)	4.4	6.0

[A] *S. hamata* cv. Verano and the volunteer *A. vaginalis*.

Animal production. During the 3 years of the study, steer growth averaged 100 kg/year at both stocking rates. A closer examination of these results is provided by dividing the year into 4 seasons based upon animal performance, which is closely correlated to the timing of the onset and cessation of rainfall. In general, the main dry season was July through to September–October, the transition season was late October through November, the wet season was December through to April, and the early dry season was May through June.

Steers lost 10–20 kg/head during the main dry season. These losses were attributed to low forage quality as the best leaf material sampled from the grasses in these pastures never contained more than 0.8% nitrogen during the dry season (unpublished data). Other studies elsewhere in the semi-arid tropics have provided similar data for sown pasture species and volunteer grasses in similar pasture systems (Norman 1963; McIvor 1990). The modest weight losses during this period of 100–250 g/day are consistent with this quality of forage.

The transition season includes the humid and stormy month or so preceding the wet season and is the most stressful period of the year for livestock. In 2 of the 3 years, weight loss was less at the lighter stocking rate, but generally steers lost about 30 kg per head during this period. This result is consistent with that of McLean *et al.* (1983) on similar pastures at Katherine and with other studies on native pastures (Winter 1984).

The mean growth rate of 835 g/day during the wet season at both stocking rates was similar to that of steers on native pastures (Table 3). However, it is important to note the large differences in stocking rates between these treatments at that time; native pastures were grazed at 0.1 steers/ha, compared with 1.25 and 2.1 steers/ha for the sown pastures. Notably, growth rates were greater than for steers which had gained weight on ley pastures during the dry season.

Steers gained weight at about 400 g/day during the 2-month early dry season period. The better growth of steers at the lower stocking rate in 2 of the 3 years (a difference of about 100 g/day), was probably due to improved diet selection options. The advantage of sown pastures over native pastures during this period was attributed to prolonged pasture growth, better retention of green leaf and a substantial presence of legumes.

The stocking rate of 2.1 steers/ha used in this work is considered to be commercially viable. We recognise that pasture production might be lower under commercial conditions, but there would be a trade-off between this lower pasture production and a reduction in grazing pressure by turning stock off at lighter weights than about 500 kg in this study. Grazing these pastures at the higher stocking rate had the added advantage of a higher proportion of sown grasses and legumes, and a reduced incidence of annual weeds.

Comparison of production options

A target market weight of 290–300 kg is common for cattle destined for the live cattle export market. The time required for cattle to reach the target is a central performance criterion for producers. Pasture systems used to support this market need to be robust over time and to provide flexibility within a year to allow for ad-hoc adjustments forced by the market. Year to year variations in the length and nature of the wet and dry seasons will affect pasture growth and quality and thus cattle growth rates and the time to turn-off, irrespective of what production system is used. There will also be considerable variability between and within drafts of cattle for initial weight and growth potential. This variability provides a mix of opportunities and problems for managers and consideration of the various options takes these issues into account.

Four hypothetical pasture options are compared using slight variations in data presented here, i.e. native pasture, native pasture–legume leys, sown pastures and a combination of sown pasture and legume ley. Ley pastures are grazed during the dry season, after animals have ceased growth on the native or sown pastures. It is assumed that weaner cattle of 150 kg (6–8 months old) are available in early May, and turn-off is at 290–300 kg. Hypothetical growth rates of steers grazing these pastures throughout the year are summarised in Table 5. These growth rates were determined after considering a range of information. The 3 years of the 2 studies reported here tended to have wet seasons which were shorter than average, resulting in lower than average annual liveweight gains. In addition, the legume content of the sown pastures was about 10% less than the long-term average (W. H. Winter unpublished data). Taking into account other data, particularly that of Winter (1989) from Katherine, and from Douglas–Daly to the north (D. Zuill unpublished data), annual gains of about 125 kg/steer are expected for leniently grazed native pastures and 120 kg/steer for sown pastures grazed at about 2 steers/ha for this class of cattle. Data on the production from the ley pastures reported here appears robust and consistent with other published data. The flow-on effects (of grazing ley pastures) during the subsequent transition and wet season periods are taken into account in the proposed scenarios in the absence of other such data.

We recognise that, in reality, a draft of weaner cattle with an average weight of 150 kg will contain a weight range of probably 125–175 kg, usually due to variable calving date. This variability will ultimately be reflected in the time to turn-off and the robustness, flexibility and attractiveness of the pasture system options. This is of particular importance for the live cattle market, as the acceptable variability of weight at sale of store cattle is less than that of purchase or supply of the weaners.

Mean annual liveweight gains from the systems are 124 kg for native pasture, 120 kg for sown pasture, 154 kg for ley–native pasture and 160 kg for ley–sown pasture. The growth patterns of cattle to reach the target weight for each pasture system are presented in Figure 2. The target weight of 290–300 (295) kg is shown, as are the 270 and 320 kg boundaries which reflect the anticipated 50 kg variability in starting weight.

On both native and improved pastures, cattle with an initial weight of 150 kg or more (50–60% of the draft) could reach the target weights after about 14 months, at the end of the early dry season. The remaining 40–50% would be in the weight range of 270–295 kg. Both of these options become less attractive when climatic variability is considered. As experienced in the

Table 5. Growth rates and annual production of steers grazing different pastures used for consideration of production options

Pasture system	Wet season (g/day)	Early dry season (g/day)	Main dry season (g/day)	Transition season (g/day)	Annual (kg)
Native pasture	875	300	0	–250	124
Sown pasture	930	500	–105	–500	120
Native pasture–ley pasture	810	300	450	–350	154
Sown–ley pasture	860	500	450	–600	160
Period (days)	135	70	100	60	365

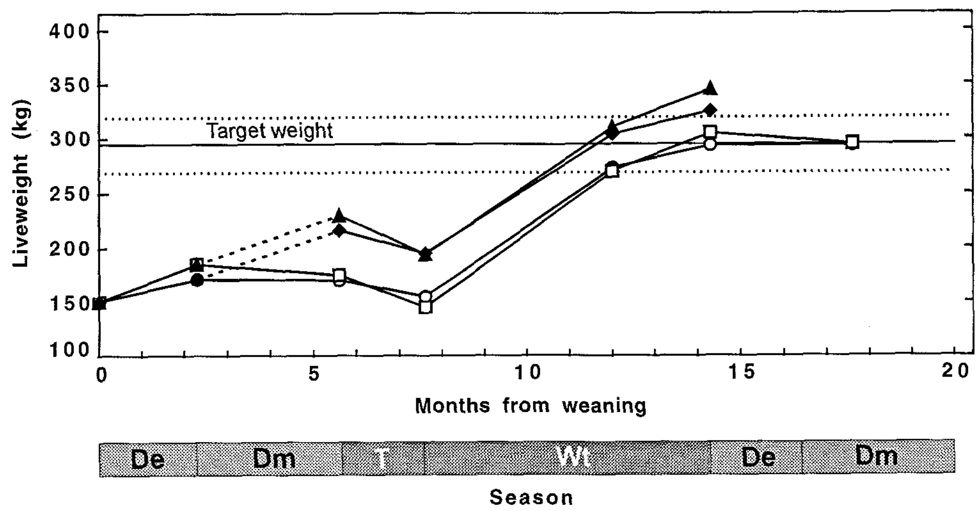

Figure 2. Hypothetical cumulative liveweight gains from May onward for weaner cattle of average weight (150 kg) when grazing native or permanent sown pastures alone or in combination with ley pastures (see Table 5 for data). The mean target weight of 295 kg is indicated along with a positive and negative spread of 25 kg which reflects the 50 kg variability in weaning weight.

experiments reported here, annual weight gains may be 20–30 kg less than average in possibly 3 in 10 years. On such occasions very few of the cattle might reach the target weight by July, presenting managers with difficult marketing and/or feeding decisions.

It is noteworthy that annual cattle growth on sown pastures is little different than that from native pastures. This proposition assumes: a difference of 10–15-fold in stocking rate; the sown pastures are well maintained with an appropriate fertiliser regime; cattle grazing sown pastures are supplemented with sodium; the native pastures are appropriately managed with fire; and cattle grazing native pastures are provided with appropriate supplements during the wet and dry seasons. More sophisticated sown pastures, such as those which include the shrub legume *Leucaena*, would give higher production, but less is known of their management requirements.

The combination of ley pastures with either native or sown pastures, appears to provide robust and flexible systems for graziers to meet market requirements and systems with fewer management problems. Using ley pastures, the time to turn-off could be reduced when compared with single pasture systems. Cattle of average and above-average starting weight could be available for sale within 11–12 months, March through April. The potential continued growth during the early dry season might provide a buffer to accommodate finishing the lighter steers in a draft and/or finishing more animals in below-average years.

This analysis indicates that grazing ley legumes in the dry season provides more flexible management options than single pasture systems. Ley pastures overcome the major limitation of both native and sown pastures—poor dry season performance. The weight loss experienced by cattle during this period is unlikely to be ameliorated by different pasture management practices. For instance, dry season performance of cattle grazing sown pastures left ungrazed during the wet season is not likely to be very different than presented here for continuously grazed pastures. Data from an associated experiment (W. H. Winter unpublished data), do not indicate that light grazing during the wet season results in better dry season cattle growth. In addition, sown pastures grazed lightly in the wet season tend to become very weedy with low quality annual grasses and forbs, to the exclusion of the perennial grasses, and sown and volunteer legumes.

A positive attribute of sown pastures is that, if current pasture management knowledge is well applied, they can be maintained for more than 10 years at relatively low cost. Thus, in making choices between systems, producers will need to compare the ease of management, lower year-round animal production and limited flexibility of an all-sown pasture system with the higher costs, risks and management requirements of a system which incorporates legume-dominant ley pastures. Integration of the 2 pasture systems appears to offer advantages of more rapid turn-off and greater management flexibility.

Naturally, if the market requirements change, or the initial weight changes and/or the transfer date to improved pastures changes, the combination of pasture types would vary.

Maintaining ley pastures

Maintenance of legume dominance in ley pastures is a major challenge. Within 2 years of establishment, important botanical shifts can occur (Table 2) that are detrimental to animal production in the dry season and to subsequent crop yields (McCown 1988; McCown *et al.* 1986). Accumulation of soil nitrogen under these ley pastures provides an ideal environment for the establishment and growth of a range of annual and perennial grasses and forbs. Unfortunately, their quality during the dry season is inferior to that of ley legumes, and cattle growth is reduced.

Traditionally, crops have been used to deplete the soil nitrogen and so provide better conditions for the establishment of legumes in the subsequent wet season. However, the appeal of the grain production appears to be declining in the region (McCown 1996). It is clear from discussions with farmers that this decline is due to the higher returns and lower risks of production of live cattle for export compared with coarse grain production. Farmers are now faced with the dilemma of how to maintain their legume-dominant ley pastures.

The substitution of gramineous forage crops for coarse grains in a legume ley system might be a feasible adaptation to these circumstances. In addition to increasing grazing options, forage crops would enable a further response to markets created by the live cattle export market by the production of hay. In addition, climate-based risks are greatly reduced because forage crops have a greater tolerance of climate-induced stress when compared with grain crops. Forage crops would adequately substitute for grain crops in creating a favourable soil environment for pasture legumes by depleting soil nitrogen and controlling weeds during the cropping phase.

The need for late flowering and high quality forage may be met by the modern dwarf forage millets, but to our knowledge this material has not been evaluated in the semi-arid tropics. Earlier studies with bulrush millet at Katherine produced liveweight gains of 580 g/day over 70 days when grazed from late March, 290 g/day from late April and 220 g/day when grazed from late May (Norman and Begg 1968; Norman and Phillips 1968). These gains are less than those reported here for sown pastures, but stocking rates were much higher (5 steers/ha). Higher growth rates might be achieved at lower stocking rates and the modern varieties may give higher growth rates, given that they were selected for forage quality attributes. Their contribution to finishing cattle at the end of the wet season, and to relieving pressure on the pastures in the forage systems, needs to be considered and compared with their value as hay sold for feeding cattle whilst in transit.

Conclusions

There is an opportunity for more intensive and efficient production of young cattle for live export in the Katherine–Douglas Basin through the strategic use of ley and sown pastures.

Suitable ley farming technology has been developed for much of Australia's semi-arid tropical croplands. Adoption of this technology was limited until there was a demand for high quality pasture to meet the needs of the live cattle export trade. However, maintenance of legume dominance in the ley pastures has become a problem with infrequent cropping.

Permanent sown grass–legume pastures are an alternative option to ley pastures, but the work reported here indicates that they provide less flexibility of operation than combinations of native or sown pasture with ley pastures.

We recommend that the ley farming system be retained, at least as a proportion of the operation. If necessary it should be modified, by the use of forage crops instead of grain crops, rather than be abandoned. A particular merit of ley farming is that the mix of livestock and crop production is more flexible in changing economic circumstances. Although economic returns from cattle are presently acceptable, it can be expected that the balance of commodity prices will vary over time.

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