TROPICAL PASTURES IN THE FARMING SYSTEM:

INTEGRATION OF CROPS AND PASTURES

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ABSTRACT

Efficient land use often requires some integration of crop and livestock production. Mixed farming has the advantage of income stabilization via risk spreading, and the capacity to use synergistic crop /pasture relationships to enhance or maintain productivity of the land resource.

While there are few examples of integrated crop /pasture systems in Northern Australia, the integration of crop and livestock production is a common practice in the beef/grain regions of Central and Southern Queensland. Integration mainly occurs through: discrete land use for crops and pastures but with integration of labour, capital and management; or alternate land use for cash crops and forage crops grown in some rotation through time. In areas of reliable winter rainfall the most frequently used forage crop for fattening beef cattle is oats but in tropical areas forage sorghum is the main crop. The expansion of grain cropping onto the more fertile pasture lands traditionally used to fatten cattle, and more stringent beef marketing requirements are likely to increase use of crops for beef production. A major threat to the long-term productivity of these cultivated lands is soil erosion.

Two ley systems appear worthy of further investigation for use in conjunction with cash crops. They are: (i) use of perennial forage crop grasses and legumes in leys lasting three to four years, and (ii) use of self regenerating annual leguminous ley pasture that is grown as a companion to annual cash crops and used in conjunction with zero tillage techniques for establishing the cash crop. These systems should reduce soil erosion, replenish soil nitrogen and give quality feed for grazing.

INTRODUCTION

Historically, most land in Australia's sub-tropics and tropics has been used for grazing, even though substantial areas are suitable for cropping (Weston et al. 1981; Williams et al. 1985). Often the arable land is interspersed with land suited only for grazing and thus an integrated approach to cropping and grazing is usually the most practical and efficient method of using the land resource.

In the sub-humid regions of Central and Southern Queensland the expansion of cropping on lands traditionally used for grazing has been rapid in recent years. For example, in Central Queensland the area of cereal and forage crop lands has expanded from 0.2 to 0.5 M ha in the period 1973/74 to 1982/83 (Australian Bureau Statistics agricultural census data; abbreviated later to ABS data). Approximately one third of the properties on the Central Highlands now derive a significant proportion of their income from both beef and grain (G. Spackman pers. comm., 1984 survey data). In many cases the integration of crops and pastures has been essential for profitable management of the land resource (Donovan 1984; Middleton 1984).

In North Queensland and the 'Top End' of the Northern Territory, very little of the potentially arable land within the extensive beef production regions has been developed for crop production, in spite of several notable attempts (Bauer 1985). However, the concept of integrating crops with beef production has both economic and ecological appeal as a form of intensifying land use in this zone.

This paper considers methods of integrating crop and livestock production systems and then gives emphasis to: (a) forage crop systems for beef production and factors causing change in forage crop usage, and (b) two research programmes which aim to determine the value of perennial forage crop and pasture legume leys in beef systems.

SYSTEMS FOR INTEGRATING CROP AND LIVESTOCK PRODUCTION

Relationships between co-existent crop and livestock production vary in degree of both economic and ecological inter-dependence. Leslie (1984) classified this spectrum of relationships into four farming systems. At one end of the spectrum cash crop and livestock production may utilize separate land areas within a property without rotation of those areas in time. The climate /soil /plant interactions of the two systems and the technologies for managing those interactions are discrete. Such systems were defined by Leslie as discrete land use systems. Integration within these systems is concerned with optimizing allocation of managerial, labour, financial and material resources between two spatially discrete but adjacent businesses. Risk spreading is a particularly useful aspect of discrete land use systems (Williams 1984), as is efficient use of labour.

Absolute separation of lands used for crops and livestock is rare, but is approached on many properties where intrusion of livestock onto cropping lands may be the occasional grazing of crop stubbles or fallow weeds. Intrusion of cultivation into pasture lands may be limited to ploughing for woody weed control or renovation of run-down pasture.

In other mixed enterprises, cultivated lands may be used partially for cash crop production and partially or wholly to produce annual fodders or forages for livestock such as forage oats and sorghums, Lablab and maize. These systems, defined as cash-crop / forage crop systems, may be extended with deliberate reliance on cash crop stubbles, e.g., grain sorghum. These systems introduce important climate /soil /plant /animal interactions such as those concerning conservation of soil moisture, soil nutrient cycling, and the timeliness of crop and livestock operations.

When agricultural lands are rotated between annual crops and sown pastures (or leys), the technology of soil fertility becomes a major consideration for crop and livestock integration. Such systems, termed ley systems, are common in the temperate sheep / wheat regions of

Australia (White *et al.* 1978) but there are very few examples (in area terms) in tropical Australia. In truth, there is probably more interest in ley systems for the tropics among agricultural scientists than among primary producers. An exception may be the use of purple pigeon grass (*Setaria incrassata*) sown with wheat to convert cropping land to grazing land. This practice has met with some success in southern Queensland (Scattini pers. comm.) and while seed supplies are limited, the present demand for seed by producers is much greater than supply.

Finally there are *intensive crop /livestock systems*, e.g. lot feeding of beef cattle, which are extreme cases of spatially discrete land use systems. These systems cover a diversity of sub-systems from the intensive feed year planning programmes used in the dairy industry to the occasional but important hand feeding / drought mitigation programmes used in the extensive beef and sheep industries of the semi-arid zone.

Crops and livestock are also integrated regionally where the spatial and temporal distributions of land use for crop and livestock production are related to land resource capabilities, infrastructure, land tenure, market forces and the weather.

FORAGE CROP SYSTEMS

Virtually all forage crops grown in Queensland are managed as annuals with oats and forage sorghum being the most commonly grown (Table 1). The area of land annually sown to forage crops (0.34 M ha) is about one tenth of the area in permanent improved pasture and one sixth of the total area annually sown to agricultural field crops. The main regions for forage cropping in Queensland are those where winter rainfall for oats production is reliable, and hence the proportion of land sown to forage decreases in a northerly direction (Table 1) as the reliability of winter rainfall decreases. The proportion of land sown to forage sorghum does not vary greatly among regions being 3 to 5 per cent of land sown to agricultural field crops.

TABLE 1
Mean areas (ha) of forage crops for statistical divisions of Queensland over the six year period 1977/78 to 1982/83 (ABS data)

Statistical division	Area of forage crop				Total field crops*	
	Oats	Forage sorghum	Other	Total	Area	Percent forage
Moreton	7257	2730	4269	14256	47987	30
Wide Bay / Burnett	15146	6343	6111	27599	158833	17
Darling Downs	144194	38294	39262	221750	1257171	18
South West	26714	7155	5624	39493	160464	25
Fitzroy	6813	20011	4009	30833	364465	8
Mackay	616	3224	682	4522	69016	7
North & Far North	506	1207	614	2326	25543	9
Central & N. West	3	114	20	137	306	45
Queensland total	201249	81414	58256	340919	2045649	17

* All agricultural crops excluding sugar cane, fruit and vegetables.

Beef production from forage crops

Liveweight gains of beef cattle on native pastures in tropical Australia are usually low during winter and spring; typically - 0.1 to +0.1 kg/hd/day compared with 0.4 to 0.8 kg/hd/day during summer and autumn (McCown et al. 1981). The main aim of crop fattening programmes is to finish cattle for market at an earlier age by using forage crops to maintain rapid liveweight gains until the end of winter. Frequently, cattle of 2.5 to 3.5 years of age are selected for this purpose, grazed for a period of 3 to 5 months on forage crop and then turned-off to market. This often reduces the age of turn-off by some 8 or 9 months. Increased carrying capacity and cash flow and reduced grazing pressure on other pastures are major factors motivating producers to use this system.

Crop fattening is an important feature of grazing management in southern Queensland. For example in the Maranoa region, where almost all forage crops are used for grazing beef cattle (Bourne 1980), there are approximately 136 ha of forage crop per 1000 adult beef animals turned-off (ABS data, 1977-83). About one beast in four is finished for market on crop or crop residues. The ratio is slightly less in Central Queensland but in this region the grazing of grain sorghum residues is of much greater importance and possibly of equal importance to forage crops.

Daily liveweight gains of cattle on winter oats are generally higher than can be expected from standover crops of forage sorghum grown in summer / autumn and grazed in winter (Table 2). While forage sorghum can be reliably grown during summer in sub-humid tropical areas, the low protein content and digestibility of standover sorghum often means that cattle do not gain weight at a rate fast enough to adequately finish for market (Rudder 1977). Winter liveweight gains of cattle grazing stand over forage crop legumes such as Lab-lab are only marginally better than gains from stand-over forage sorghum (Strachan 1968; Hendricksen 1980; Paull and Wildin 1980), and thus endeavours to find a suitable summer growing forage for winter grazing should continue.

TABLE 2
Liveweight gains of beef cattle on winter oats, stand-over forage sorghum and grain sorghum stubble in Central Queensland **

	Winter oats	Forage sorghum	Grain sorghum
No. of observations	24	8	5
Mean date start of grazing	4th June*	3rd May	22nd May
Duration of grazing (days)	98	150	136
Stocking rate (beast/ha)	2.1	2.2	1.0
Liveweight gain (kg/ha)	167	165	52
Liveweight gain (kg/hd)	80	74	53
Liveweight gain (kg/hd/day)	0.82	0.49	0.39

** Source : Rudder (1977). * Excludes three failures out of 24 attempts.

The capacity of forage crops to improve the finish of animals is an important issue in crop fattening programmes because of the premium market prices paid for well finished cattle. For example, long-term data from Cannon Hill show the price of 440 kg steers at fatscore 4 to be on average 3.8 c/kg higher than steers of equal weight at fatscore 3 (Williams 1984).

Table 3 shows gross margins for crop fattening with oats and stand-over forage sorghum based on the liveweight data given in Table 2, and assuming the cattle are reared on the same property. The two salient points of this table are: (i) crop fattening is very sensitive to market prices, and (ii) the gross margin from oats is likely to be far higher than from the sorghum because the higher daily weight gains of cattle on oats are likely to attract premium market prices. Since the gross margin of dryland grain crops in Central Queensland is typically $50 to $80 /ha (J. Turner, pers. comm.) forage cropping can thus be a viable economic alternative on mixed farms in the region.

The main disadvantages of forage oats in Central Queensland are: (i) the land is exposed to soil erosion because crop residues after grazing are minimal, and (ii) production is unreliable. The reliability of oats in Central Queensland was quantified by estimating a time series of oats production for a period of 89 years using long-term daily weather data from Emerald and the PROBE model of McKeon et al. (1986).

TABLE 3

Gross margins ($/ha) for crop fattening on oats and stand-over forage sorghum at three beef prices (c/kg) *

	oats	forage sorghum
	$/ha	
Crop Costs **		
Fuel, oil, repairs and maintenance	20.40	20.40
Seed (Oats at 30 kg/ha, Sorghum at 5 kg/ha)	15.00	12.10
Cattle Costs **		
Value of cattle at start of grazing (30 th May) (Assuming cattle weigh 400 kg/hd with a value of 90 c/kg and stocking as per Table 2.)	756.00	792.00
Interest on Cattle at 16 % per annum	32.48	52.08
Animal health and market costs at $10.50/hd	22.05	23.10
Total variable costs	845.93	899.68
Livestock Returns (assuming liveweight gains as per Table 2)		
When selling price = 85 c/kg then Gross return =	856.80	886.38
and Gross margin =	10.87	-13.30
When selling price = 90 c/kg then Gross return =	907.20	938.52
and Gross margin =	61.27	38.84
When selling price = 95 c/kg then Gross return =	957.60	990.66
and Gross margin =	111.67	90.98

* Reliability of cropping is not taken into account.
** June 1985 prices (J. Turner, pers. comm.)

The simulated time series showed crop failure in 26 per cent of years due to absence of planting rain, absence of rain for secondary root development, or insufficient forage growth to support grazing at 1 beast/ha for 100 days. Sufficient oats production was estimated for crop fattening at 1, 2 and 3 beasts/ha for 100 days in 21, 25 and 28 per cent of years respectively. In contrast, corresponding values at Brian Pastures in the Burnett region were found to be 16, 37 and 37 per cent with crop failure in only 10 per cent of years.

An advantage of crop fattening is the indirect effect of reduced grazing pressure on other pastures when a portion of the herd is drafted off to intensively graze the forage crop. Animals remaining on pasture have greater opportunity to select a higher quality diet. This benefit is often regarded as important by graziers but is difficult to quantify and often neglected in economic analyses. Simulation of beef production at Brian Pastures showed that when oats was used to finish three year old animals, the benefit to the remaining weaners and two year olds grazing native spear grass pasture was an additional liveweight gain of 5 to 20 kg/hd/yr depending on stocking rate (McKeon et al. 1986).

Factors causing change in forage crop usage

Forthcoming changes in both the the beef and grain industries are likely to have significant effects on forage cropping. The current rapid expansion of grain cropping onto the fertile pasture lands traditionally used for cattle fattening in Queensland is increasing the opportunities for and the relevance of forage cropping. An increasing number of properties are gaining the skills and machinery for forage cropping and at the same time becoming more reliant on crops for their cattle fattening programmes. If the expansion of cropping in Central Queensland continues at its expected rate of 12 per cent per annum over the next 15 years to 1.4 million ha (Burrows 1984) and the proportion of cropped land sown to forage continues at eight percent, then an estimated 119,000 ha of land will be sown to forage in Central Queensland by the year 2000. This area of crop would be sufficient to finish more than fifty per cent of the region's current mean annual cattle turn-off (422,000 head; ABS data 1977-83).

The Japanese beef export market has in the past required well finished steers and bullocks without restriction on the animal's age. The average liveweight of animals for this market from Queensland exceeds 550 kg with 72 per cent of animals older than 48 months (J.J.Daly, pers comm.). Production of such animals suits the native pasture grazing systems of central and northern Queensland. However, the Japanese, and possibly the Korean markets,may soon require younger animals of the same liveweight (J.J.Daly, pers comm). This requirement would undoubtedly increase the use of crop fattening.

LEY SYSTEMS

Soil erosion is a major threat to the long term productivity of cultivated lands in tropical Australia (Richards 1978; Murray 1980; and Nix 1980). The combination of high intensity summer storms, absence of plant cover, long slope lengths and easily erodible clay soils predispose the land to sheet, rill and gully erosion.

Two options appear worthy of investigation for use in conjunction with cash crops to reduce the susceptibility of land to soil erosion, replenish soil nitrogen for the cropping phase and provide quality feed for grazing. They are: (i) use of perennial forage crop grasses and legumes in leys lasting three to four years, and (ii) use of self regenerating annual leguminous ley pasture that is grown as a companion to annual cash crops. This later option when used in conjunction with zero tillage techniques for establishing the cash crop could be very suitable to monsoonal areas of Northern Australia where the lack of soil moisture for crop growth is not so critical.

Perennial forage crop leys

Small seeded pasture grasses such as *Cenchrus* spp are not only difficult to establish on the cracking clay soils that are frequently used for cash cropping (Leslie 1965), but also require twelve months to be ready for grazing. In contrast, ley pastures based on perennial forage crops can be readily established by conventional farming methods and machinery, and time delays in gaining economic returns are minimal because grazing may commence within 6 to 8 weeks of planting.

Perennial forage crops are potentially less costly than annual forages because planting costs are incurred only once every few years, however, the absence of annual cultivation also has the disadvantages of reducing soil nutrient cycling and conservation of soil moisture during summer. It is possible that the quality and annual dry matter production of perennial forage crop grasses can be maintained with either companion legume species or nitrogen fertilizer inputs equivalent to expenditure on cultivation for annual forage crops.

A key requirement of forage crop grasses is vigorous seed germination and seedling growth so that they can successfully establish when sown into moist soil after rain. While this generally requires a large seed, greater than say 4 mg, there are only a few perennial tropical grasses which meet this requirement. A current example is 'Silk' sorghum.

Perennial forage crops could also play an important role in the redevelopment of degraded pasture lands such as those found in the Brigalow region. Anderson *et al*. (1984) found that only 31 percent of Brigalow pastures in the Nebo and Broadsound shires were in good condition and that 42 per cent of pastures had serious woody regrowth problems. Improving the productivity of such pastures is costly. Cultivation and use of perennial forage crops oversown with small seeded permanent pastures species may well be a viable economic alternative.

Use of perennial forage crops for cattle production and control of soil erosion is a current research programme in Central Queensland. While Silk sorghum is the main species in the programme, research is also directed at alternatives to *Sorghum* spp. because of features which may conflict with cash cropping, such as sorghum being an alternate host for midge and sugar cane mosaic virus. *Pennisetum* is a genus with potential. While tropical legume genera such as *Dolichos*, *Macroptilium*, *Vigna* and *Phaseolus* do not persist in permanent pasture they may be useful companion species in short-term leys. Silk planted between wide rows of *Leucaena* is a potentially useful forage system.

Prospects for cash crop / pasture legume leys in Northern Australia

Northern Australia has the advantage of reliable and adequate rainfall for cropping but it also has a number of geographic disadvantages when compared to Southern and Central Queensland. Marketing costs are high, the infertile soils require high rates of fertilizer, and the monsoonal rains can be very damaging in terms of soil erosion.

A large proportion of agricultural research conducted in the North has sought to improve the dry season nutrition of cattle by using sown forages with results converging conclusively on the use of summer-grown legumes (Winter et al. 1985). These legumes either retain green leaf well into the dry season or shed dry leaf which is grazed from the ground. Commercial adoption of legume pastures has been slow.

Research to evaluate a system of integrating annual cash crops with extensive beef production in the Northern Territory began at Katherine in 1978 (McCown et al. 1985). This concept potentially offers synergistic alleviation of most of the above problems. The main features are: (i) use of self-regenerating legume leys of 1-3 years duration grown in rotation with maize or sorghum, (ii) cattle that graze native pastures during the green season and leguminous ley pastures and cash crop residues in the dry season, and (iii) cash crops that are planted directly into the ley pasture that has been chemically killed shortly before planting.

The above system was tested using two year leys alternating with one year of maize or sorghum (McCown et al. 1985). During the main dry season, steers on native pasture lost 0.07 kg/day while steers on legume leys and crop residues gained 0.45 kg/day. The cattle on native pastures all year gained an average of 93 kg/hd/yr while the cattle which grazed the ley system in the dry season and native pasture in the green season gained an average of 123 kg/hd/yr. Crop data from the experiment showed legume leys to greatly increase grain yields of subsequent maize and sorghum crops. The effect of a one or two year legume ley was equivalent to application of 40 to 80 kg/ha of nitrogen. Yields of maize were on average 20 per cent higher with no-till than with conventional tillage.

Benefits to both crop and livestock production from this system appear to be significant. The need to produce younger animals for the beef export market, and the need for more intensive stock management in Northern Australia's disease eradication programme could substantially increase the incentive of producers to adopt ley pasture systems.

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