BUFFEL GRASS *(Cenchrus ciliaris)* IN AUSTRALIA

by Richard G. Silcock

Introduction

The plant known as buffel grass in Australia is mostly *Cenchrus ciliaris* L. Around the Gulf of Carpentaria, *C. pennisetiformis* (Cloncurry buffel) is commonly called buffel grass also. The former is the same as Anjan grass in India and *Pennisetum ciliare* which Highight *et al.* (1991) studied cytologically. In Africa, other grasses, for example *Panicum maximum* are also called buffel grass. Despite being strongly apomictic, the material introduced to Australia from the Afro-Indian crescent is very variable. Buffel grass in Australia is now a valuable, naturalised pasture grass of similar value to crested wheatgrass *(Agropyron cristatum)* in USA rangelands or cocksfoot (*Dactylis glomerata* L.) in temperate climates.

History

The history of buffel's introduction into Australia is well documented by Humphreys (1967). The first types were low growing, dark purple seedheaded forms from the Afghanistan region that have become known as the West Australian cultivar. Other types were imported by Government agencies and pastoralists and disseminated from the early 1920s. Such activity has continued into the 1980s. The Gayndah cultivar comes from CPI 1848 introduced from Kenya in 1930. So popular has Gayndah been since the 1950s, that seed material from numerous channels, for example the USDA, has been tested throughout tropical Australia. The cultivar American can be traced to accession T4464 from Texas A. & M. University, USA in 1960.

Because the plant seeds freely and the seed is easy to harvest in small quantities, pastoralists have frequently exchanged seed to produce their own for further sowings. Hence the genetic makeup of many commercial sowings is doubtful and this deficiency is exacerbated by a lack of definitive descriptors or visible markers to identify most commercial cultivars.

Much of the buffel grass in Western Australia is the West Australian type which has spread naturally without clearing timber or cultivation. Elsewhere buffel was originally sown into cleared scrub or woodland, from where it spread naturally to adjacent roadsides, towns and paddocks. The big expansion in buffel planting began in the 1950s after Mr Stan Marriott and Mr Bede Rich achieved impressive results in a 500 mm rainfall environment of the Blackall district of Queensland (24°S). At this time, land development schemes were clearfelling large areas of *Acacia* shrublands, for example, 7.1 million hectares of brigalow (*A. harpophylla)* country and 1.4 million hectares of gidyea *(A. cambagei)* country in central Queensland. Although green panic *(Panicum maximum* var. *trichoglume)*, Rhodes grass *(Chloris gayana)*, blue panic *(P. antidotale)*, and *Sorghum almum* were commonly sown as a mixture with buffel after clearing and burning (Purcell 1964), buffel grass was often the only species to persist (Walker *et al.* 1987) after the first dry summer. Demand for better types resulted in a rapid release of cultivars in the early 1960s but these could sometimes not be differentiated from existing cultivars, for example Biloela is very similar to Nunbank and Boorara.

Photo 1. Buffel pasture plus bottle trees

No new cultivars have been released since then and there are now only 3 or 4 commercially available. The cultivars which have stood the test of time - Biloela, Gayndah, American and West Australian - are still widely sown wherever a persistent, drought-tolerant, tropical grass is needed. However, for such a widespread plant, not much seed is traded now because natural spread and persistence once established is so good.

In much of semi-arid subtropical Australia, buffel grass is the only recommended and commercially available pasture seed. It is now part of north Australia's national ethos, known to every resident in its region of adaptation. It frequently forms nearly monospecific pastures in blocks of thousands of hectares, interrupted only by shadelines or shapely bottle trees deliberately left by the clearing bulldozers. It dominates the footpaths of most country towns in inland Australia north of about 30°S.

Distribution

In general terms, buffel grass is found throughout sub-humid and semi arid Australia north of about 26°S (Coaldrake 1979). In areas of eastern Australia with summer rainfall it will grow as far as 30°S but it is rarely found where summer rains exceed about 900 mm except in strongly monsoonal parts of northern Australia. There it grows on red earths in the Douglas-Daly River area of the Northern Territory where the annual rainfall reaches 1200 mm (Map 1). It is not clear what limits its spread, but it seems to require regular dry winters, minimal prolonged leaf dampness in summer and it cannot compete with vigorous stands of grasses such as Rhodes and Sabi grass *(Urochloa mosambicensis).*

Edaphic needs of buffel

Buffel grass can grow in Australia at any time of year, provided rainfall and temperatures are sufficient. There is no daylength induced dormancy such as with big bluestem (*Andropogon gerardii),* nor a strong daylength or temperature control over flowering (Burt 1968). However, buffel tillers grow at a prostrate angle in winter if moisture is available (Silcock *et al.* 1988). Buffel leaf is killed by radiation frosts but plant crowns are unaffected by the winter conditions of semi-arid Australia – grass minimums of - 5 to -10°C just after dawn, rising to 20°C by midday. In this, it is similar to the common mulga mitchell grass *(Thyridolepis mitchelliana)* and others, except they can set seed from prostrate tillers in winter. It is, however, more winter active than curly mitchell grass *(Astrebla lappacea)*, kangaroo grass *(Themeda triandra)* and black speargrass *(Heteropogon contortus)* which are major native species in its area of adaptation. Summer growth of all these grasses is similar and driven by rainfall but flowering is daylength sensitive in *Themeda* and *Heteropogon*. In north-western New South Wales, buffel is less winter active than rough speargrass *(Stipa scabra)* but the latter is less summer active.

Soil needs

In areas where buffel is adapted climatically, it prefers loose surfaced soils of neutral to alkaline pH. It freely colonises sandy red earths, but has been widely sown on grey and brown alkaline, self-mulching clays cleared of *Acacia* shrubland. Establishment on such heavy soils was aided by an ash layer several centimetres thick after the pulled timber was burned. In the Blackall district, G.R. Lee (pers. comm.) tested the range of commercial cultivars on seven representative gidyea soils ranging from sandy loams to heavily gilgaied alkaline clays. Biloela buffel preferred the heavy clays whereas West Australian buffel grew best on the sandy soil. The buffels were more productive and persistent than Sabi grass. Where cultivation is feasible, buffel has been established on hard-setting neutral, red clay loams (Wilson 1964) but it rarely spreads or regenerates well there.

Most cultivars of buffel grass are quite tolerant of soil salinity (Graham and Humphreys 1970) but less so than *Cynodon dactylon*. Extensive areas of strip-mined coal overburden have been rehabilitated with buffel grass in central Queensland, as have large areas of degraded river frontage in the Ord River district of northern Western Australia and the Victoria River district in the Northern Territory. At Carnarvon, the southern limit of buffel's distribution in Western Australia, it grows prolifically on sand dunes, but will not colonise the clay pans between. Around Alice Springs, some 4200 square kilometres of land contains a significant amount of buffel grass amongst the native pastures (Phillips 1991). In southern Queensland it also colonises the deep sandy soils rather than loams and clays, provided they are not too acidic (Silcock and Smith 1984) or too low in available phosphate.

Map 1. Distribution of Buffel Grass in Australia

Buffel grass does not grow well on infertile, strongly acid red earths *(Triodia* hummock grasslands), very heavy self-mulching clays and soils subjected to periodic flooding, such as in the channel country of south-west Queensland. Where phosphate is added, buffel will grow well on a wide range of acid soils (Silcock, Smith and Warrell unpublished data) provided there is sufficient exchangeable calcium and exchangeable aluminium levels in the soil are low (Table 1). In practice, buffel grass soil adaption is controlled primarily by the pH, exchangeable calcium and available P level of the soil because this controls seedling regeneration.

All buffel pastures are subject to a rundown in growth after clearing or cultivation as the available soil nitrogen is tied up in organic matter. This effect is greater in the strongly rhizomatous types and more noticeable on the heavy clay soils. Rundown buffel grass can be renovated by severe cultivation (Graham *et al.* 1985).

A close relative of *Cenchrus ciliaris* - *C. pennisetiformis* (Cloncurry buffel) - has extensively colonised phosphate-rich alluvial soils of the river systems of the southern Gulf of Carpentaria (Hall 1978). In the Northern Territory, another close relative - *C. setiger* (Birdwood grass) especially the purple seedhead black Birdwood grass - is superior. *Cenchrus glaucus* looks similar to the Biloela cultivar of *C. ciliaris*, but has not been widely tested in Australia.

Forage role

Commercial Australian buffel cultivars can be grouped into three major types:

(1)tall, rhizomatous, blue-leafed types with straw-coloured ripe seed — Biloela, Nunbank, Molopo, Boorara, Lawes, Tarewinnebar

(2)mid-height, green leafed, weakly rhizomatous ones with purple seed — Gayndah and American

(3)short, non-rhizomatous green-leafed ones with deep purple seeds – West Australian.

However, there is a greater range of morpho-agronomic groups (O'Donnell and Smith unpublished; Nicholson *et al.* 1985; Pengelly *et al.* 1992). Every combination of leaf colour (green to blue) and seedhead colour (purple to pale) existed in 170 accessions (CPI 48164-48331) collected by B. Walker from Uganda (Plant Introduction Review 1969); a few resembled West Australian. A promising Ethiopian type (Q10077) has a distinctly zigzagged stem and short rhizomes. Most lines flower freely but some strongly rhizomatous types (CPI 51089-51097) received from South Africa would not flower readily in pots in Brisbane.

The robust, rhizomatous Biloela type (Humphrey's Type D) is used mostly for cattle grazing and is successful commercially only on clay soils. It can be a shy seeder if nitrogen is limiting. Biloela buffel colonises poorly on infertile soils, although it will establish on acid, mulga red earths (pH 4.5) if phosphate is applied at sowing. However, natural seedling regeneration is rare on these soils except on higher fertility patches under eucalypts (Christie 1975) and it often fails to set seed because soil moisture is exhausted rapidly by the bulk of leafy foliage. After the same rain on the same soils, shorter types such as Gayndah and Q10077 will set seed because they flower more rapidly and use less moisture to reach maturity (Silcock 1983).

The Gayndah type is the most ubiquitous buffel in Australia because it is less demanding edaphically, colonises loose disturbed soil easily and will persist under low rainfall conditions. It is found throughout western Queensland in the 450 – 550 mm rainfall zone and established best in the dust control zone around Alice Springs in the Northern Territory and near Katherine (Cameron and Austin 1988). At Alice Springs, strictly controlled grazing management and relatively high soil P levels have allowed buffel to naturalise in this much drier climate (MAR 250 mm).

The small West Australian type is found in the low rainfall extremities of buffels distribution in northern New South Wales, Northern Territory and Western Australia, where its low dry matter potential and free seeding habit make it better adapted.

Where buffel is well adapted, it is extremely resistant to heavy grazing. At Blackall in Queensland, it regenerated well when the grazing pressure was relaxed after three years from 10 sheep/ha to 1.25 sheep/ha for three years (Lee, Payne, and Orr, in press). In the same trial, buffel grass pasture could be grazed continuously (over 10 years) at 2.5 sheep/ha in an area where the original gidyea scrub could support only 1 dry sheep/15 ha. In buffel pastures developed from gidyea, few other herbaceous plants are found (Lee and Silcock 1970) and the impediment to long term pasture productivity is regrowth of the gidyea and bastard sandalwood *(Eremophila gilesii).*

Buffel management

Under Australian conditions, buffel is most useful when grazed heavily for short periods and then rested until another burst of growth occurs following good rain. Under this management, the pasture is leafy, of optimal digestibility and free of weeds. Surplus buffel grass is rarely harvested for hay in Australia (Cavaye 1990); instead it is either heavily grazed when green or stocked continuously but more leniently. The most common system of management where a property has only a small area of buffel, is to hold it ungrazed until shearing or mustering time. Then a large number of animals (up to 20 sheep/ha) will eat it out completely. This intensive grazing also controls woody weed regrowth.

Comparison with other perennial forages

Within its area of adaptation, buffel has few rivals in sown forages except on dark alkaline clay soils in Queensland. There perennial Silk sorghum (*S. halepense* x *S. rohxburghii)*, green panic, Bambatsi panic *(P. coloratum* var. *makarikariense)*, Rhodes grass, purple pigeon grass *(Setaria incrassata)* and lucerne or alfalfa *(Medicago sativa)* are sometimes sown. Only green panic and Rhodes grass have a comparable forage role. Silk sorghum and purple pigeon grass are relatively short-term pastures most suited to leys in a rotation. Lucerne provides top quality feed and is often sown with the grasses. However, it lasts only 2 - 4 years and yields much less bulk. Bambatsi is sown mostly in areas subjected to seasonal flooding or waterlogging, for example gilgaied clays, where buffel is less well adapted (Anderson 1974).

Green panic performs best on very friable, high-fertility soils and will generally not persist well where the annual rainfall drops below 600 mm. However, it is more palatable and nutritious than buffel and is grown in preference on such soils. The dry matter yield of green panic is similar to that of buffel and Rhodes grass pastures (Robbins and Bushell 1985). Rhodes grass - Pioneer, Katambora or Callide - has poorer drought tolerance than buffel, and is only slightly more palatable. However, it establishes faster and its stolons are better for soil conservation. Rhodes grass will also grow on a wider range of soils - more poorly drained, harder-setting - in coastal and subcoastal environments. In the higher rainfall, monsoonal climates of northern Australia Sabi grass tends to replace buffel grass in special pastures.

In the Northern Territory and Western Australia, purple-seeded Birdwood grass (*C. setiger*) often grows with buffel grass and outperforms it on more arid soils. Since Birdwood grass is so successful under these conditions, it is surprising that so little is growing in Queensland and New South Wales. Greater seasonality of rainfall and lack of frosts in the north may be involved.

Sowing buffel seed

One significant problem with buffel grass is its large, bristly seed (fascicle) which makes sowing through conventional combines difficult. Special rolling drum seeders have been designed to overcome these problems (Paull and Lee 1978; Sallaway 1978), but the bulk of the seed demands frequent reloading. Air seeders may overcome this problem, but they are expensive and used more by grain farmers than by pastoralists. A new seeder which can handle chaffy seeds well has been released recently in Queensland (Seabrook Seeder, Gayndah).

The problem of seed bulk is reduced where buffel is sown after blade ploughing or into clay pans dug up by pitters, as the rate of ground coverage is fairly low. The sowing rate here is also low (1 - 2 kg/ha), and the seed a minor component of the total cost ($40 - 60 per hectare).

Photo 2. Buffel drum seeder

Because the fluffy seed is a problem, especially for aerial sowing, ways to improve its flow have been tested. Methods included hammermilling (Humphreys 1958), coating (Norton 1969) and singeing the bristles (Pogue 1983). Hammermilling damages much of the seed kernels (caryopses) but also removes some dormancy from fresh seed. Singeing is difficult on a large scale because prior moistening of the seed is required to prevent complete combustion of the stream of seed. Some buffel seed is coated commercially in Australia (e.g. Heritage Seeds), but the extra cost is difficult to justify (Blacket and Thompson 1992). The coating enhances flowability of the seed and is advertised to contain nutrients and sometimes insect repellents. However, coating with nutrients is not cost effective, and unless the soil is low in available P, no phosphate response is likely (Silcock and Smith 1980).

Silcock and Smith (1982) showed the phosphate coatings greatly increased seedling growth rates in pots of infertile soils, but P coatings had virtually no effect when used in the field under natural rainfall. Presumably this was because the surface soil was damp for a much shorter period and the fertiliser was not available for long enough for the seedlings to benefit. In the Katherine district (MAR 800 mm), application of 125 kg/ha of superphosphate at sowing is recommended (Stockwell 1980) to aid establishment on acid red soils.

In summary, under field conditions on low fertility soils in semi-arid, subtropical Australia, establishment of surface sown buffel seed coated with phosphate is still restricted by the lack of available moisture. There may still be potential for this technology where the wet season is more reliable e.g. Katherine and where the seed is drilled at shallow depth in drier regions.

III Seed production systems

The buffel grass seed industry in tropical Australia is economically significant (195 tonnes in 1989/90

- Australian Bureau of Statistics Online Database). Because sown buffel grass pastures are usually monospecific, seed purity is rarely a problem and graziers can simply lock up a grazing paddock for two months after opportune rains and take off a seed crop (Paull and Lee 1978).

Photo 3. Primitive buffel seed harvester

Photo 4. Modern buffel seed harvester with auger and baling system

The method of harvest can be primitive using a seed beater, although more sophisticated machinery, based on headers or cotton pickers, with an auger feeding into a bale is now used by specialist seed growers (Phillips 1991). Merchants often purchase seed from graziers who have harvested seed surplus to their demands. The seed, as harvested, often contains a significant amount of stalk, but bicycle wheel filters, for example, the Walker buffel seed cleaner (Linnett 1986) effectively minimises such trash.

The greatest problem for the buffel seed industry is varietal purity as it is difficult to identify a cultivar with certainty. American and Gayndah buffel are easily confused, but as both cultivars are used in the same regions for the same purpose the consequences are of little concern to most graziers. Gayndah and American both have purple or red coloured seed, especially the American, and their basal bristles tend to curl outwards strongly compared to all other cultivars. The very dark purple seed of West Australian could be confused with American. The other cultivars have no such colouring in the fully ripened seed and the bristles of the fascicle are straight.

Ferguson *et al.* (1978) tried to separate the cultivars, even to the extent of using gel electrophoresis of seed proteins, but could not produce an unambiguous key. Experienced pasture agronomists are also usually reticent to make definitive identifications to a cultivar level.

Because most buffel seed is harvested opportunistically, no strong pasture management systems are used by growers. Buffel grass seeds most profusely in late summer, although it will seed in early summer with good October rainfall. Synchronisation of seeding is best if the sward has been heavily grazed or defoliated during a dry period, for example the previous spring or summer. Specialist seed producers will apply nitrogen fertiliser (40 - 80 kg N/ha) after a clearing cut or burn, and could apply 10 kg/ha P if the soil is infertile. The Molopo buffel cultivar has been shown to have a strong nitrogen demand for seed production (Cameron and Mullaly 1969).

Seed quality

There is no cultivar certification scheme for buffel grass in Australia. Minimal seed quality standards are prescribed and are fairly easily met by the industry. They are:

Min. purity	80%
Min. germination	20%(may be promoted in fresh seed by drying for 10 days at 40°C before testing)
Prescribed weeds	Nil%

Commercial seed commonly has 95 – 99% purity and 20 – 30% germination. However, hand harvested seed commonly attains 50 – 70% germination because, unlike many tropical grasses, buffel seed does not shatter readily before the whole head is ripe.

The only commercially significant pest is the buffel seedhead caterpillar (*Mampava rhodoneura*) which emerged as a problem in Queensland in 1980 (Swaine and Ironside 1983). It is the larva of a native moth and only troubles cultivars with a dense spikelet arrangement, such as Biloela. It is a problem only in the Central Highlands and Callide region and has not been recorded in the drier central west of Queensland around Blackall. Buffel is unaffected by root knot nematodes and scarab beetle larvae in contrast to *Bouteloua curtipendula* and *Dichanthium sericeum* which are often killed by them on sandy soils. A leaf spot (*Pyricularia grisea*) has been recorded on buffel in the Northern Territory but there is no evidence that it reduced production (Cameron and Austin 1988).

Nett yields of seed rarely exceed 100 kg/ha and are commonly 40 – 80 kg/ha from opportunistic harvests but the areas available are large. Seed yield per day is more important than yield/ha. However, the best machines, with 3.5 m fronts, will harvest 50 kg of seed/hour from dense stands (Ashley Adams, pers. comm.). Very little is known about the effect of soil type on seed yield and quality. Buffel cultivars flower freely on all soil types after summer rain. On acid red earths at Charleville, SW Queensland, seed quality of hand harvested seed is excellent, despite the species being only marginally adapted to the soil type.

Commercial seed is generally not stored in special environments. Seed is usually stored in jute-mesh chaff bags (holding 25 kg of seed) or woven polypropylene wool packs. The bags may be suspended from the rafters while the wool packs are stacked on concrete floors in large galvanised sheds. In inland Australia, the relative humidity in such storage is low, but temperatures high (20 – 40°C) most of the year. Seed, stored in this way keeps for several years. However, such seed can deteriorate rapidly in the humid conditions in a boat hold or on a wharf in the tropics (Hopkinson 1984).

Sowing buffel pastures

If purchased seed is to be sown immediately, it should be at least six months and preferably 12 months old so that it is no longer dormant. Seed should not be sown during the winter months as it will not germinate well if it does rain, and will probably be removed by seed harvesting ants. These ants can remove coated or partially buried seed, and can extract caryopses from bagged seed without removing the fascicles.

Viable buffel seed does not generally survive long in the field because it does not have strong innate dormancy and germinates readily on small falls of rain (Silcock and Smith 1991). Under a very dry climate at Alice Springs, seed can last a few years in the soil (Winkworth 1971), while near the coast the time is much shorter (Hacker 1989). Although stories abound about buffel seed emerging 5 – 7 years after sowing, the seed probably either blew in from adjacent headlands and roadways, or there was a scattering of plants present. On ash seedbeds, only 0.4 kg/ha of seed is needed to establish a fairly dense stand and that seed could come from a few dozen big spaced plants per hectare.

The effects of an ash seedbed can be dramatic for buffel establishment. The ash is alkaline and contains nutrients which are deficient in infertile acid soils. The fineness of the ash offsets the large ped size of heavy clay soils, but if over 2 cm deep the seedling can be desiccated easily during emergence because the ash has poor water holding capacity. It is common to find no buffel seedlings in deep ash in the first summer, but thereafter the ashy parts, for example burnt windrows, are the most productive parts of the pasture due to the extra nutrients.

An attempt to sow buffel grass seed through the dung of cattle failed (Dillon and Smith 1990). Buffel seed mixed with a molasses supplement did not pass through the animal undigested, whereas seed of Seca stylo often did.

Recommended management

A new buffel pasture should not be grazed until it has dropped ripe seed. It can then be grazed moderately heavily for a short period before being spelled until it has regrown well. In this way there would be seed for later regeneration and the plant crowns are much better developed, should a bad drought hit the young pasture.

IV Animal production

Buffel grass causes few animal management problems except with horses. Buffel grass is not highly palatable (Silcock 1990) and herbivores do not seek it avidly where there is a choice. The plant has quite high levels of water-soluble oxalates (Silcock and Smith 1980) and monogastrics, such as horses eating only buffel grass suffer osteodystrophia fibrosa.

This `big head' disease, is due to oxalates tying up blood calcium (Walthall and MacKenzie 1976) which is then compensated for by mobilisation of bone calcium. Initially horses suffer inflammation of the corona above the hoof and go lame, but if the high buffel diet continues, the hoof may be shed and the facial bones may soften and swell. In practice, the condition is rare because most horses are fed some lucerne chaff or oats which provide the required calcium, or they have access to other fodder.

A case of oxalate poisoning of sheep has been recorded in the Listowel Valley of central Queensland. The hungry sheep had only very lush, young buffel available (McKenzie *et al.* 1988) on a fertile clay soil after a drought. Similar oxalate poisoning has been recorded from nitrogen-fertilised setaria pastures (Seawright *et al.* 1970). It is possible that the unpalatability of buffel to kangaroos has partly contributed to its success in Australia. Sabi grass *(U. mosambicensis)* is palatable to kangaroos and new sowings are rapidly overgrazed. Sabi grass seed is also sought after by parrots whereas buffel seed is not.

Grazing trials

There have not been many grazing trials on buffel grass pastures in Australia, especially compared to native pastures. A major one was run with sheep near Blackall, central Queensland from 1967 to 1980. The results can be summarised as follows (Lee *et al.* in press). A commercial stand of Gayndah buffel sown in 1961 was stocked with ewes at either 1.25, 2.5, 5 and 10 sheep/hectare in 1967. Over the next five years, which were mostly dry (50 – 70% of mean rainfall) the optimal stocking rate was 2.5 sheep/hectare with standing dry matter yields reaching 3000 kg/ha in the lightly stocked paddock. The sheep ovulated normally despite buffel pastures being reputed locally to be poorer for breeding than native mitchell grasslands *(Astrebla* spp). Greasy wool cuts averaged 3.9 kg/ha at the optimal stocking rate and fibre diameter fluctuated between 19 and 23 micron, depending on time of year. Rotational grazing of some paddocks showed no benefit over continuous grazing at the same annual stocking rate (Orr *et al.* in press). The pastures maintained a very high (> 95%) dominance of the sown buffel at all stocking rates except the highest. They were considered to be stable at normal district stocking rates (1.25 sheep/hectare), being in excellent condition 21 years later in 1988 after being decommissioned and returned to commercial use in

1983.

Following summer rains, average daily liveweight gains were about 80 g per head per day. In all other aspects, the effect of stocking rate on production followed the model of Petersen *et al.* 1965; (Graham and Payne, 1973). These overgrazed paddocks were invaded by a native annual weed *(Flaveria australasica)* yet basal plant cover only fell from 6.3% to 3.5%. When the grazing pressure was reduced, the surviving butts regenerated well and, aided by windblown seed, the paddocks regenerated completely.

Another grazing trial compared the productivity of sheep on two buffel accessions (cv. Biloela and Q10077) on a fertilised acid red earth at Charleville against native pasture and the exotic grasses *Anthephora pubescens* (CPI 43713) and *Eragrostis curvula* (CPI 30374). *A. pubescens* failed to establish adequately because kangaroos selectively grazed its seedlings. At 1 sheep/1.25 ha under 485 mm rainfall environment, Biloela buffel produced the most wool followed by Q10077, CPI 30374 and native pasture (dominated by *Aristida jerichoensis).* The Eragrostis had declined after 5 - 7 years of continuous grazing, while Q10077 buffel from Ethiopia was also declining, but more slowly. Biloela buffel appeared fairly stable over the six year period. However, buffel had almost disappeared (replaced by *Aristida* spp.) in a paddock nearby that was periodically heavily grazed by sheep. Also, seedling recruitment for three accessions of buffel grass over 10 years (1975 - 85) only occurred where the poplar box trees were retained and on burnt windrows . At the same time, the native *T. mitchelliana* grew well, regenerated freely and thickened up under intermittent grazing on the acidic low fertility soil (pH in water 4.7, bicarb P 5 ppm, CEC 2.5 me%).

Data for cattle production on buffel grass pastures come from Robbins (1985), t'Mannetje and Jones (1990), Walker *et al.* (1987), and Burrows *et al.* (1987). On a fertile clay derived from basalt, Robbins (1985) found buffel to be as productive as most other tropical grasses in pastures of the same age.

Burrows *et al.* (1987) show that cattle production from buffel grass pastures on a duplex brigalow soil in central Queensland can benefit from augmentation by a legume. Few legumes will compete with buffel grass but Seca shrubby stylo *(Stylosanthes scabra cv.* Seca) survived and increased its proportion eventually. Pure Biloela buffel grass pasture produced 63 kg liveweight per hectare over summer whereas the inclusion of 25% legume in the adjacent pasture produced an additional 28 kg.

On a fertile brigalow soil, steers grazing pastures at stocking rates of 0.4, 0.7 and 1.4 animals per hectare gained less than those on green panic, but more than those on Rhodes grass at each stock rate (Walker *et al.* 1987). During the four year trial, summer weight gains averaged 650 g/day irrespective of forage availability. However in winter, available forage had a huge impact on animal performance which ranged from -70 g/ha/day to +240 g/ha/day.

At Narayen in the Burnett district of S.E. Queensland, t'Mannetje and Jones (1990) recorded an average of 117 kg live weight gain per year from buffel pastures on a fertilised red podzolic soil; this increased to 165 kg when Siratro *(Macroptilium atropurpureum)* was included in the pasture. Steers on native speargrass pasture produced only 78 kg/ha at a similar stocking rate. There was no advantage from rotational grazing.

Vigorous buffel grass pastures tend to have only a low percentage of other species and this probably limits the nutritional quality of the diet. Buffel is a fairly stemmy plant when mature and with the low leaf digestibility typical of tropical grasses. Attempts to select for higher leaf digestibility have not met with any success (J.B. Hacker pers. comm.). All buffel cultivars are frosted in winter and this causes a marked loss of feed value (t'Mannetje and Jones 1990). In some tropical areas, Seca stylo partially substitutes for this drop in winter quality, but Siratro cannot because it normally sheds its leaf in winter. In southern Queensland, buffel pastures on fertile soils often include temperate legumes such as lucerne (alfalfa), barrel medic *(Medicago truncatula)* or burr medic *(M. polymorpha).* With winter rainfall, the annual medics can provide a high quality diet to stock with the buffel grass contributing roughage. These medic/grass pastures are generally permanent and are included in a ley system of farming. The large buffel grass crowns break up only slowly after cultivation and hence make tillage difficult.

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Table 1.Effect of chemical properties of red soils in south west Queensland on seedling growth of Biloela buffel grass sown with or without a 23 mg coating of monosodium phosphate

Soil Identifier	pH (1:5 water)	CEC	Exch $Ca^{\#}$	Exch Acidity	% Al satn	Bicard P	Days to full expansion of 4 leaves	
		— mequiv/100 g —				p.p.m.	-P	+P
Angellala	5.0	1.1	0.4	0.5	39	6	37	18
Arabella	5.1	2.7	0.9	1.1	34	4	33	19
Augathella	5.4	4.7	3.2	0.1	1	5	30	20
Beechal	5.1	3.9	2.0	0.6	10	11	30	21
Boatman	5.4	3.7	2.3	0.2	3	4	38	20
Bowra	5.8	1.6	1.2	0.0	0	24	18	18
Charleville	5.5	2.2	0.7	0.7	30	5	55	22
Cheepie	5.0	2.9	1.0	0.9	26	6	36	20
Glenbar	4.9	1.5	0.1	0.7	41	3	70	28
Kalanoa	6.4	8.8	4.7	0.0	0	3	37	19
Kanalba	5.5	3.5	2.1	0.2	4	6	26	21
Langlo	5.7	3.9	2.3	0.0	0	5	27	18
Maryvale	5.0	2.0	0.7	0.6	20	8	34	20
Maxvale	5.3	4.7	2.3	0.7	11	19	25	19
Ravenscourt	5.5	5.3	3.1	0.2	2	19	24	20
Rhondavale	5.4	1.1	0.4	0.4	26	4	67	21
Rundalua	4.7	2.5	1.1	0.5	14	5	37	20
Turn Turn	5.2	2.9	0.9	1.0	29	11	32	20
Winbin	5.2	2.7	1.3	0.4	10	9	30	19
Wittenburra	6.2	9.2	4.6	0.0	0	9	25	19

n.s. = no significant effect of phosphate

LSD ($P < 0.05$) for leaf appearance data = 4.0