Bkl P13 WR Buffel Grasses (*Cenchrus ciliaris* L.) on Different Gidyea Soils

January 1963 to December 1970

Queensland Government

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Contents

List of figures

List of tables

Appendices

Summary

This project compared five different buffel grass (*Cenchrus ciliaris* L.) cultivars on four different gidyea soils in the Blackall district for their growth, nutritive value, palatability to sheep and persistence. The cultivars were American, Biloela, Gayndah, Nunbank and West Australian. Some informal comparisons were also made between these buffels and other pasture grasses commonly sown in nearby brigalow country. The information has been gathered in 2020 from surviving archival files and thus remains incomplete in some aspects. The results presented represent primarily what was known and published by the early 1970s rather than an interpretation in light of knowledge at the time of writing 50 years later. Replicated sowings were done in 30 x 30 link (36m^2) plots within a fenced area of about one third of an acre (0.14 ha) into existing West Australian buffel pastures without additional fertilizer after rotary hoeing in late January 1963. The neutral to alkaline soils were characterized in detail for the surface 0-2 (0-5cm) and 2-8 inch (5-20cm) layers.

Descriptive recordings were made of the establishment success in every plot and then of the palatability of each species to sheep, the heat and moisture stress tolerance of species and cultivars, and the general vigour of each sown line. Particularly detailed sampling was carried out over several years at one site to document the chemical composition of each buffel cultivar at three growth stages, pre-flowering, peak end-of-summer growth and late winter frosted material.

Biloela and Nunbank buffel cultivars were similar and grew the greatest bulk of herbage. The Gayndah and American cultivars grew slightly less material and were very similar to each other while the West Australian cultivar was smaller-statured, far less productive and less persistent. All buffel cultivars were frosted to a similar degree in winter and withstood summer drought conditions well, generally better than other species like panics and *Urochloa mosambicensis*. West Australian was the earliest to flower and Biloela and Nunbank were much later so that, if rainfall was very limited, they sometimes did not flower while the other three buffels did successfully.

The nutrient profile of all the buffels held no unusual proportions at any given growth stage with protein levels falling rapidly in the winter each year. However, protein levels of all cultivars were very good, 13-15% crude protein, in fresh summer growth. On these soils, calcium and phosphorus levels were more than adequate for ruminant health and good liveweight growth. Above-ground protein levels fell as stems elongated and still further as seed ripening progressed and that drop was often most evident in the early-flowering West Australian cultivar. Conversely, the late-flowering Biloela type would have constrained stem elongation later into summer and be less likely to show a rapid lowering of shoot protein because there was a smaller proportion of stem.

Soil sampling was limited after the first two years and thus was unable to detect any significant rundown of soil nutrients under the highly productive buffel pastures in the time under research. All the soils were naturally low in total nitrogen and organic carbon despite being derived from sediments that had fair mineral content and developing under a leguminous woodland recently.

Early 21st century observations of sown grass pastures in central western Queensland bear out the results of this early pasture species trial with West Australian buffel rarely seen, Biloela and Nunbank types uncommon and patchy while the Gayndah and American types are everywhere and completely dominant in commercial pastures. All the other grasses and legumes trialed still have no commercial role in western Queensland on gidyea and all other classes of country. On soils that are unsuited to buffel grasses, no other commercial sown pastures species are used to appreciable levels to this day. Where tree-clearing has been tried and dense woody regrowth has not returned, either galvanized

and other copper burrs are prominent in the pasture on saline soils, or Mitchell grass has steadily taken over on the edge of wooded downs, or wiregrasses and 'desert country' species have reclaimed the most acid, sandy soils on which buffel grass does not thrive.

Background

In the late 1950s, there was a great rush to clear gidyea scrubs in central western Queensland due to the availability of heavy machinery, the success of pasture development in similar brigalow country in higher rainfall country to the east, the low productivity per acre of gidyea scrubs and a cashed-up grazing community due to a combination of high wool prices and a run of good seasons. However, there was only limited research prior to the 1960s into what pastures or crops might be successfully grown after the gidyea scrub was cleared and what unexpected problems might arise. Gidyea had been shown not to root-sucker like brigalow and reasonable native pastures could take over (Purcell 1964) but preliminary studies showed that some sandier gidyea soils might require additions of fertilizer for nutritious pastures to grow (Edye *et al.* 1964).

Development of the brigalow country had enabled a small supply of seed of some promising pasture species to be commercially available, such as green panic (*Panicum maximum* var. *trichoglume*), buffel grass (*Cenchrus ciliaris*) and Rhodes grass (*Chloris gayana*), and buffel grass seed from Western Australia could be imported at acceptable prices (Northern Times 1954). Buffel grass was showing promise on cleared gidyea shrublands west of the Great Dividing Range (Qld Country Life 1954; Bisset 1963) but was not regarded as being as nutritious as green panic or Rhodes grass (Central Qld Herald 1956). Note, plant scientific names that were current at the time of this trial are used throughout this report but later name changes are provided in Appendix 2. Also, units of measurement current in the 1960s and used by the project team are retained and conversions provided in Appendix 3.

Nevertheless, knowledge of the best way to capitalize on the undoubted potential of the gidyea country was limited and evolving rapidly, largely through trial and error – and there had been some spectacular failures through unexpected woody regrowth, failure of seed to germinate and sowing of inappropriate pasture species (Purcell 1964). Although the Queensland Government Brigalow Land Development Scheme (Australian Government 2010) did not extend to gidyea country west of the range, great enthusiasm for similar development of gidyea scrub existed and, by 1964, over 500,000 acres were pulled in western Queensland (Purcell 1964). Buffel grass seed prices were as high as 10s. to 20s. per lb compared to 2s. to 6s. for common Rhodes grass and 10d./lb for *Sorghum almum* (Allen 1958; Marriott & Wilson 1962). Thus, there was scope for poorly adapted plants, such as Rhodes grass, to be sown by cash-strapped graziers when buffel was unavailable despite experience that in dry years Rhodes grass often died (Fox & Wilson 1959; Bisset 1964). What seed was available at an affordable price sometimes determined what was sown rather than the appropriateness of a cultivar.

Some grasses were regarded as better for sheep than cattle. The smaller-statured, fine-stemmed West Australian type was well-suited for sheep and came from sandy soils (The Land 1954) whereas the tall, robust Biloela and Molopo types grew well on heavy clays and did not hinder cattle movement. The Molopo type was proving far superior to the West Australian type at Trangie in NSW (Beverley Times 1958). Long term persistence was uncertain for all types in the gidyea country at that time (Grof 1957; QAJ 1961; Wilson 1962) but plants of the West Australian buffel type were said to last up to 15 years and to eliminate galvanised burr (Western Herald 1959). By 1963 most reports said this buffel variety was more nutritious than most native grasses (Adelaide Chronicle 1954; Western Herald 1959). It was also one of the most nutritious sub-tropical grasses tested at Gatton by Milford (1960).

Purcell's gidyea development survey in 1963-64 identified up to 20 different gidyea soil types, with varying degrees of pebble, based on texture, structure and colour with the most widespread types being brown to grey clays and clay-loams (Purcell 1964). He also found a wide variation in phosphorus levels in these soils and no consistent association with any other soil property. Soil acidity was likewise variable but lighter textured soils were generally more acidic. The carrying capacity of gidyea scrub was rated around 1 sheep per 10 or more acres compared to 1 to 3 acres for adjacent Mitchell grass downs. At those low stocking rates, the gidyea country carried the stock well and was used almost exclusively for wool-growing at the time (Purcell 1964). Both tall robust 'Biloela or Type D' buffels and shorter 'Gayndah types' were commonly sown but the small West Australian type was falling out of favour (Bisset 1964) after being commonly sown initially because it was the only affordable seed readily available.

Purcell saw the need for more objective information about the strengths and weaknesses of the range of buffel grass types being vigorously promoted in commercial circles. Seed was expensive and in short supply. The West Australian type was initially the most available at a moderate price but then had to be transported across from Western Australia at a significant added cost. Other types being grown in Queensland presented difficulties in their seed production (Loch 1999) due to the bulkiness of the seed, its rapid shedding once ripe, lack of certification of genetic origin (Hibberd 1958) and a general shortness of experience by seed producers in the commercial production of such seed ('t Mannetje 1984). Edye *et al.* (1964) had reported that the drought tolerance and ease of establishment of West Australian buffel was inferior to that of Gayndah and Biloela cultivars in sandy desert soils from the same region.

So funding was sought and received to conduct an objective comparison of seven of the most commonly promoted buffel grass varieties then available. At the last minute, sufficient seed of two varieties was not available, unstated but probably Molopo and Tarewinnabar, and gaps existed in the hoed-up plots. Hence four commonly sown tropical grasses, native Mitchell grass (*Astrebla* sp.) and three tropical legumes were opportunistically sown, some as mixtures. The legumes were included because a persistent legume component for any permanent pasture was perceived to be vital for their long-term productivity (Bisset 1963; Davies 1970). This modification also allowed a comparison to be made between the results for those species from gidyea as opposed to brigalow country.

The limited personal knowledge of the early implementation of this project by the compiler of this final report, means that many questions that current readers may pose about experimental details and their comparability to other studies will potentially not be fully addressed. Only what can be retrieved from government archives could be used in collating much of this report. Nonetheless, it is believed that a comprehensive final report of this work is still warranted to provide scientists with information that can assist future scientific endeavours, such as those regarding landscape and pasture stability changes or sudden disease incursions. Changes since the 1970s in taxonomic names for species mentioned are listed in Appendix 2 as are conversions in Appendix 3 from measurement units used at the time to those more commonly used in Australia in the 21st century.

The Experimental Project

This project was conducted by Queensland Government staff under Mr. Stan Marriott's guidance in an era of great expansion of research into tropical pastures and an increase in primary industries staffing. Dennis Purcell was appointed to Blackall to undertake pasture research in the gidyea areas and got this project underway. However, he was transferred in early 1965 and Graeme Lee did not replace him until July 1966. In the interim, staff from Charleville, such as Ian Beale, undertook some sampling duties. Lee was transferred out in 1968 but made itinerant visits to continue vital aspects of the project before Richard Silcock undertook some minimal surveillance of the sites during 1969 from his Charleville base. Then Gavin Graham was appointed to Blackall in early 1970 and continued some sampling before the project was officially terminated in 1971 when its primary objective was considered achieved, i.e. which buffels are best, along with data about their productivity, nutritive value and persistence being recorded compared to other potential sown species.

Sites

Arrangements were made to establish sites to compare 7 buffel grass varieties on 4 properties in the Blackall district. The gidyea soils on those places represented the major types found amongst the 20 gidyea soil variations identified by Purcell's survey that year (Purcell 1964). "Eastwood" site represented an extreme clay soil while "Evora" represented the most sandy soil type. All sites had an existing sown pasture of West Australian buffel grass and cover the range of texture types that Purcell had identified. They were —

1. "Eastwood" – 30 km south of Blackall; 24° 41.55' S, 145° 31.111' E
2. "Inverness" – 22 km south of Blackall; 24° 37.615' S, 145° 28.272' E
3. "The Scour" – 3.5 km NE of Blackall; 24° 24.063' S, 145° 29.254' E
4. "Evora" – 43.5 km N of Blackall; 24° 2.108' S, 145° 29.700' E

Soils

Soils at the sites ranged from clay to loamy sand. The "Evora" and "The Scour" sites were much sandier than the other two (Table 1) while the "Inverness" site was thought by Purcell to represent the most common type of gidyea soil in the region.

Table 1 *Physical properties of the soil's surface and 2-8 inches (5-20cm) depth layer at each site*

Site	Texture	% clay		% silt		% sand		Colour	
	Depth (in)	0-2"	2-8"	0-2"	2-8"	0-2"	2-8"	0-2"	2-8"
Eastwood	Clay	32	41	15	12	53	47	GB	GB
Inverness	Silty clay	29	42	19	12	52	46	B	B
The Scour	Silty clay-loam	9	13	8	7	83	80	rB	rB
Evora	Loamy sand	13	10	5	2	82	88	B	B

GB = Grey-Brown, B = Brown, rB = reddish brown

The "Inverness" site was slightly unusual by having a higher pH in the 2-8" layer while the other sites had a lower value in the subsurface. Other chemical parameters varied amongst the sites but all would be regarded as relatively fertile, benign soils but of low organic matter content (Table 2).

Table 2 Chemical properties of the surface soil at each site in February 1964

Site	Depth (ins)	pH (water)	P_2O_5* (BSES)	K me/ 100g	Total N (%)	NO_3-N (Morg.)	NH_4-N (Morg.)	Org C (W&B)	C/N ratio
Eastwood	0-2	7.4	86	1.00	0.09	M	L	0.80	8.9
Eastwood	2-8	7.0	36	0.55	0.06	L	L	0.59	9.8
Evora	0-2	6.8	246	0.35	0.07	M	VL	0.83	11.9
Evora	2-8	6.6	101	0.64	0.04	L	VL	0.50	12.5
Inverness	0-2	6.9	101	1.25	0.10	L	L	0.67	6.7
Inverness	2-8	7.1	55	0.64	0.08	M	L	0.69	8.6
The Scour	0-2	6.4	138	1.00	0.06	L	VL	0.57	9.5
The Scour	2-8	6.1	86	0.79	0.04	L	VL	0.36	9.0

* Bureau of Sugar Experiment Stations acid extraction technique. Colwell and bicarbonate assays for available phosphorus were not done.

Site Preparation and sowing

The existing pasture was rotary-hoed just before sowing in late January 1963 when the area was fairly dry. No details exist about how thoroughly this was done but the weak crown structure of West Australian buffel would suggest that removal of such competition should have been very effective, especially as very limited rain fell for several weeks afterwards. Such mechanical hoeing usually goes at least 3 inches deep and leaves the soil surface very uneven, especially on clayey soils. Notes say that the pastures contained a mix of buffel and native grasses. At “The Scour” the native grasses were identified as wiregrasses, bottlewasher grass, blackspear and chloris while galvanized burr also had a significant presence

The pasture seeds were broadcast (presumably by hand) but no comment was recorded about whether the ground was raked over afterwards to assist with seed burial in the rough surface. The seed was presumably in the normal state provided by commercial suppliers as no mention was made about further treatment before this initial sowing, such as scarification, hammermilling, pelleting or insecticide dusting. However, dusting with insecticide was undertaken at some subsequent resowings and any resown plots were only ‘grubbed’ with a mattock to produce new soil disturbance before broadcasting the new seed.

Sown Species

Inability to quickly acquire enough seed of all the buffel cultivars desired saw two (unnamed) omitted initially and substituted opportunistically with a range of other species, some including mixtures with the legumes Siratro (*Phaseolus atropurpureus*), Glycine (*Glycine javanica*) and Phasey bean (*Phaseolus lathyroides*) (Table 3). The latter was one of few that had shown real promise (Bisset 1963), despite being only weakly perennial, in drier parts of the developing sown brigalow country pastures (Wilson 1958; Russell & Coaldrake 1970). The 5 core buffel varieties sown were then American (or USA), Biloela, Gayndah, Nunbank and West Australian (or W.A.).

Note: The project records only ever talk of ‘glycine’ so the references to that plant in this report assume that it was *G. javanica* because that was its common name at the time (Murtagh and Wilson 1962) and it was being extensively tested at that time. Likewise, the records refer to urochloa and this report assumes that it was *U. mosambicensis* which was the commonest perennial used from that genus at the time.

Table 3 *Species and buffel cultivars sown initially and at later times and the number of sites and extent of replication used at sites.*

Buffel grasses	Other grasses	Grass/legume mixes
	Initial sowing	
American (A4)[#]	Urochloa (A2)	Bambatsi + Siratro (A1)
Biloela (A4)	Mitchell grass (A2)	Green panic + Glycine (A2)
Gayndah (A4)		Blue panic + phasey bean (A1)
Nunbank (A4)		
West Aust (A4)		
	Later sowings	
Molopo (M2)		
Tarewinnabar (M1)		
Lawes (M1)		
Q1004 (M1)		

[#] Codes in brackets A4 = 4 reps sown at all 4 sites, A2 = 2 reps at all sites, A1 = 1 rep at all sites, M2 = 2 reps at all sites except "Eastwood" & M1 = 1 rep at all sites except "Eastwood"

The substitute grasses sown were *U. mosambicensis* (sometimes known as Sabi grass for which a cultivar Nixon was subsequently registered, Barnard (1972), green panic (*Panicum maximum* var. *trichoglume* from which the cultivar Petrie was registered later), blue panic (*P. antidotale*), Bambatsi panic (*P. coloratum* var. *makarikariense* cv. Bambatsi) and the native Mitchell grass (*Astrebla* sp., most probably *A. lappacea*, curly Mitchell but might have included seed of *A. elymoides* – hoop Mitchell). The source of the Mitchell grass seed was not stated; it could have been from local sources or from the Moree district of northern NSW. The *U. mosambicensis* and green panic were sown in 2 plots at each site with the former as a pure stand while the green panic had glycine mixed with it. The variety of glycine used was not stated but would probably have been the Cooper cultivar which had been selected from more frost susceptible test sites. Bambatsi had Siratro mixed in with its seed and blue panic had Phasey bean mixed with it, both being sown in only 1 plot at each site. Mitchell grass appears to have been sown into two plots at each site without any other species (Table 3).

A common plot layout, as used at the "Evora" and "The Scour" sites is shown in Figure 1 below. A randomized block design with 4 blocks existed at all sites but the plot allocation within a block varied slightly amongst sites. There was apparently no border between adjacent plots or replicates.

Subsequently at three sites, some of the non-buffel plots that had not persisted well were resown with Molopo, Lawes, Tarewinnabar or Q1004 buffel cultivars in December 1964 and February 1965 after grubbing up the plots and raking over the broadcast seed which had been treated with Lindane to deter ant theft (Table 3). Q1004 is described by Humphreys (1967) as being similar to cv. Molopo. At "Eastwood", no additional buffel cultivars were sown but buffel plots that had a very poor initial establishment were resown to their initial cultivar in February 1965.

9	8	2	4	5	1	3
1	2	5	6	3	7	4
5	1	3	8	4	10	2
4	6	7	2	1	5	3

Figure 1 *Typical plot layout at each site. Each plot was 30 lk x 30 lk. Sown species code numbers are 1 - American, 2 - Biloela, 3 - Gayndah, 4 - West Aust, 5 - Nunbank, 6 - Urochloa, 7 - Green panic + glycine, 8 - Mitchell grass, 9 - Bambatsi + Siratro, 10 - Blue panic + Phasey bean.*

Sowing rate of the buffel grasses was equivalent to 3 lb/ac (3.3 kg/ha) but no rates have been recorded for the ancillary grasses or legumes. No information exists on whether the legume seed was scarified or inoculated with appropriate Rhizobia. No seed germinability tests appear to have been done prior to sowing to confirm that the seed was capable of achieving a good strike

Site Management

Each site was fenced off from the surrounding paddock by mesh fencing with a gate in the corner adjacent to the Bambatsi plot. The fenced area amounted to about one-third of an acre (0.14 ha) and was normally only opened to grazing once a year in winter after pasture yields had been recorded. In some cases, a trough of water was provided, and a group of sheep was locked inside the plot for 1-2 weeks to allow an assessment of the relative palatability of each species.

After sites had been grazed, notes were made of the state of the remaining plant crowns and the plots were then mowed off with a sickle bar autoscythe with the blades set as low to the ground as possible. This management system continued for several years but the surviving records are unclear about how consistently that grazing and subsequent mowing occurred in the years of the late 1960s.

Sampling and analysis procedures

Palatability and grazing preference

In November 1963, 4 rams that were accustomed to grazing buffel grass were locked into “The Scour” plot for 4 days and regular notes taken of their plant preference and the manner in which they grazed the buffel tussocks. From those observations, a system for collecting ‘Selected Samples’ of each cultivar was devised and used thereafter in the regular collection of samples for chemical analysis from all sites. A second similar assessment of grazing behavior was done at “The Scour” in May 1964.

Pasture harvests

Samples for plant chemical composition were taken fairly regularly in two ways, Selected Samples that tried to mimic what grazing sheep would harvest and Whole Plants harvested to ground level at the same time. Such samples were collected at three different stages of the annual pasture growth pattern:

- pre-flowering as growth resumed after rain following winter
- at seed ripening which usually occurs at peak pasture yield for that summer

- late winter when plants have been frosted and some flag has been lost.

The selectively harvested material from all replicates of a cultivar was bulked and sent as one sample for chemical analysis in the early years but later on, some were submitted separately and thus the results could be statistically analysed for any significant difference amongst the 5 buffel cultivars at a point in time. The whole plant samples were initially submitted in their entirety for the chemical laboratories to cut up or grind before taking subsamples for analysis. The analyses done changed slightly over the years with full proximate analysis (AOAC 1960; Ahmed *et al.* 2013) being done on two occasions in the first year. That method involves doing several separate analyses for Crude Fibre, Ash, Carbohydrate, Fats, Moisture content and possibly other nutrients such as Nitrogen, Phosphorus and Calcium (Ahmed *et al.* 2013). On most other occasions, analysis was for nitrogen and phosphorus content only, reported as Crude protein and P_2O_5 equivalent respectively.

Sampling for peak plot yield was done after the samples were taken for chemical composition and was done with a sickle bar autoscythe. A strip 16’ 6” (16 feet 6 inches) long and 3’ wide was cut 2’ in from the northern edge of each plot and bagged and then the same strip was re-mown in the opposite direction to catch & bag stems and foliage pushed over by the initial cut. The mower was set as low to the ground as possible. The strip mowed was moved steadily further south for subsequent harvests in later years. The harvested material from each plot was kept separate and air-dried over the next few weeks before weighing. In later years, a drying oven was available that allowed the air-dried material to be dried further to a standard oven dryness.

Subsamples of all harvested material were sent away for chemical analysis.

Lee’s annual report for 1966-67 provides the following information about samplings undertaken –

- **Inverness** – sampled in September 1966 for plant quality, and for DMY (Dry Matter Yield) and plant quality in March 1967.
- **Eastwood** – tried to harvest in August 1966 prior to new growth but mower broke down. Thus no clearing cut and no scheduled summer growth harvest was done in March 1967.
- **Scour** – plots mowed in August 1966 but very poor rainfall meant very little growth and so no harvest done in March 1967
- **Evora** – was sampled for DMY in March 1967

Soil sampling

An attempt to measure any changes in soil fertility that might occur under long term pasture growth compared to the fertility of the soil initially was started. It is recognized that the soils at the beginning of this project were possibly already somewhat different from that which had existed under the virgin gidyea scrub. Ash from burning the pulled scrub could potentially elevate levels of some nutrients while exposure to more strong sunlight may alter surface soil ped structure. There was no record of whether the sites had been burnt before being sown to West Australian buffel initially or how many years beforehand that had happened.

An initial set of bulked soil analyses were taken to characterize the 4 sites physically and chemically in February 1964 for 0-2” and 2-8” depths. Then another sampling was done in December 1964 where a separate sample was taken and analysed separately from each buffel plot. “Eastwood” was missed in December and the equivalent set of samples was taken in May 1965. Each time pH, available P, exchangeable K and Morgan Nitrate & Ammonium were determined while the initial characterization also included total Nitrogen, organic carbon and C/N ratio. Morgan ratings range from VL (Very Low) through L, ML, M, MH to H (High) based on protocols then current in the DPI Agricultural Chemical Laboratories (Crack & Isbell 1970; Rayment & Warrell 1971).

Results

Rainfall

No comprehensive rainfall data is available from the sites and homestead records in the file archive are scattered and minimal. Hence the synthetic rainfall data available from the Long Paddock website (SILO 2019) has been consulted and summarized in Appendix 1 as an objective comparison for the 4 sites over the years. A summary of that information is shown in Table 4 below.

Table 4 *Trial sites mean rainfall for the summers (deciles), winters (relatively) and calendar years (mm and deciles) derived from Bureau of Meteorology synthetic data (SILO 2019).*

Sequence	Summer (deciles)	Winter	Year (mm)	Year (deciles)
First (1963)	9	poor	792	9
Second	2	fair	377	3
Third	2	v poor	301	3
Fourth (1966)	7	good	386	3
Fifth	1	poor	306	2
Sixth	4	fair	341	2
Seventh	1	v poor	263	1
Eighth (1970)	3	poor	385	3

Table 5 *Monthly rainfall (points) at the homestead associated with each of the 4 trial sites from June 1966 to May 1967.*

Month	Eastwood		Evora		Inverness		The Scour	
	Rain	Falls	Rain	Falls	Rain	Falls	Rain	Falls
Jun 1966	0		58	1	0		73	2
Jul	0		0		0		1	1
Aug	413	8	365	8	253	7	467	9
Sep	75	2	105	1	184	3	76	2
Oct	75	1	35	1	0		41	1
Nov	171	3	92	2	50	1	180	5
Dec	0		0		0		7	1
Jan 1967	73	3	0		0		30	6
Feb	256	4	118	3	299	3	296	6
Mar	159	4	115	4	121	3	126	6
Apr	0		0		0		0	
May	0		0		0		6	3

There is a comprehensive set of monthly rainfall from the homestead associated with each site that was compiled by Lee in 1967 (Table 5). It illustrates the differences that occur amongst locations in the same region under the influence of broad weather and local meteorological events each year. Some months receive no rain anywhere, others have scattered showers or storms that are only received at some places while at other times good, general rains fall everywhere.

Table 5 illustrates how excellent rain fell everywhere in August-September 1966 and February-March 1967 but how dry April-May 1967 was everywhere. Conversely, “The Scour” and “Evora” received useful rain in June 1966 while "Inverness" and Eastwood", both well south of Blackall, received nothing that month.

Plant establishment

The results and conclusions drawn from this study were very dependent on achieving successful establishment of replicate plots of each cultivar at all sites. This was achieved for the buffel grasses, green panic and *U. mosambicensis* at most sites (Table 6). Because establishment was not very successful for some species there is the possibility that the seed was of poor quality or not suitable for sowing at that time, e.g. dormant (Humphreys 1958). No information was provided to allow such a judgement to be made in hindsight. It is also assumed that broadcast seed was trapped and lightly buried by wind and the small showers that followed. The stated sowing rate of 3 lb/ac for the grasses (and presumably for the legumes) would be more than adequate to establish a dense stand of those grasses after good rainfall and an adequate population of the legumes within the mixtures sown, if seed was of reasonably good quality. However, experience has shown that scarified legume seed and dehulled grass seed often fails to produce successful establishment in western Queensland (Edye *et al.* 1964; Silcock & Johnston 1993) because that seed germinates on limited rainfall and the tiny seedlings die if there is not good follow-up rain soon afterwards.

Table 6 *Initial establishment success ratings in July 1963 of the cultivars sown in late January at the 4 sites. Nil = No plants, P = Poor strike, F = Fair strike, G = Good to Excellent strike of plants*

	Trial site			
Sown cultivar	Eastwood	Evora	Inverness	The Scour
American buffel	4 Good plots	3 G, 1P	4 Good	3 G, 1 F
Biloela buffel	4 Good	4 Good	4 Good	4 Good
Gayndah buffel	1 G, 1F, 2 P	3 G, 1 F	1 G, 3 F	1 G, 2 F, 1 P
Nunbank buffel	4 Good	4 Good	3 G, 1 F	4 Good
W.A. buffel	1 G, 2 F, 1 P	3 G, 1F	4 Good	1 G, 2 F, 1P
Bambatsi panic #	Good	Good	Good	Very good
Blue panic #	Poor	Poor	Good	Poor
Green panic #	1 F, 1 P	Good	1 G, 1 P	Poor
U. mosambicensis	Fair	Good	Good	1 G, 1 F
Glycine	Nil	Nil	1 G, 1 P	Nil
Phasey bean	Nil	Poor	Good	Poor
Siratro	Nil	Poor	Nil	Nil
Mitchell grass	Poor	1 F, 1 Nil	Fair	1 G, 1 P

Only 1 plot of Bambatsi & Blue panic mixes, 2 reps of Green panic mix, Urochloa & Mitchell grass

There is no indication that the seed of the buffel grasses was dehulled nor that of the other grasses and the normal state of their seeds for sowing is with much of the protective outer husks intact. Scarification of legume seeds was normally practiced at the time, so it is possible that they were and thus their poor establishment results may be due to germination in February after small falls of rain (e.g. 10mm on 3-4 Feb) and failure of the seedlings to survive in the baked summer soil until the really good rains began on 9th March. Then between 380 and 435 mm fell around the sites in about a dozen falls over 3 weeks to provide excellent establishment conditions for germinable seeds. Another possibility is that the seed of the panics and *U. mosambicensis* was new and still partly dormant

(Gillard 1971; Hopkinson & English 2004) and not ready to germinate when sown. However, the 5-6 weeks exposure in the field to heat and small showers of rain before the good March rains occurred would very likely have broken much of any such dormancy in all grasses (Adkins *et al.* 2002; Silcock pers comm.). Selective theft by birds and ants immediately after sowing cannot be ruled out either.

In the case of plots that were re-cultivated the next year and resown to either the same cultivar or to other cultivars that had created recent interest, such as Lawes, Tarewinnabar and Q1004 buffel, few records of establishment success appear to have been made. At "The Scour" a dense seedling population arose but records say plants were small, yellow and struggling in August 1965.

Buffel cultivar characteristics

Biloela and Nunbank had characteristically bluish foliage and long leaves while the others had green leaves that readily developed reddish hues with age or moisture stress. Leaves of West Australian were green and shorter than all the others. Culms of Biloela and Nunbank were very sturdy and held almost erect, those of West Australian were quite fine, with Gayndah and American culms in-between but with very sturdy bases. In winter, if moisture was available and temperatures mild, new shoots of Gayndah would often grow almost prostrate. American also did this sometimes but not West Australian or the other two types.

Young seed-heads of West Australian were a dark purplish red which was retained until almost completely ripe. Gayndah and American also had pinkish red young seed-heads but that changed to fawn as they ripened, especially in the Gayndah cultivar. Biloela and Nunbank had identical seed-heads that emerged as either pale pink or fawn and ripened to a pale fawn colour. Their seed-head was also much more compact than that of the other three.

Plant Chemical composition

The airdried samples that were sent to Brisbane labs for analysis generally contained 8 to 10% moisture with no obvious hierarchy amongst the cultivars of buffel.

Crude protein content in all cultivars declined in mid-winter and rose in the summer growing season. However, there was no consistent relativity amongst the 5 buffel varieties and by 1970 negligible amounts of the West Australian strain persisted at the "Inverness" site which was the most consistent source of such samples (Figures 2 & 4). When included in these samples, *U. mosambicensis* had amongst the highest level of crude protein (3 samples) and Blue panic was outstanding in May 1965 with 20% from a single, May post-flowering stage. The buffel cultivars often reached about 12% crude protein at the pre-flowering stage if sufficient rain was received but all species fell to sub-maintenance levels (<7%) for animal growth in mid-winter if frosted (July 1969) and in summer drought times (March 1967).

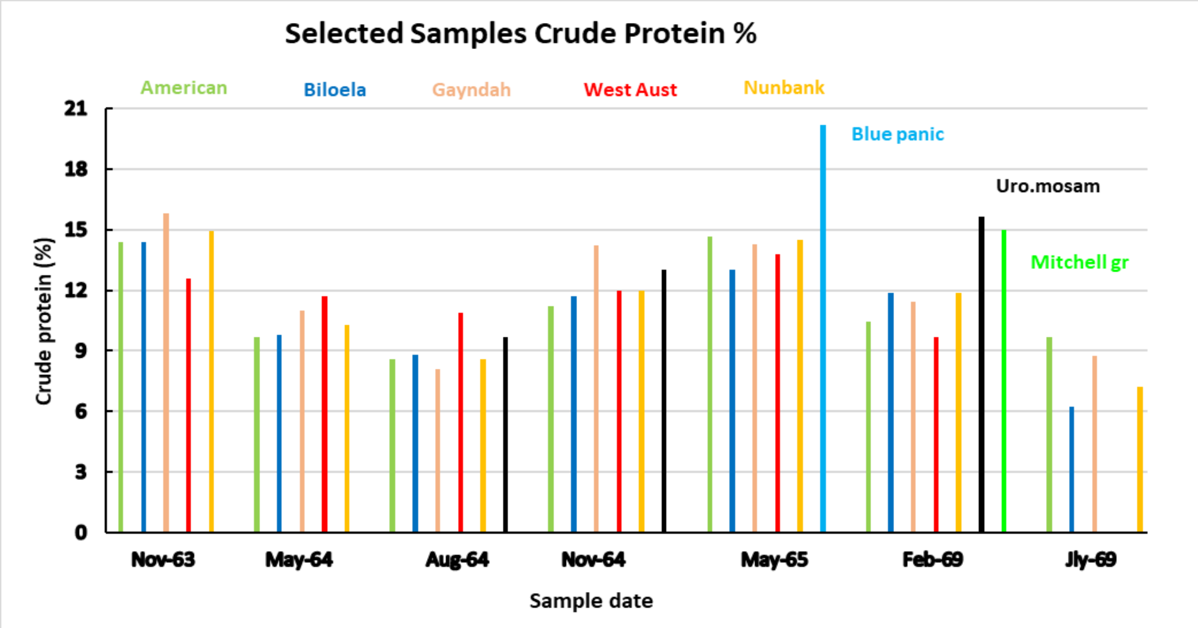

Figure 2 *Crude protein content at the "Inverness" site of the Selected foliage parts at different times for the 5 buffels plus* Urochloa mosambicensis, *blue panic and Mitchell grass.*

The buffel with the highest crude protein content varied with sampling date although it was rarely Biloela and the buffels were regularly lower than *U. mosambicensis* and the *Panicum* species (Figure 2) when harvested at the same time. On the one occasion when Mitchell grass was sampled (February 1969), its Selected leafy foliage and upper shoots had a much higher protein content than the equivalent parts of the buffels at the time.

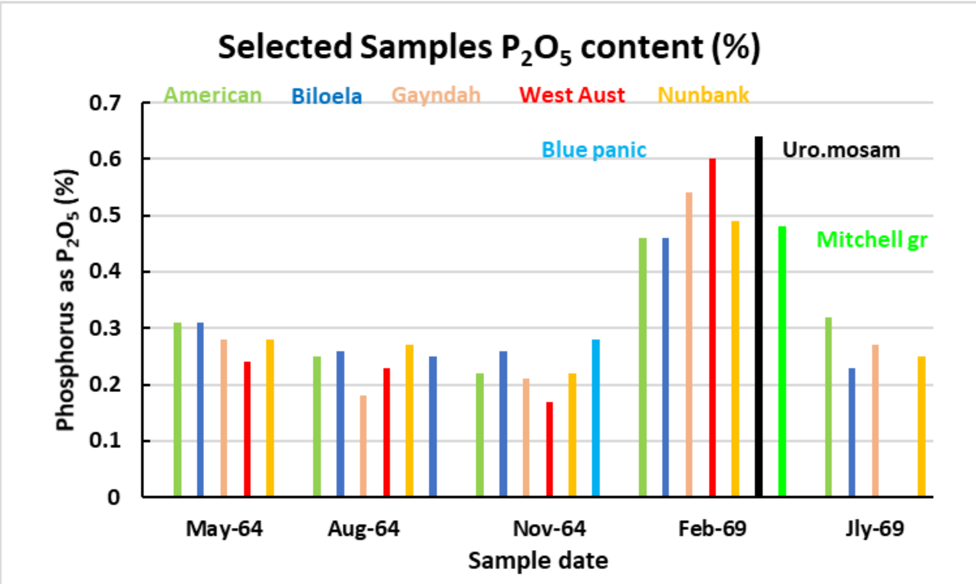

Figure 3 *Phosphorus content at the "Inverness" site of the Selected Samples, expressed as % P_2O_5, at 5 different times plus single recordings for* U. mosambicensis, *blue panic and Mitchell grass.*

Phosphorus levels were far less variable at different times of the year, and again there was no consistent pattern of difference amongst the 5 buffel varieties. However, P levels of Biloela and Nunbank did fall to a much lower level in July 1969 in the midst of a protracted dry period after a poor summer (Figures 3 & 5). The phosphorus levels were normally more than adequate for healthy animal growth and tended to trend in a similar way seasonally as the crude protein. However, there was only a weak (r = 0.34) correlation between crude protein and plant phosphate level changes for both the Selected Samples and the Whole Plant harvests at "Inverness" (See Figure 6).

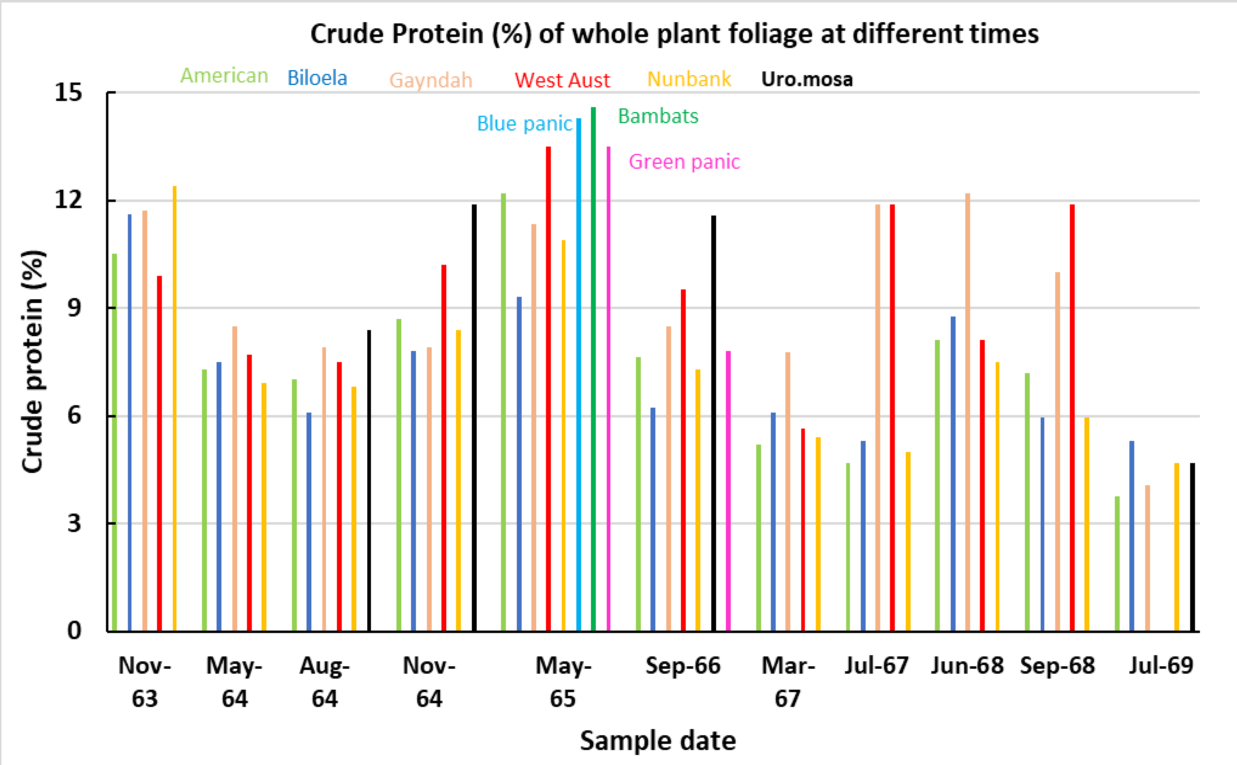

Figure 4 *Mean crude protein content (% of DM) of Whole Plants of all main sown grass cultivars when harvested at various dates at the "Inverness" site. n = 11 for the buffel means.*

Because samples taken from each replicate were often bulked before being sent away for chemical analysis, few statistical tests could be done on these data for differences between cultivars. However, it was possible from multiple samples on a few occasions, September 1966, March 1967 and February 1969. ANOVA tests on the Nitrogen and Phosphorus content amongst all buffels from the September 1966 and March 1967 harvests found no statistically significant differences ($P<0.05$) amongst the cultivar means on both occasions. When averaged over all sampling dates, few appreciable differences emerge (Table 7).

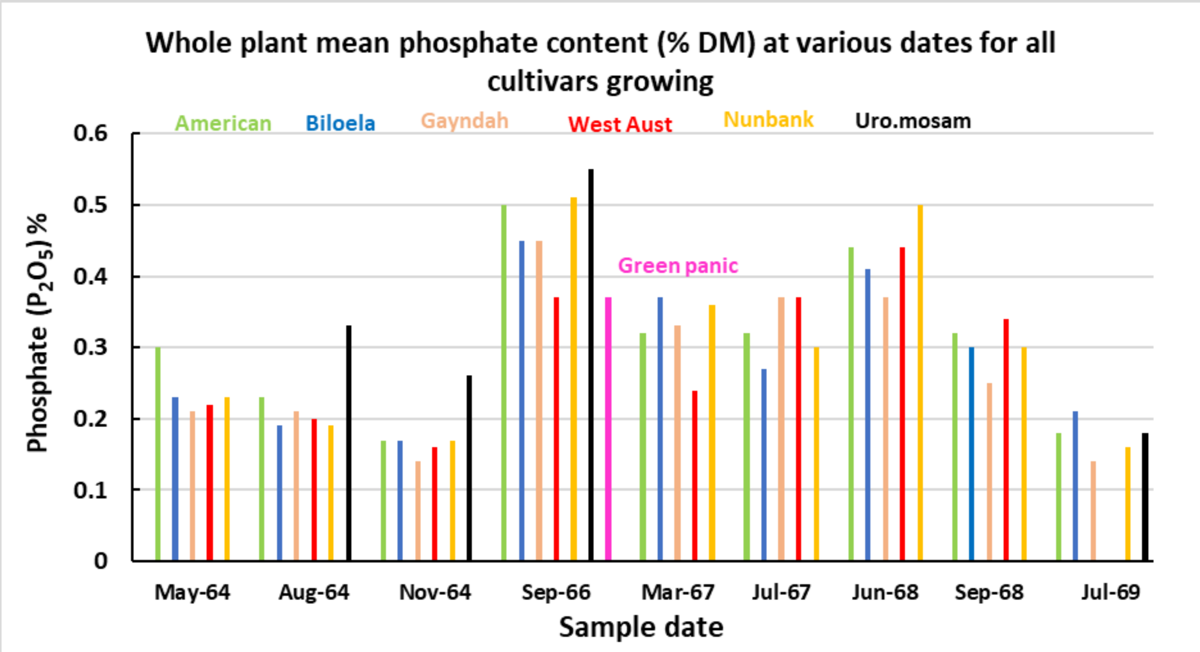

***Figure 5** Mean Phosphate content (as % P_2O_5 in DM) of whole plants when harvested at various dates from the "Inverness" site. n = 11 for the buffel means.*

When the individual samples were taken of non-buffel cultivars, the protein and phosphorus levels of the buffels was generally lower than in the alternative species, except green panic (Table 7). The difference was most marked for phosphorus content of *U. mosambicensis*. Also, the difference between the selected samples and the whole plants was not as great for *U. mosambicensis* as it was for the buffel grasses. At the same date in May 1965 after good late summer rain, crude protein levels in the 3 panic species post-flowering was greater than that of the buffel grasses, 14.1% versus 11.4% (Table 8) but the use of bulked samples precludes the assignment of statistical significance.

***Table 7** Mean crude protein (%) and phosphorus (as % P_2O_5) from numerous dates for samples of buffel grass Selected leafy parts and Whole plants at the "Inverness" site, plus similar data from fewer samples of other grasses sown at the site.*

		Selected leafy samples		Whole plants	
		Cr Prot (%)	P_2O_5 (%)	Cr Prot (%)	P_2O_5(%)
Cultivar	Samples	n = 7	n = 7	n = 11	n = 11
American		11.2	0.22	7.5	0.18
Biloela		10.8	0.23	7.3	0.16
Gayndah		11.9	0.21	9.2	0.15
West Aust		11.8	0.23	9.6	0.17
Nunbank		11.3	0.22	7.4	0.17
Uro.mosam †		12.8	0.27	9.1	0.23
Blue panic #		20.2		14.3	
Bambatsi #				14.6	
Green panic #				10.7	0.16
Mitchell gr #		15.0	0.21		

Single sample † 4 samples

Table 8 *Crude protein and phosphorus (as P_2O_5 %) of ancillary grasses compared to the mean of the 5 buffel grasses at the "Inverness" site at various dates.*

		Selected leafy sample		Whole plant	
Date	Species	Cr Protein	P_2O_5	Cr Protein	P_2O_5
4 dates	Uro.mosam	9.7	0.25	8.4	0.33
	Buffels	9.0	0.24	7.1	0.20
27/5/1965	Blue panic	20.2		14.3	
	Buffels	14.0			
27/5/1965	Bambatsi			14.6	
	Green panic			13.5	
	Buffels			11.4	
29/9/1966	Green panic			7.8	0.16
	Buffels			7.8	0.20
22/2/1969	Mitchell gr	15.0	0.21		
	Buffels	11.1	0.22		

The other feature is the regular high N and P ranking by West Australian buffel when it was included. Unfortunately, by 1969 it had almost disappeared from the "Inverness" site and was a poorer performer at the other sites than the other more robust cultivars.

Over all the samplings of whole plants at "Inverness" (n=11), the average for the 5 buffel varieties for crude protein and phosphate was respectively –

American	7.5%	and	0.18%
Biloela	7.3%	and	0.16%
Gayndah	9.2%	and	0.15%
Nunbank	7.4%	and	0.17%
West Australian	9.6%	and	0.17%.

The only plant composition analyses available from the other sites come from "Evora" and "The Scour" in winter 1968 (Table 9). At that time, buffel grass at "Evora" had significantly less ($P<0.01$) crude protein than at "Inverness" but not "The Scour" while the "Inverness" site buffel plants were non-significantly better than those at "The Scour". The protein content of the West Australian buffel sample from "Evora" was appreciably higher than the others for some reason. By comparison, the protein content of Gayndah was much higher at "Inverness" than that of the others yet its phosphate content at the same time was the lowest. Unfortunately, the data do not say what part of the plants was sampled but it would appear to be from whole plants. At "The Scour" and "Inverness" much greater variability existed amongst the buffels at that time. This could be related to the degree of flowering or new growth or frosting that may have differed amongst the 3 sites in mid-winter.

Phosphate content was quite good for all buffels at all sites with overlap in the range of values (Table 9).

Table 9 *Crude protein (%) and phosphorus (as P_2O_5 %) content of the buffel cultivars in the 1968 winter at "Evora", "Inverness" and "The Scour" sites*

Buffel cultivar	Evora	13/7/1968	Inverness	7/6/1968	The Scour	6/6/1968
	Crude protein (%)	Phosph. as P_2O_5 (%)	Crude protein (%)	Phosph. as P_2O_5 (%)	Crude protein (%)	Phosph. as P_2O_5 (%)
American	4.1	0.48	8.1	0.44	6.6	0.48
Biloela	4.7	0.46	8.8	0.41	8.4	0.41
Gayndah	4.7	0.39	12.2	0.37	6.3	0.50
Nunbank	4.4	0.37	7.5	0.50	5.0	0.44
West Australian	7.2	0.37	8.1	0.44	7.5	0.55

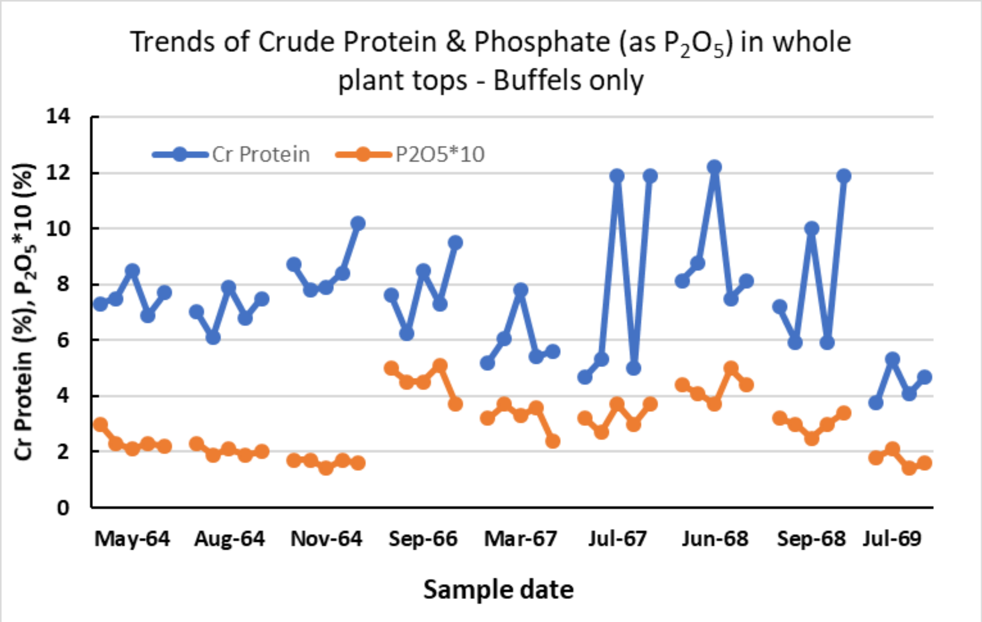

Figure 6 *Lack of close correlation between changes in whole plant crude protein and phosphorus content of the 5 buffel cultivars at different dates throughout the trial. Cultivars at each date are, L to R, American, Biloela, Gayndah, Nunbank and West Australian. No W.A. samples in July 1969.*

Often, as soil moisture fluctuates over time, the nutritive value of pasture alters but the change is not proportional for different plant mineral components. Crude protein and phosphorus levels altered more in some cultivars than others so that graphical plots of data for the 5 buffel cultivars did not follow a similar pattern (Figure 6). The order of plotting of the 5 cultivars at each date, L to R, is American, Biloela, Gayndah, Nunbank and West Australian. Differences in crude protein at some dates were huge (July 1967 and September 1968) and at other times minimal (August 1964 and July 1969). Sometimes protein and phosphorus rise and fall at the same time (Figure 6, July 1967) but at other times one may rise while the other falls for a cultivar (September 1966 and June 1968). The marked change in P_2O_5 levels between Nov 1964 and Sep 1966 occurred at the same time as the chemical labs altered their assay reports from P_2O_5% to P%.

So nutrient content does not seem to be a useful criterion on which to judge a buffel cultivar at any point in time where different sites are involved. Is consistency of sampling system between sites and dates part of the problem? All those 1968 winter samples were taken by the same person who had been doing that for several years beforehand. All cultivars could rank between best and worst for either parameter (Table 9, July 1968, phosphate). Nunbank tended to rate poorly for nutritive value (Tables 7 and 9).

Proximate analysis

Formal Proximate Analysis (AOAC 1960) was conducted on both types of plant samples submitted from the "Inverness" site on 3 dates early in the trial, autumn 1964, mid-winter 1964 and early summer 1964/65 (Table 10).

Proximate analysis was presumably undertaken to allow differentiation of the potential nutritional value of the different pastures. It was a common approach in the 1960s when chemical analysis equipment was far less sensitive and more cumbersome than today (Walker & Hepburn 1955; Butterworth & Diaz 1970).

Estimates often took the form $TDN = a + b*\log_e CP + c*CF + d*\log_e EE$ where TDN = Total Digestible Nutrients, CP = Crude Protein, CF = Crude Fibre and EE = Ether Extract. a, b, c and d are numeric constants that vary with the dataset used to derive a relationship.

Carbohydrate was generally calculated by subtracting these values from the ash-free initial weight.

There is nothing unusual about the general range of values for buffel grass compared to other tropical grasses (see Ashraf *et al*. 1995; Onyeonagu & Eze 2013; Rafay *et al.* 2013). Fat levels were low, fibre ranged between 20 and 30%, ash was around 10-15% and the latter two varied with the stage of plant growth during the year. All that data fits with modern understanding of how the nutritive value of tropical pastures depends very much on the amount of green leaf, the proportion of leaf to stem and the protein level in the leaf ('t Mannetje 1974).

Use of the proximate analyses to estimate nutritive value brings into question which published formula is more appropriate in the absence of any detailed experimental work with these grasses *in situ*. Table 11 shows the Total Digestible Nutrients (TDN) derived from the proximate analysis data, calculated by 2 different published equations for sheep.

There is a vast difference between the TDN values calculated by the two different methods which derive their coefficients from very different forage sources. The equation of Walker and Hepburn TDN-1 ($TDN = CP + 2.25*EE + Fibre + Carbohydrate$) is based on feeding studies using hays made from temperate meadows with a high clover component. Ether Extract (EE) is equivalent to their Fat and Carbohydrate is regarded as equivalent to NFE (Nitrogen Free Extract). The Butterworth and Diaz equation TDN-2 ($TDN = 50.99 + 5.46*\log_e CP - 0.32*CF + 4.96*\log_e EE$) was derived from subtropical grasses fed as fresh fodder, hay or silage to sheep in numerous studies around the globe but its r^2 was only 0.35. There is also an issue with the proximate percentages in the files being calculated once on a dry weight basis (selected samples in May 1964) but mostly on the correct fresh weight basis.

***Table 10** Proximate analysis at three growth stages at three dates on the Selected Samples and Whole Plant samples of buffels and U. mosambicensis.*

			Selected Samples Percentage in dry matter						Whole Plant Percentage in dry matter					
Date	Cultivar	Growth stage	Protein	Fat	Carbo-hydrate	Fibre	Ash	CaO	Protein	Fat	Carbo-hydrate	Fibre	Ash	CaO
29/05/64	American	after	9.7	2.1	40.5	22.7	15.4	0.93	7.3	1.0	45.7	25.2	10.9	0.87
	Biloela	seeding	9.8	2.3	36.8	23.6	17.7	0.88	7.5	1.6	41.5	26.9	12.5	0.74
	Gayndah	"	11.0	1.9	39.4	23.0	14.6	0.97	8.5	1.2	46.5	23.2	11.1	0.76
	West Aust	"	11.7	2.0	39.2	22.3	14.1	0.77	7.7	1.3	45.8	21.4	14.3	0.77
	Nunbank	"	10.3	2.5	37.0	23.2	16.7	0.95	6.9	1.6	42.4	27.2	12.4	0.87
18/08/64	American	frosted,	8.6	0.9	56.7	24.6	9.2	0.90	7.0	1.1	55.0	27.0	9.9	0.90
	Biloela	dry	8.8	1.3	52.5	26.5	10.9	0.96	6.1	1.1	53.0	29.9	9.9	0.92
	Gayndah	"	8.1	0.8	55.4	25.7	10.0	1.04	7.9	0.7	49.6	27.8	14.0	0.92
	West Aust	"	10.9	0.9	i.s.	23.6	i.s.	1.02	7.5	0.9	54.2	24.4	13.0	0.93
	Nunbank	"	8.6	1.6	50.2	26.9	12.7	0.94	6.8	1.2	54.1	28.2	9.7	0.97
	Uro.mosam	"	9.7	1.5	55.4	22.7	10.7	1.32	8.4	1.5	53.4	24.7	12.0	1.10
7/11/64	American	pre-	11.2	2.1	51.9	20.7	14.1	0.59	8.7	1.6	54.8	23.5	11.4	0.33
	Biloela	flower	11.7	2.7	46.7	23.3	15.6	0.52	7.8	1.7	52.0	26.6	11.9	0.34
	Gayndah	"	14.2	2.1	48.4	19.6	15.7	0.57	7.9	1.4	54.7	23.8	12.2	0.40
	West Aust	"	12.0	2.8	51.4	23.2	10.6	0.36	10.2	1.8	54.9	22.2	10.9	0.30
	Nunbank	"	12.0	2.9	48.9	22.7	13.5	0.53	8.4	1.8	52.3	24.8	12.7	0.39
	Uro.mosam	"	13.0	2.3	48.7	18.9	17.1	0.93	11.9	1.8	50.8	21.1	14.4	0.70

i.s. means insufficient sample to allow analysis for this parameter

a.

Table 11 *Total Digestible Nutrients (TDN) of the main grasses at three different times estimated from the proximate analysis data in Table 10, based on two different published equations.*

		Selected Samples			Whole Plants		
Date	Cultivar	Protein	TDN-1*	TDN-2	Protein	TDN-1*	TDN-2
29/05/1964	American	9.7	77.6	59.8	7.3	80.5	53.8
	Biloela	9.8	75.4	60.0	7.5	79.5	55.7
post-flowering	Gayndah	11.0	77.7	59.9	8.5	80.9	56.2
	West Aust	11.7	77.7	60.7	7.7	77.8	56.6
	Nunbank	10.3	76.1	60.8	6.9	80.1	55.2
18/08/1964	American	8.6	91.9	54.3	7.0	91.5	53.4
	Biloela	8.8	90.7	55.7	6.1	91.5	51.8
dry, frosted	Gayndah	8.1	91.0	53.1	7.9	86.9	51.6
	West Aust	10.9	i.s.	56.0	7.5	88.1	53.7
	Nunbank	8.6	89.3	56.5	6.8	91.8	53.3
	Uro.mosam	9.7	91.2	58.1	8.4	89.9	56.7
7/11/1964	American	11.2	88.5	61.2	8.7	90.6	57.6
	Biloela	11.7	87.8	61.9	7.8	90.2	56.3
pre-flowering	Gayndah	14.2	86.9	62.9	7.9	89.6	56.3
	West Aust	12.0	92.9	62.2	10.2	91.4	59.5
	Nunbank	12.0	90.1	62.6	8.4	89.6	57.6
	Uro.mosam	13.0	85.8	63.1	11.9	87.9	60.7

* TDN-1 from Walker & Hepburn (1955) TDN-2 from Butterworth & Diaz (1970)

However, it is appropriate here to ignore those calculation issues and just concentrate on the differences amongst the buffel cultivars on each sampling date from a particular calculation formula. Then the differences are relatively small and variable with sample date and sample type. The range varied from 1.8 units around a mean of 90.3 in November 1964 to 3.4 units around 55.1 in August 1964, which equates to 2 to 6%, which is not large considering the variation in cultivar rankings amongst all the comparable sampling times (Table 11).

Within the 5 buffel cultivars, West Australian averaged the highest crude protein level (7.9%) while American was lowest (7.4%) under proximate analysis methods. The reverse was true for the Ash and Crude Fibre levels. Overall, there was no strong trend for one buffel cultivar to consistently provide higher nutritive value based on the parts of the plant which sheep normally select to graze if choice is possible. If the ability to selectively graze has been lost, then Biloela might be regarded as the poorest buffel and Gayndah one of the best (Table 7), but the differences were often small, 2-6% maximum for TDN from a proximate analysis.

Cultivar yield

As has already been indicated, the summer of 1963-64 was a poor one. Harvests in early July 1964 were possible at “Inverness” and “Evora” in all four reps. At “Eastwood” yields were only obtained from two of the four reps of each buffel, except W.A. which was not worthwhile harvesting at all according to file notes. At “The Scour”, the earlier use of this area for the palatability assessments eliminated it from the dry matter yield measurement this year. The harvest from each plot was kept separate, air dried, and the results are shown in Table 12 for the 3 harvested sites.

At “Inverness” in 1964, Nunbank yield was significantly greater (P<0.05) than that of Gayndah and West Australian but plot variability did not permit a statistically significant difference to be found between any of the others.

At “Evora” in July 1964, West Australian yield was statistically lower than all the other buffels (P<0.01) and Nunbank yield was statistically greater than that of Gayndah (P<0.001) but not Biloela or American. Thus, the yields of the similar types Gayndah and American were not statistically different nor were they between Nunbank and Biloela. “Evora” had experienced a slightly better season which is reflected in the results.

Table 12 *Standing air-dry plot pasture yields (lbs) at 3 sites on 3 July 1964 and the equivalent mean weight per acre for each cultivar at each site.*

Cultivar		Site		
	Rep	Inverness	Evora	Eastwood
American	1	1.7	3.2	1.1
	2	1.7	4.4	
	3	2.5	1.6	0.7
	4	1.6	4.1	
	lb/ac	1640	2900	780
Biloela	1	2.9	3.3	0.8
	2	1.7	3.4	
	3	2.4	2.1	0.7
	4	1.4	4.5	
	lb/ac	1830	2900	650
Gayndah	1	1.3	2.6	1.1
	2	1.2	2.5	
	3	1.6	2.1	0.7
	4	1.5	1.9	
	lb/ac	1220	2000	780
Nunbank	1	2.2	3.5	1.2
	2	2.1	3.2	
	3	2.9	3.4	1.2
	4	1.9	4.0	
	lb/ac	2000	3000	1050
West Aust	1	1.7	1.7	No yield
	2	1.2	1.9	
	3	1.3	1.6	
	4	0.7	0.8	
	lb/ac	1070	1300	0

In March 1967 another set of mean standing yields are recorded for 2 sites that again show relatively low yields for West Australian, high yields for Nunbank and a continuing fairly low yield for Gayndah at “Inverness” (Table 13). That seems to reflect the rather poor establishment recorded for some plots of Gayndah at the “Inverness” site four years earlier (Table 6).

Table 13 *Mean standing dry matter yield (lb/ac) at “Evora” and “Inverness” in March 1967*

Site	Date	Buffel cultivar				
		American	Biloela	Gayndah	Nunbank	West Aust.
Evora	30/3/67	1850	2461	1529	2737	826
Inverness	31/3/67	1173	1759	874	2127	575

A set of standing dry matter yields also exists in the archives for the winter of 1968 (Table 14). At both "The Scour" and "Evora" sites, Rep 1 of the West Australian type had an abnormally high yield, indicative of invasion from another buffel that looked like it, such as American. That inflated the average yield to a much greater relative value than other visual ratings provide. Again, Nunbank was still always the highest yielding cultivar and Gayndah remained low-yielding at the "Inverness" site. Individual plot yields varied greatly so that few significant statistical differences were secured except between the extremes of Nunbank and West Australian.

Table 14 *Standing dry matter yields (lb/ac) of the buffels at 3 of the sites in the 1968 winter.*

Site	Date	Buffel cultivar				
		American	Biloela	Gayndah	Nunbank	West Aust.
Evora	13/7/68	1471	1008	1149	1969	679
Inverness	7/6/68	885	1016	361	1059	51
The Scour	6/6/68	862	849	875	945	299

A final set of dry matter yields was taken at "Evora" on 9 August 1970, 7 years after the plots were sown. Biloela gave the highest average yield and West Australian the worst.

Means	lb/ac
Biloela	2124
Nunbank	1970
Gayndah	1889
American	1799
West Australian	281

The only statistically significant difference ($P<0.05$) was between West Australian and all of the other 4 buffel cultivars. West Australian buffel has been lost completely from two of the 4 reps on this sandier type of gidyea soil to which it should be better suited than at other sites.

It appears that Green panic, Blue panic, Bambatsi and *U. mosambicensis* were no longer in existence there, but that may be misinterpreting the intention of the harvest. By that time, interest in the performance of the other poorly-performing, non-buffel cultivars had waned. A single healthy plant of Siratro was recorded to persist here for some years.

The results for individual plots of surviving buffel cultivars are shown below (Table 15). Harvested moisture content on a fresh weight basis ranged between 20 and 29%.

Table 15 *Individual plot dry matter yield (lb/ac) and pasture moisture content at "Evora" on 9 August 1970. F Wt = Plot Fresh weight harvested*

Plot	Species	F Wt (lbs)	% H_2O	DM (lb/ac)
1	West Aust	0.2	23.4	556
4	Biloela	0.7	24.6	1887
5	American	0.8	28.3	1936
6	Nunbank	1.0	26.7	2544
7	Gayndah	0.9	22.2	2570
8	Nunbank	0.6	-	1560
9	American	0.6	28.6	1440
10	Gayndah	0.4	20.4	1190
12	West Aust	overgrown by American		
14	Biloela	0.8	22.2	2285
15	American	0.6	27.1	1646
16	Biloela	0.9	19.6	2722
17	Nunbank	0.9	21.8	2592
19	Gayndah	0.7	24.6	1887
21	West Aust	0.2	22.4	568
24	Biloela	0.6	25.0	1600
25	West Aust			
26	Nunbank	0.5	28.9	1186
27	American	0.9	28.4	2174
28	Gayndah	0.7	24.0	1912

Condition of the plots in mid-March 1967

Lee's notes in March 1967 after some late summer rains (Table 5) provide a snapshot of how the buffel cultivars were performing after 4 years relative to each other at all four sites. The preceding 2 months had been very dry.

"Eastwood"

Biloela grew to 2' high without seeding. Nunbank grew to 2'6" without seeding. Gayndah grew to 15" & seeded heavily. American grew to 15" with an occasional seedhead. West Aust stand is very thin; plants grew to 4" without seeding.

"Evora"

Biloela and Nunbank grew to 18" with only an odd seedhead. Gayndah & American both grew to 15" and seeded heavily. West Aust grew to 1' and was flowering.

"Inverness"

Biloela and Nunbank cultivars had grown to a height of 1 foot. The stand was drying out rapidly with no evidence of seeding. Gayndah grew to a height of 9" and dried off without seeding. American also grew to 9" with only a few seedheads seen. West Aust stand is very thin. Plants grew to 6" without seeding.

“The Scour”

Overall stands are very thin. Biloela and Nunbank made very light growth, reaching 9” high without seeding. Gayndah and American grew to 9” and were flowering. West Aust grew to 4” and was flowering.

Flowering and seed set

Purcell made copious notes about flowering and seed-set of the plants, perhaps because that was the easiest phenological character to record fairly objectively. Earliness to flower after each winter and big rainfall event was regularly in the order — West Australian, then Gayndah and American, then Nunbank and Biloela, with the panics generally starting to flower around the same time as the Biloela buffel. However, the flowering of Biloela, Nunbank and the panics was generally weaker/less profuse than that of the other 3 buffels. Seed ripeness was achieved in the same order as initiation of flowering. If the amount of available moisture was limited, it was common for the early flowering buffels to ripen seed while Biloela and Nunbank buffel would not flower at all and the panics would perhaps flower weakly.

Flowering was not strongly controlled by daylength for the West Australian, Gayndah and American buffel grasses but daylength did seem to influence all the other grasses. Queensland experience has shown since that daylength and time of year does have some effect on the flowering of the panics, as well as Biloela and Nunbank buffel but not as much on Gayndah, American and West Australian and *U. mosambicensis* (Loch *et al.* 1999). This accentuated the weak or non-existent flowering events of Biloela and Nunbank buffels when limited rainfall curtailed their development to foliage production only. Some published results indicate limited effects of daylength on all these species but no individual cultivar information was provided (Nada 1980).

There are no observations about the degree of successful seed-set or the plumpness of the grains in ‘seeds’ that looked to have ripened. Experience in more recent years has shown that sometimes the grain within the mature-looking, fluffy buffel ‘seed’ does not fill out if the plants run out of soil moisture, particularly if a large bulk of foliage had initially grown prior to flowering on a sandy soil (Silcock pers. comm.). However, other observations around the plots stated that seedlings of West Australian buffel were common and that there seemed to be almost no spread of the Biloela and Nunbank buffels from their sown plots. That would possibly correlate with the abundance of mature seed set because seedling establishment from the sown seeds was often very good for Biloela and Nunbank buffel. Stronger seasonality of flowering of these latter two would accentuate the lack of viable seed in the soil when effective establishment rains did fall by which the other 3 buffel cultivars could gain an advantage.

Cultivar heat and drought tolerance

Heat and drought tolerance were intrinsically enmeshed because the major growth periods were in summer when conditions were often reported as very hot. Apart from the first and fourth summers, rainfall over the other summers was fair at best and very dry for 2 (Table 4). Green panic and *U. mosambicensis* were reported to have died back badly on several occasions so that their crowns were crumbly and could be ‘kicked out of the ground’. Such observations were not made about the buffel grasses with the possible exception of West Australian. Biloela and Nunbank generally seemed able to maintain their healthy leaf condition and colour a little longer into a moisture and heat stress period than American and Gayndah.

Thus, the heat and drought tolerance of the buffel grasses was well established by this study while such was poor or questionable for the other grasses and the legumes. It was noticed that a very thick stand of buffel in some reps dried off much more rapidly. This is to be expected when plants in a particular plot are denser than elsewhere and extracting more soil moisture from the same area as other less dense plots.

In mid-February 1965, it was noted that Biloela and Nunbank appeared to be standing the severe heat and moisture stress the best and West Australian the worst. American and Gayndah were rated as intermediate tolerance with American perhaps slightly less stressed than Gayndah.

Cultivar frost tolerance

Frost severity can vary greatly amongst winters in the Blackall district. All are radiation frosts and screen temperatures can drop to –3°C and occasionally lower, with frost-producing temperatures between 2.2° and 0°C quite common in most winters. Between 1963 and 1970, Bureau of Meteorology minimum temperature data for Blackall (SILO 2019) would indicate the probability of frosts as shown in Table 16.

Table 16 *Monthly frost incidence and extreme low temperature (°C) recorded at Blackall (number / extreme low) for the winters 1963 to 1970. A frost event is regarded to occur when the recorded Stevenson screen temperature falls below 2.2°C.*

	Frost number per month/extreme temperature							
Month/ Year	1963	1964	1965	1966	1967	1968	1969	1970
May	0	0	0	0	0	0	0	0
June	6 / -0.6	0	2 / -0.1	3 / 1.1	0	0	2 / 1.6	0
July	8 / -1.7	4 / 1.8	9 / -1.1	8 / -2.0	1 / 1.9	6 / -1.1	0	4 / 1.2
August	0	1 / 1.7	1 / 1.1	0	3 / 0.5	2 / 0.6	0	1 / 0.3
September	0	0	0	0	0	0	0	0
Total frosts	14	5	12	11	4	8	2	5

Based on the Blackall records, the first winter in 1963 was the most severe for frosts while 1969 was the mildest. Purcell noted the severity of the frosts in 1963 and historical experience would indicate that such conditions can kill seedlings of many tropical grasses and legumes if they have not yet developed a study crown and root system (Moore *et al.* 2006). Thus, the July 1963 establishment ratings could have been influenced by the early frosts that winter as well as earlier rainfall and germination success.

Purcell noted very early in the trial that all the buffel cultivars were frosted in winter to a similar degree by whatever frosts occurred. Though such recorded observations were less common in later years, minimum temperatures were as or more severe sometimes and would probably kill *Glycine javanica* and Phasey bean (Ferguson 1969; Cameron 1985). The pastures were considered to be too dry in the 1964 winter to do a meaningful frost tolerance assessment.

Thus, the trial showed that all the buffel cultivars had sufficient frost tolerant to persist through the normal frost challenges that the district experiences and so too had the other sown grasses and the native Mitchell grass (not unexpectedly). However, spring leaf regrowth response tended to be earliest by the robust, blue-leafed Type D Biloela and Nunbank cultivars.

Cultivar palatability

Rating this parameter was only done for sheep although cattle grazed the plots with sheep at "Evora" at one time. These observations were carried out at three different growth stages of the grasses —

In early regrowth – before flowering.

After seeding, towards the end of the summer growing season.

At the end of the winter before any spring rains.

The animals were grazed on one site only at each of the three stages. "The Scour" was used for stages A and B, and "Evora" for stage C. These sites were selected because they had lighter soils and it was thus likely that they would be further advanced in their growth cycle than the buffel on the heavier soils. This enabled a selective foliage sample to be subsequently collected at "Inverness", based on the portions of the plant which were grazed by the sheep at the particular growth stage.

The sheep grazing preferences were as follows: –

Stage A. – November 1963

There was a little flowering in the West Australian variety, and also a little on the side of odd plants of other varieties where the spring mowing had pushed over and not cut that portion of the plant back to the butt.

Some of the young leaves and shoots of all buffels were eaten by the end of the week's grazing. West Australian variety was not grazed immediately, but the young leaves and shoots were accepted by the end of the week, though not to the degree of the other buffels. This was most certainly due to the more advanced stage of growth in the West Australian.

No flowering stalks present were eaten on any buffel variety at "The Scour" at this time.

Stage B. – May 1964

At this grazing, West Australian, American, and Gayndah strains were preferentially grazed before Nunbank and Biloela. In the more palatable former three strains, the leaf and softer culm portions were eaten. On Nunbank and Biloela only the softer leaf tips were eaten.

The preference for West Australian, American and Gayndah occurred despite the fact that these three had seeded well, while the other two had only experienced a light seeding in this dry summer.

Stage C. – August 1964

All buffels were completely hayed off to a yellow-brown colour at this time at "Evora". West Australian was eaten from the sides and most of the leaf was grazed off the culms. American and Gayndah were eaten from the sides as for West Australian, and also eaten down from the top of the plant, taking the top off the culms. Nunbank and Biloela were only slightly grazed on the softer leaf portions.

Palatability of other grasses in the trial area.

At Stage A and B, Bambatsi panic, Green panic, Blue panic and *U. mosambicensis* were all very well accepted.

At Stage C, Bambatsi and Green panic were very well accepted.

There are no recorded notes about grazing of the few legume plants that established at either site.

Soil characteristics

The initial soil characterization data (Tables 1 & 2) included a full assessment of the proportion of sand, silt and clay as well as chemical properties, which for ease of reference are now repeated here in Table 17.

Table 17 *Surface and subsurface chemical and physical soil values for the 4 sites in February 1964.*

Site	Depth (ins)	pH (water)	P_2O_5 (BSES)	K me/ 100g	Total N (%)	NO_3-N (Morg.)	NH_4-N (Morg.)	Org C (W&B)	C/N ratio	Silt (%)	Clay (%)	Sand (%)
Eastwood	0-2	7.4	86	1.00	0.09	M	L	0.80	8.9	15	32	53
Eastwood	2-8	7.0	36	0.55	0.06	L	L	0.59	9.8	12	41	47
Evora	0-2	6.8	246	0.35	0.07	M	VL	0.83	11.9	5	13	82
Evora	2-8	6.6	101	0.64	0.04	L	VL	0.50	12.5	2	10	88
Inverness	0-2	6.9	101	1.25	0.10	L	L	0.67	6.7	19	29	52
Inverness	2-8	7.1	55	0.64	0.08	M	L	0.69	8.6	12	42	46
The Scour	0-2	6.4	138	1.00	0.06	L	VL	0.57	9.5	8	9	83
The Scour	2-8	6.1	86	0.79	0.04	L	VL	0.36	9.0	7	13	80

It shows the usual higher available phosphorus and total nitrogen level in the surface soil and, in all cases except "Inverness", soil pH and organic carbon were lower in the subsurface layer. Ammonium nitrogen was lower at the two sandier sites, "Evora" and "The Scour", while nitrate nitrogen levels were variable across the sites. Exchangeable potassium was much higher in the surface soil at all sites except "Evora". The Morgan ratings for available ammonium and nitrate nitrogen in samples was typical of the way such laboratory information was supplied at the time. Low (L) ratings were common for tropical rangeland soils as were very low (VL) ratings from sandy soils.

A more extensive set of soil data, with analyses for each of the 4 reps for each buffel cultivar, was collected in December 1964 at three sites and at "Eastwood" in May 1965 but only for the surface 2-inch soil layer. This data (Table 18), presented as means with range and standard deviation, illustrates the spatial variability to be found in many soil properties amongst quite close locations. Each sample analysed was itself from 20 bulked collections within a 30 x 30 link plot. Also shown is the single data value returned from bulking 6 samples from each of the 4 reps from the same sites to provide the initial site characterization shown in Table 17.

The variability was quite small but not insignificant for pH, given that the range at "The Scour" was from 6.6 to 7.3. For available P_2O_5 the range was over 50% at the "Eastwood" site but nearer 20% at the other three (Table 18). Exchangeable potassium had a similar degree of variability to that of available phosphorus but all values were well above what is required for healthy grass growth, 0.2 me% (Crack & Isbell 1970). The difference in the mean pH value for "Inverness" between February and December 1964 is huge for some reason, 6.9 versus 8.1, with 6.9 in February being way outside the range measured in December (Table 18). Strong gilgai development can lead to such localized differences but gilgai development at all sites was weak at most. Localised ash deposits from the burning of the pulled scrub would seem a more likely explanation. Similar discrepancies apply to the "Eastwood" and "The Scour" pH values although the difference between the means is smaller. The exchangeable K value of the February 1964 sample from "Evora" is also outside the range measured from the twenty December 1964 samples but it is the only other example of a surprising difference.

Table 18 *Mean, range and standard deviation of 3 soil parameters (pH, available P & exch. K) from 20 samples of surface soil from each of the 4 sites during the 1964/65 summer, each itself a composite of 20 samples from a 30 x 30 lk area.* ***.*** *Alongside are equivalent results from bulked samples taken in February 1964 from the same plots.*

		Summer '64/65			Feb '64		
Site	Statistic	pH	avail P	Exch K	pH	avail P	Exch K
Eastwood	Mean	7.9	74	1.40	7.4	86	1.00
	Max	8.2	162	2.98			
	Min	7.7	24	0.70			
	StdDev %	1.9	53	41			
Evora	Mean	7.7	288	1.04	6.8	246	0.35
	Max	8.1	376	1.45			
	Min	6.7	184	0.43			
	StdDev %	4.5	19	26			
Inverness	Mean	8.1	121	1.61	6.9	101	1.25
	Max	8.2	168	2.52			
	Min	7.9	72	0.96			
	StdDev %	1.0	24	25			
The Scour	Mean	6.9	182	1.38	6.4	138	1.00
	Max	7.3	240	1.87			
	Min	6.6	125	0.78			
	StdDev %	2.8	17	18			

A note in the files says "It is known that soil pH can vary markedly depending on climatic conditions immediately prior to sampling." A paper by Friesen *et al.* (1985) supports that contention with soil pH ranging over 0.7 units each year near Armidale on a gleyed podzolic soil and the changes being correlated with soil moisture and temperature fluctuations.

At the "Inverness" site, some extra soil sampling was done later because this was the focal site of the study in terms of its similarity to the majority of gidyea scrub soils in the region. The aim was to see if soil characteristics shifted markedly over time under the permanent pastures and whether any such change was cultivar-related. Thus, these same 3 soil parameters can be compared over a longer time for each of the buffel grass cultivars for the surface 0-2 inches of soil (Table 19). There was a general increase in all parameters between February and December 1964 and then a drop back down towards or to below the first values by the 1969 records. The exceptions were the pH under Biloela buffel and the available P and exchangeable K under West Australian buffel (Table 18). The 1969 values were often well below the February 1964 values and only the pH under the American and Gayndah buffel plots was still higher than the original value. Available phosphorus levels were all 50 ppm or greater which is well above the range normally regarded as critical for healthy pasture growth (Rayment *et al.* 1977).

Table 19 *Shifts in surface (0-2") soil pH, available Phosphorus and exchangeable Potassium on plots that were covered with 5 different buffel grass cultivars between Feb 1964 and Feb 1969.*

Cultivar	Date	pH	Avail P_2O_5	Exch K
American	Feb '64	7.5	95	1.31
	Dec '64	8.2	121	1.51
	Feb '69	7.9	86	0.83
Biloela	Feb '64	8.1	86	1.56
	Dec '64	8.1	129	1.76
	Feb '69	7.9	55	1.30
Gayndah	Feb '64	7.8	122	1.00
	Dec '64	8.1	125	1.79
	Feb '69	7.9	74	0.99
Nunbank	Feb '64	8.0	98	1.13
	Dec '64	8.1	126	1.72
	Feb '69	8.0	61	0.95
West Aust	Feb '64	8.0	118	1.56
	Dec '64	8.1	105	1.28
	Feb '69	8.0	61	1.56
Average	Feb '64	7.9	104	1.31
	Dec '64	8.1	121	1.61
	Feb '69	7.9	67	1.13

In 1969 the equivalent values for soil under the gidyea scrub in the nearby shade-line at "Inverness" were pH 8.0, available P (BSES assay) 78 ppm and exchangeable K 1.40 me/100g, all within the range of values recorded from the buffel grass plots at that time. There was no statistically significant shift in any surface soil properties over the 5 years and no apparent significant difference for the soil under the different buffel cultivars. Lack of replication for the 1969 data prevents formal statistical testing.

Persistence

Persistence is indirectly measured by the availability of samples in the late 1960s and the plot observations. The observation notes show that the legumes never developed a significant population that persisted beyond 2 years. Persistence of the 3 *Panicum* species was very poor which was disappointing because they established satisfactorily at "Evora" and "Inverness" and rated well for nutrient content (Figures 4 & 5) and animal acceptability. Green panic often rated very highly in the early years, but the drought ended its existence. The *U. mosambicensis* established well at all sites and was productive and fairly palatable but its drought tolerance was insufficient for long term persistence in the run of poor years that occurred during this trial. At "Evora" in 1970, it either did not warrant harvesting or had died out completely because no yield was recorded for it (Table 12). Fifty years later, this species is quite commonly seen growing along roadsides in lighter soil country so it seems that inadequate soil moisture reliability caused its demise.

Even the native Mitchell grass that is so well adapted to nearby open and wooded downs country and which achieved some establishment in the sowing year, did not apparently persist as a worthwhile stand that commanded written observations and harvests for nutrient content and yield in later years. However, current recollections by Silcock from 1969 are that urochloa was still present at "Inverness" and by 1988 Mitchell grass dominated much of the paddock around the plot where the original sowing of West Australian buffel had died out.

This trial showed that 4 buffel cultivars – American, Biloela, Gayndah and Nunbank persisted equally well on all sites for the 6 years that it ran, even if the initial establishment density was not always as good as desired. No reliable information exists in the records about the establishment, growth or persistence of the later-sown buffel cultivars Lawes, Molopo, Tarewinnabar and Q1004. They have not become obvious anywhere in the region since, nor in the brigalow country.

Recording the natural spread of these persistent cultivars was not addressed directly by the project but American is recorded in 1970 as invading weak West Australian buffel plots at "Evora". West Australian was sometimes mentioned as being in plots sown to other species but, as the paddocks had originally existed as a pasture of that cultivar, remnants from that could have re-established in plots where a newly-sown line had not established well. It still did not rate well for persistence compared to the other buffels.

Other observations

From the project records there is no data about fire tolerance differences amongst the species or in fact about flammability comparisons. No fires were recorded to have occurred at the sites during the study. No problems were noted about pest or disease attack of the sown plants but that may be because minor issues were not appreciated at the time. Such minor problems that have arisen with buffel grass since the 1960s, such as dieback, were not recorded.

Pasture rundown is common in most buffel pastures after the initial few years (Myers & Robbins 1991) which is why companion legumes were, and still are being sought. No obvious signs of buffel rundown were recorded, except for West Australian, and most drops in aboveground yield were attributed to seasonal conditions, particularly effective rainfall. The rather rapid loss of the sown panics and urochloa may be regarded as an extreme case of pasture rundown but was not regarded as being due to inadequate soil nutrients or to pests or disease. Rather it was thought to be due to inadequate drought tolerance, possibly accentuated by occasional heavy grazing and mowing to near ground level in spring.

Discussion

When this experiment started, it was generally accepted in western Queensland that green panic will establish readily but die in a drought and Rhodes grass only survives as scattered plants in wetter gullies (Purcell 1964). Blue panic tended to become rank with coarse stems and *Sorghum almum* was recommended for sowing to give early feed but not as a permanent pasture, which was what was required (Purcell 1964). This experiment confirmed those impressions based on truly comparable information and added information about the relative nutritive value and yield potential of the various cultivars. Poorer drought survival of West Australian compared to that of Biloela and Gayndah cultivars also agreed with pot studies done by Edye *et al.* (1964).

Anecdotal evidence would suggest that the Biloela and Nunbank cultivars have not shown great ability to spread in this district on any soil type but that the American/Gayndah type does spread very easily under gentle grazing pressure. In the towns of the region, Gayndah-type buffel grass has colonized most footpaths and disturbed building sites. Such ability to naturally spread and thicken poor stands is regarded by most pasture scientists and local graziers as a positive (Cavaye 1991; Fensham & Fairfax 2007) but many environmentalists and conservationists look upon it as an ecological disaster (Friedel *et al.* 2006; Staight 2015). There is currently no reliable way to distinguish Gayndah from American buffel visually and the author is unaware of any chemical or genetic test that has been developed to do it either, but it could be done. Also, in 1988 a visiting USA specialist on buffel grasses in New Mexico was in an area near Yalleroi, Queensland where historically both Gayndah and American were sown on a large scale. When asked to say which of two nearby buffels of that type that looked different in full flower was American, suggested the opposite to that of this author who is also very familiar with the varieties of buffel grass.

The long term and continuing dominance of the Gayndah/American type in the region was aided, not only by their greater ease of natural spread but by the active production of their seed by local enthusiasts. Chief amongst them were the Rich and Adams families based around "Boorara" and "Darracourt" respectively, near Yalleroi (Qld Country Life 2013). They managed their expanding sown buffel areas in the early 1960s by allowing well-established areas free of large unburnt logs to go to seed regularly for their own purposes and to sell to other local people. They became very skilled at producing buffel grass seed in bulk and it naturally boosted the financial success of their family businesses. This enabled neighbours to acquire good quality seed, often at short notice, far more easily and at competitive prices. That seed had always existed in a low humidity environment which reduces the rate of natural seed deterioration in storage (Roberts 1972) which would occur much more rapidly in the places closer to the sea that were potential competitors in the buffel seed market. The cost of transporting Yalleroi seed to western Queensland buyers would also have been lower, often as back-loaded goods on trucks that had brought wool bales to railway sidings at Blackall, Barcaldine, Jericho or Yalleroi.

The broad, high-ranking value of the Gayndah buffel type on these 4 gidyea soils has also been a welcome confirmation that the results of the sheep production trial conducted on another part of "Eastwood" between 1967 and 1982 (project Bkl P50 WR) are applicable to the vast majority of gidyea country that has been cleared and sown to buffel grass. Though many buffel pastures in western Queensland now support cattle production rather than sheep and wool, that is a general shift in industries that has occurred on most classes of land in semi-arid Queensland since the 1960s and is not a reflection on the general high pastoral value of buffel grass in western Queensland.

The failure of all the legumes, while a disappointment and an ongoing need to be overcome, matches what has occurred in the brigalow country further east. However, unless proper trials are conducted, researchers can never be certain that initial predictions will prove correct in a different environment. This applies particularly to pests and diseases as exemplified by the regional differences between coastal and inland areas in the occurrence of cattle ticks and of anthracnose disease in stylos.

The poor economics of interventions to correct pasture rundown, such as nitrogen fertilizer, currently prevent their widespread use and renovation by ploughing has been shown to produce a fairly short-term benefit unless accompanying benefits such as enhanced moisture infiltration or runoff capture create enhanced site potential (Peck *et al.* 2011). Rundown is an issue with old perennial pastures worldwide and without economical ways to resow or to boost fertility, as happens in higher rainfall and cooler climate regions, studies continue to try to find suitable legumes for both the brigalow and gidyea soils. Some progress has been made for the higher rainfall brigalow country but the drier gidyea country presents an even greater challenge (Peck pers. comm.)

Buffel dieback is a current (2000s) issue for which there is no conclusive cause yet (Buck 2017). The dieback problem is not confined to buffel grass and is most commonly reported in more subcoastal districts than west of the Great Dividing Range, but it may become an issue there in future. It was not noticed or reported as the cause of the poor persistence of West Australian buffel.

To the author's knowledge, there are still no pest or diseases attacking buffel grass in the Blackall district. There are well documented cases of bighead disease in horses grazing pure buffel pasture on a long-term basis (Emeraldvet 2011) and of it causing oxalate poisoning of sheep on rare occasions when young regrowth was occurring on nutrient-rich sites like stock yards or recently burnt country (McKenzie 2012). Such issues arise with many other grasses under unusual conditions, such as photosensitization by Bambatsi panic (DAF Qld 2013). Kangaroos have been observed on many occasions to selectively graze perennial urochloa in preference to buffel grass at trial sites in western Queensland and this may have contributed to its poor persistence during this project. No pasture species is completely without potential problems, but buffel grasses in central western Queensland have very few after 60 years of widespread use.

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Appendices

Appendix 1 *Synthetic rainfall (mm) for each site based on the nearest 0.05 degree data point provided by SILO (SILO 2019) for 1963 to 1971*

Time period	Evora	The Scour	Inverness	Eastwood	Average	Std Devn	STD %	Observations made in 2019
1st summer post planting	490.9	438.1	453.7	474.1	464	23.1	5.0	excellent post planting rains
Up to 1st establishment rating	507.2	455.6	474	497	483	23.2	4.8	v good rain up to 1st rating
First winter (My-Se 1963)	73.5	90.2	77.4	76.5	79	7.4	9.3	poor
Between establishment ratings (Jy-Oc 1963)	57.3	72.8	57.6	54	60	8.4	13.9	August rain
1963 year	788.5	791.2	779.1	810.7	792	13.3	1.7	decile 9;
2nd summer (No-Mr 1963/64)	200.9	184.4	190.9	225.5	200	18.0	9.0	decile 2;
2nd winter (1964)	89.2	101.1	89.9	92.4	93	5.5	5.9	fair
1964 year	338.4	417.8	365.6	386.7	377	33.6	8.9	decile 3;
3rd summer (1964/65)	226.9	183.1	152.5	158.9	180	33.7	18.7	decile 2;
3rd winter (1965)	1.7	1.4	4.4	6.8	4.0	2.5	71.0	extra poor
1965 year	327.2	327.8	276.3	270.8	301	31.2	10.4	decile 2;
4th summer (1965/66)	268.3	429.6	391	388.8	369	70.0	18.9	decile 7;
4th winter (1966)	141.3	158.2	140.8	155.5	149	9.2	6.2	good
1966 year	323.8	421.3	402.2	395.4	386	42.7	11.1	decile 3;
5th summer (1966/67)	106.4	148.9	146.4	147.2	137	20.6	15.0	decile 1;
5th winter (1967)	72.7	82.5	80.2	80	79	4.3	5.4	poor
1967 year	248.7	330.3	323.2	323.3	306	38.6	12.6	decile 2;
6th summer (1967/68)	214.4	252.9	279.1	279.5	256	30.7	12.0	decile 4;
6th winter (1968)	73.1	109.3	100.4	100.3	96	15.7	16.4	fair
1968 year	309.5	353.5	348	354.5	341	21.4	6.3	decile 2;
7th summer (1968/69)	120.4	196.9	136.4	141.7	149	33.3	22.4	decile 1;
7th winter (1969)	38.7	46.6	30.2	25.5	35	9.3	26.5	v poor
1969 year	244.8	301.5	256.1	248.6	263	26.3	10.0	decile 1;
8th summer (1969/70)	306.9	210.8	223.1	223.3	241	44.3	18.4	decile 3;
8th winter (1970)	62.5	65.3	57.1	57.2	61	4.1	6.7	poor

1970 year	401.9	418.6	362	358.8	385	29.6	7.7	decile 3;
9th summer (1970/71)	230.1	316.8	271.7	256.2	269	36.4	13.5	decile 4;

Colour shading of comments is used to highlight the quality of the growing season that year, green shades for good, brown shades for dry seasons.

Grey shading highlights where one site differed noticeably from the other three for that period

Std Deviation is calculated from the average amongst the four site synthetic rainfall values

Appendix 2 *Changes in scientific names between 1960 and 2020 of plant species mentioned*

Common name	1960s scientific name	2020 scientific name
Buffel grass	*Cenchrus ciliaris*	*Pennisetum ciliare* (only in some jurisdictions)
Green panic	*Panicum maximum* var. *trichoglume*	*Megathyrsus maximus* var. *pubiglumis*
Siratro	*Phaseolus atropurpureus*	*Macroptilium atropurpureum*
Phasey bean	*Phaseolus lathyroides*	*Macroptilium lathyroides*
Glycine	*Glycine javanica*	*Neonotonia wightii*
Galvanised burr	*Bassia birchii*	*Sclerolaena birchii*

Appendix 3 *Measurement unit conversions*

1 link (lk) = 7.92 inches

30 links = 6.6 yards;   100 lk = 1 chain (22yds)

1 yard (yd) = 0.914 metres (m) = 3 feet [3’]

1 foot (ft) = 12 inches (in)   [1’ = 12”]

1 acre (ac) = 0.405 hectares (ha)

1 pound (lb) = 0.454 kilograms (kg)

1 lb/ac = 1.121 kg/ha

P_2O_5 % = Phosphorus % * 2.2912

Crude Protein % = Nitrogen % * 6.25

CaO % = Calcium % * 1.3992

£1 = 20s. = $2   [1 pound currency = 20 shillings = 2 Australian dollars]

1s. = 12d.   [1 shilling = 12 pence (pre-1966 Australian currency)]

Rainfall 1 point = 1 hundredth of an inch

1 inch = 25.4 mm = 100 points