BUFFEL GRASS (CENCHRUS CILIARIS) IN AUSTRALIA

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EARLY HISTORY

Buffel grass *(Cenchrus ciliaris)* is now one of the three most commercially significant sown pasture grasses in Northern Australia. The increased use of this grass in its diverse forms is due to many people of varied interests; perhaps it is the laymen who predominate in the following account.

Buffel grass is native to Africa, India and Indonesia (Whyte, Moir, and Cooper 1959). According to Marriott (1955) one point of entry to Australia was Wallal, on the north-west coast of Western Australia, where buffel grass is believed to have been accidentally introduced between 1870 and 1880 in Afghan camel harness. In 1910 J. Moore brought seed from Wallal to Port Hedland, where its spread was systematically encouraged. After the 1914-18 war the W.A. Department of Agriculture was active in distributing Cenchrus lines sent by General Birdwood from Afghanistan. A. M. Morrison of Maronan Station, Cloncurry, received in 1926 sixteen seeds from a Mr. Macrae of Andover Downs in the Roeburn district of W.A., whose original source was General Birdwood. (W. A. Arndt, personal communication.) From these sixteen seeds twelve plants of Birdwood grass *(Cenchrus setigerus)* and three plants of a white seeded buffel grass were obtained: the latter spread more rapidly than the heavier seeded Birdwood grass, and was sown about the property. By 1928 the grass had spread to the denuded Cloncurry Town Common, and was being distributed throughout the district.

Whittet (1923) described trials in New South Wales with buffel grass introduced from Pretoria, and referred to its success in "fairly dry localities, especially where the soil is inclined to be of a light, sandy nature". Another State Department of Agriculture officer, G. B. Brooks (1929) sowed buffel grass seed obtained from Port Hedland at "Archer", Rockhampton, in 1928. He referred to its excellent germination, rapid growth and heavy seeding, and remarked that it was evidently a very hardy grass, since it established under conditions fatal to Rhodes grass and paspalum. The late Queensland Government Botanist C. T. White in 1930 identified a buffel grass specimen from Alice Springs, N.T. In the early 1930's, experimental sowings were made in many Queensland districts, the first ones being located at Lawnton, St. Lucia, Queensland Agricultural College Gatton, Inglewood, and Scrubby Creek. Most early scientific reports were favourable, but one noted scientist spoke of "a low yielding species that might easily become a very undesirable weed of pasture". In 1934 the C.S.I.R. Division of Plant Industry included a buffel grass introduction C.P.I. 1848 ex Kenya in twelve pasture species sent to the Queensland Department of Public Instruction for use in school "hobby plots". In the grounds of the Gayndah school buffel grass became dominant; F. L. Rasmussen, a local teacher, encouraged children to collect seed, which was distributed locally to farmers. W. R. Gordon and J. Sandford established the grass on extensive areas of their properties; C. J. Pinwell subsequently acquired the property of J. Sandford, which became the principal source of commercial Gayndah variety seed.

In central western Queensland, G. L. Towner successfully sowed buffel grass in 1937 on "desert" country at "Thrungli" near Yalleroi. S. L. Everist, now Queensland Government Botanist, established the plant in 1938 at Blackall State School, and at the Barcaldine State Farm.

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Well over one hundred introductions of buffel grass have been made since those pioneering days. J. F. Miles (1949) grew C.P.I. 6934 (Type D ex Dodoma, Tanzania) at Fitzroy Vale, near Rockhampton; this was taller and more rhizomatous than the material so far mentioned, and Miles advocated regional testing. Work by B. Grof (1959) at Biloela Research Station led to its very successful release as Biloela variety. An additional five tall varieties have since been released. In 1954 S. Marriott of the Queensland Department of Primary Industries sent 2 oz of seed of a line Q.2953 to W. H. Rich of "Boorara" Yalleroi. Mr. Rich rapidly multiplied this line, and four years later it covered several thousand acres of land previously bearing gidyea *(Acacia cambagei)* forest. Molopo buffel was imported commercially into N.S.W. from South Africa in 1958, following earlier testing at Trangie, N.S.W. (Flemons and Whalley 1958). Nunbank variety, C.P.I. 12778 ex Uganda was released subsequent to work by L. A. Edye of the C.S.I.R.O. Division of Tropical Pastures at Taroom, where B. C. Clark multiplied seed very efficiently. C.P.I. 14365, Lawes, originally ex South Africa, a variety very similar to Molopo, and the tall green variety Tarewinnabar, C.P.I. 13246 also ex South Africa, were released in 1962.

Finally, reference might be made to the shorter variety American, which was commercially imported, and which appears to be identical with T4464 ex Texas A. & M. College.

Buffel grass has been the subject of agricultural extension activity in northern Australia at least since 1923. In addition to the authors already mentioned, there are many early summaries of performance, nutritive value, and recommendations for use (Winders 1937; Gardner 1941; McTaggart 1942; Schofield 1944, 1945, 1946; Snook and Durack 1946; Suijendorp 1953*a*, 1953*b*; Marriott and Anderssen 1953; Nunn 1954, 1958; Fitzgerald 1955; Mallet 1955; Wilson 1955; Allen 1956: C.S.I.R.O. 1957), whilst Young, Fox and Burns (1959) were the first workers to record stock productivity from a buffel grass pasture.

GENETIC VARIATION IN ADAPTATION

Buffel grass was believed to be an obligate apomict (Fisher, Bashaw and Holt 1954; Bogdan 1961) with apospory followed by pseudogamy suggested as the mechanism (Snyder, Hernandez, and Warmke 1955). Although great variation is found within the species, commercial varieties breed true to type. The discovery by Bashaw (1962) of sexuality in buffel grass and the subsequent use of apomictic male parents and sexual female parents in breeding programmes (Taliaferro and Bashaw 1966) has aroused interest. A. J. Pritchard (personal communication), has included Bashaw's material in Queensland breeding work; progeny have been derived which extend the existing range of such characters as flowering time and leaf density.

Considerable differences in morphological form and maturity are evident in the varieties in Australian commercial use, as indicated in Table 1. The components

TABLE 1.

BUFFEL GRASS VARIETAL CHARACTERISTICS.

(Mid-season, Brian Pastures, Gayndah).

Variety	Height (cm)	Stem. diam. (mm)	Percentage shoots vegetative	No. Main shoots/sq dm	Percentage leaf (by weight)	Seed fascicle wt. (mg)
West Australian	45	0.92	35	65	40	2.9
Cloncurry	60	1.20	50	34	45	3.7
Gayndah	60	1.31	94	41	45	2.2
Boorara	85	1.50	85	14	52	1.1
Biloela	99	1.78	65	15	47	1.3
Q1004 (Similar to Molopo)	105	1.45	99	12	54	0.8
Tarewinnabar	125	1.74	87	18	40	2.1

of yield are to a large extent compensatory, e.g. leaves in cv. *Biloela are longer, broader, and fewer than in cv. Gayndah, shoots are longer and sparser, seed fascicles are smaller but more numerous. However, experience over some scores of comparative varietal plantings in Queensland (e.g. Grof 1957) indicate that Gayndah, American, Cloncurry and West Australian varieties do not usually yield as much dry matter as the six tall commercial varieties. On the other hand, yield variation between these six has not been consistent from site to site e.g. cv. Tarewinnabar outyielded cv. Biloela and cv. Boorara at Brian Pastures Research Station, Gayndah and at Fanning River; cv. Molopo outyielded cv. Tarewinnabar, cv. Biloela, and cv. Nunbank at Biloela Research Station (Cameron and Courtice 1965); cv. Nunbank outyielded cv. Biloela at Lansdown (Edye 1966) whilst cv. Biloela and cv. Boorara have given equivalent performance at Brian Pastures and at Biloela Research Stations (Davidson 1966). There are many field trials (e.g. Bisset 1966) where total yields have been similar for these cultivars.

Climatic adaptation

The drought resistance of established buffel grass seems consistent (e.g. Fitzgerald 1955; Dolling and Sheaffe 1961; Bryant 1961*b*; C.S.I.R.O. Division of Tropical Pastures 1966; Winkworth 1966); although the shorter forms occur naturally in the more arid areas, some tall varieties such as Molopo and Biloela were originally collected from very dry country. The short varieties have shown poorer competitive ability with native grasses in Queensland. Buffel grass is intolerant of flooding and of soils with poor internal drainage.

Buffel grass grows less in cool weather than many tropical grasses. In an experiment in the CERES phytotron, S. Kawanabe and C. A. Neal-Smith (personal communication) found that relative growth rate (R.G.R) rose steeply from 15/10°C to 30/25°C, with a small further increment to 36/31°C. In contrast, green panic, paspalum, Rhodes grass, and *Panicum coloratum* had higher R.G.R's at 15/10°C. There is some field evidence to suggest that early spring and winter growth is superior in cv. Molopo, cv. Lawes and cv. Tarewinnabar. Winter killing is not common in Australian regions where sufficient summer rain occurs to make the growing of buffel grass worthwhile. Cameron (1959) recorded death of cv. Biloela at Cowra, N.S.W., whilst Evans (1962) found that cv. Molopo persisted at Temora, N.S.W., despite ground recordings below 20°F.

Edaphic Adaptation

Although buffel grass exhibits best growth on light textured, deep soils, it will also grow well on many clay soils (e.g. Young, Fox and Burns 1959). The more rhizomatous varieties such as Molopo are believed to show superior adaptation to heavy soils (Wilson 1961*a*; Cameron and Courtice 1965). Wilson (1961*a*) believes soil texture to be more significant than nutrition in determining colonisation success; requirements for establishment may well differ in importance relative to those for continued growth. W. H. Burrows (personal communication) found that seedling survival of cv. American under very low pH conditions was superior to that of Biloela, Gayndah and West Australian. In East Africa, R. J. Jones (personal communcation) found no natural spread of buffel grass on soils of pH below 7.0, although establishment after cultivation was good on soils of lower pH; most collections were made on soils of pH 7.0-7.5. The commonly noted inferior growth of buffel grass on Queensland coastal soils may be related to pH or confounded factors. Poor tolerance of salinity was demonstrated by Gausman, Cowley and Barton (1954).

Buffel grass responds to improved fertility, and its most rapid spread has occurred on soils of good nutrient status e.g. Cloncurry River alluvials, brigalow, softwood scrub and gidyea soils. It has a reputation as a phosphophilic grass; in

* Cultivar or variety.

early experiments at South Johnstone Schofield (1946) found it had the highest P content of any grass tested, and a high P/Ca ratio. On a lateritic red earth previously growing mulga at Charleville, Skerman (1958) found buffel grass very responsive to superphosphate and to trace elements. At Yalleroi on a red earth, Edye et al (1964) found that P. and N. were the chief nutrients limiting the establishment and growth of buffel grass. Somewhat unexpectedly, native spinifex pastures and buffel grass showed similar responses to the application of N.P.K. fertiliser; on the other hand, improved fertility favoured the competition of buffel grass with spinifex. Seedling survival of drought was enhanced by phosphate application; however, Winkworth (1964) stated that at Alice Springs in range seeding trials with buffel grass on spinifex land, top-dressing with complete fertiliser did not enhance survival of seedlings. Ebersohn and Lucas (1965) observed natural colonisation of buffel grass in the immediate vicinity of poplar box *(Eucalyptus populnea)* trees; this was absent in the inter-tree areas. "Available" P_2O_5 values averaged 156 p.p.m. in the 0-1 in. layer under the tree, compared with 51 p.p.m. in the inter-tree habitat; K values were also affected.

The finding of nutritional races in buffel grass would be of great practical significance. Humphreys (1958) examined the effects of variation in N and P supply on the growth characters of five *Cenchrus* genotypes. In general, responsiveness to nutrients was simply related to genetic potential for growth, but the effect of P supply on root growth differed; P application widened the shoot/root ratio more in varieties such as West Australian which already possessed a high shoot-root ratio.

Compatability

Norman (1962) showed that the tall Biloela variety suppressed a companion annual legume, Townsville lucerne, more than the medium height Gayndah variety, when these were grown at Katherine, N.T. Similar experience has been noted under Queensland conditions. The content of lucerne in Rhodes grass and green panic swards was greater than in Gayndah buffel swards at Brian Pastures (Young, Fox and Burns 1959).

ESTABLISHMENT

Seed Factors

The seed unit or fascicle of buffel grass comprises a cluster of one to three spikelets, enclosed in an involucre composed of two series of bristles. Caryopsis weight is usually 25-30 per cent of fascicle weight. Fascicle weight at Brian Pastures varied in one season to give a range of 85,000 to 550,000 fascicles per pound, according to genotype. (This might be contrasted with values of 40,000 to 90,000 per pound quoted by Whyte, Moir and Cooper (1959).) Caryopsis weight was determined on fewer samples, and varied from 0.5 to 1.1 mg, cv. Biloela registering high values. When this figure is compared with caryopsis weights of 15-20 mg for cultivated *Sorghum* species, the slower seedling growth rate of buffel grass is readily understood. Caryopsis weight is often independent of fascicle weight. Biloela had a higher proporton of single spikelets (an aid to dispersion), whilst the larger fascicles of cv. Cloncurry contained more double and triple spikelets.

There is evidence of genotypic variation in germination behaviour. Germination improves with storage (Winchester 1954; Fitzgerald 1955); the West Australian variety requires longer storage and may respond to moist chilling, in contrast to other varieties tested (Edye et al 1964). The ability of seeds to retain viability in dry soil for at least three years (Winkworth 1963*b*) is a distinct asset. Seeds respond to hammer milling (Grof 1957) or acid scarification (24N sulphuric acid for 30 min, Edye et al 1964); however, this increases germination at low soil moisture contents, with its ancilliary hazards. Norman (1960*a*) found no establishment benefit from milling at Katherine. Dry storage at 40° C increased establishment of freshly harvested seed at Brian Pastures from a density of 0.12 to 0.72 plants sq lk. Unexpectedly, a subsidiary experiment indicated that this effect was stronger at low soil moisture contents than at high soil moisture contents.

Pelleting buffel grass seed has been inconsistent in its effects. Norman (1961) and P. G. Walter (personal communication) found that pelleting with superphosphate depressed emergence; Champ, Sillar and Lavery (1961) were successful with basic superphosphate, and seed harvesting ants (*Iridomyrmex* sp.) were controlled with lindane. Flemons and Whalley (1958) recorded depressed emergence if seed was sown in contact with superphosphate; Bryant (1961*a*) showed that this effect was mitigated if seed and superphosphate were mixed immediately prior to sowing into a moist seed bed.

The Queensland Department of Primary Industries introduced in 1958 a seed certification scheme for Biloela and Gayndah varieties (Hibberd 1958). Certification was discontinued because of insufficient demand at premium prices for this grade of seed; advances in harvesting and cleaning techniques now make the standard then demanded (25 per cent germination, maximum 18 per cent inert matter) less exigent.

Sowing Techniques

Most successful sowings of buffel grass have occurred where the original vegetation has been destroyed. Buffel grass is a seral species; provided other factors are favourable, colonisation may well occur under conditions of denudation through overstocking, whether this be a permanent regimen or an intermittent one, as may arise after a prolonged drought. Invasion of undisturbed vegetation is a most likely event. The successful natural colonisation of the Cloncurry River alluvials and the Cloncurry Town Common have occurred under conditions of stock and fire disturbance. The rate of spread is not constant; colonization occurs mainly in seasons of above average rainfall.

Buffel grass has been sown extensively in cleared gidyea and brigalow (*Acacia harpophylla*) forests. Sowing techniques have been described by Marriott and Wilson (1962), Bisset (1963, 1964, 1966), Sillar (1963), Johnson (1964), and Purcell (1964, 1965). Purcell emphasises the importance of fire in providing ash for seed coverage and in controlling regrowth of false sandalwood (*Eremophila mitchellii*). However, in lower rainfall gidyea areas e.g. 13-17 in. annual rainfall in the Emmet-Yaraka area, insufficient fuel may be available for a successful fire, and broadcasting should be carried out soon after pulling operations. The initiative of Western Queensland landholders in sowing over half a million acres of otherwise poorly productive gidyea forest in the under 20 in. rainfall belt to buffel grass is a considerable achievement.

Buffel grass has saved large areas of the Queensland Brigalow Development Scheme from failure. Because of the adverse seasonal conditions in the early years of the recent settlement, some grasses such as Rhodes grass have often not established or have since died. The excellent performance of buffel grass under these drought conditions indicates a permanent asset. The superior behaviour of buffel grass has been especially noteworthy on the lighter brigalow soils, for example in the Arcadia Valley.

The degree of ground disturbance necessary for establishment is closely related to the competitive situation of the existing flora. On spinifex dominant land at Yalleroi, establishment was positively related to the degree of cultivation (Edye et al 1964); similarly at Brian Pastures in open forest country full cultivation was required and a preliminary fodder cropping phase beneficial (Norton and Cull 1966). The disturbance associated with pulled mulga and the more favourable moisture situation in stump holes has provided localised establishment conditions (O. W. Smith, personal communication; Wilson 1962*c*). Ripping (Wilson 1962*b*) and root ploughing (Wlson 1964) have specialised application. Plough furrow establishment allied with stock removal has promoted establishment on the Ord River (Nunn 1958).

Buffel grass was aerially seeded in 1926 on Mundabullangana Station (Nunn 1954), surely an early example of aerial agriculture. Seed flow difficulties are still encountered, and it is usual to seed from the plane no more than ¼ of the seed mixture by weight as buffel grass, e.g. in gidyea areas a common mixture is ⅓ lb buffel grass plus 1 lb sorghum alum per acre. Carriers such as sawdust have been used in ground drills (Wilson 1955); improvisations (Anderssen 1959) and new equipment (e.g. Fitzgerald 1958) were subsequently originated and commercial drills are now available which will sow buffel grass quantitatively.

Establishment is primarily dependent upon moisture conditions after sowing. Norman (1960*a*) found that at Katherine successful emergence (10 per cent) occurred where following rains maintained the top six inches of soil above wilting point for 5-6 days. Winkworth (1963*a*) advocated deep sowings; at Alice Springs the top inch of soil dried to below 15 atmospheres tension within one day of rain, whereas the 1-3 in. layer remained moist for 2-5 days. Edye et al (1964) found that in a moist loamy sand emergence was very little depressed from 2 in. depth. The usual recommended sowing depth in cultivated seed beds is 0.5 in.

Seedling Growth and Development

Studies of seedling growth and development, using conventional growth analysis techniques, were carried out at the University of Queensland in 1955 (Humphreys 1958) and at the Brian Pastures Research Station, Gayndah, from 1958-1960. Although all buffel grass varieties tested are early flowering (e.g. February sowings led to floral initiation 12 days after emergence in cv. West Australian and 24 days in cv. Biloela), seedling growth rate is closely related to maturity. The later flowering Gayndah and Biloela varieties sustain a higher growth rate into the autumn; this is principally due to less reduction in net assimilation rate with advancing season. It is of interest that the order of maturity in varieties is sensitive to sowing time: Gayndah variety is later than Biloela (which originates from a slightly higher latitude) if spring sown, but earlier than Biloela under shortening day conditions. Flowering extends over a long period. The peak rate of tiller differentiation occurs after first heading, but before maximum rate of inflorescence appearance: tillering is sustained at a reduced rate during seed maturation. The rate of leaf appearance is closely in sympathy with tillering. As might be expected, leaf weight ratio falls off more quickly in the earlier maturing varieties.

Maximum relative growth rates recorded on a whole plant basis were 0.35 g/g/day. Values of leaf area ratio were not large by comparison with world standards, but net assimilation rates recorded at Gayndah ranged up to 0.25 g/sq dm/day, a value in excess of most values registered at other centres. Buffel grass has a more massive root system than most other pasture grasses. A smaller proportion of the roots occurs in the upper soil layers than occurs in green panic. The root to total plant weight ratio may vary from as much as 0.7 four days after emergence to 0.1-0.3 60 days after emergence, according to conditions. The experimental evidence indicated very clearly that the ratio of the relative growth rate of roots to the relative growth rate of shoots remains constant, with values about 0.75-0.9 dependent on cultivar and growth regimen. The onset of flowering does not alter the relationships of shoot and root growth, as occurred in the experiments with temperate-type grasses reported by Troughton (1956). Consequently, the decision to commence grazing in the establishment year, insofar as this decision is influenced by the amount of rooting, may be taken on the basis of plant size rather than on the basis of flowering stage.

The root system of West Australian and Cloncurry varieties is smaller than that of Gayndah. The seedling drought survival of the former varieties is also inferior to that of Gayndah (Edye et al 1964), and any advantage these short varieties may possess in arid areas must be associated with some other factor, such as greater early seed production.

MANAGEMENT

Grazing and Cutting

Buffel grass, once established, is known to withstand severe grazing pressure; reports of critical management experiments dealing with this factor have not been sighted. However, some cutting experiments have been carried out. Norman (1960*b*) found at Katherine no significant differences in the dry matter yield of buffel/Townsville lucerne swards cut 1, 2, or 3 times per season, although the proportion of legume was increased by frequent cutting. At Lansdown Edye (1966) found that infrequent cutting increased yield, a finding also in sympathy with that of Lander (1942) for buffel grass in the Punjab, and of Schofield (1944, 1945) at South Johnstone. The latter workers also found that frequent cutting increased nitrogen content and nitrogen uptake.

At Brian Pastures, Humphreys and Robinson (1966) followed the growth of buffel grass and green panic plant organs and the accumulation of non-structural carbohydrate (total available carbohydrate or T.A.C.) under two extreme cutting regimes of 1 or 8 cuts per annum. Frequent defoliation reduced fluctuations in shoot growth rate, enhanced leaf growth and tillering, and reduced stem, inflorescence and root growth. T.A.C. accumulated in the roots during autumn, winter, and early summer, and was depleted in the spring. Buffel grass had both higher concentration and amount of T.A.C. than green panic; frequent defoliation reduced amount of T.A.C. Despite wide differences in root mass, T.A.C. tillering, and leaf growth, total shoot growth did not vary between treatment by more than eight per cent, suggesting that flexibility of management of established buffel grass swards is possible, with animal requirements and responses becoming the overriding factors.

Milford (1960, 1961) has drawn attention to the decline in nutritive value of sub-tropical pastures with advancing season and with time since cutting. He found that cv. West Australian buffel grass had a superior value (in terms of N content, N digestibility and N balance) to that of most grasses with which it was compared, and that large seasonal differences in dry matter digestibility and intake were not recorded at Gatton. On the other hand sheep exhibited less intake of cv. Biloela.

Purcell and Stubbs (1965) have found joint grazing of cattle with sheep to be beneficial on tall buffel pastures; cattle tend to eat the plant from the top down and create tracks for sheep access, whilst sheep eat more selectively the younger leaf and softer stem parts from the bottom and sides of the stool.

Fire

Field experience indicates that buffel grass will persist after firing. However, since more effective dry season use can be made of buffel grass than most natural pastures, the need to burn to promote accessible green leaf need not become acute.

Irrigation

Buffel grass is rarely grown under conventional irrigation, but the practice of "water spreading" has increased rapidly in south-western Queensland. These water redistribution schemes, in which run-off water from hard sloping land is collected and flooded over gently sloping areas of better fertility (Cull 1964), often have buffel grass as a major component. The growth of feed and duration of green feed availability may be increased for strategic animal husbandry practices, or seed production promoted to provide for property re-seeding needs (Wilson 1961*b*, 1962*a*).

Seed Production

Seed production is enhanced by row culture and by proper nutrition. The application of nitrogenous fertilizer, at least in Queensland sub-coastal areas, gives a high economic response. The Molopo variety, once described as shy-seeding, has given seed yields as high as 450 lb per acre at high levels of nitrogen fertilizing (D. G. Cameron, personal communication). Applications in excess of 200 lb N per acre as split dressings are indicated.

The uneven ripening of buffel grass and its bristly involucre have caused harvesting difficulties. Simple harvesters have been improvised (Stevens 1957; Cull 1963) and considerable improvements effected in subsequent cleaning; Messrs. Kirby Bros. of Dirranbandi and D. McWilliam of Blackall were among the pioneers of mechanical harvesting.

CONCLUDING OBSERVATIONS

In this review attention has been concentrated on Australian reports; African, Indian, and American studies are also available. It is believed that buffel grass will continue to occupy a dominant role in the pastoral development of northern Australia. Buffel grass will be used as a perennial pasture component in inland and sub-coastal areas where drought and fire resistance and ability to withstand heavy grazing are at a premium.

Buffel grass is not regarded as a ley species. Although improvements in soil structure are effected (Humphreys and Robinson 1966), the plant is difficult to eradicate by ploughing and the massive, fibrous root system affects nitrogen availability adversely. J. K. Cull (personal communication) found at Brian Pastures that the yield of a first crop of sorghum following buffel grass was about one half of the sorghum yield following green panic or Rhodes grass.

It is believed that buffel grass improvement programmes should concentrate on seeking improved stock intake, later flowering, improved seedling vigour, wider nutritional adaptation, and better cool season growth. The use of buffel grass has meant more effective exploitation of the physical factors of the environment; more edible feed has been produced in place of woody species or less acceptable herbage. This development has been rarely associated with legume sowings, and the need to find suitable companion legumes for buffel grass represents an outstanding challenge to scientists.

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