Pastures for production and protection:
Pastures on cropping soils

Which grass for where?

B.G. COOK[1] AND R.L. CLEM[2]
[1] *Department of Primary Industries, Gympie, and*
[2] *Brian Pastures Research Station, Gayndah, Queensland, Australia*

Abstract

Grasses comprise a relatively old group of flowering plants found in most of the land environments of the world. They vary from low-growing herbs to tall, woody bamboos, and have developed a variety of mechanisms to survive under a wide range of conditions. This has led to variation in growth habit, soil preferences, drought and flood tolerance etc. which humans can use to their benefit. This paper discusses the development of diversity within the grasses, and describes the characteristics of a number of exotic warm season species that can be used for forage, soil conservation and soil improvement in the subhumid subtropics of Australia.

Introduction

Grasses in general are perennial and annual plants, mostly herbaceous, with fibrous root systems and parallel veins in the leaves. They resemble, but should not be confused with, the similarly shaped group, the sedges, the best known of which is unfortunately called nut *grass*. The fossil record has grasses dating back at least to the Eocene epoch (54 to 38 M years ago) of the Tertiary Period, but they are probably much older. Since they occur on all continents, we must conclude that they date back at least to the Jurassic Period (245 to 208 M yr ago) when the supercontinent, Pangaea, started to separate into Gondwanaland and Laurasia, which subsequently broke up into the continents as we know them today. Some grass species are found on more than one continent, suggesting those species had evolved and spread before the continental plates separated. For example, the Australian Tropical Forages Genetic Resource Centre holds seed of the species we call forest bluegrass (*Bothriochloa bladhii*), collected not only in Australia, but also in India and Madagascar. To the casual observer, these look like different grasses, but to the botanist, they are sufficiently closely related to be considered the same species. With movement of the landmasses, and through other influences, the environments in which the various grasses were growing have undergone constant change. Grasses had to adapt to the changes if they were to survive. Consequently, they have developed into a very diverse group of plants.

They range in shape from minute herbs less than 2 cm high to giant bamboos over 30 m high, and exist in almost every imaginable habitat–temperate to tropical, desert to swamps (fresh and brackish water), coastlines to high mountains, and even in the Arctic and Antarctic regions. Just under 800 genera and 10 000 species of grasses have been described, making the grass family, *Poaceae* (formerly *Gramineae*), the fifth largest among the flowering plants. Natural grassland and grass-dominant savannas cover over 30 per cent of the land area of the earth. Grasses provide an enormous economic and social benefit to man. Most of the world's population are dependent on grasses such as rice, maize and wheat, and the other cereals as their food staples. Other grasses including sugar cane, bamboo and lemon grass also have a role in human nutrition. In some parts of the world, grasses such as bamboo and various thatch grasses are used to provide human and livestock shelter. However, this paper focuses on that group of grasses whose importance derives from their ability to supply nutrients to grazing animals, to suppress weeds, to protect soil and to improve soil structure and soil organic matter.

Correspondence: Bruce G. Cook, DPI, PO Box 395, Gympie, Qld 4570,Australia. e-mail: cookb@dpi.qld.gov.au

Plant adaptation

As noted above, grasses have developed in a multitude of ever-changing environments, which changes, over time, may have been as extreme as from rainforest to desert, or from temperate to tropical. Also during this period of grass evolution, animals have evolved that utilise grasses as feed, placing another selective pressure on this group of plants. For any organism to survive change, it must develop a mechanism or mechanisms to accommodate the change, and grasses have been no exception. The mechanisms developed to help survival under a given set of conditions vary from species to species, and any one species may have developed a range of mechanisms to tolerate a particular facet of the environment. For example, let us consider grasses from dry environments. What systems have they developed either to improve access to deeper soil moisture, or to minimise the amount of moisture lost? Obviously, a deep root system as found in buffel grass (*Cenchrus ciliaris*) or the various sorghums, assists the plant to obtain water as the surface dries out. Development of a hairy leaf surface as in green panic (*Panicum maximum* var. *trichoglume*) reduces evaporation from that surface, thus helping to minimise moisture loss from the plant. Plants have developed other systems to help ensure long-term survival in a dry environment. Where there is a pronounced wet season of say 4 months followed by 8 months without rain, as happens in parts of India, plants often escape the dry period by completing their life cycle in the period of adequate moisture, *i.e.*, they behave as annuals. They survive the dry period as seed in the soil, so when the rains come, the seed germinates, and the plants grow and set seed before the onset of the next dry season. In the same environment, other plants, including some bluegrasses, assume dormancy, thus reducing their metabolic activity.

Grasses have also developed a variety of methods of surviving in the presence of grazing animals. The most obvious of these is where the plant develops characteristics that make it less attractive to the grazing animal. Some grasses such as giant paspalum (*Paspalum urvillei*) and lemon grass (*Cymbopogon citratum*) appear succulent but are eaten only when no other feed is available. There may also be relative differences in palatability between 2 varieties of the same species. For example, Callide rhodes grass (*Chloris gayana*) is usually selected by cattle in preference to Pioneer rhodes grass at the same stage of growth; and Bisset creeping bluegrass (*Bothriochloa insculpta*), to the earlier released cultivar, Hatch. Other grasses avoid grazing damage by virtue of high fibre levels in the leaves, making it almost impossible for the animal to remove the leaf. A topical example here is the Zimbabwean species, giant rat's tail grass (*Sporobolus pyramidalis*), which is currently invading large areas of coastal and subcoastal Queensland. Finally, some grasses have adapted to the grazing animal by evolving a system that protects the growing points of the plant, despite removal of leaves. In tussock grasses, this may simply be by virtue of a low central growing point (apical meristem), an example being the new cultivar, *Paspalum atratum* cv. Hi-Gane. Other grasses have developed stems that creep across the surface of the ground, stolons, as in blue couch (*Digitaria didactyla*) and Indian bluegrass (*Bothriochloa pertusa*), or under the ground, rhizomes, as in johnson grass (*Sorghum halepense*) and brunswick grass (*Paspalum nicorae*). Stoloniferous and rhizomatous species can usually tolerate heavy grazing, and are often indicators of overgrazing.

Since many of our imported warm season grasses come from Africa, it is useful to illustrate how some of these species are distributed in their native environment. In 1971-72, a CSIRO scientist, R.W. Strickland, undertook an extensive plant-collecting trip in southern and eastern Africa, during which he collected 118 species of grass covering 36 different genera (Strickland 1972).

Some species were found in most or all of the 11 countries visited, and over a range of soil and rainfall conditions *e.g. Digitaria milanjiana* and *Panicum maximum*. Quoting from his report: "*D. milanjiana* occurs in all countries visited with a latitude range of 2° N to 24° S, an altitude range of 30 to 1667 metres and a rainfall range of 425 to 1700 mm, either bimodal or over 5 to 6 months with a prolonged dry season. It occurs in grassland, savanna, or woodland, in tall grass associations and in short grass associations. It is the most widespread species encountered, occurring on acid, neutral and alkaline soils ... *Panicum maximum* ... was collected in every country visited with the exception of Namibia in the latitude range 2° N to 33° S, altitudes from 15 to 1818 metres, and acid to alkaline soils ranging in texture from sand to clay-loam with rainfalls between 250 and 1600 mm per annum. This species is invariably associated with woodland in the better rainfall areas where it assumes the robust form normally associated with it in Australia. In drier regions of Mocambique (now Mozambique), Rhodesia (now Zimbabwe), Botswana, Zambia and South Africa, however, it is only to be found around the base of trees growing in shade. On the Kalahari sands of Rhodesia and Botswana it behaves as a slender annual around the base of trees and more rarely as a biennial ... It is generally regarded as having very little persistence under grazing." This wide-spread distribution and diversity of habitats suggest these are either very variable or adaptable species. Either way, providing they have good quality and production characteristics, it draws attention to their being a source of genetic material that might be exploited. In Australia, we have 3 cultivars of *Digitaria milanjiana*, and 5 of *Panicum maximum*, selected for a range of habitats.

Other species were more restricted in their distribution *e.g.* the very palatable *Anthephora pubescens* and *Brachiaria nigropedata*. "*Anthephora pubescens* occurs in the drier (175–500 mm rainfall) regions of Southern Rhodesia (Zimbabwe), South Africa, northern Botswana and northern Namibia. It is usually ... on acid to neutral sands to sandy loams" and "on deep sands" (in different parts of Botswana) "and on heavier soils in Namibia." "*Brachiaria nigropedata* occurs on neutral sands to sandy loams in western Rhodesia, Botswana and Namibia with rainfall of 400 to 575 mm ... ". While both species are recognised as having valuable forage characteristics, neither has been commercialised to date, possibly due to restricted adaptability.

While the function of many characteristics found in grasses, such as deep roots, hairy leaves, rhizome development etc., is obvious, there are other less obvious characteristics which may be no less important in selecting species that might be useful to man. One of the most useful of these is differential response to herbicide. There is, of course, no reason why such inherent differences should occur, since herbicides are a modern adjunct to biological systems. The differences undoubtedly relate to another biochemical system in the plant, and bear only a casual relationship to modern chemicals. Regardless of the reason for their development, these differences can be important in synthesising a forage system. For example, we know that seedlings of the serious pasture weed, giant rat's tail grass, are susceptible to atrazine, and that those of certain other grasses are less affected or unaffected by the chemical. This then provides us with a potential tool in eliminating giant rat's tail and replacing it with a species that cattle can graze.

Native grasses

It should be noted that our native grasses are no less variable than the exotics quoted above. Species such as kangaroo grass (*Themeda triandra*), black speargrass (*Heteropogon contortus*) and Queensland bluegrass (*Dichanthium sericeum*) all show considerable variability, even within a fairly small area. However, the selection pressures from grazing on these native species have been different from those on many of their exotic cousins. In Australia, grasses have mostly developed under the fairly lax grazing pressure imposed by marsupials. As a result, many of our native species have been unable to tolerate the grazing pressures imposed in commercial live-stock production systems, and considerable areas of native pasture are in a state of decline. By contrast, many of the exotic grasses, particularly in Africa, have evolved under conditions of heavy grazing by large wild herds, and are better able to tolerate commercial extremes. Many of the native grasses have also responded to the vagaries of the Australian climate coupled with the often shallow soils, by developing the early-flowering characteristic to ensure seed set in favourable conditions. This limits their nutritive value to animals at the end of the growing season. Once again, exotic species that have evolved under more reliable, though not necessarily better, moisture conditions, may have characteristics that are different from those of our native species. These characteristics may be used to our advantage.

The sustainability issue

We are becoming increasingly aware of the need to have sustainable farming systems. Expanding on the theme presented by Gomez *et al.* (1996), these may be defined as: *systems that satisfy the needs over time of farmers today, at the same time conserving the resource and not compromising* *the needs and aspirations of farmers of the future.* No farming system can be considered sustainable if it is not profitable, and to be so, it must produce to satisfy the more rewarding markets. Further, it cannot be profitable in the long term if it contributes to a decline in the natural resource base. It is being increasingly recognised that traditional systems must be modified if a greater measure of sustainability is to be achieved. Current grazing practice is leading to decline of desirable species, and an increase in the proportion of less-desirable species in many of our native and sown pasture areas. Similarly, cropping practices that contribute to declining soil organic matter levels and soil loss are also challenging sustainability.

The right grass

We need to analyse current practice and determine what interventions are necessary to reverse any negative production trend that may be developing. In grazing systems, it may be necessary only to reduce stock numbers and/or adopt different pasture management. However, early maturing native grasses may place a ceiling on levels of production achievable, and later-flowering species may be necessary to extend the growing season. Land prices may influence decisions on stock numbers necessary to receive a return on investment, indicating a need for more productive and grazing-tolerant species. In cropping systems where soil organic levels are declining, there may be benefit in incorporating a pasture phase to facilitate increase in soil organic matter. Where excessive grazing or stock activity is contributing to erosion, rhizomatous and stoloniferous grasses may be necessary to provide the level of ground cover needed to reduce the erosion risk significantly. In all cases, exotic grasses will probably be involved in developing more sustainable practices or systems, since there are few native species with the appropriate combination of characteristics to achieve the various goals. Even where native grasses are appropriate, low seed availability may preclude their use.

When planting grasses, it is important to define the environment where the grass is to be sown, and to know the range of adaptation of the list of potential sown grass varieties. The environment description, while including the more obvious soil and climatic variables, also should include human-controlled factors such as fertiliser inputs and likely grazing pressure, since these also impact on selection of a grass for a particular situation. It is also necessary to determine expectations for the pasture. For long-term pasture, it may be more appropriate to select a less-productive, more-persistent species than for a short-term pasture. If the pasture is only a temporary measure to improve soil structure and fertility, only species that pose minimal weed threat to subsequent crops should be selected. The following outlines the more important characteristics of some of the major sown grasses with potential in the cropping lands of central Queensland. Further details about these species can be obtained from the DPI Web site http://www.dpi.qld.gov.au/ and hitting on "DPI Notes" or "Plants" and selecting "Pastures".

Bluegrasses

Forest bluegrass (Bothriochloa bladhii). Perennial tussock; native varieties mostly erect to about 1m high; cv. Swann lower-growing and less upright. Swann best adapted to well-drained, low to medium-fertility soils; forms good drought-hardy ground cover. Well eaten by cattle before onset of flowering; tolerant of heavy grazing.

Creeping bluegrass (Bothriochloa insculpta). Stoloniferous perennial to about 1 m high; cv. Hatch less stoloniferous and earlier flowering than cv. Bisset; grows best on moderately fertile, well-drained, dark and red clays and clay loams, not well suited to sandy soils; forms good drought-hardy ground cover. Well eaten by cattle, tolerant of heavy grazing. Flowers in April-May, later than many native grasses.

Indian bluegrass (Bothriochloa pertusa). Stoloniferous perennial from 20-80 cm high; numerous types naturalised in Queensland, ranging from the very early flowering Bowen type to the late flowering Medway, Dawson and Keppel/Yeppoon types; Medway and Keppel tall and leafy, Dawson a low-growing, widely adapted turf type; Bowen not preferred for any purpose. All best adapted to well-drained, low-fertility, well-structured or hard-setting soils; form good, drought-hardy ground cover. Well eaten by cattle before onset of flowering; very tolerant of heavy grazing.

Sheda grass (Dichanthium annulatum). Perennial to about 60 cm high, tufted, spreading and stoloniferous; best adapted to dark, near-neutral clays and clay loams of at least moderate fertility;

good salt tolerance; tolerant of drought and short duration flooding; forms good ground cover. Well eaten by stock, and withstands heavy grazing.

Angleton grass (Dichanthium aristatum). Perennial tussock to about 1 m high, with some ability to spread by poorly developed stolons; best adapted to dark, near-neutral clays and clay loams of at least moderate fertility; highly tolerant of salt, poor drainage, and flooding, also drought-hardy. Widely naturalised in southern and central Queensland; leafy, productive, very palatable cultivar, 'Floren', released recently. Forms good ground cover, even under heavy grazing.

Queensland bluegrass (Dichanthium sericeum). Erect, fine stemmed perennial tussock to about 60 cm high; variable leaf colour and hairiness, stem thickness, and leafiness; native to fertile, friable black clay soils; drought-hardy. Very palatable to stock before commencement of flowering in summer; not tolerant of heavy grazing; little value for soil conservation. Limited seed available commercially.

Grasses with foxtail seedheads

Buffel grass (Cenchrus ciliaris). Mostly perennial tussock from 30 cm to 1m high, often with short rhizomes; deep, coarse, fibrous root system; many varieties but low-growing cvv. Gayndah and American, and taller cvv. Biloela and Nunbank most commonly used today. Grows best on well-drained, fertile, lighter-textured soils, but also grows well on brigalow and gidgea clay loams and clays. Extremely drought-hardy, but not as salt-tolerant as rhodes grass, or flood-tolerant as Bambatsi panic and angleton grass. Has declined as native fertility declines, and as a result of more recent undefined problem. Forms good ground cover, is well eaten by cattle but has been associated with bighead disease (osteodystrophia fibrosa) in horses due to high oxalate levels in the plant (Everist 1981).

Purple pigeon grass (Setaria incrassata). Perennial tussock to about 1.5 m high; cv. Inverell. Well adapted to fertile, black, cracking clay soils; establishes readily; drought-tolerant but intolerant of waterlogging; early flowering; considered least palatable of introduced grasses; contains oxalate and can cause bighead in horses. Can form dense stands thus limiting erosion.

Rhodes and star grasses

Rhodes grass (Chloris gayana). Stoloniferous perennial to 1.5 m high. Range of cultivars released; cvv. Callide and Samford late-flowering, more palatable types; cvv. Pioneer and Katambora earlier flowering, less palatable, more adaptable types; cv. Nemkat a newly released selection from Katambora, low nematode problem; cvv. Topcut and Finecut derived from cvv. Pioneer and Katambora, respectively, as hay varieties, not as palatable as Callide. All prefer fertile, well-drained soil, and tend to decline as nitrogen levels decline; one of the best grasses for salty areas; good, moderately drought-hardy ground cover. Readily controlled prior to cropping. Good for both cattle and horses.

Star grass (Cynodon nlemfuensis, C. aethiopicus). Stoloniferous, mat-forming perennial; excellent for soil conservation, good forage when young, but very difficult to control in cropping land.

Finger grasses

Milanje finger grass (Digitaria milanjiana). Stoloniferous perennial, often over 1m high; diverse species originating from wide range of climates; two morphologically distinct cultivars released in Queensland, Jarra and Strickland, agronomic distinctions not clear at this stage; cv. Arnhem released in the Northern Territory.

Digit grass/woolly finger grass (Digitaria eriantha). Tufted perennial, usually less than 1 m high; two cultivars released, Premier and Apollo, but only Premier available; best in the subtropics on well-drained, not necessarily fertile, sandy soils, but will grow on more fertile lighter clays. Drought-hardy, but intolerant of waterlogging. Well eaten by livestock, and tolerant of heavy grazing. Not well suited to erosion control. Pangola grass belongs to this species but is completely different from the two cultivars; although ideal for grazing and erosion control, it would be difficult to eradicate in a cropping system.

Panics

Makarikari grass (Panicum coloratum). Erect, perennial tussock to over 1m high, short rhizomes. Grows best on fertile, self-mulching, black clay soils; moderately drought-hardy and very tolerant of flooding and waterlogging; good salt tolerance; slow to establish. Tolerates heavy grazing once established. Not effective for erosion control.

Panic (Panicum maximum). Perennial erect tussock to about 1.5 m high; some types, the guinea grasses, grow much taller but are not relevant here; two main cultivars are Petrie (green panic) and Gatton. Grow best on fertile, well-structured, well-drained soils; moderately drought-hardy; intolerant of waterlogging and salinity. Green panic early flowering, Gatton later. Both very palatable, particularly before flowering; not tolerant of heavy grazing; decline as soil nitrogen declines. Not effective for erosion control; green panic shade-tolerant.

Other

Silk sorghum (Sorghum *hybrid*). Erect, perennial tussock to 3 m high; well-adapted to fertile, heavy clay soils; establishes readily. Productivity declines rapidly as nitrogen fertility declines. There are many other *Sorghum* species and hybrids that may be useful in beef/cropping systems.

Sabi grass (Urochloa mosambicensis). Stoloniferous perennial, usually to no more than 60 cm; cvv. Nixon and Saraji (selected for mine-waste revegetation); adapted to lighter soils of moderate fertility; establishes readily; well eaten by cattle, and tolerant of heavy grazing. Provides excellent ground cover for erosion protection.

Conclusion

This paper gives some insight into the extent of the diversity within the grass family, and how this came about. It also discusses how specifically or broadly adapted grasses might be, and how important it is to understand this variability in form, makeup and adaptation, in selecting a grass for a particular situation. However, technologies cannot be static. They need to be adapted to changing environments, perceptions and priorities. Species and cultivars described here may become less relevant as soil fertility declines, with developing salinity, or if a new disease were to appear. High-input systems may become a consideration if commodity prices were to improve. It is therefore important to monitor the situation, and be prepared with alternative technologies should the need arise. The decline of buffel grass in some areas, and the invasion of giant rat's tail grass in others, are current problems challenging existing technologies and demanding alternative solutions. The best model to maintain a sound level of preparedness is through close collaboration between the farming and research communities.

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Summary of discussion

Q. The dominance of buffel grass in central Queensland is an issue for two reasons. Producers rely heavily on it for grazing and hence would be severely affected by its decline due to pests or diseases. It is of concern because of its environmental impact on native fauna. Are there alternative grasses? (Ross Gutteridge, The University of Queensland).

A. Other buffel grass types especially those more readily eaten than the taller varieties could be used as could several grasses tolerant of lower nitrogen *e.g. Bothriochloa.*

Comment (Mike Gilbert, Dept of Mines and Energy). A monoculture of buffel is not necessarily a problem. They are created by us but are often temporary. If gaps occur, replacements are actively sought and where there is a slow decline, other species will often colonise. Monocultures rarely occur in the wild, so it is unlikely they will be here in the long term.

Q. Is there any danger that new grasses will not be released? (Peter Emmery, producer, Marlborough).

A. This depends very much on how the need for pasture plants in the beef industry is promoted and how these effects can be shown to flow into the economy.