Department of **Agriculture and Fisheries**
Biosecurity Queensland

Invasive plant risk assessment

Aleman grass

Echinochloa polystachya

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Identity and taxonomy

Taxa

Echinochloa polystachya (Kunth) Hitch.

Subordinate taxa

Echinochloa polystachya (Kunth) Hitch. var. *spectabilis* (Nees ex Trin.) Mart. Crov.

Synonyms

Echinochloa spectabilis (Nees ex Trin.)
Panicum spectabile Nees ex Trin.
Panicum bonplandianum Steud
Oplismenus polystachyus Kunth.
Echinochloa praestans PW Michael

Common names

Aleman grass, German grass, carib grass (Australia, Panama), river grass, Yerbia de rio, Zacate aleman (Spanish), corzo grass (Cuba), creeping river grass (North America), pasto alemin, pasto chiguirera, paja pelu (Venezuela); pardegrao, prasi-grasi (Surinam); capim-mandante (Brazil), African wonder cockspur; mudflat-millet, Habetz grass, perennial barnyard grass, water Bermuda (AFRIS 2006; Gri n 2006; Judd 1975; Medeiros et al. 2003; Shepherd *et al*. 2001; Cook *et al*. 2006; Csurhes & Edwards 1998).

Taxonomy and genetics

Kingdom	*Plantae*—plants
Subkingdom	*Tracheobionta*—vascular plants
Superdivision	*Spermatophyta*—seed plants
Division	*Magnoliophyta*—flowering plants
Class	*Liliopsida*—monocotyledons
Subclass	*Commelinidae*
Order	*Cyperales*
Family	*Poaceae*—grass family (alt. Gramineae)
Sub-family	*Panicoideae*
Tribe	*Paniceae*
Genus	*Echinochloa* Beauv.—cockspur grass
Species	*Echinochloa polystachya*—Aleman grass

Description

Aleman grass is an aquatic or semi-aquatic perennial with course culms 1–2.5 m high, thick in the lower parts, from long rhizomes, internodes glabrous, nodes glabrous or obscurely pubescent (see cover photo). Ligule a rim of stiff, yellow hairs to 4 mm long. Leaf blades 20–60 cm long 10–25 mm wide, scabrous on the margin. Panicles mostly 15–25 mm long, dense, the short, thick branches ascending. Spikelets 5–7 mm long, lanceolate. Upper floret hermaphrodite, 5–6 mm long, with awn 5–7 mm long, or mucronate; lower floret staminate with awn on lemma 7–17 mm long. (Cook *et al*. 2006; Wildin 1988).

The cultivar 'Amity' commonly planted in Queensland differs from the species norm in having flowering culms 100–200 cm long, 7–10-noded, nodes glabrous. Ligule hairs 1–1.5 mm long. Leaf blades 30–36 cm long, 10–12 mm wide. Panicle axis 20–30 cm long. Spikelets 4.5–5.5 mm long, 1.7–2.0 mm wide. The most distinctive differences are the much shorter mucros of the lemmas of 'Amity'; the lemmas of Aleman grass are normally awned rather than mucronate (Cook et al. 2006; Wildin 1988).

'Amity' has flat linear, glabrous leaves, tapering to a narrow apex, rounded or auriculate at the base. Panicle axis scabrous; primary branches with spikelets appressed to the rachis, 2.5–9.0 cm long. Pedicels 0.2–2.0 mm long, scabrous, disarticulation at the base of the spikelet. Spikelets plano-convex, lanceolate. Lower glume 2.5–3.0 mm long, ovate-lanceolate. Upper glume 4.5–5.5 mm long, lanceolate 6–7-nerved, chartaceous, glabrous, strigose on the nerves apically, acuminate, 5.0–5.5 mm long. Lemma of lower floret 5.0–5.5 mm × 1.0–1.5 mm, lanceolate, chartaceous, 7–9-nerved, the surface glabrous, acuminate, with mucro 1.0–1.5 mm long; lower palea linear, acute. Upper floret lemma 4.5 mm long, white, cartilaginous, smooth, ovate-lanceolate, acuminate, with mucro 0.5 mm long; upper palea cartilaginous, smooth, enclosed at its apex by the lemma. (Cook *et al*. 2006; Wildin 1988).

Reproduction and dispersal

In its native range in Brazil, the majority of seed is destroyed by the larvae of an insect from the family Cecidomyidae (Junk 1970). The remainder is eaten by different bird species of the family Anatidae (Junk 1970). Junk (1970) reported that even though laboratory investigations showed that the seeds could germinate in its native habitat, vegetative reproduction was predominant. Although few seeds are produced by weedy Aleman grass in Louisiana, laboratory tests show that germinability is high (70%) and seedlings have good vigour (Bottoms et al. 2006). In Texas, Aleman can have seed yields of 98 lbs/acre (110kg/ha) and averages 495 000 seeds/lb (1 090 000 seeds/kg) (Kadin 2001). Kadin (2001) states that poor seed fill and poor seed retention can be a problem. Reproduction by seed in Queensland is claimed not to occur. No viable seed production has been recorded in Central Queensland (Wildin 1988). However, germination studies in Texas showed that seed harvested from plants grown partly submerged in a wetland trough have significantly better germination (41%) than seed harvested from an irrigated field planting (0%). There were also effects between year harvested and method of seed storage, wet versus dry (Lloyd-Reilley 2002). Further studies will need to be conducted to determine that optimum inundation and drawdown periods that stimulate seed production in Aleman grass.

On a district scale, dispersal occurs when pieces of stems and their roots are broken and carried by floodwaters. After Aleman grass invades a new location it spreads by the growth of decumbent stolons. After establishment occurs shoots grow from the nodes. On a wider scale, Aleman grass is dispersed through the intentional actions of graziers, such as field trials, farmers giving each other samples and occasionally as an ornamental (Darke & Griffiths 1992).

Aleman is normally planted from stem or stolon cuttings (1–2 t/ha) at spacings of 1–4 m between rows and plants within the rows. Stem sections with 2–3 nodes are planted with 1 node above the surface. They can be planted manually into wet mud or dropped into the surface of shallow water and pushed into the soil by special wheels on a lightweight tractor. Establishment is most successful where competition from existing vegetation has been removed (Cook *et al.* 2006).

Wood et al. (1996) compared the primary and secondary establishment of Aleman grass into an established waterlogging tolerant pasture (*Cynodon dactylo*n and *Paspalum paspaloides*) and bare soil in a new ponded pasture on Daly Creek near Yeppoon. Establishment was measured after four and nine months. Root competition did not influence Aleman grass productivity until the secondary establishment stage (Table 1). Ramet formation was greater in number (P = 0.003) and in average dry weight (P = 0.004) in the absence of competition. Ramets altered the source-sink relationship, with the average ramet dry weight greater than the parent and a 60% reduction in the survival of primary tillers in the pasture (20% reduction in the bare soil).

Table 1. Comparison of Aleman grass productivity at the primary and secondary growth stages planted in bare soil and in resident pasture (standard deviation in brackets) (from Wood *et al.* 1996).

	Primary establishment 2.4.1995		Secondary establishment 25.9.1995		
Pasture status	**No secondary tillers**	**Primary tiller length (cm)**	**No ramets per parent**	**Dry wright parent (g)**	**Ave. dry wt. ramet (g)**
Bare soil	2.6 (1.7)	29.9 *18.5)	1.8 (1.1)	16.2 (10.2)	32.9 (72.6)
Pasture	2.7 (1.2)	23.9 (18.0)	6.0 (3.7)	30.7 (13.3)	71.1 (23.6)

Phenology and seed production

The lifecycle of Aleman grass in Lago Camaleão, and elsewhere in the Amazon floodplains, is regulated by the annual oscillation in water level. When the water level drops exposing the sediment surface in October, new shoots form at the nodes of old stems, and root in the sediment. The old stems die and rot away so that each of the new shoots becomes an individual plant. Each new plant normally remains as a single unbranched shoot. A single cohort of new plants is produced annually at low water, with little overlap between generations. The stands are perpetuated by vegetative reproduction. As the water level rises to cover the sediment in late November or December, the stems grow upwards, keeping pace with the steady rise in water level. As each node becomes submerged its leaf dies and adventitious roots form. In the white-water rivers that feed the floodplains bearing Aleman grass, inorganic phosphorous and nitrogen concentrations range from 62–100 mg m^{-3} and from 140–211 mg m^{-3}, respectively (Piedade *et al.* 1992). The flow of such nutrient-rich water over the adventitious roots of Aleman grass, in effect, provides a natural flowing hydroponic system, which continuously delivers nutrients to the roots of growing plants. New leaves are formed at the top of the stems with sufficient rapidity to maintain a dense canopy.

As the water level drops, the stems become increasingly exposed and bent, eventually collapsing onto the re-exposed sediment surface in October (Piedade *et al*. 1991; Piedade *et al*. 1997).

When there is no sediment exposure, the old stems can survive until another dry time, but the productivity of the following cycle will be lower (Pompêo *et al*. 2001).

Seed longevity

Neither the longevity of Aleman grass seed nor the persistence of its seed bank (if it exists) is not known; however, the related species, barnyard grass (*Echinochloa colona* (L.) Link) shows a persistence of 2% after two years at 0–2 cm depth and 19% at 10 cm depth in a controlled non-disturbed experiment (Walker et al. 2006).

Origin

Echinochloa polystachya is a tall C4 grass with a pseudo-annual lifecycle, which is in phase with the annual cycle of water levels in the central Amazon. It is one of the most frequently encountered aquatic grasses in the Amazonian Várzea rivers (Colares and Colares 2002). It is estimated that the area of the Amazon floodplains covered by Aleman grass is in the order of 5000 km2 (Piedade *et al*. 1997).

History of introduction

It is believed that Aleman grass was initially imported into Australia in the 1970s. The cultivar of Aleman grass used was called Amity and it is coded as CPI 61147. The original specimen's provenance is from the Orinoco Delta in Venezuela. This material came via the International Research Institute in Tucupita, Venezuela; this was also the source of the Australian Weed of National Significance, hymenachne, *Hymenachne amplexicaulis*.

Aleman grass was introduced to supplement the use of para grass because it could grow in water more than 30 cm deep, it is resistant to leaf hopper damage, it is more palatable to stock, and up to 50% more productive than para grass (Wildin & Chapman 1988). This low maximum depth restricted the water storage capabilities of ponded pastures. Aleman grass can grow in water that is seasonally up to more than 2 m deep, which means more water can be stored in the ponded areas, enabling it to last longer in the dry season. The greater amount of water is also better at protecting the grass against frost.

The original testing sites for this grass were in Central Queensland, especially on the property Granite Vale situated on Amity Creek near St. Lawrence. Granite Vale was also a property on which hymenachne was initially tested. The Queensland Herbage Plant Liaison Committee approved Aleman grass for general release in July 1988 (Reg. No. A-25a-1) (Wildin 1988).

In the 1996–97 CSIRO Northern Australia Beef Producer Survey, 14% of respondents in the Central Queensland coastal region, 14% of respondents in the Central Highlands, 17% of North Queensland and 11% of Northern Territory replied that they had planted Aleman grass in pasture improvement programmes (Bortolussi *et al*. 2005). This equates to 29 of the 202 properties that replied to the survey in these four survey areas. Six of these property owners replied that Aleman grass was spreading naturally on the property; four in the greater than 1000 mm rainfall zone and two in the 500–750 mm rainfall zone (Bortolussi *et al*. 2005).

Worldwide distribution

Native: NORTHERN AMERICA
South-eastern USA: Florida; Louisiana
South-central USA: Texas [east coastal]
Mexico

SOUTHERN AMERICA
Mesoamerica: Belize; Costa Rica; Honduras; Nicaragua; Panama
Caribbean: Antigua and Barbuda; Cuba; Dominican Republic; Haiti; Jamaica; Martinique; Puerto Rico; St. Lucia; Trinidad and Tobago
Northern South America: French Guiana; Guyana; Suriname; Venezuela; Brazil
Western South America: Bolivia; Ecuador; Peru
Southern South America: Argentina; Paraguay; Uruguay

Other: Naturalised in tropical and South Africa, Egypt, tropical Asia, India, Sri Lanka, Australia, southern South America, and Hawaii.

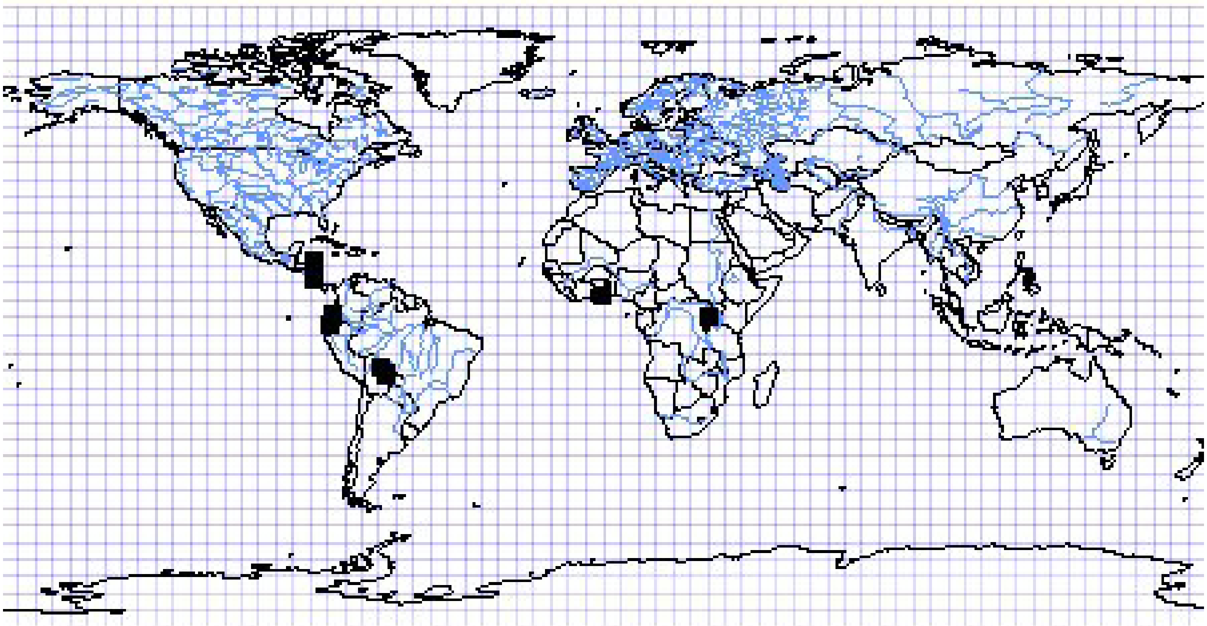

Figure 1. Collections of Aleman grass from the Missouri Botanical Garden (2006) W3— TROPICOS database.

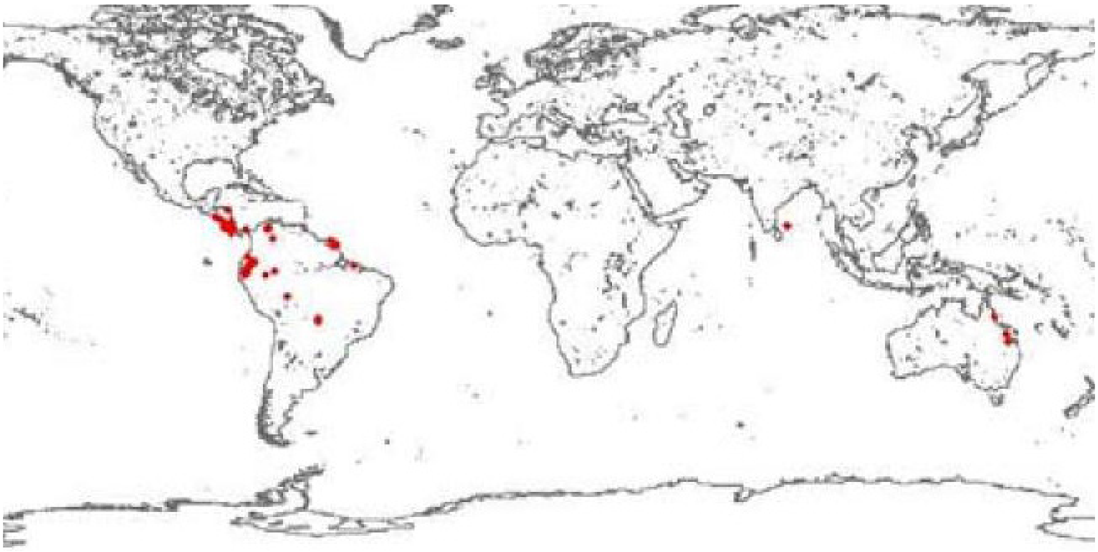

Figure 2. Collections of Aleman grass from various sources (GBIF 2006).

Distribution in Australia

Aleman grass is believed to have been released into Western Australia and Northern Territory during the 1990s (Cameron & Lemcke 2003; Lazarides *et al*. 1997; Smith 1995). It has naturalised on the Mary River, Northern Territory (Clarkson pers. comm.).

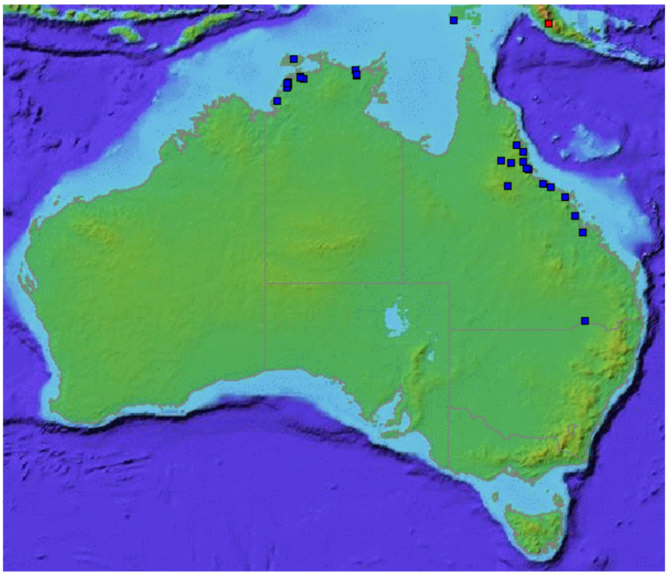

Figure 3. Australian collections of Aleman grass from major Australian herbaria (AVH 2006).

Preferred habitat and climate

In its native habitat, it forms extensive colonies in seasonal swamps along stream banks and other seasonally flooded areas (Wildin 1988). Aleman grass can grow in water that is seasonally more than two more metres deep. This characteristic makes it a threat to open water in wetlands.

According to Pompêo et al. (2001), the main environmental factors that govern the growth of Aleman grass are temperature, precipitation and the fluctuation of the water level. As with hymenachne, no quantitative information regarding the direct influence of soil type on survival and abundance could be found, although it is known that Aleman grass does well in moderate to heavy clay soils (Wildin & Chapman 1988).

Soil requirements

Aleman grass tolerates a wide range of soil fertility, but is best on soils of medium to high fertility. In Colombia, it is found on clay soils. It is adapted to soil pH 4.0–8.0 and has some resistance to sodicity. It is very tolerant of poor drainage. (Cook *et al.* 2006), and is adapted to wet to very wet soils (Rattray 1973, cited in Skerman & Riveros 1990). In Florida everglades, it is reported from flooded Histols (Porter et al. 1991). In Northern Territory, Australia, Aleman grass is reported to grow well on black cracking clays under flooding for 7–12 months and solodic (bull dust) plains (Lemcke 1995).

The Várzea rivers are sediment-laden nutrient-rich white-water rivers. Nutrient dynamics studies of Aleman grass in the Várzea floodplain show that nitrogen and phosphate increases in the plant appear closely linked to water level, suggesting that most nitrogen and potassium may be derived from the flooding river water. Potassium continues to increase throughout the growth of the stand, suggesting that its uptake is not directly linked to supply from the flooding river water.

Moisture

The natural habitat of Aleman grass is seasonally flooded wetlands, but it can grow under very high rainfall conditions (>1900 mm). Generally, there is no growth under dry conditions unless there is a high water table, but it re-establishes from stems and stolons with subsequent flooding. Normally it is grown in water to 1 m depth, but it can persist for short periods in deeper water to 3 m. It grows best in wet or seasonally flooded areas, where flooding can occur for 7–12 months of the year. (Cook et al. 2006)

If planted in dry uplands it will thrive for the first year after planting, but then it becomes weak and slowly succumbs (Judd 1975).

Six property owners who replied to the 1996–97 CSIRO Northern Australia Beef Producers survey indicated that Aleman grass was spreading naturally on their properties; four of these were in the greater than 1000 mm rainfall zone and two were in the 500–750 mm rainfall zone (Bortolussi et al. 2005).

Temperature

Aleman grass only has summer growth. It has no frost tolerance, but is often protected from overnight frosts by the surrounding volume of water. Cook *et al.* (2006) suggest that Aleman grass prefers tropical and marginally subtropical lowlands.

Light

Aleman grass requires full sunlight (Cook *et al.* 2006).

History as a weed overseas and interstate

Aleman grass is not a declared weed in any state or territory of Australia. It is listed in the local government area pest management plans of two local governments (see Table 2). Aleman grass is listed in the Far North Queensland Regional Organisation of Councils (FNQROC) Regional Pest Management Strategy as a Category 4 species with the following goal: 'Control to be consistent with level of declaration and/or local adverse impact'. The FNQROC Regional Pest Management Strategy integrates the individual pest management plans of the 10 member councils and Hinchinbrook Shire Council in tropical northern and north-eastern Queensland. This covers most of the Wet Tropics Bioregion and parts of three other bioregions—Cape York Peninsula, the Einasleigh Uplands and a portion of the northern Gulf Plains.

Table 2. Queensland local governments that specifically mention Aleman grass in their local government pest management plans (as at August 2006).

Local government area (LGA)	Priority in weed management plan
Burdekin	High
Hinchinbrook	Very low
Thuringowa City	Watch list
FNQROC (comprising the LGAs of Atherton, Cardwell, Cairns, Cook, Douglas, Eacham, Herberton, Hinchinbrook, Johnstone, Mareeba and Torres)	Category 4

Holm *et al*. (1991) lists Aleman grass as a serious weed of a crop in Argentina and Mexico, a principle weed of a crop in India and Mexico, present as a weed in Zaire and Chad and present in the flora of Hawaii, Sri Lanka and South Africa.

Humphries *et al*. (1991) listed Aleman grass as one of Australia's main environmental weeds and recommended urgent control action and a review of current planting policy.

There are only a few direct references to Aleman grass as a weed elsewhere in the world. It is considered an invasive plant species on some Pacific Islands (PIER 2006). It is likely that it has become a weed, at least of the environment, in other areas of introduction such as Mexico, West Indies and other South American countries where it is not native. In its native range in central Amazon, Aleman grass commonly forms monospecific stands. This suggests that it either out-competes any other plants capable of colonising these areas or that it occupies a niche that no other plant can occupy (Piedade *et al*. 1991).

In south Louisiana, Aleman grass is a weed of rice crops presently infesting 12 000–15 000 acres of rice (Oryza sativa) and crayfish production (Griffin 2006). It is also a weed of inundated and rain-fed rice fields in Java where it may suppress other plants (Michael 1989). Growing conditions and cultural practices (flooding/draw down and fertilising into flood) in rice production which mimic the conditions in the native range of Aleman grass in the Amazon flood plain may advance the weediness.

Impact

The impacts on the sugar industry, water resources, beef industry and human health, probably will be similar to that of *Hymenachne amplexicaulis* (Csurhes *et al.* 1999). The effect on fisheries would probably be greater because Aleman grass can grow in deeper water.

Similar to hymenachne, Aleman grass has the potential to invade large areas of wetlands and areas with high average annual rainfall in Northern Australia. Of particular concern is its ability to cover large areas of open water, which was previously out of range of para grass due to the limitations on the depth of water in which para grass could grow. Aleman grass would threaten the habitat of water birds, in particular magpie goose (*Anseranas semipalmate* Latham 1798) and cotton pygmy-goose (*Nettapus coromandelianus albipennis* Gould 1842), which, like other water birds, are already suffering because of habitat destruction. In the case of magpie geese, introduced ponded pasture species such as para grass and hymenachne are invading their breeding habitat and displacing principal food plants. The cotton pygmy-goose is impacted by closure of open water where it feeds (Garnett & Crowley 2000).

There is a report from Paraíba in north-eastern Brazil of an outbreak of nitrate poisoning ascribed to Aleman grass (Medeiros *et al.* 2003) where death occurred in five of the eleven animals poisoned. It was reported that the main reason for the nitrate accumulation in the grass was the prolonged drought followed by rain.

Given the high productivity of Aleman grass (see Table 3 and Table 4) it would be reasonable to assume that as wetlands dry out there is the potential for grass fires to be fuelled by Aleman grass, and these fires are likely to reach intensities not normally experienced with native grasses.

Aleman grass is a susceptible host species for maize streak monogeminivirus (MSV) (Brunt *et al.* 1996; Gibbs et al. 2000). Maize streak virus is the most serious disease of maize in Africa (Van Rensburg & Kuhn 1977; Rose 1978; Mzira 1984; Kim et al. 1989); it affects 60% of the planted area and causes an estimated 37% yield loss, or roughly 5.5 million tonnes yr-1 losses in production in Africa (Jeffers 2001). MSV is transmitted by a wide range of genera and species leafhoppers (Cicadellideae). MSV spread is facilitated by successive cropping and the presence of wild grasses as reservoirs of both virus and vectors (Autrey & Ricaud 1983), as well as the wide variety of plant species on which leafhoppers feed, the ability of the vectors to transmit MSV persistently, and the insects' often considerable migration distances (Bosque & Buddenhagen 1999; Rose 1978). MSV is not known to be in Australia.

Two leafhopper species, *Cicadulina bimaculata* and *C. bipunctata* (syn *bipunctella)*, recorded as vectors of MSV in Africa, are also recorded in Australia (Day & Fletcher 1994), though the genetic relationships of the two populations have not been compared, nor has the vector efficiency of the Australian populations for MSV transmission been assessed.

Economic benefits

Aleman grass is a useful summer pasture under high-rainfall conditions, with some seasonal waterlogging widely used in South American tropics and subtropics (FAO Grassland and Pasture 2006). The primary benefit of Aleman grass is that when used in ponded pastures it reduces the impact of the 'protein drought' during the dry season. By having this forage available during the dry season, it reduces stock weight loss and improves the price and marketability of stock. Detailed economic assessments of Aleman grass benefits could not be located.

In Brazil, in its native range and habitat, the annual net primary production of Aleman grass is 99 tonnes/ha of dry matter which is among the highest values recorded for natural vegetation (Piedade *et al*. 1991). Dry matter yields of Aleman grass are comparable to those of hymenachne and para grass (Table 4).

In an Indian study, Aleman grass gave significantly higher green fodder, dry-matter and crude protein than did para grass during three years of harvesting (Table 3).

Table 3. Comparison of yields of Aleman grass and para grass under different cutting management strategies (after Dhar et al. 2001).

Grass cutting (cuts per 3-year period)	Green fodder yield (tonnes/ha)			Dry matter yield (tonnes/ha)			Crude protein yield (kg/ha)		
	Para grass		Aleman grass	Para grass		Aleman grass	Para grass		Aleman grass
2	17.8		24.2	3.8		5.2	257		355
3	20.3		25.5	4.4		5.5	298		393
4	23.1		30.5	5.4		6.5	323		465
SEM +		2.0			0.3			8.2	
CD (p=0.05)		5.5			0.7			23.1	

Aleman grass is very palatable and eagerly sought by grazing animals (Table 6). In Venezuela, dry matter digestibilities for cattle after 41, 48, 55, 92 days regrowth were 63%, 62.2%, 59.1% and 60.5% respectively, and crude protein levels were 10.3%, 9.1%, 8.9% and 8.2% respectively (Combellas and Gonzales 1973). Digestibility figures were also recorded by Jiménez and Parra (1973) for the giant rodent, the capybara, in Venezuela. The intake of Aleman grass was 83 g DM/kg B.W. of capybara. The total digestibility of the dry matter was 58.8%, based on Aleman grass having 11.7% crude protein and 36.2% crude fibre, with digestibility ratios of 63% and 52.1%, respectively. By comparison, the equivalent intake of para grass was 124 g DM/Kg B.W. with a DM digestibility of 61.7%, protein 68.8% and fibre 60.5%.

Table 4. Forage yields of Aleman grass compared with para grass and hymenachne.

Grass	Location	Dry matter (tons/ha/yr)	References
Para grass	Innisfail, Qld	12*	Schofield 1944
	Innisfail, Qld	30	Grof & Harding 1970
	Uganda	40	Novoa & Rodriquez-Carrasquel 1972
	Taiwan	45	Yeh 1978
	Venezuela	36	Anon 1981
	Florida	110++	Handley & Ekern 1984
	India	18–23#	Dhar *et al*. 2001
Hymenachne	Venezuela	18	Teys 1978
Aleman grass	Venezuela	22	Anon 1981
	Florida	57–69	Pate & Snyder 1984
	Colombia	16–25+	Monsalve 1978
	India	24–30#	Dhar *et al*. 2001

* First year after sugarcane and with no fertiliser.
+ Mean of two years without N fertiliser.
++ Irrigated with sewerage effluent plus up to 2600 kg N/ha.
# Under various harvesting regimes.

Table 5. Comparison of chemical analysis of Aleman grass, para grass and hymenachne (after Göhl 1975, Skerman and Riveros 1990).

Grass	Description	As % of dry matter						Reference
		DM	CP	CF	Ash	EE	NFE	
Para grass	Fresh, 45 cm, Philippines	33.7	11.6	29.7	12.8	12.8	12.8	Loosli *et al*. 1954
	Fresh, 90 cm, Philippines	22.3	9	33.6	12.6	12.6	12.6	Loosli *et al*. 1954
	Fresh, 100 cm, Philippines	20.5	8.8	31.7	10.7	10.7	10.7	Loosli *et al*. 1954
	Fresh, mid-bloom, Trinidad	24.9	4.5	32.8	7.6	7.6	7.6	Butterworth 1963
	Fresh, dough stage, Hawaii	25.6	8.1	34.2	12.6	12.6	12.6	Work 1937
	Fresh, whole aerial part, Suriname		8.8	37.5	6.9	6.9	6.9	Dirven 1962
	Fresh leaves, Suriname		14	31	8.1	8.1	8.1	Dirven 1962
	Fresh stems, Suriname		5.9	41.5	6.3	6.3	6.3	Dirven 1962
	Fresh tops, Thailand		15.4	27.2	11.8	11.8	11.8	Bhannasiri 1970
	Hay, wet season, 6 weeks, 60 cm, Thailand		7.7	31.8	10.3	10.3	10.3	Holm 1971
	Hay, wet season, 8 weeks, 80 cm Thailand		9.1	33.6	9.2	9.2	9.2	Holm 1971

Grass	Description	As % of dry matter						Reference
		DM	CP	CF	Ash	EE	NFE	
Para grass	Hay, wet season, 10 weeks, 90 cm Thailand	85.3	5.5	35.1	8.9	1.8	1.8	Holm 1971
	Hay, wet season, 12 weeks, 110 cm Thailand	84.9	4.2	34.5	10.5	1.6	1.6	Holm 1971
	Hay, dry season, 6 weeks, 40 cm Thailand	81.2	12.4	30.3	10.7	2	2	Holm 1971
	Hay, dry season, 8 weeks, 55 cm Thailand	91.7	9.3	30	12.3	2.1	2.1	Holm 1971
	Hay, dry season, 10 weeks, 60 cm Thailand	85.5	6.5	32.4	10.9	1.8	1.8	Holm 1971
	Hay, dry season, 12 weeks, 65 cm Thailand	88.8	6.5	32.4	11.1	2.1	2.1	Holm 1971
	Floral initiation, Costa Rica		6.36	30.34	8.41	1.35	1.35	Gonzalez & Pacheco 1970
	Flowering November, Africa	29	6.50	35.20	7.00			Boudet 1975
	Regrowth March, Africa	23	8.90	32.30	15.40			Boudet 1975
	30 days regrowth, Africa	19	18.20	29.20	12.21			Boudet 1975
	Silage, old forage	26.6	5.80					Paterson 1945
Hymenachne	Fresh, whole aerial part, Suriname		15.8	34.6	9.4	1.9	1.9	Dirven 1962
	Fresh, stems only, Suriname		8.9	36.7	11.5	1.0	1.0	Dirven 1962
	Fresh, leaves only, Suriname		22.6	32.4	7.2	2.8	2.8	Dirven 1962
	Fresh, mid-bloom, India		9.4	22.1	12.2	2.3	2.3	Talapatra 1949
	Hay, mid-bloom, India		7.5	29.2	12.9	1.4	1.4	Talapatra 1949
	Silage, mid-bloom, India		6.9	27.8	17.9	1.9	1.9	Talapatra 1949
Aleman grass	Fresh, 2 weeks, Costa Rica	16.0	13.8	32.0	12.7	4.2	4.2	INFIC 1978
	Fresh, 4 weeks, Costa Rica	17.0	13.0	31.6	13.3	2.9	2.9	INFIC 1978
	Fresh, 6 weeks, Costa Rica	18.5	10.5	33.4	12.9	3.0	3.0	INFIC 1978
	Fresh, 8 weeks, Costa Rica	20.7	8.3	35.6	11.5	2.1	2.1	INFIC 1978
	Hay, late vegetative, Costa Rica	83.9	12.9	32.2	12.6	3.3	3.3	INFIC 1978

Grass	Description	As % of dry matter						Reference
		DM	CP	CF	Ash	EE	NFE	
	Hay, mid-bloom, Costa Rica	86.4	7.9	35.5	10.5	2.1	44.0	INFIC 1978
	Fresh, vegetative, Cuba	29.7	13.1	26.2	11.6	3.1	46.0	Calvino 1952
	Suriname		14.3					Dirven 1963

Milk protein of Holstein-Friesian X zebu cows was lowest on Aleman grass compared with *Brachiaria ruziziensis* (Kenya grass), *Urochloa mutica* (para grass) or *Panicum maximum* (Guinea grass) (Perez-Infante & Gonzales 1985).

Table 6. Comparison of digestibility of Aleman grass, para grass and hymenachne (Göhl 1975).

Grass	Animal	Digestibility (%)					Reference
		CP	CF	EE	NFE	ME	
Para grass, fresh, 45 cm	Sheep	73.5	77.5	54.2	79.8	2.57	Loosli *et al.* 1954
Para grass, fresh, 90 cm	Goats	53.9	56.9	20.9	51	1.72	Loosli *et al.* 1954
Para grass, fresh, 100 cm	Sheep	48.4	40.9	23	37.1	1.31	Loosli *et al.* 1954
Para grass, fresh, mid-bloom	Sheep	31.6	60.7	50	63.5	2.07	Butterworth 1963
Para grass, fresh, dough stage	Oxen	60	67	52	64	2.11	Work 1937
Para grass, hay, 8 weeks	Sheep	50	50	35	52	1.67	Holm 1971
Para grass, hay, 12 weeks	Sheep	35	49	54	51	1.64	Holm 1971
Para grass	Capybara	61.7	60.5				Jiménez & Parra 1973
Hymenachne, mid-bloom	Bullocks	58.6	61.5	60.5	37.9	67.0	Talapatra 1949
Hymenachne, hay, mid-bloom	Bullocks	56.2	42.4	70.7	39.1	60.6	Talapatra 1949
Hymenachne, silage, mid-bloom	Bullocks	58.5	43.9	69.3	40.9	60.3	Talapatra 1949
Aleman grass, 6 weeks regrowth	Cattle	63					Combellas & Gonzales 1973
Aleman grass	Capybara	63	52.1				Jiménez & Parra 1973

Animal production

The data in Table 7 indicates similar animal productivity levels for Aleman grass compared with the widespread para grass. Average daily live weight gains of the order of 0.5–0.65 kg/animal and stocking rates of 0.3 for Aleman grass are comparable to the range for para grass (0.2–1.0); production of more than 700 kg live weight/ha are reported. In Queensland, the alternatives to ponded pasture, where it is used, are mostly dry land native pasture with a production capacity of only 20–40 kg live weight gain/ha/yr (Middleton *et al.* 1991).

Table 7. Animal production from Aleman grass and para grass (after Middleton *et al.* 1991).

Grass	Location	Stocking rate ha/an	Animal live weight gain		References
			g/day	kg/ha/yr	
Para	Tully, Queensland	0.9	520	210	Seddon & Mulhearn 1939
Para	Innisfail, Queensland	0.5	430–590	315–430	Alexander & Chester 1956
Para & legume (irrigated)	Mareeba, Queensland	0.26–0.33	570–608	640–780	Miller & van der List 1977
Para & legume (irrigated)	Ayr, Queensland	0.24	450	670	Allen & Cowdry 1961
Para	Columbia	0.4	600	550	Crowder *et al.* 1970
Para & fertiliser (irrigated)	Columbia	0.4	780	715	Crowder *et al.* 1970
Aleman	Mexico	0.30	496	605	Navarro 1980
Para	Venezuela		413		Anon 1981
Aleman	Venezuela		653		Anon 1981
Para	Venezuela	0.17	217	475	Gabaldon *et al.* 1982
Aleman	Venezuela	0.17	309	677	Gabaldon *et al.* 1982
Para/Aleman	Venezuela	0.25	440	642	Gabaldon *et al.* 1982
Para/Aleman	Venezuela	0.13	185	540	Gabaldon *et al.* 1982
Para	Solomon Islands	0.28	447	558	Watson, 1986

In Vera Cruz, Mexico, with a rainfall of 1060 mm from May to October and an altitude of 10–16 m, zebu steers grazed on a put-and-take system gained 280 kg/ha on Aleman grass compared with 406 kg/ha on *Digitaria decumbens,* 223 kg/ha on *Brachiaria mutica*, 190 kg/ha on *Hyparrhenia rufa* and 157 kg/ha on *Panicum maximum* (Arroyo & Teunissen 1964 cited in FAO, 2006). This indicates that animal production on Aleman grass is 1.25 times that on para grass.

The potential benefit to Queensland of the use of Aleman grass in pasture systems can be estimated from a comparison of beef production on Aleman grass pasture compared with an equivalent area of para grass pasture. For this comparison, it will be assumed that all the claimed 100 000 ha of para grass in Queensland (Walker & Weston 1990) is available for grazing (this is an overstatement as some of those areas are not in beef production).

Para grass: 100 000 ha × 1.3 animal/ha x 150 kg/animal × $1.80/kg = $35 100 000 Aleman grass: 1.25 × para grass production = $43 875 000

The estimated potential benefit of Aleman grass pasture over para grass ponded pasture for Queensland is $8.775m per annum. This estimate does not factor in the cost of converting from one pasture species to another.

Alternative pasture species

The most readily available alternative to Aleman grass is the introduced para grass (*Urochloa mutica*), which occurs over wide areas of Queensland. As shown above, forage yields (Table 4), chemical analysis (Table 5), digestibility (Table 6) and carrying capacity (Table 7) of para grass are similar to Aleman grass. The advantage of Aleman grass over para grass is that Aleman can grow in deeper water than para grass and so will be available longer into the dry season as the ponded pastures dry out and the resulting shallower water depth allows the stock to graze further out into the previously deeper parts of the ponds.

There are several species of native grass that are suitable for use in ponded pasture systems. Water couch (*Paspalum paspalodes*) has been said to be a good grass for ponded pastures especially if it is exposed to heavy grazing pressure (Wildin & Chapman 1988). It is also drought-tolerant, but this species is not being widely promoted compared with the exotic pasture species.

The native wetland grass, *Hymenachne acutigluma*, has significant value as a ponded pasture grass in tropical areas and was the main species grazed by water buffalo in the tropical floodplains of the Northern Territory. It exists in North Queensland but plantings have not persisted south of Mackay (Wildin *et al.* 1996). Calder (1981) and Cameron (2003) reported the distribution, fertiliser response, growth pattern, potential use and productivity of native hymenachne in the Northern Territory. Native hymenachne has considerable potential as a tropical ponded pasture but this potential appears to have been largely ignored in northern Australia, in favour of robust exotics that are more readily available.

Other native grasses that are useful in ponded pastures include swamp rice grass (*Leersia hexandra*) (Anning & Kernot 1991) and spiny mudgrass (*Pseudoraphis spinescens*) (Wildin 1991). Consideration could be given to promoting other native wetland grasses, such as the native rices, *Oryza australiensis, O. meridionalis* and the possible use in considered locations, *Paspalidium udum* (Paul Williams, pers. comm.).

The use of native species in pondage has been suggested many times but the available native species are not considered anywhere near as productive as para grass and there is little chance of adoption (John Clarkson, EPA, pers. comm.).

Pest potential in Queensland

The pest potential of Aleman grass in Queensland is comparable to that of hymenachne and para grass.

As a 'floating grass', Aleman grass is well adapted to being dispersed by flood waters.

Its effect on stream and wetland hydrology will be greater than that of para grass or hymenachne as Aleman grass can grow in deeper water than those two species and can potentially affect deeper channels in wetlands.

Its adaptation to and requirement for cyclical inundation make Aleman grass a major threat to seasonally flooded wetlands in Queensland.

The northern region of Queensland Parks and Wildlife Service (QPWS) considers that para grass, Aleman grass and hymenachne are significant threats to the biodiversity of tropical wetlands (Paul Williams, QPWS, pers. comm.). Para grass is a threat to wetlands of a large proportion of northern region protected areas, including the Bowling Green Bay wetlands, listed under the international RAMSAR agreement. There is potential for Aleman grass to spread further through a large area of this wetland.

Establishment risk assessment

Table 8. Aleman grass Pheloung risk assessment prepared by Randal (2006)

			Echinochloa polystachya Aleman grass RR
A. Biogeography/historical			
1 Domestication/cultivation	1.01	Is the species highly domesticated?	No
	1.02	Has the species become naturalised where grown?	Yes
	1.03	Does the species have weedy races?	
2 Climate and distribution	2.01	Species suited to Australian climates (0—low; 1—intermediate; 2-—high)	1
	2.02	Quality of climate match data (0—low; 1—intermediate; 2—high)	1
	2.03	Broad climate suitability (environmental versatility)	No
	2.04	Native or naturalised in regions with extended dry periods	No
	2.05	Does the species have a history of repeated introductions outside its natural range?	Yes
3 Weed elsewhere (interacts with 2.01 to give a weighted score)	3.01	Naturalised beyond native range	Yes
	3.02	Garden/amenity/disturbance weed	Yes
	3.03	Weed of agriculture	Yes
	3.04	Environmental weed	Yes
	3.05	Congeneric weed	Yes
B. Biology/ecology			
4 Undesirable traits	4.01	Produces spines, thorns or burrs	No
	4.02	Allelopathic	No
	4.03	Parasitic	No
	4.04	Unpalatable to grazing animals	No
	4.05	Toxic to animals	No
	4.06	Host for recognised pests and pathogens	No
	4.07	Causes allergies or is otherwise toxic to humans	No
	4.08	Creates a fire hazard in natural ecosystems	
	4.09	Is a shade tolerant plant at some stage of its lifecycle	No
	4.10	Grows on infertile soils	Yes
	4.11	Climbing or smothering growth habit	No
	4.12	Forms dense thickets	
5 Plant type	5.01	Aquatic	Yes
	5.02	Grass	Yes
	5.03	Nitrogen fixing woody plant	No
	5.04	Geophyte	No
6 Reproduction	6.01	Evidence of substantial reproductive failure in native habitat	
	6.02	Produces viable seed	
	6.03	Hybridises naturally	
	6.04	Self-compatible or apomictic	
	6.05	Requires specialist pollinators	No
	6.06	Reproduction by vegetative fragmentation	Yes
	6.07	Minimum generative time (years)	1

			Echinochloa polystachya Aleman grass RR
7 Dispersal mechanisms	7.01	Propagules likely to be dispersed unintentionally (plants growing in areas with much vehicle movement)	No
	7.02	Propagules dispersed intentionally by people	Yes
	7.03	Propagules likely to disperse as a produce contaminant	No
	7.04	Propagules adapted to wind dispersal	No
	7.05	Propagules water dispersed	
	7.06	Propagules bird dispersed	No
	7.07	Propagules dispersed by other animals (externally)	No
	7.08	Propagules survive passage through the gut	
8 Persistence attributes	8.01	Prolific seed production (>2000/m2)	No
	8.02	Evidence that a persistent propagule bank is formed (>1 yr)	No
	8.03	Well controlled by herbicides	No
	8.04	Tolerates, or benefits from, mutilation or cultivation	Yes
	8.05	Effective natural enemies present in Australia	No
		Outcome: Score:	Reject 13
Stastical summary of scoring		Biogeography Score partition: Undesirable attributes Biology/ecology	7.5 0 5
		Biogeography Questions answered: Undesirable attributes Biology/ecology Total	7 9 18 34
		Agricultural Sector affected: Environmental Nuisance	6 8 1.5

Table 9. Aleman grass Pheloung risk assessment prepared for this reportZ

			Echinochloa polystachya Aleman grass
A. Biogeography/historical			
1 Domestication/cultivation	1.01	Is the species highly domesticated?	No
	1.02	Is the species naturalised where grown?	Yes
	1.03	Does the species have weedy races?	
2 Climate and distribution	2.01	Species suited to Australian climates (0—low; 1—intermediate; 2-—high)	2
	2.02	Quality of climate match data (0—low; 1—intermediate; 2—high)	1
	2.03	Broad climate suitability (environmental versatility)	No
	2.04	Native or naturalised in regions with extended dry periods	No
	2.05	Does the species have a history of repeated introductions outside its natural range?	Yes
3 Weed elsewhere (interacts with 2.01 to give a weighted score)	3.01	Naturalised beyond native range	Yes
	3.02	Garden/amenity/disturbance weed	
	3.03	Weed of agriculture/horticulture/forestry	Yes
	3.04	Environmental weed	Yes
B. Biology/ecology			
4 Undesirable traits	4.01	Produces spines, thorns or burrs	No
	4.02	Allelopathic	No
	4.03	Parasitic	No
	4.04	Unpalatable to grazing animals	No
	4.05	Toxic to animals	No
	4.06	Host for recognised pests and pathogens	Yes
	4.07	Causes allergies or is otherwise toxic to humans	Yes
	4.08	Creates a fire hazard in natural ecosystems	No
	4.09	Is a shade tolerant plant at some stage of its lifecycle	No
	4.10	Grows on infertile soils	No
	4.11	Climbing or smothering growth habit	No
	4.12	Forms dense thickets	Yes
5 Plant type	5.01	Aquatic	Yes
	5.02	Grass	Yes
	5.03	Nitrogen fixing woody plant	No
	5.04	Geophyte	No
6 Reproduction	6.01	Evidence of substantial reproductive failure in native habitat	
	6.02	Produces viable seed	Yes
	6.03	Hybridises naturally	
	6.04	Self fertilisation	
	6.05	Requires specialist pollinators	Yes
	6.06	Reproduction by vegetative fragmentation	1
	6.07	Minimum generative time (years)	

			Echinochloa polystachya Aleman grass
7 Dispersal mechanisms	7.01	Propagules likely to be dispersed unintentionally	No
	7.02	Propagules dispersed intentionally by people	Yes
	7.03	Propagules likely to disperse as a produce contaminant	No
	7.04	Propagules adapted to wind dispersal	No
	7.05	Propagules buoyant	Yes
	7.06	Propagules bird dispersed	No
	7.07	Propagules dispersed by other animals (externally)	
	7.08	Propagules dispersed by other animals (internally)	No
8 Persistence attributes	8.01	Prolific seed production	No
	8.02	Evidence that a persistent propagule bank is formed (>1 yr)	No
	8.03	Well controlled by herbicides	No
	8.04	Tolerates, or benefits from, mutilation or cultivation	Yes
	8.05	Effective natural enemies present in Australia	No
		Outcome: Score:	Reject 20
Stastical summary of scoring		Biogeography Score partition: Undesirable attributes Biology/ecology	12 1 7
		Biogeography Questions answered: Undesirable attributes Biology/ecology Total	7 12 19 38
		Agricultural Sector affected: Environmental	11 16

Appendix 1. CLIMEX parameters used to prepare Figure 4

Parameters	Values
Temperature index	
Limiting low temperature	15
Lower optimal temperature	28
Upper optimal temperature	33
Limiting high temperature	36
Moisture index	
Limiting low moisture	0
Lower optimal moisture	0.01
Upper optimal moisture	5
Limiting high moisture	10
Light index	Not used
Diapause index	Not used
Cold stress	
Cold stress temperature threshold	2
Cold stress temperature rate	0
Cold stress degree–day threshold	25
Cold stress degree–day rate	-0.002
Cold stress temperature threshold (average)	0
Cold stress temperature rate (average)	0
Heat stress	
Heat stress temperature threshold	37
Heat stress temperature rate	0.0002
Heat stress degree-day threshold	0
Heat stress degree-day rate	0
Dry stress	
Dry stress threshold	Not used
Dry stress rate	Not used
Cold–dry stress	Not used
Cold–wet stress	Not used
Hot–dry stress	Not used
Hot–wet stress	Not used

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