Growth and spread of *Digitaria eriantha* cv. Premier and *Urochloa mosambicensis* cv. Nixon oversown into native speargrass (*Heteropogon contortus*) pasture in south-east Queensland

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Abstract

Six grass species were oversown into speargrass (*Heteropogon contortus*) (low fertility) and speargrass-siratro (*Macroptilium atropurpureum* cv. Siratro) (high fertility) pastures on granite soils in south-east Queensland in 1979 and 1980.

Establishment from both sowings was very poor for all species; however, sabi grass (*Urochloa mosambicensis* cv. Nixon) and digit grass (*Digitaria eriantha* cv. Premier) persisted, increased in density and gradually spread into adjacent plots. For both species, spread was greater in the high fertility pasture than in the low fertility pasture.

After 16 years, the yield of digit grass was significantly less than that of speargrass or sabi grass at the low fertility level, and this grass showed a higher response to application of N.

Both sown grasses were highly competitive and reduced the number of native species where they were sown. Digit grass caused a far greater reduction than sabi grass, and the amount of bare ground in digit grass plots was 3 times that in speargrass areas.

On low fertility granite soils, neither species offers any benefits in productivity over good speargrass. The potential dominance of digit grass suggests it should not be sown on these soils, whereas sabi grass may have a role for oversowing into badly degraded native pastures.

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Introduction

Black speargrass (*Heteropogon contortus)* pastures, covering an area of 23M ha, are an important native pasture resource in Queensland, but their productivity is low relative to fully improved grass-legume pastures (Hacker *et al.* 1982; Mannetje and Jones 1990). Complete clearing, cultivation and sowing of improved pastures is effective in improving productivity, but may not be the most economical way of utilising the region for cattle production, and can pose some risk through soil erosion. Incorporating a legume into these native pastures can improve animal production per hectare by up to 4 fold, and after fertilisation with superphosphate, by up to 6 fold (Hacker *et al.* 1982).

Tothill (1974), with the addition of superphosphate, introduced siratro (*Macroptilium atropurpureum* cv. Siratro) successfully into speargrass pasture using low-cost methods, with substantial benefits to animal production. However, one disadvantage of incorporating siratro into the native pastures was the increased susceptibility to weed invasion. In years of good early spring rain, spring weeds, primarily spear thistle (*Cirsium vulgare*), peppercress (*Lepidium bonariense*) and fleabane (*Conyza bonariensis*), became very prominent (Tothill and Jones 1977; Tothill and Berry 1981) in these pastures. By comparison, there was less than half the yield of weeds in the buffel-siratro pasture of equivalent fertility, and minimal yield in the low fertility speargrass pastures.

One way of reducing the invasion by spring weeds in pastures oversown with legumes could be to establish a grass species which is more active in spring than speargrass. Such a grass could compete more effectively with the weeds for the available nutrients and be utilised more readily by the grazing animal. The grass could be sown either with the legume at the initial sowing, when fertility and the competitive ability of introduced species would be low, and that of the existing species may be low, or some years after the legume, when fertility and competitive abilities of introduced and existing species would be higher.

An experiment was established to evaluate a number of grass species for oversowing into speargrass (low fertility) and speargrass-siratro (high fertility) pastures and to examine whether the grass should be sown with the legume or at a later date. This paper describes 2 studies within this experiment: the first compared the increases in frequency of 2 oversown grasses, digit grass (*Digitaria eriantha* cv. Premier) and sabi grass (*Urochloa mozambicensis* cv. Nixon) which established successfully, and their spread into neighboring speargrass areas; the second studied the effect of these grasses on pasture yield (with and without added N), ground cover and species diversity in comparison with that of speargrass.

Materials and methods

Site and experimental treatments

The studies were carried out at the Narayen Research Station (25°41′S, 150°51′E) in the south Burnett region of south-east Queensland. The climate is subhumid subtropical, with a mean annual rainfall of 707 mm, 64% of which falls in spring–summer. The original vegetation was a grassy eucalyptus woodland dominated by silver-leaf ironbark (*Eucalyptus melanophloia*); the trees had been treated chemically in 1971. The soil is a yellow-red podzolic (paleustalf or albic luvisol) derived from granite, with a sandy surface horizon, ranging in depth from 25–60 cm.

In each of 2 consecutive years, a range of grasses was oversown into native speargrass and speargrass-siratro pastures established in 1972 (Tothill 1974).

There were 2 paddocks each of speargrass (low fertility) and speargrass-siratro (high fertility) pastures. The high fertility paddocks were fertilised with 200 kg/ha molybdenised superphosphate (9.8% P) and oversown with siratro in January 1972. Subsequently, these paddocks were fertilised biennially with 100 kg/ha triple superphosphate (20.7% P) until 1984. Siratro averaged approximately 40% of pasture dry matter from 1972–76 (Tothill and Jones 1977), but then declined. By 1982, there were 9.5 kg/ha available N and 34.5 kg/ha acid-extractable P in the top 10cm of the soil in high fertility paddocks compared with 2 kg/ha N and 10.5 kg/ha P in the low fertility paddocks (Filet 1990).

Five grasses were oversown within each paddock with 2 replications in a randomised block design. Plots of 0.1 ha (10 m × 100 m) were oversown in January 1979 and an additional set in January 1980. Grasses planted in 1979 were green panic (*Panicum maximum* var. *trichoglume*), creeping blue grass (*Bothriochloa insculpta* cv. Hatch), signal grass (*Brachiaria decumbens* cv. Basilisk), digit grass and sabi grass. The same grasses were oversown in 1980, except for creeping blue grass, which, due to lack of available seed, was replaced by rhodes grass (*Chloris gayana*) cv. Pioneer.

All grasses were sown at 3 kg/ha, except for creeping blue grass and digit grass, which were sown at 2 kg/ha. Seed was broadcast on to a lightly cultivated seedbed and then rolled. The 2 low fertility paddocks were oversown with siratro at 4 kg/ha in January 1979, at the same time as the oversown grass plots. Paddocks were stocked at 0.7 hd/ha with 1–2 year-old steers until 1986, when all paddocks were opened to common grazing by cows and calves.

Study 1 — establishment and spread

Frequency percent of occurrence was determined by recording the presence of sown species in 0.5 m × 0.5 m quadrats located at 4 m intervals along 2 transects per plot, each with 25 sampling positions. Measurements were taken in 1979, 1980, 1981, 1982, 1983 and 1993. In 1993, following the spread of digit and sabi grass into adjoining plots, the frequency of all oversown grasses, as well as speargrass, was measured in each plot. The frequencies of any other unsown grasses were combined as ‘other grass’ and dicots and sedges were combined as ‘other species’.

Study 2 — cover, yield and species richness

Owing to the very poor establishment and persistence of all but 2 of the sown grasses, the detailed measurements in Study 2 were taken on the digit grass and sabi grass plots only, and on areas of good speargrass within the same paddock, adjacent to the oversown plots, which had not been invaded by either sown grass, and were not degraded. Sampling was restricted to the 2 replicates of the 1979 sowing of Experiment 1, within one paddock each of the high and low fertility pasture. A single transect of 25 positions at 4 m intervals was assessed in each plot, with transects selected to pass through dense areas of each grass.

Amount and type of cover were determined at each position using a point quadrat technique in November 1994. A 0.5 m × 0.5 m quadrat with a grid of cross wires giving 100 intersecting points within the quadrat was used. On a vertical projection below each intersection point, the cover was classified as basal cover (basal area), plant (canopy) cover, litter cover or bare ground.

The presence of all unsown species within 25 quadrats (0.5 m × 0.5 m) in each plot, along transects similar to those discussed above, was recorded in April 1995.

Summer yield response to nitrogen fertiliser was measured in 1995 and 1996. In spring (October–November) of each year, 2 cages of 1.4 m × 1.4 m were placed in each plot of the 2 replicates. The area around one cage was not fertilised and the other was fertilised with a total of 200 kg/ha urea applied in 2 equal dressings in November and January of each summer. To minimise edge effects, an area of 4 m × 4 m was fertilised with the cage placed in the centre. Summer yield was determined by cutting the central 1 m^2 within each cage to a height of 5 cm in April 1995 and February 1996. Early spring growth in October 1995 was measured by cutting the same central 1 m^2 within the same cages that were cut in April 1995. The cages were then moved for the 1996 sampling. In Autumn 1995, the number of inflorescences in the digit grass cages were counted prior to cutting, and the cut samples for all species were hand sorted into leaf and stem.

For comparison, measurements of yield and cover were taken in a nearby buffel grass (*Cenchrus ciliaris*)-siratro pasture, sown in 1972 and grazed at a higher stocking rate from 1972–1984. None of the pastures was grazed between Autumn 1994 and Autumn 1995.

Statistical analysis

Statistical analysis was done with an ANOVA model adjusted for the split-split plot design of the experiment.

Results

Rainfall

Eleven of the 17 summer periods (October–March) after sowing had below median summer rainfall (500 mm), with 6 below Decile 2 (376 mm) and only 3 above Decile 8 (614 mm). The last 7 years, except for 1995–96, had less than median summer rainfall, with 3 years below Decile 2.

Study 1 — establishment and spread

The initial establishment of all oversown species was poor and only digit grass and sabi grass persisted and spread. Results presented for the oversown grasses will be restricted to digit grass and sabi grass only, with later comparisons with speargrass.

Frequency. Initial establishment was poor in both the 1979 and 1980 sowings, but frequency of digit grass and sabi grass increased greatly over time (Table 1). There were significant differences between the high and low fertility paddocks, with the increase in frequency more gradual in the low fertility paddocks than in the high fertility paddocks.

There was an interaction between species and fertility level; over time there was a change from a higher frequency of sabi grass to a higher frequency of digit grass. In the 1979 sowing, the frequency of sabi grass was significantly ($P<0.05$) higher than that for digit grass in the high fertility paddocks in 1981 and 1982, but there were no significant differences in 1983 and 1993, although frequency of digit grass then exceeded that of sabi grass. Results from the 1980 sowing were similar.

In the low fertility paddocks, there was an early tendency for sabi grass to have a higher frequency than digit grass in the 1979 sowing, but there was no significant difference until 1993 when digit grass occurred more frequently ($P<0.001$) than sabi grass. In the 1980 sowing, the frequency of sabi grass was significantly ($P<0.05$) higher than that of digit grass in 1981; by 1993 digit grass occurred more frequently than sabi grass, but not significantly so ($P>0.05$).

Spread. As the frequency of all oversown species was measured in every plot in 1993, it is possible to document the spread of digit grass and sabi grass from where each was sown. In most instances, the spread of digit grass

Table 1. Frequency percent of occurrence from 1979–1993 of sabi grass and digit grass, at 2 levels of fertility (high and low) in the 1979 and 1980 sowings.

Fertility level	Date						LSD (P<0.05)
	11.79	5.80	3.81	4.82	1.83	12.93	
Digit grass — 1979 sowing							
High	1	14	41	56	78	99	16.1
Low	2	3	9	15	nm[1]	90	16.1
Signif.	ns[2]	ns	**	**	—	ns	
Sabi grass — 1979 sowing							
High	11	28	74	80	69	86	22.3
Low	2	9	15	14	nm	48	22.3
Signif.	ns	ns	**	**	—	*	
Digit grass — 1980 sowing							
High	—	nm	7	23	44	99	14.0
Low	—	nm	2	9	nm	57	14.0
Signif.	—	—	ns	*	—	**	
Sabi grass — 1980 sowing							
High	—	nm	46	71	63	90	33.8
Low	—	nm	24	20	nm	45	33.8
Signif.	—	—	ns	*	—	*	

[1]Not measured.
[2]Not significant.

was retarded by the presence of the original plot of sabi grass, and vice versa. Further, the frequency of digit grass was noticeably less beyond the original plot of sabi grass than before it. This gave 3 distinct zones of spread: the spread of digit grass before it reached an original sabi grass plot; the spread into an original sabi grass plot; and the spread beyond the original sabi grass plot. Three similar zones occurred for sabi grass in relation to original digit grass plots. As the original plots were allocated randomly within each replicate, the digit and sabi grass plots were varying distances apart. This allowed a comparison of spread over varying distances for each of the 3 zones.

As the trial was not set up to measure the spread of the 2 species, there were insufficient occurrences of each combination to allow statistical analysis. Frequency of both species declined as distance from their original sown plots increased in both low and high fertility paddocks (Figure 1). There was a marked drop in the frequency of occurrence of digit grass between 10–20 m from its source, where it was spreading into an original sabi grass plot. There were further slight declines at distances between 20–40 m, beyond an original sabi grass plot. The negative effect of an original digit grass plot on spread of sabi grass was even greater.

Study 2 — cover, yield and species richness

Cover. In November 1994, the basal cover of digit grass was more than double that of sabi grass and speargrass (P<0.001) (Figure 2), but litter cover was only one-third that of sabi grass and speargrass (P<0.001). The biggest difference was in bare ground where digit grass plots had a significantly higher (P<0.001) proportion (34%) than sabi grass plots (12%), which had a significantly higher (P<0.05) proportion than speargrass areas (7%). By comparison, the nearby buffel grass-siratro pasture had 10% bare ground.

Yield. Yield in autumn 1995, following a dry summer, was significantly lower (P<0.05) within cages of digit grass than within cages of speargrass or sabi grass in the low fertility paddocks without added N (Table 2). There were no significant differences (P>0.05) with added N, or in the high fertility paddocks (Table 2). As would be expected, application of N had a significant (P<0.001) effect on yield with the low fertility paddocks having a greater response than the high fertility paddocks.

Associated with the increase in yield of digit grass following N fertilisation was a large increase in the number of inflorescences. In the high fertility paddock, the mean number of inflorescences rose from 116/m^2 in areas without

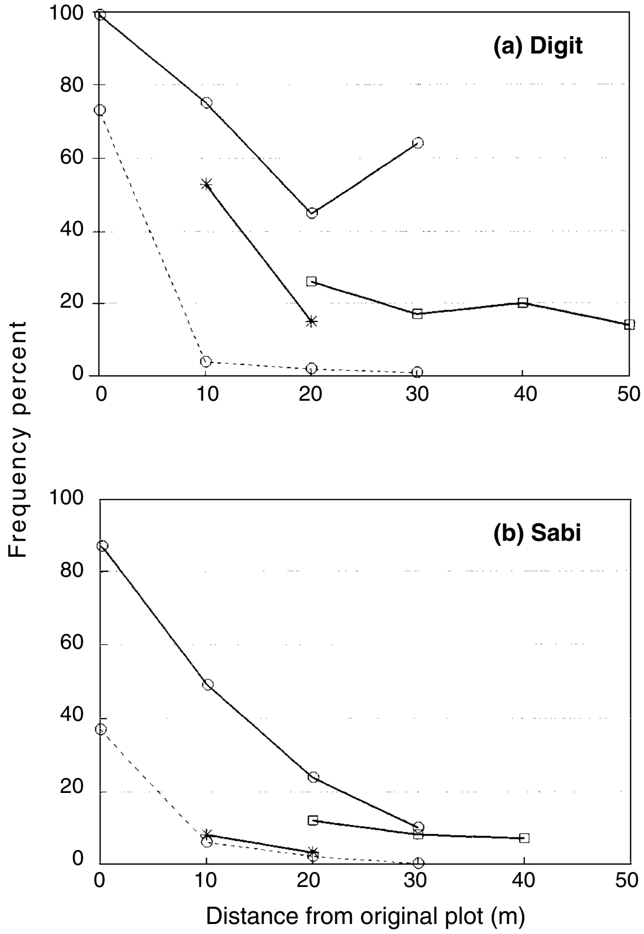

Figure 1. (a) Mean percentage frequency of occurrence of digit grass before (s), within (✳) and beyond (h) the original plot of sabi grass in the high fertility paddock (———) and before the original plot of sabi grass in the low fertility paddock (- -). (b) Frequency of occurrence of sabi grass in relation to the original plot of digit grass.

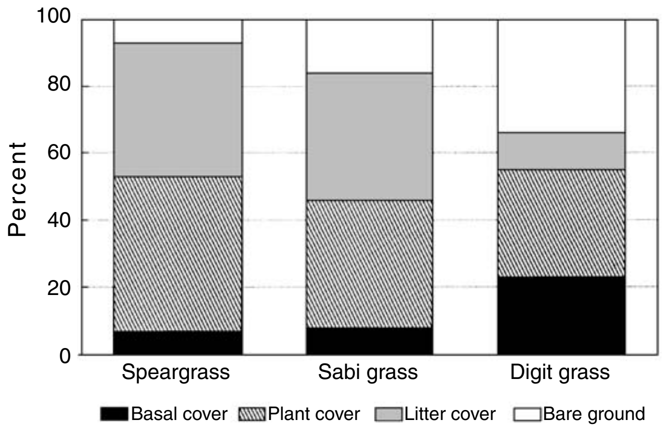

Figure 2. Percent basal cover, plant cover, litter cover and bare ground for speargrass, sabi grass and digit grass.

N to 207/m^2 where N was applied. The corresponding rise in the low fertility paddock was from 67 to 124/m^2.

At this time, leaf and stem separation showed that ungrazed digit grass had only 13% leaf compared with 33% for speargrass, sabi grass and buffel grass. Total leaf yields of speargrass and sabi grass were nearly 5 times the leaf yield of digit grass.

Despite good spring rain, there was no significant difference between species in spring regrowth in October 1995, except where N had been applied in the previous growing season. With added N, digit grass significantly (P<0.05) out-yielded sabi grass and speargrass in the high fertility paddock, and digit and sabi grasses significantly (P<0.05) out-yielded speargrass in the low fertility paddock. In February (summer) 1996, without added N, digit grass again had lower yields than both sabi grass and speargrass, although not always significantly lower.

The buffel grass in the nearby paddock out-yielded both digit and sabi grasses at each sampling, with and without added N, except for digit grass with added N in the high fertility paddock in February 1996.

Table 2. Yield (kg/ha) at 3 harvests in high and low fertility paddocks, with and without the addition of fertiliser N. Within each column within each harvest, values followed by different letters are significantly different (P<0.05).

Species	Nil N		100 N	
	High fertility	Low fertility	High fertility	Low fertility
Autumn 1995				
Speargrass	3220a	2610b	3910a	4460a
Sabi grass	2960a	2760b	4060a	4970a
Digit grass	2130a	1390a	4150a	3710a
Spring 1995				
Speargrass	740a	600a	1030a	850a
Sabi grass	730a	570a	1060a	1280b
Digit grass	860a	570a	1700b	1550b
Summer 1996				
Speargrass	6000b	4090a	7530a b	7640a
Sabi grass	3690ab	2760a	6440a	7040a
Digit grass	2780a	1890a	10060b	7340a

The material harvested from speargrass quadrats was approximately 75% speargrass and 25% other native grasses and forbs, while sabi grass quadrats were more than 90% sabi grass and digit grass quadrats were almost 100% digit grass.

Species richness. Species richness per quadrat (number of different species per quadrat) in April 1995 was highest in speargrass areas and lowest in digit grass (Table 3). There was no significant difference in species richness between the high and low fertility paddocks.

In the November 1994 sampling, every quadrat in speargrass areas had more than 3 species, while, for the digit grass plots, only 1% of quadrats had more than 3 species and 91% had fewer than 3. In the sabi grass plots, 89% of quadrats had 3 species or more, and in the nearby buffel paddock, 48% had 3 or more. Although these measurements were restricted to only the 1979 sowing in 2 replicate paddocks, results from the 1993 frequency data taken over both the 1979 and 1980 sowings in all 4 replicate paddocks showed there was little difference between sowings or paddocks at the same fertility level. Speargrass was present in only 11% of quadrats in digit grass plots and 27% of quadrats in sabi grass plots. In plots of 'other sown grasses' which failed to persist, and which had less than 10% invasion by digit or sabi grass, speargrass was present in 50% of quadrats. Other native grasses were present in 32, 69 and 94% of digit grass, sabi grass and 'other sown grass' plots, respectively.

Species richness per plot (number of different species per plot), showed similar differences (Table 3), with digit grass having significantly fewer (P<0.001) than sabi grass or speargrass. No statistical test could be done on the total number of species found over all plots of each species (Table 3). However, of the 8 species found in digit grass plots, only 3 were grasses (all annuals), and only 2 of the 8 species were perennials. In contrast, there were 5 perennial grass and 4 annual grass species in the sabi grass plots.

Table 3. Average number of species per quadrat (0.5 m × 0.5 m) and per plot (25 quadrats), and total number of species over all plots (100 quadrats).

	Speargrass	Sabi grass	Digit grass	LSD (P<0.001)
No.species/quadrat	5.8	3.8	1.6	1.8
No.species/plot	24.5	18.5	4.3	11.1
No.species over all plots	42	30	8	

Discussion

Yield and spread

Despite poor establishment, the density of both digit grass and sabi grass increased with time. The competitive ability of both species enabled them to displace speargrass and other native species. The biggest restriction to spread of each was the presence of the other, with digit grass being more dominant. This ability to spread and persist is desirable in pasture species, and over the 17-year period, the proportion of these 2 grasses increased whereas that of speargrass decreased. However, the lack of any advantage in productivity over speargrass on this soil, without added N, means that, unless a suitably adapted legume can be found to persist with these introduced grasses, they are of limited pasture value relative to good stands of native speargrass pasture.

Both digit and sabi grass showed they could spread into speargrass on low fertility granite soil but spread more rapidly where soil fertility had been improved. While the results show a good yield response to added N, it should be noted that, in this case, both N and P status of the soil had been improved.

Early spring growth of both species was little better than that of speargrass and less than that of buffel, except with added N. Hacker *et al.* (1995) also found digit grass to have poorer spring growth than buffel grass, although it had better late winter growth than buffel. With the unreliability of August–September rainfall in this region, neither species is likely to produce significantly more than speargrass or buffel. Spring regrowth in speargrass may have been underestimated in this trial because speargrass regrowth, cut in exactly the same quadrat position as the autumn cut, was noticeably less than in the immediate surrounding area. This did not apply to digit and sabi grass and could indicate a possible susceptibility of speargrass to severe defoliation in late autumn.

In Autumn 1995, without added N, both species had higher yields in the high fertility paddock than in the low fertility paddock, with digit grass having considerably lower yields than sabi grass. The higher response of digit grass to application of N shows that the low productivity of these grasses, particularly digit grass, is probably due to N deficiency. This supports the findings of Robbins *et al.* (1987) for many other sown grass pastures and agrees with the South African recommendations for high levels of N fertiliser when growing commercial pastures of *Digitaria eriantha* on low-N soils (Fair 1989).

Personal observations indicated that growth of individual digit grass tussocks was comparable with or better than that of speargrass for the first 3 years, before declining, while growth of sabi grass was always less than that of good speargrass. A decline in productivity of digit grass 3 years after establishment has occurred in several plantings on this soil type (C.K. McDonald, unpublished data). The time lag highlights the risks associated with short-term evaluations. Recommendations based on the performance of digit grass 3 years after oversowing would have over-estimated its potential productivity, while recommendations for sabi grass would have been more accurate. In reverse, a similar time lag for sabi grass to show its good potential in north Queensland was reported by Coates (1991).

The decline in pasture productivity in sown grass pastures over time is well recognised (Myers and Robbins 1991) and is accompanied generally by a change in species composition. However, we recorded no decline in the population of sabi grass and digit grass over 12 or more years; in fact, they have continued to spread and increase in density. This has implications if the species were to spread into areas where they were not wanted.

Species richness

McIntyre (1994) suggests that the future maintenance of biodiversity in native pasture communities will come primarily from our grazing lands and not from our national parks. Thus, while it is desirable to preclude an excessive build up of the proportion (by biomass) of 'weeds' in a pasture, it is preferable, as much as possible, that this not be done at the expense of species richness. The competitive nature of digit grass in reducing the species richness of the immediate area in which it is established, is a matter of concern. While some loss of species richness may be acceptable in limited areas when accompanied by high productivity, it is undesirable if accompanied by persistent lowly productive grasses such as digit grass reported here. If the digit grass died out, the ability of the system to recover would be markedly different from a system where many unsown species still remain.

Lonsdale (1994) expressed concern over the problems of introduced species becoming weeds. Interestingly, on his somewhat arbitrary criteria, digit grass was 1 of only 4 species listed as useful but not a weed. In this region, the ability of sabi and particularly digit grass to spread in areas of low fertility means they could have greater potential as so called 'weeds' than species such as buffel grass or green panic. The latter species have been listed as weeds (Lonsdale 1994) but do not spread in grazed pastures on granite soils in this region.

The amount of bare ground in areas dominated by digit grass could be environmentally damaging. While less than 40% bare ground may greatly reduce runoff and erosion in some pastures (Silburn *et al.* 1992), that 40% would be part of a mosaic of litter and small bare areas. In the digit grass pasture reported here, the 34% bare ground was almost completely bare, with channelling between tussocks and areas of deposition clearly evident (authors, unpublished data). Sallaway and Waters (1994) showed increased run-off and soil loss on granitic lands where speargrass was replaced by lowly productive annual species. The low productivity leads to a lower return of plant material to the soil and exposure of soil to a harsher environment. The structure of the pasture at this fine scale (10–100 cm) can be important to the stability of a grassland system (Tongway and Ludwig 1994).

Although there was more litter in areas dominated by digit grass after the good summer growth of 1995–96 than measured in November 1994, there was still noticeably less than in areas dominated by sabi grass or speargrass. As a result of its high palatability, selective grazing of digit grass would contribute to its low litter yield.

Conclusion

Planting introduced grass species should be encouraged only when there are demonstrated long-term benefits over native grass species or where the native grass species have been irretrievably lost due to degradation of pastures.

The more rapid increase in frequency of both species in the high fertility paddocks suggests that, if grasses are to be oversown, it would be advantageous to do this after soil fertility has been improved by fertilisation and introduction of a legume. However, the costs of the fertiliser and the extra sowing must be taken into account.

The fact that sabi grass displaced speargrass may indicate that it could persist at a higher stocking rate than speargrass. However, sabi grass has no productivity benefit over speargrass and is less productive than buffel. Hence, unless it can be shown to have a nutritional advantage, we could not recommend it be used to replace good speargrass pastures on these soils. Sabi grass has the ability to spread, so it may have a role for low-cost reclamation of degraded land, where the native grass pasture cannot be restored by management.

Digit grass is much more competitive than sabi grass, but is less productive on these low fertility granite soils. If a suitable vigorous legume could be found to persist with digit grass, as the annual winter-growing serradella (*Ornithopus compressus*) does on sandy-surfaced soils in south-east Queensland (Johnson and Lloyd 1990), this grass may give useful productivity. Alternatively, with heavy applications of N, it could be used as a forage crop, as it is in southern Africa (Fair 1989; Hardy 1994). However, under present usage on granite soils in the south Burnett region, it offers no production benefits relative to undegraded speargrass and has a number of disadvantages. Based on this, we would recommend that digit grass not be sown on these soils.

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