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Competition affects survival and growth of buffel grass seedlings — is buffel grass a coloniser or an invader?

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Abstract

The survival of buffel grass seedlings in quadrats either with or without competition from other plants was measured in 2 pastures near Townsville over a 65-week period. No buffel grass seedlings survived in the competition treatment but 40% and 80% of the seedlings without competition survived. These results suggest buffel grass is able to colonise bare areas but is unable to invade dense vegetation. The studies need to be extended to other vegetation types to determine the generality of the results.

Introduction

Buffel grass (*Cenchrus ciliaris*) invokes diverse opinions in Australia. Agriculturally, it is recognised as the most valuable introduced grass in arid and semi-arid tropical areas where it is widely sown for pasture and soil conservation. It is usually sown on a cultivated seedbed or into country that has been cleared and burnt and where most of the existing ground layer has been destroyed. Establishment success varies but many good buffel grass pastures have established and persisted. However, spread from these established pastures has often been slow or non-existent and many producers consider buffel grass would be even more valuable if it was able to colonise unsown areas more rapidly. Gardener and McIvor (1986) showed that spread from initial establishment in rows on a number of experimental sites in north Queensland was much less for buffel grass than for a number of other introduced grasses including *Urochloa mosambicensis, Bothriochloa insculpta* and *Chloris gayana.*

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Environmentally, buffel grass is recognised as one of Australia's worst weeds (Humphries *et al.* 1991). Buffel grass is invading along river banks into mesic habitats in the arid zone, forming dense monocultures, changing fire regimens, threatening key refugia, and displacing native and endemic plants (Humphries *et al.* 1991; Griffin 1993; Low 1997). It is an aggressive coloniser of moist habitats such as run-ons, river levees and alluvial pans and is capable of spreading into adjacent habitats.

Why is there this difference in opinion about the spread and colonising ability of buffel grass? Cavaye (1991) reported "Natural spread occurs only on fertile lands where the residual vegetation is removed one way or another. Its spread into good native pastures is poor." This suggests two factors affecting spread by buffel grass — soil fertility and competition from other plants. Buffel grass has medium to high requirements for phosphorus and a number of studies have linked the performance of buffel grass to soil fertility and phosphorus supply (Christie 1975; Christie and Moorby 1975; McIvor 1984). The competitive ability of buffel grass seedlings, and the competition offered by the resident vegetation is another possible factor. Humphreys (1967) suggested that the degree of ground disturbance necessary for successful establishment of buffel grass is closely related to the amount of competition from the existing flora. Ash *et al.* (1997) reported observations and measurements near Charters Towers and Katherine which showed little spread of buffel grass into surrounding native pasture when the pastures were grazed separately and the native pasture was largely undisturbed. However, following a 5-year drought period when rainfall was less than 50% of the long-term average, the native pastures at Charters Towers were severely weakened and there was considerable invasion (McIvor *et al.* 2000).

These observations and measurements led to the following hypothesis — while buffel grass is strongly competitive as an established plant, it is only weakly competitive as a seedling. Hence, it can establish where there is little competition and colonise bare areas but it cannot invade established vegetation. This was tested by comparing survival of buffel grass seedlings regenerating from the soil seed bank in 2 pastures with and without competition.

Materials and methods

Site

The experiment was conducted at the CSIRO Lansdown Research Station (19°36'S, 146°50'E), 50 km south of Townsville. Lansdown has an average annual rainfall of 865 mm of which 78% falls during December–March. The experimental site was cleared of trees in 1972. The soil was an infertile yellow earth with low levels of total nitrogen (0.06%) and extractable phosphorus (3–4 ppm with 0.01 M H_2SO_4 extraction) in the sandy loam surface layer.

Two plots from a large experiment studying the ecology of *Stylosanthes* species were used (Gardener 1975). The plots (0.33 ha) were cultivated and sown to pasture at the start of the 1974–75 wet season. Both plots were sown with *Cenchrus ciliaris* cv. Gayndah (5kg/ha) and either *Stylosanthes hamata* cv. Verano (Plot A) or *S. scabra* CPI 34925 (Plot B). The plots were fertilised with 300 kg/ha of superphosphate annually and grazed by yearling Droughtmaster (approximately 50% *Bos indicus*) steers from 1975 at a rate equivalent to 1.5 steers/ha.

Daily rainfall and evaporation were measured at a recording station approximately 3 km from the plots. The simple water balance model, WATBAL, (Keig and McAlpine 1974) was used to calculate the moisture index of Fitzpatrick and Nix (1970). Available water storage capacity of the soil was estimated to be 100 mm from the soil profile description (Murtha and Crack 1966) and relationships of Greacen and Williams (1983), and a potential evaporation rate of 0.75 × pan evaporation was assumed.

Experimental details

In late December 1979, 10 pairs of quadrats each 45 cm × 30 cm were selected in each plot. All quadrats contained buffel grass but the content varied from small amounts to dominance by buffel grass. The average basal area of buffel grass in the quadrats was 3.5%. All quadrats were enclosed in individual wire mesh cages (1 m diameter) to prevent grazing by large herbivores.

The quadrats in each pair were allocated at random to the 2 treatments — competition or no competition. For the *competition* treatment, the dry herbage in the cage was cut to 10–15 cm and removed. The pasture was then allowed to regrow without any further treatment. For the *no competition* treatment, the cage was kept free of above-ground herbage. The dry herbage was removed as in the competition treatment and then any remaining plants were cut at ground level and all material removed — this was done carefully so soil disturbance was minimised. This removal of above-ground plant material was repeated at each sampling time. Thus, the cages were maintained free of above-ground material but there may have been some shading (although small) from the herbage outside the cage. No attempt was made to control below-ground competition.

From January 4–8, 1980 (Week 1, one week after germination commenced), all buffel grass seedlings in each quadrat were labelled with coloured plastic bands. The survival of these tagged plants was monitored at weekly intervals until Week 8 (February 27), then at 2-weekly intervals until Week 35 (September 4). By this time, it became difficult to determine if plants were dead or just dry and senescent but still alive. Observations ceased until the next growing season in January 1981. Two further observations were made at Week 53 (January 6) and Week 65 (March 31). Most germination of seed in these pastures occurs following the opening rains of the wet season (McIvor and Gardener 1991) and few seedlings emerged after the initial cohort. Where seedlings did emerge, they were also labelled but none survived and no results are presented for these cohorts. At each sampling date, all surviving seedlings were counted. During the 1980 growing season up to Week 14 (April 9), the seedlings in each quadrat were rated for size and health of the median plant using a similar scale to that used by Cook (1984) (Table 1). Buffel grass seedlings growing outside the quadrats were also rated and a total of 20 plants covering the rating scale of 1–10 were cut at ground level, oven dried and their dry weights determined. A regression equation relating ratings to seedling dry weights was calculated and used to convert the ratings made on seedlings in the quadrats to plant weights.

Table 1. Rating scale used to assess size and health of buffel grass plants.

Rating	Plant description
1	Plants less than 4 cm high, 1 tiller, 1–3 leaves, pale with some dead leaves
2	Plants similar size to 1 but more healthy and no dead leaves
3	Plants 4–6 cm high, 1–2 tillers, some dead leaves
4	Plants similar size to 3 but dark green and no dead leaves
5	Plants 6–8 cm high, 2–4 tillers, some dead leaves
6	Plants similar size to 5 but dark green and no dead leaves
7	Plants 8–10 cm high, 2–6 tillers, green and healthy
8	Plants 10–12 cm high, 2–6 tillers, green and healthy
9	Plants 12–15 cm high, 3 or more tillers
10	Plants more than 15 cm high, 3 or more tillers

Results

Growing conditions and pasture growth

The weekly values for the water index are shown in Figure 1. Conditions were very dry until the last week in December 1979 (Week 0) with no rain in the previous 4 weeks and only 90 mm in the previous 8 months. Rainfall and growing conditions were good until June (although there was some moisture stress from April onwards) followed by a long dry season until December 1980. There was very high rainfall during the 1981 wet season. Overall, growing conditions during the experiment were good. During the 1980 growing season, pasture yields were estimated to exceed 4000 kg/ha in both plots. The sown legumes were the largest component in both pastures but there were also substantial amounts of buffel grass and annual grasses, and smaller amounts of sedges and forbs. Both pastures were more than 50 cm high during much of the experiment and the dense swards provided strong competition to any seedlings.

Survival of buffel grass plants

There was a large germination of buffel grass seeds following the rain during Week 0 with an average of 160 seedlings per m^2.

The survival of the tagged buffel grass seedlings is shown in Figure 2. Competition did not affect survival initially and seedling mortality in the first 2 weeks was approximately 20% in Plot A and 40% in Plot B. In the no-competition treatment, there was little mortality during the remainder of the experiment with final survival values at Week 65 of approximately 80% in Plot A and 40% in Plot B. In the competition quadrats, mortality continued so that by Week 20 only 20% of the original seedlings survived. These plants survived until the following growing season when they too succumbed.

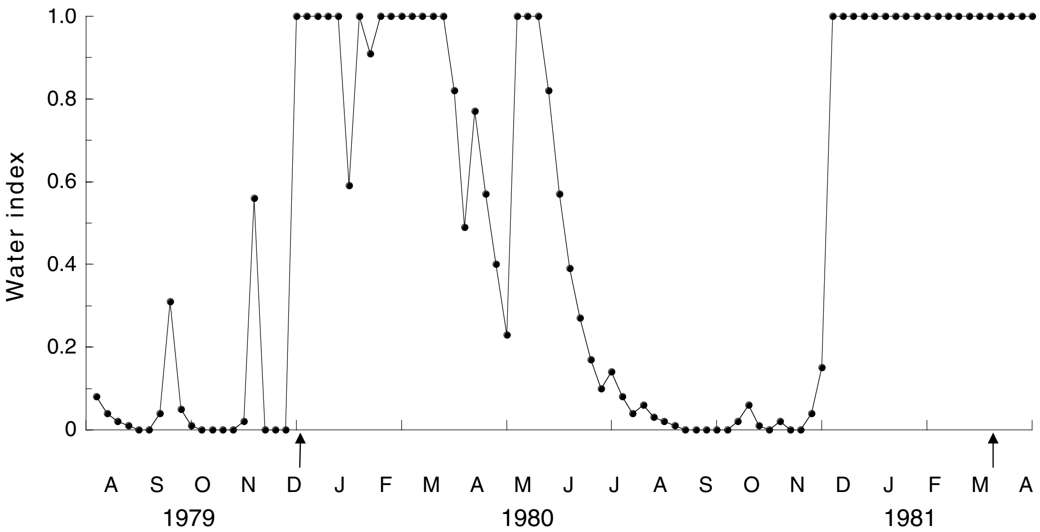

Figure 1. Weekly values of the water index of Fitzpatrick and Nix (1970) at Lansdown during the experimental period. The arrows mark the times of initial germinating rains (Week 0) and the final sampling (Week 65).

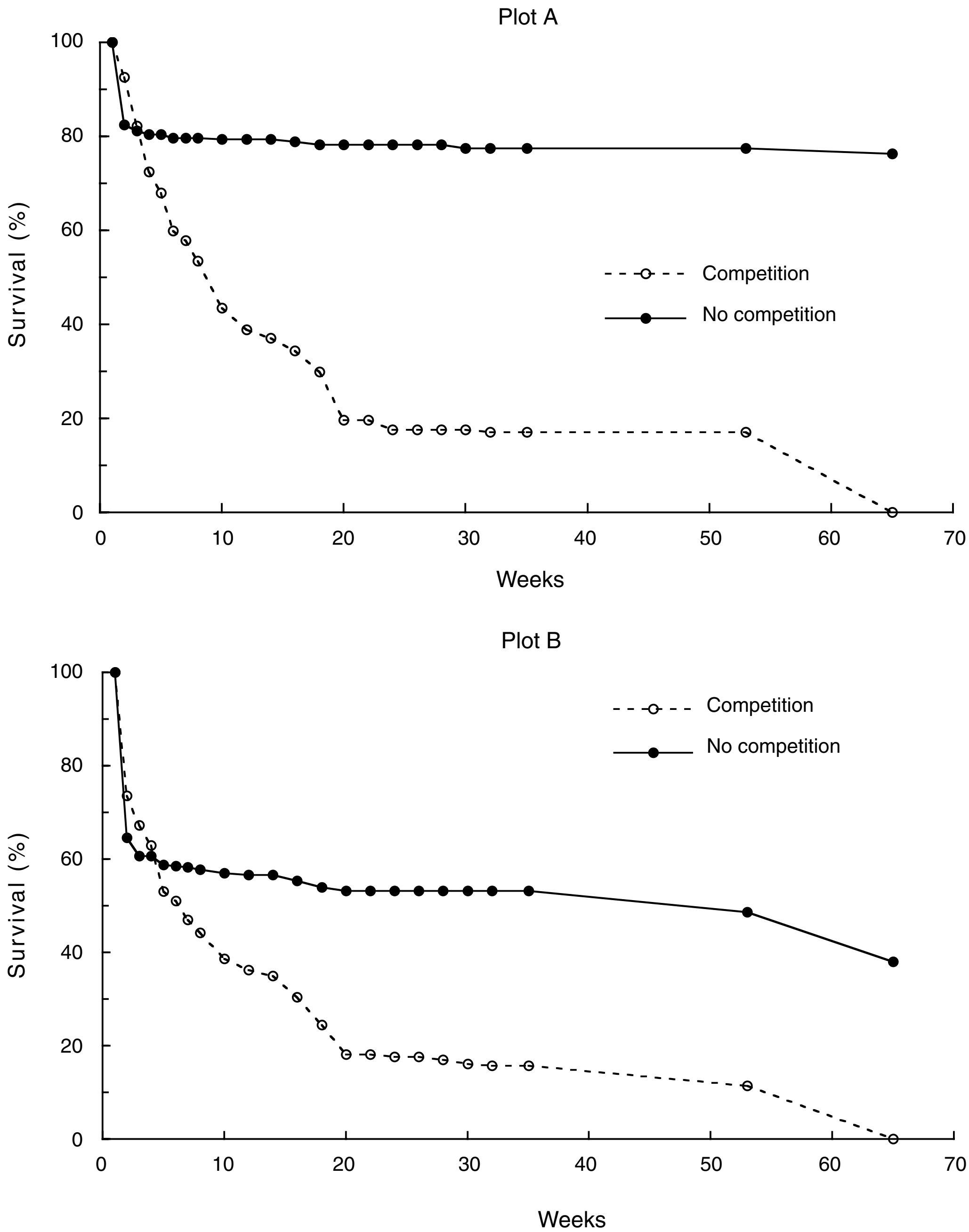

Figure 2. The effect of competition on the survival of buffel grass seedlings in a *Stylosanthes hamata*-based pasture (Plot A) and a *Stylosanthes scabra*-based pasture (Plot B).

Growth of buffel grass plants

There were large differences in size of the buffel grass plants in the 2 treatments. Most plants in the competition treatment remained as single tillers although some grew to 40–50 cm tall. None of these plants flowered. In contrast, the plants with no competition began producing additional tillers from Week 2 and some began flowering in Week 5. By Week 14, typical plants in the no-competition treatment had more than 5 tillers, had flowered, and had more than 10 times the biomass of plants in the competition treatment (Figure 3).

Discussion

These results demonstrate very large impacts of competition on the survival of buffel grass seedlings — no seedlings survived where there was competition from a dense pasture but 40–80% of seedlings survived when there was no competition.

Van Hulst *et al.* (1987) have contrasted the behaviour of colonisers and invaders. Colonisers can spread rapidly on bare areas where the bare areas are large enough for plants to establish and complete their life cycles without suffering from plant interference. Invaders can enter and multiply in vegetation lacking large gaps and are able to complete their life cycles under

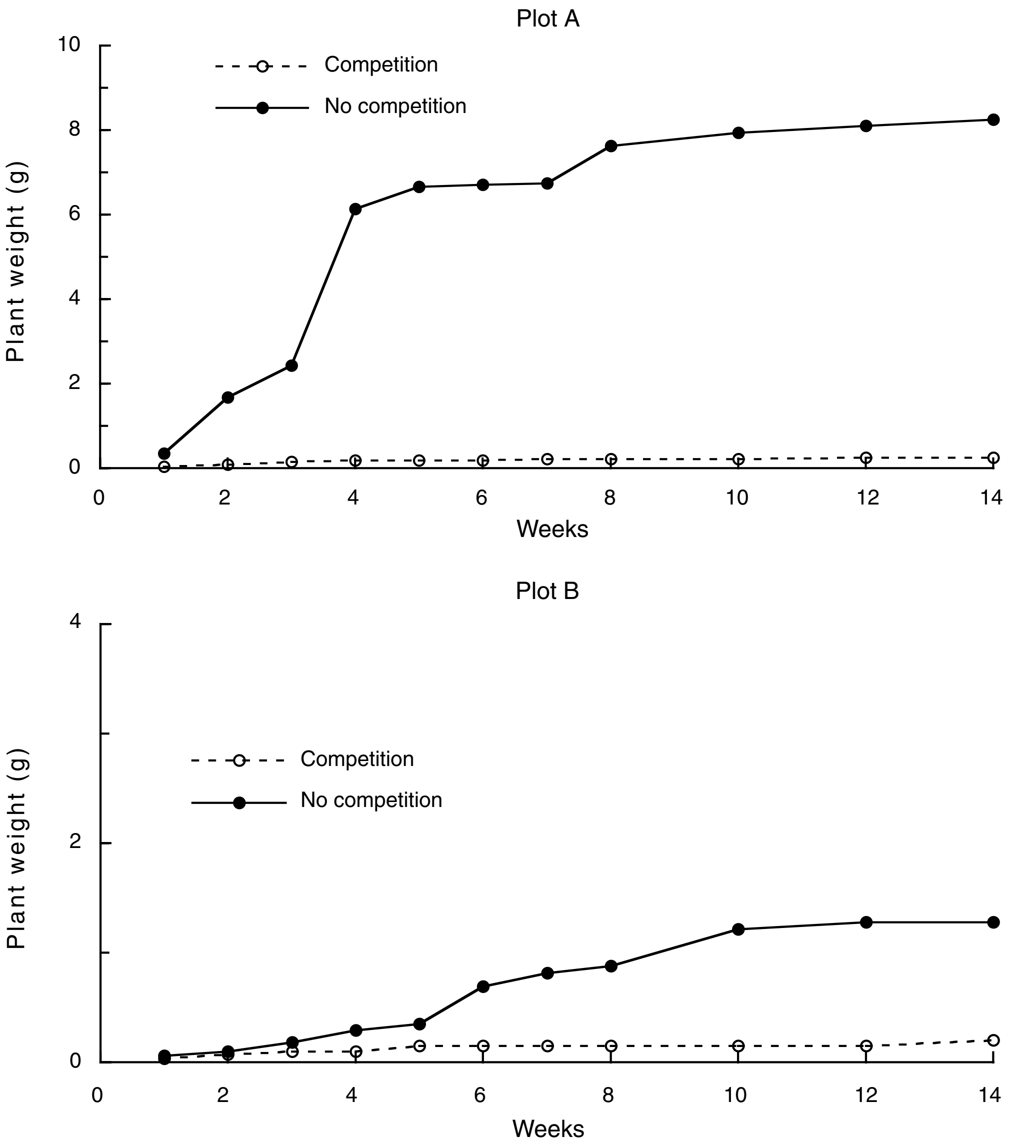

Figure 3. The effect of competition on changes in size of buffel grass seedlings during the first growing season in a *Stylosanthes hamata*-based pasture (Plot A) and a *Stylosanthes scabra*-based pasture (Plot B).

conditions of severe competition. The results of this experiment suggest that buffel grass can be classed as a coloniser but not as an invader.

My findings present a possible explanation for the differences in opinions about buffel grass outlined in the Introduction. It is likely there are large differences in the degree of competition faced by buffel grass seedlings in riparian areas in arid zones compared with many native pastures in higher rainfall areas. In the arid zone, the more fertile and better-watered riparian areas are preferentially grazed by animals and some of these areas have been overgrazed creating bare areas. Even with no or little grazing, bare areas are created during the droughts common in these areas. Thus, bare areas are available for buffel grass to colonise. In contrast, unless native pastures in higher rainfall areas have been overgrazed, there will be few bare areas and buffel grass will not be able to invade. However, where native pastures are weakened by drought or overgrazing, buffel grass will be able to colonise these areas as Cavaye (1991) and McIvor *et al.* (2000) reported.

Where the aim is to discourage the spread of buffel grass, maintaining competition from existing vegetation will be important. This will reduce spread but it is unlikely to prevent it altogether as some gaps will eventually occur, *e.g.* due to death of plants during drought. Conversely, where the aim is to encourage spread, gaps should be created in the vegetation (*e.g.* by heavy grazing) to provide space for buffel seedlings to establish.

Widespread extrapolation of these findings to other locations and pasture situations may be premature at this stage as they were derived from 1 site only and on only 1 occasion. There is a need to study how buffel grass seedlings compete with other species, to examine other buffel grass cultivars, and to conduct studies under a range of conditions to test the generality of these conclusions.

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