Evaluation of perennial peanuts (*Arachis* spp.) as forage on the New South Wales north coast

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Abstract

Eleven accessions of perennial *Arachis* species were planted (as 30 × 30 cm sods) alone or with Argentine Bahia grass (*Paspalum notatum*) or with Bahia grass and Haifa white clover (*Trifolium repens*) in swards at Grafton in northern NSW. Swards were cut to 2–4 cm stubble at 2 cutting frequencies. The dry matter production and spread of the *Arachis* accessions were measured over 4 years from the beginning of summer 1990–91 until the end of summer 1993–94. Rainfall was below the long-term average (1074 mm) in 3 of the 4 years.

Arachis glabrata accessions, CPI 93469 and CPI 93483 (now cv. Prine) were the most productive, averaging between 0.9 and 2.9 t/ha of dry matter each year across the treatments. A hybrid (*Arachis pintoi* × *Arachis repens*) and *Arachis glabrata* CPI 93476 had the greatest spread, covering between 2.5 and 5.4 m^2 of ground area after 4 years of growth in pure stands.

The infrequent cutting treatment (twice per year) resulted, on average, in up to almost an extra tonne of dry matter produced per year by some *Arachis* accessions compared with the frequent cutting treatment (3–4 times per year). With lower cutting frequency, some accessions also covered up to an extra 1.5 m^2 of area after 4 years growth compared with more frequent cutting.

Cutting frequency usually had a greater effect on dry matter production and rate of spread of the *Arachis* spp. than did grass competition, although all accessions produced higher yields in pure swards than in mixed swards. The ability of some accessions, such as *Arachis repens,* to spread was also significantly reduced in mixed swards.

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Introduction

Perennial wild-type peanuts, *Arachis* spp., have demonstrated adaptability to the soil types and moisture regimes of coastal, subtropical Australia (Jones 1993; Cook *et al.* 1994; Bowman and Wilson 1996). They can provide high quality forage for this region as they have high dry matter production and some types can spread through swards of the aggressive, summer-growing grass species (Cook *et al.* 1994). In previous work (Bowman and Wilson 1996), rhizomatous *Arachis glabrata* types, were shown to have potential as pasture species for the north coast of New South Wales. We have further evaluated accessions of *Arachis* spp. and investigated their ability to produce and spread in swards with 2 other common pasture species, Bahia grass (*Paspalum notatum*) cv. Argentine and white clover (*Trifolium repens*) cv. Haifa under 2 cutting regimes.

Materials and methods

Site

The experimental site was at Grafton Agricultural Research Station (29° 30'S; 1074mm annual average rainfall) where the soil was a red-brown clay with pH 4.7 (in water), electrical conductivity 38 mmhos, 0.124% N and 78 ppm available phosphorus (bicarbonate extraction).

Treatments

Eleven *Arachis* accessions (Table 1) were established in 3 sward types (accession sown alone, accession +Bahia grass, accession +Bahia grass and white clover) and 2 cutting frequencies (frequent and non-frequent) were applied. The site was chisel ploughed and harrowed in August 1990 and then marked out in two hundred and eighty 2.5 m x 2.5 m squares with 0.5 m borders around each square. There were 4 replicates of 70 treatments (11 *Arachis* accessions x 3 sward types x 2 cutting frequencies plus 4 pure grass treatments) laid out in an 8 row x 35 column rectangular array of plots. The replicates were sown in pairs of adjacent rows and the treatments were allocated to the plots using a neighbour balanced design. Border areas between the plots were kept free of weeds by spot spraying throughout the experiment.

A 30 cm square of each of the 11 *Arachis* accessions, cut out with a turf cutter, was planted into the centre of each 2.5 m x 2.5 m square by hand on August 22, 1990. The *Arachis* was watered until established. Bahia grass seed was sown across the appropriate plots by hand (9 kg/ha) and all plots were raked and watered. Molybdenum-superphosphate at 500 kg/ha and sulphate of potash at 200 kg/ha were then applied to all plots. Plots were raked, watered again and rolled. White clover seed was already present in the soil and was allowed to regenerate in the "plus white clover" plots. All other plots were hand weeded to remove establishing white clover plants. Once the treatments had established, all watering ceased. Weed control was undertaken chemically or by hand weeding when required and pure *Arachis* treatments were kept as weed-free as possible.

Cutting frequency varied from year to year, largely influenced by rainfall patterns. Swards under the frequent cutting regime were cut approximately twice as often as those under infrequent cutting. However, in Year 1, all plots were cut twice only. In Year 2, low-frequency plots were cut twice and frequently-cut plots 4 times, and in Years 3 and 4, low-frequency plots were cut twice and frequently-cut plots 3 times. Cutting was done with hand-held electric shears to a stubble height of approximately 2–4 cm.

There were 16 dry weight harvests between November 20, 1990 (3 months after planting) and April 11, 1994 (when the experiment was terminated). At each harvest, a 1 m^2 quadrat was fitted across the centre of the plots from 2 diagonal permanent corner pegs and the material inside was cut and removed. This material was then sorted into *Arachis*, Bahia grass, white clover and weed components. The sorted material was dried at 105°C for 72h and then weighed. The yield data was therefore taken at times when there was incomplete cover of the quadrat by *Arachis*.

The spread of *Arachis* in the plots was measured by placing a grid over the whole plot and mapping the position of the plants. These measurements were taken at the end of the seasonal growth period (June–July) of 1991, 1992, 1993 and 1994.

Data for dry weight and spread measurements were analysed after log transformation as there was variance heterogeneity at varying levels in the raw data. Linear mixed models were used to analyse log (dry weight) and log (spread) with terms included to account for temporal variation

Table 1. Perennial *Arachis* accessions planted into swards at Grafton in 1990.

Accession	Species	Note
CPI 12121	*glabrata*	semi-erect, rhizomatous, plantings in Australia since 1948 have shown it to be very persistent
CPI 19898	*glabrata*	ex. Paraguay, rhizomatous
CPI 22762	*glabrata*	low-growing, compact, erect, known to have good early season growth, persistent in closely defoliated swards
CPI 29987	*glabrata*	ex. Brazil, rhizomatous
CPI 58111	*glabrata*	ex. Paraguay, cv. Arblick (USA), rhizomatous
CPI 93469	*glabrata*	ex. Paraguay, 80 m a.s.l., rhizomatous
CPI 93476	*glabrata*	ex. Brazil, 200 m a.s.l, rhizomatous
CPI 93483	*glabrata*	ex. Argentina, cv. Prine (Australia), forms a dense mat of thick rhizomes in the top soil but also has deep roots
CPI 58113	*pintoi*	ex. Brazil, cv. Amarillo (Australia), stoloniferous, high seed yields, persistent
CPI 28273	*repens*	ex. Brazil, stoloniferous
Hybrid of 28273 x 58113	*repens x pintoi*	selected by G. Wilson from old *Arachis pintoi* stands in northern NSW, stoloniferous, spreads quickly, drops leaves in times of moisture stress.

in the treatment effects, temporal correlation and the blocking structure of the design. The REML variance component estimation and best linear unbiased prediction were used for the random effects. All analyses were undertaken using the FORTRAN program ASREML (Gilmour *et al.* 1996).

Results

Seasonal conditions

Only in the sowing year of 1990 was the yearly rainfall above the long-term average of 1074 mm.

The growth period of *Arachis* is from spring until the end of autumn. The rainfall for this period (August–June) for 1990–91 to 1993–94 was 556, 986, 612 and 603 mm, respectively, compared with a 25-year average for this same period of 959 mm (Table 2). Therefore, for 3 of the 4 summers of the experiment, there was below-average summer rainfall.

Dry matter production

There were significant differences ($P<0.01$) in yields of the *Arachis* accessions, and the year, cutting frequency and sward type also significantly ($P<0.05$) affected dry matter production. Second-order interactions of accession × year, cutting frequency × year and sward type × year were also significant, but other high-order interactions were not.

On average, CPI 93469 was the most productive accession (mean = 1.97 t/ha, mean of 6 treatments, Table 3), followed by CPI 93483 (1.68 t/ha). *Arachis repens* (0.48 t/ha), CPI 19898

Table 2. Monthly rainfall (mm) for Grafton Research Station from January 1990 until December 1994 and 25-year average.

Month	1990	1991	1992	1993	1994	25-yr mean (1971–1994)
Jan	59	145	171	108	7	133
Feb	373	60	209	81	111	134
Mar	72	16	48	57	140	119
Apr	246	19	95	51	6	92
May	157	39	54	26	27	78
Jun	28	146	13	12	8	72
Jul	56	19	26	112	22	55
Aug	9	1	9	13	12	37
Sep	19	1	19	17	11	40
Oct	47	27	18	57	18	65
Nov	16	62	121	29	45	61
Dec	39	306	111	189	124	109
Total	1121	841	894	752	531	1025

Table 3. Average annual dry matter production (t/ha) of 11 *Arachis* accessions at Grafton over 4 years under 2 cutting frequencies (F = frequent; NF = non-frequent) and established in pure swards, with Bahia grass or with Bahia grass and white clover. Different letters indicate significant difference at the 5% level between treatments within an accession.

Accession	Pure stand		+ Bahia grass		+ Bahia grass + white clover	
	F	NF	F	NF	F	NF
CPI 12121	1.59 b	2.09 b	1.14 b	1.58 b	1.02 b	1.29 b
CPI 19898	1.00 a	1.11 b	0.51 a	0.90 a	0.32 a	0.63 a
CPI 22762	1.57 b	2.41 b	0.96 a	1.70 b	0.65 a	1.68 b
CPI 29987	1.91 b	2.58 b	1.16 b	1.73 b	1.09 b	1.69 b
CPI 58111	1.44 b	1.70 b	1.07 a	1.16 b	0.75 a	0.86 a
CPI 93469	2.10 b	2.58 b	1.45 b	2.25 b	1.41 b	2.05 b
CPI 93476	1.09 a	0.85 a	0.64 a	1.16 b	0.63 a	0.79 a
CPI 93483	1.49 b	2.93 c	0.95 a	1.90 b	1.31 b	1.52 b
Arachis pintoi	0.51 a	0.55 a	0.33 a	0.56 a	0.26 a	0.25 a
Arachis repens	0.53 a	0.73 a	0.41 a	0.26 a	0.34 a	0.43 a
Hybrid	1.21 b	1.13 b	1.21 b	1.19 b	0.95 a	0.64 a

(0.74 t/ha) and *Arachis pintoi* (0.41 t/ha) were the least productive accessions.

While dry matter yields of CPI 93469, CPI 93483, CPI 93476, CPI 12121 and the hybrid increased significantly with each year, production of the other 6 accessions decreased or stayed the same (Figure 1).

For 9 of the 11 accessions, the pure stand under an infrequent cutting regime was the highest yielding treatment (not CPI 93476 and the hybrid, Table 3). However, in most years, the difference between this treatment and the pure stand under a frequent cutting regime was not significant for an individual accession. The exceptions were CPI 93483, where the yield was markedly reduced under frequent cutting in Years 3 and 4, and CPI 93469, *Arachis pintoi* and *Arachis repens* in Year 4 only.

Yield of *Arachis* was reduced significantly when grown with Bahia grass or Bahia grass plus

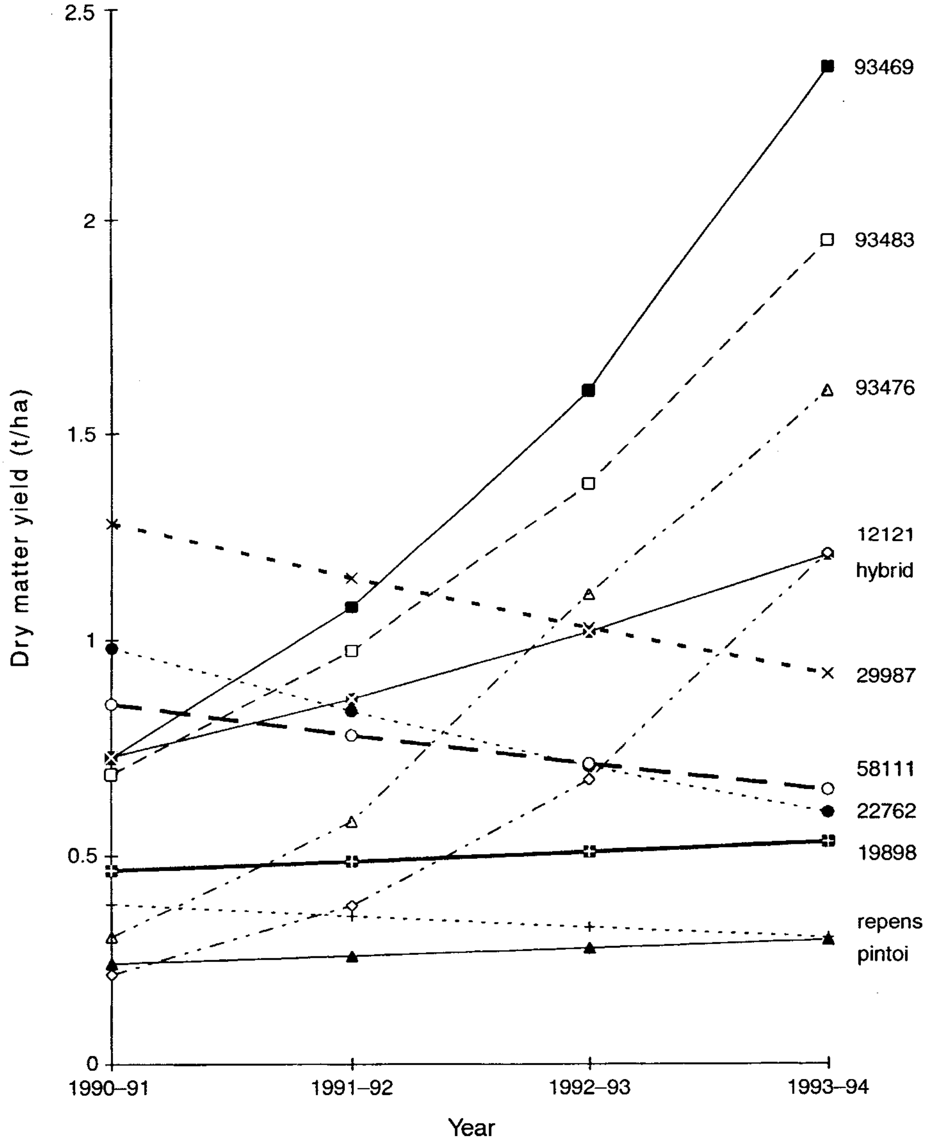

Figure 1. Annual dry matter production (t/ha) of 11 *Arachis* accessions (averaged over 6 treatments) grown at Grafton from mid-1990 until mid-1994.

clover for accessions CPI 19898, CPI 22762 and CPI 58111 (the latter 2 when combined with the frequent cutting regime, Table 3). In most cases, addition of white clover to the sward did not greatly reduce *Arachis* yields beyond that associated with Bahia grass alone.

The production of Bahia grass did not vary significantly with the *Arachis* treatments and averaged 0.69 t/ha in 1991–92, 0.93 t/ha in 1992–93 and 0.69 t/ha in 1993–94. White clover production was negligible and varied between 0.1 and 0.2 t/ha over the same seasons. No material of either Bahia grass or white clover was harvested in 1990–91 as there had been little growth of either.

Yields of *Arachis pintoi* and *Arachis repens* were always low irrespective of cutting frequency or competition. The yield of the hybrid was reduced significantly only when both Bahia grass and white clover were sown in the sward; the reason for this is not clear given the low white clover yields, while cutting frequency had little effect.

Spread of Arachis *accessions*

All treatments had a significant effect ($P<0.01$) on the spread of the *Arachis* accessions. The accession × year, sward × year and cutting frequency × year interactions were also significant but all other higher-order interactions were not.

The hybrid had the greatest spread (Table 4) and after 4 years covered an average area which was at least twice that obtained by any other accession when grown as a pure sward.

Spread of some accessions (for example, CPI 12121, CPI 58111 and *Arachis repens*) was reduced when they were grown with Bahia grass and white clover. The average area covered by the hybrid, CPI 22762 and CPI 93476 was not affected significantly by either cutting frequency or competition.

Discussion

Dry matter production

The experiment at Grafton was carried out during years of low rainfall which greatly reduced dry matter production. The *Arachis glabrata* accessions were the highest yielding in this experiment but the yields were still low in comparison with those measured in other regions of Australia. For example, cv. Prine (CPI 93483), which is suited to areas of above 900 mm average annual rainfall (B.G. Cook, personal communication), produced 11.9 and 7.6 t/ha over 2 years at Gympie compared with a mean of 1.68 t/ha over 4 seasons at Grafton. However, in the pure sward under a low cutting frequency in this experiment, it did produce 8.93 t/ha in one season (data not presented). Yields could have been limited in the early years at Grafton because there was not complete cover by *Arachis* of the 1 m^2 quadrat in which the cuts were taken.

Arachis pintoi cv. Amarillo performs best in Australia on the far north coast of Queensland where annual rainfall is above 1500 mm. It tends to grow rapidly under warm, moist conditions and is productive where soil moisture and

Table 4. Total ground area covered (m^2) by *Arachis* accessions at Grafton after 4-years growth, under 2 cutting frequencies (F = frequent; NF = non-frequent) when established in pure swards, with Bahia grass or with Bahia grass and white clover. Different letters indicate significant difference at the 5% level between treatments within an accession.

Accession	Pure stand		+ Bahia grass		+ Bahia grass + white clover	
	F	NF	F	NF	F	NF
CPI 12121	1.40 b	2.51 b	0.99 a	1.31 b	0.58 a	0.73 a
CPI 19898	1.27 a	1.82 b	0.57 a	1.32 b	0.27 a	0.75 a
CPI 22762	0.45 a	0.91 a	0.30 a	0.64 a	0.22 a	0.49 a
CPI 29987	1.16 b	2.38 b	0.82 a	1.33 b	0.58 a	1.10 b
CPI 58111	1.04 b	1.59 b	0.96 a	1.11 b	0.51 a	0.61 a
CPI 93469	1.64 b	1.88 b	0.93 a	1.61 b	0.96 a	1.19 b
CPI 93476	2.48 b	3.07 b	1.65 b	2.87 b	1.38 b	1.72 b
CPI 93483	1.92 b	2.45 b	0.95 a	1.40 b	1.41 b	1.63 b
Arachis pintoi	0.64 a	1.08 b	0.28 a	0.96 a	0.17 a	0.14 a
Arachis repens	1.64 b	3.88 b	0.58 a	0.16 a	0.44 a	0.60 a
Hybrid	5.35 b	3.03 b	3.64 b	3.01 b	1.67 b	1.32 b

humidity are high. It is not regarded as drought-tolerant; however, it will survive dry conditions (as individual plants or by recruitment from seed) even if it provides little dry matter (Clarke 1996). In the dry conditions at Grafton, its dry matter production was reduced greatly, and in fact, declined over time under some treatments. This confirms earlier findings in NSW (Bowman and Wilson 1996) and we concluded that this cultivar is not as well adapted as some other *Arachis* accessions to this area of northern NSW.

Rhizomatous peanuts are productive and persistent legumes in heavily grazed grass-legume pastures in the humid tropics, although under set-stocking, adequate residue of leaf must be maintained in the sward to optimise regrowth rates (Ortega-S *et al.* 1992). Under the cutting frequencies combined with low rainfall in the Grafton experiment, adequate regrowth of some accessions may not have occurred causing dry matter production to decrease with time.

Spread

At Gympie, Queensland, *Arachis pintoi* spread 20 cm in 5 years and *Arachis repens* 72 cm (Cook *et al.* 1994) while rhizomatous accessions spread up to 140 cm (this experiment included cv. Prine, CPI 93483, which spread 70 cm and CPI 29987 which spread only 20 cm in 5 years). In another Queensland experiment, the best accessions of *Arachis glabrata* spread into existing grass pastures at 30 cm per year (Cook *et al.* 1994). In the Grafton experiment, some rhizomatous accessions, as pure swards and under infrequent cutting (CPI 12121, CPI 29987, CPI 93476 and CPI 93483) covered more than 2 m^2 after 4 years of growth, while the hybrid line covered more than 5 m^2. The hybrid spread more than 1 m in all directions from the original 30 cm square.

Arachis repens, as a pure sward, covered up to 3.88 m^2 in 4 years at Grafton, but covered only 0.58 and 0.44 m^2, respectively, when grown with Bahia grass and Bahia grass with white clover in the same time. This indicated that *Arachis repens* would not be a successful pasture species for the less humid parts of the NSW north coast where it would commonly be grown in a mixed sward with perennial subtropical grasses. *Arachis glabrata* accessions spread further when grown without competition, with the better accessions covering up to 3.5 m^2 after 4-years growth in pure swards.

If *Arachis glabrata* is used commercially in Australia, it is likely to be planted as vegetative material in rows as has been the case in Florida (French *et al.* 1993). This ability to spread rapidly either into chemically fallowed pasture or into actively growing mixed swards will be important in getting the *Arachis* to become a major component of a pasture as quickly as possible.

Effect of cutting frequency and competition

Clarke (1996) comments that regrowth of Prine rhizoma peanut, after uniformly close grazing, is slow and that the grass component of a Prine-based pasture will increase with increased grazing pressure. Ortega-S *et al.* (1992) also found that the percentage of rhizomatous peanut in accumulated herbage was greatest when there was high residual dry matter after grazing and a long spell between grazings (producing up to 6.13 t/ha) and lowest with low residual dry matter and short grazing cycles (0.24 t/ha). Their data suggested that very close grazing in association with short regrowth periods greatly reduced the yield of rhizomatous peanut. In the Grafton experiment, the treatments under the infrequent cutting regime almost always produced more dry matter in a season than the same treatments under a frequent cutting regime. However, the low frequency cutting meant that dry matter was being removed only twice in a growing season in most years. This is unlikely to be sufficient grazing time to be practical for livestock production. Even the frequent cutting regime in this experiment, although it depressed dry matter production and spread of the accessions, could be considered light in terms of commercial grazing pressures.

Conclusion

This work confirms the results of a previous study (Bowman and Wilson 1996) that some *Arachis glabrata* accessions, particularly CPI 93483 (cv. Prine) and CPI 93469, have the ability to persist and spread on the north coast of New South Wales. It also allows the group of accessions available in Australia to be narrowed down to those most useful for further work, particularly for screening in paddock situations under grazing.

The authors would also recommend that other hybrid lines be evaluated if they appear, as there is potential to develop accessions from them, with tolerance to grazing and competition as well as spreading ability of the hybrid used in this study, combined with better dry matter production.

The spreading ability of the hybrid evaluated in this study would make it suitable for use as a ground-cover or erosion-control species in horticultural situations, where the low dry matter production would be of little consequence.

Most of the *Arachis glabrata* accessions are shy seeders, and because of this, have been difficult to commercialise as pasture species. With the introduction to Australia from the United States (B.G. Cook, personal communication) of specialised equipment for harvesting and planting rhizomes of *Arachis glabrata,* it is increasingly likely that these types will have a place in commercial pasture development. There is also the possibility of finding further, freely seeding accessions with similar attributes. These may be particularly useful in those areas of northern New South Wales and Queensland where the aggressive, but not particularly productive, Bahia grass is a common species in pastures.

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