Response of *Lablab purpureus* cv. Highworth, *Macroptilium bracteatum* and *Macrotyloma daltonii* to different intensities and frequencies of cutting

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Abstract

Two promising ley legumes, *Macroptilium bracteatum* (CPI 27404) and *Macrotyloma daltonii* (CPI 60303), were compared under glasshouse conditions with the widely used *Lablab purpureus* cv. Highworth in terms of response to defoliation and nutritive value. Plants were grown for 5 weeks prior to cutting at 2-, 4- or 6-weekly intervals at 7 or 15 cm height. The treatments were applied over 12 weeks and compared with uncut controls.

M. bracteatum was the most persistent and productive legume under frequent defoliation, producing more growing points than the other species when cut at 7 cm. It had the highest yields of roots under all cutting regimes and set seed under the most lenient regime.

All *M. daltonii* plants died when cut at 7 cm, mostly after the initial cutting. Although survival was much better when cut at 15 cm, this species gave lower top-growth and root yields than *M. bracteatum* and *L. purpureus*. It set seed only under the most lenient cutting regime.

L. purpureus outyielded the other 2 species in the uncut controls. However, the relative decline in top-growth yield with increasing severity of cutting was greater than for *M. bracteatum*. Half the plants died under the combination of frequent (2- or 4-week) and intense defoliation (7 cm). It did not flower during the experiment.

The main difference in quality, as assessed by N%, P%, acid detergent fibre and grinding energy, was between leaf and stem. Differences in leaf or stem quality between the 3 species were relatively minor.

Macroptilium bracteatum was identified as a productive legume more tolerant of severe defoliation than *L. purpureus*.

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Introduction

Declining levels of soil organic matter and physical structure are serious problems on clay soils of the inland cropping areas of the Australian subtropics (Dalal *et al.* 1991; Chan *et al.* 1995). Growing legume-based ley pastures in a rotation with crops is one way of overcoming this problem and, at the same time, providing high quality feed to grazing animals. Ley pastures based on lucerne (*Medicago sativa)* and annual medics (*Medicago* spp.) are used commercially in the subtropics (Lloyd *et al.* 1991). However, lucerne and medics become increasingly less adapted with decreasing latitude, as rainfall becomes increasingly summer-dominant.

Currently, 2 annual legumes, lablab (*Lablab purpureus)* and cowpea (*Vigna unguiculata*), are the main tropical species used in leys. Approximately 600 t of lablab seed and 300 t of cowpea seed are produced in Queensland each year (Smith 1996), although some of this seed is fed as grain. However, when used as fodder crops, both usually fail to persist into the second year or re-establish from seed. With temperate legumes, it usually takes more than 1 year for legume ley pastures to optimise soil nitrogen status (Lloyd *et al.* 1991). Thus, there could be considerable commercial potential for productive tropical ley legumes that could persist for 2 or more years.

Small plot evaluation of potential ley pasture legumes on clay soils has revealed a number of promising alternative species to lablab and cowpea. *Macroptilium bracteatum* persists and is productive for 2 or 3 years (Jones and Rees 1972 — as *Phaseolus bracteatus*; Jones and Rees

1997). The annual *Macrotyloma daltonii* shows some promise in southern inland Queensland (Conway *et al.* 1988; Rees *et al.* 1995) and regenerates from seed (Blumenthal and Staples 1993). However, nothing is known about their defoliation tolerance or nutritional quality. The experiment described here compares their response to cutting and their nutritional status with that of lablab.

Materials and methods

Experimental design

The glasshouse experiment was conducted at the University of Queensland, St Lucia, Brisbane (27°28'S, 153°02'E) from December 17, 1993 to April 14, 1994. Glasshouse air temperatures were monitored using sensors connected to data loggers.

Seven defoliation treatments were imposed on 3 legume species with 4 replications in a randomised block design. The forage legumes investigated were *Lablab purpureus* cv. Highworth, *Macroptilium bracteatum* (CPI 27404) and *Macrotyloma daltonii* (CPI 60303). In the control treatment, plants were cut once only, after 17 weeks. The remaining 6 treatments were cut first at 5 weeks and again at 2-, 4- or 6-week intervals at heights of 7 or 15 cm over a 12-week period. The 2 heights were chosen to represent severe and lenient defoliation. Preliminary trials revealed that at least 1 axillary bud remained under the 7 cm height, giving all species the potential for regrowth.

Soil collection and preparation

The soil used was a fertile, neutral brigalow clay from Narayen Research Station (25°41'S, 150°52'E) in the Central Burnett area of Queensland. Soil was collected from the top 15 cm of the profile adjacent to sites described by McDonald *et al.* (1995). Soil was air dried before sieving.

The 84 plastic pots of 255 mm diameter were each filled with 8.3 kg of air-dry soil. Chemical analysis indicated the soil contained adequate amounts of all essential plant nutrients with the possible exception of boron (0.33 mg/kg). Thus 12.6 mg of B, as a boric acid solution (H_3BO_3), was added to each pot prior to sowing and then leached beyond the seedling root zone to avoid B toxicity. Soil P concentration was 84 mg/kg (bicarbonate extraction).

Planting and management

M. daltonii seed was scarified to break the hard seed coat. Seed of all 3 species was inoculated with an equal mixture of *Bradyrhizobium* strains CB 756 and CB 1024 using 0.1 g inoculum/g for seed of *L. purpureus* and 0.02 g inoculum/g for seed of *M. bracteatum* and *M. daltonii,* using methyl cellulose as an adhesive. Between 8–12 seeds were planted in the top 1–2 cm of soil in each pot.

Pots were watered daily to field capacity (31% gravimetric water content) as determined in a pressure plate set at 0.1 bars. Towards the end of the experiment, the larger control plants were watered twice a day to avoid moisture stress.

Seedlings were removed progressively to give 3 plants/pot. Weeds were removed daily and, as the twining legumes grew, staking facilitated easy management and watering. Pots were re-randomised weekly. Although there were no visible signs of N deficiency in the legumes, concurrent research indicated that *Bradyrhizobium* strain CB 1717 was more effective in nodulating *M. bracteatum* than the strains used previously (R.A. Date, personal communication). Therefore, *M. bracteatum* was re-inoculated with the more effective CB 1717 strain 8 weeks after sowing, when a slurry of 0.7 g inoculum/pot was poured into holes bored into the soil. Mites and other insect pests were controlled by chemicals as necessary.

Measurements

At the first cutting, 5 weeks after sowing, all top-growth above the designated cutting heights was harvested, dried and weighed. Subsequent harvests were then made as scheduled, with top-growth sorted into leaf (petiole and lamina) and stem. At the final harvest, the following additional measurements were made:

(1) dry weights of stubble (0 cm to cutting height) and, where appropriate, pods;
(2) dry weight of roots washed out using the dispersion agent 'Calgon' (sodium hexametaphosphate);
(3) numbers of nodules and flowers;
(4) total number of growing points initiated

below cutting height (including points which had commenced growing after defoliation and then died); and

(5) plant survival.

The above measurements were also made on the control plants which were cut at the soil surface.

Measurements of forage quality were made on the leaf and stem fractions of the control plants after 17-weeks growth as well as the second 6-week growth of plants cut to 15 cm. Samples were ground through a 1 mm screen in a modified grinder (J.B. Hacker and F.F. Berta, personal communication), enabling the energy required to grind 20 g to be measured. The ground samples were analysed for N, P and acid detergent fibre (ADF), the latter by the method described by Clancy and Wilson (1966). The samples from the control treatment were also analysed for neutral detergent fibre (NDF), using a modified van Soest procedure, and those from the 15cm/6wk treatment for lignin.

Results

Glasshouse temperatures

Mean monthly maximum and minimum ambient temperatures in the glasshouse in January were 35.8 and 26.4°C, respectively. Corresponding temperatures in April were 33.1 and 24.5°C.

Plant survival and number of growing points

All *M. bracteatum* plants were alive at the end of the experiment. All *M. daltonii* plants cut at 7 cm had died, with most dying after the initial cutting. When cut at 7 cm, 50% and 8% of *L. purpureus* plants died under the 2- and 4-week cutting frequencies. When cut at 15 cm, only 19% of *M. daltonii* and no *L. purpureus* died.

There was a significant 3-way interaction ($P<0.01$) of species, cutting height and cutting frequency on numbers of growing points per plant initiated during the experimental period. Consequently, the effect of cutting height and frequency is examined separately for each species (Table 1).

There was no effect of cutting frequency on numbers of growing points of *M. daltonii*, but a 6-fold reduction in numbers at the lower cutting height. The few growing points that were produced at this height all died. In contrast, there was no effect of cutting height on the number of growing points of *M. bracteatum*, although numbers were slightly reduced at the 6-week cutting frequency. There was a significant cutting height × frequency interaction in *L. purpureus*, where the numbers of growing points were reduced at the lower cutting height when cut every 2 and 4 weeks, but not when cut every 6 weeks.

With the exception of *M. daltonii* cut at 7 cm, where all plants died, approximately 40–50% of the total number of growing points produced over the 12-week period were still alive at the end of the 12 weeks.

Table 1. The number of growing points per plant produced over a 12-week experimental period under 3 cutting frequencies and 2 cutting heights.

Treatment	Number of growing points/plant *L. purpureus*	*M. bracteatum*	*M. daltonii*
Frequency			
2 weekly	4.2	9.9	5.3
4 weekly	4.8	9.8	4.8
6 weekly	3.4	6.8	6.3
LSD (P<0.05)	0.6	1.7	ns[1]
Height			
7 cm	2.8	8.4	1.3
15 cm	5.5	9.3	9.6
LSD (P<0.01)	0.5	ns	1.2
Height × frequency			
2 weekly — 7 cm	1.7	8.8	1.1
2 weekly — 15 cm	6.8	11.1	9.6
4 weekly — 7 cm	3.5	9.8	1.1
4 weekly — 15 cm	6.1	9.8	8.5
6 weekly — 7 cm	3.1	6.5	1.9
6 weekly — 15 cm	3.7	7.1	10.8
LSD (P<0.05)	0.9	ns	ns

[1]Indicates not significant at P<0.05.

Dry matter production

L. purpureus seedlings produced the most shoot material in the initial 5-week period (Figure 1) ($P<0.01$). Final top-growth yields of the uncut control plants were greater ($P<0.05$) for *L. purpureus* (290 g/pot) than *M. bracteatum* (250 g) and *M. daltonii* (151 g) (Figure 1).

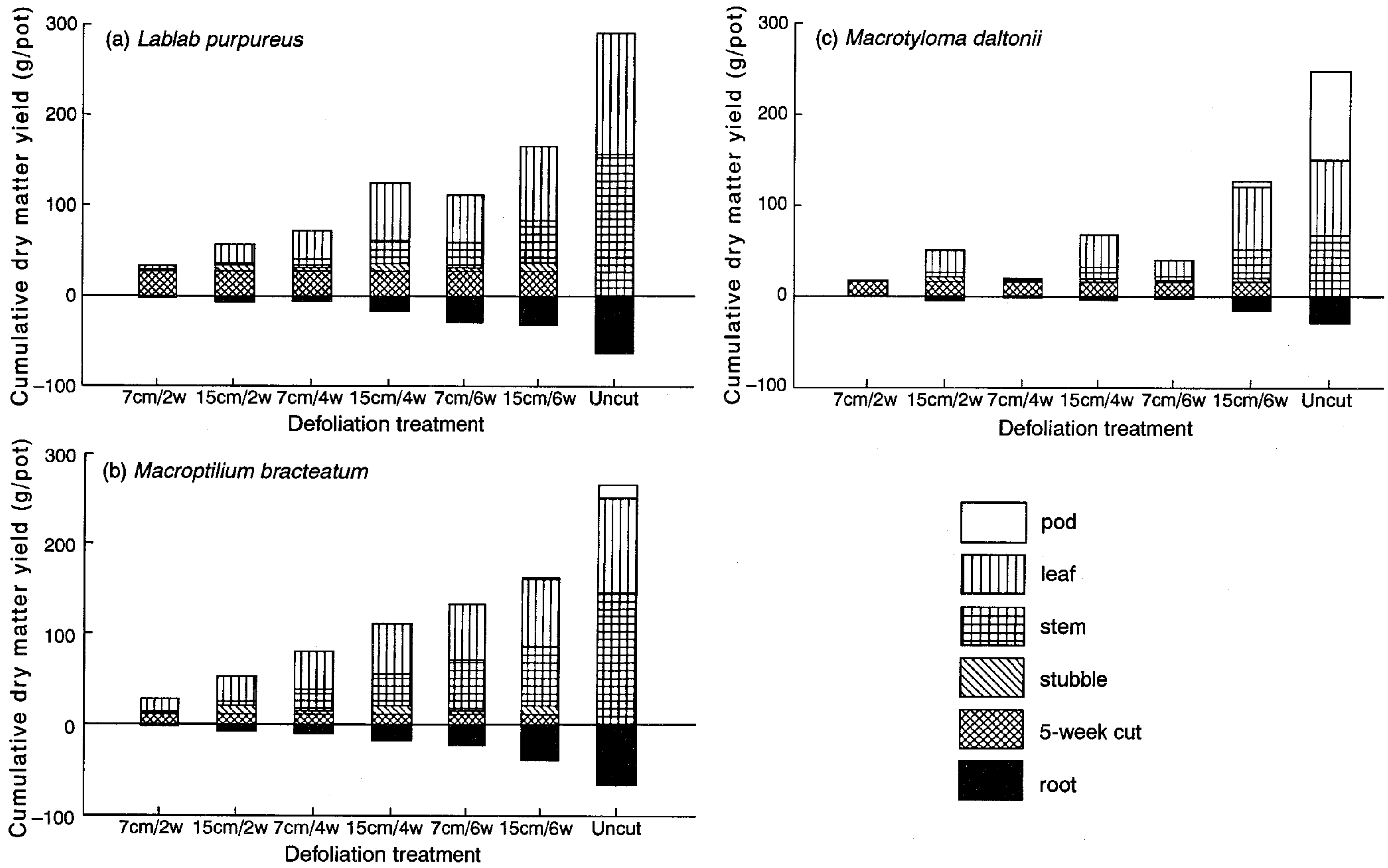

Figure 1. Cumulative dry matter yields (g/pot) of pod, leaf and stem over 12 weeks of 3 legumes, (a) *Lablab purpureus*; (b) *Macroptilium bracteatum*; and (c) *Macrotyloma daltonii*; under 7 defoliation regimes (nil, and at 7 or 15 cm every 2, 4 or 6 weeks). Yields of stubble after 17 weeks and yields from the initial 5-week cutting are given immediately above the zero line on the y axis. Root yields as measured at 17 weeks are given below the zero line.

However, cumulative dry matter yield above cutting height over the 12 weeks was often greater ($P<0.05$) for *M. bracteatum* than *L. purpureus*, particularly where defoliation was severe (Figure 1). *M. daltonii* produced less shoot material than the other species under all treatments ($P<0.05$), except for the 15cm/2wk treatment.

In the control treatment, *M. daltonii* had a significantly ($P<0.05$) higher proportion of leaf (55%) than *M. bracteatum* (42%) or *L. purpureus* (46%). The percentage of leaf in the cumulative yield of the cut treatments was not significantly affected by cutting height. However, it declined with longer cutting intervals, with the average percentage leaf of *L. purpureus* and *M. bracteatum* being 94%, 69% and 55% at cutting intervals of 2, 4 and 6 weeks ($P<0.05$). Although the total yield of the controls of all 3 species was almost twice that of the treatments cut at 15 cm every 6 weeks, there was much less difference in the yield of leaf. The higher total yields of the controls were primarily due to higher yields of stem and, in the case of *M. daltonii*, pods (Figure 1). The cumulative leaf yield of *M. bracteatum* and *L. purpureus* was less affected by cutting treatments than the leaf yield of *M. daltonii* (Figure 1).

Root yield and nodule numbers

M. daltonii had lower root yields than *L. purpureus* and *M. bracteatum* ($P<0.05$) (Figure 1). Root yields of all species were highest in the controls and declined with increasing severity of defoliation, though the decline was greatest in *M. daltonii*.

M. bracteatum had more than 100 nodules per treatment, except for the most severe treatment, cut every 2 weeks at 7 cm. *L. purpureus* exceeded 100 nodules, except when cut at 2 or 4 weeks at 7 cm and every 2 weeks at 15 cm. *M. daltonii* had more than 100 nodules only in treatments cut at 15 cm every 4 (15cm/4wk) or 6 (15cm/6wk) weeks.

Flowering and seed set

More frequent cutting resulted in fewer flowers. *M. daltonii* was the first to flower and flowered under the 2-week defoliation frequency. *L. purpureus* did not flower over the 17-week growing period, although buds had developed on the uncut controls and the 15cm/6wk treatment. *M. bracteatum* flowered when cut every 4 or 6 weeks but not when cut every 2 weeks.

Seed pods comprised 40% of the yield of *M.daltonii* and 6% of the yield of *M. bracteatum* in the controls (Figure 1). *M. daltonii* produced a much smaller amount of pods under the most lenient defoliation (15cm/6wk).

Forage quality

There were significant interactions between species and the 2 cutting treatments (control and 15cm/6wk) on measurements of nutrient value. Thus, the results for leaf and stem are presented separately for each species in each cutting treatment.

Differences between leaf and stem in all attributes were greater than differences between species (Table 2). Stems had a 5-fold higher grinding energy requirement than leaves. Leaf and stem samples from the control plants had significantly higher grinding energy and ADF levels and lower N and P levels than corresponding samples from the 15cm/6wk treatment. Trends in NDF in the leaves and stems of the control plants were similar to those in ADF although the NDF levels were about 50% higher in leaves and 40% higher in stems.

In leaf samples from both treatments (control and 15cm/6wk), ADF levels were highest in *M. bracteatum*. ADF level in leaves of *L. purpureus* was higher than that of *M. daltonii* in plants cut every 6 weeks, but similar in the uncut plants. The N concentration in leaves was lowest in *M. daltonii* in both treatments.

M. daltonii stems had the highest grinding energy requirement, the highest ADF level and the lowest N% in both cutting treatments. In the 15cm/6wk treatment, the stems of *M. daltonii* also had higher lignin levels (9.3%) than *M. bracteatum* (6.9%) and *L. purpureus* (7.1%) ($P<0.05$). In contrast, lignin levels in leaves were lower ($P<0.01$) in *M. daltonii* (3.0%) than in *L. purpureus* (3.9%) or *M. bracteatum* (4.4%).

Table 2. Grinding energy (GE) (joules to grind 20g OD sample), N%, P% and ADF% of leaf and stem of *Lablab purpureus*, *Macroptilium bracteatum* and *Macrotyloma daltonii* from: (i) control plants cut to ground level after 17-weeks growth (17w); and (ii) plants cut back to 15 cm after 6-weeks regrowth (6w).

Plant part	GE		N%		P%		ADF	
Species	17w	6w	17w	6w	17w	6w	17w	6w
Leaf								
L. purpureus	65	42	2.61	3.49	0.14	0.25	26.6	21.7
M. bracteatum	58	48	2.33	3.27	0.12	0.23	30.2	25.9
M. daltonii	53	44	1.72	2.99	0.11	0.29	27.5	16.6
LSD (P<0.05)	ns	ns	0.17	0.34	ns[1]	ns	ns[1]	2.8
Stem								
L. purpureus	231	—[2]	1.09	1.32	0.06	0.16	43.6	39.7
M. bracteatum	300	247	0.78	1.00	0.05	0.14	46.0	38.6
M. daltonii	430	—[2]	0.56	0.89	0.05	0.19	61.3	46.7
LSD (P<0.05)	80		0.18	0.10	ns[1]	ns	3.9	4.2

[1]These differences were significant at P<0.10.
[2]Insufficient samples of stem to measure grinding energy.

Discussion

Yield and tolerance of cutting

Early vigour of *L. purpureus* was greater than that of the other species, and after the intial 5 weeks of growth, it had 3–4-fold higher yield than *M. bracteatum* or *M. daltonii*. This is primarily attributed to its higher seed weight, 25 g/100 seeds compared with 0.8 g and 1.7 g/100 seeds for *M. bracteatum* and *M. daltonii*, respectively.

M. bracteatum was the most persistent species with all plants surviving under all cutting regimes. Furthermore, this species was able to initiate more growing points at the 7-cm cutting height than the other species. It was also the only species able to retain some leaves below the 7-cm cutting height. The ability of plants to develop or maintain active meristem under defoliation is an important attribute determining the persistence of forage legumes under grazing (Clements 1989; Curll and Jones 1989). All these results suggest that *M. bracteatum* would have better tolerance of defoliation under field conditions.

M. bracteatum also retained more nodules with relatively higher root weights under the more severe cutting treatments than the other 2 legumes. This suggests that, under regular close defoliation, it may have at least the same ability as *L. purpureus* to contribute to soil carbon and nitrogen levels through decay of root residues and nodules. Root yields of *M. daltonii* were very low in the defoliated treatments. Even in the control plants, 17% of the biomass of *L. purpureus* was root material compared with only 9% for *M. daltonii.*

M. daltonii was the species most affected by cutting height. It had the most growing points of all 3 species in the 15cm/6wk treatment, but died if cut to 7 cm. *L. purpureus* was intermediate in its reaction to defoliation, with 50% of plants dying when cut to 7 cm every 2 weeks. Hendricksen and Minson (1985) have also reported death of *L. purpureus* cut every 2 weeks in a field trial.

Flowering and seeding

Adequate seed production is essential for annual forage species to re-establish in the second year (Curll and Jones 1989). *M. daltonii* flowered early and profusely when undefoliated but seed set was drastically reduced under cutting. Our results suggest that its potential for successful recruitment would be negated by close grazing or cutting. *L. purpureus*, which usually acts as an annual, failed to flower during the 17-week trial even though cultivar Highworth, used in this experiment, is earlier flowering than cv. Rongai. *M. bracteatum* flowered and set seed under less frequent defoliation, demonstrating a possible mechanism of recruitment. However, field observations by the authors suggest that perennation rather than seedling recruitment is the major factor enabling *M. bracteatum* to persist into the second or third year.

Forage quality

Differences in quality between species were minor. Leaf of all species was clearly of higher quality than stem in terms of NDF, ADF, lignin, N and P. ADF is of particular interest as it was as good a predictor of *in vivo* digestibility in a range of tropical legumes as *in vitro* digestibility (McLeod and Minson 1976). The decline in quality of both leaf and stem with increasing age reflects similar trends recorded in *L. purpureus* in a field experiment (Hendricksen and Minson 1985).

Conclusions

M. bracteatum had a greater ability than *L. purpureus* to grow when defoliation intensity was severe. Under lighter defoliation pressure, it is most unlikely to yield as much as *L. purpureus* in the first year, though differences in leaf yield may be less than differences in stem yield. Its potential advantage over *L. purpureus* is its ability to persist into a second or third year. In contrast, *M. daltonii* was unable to survive close defoliation and even the lighter defoliation treatments severely restricted seed set, which would be vital for its recruitment in the second year.

Given the much higher quality of leaf as compared with stem, advanced evaluation of promising ley legumes should take account of leaf yield as well as total yield.

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