Evaluation of chicory cultivars and lines and plantain cultivars on the North-West Slopes of New South Wales

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Abstract: *Herbage mass and plant frequency of 7 cultivars and 11 lines of chicory and 2 cultivars of plantain were evaluated over three years near Manilla, North-West Slopes, NSW. By the second spring there was a large variation in the herbage mass and persistence of the cultivars/lines, but by the third year, both herbage mass and plant frequency were low with little agricultural value. Chicory lines SA39441, SA39442 and SA39444 had similar higher plant frequency than most of the commercial cultivars, and so could be included in any future breeding program. Chicory is unlikely to have a major role as a permanent pasture in the farming systems on the North-West Slopes of NSW, however investigation of seedling recruitment and grazing management strategies may improve its potential in this region.*

Introduction

Cichorium intybus (chicory) is a deep-rooted perennial herb capable of producing large quantities of forage under favourable conditions with animal performance being similar to that of legumes and superior to grass-based pastures (Li & Kemp 2005). It also has the advantage of being more tolerant to acid soils than *Medicago sativa* (lucerne) (Li & Kemp 2005; Li *et al.* 2008). Chicory is used extensively throughout the world and in parts of southern NSW and Victoria, but it has not previously been evaluated in the summer-dominant rainfall environment of the North-West Slopes of NSW.

An experiment was conducted to test the hypothesis that there could be marked differences among the cultivars/lines that were available. Identification of superior cultivars/lines would provide a sound basis for future selection and breeding programs, as well as providing direction for further management studies and the development of local informed cultivar/species recommendations.

Materials and methods

In May 2005, an experiment was sown on a site 12 km west of Manilla, NSW (30.74°S 150.61°E; elevation 400 m) on a Brown Vertosol (Isbell 1996). Full details of the site are described in Boschma *et al.* (2009). Seven cultivars (Chico, Choice, Commander, Grasslands Puna, Puna II, Grouse and La Lacerata,) and 11 lines of chicory (SA38488, SA38500, SA38589, SA38955, SA38972, SA39000, SA39441, SA39442, SA39444, SA39452 and SA42961) and 2 cultivars of plantain (Lancelot and Tonic) were sown in plots (6.0 by 1.15 m) at a rate of 4 kg/ha, adjusted for differences in percentage germination. The experiment was a spatially adjusted randomised complete block design with partial neighbour balance and 4 replicates. A 1.35 m buffer of chicory cv. Grasslands Puna was sown around the perimeter of the experimental area. To assist establishment, all plots were sown with 40 kg/ha of nitrogen (N, urea 46% N) and irrigated with 30 mm of water in May and a further 35 mm in June. The experimental area was top-dressed with 125 kg/ha single superphosphate (8.8% phosphorus, 11% sulfur) in July 2006 and March 2007, 20 kg N/ha in November 2005 and a total of 60 and 40 kg N/ha in 2006 and 2007 respectively. Fertiliser was applied after herbage mass assessments in November 2005 and in July, August and November 2006, and March and June 2007, but timed to coincide with a high likelihood of rain to minimise volatilisation. Analysis of soil samples (0–0.1 m) showed that there were no soil chemical constraints likely to impede plant growth (Boschma *et al.* 2009).

Herbage mass was assessed at the start-end of each season (total of 13 assessments) and plant frequency in spring and autumn each year (total of 8 assessments) from spring 2005 until autumn 2008 using the procedures described by Boschma et al. (2009).

Herbage mass and plant frequency data were analysed using the cubic smoothing spline approach of Verbyla *et al*. (1999) which incorporated cubic splines into a linear mixed model. This model was fitted to transformed herbage mass data (square-root herbage mass, kg DM/ha) and percent frequency with day as a covariate. The term cultivars/lines and its interaction with day (cultivar/lines.day) were fitted as random coefficients. A cubic spline [spline(day)] term and the interaction of this term and cultivars/lines [cultivar/lines. spline(day)] were also included. The start date was 10 August 2005. Significance of the fixed term (day) was determined using the Wald statistic (an approximate F-test) while the significance of the random terms was examined by testing twice the change in log-likelihood (d) as a χ_1^2 statistic. Significance of the test for the spline terms was given by $0.5[1-Pr(\chi_1^2 \leq d)]$ and by $1-Pr(\chi_1^2 \leq d)$ for the other random terms. Smooth fitted lines for predicted herbage mass and plant frequency of each cultivar/line were presented graphically.

Results and discussion

Rainfall was below average for 20 of the 34 months (~60%) of the experimental period (Table 1). Most of the dry period occurred from February 2006 to November 2008 inclusive, when monthly average rainfall was exceeded on only 5 occasions. All cultivars/lines established well with > 45 plants/m^2.

All cultivars and the lines SA89452 and SA42961 had above average herbage mass at the initial assessment (i.e. >1200 kg DM/ha). However, at the final assessment average herbage mass was 70 kg DM/ha and all values were <300 kg DM/ha (Fig. 1*a*). These are below levels considered useful for animal production. Six of the lines (SA38488, SA38500, SA38589, SA38955, SA38972 and SA39000) had below average predicted herbage mass at both the initial and final assessments and the predicted herbage mass of both plantain cultivars was near zero at the final assessment. Smooth fitted lines highlighted the decline in cultivar/line herbage mass over time. Based on the

Table 1. Monthly rainfall (mm) at the site and the mean and the long-term average monthly rainfall (LTA, 122 years) for Manilla, NSW

	Rainfall (mm)				
Month	2005	2006	2007	2008	LTA
January	77.5	143.5	45.0	100.5	88
February	18.0	60.5	81.0	123.5	66
March	9.5	16.0	73.0	2.5	54
April	1.5	38.0	19.5	–	40
May	16.5	0.0	19.5	–	42
June	116.0	34.5	165.0	–	44
July	24.0	34.5	6.5	–	42
August	18.5	22.5	60.5	–	40
September	92.0	28.0	0.0	–	42
October	67.5	33.0	51.5	–	58
November	118.0	76.0	41.0	–	66
December	87.0	11.0	111.0	–	73
Annual	646	497.5	673.5		655

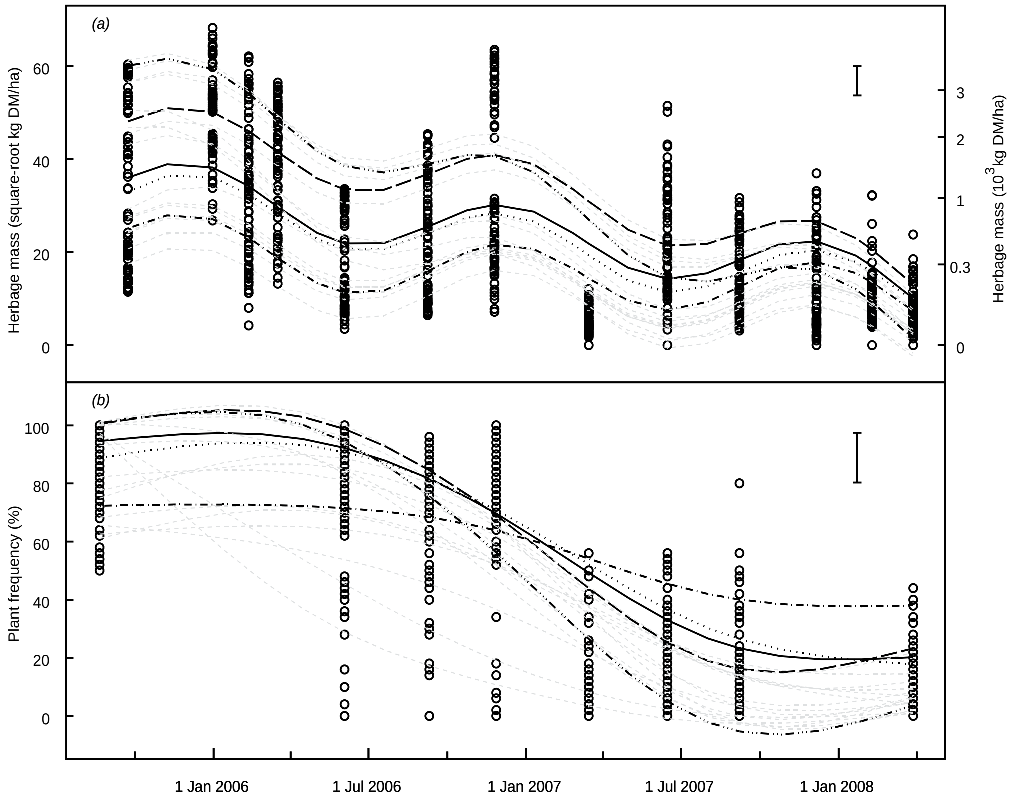

Figure. 1. Smooth fitted lines of chicory cultivars/lines for (*a*) herbage mass (square-root herbage mass, kg DM/ha) and (*b*) plant frequency (%). For the highlighted (dark) lines the chicory cultivars/lines are SA89114 (—), SA89442 (···), SA89444 (–·–), Puna II (– –) and Commander (–···). Error bars indicates the l.s.d. (*P* = 0.05). Statistical analyses for herbage mass were on the transformed scale and the kg DM/ha scale is only provided to assist interpretation.

rate of decline, cultivars/lines divided into 4 groups (Fig. 1*a*); 1) chicory cvv. Puna II and Grouse that had high herbage mass at the initial assessment and consistently performed well, with an intermediate rate of decline; 2) the lines SA39441, SA39442 and SA39444 that had a slower rate of decline than group 1 with their herbage mass being similar to most cultivars at the final assessment; 3) chicory cvv. Chico, Commander and line SA89452, and the plantain cultivars, that had a higher rate of decline than group 1, and 4) all of the other experimental lines which consistently had low herbage mass. In spring of the second year, all chicory cultivars, except Grasslands Puna and Puna II, had herbage mass >1000 kg DM/ha.

At the initial plant frequency assessment in spring 2005, all 9 cultivars and 3 lines (SA39441, SA39442 and SA39452) had a plant frequency above the average (87%). Of the 20 cultivars/lines tested, 13 had a predicted plant frequency below the average (10%) at the final assessment (Fig 1*b*), with Puna II and 6 of the lines (SA39441, SA39442, SA39444, SA38500, SA42961 and SA39000) being above average. At the final assessment, only the line SA39444 had a predicted plant frequency >30%. Smooth fitted lines for individual cultivars and lines highlighted the variation in responses over time. Plant frequency of the cultivars was initially high (>98%), but declined rapidly in the second year (e.g. Commander chicory, Fig. 1*b*). In contrast, SA39444 had the least reduction in predicted plant frequency, declining from 72 to 33% over time. The lines SA39441 and SA39442 responded similarly to one another, with plant frequency declining in the second year, but less so than for the commercial cultivars.

After 3 years of evaluation, the best performing cultivars/lines were Puna II, SA39444, SA39441 and SA39442, but their overall herbage mass and/or plant frequency was too low for them to be considered useful for animal production. Grasslands Puna chicory has been reported to lose about 30% of its population each year with persistence dependent on survival of the original plants as recruitment from seed was unlikely in mature stands (Li & Kemp 2005). As such, chicory may have a role as a short-term pasture in our region, but is not likely to be suitable as a long-term pasture, unless it can regularly recruit seedlings as new plants. In our experiment, plants were defoliated to prevent seed fall and potential regeneration and so avoid contamination of adjacent plots. However, in a separate study at the previously cropped site (Boschma *et al*. 2009), seedling regeneration of Grouse chicory occurred regularly. Hence, grazing management that allows for seed set, seed fall, and recruitment could possibly be used to improve the potential of chicory as a long-term pasture on the North-West Slopes of NSW.

The 2 plantain cultivars established well, with high initial predicted plant frequencies (>90%), but declined significantly over the first summer to be ~35 and 45% in May 2006. Plantain failed to persist, confirming the results of a previous study (Boschma *et al*. 2009). Although it occurs naturally throughout the region it cannot be considered as a suitable pasture option.

Conclusion

Within the chicory cultivars/lines we evaluated there was a large variation in the herbage mass and persistence in the second spring, but by the third year, both herbage mass and plant frequency were low and of little agricultural value. Of the 11 chicory lines tested, SA39441, SA39442 and SA39444 had similar higher plant frequency than most of the commercial cultivars. While it is unlikely that chicory would have a major role as a permanent pasture in the farming systems on the North-West Slopes of NSW, these lines could be included in any future breeding program. Although not tested in this experiment, previous studies (Boschma *et al*. 2009) indicated a likely role for seedling recruitment in improving chicory persistence. Further investigation of grazing management strategies may be warranted to improve the potential of chicory on the North-West Slopes of NSW.

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