GROWTH CURVES AND HERBAGE QUALITY OF BIRDFOOT TREFOIL IN DRYLAND AREAS OF THE ANDES FOOTHILLS

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ABSTRACT

The objectives of this study were to describe the growth curves and the herbage quality changes of birdfoot trefoil (*Lotus corniculatus*) during spring and early summer in the dryland areas of The Andes foothills. The DM accumulation, from different dates, was fitted to a logistic function, $y = A/ 1 + b e^{-ax}$. The derivative of that function, $dy/dx = Abae^{-ax} /(1 + be^{-ax})^2$, allowed determination of the rates of growth. The curves show that the maximum accumulation was reached around mid December and the highest rates of growth were registered between 15 September and 15 November (100 kg ha^{-1} day^{-1}, approximately) when the regrowth started before October. After that the maximum accumulation was lower and it was reached later, in summer. Crude protein, P, K, Ca and Mg concentration in DM decreased and acid detergent fibre content increased when the number of days after regrowth initiation increased. To conclude, different calendars of utilisation can be derived from the curves, according to the requirements of animal production systems.

KEYWORDS

Birdfoot trefoil, growth, quality, yield.

Introduction

A former experiment (Acuña, 1985) of establishment, response to fertilizer application and growth of birdfoot trefoil (*Lotus corniculatus*) on volcanic soils of The Andes foothills in the VIII region of Chile, showed that this specie is well adapted to the local conditions. The zone is between 300 to 600 m above sea level and its annual average of rainfall is 1400 to 1700 mm, recorded mainly during the winter months (April-September). The rest of the year the weather is dry and hot and the soil water for plant growth is extremely restricted for shallow rooted plants. The minimum mean temperature of July is around 3 celsius degrees and the maximum mean of January is 28 degrees. The soils have high P-retention, low levels of available P (3 mg/kg in the layer 0-10 cm) and pH of 6.0. The area of the zone reaches one million hectares, approximately. The land is used with a rotation of cereals (1 year) and natural or subterranean clover pasture (2-3 years). The alternative is to grow a perennial forage legume such as birdfoot trefoil which has deep roots and the ability to produce herbage during spring, early summer and autumn, which allows harvesting hay during spring and having high quality green herbage for grazing when subterranean clover or natural pasture are dried. Therefore, the objectives of the experiment reported in this paper are to describe the growth curves and the herbage quality of birdfoot trefoil cut at different dates during the spring and summer, to have detailed information for planning animal production systems to ensure better yield than systems based on annual pastures.

METHODS

The experimental plots were located at Ñuble province (Lat. 36° 32' S, Long. 71° 44' W, 344 m above sea level) on a volcanic soil of the Santa Barbara series. They were sown in August 1993, in rows 20 cm apart with 10 kg/ha^{-1} of birdfoot trefoil (cv. Quimey) seeds inoculated with *Ryzobium lotii*. Triple superphosphate was applied at sowing (300 kg/ha^{-1}) and each autumm (100 kg/ha^{-1}) and potassium sulphate (100 kg/ha^{-1}) each spring. No nitrogen was applied.

The spring sowing plants did not grow enough to harvest forage, as it was expected, and from the 1994 spring the plants were kept under cut. The experiment ran from May 1995 until April 1996. The layout of plots allowed evaluation of DM accumulation from 1 May, 12 August, 12 September, 7 October, 25 October and 28 November, each 20 to 30 days from August to April, in subplots of 1.5 x 1.5 m, cutting at 3 cm height. One replicate was done.

The exact way in which the plots were distributed and curve fitting methods are reported in Acuña, Soto y Melín (1985). Summarily, by the minimum squares methodology the DM accumulation was fitted to a logistic function, with known asymptote $y = A/1+b e^{-ax}$, where A is the maximum accumulation and x the number of days from growth initiation.

Because of this, the function was linealized and, therefore, a and b are two coefficients which determine the slope of the linealized curve (-a) and the intercept (ln b).

The derivative of the function, in relation to the time, $dy/dx=A bae^{-ax} / (1+be^{-ax})^2$, allows determination of the rates of growth (kg of DM/ha^{-1}/day) for the whole period comprised in each set of data. Herbage samples of each date of cutting were analyzed to determine crude protein (micro kjeldahl), acid detergent fibre (Van Soest), metabolisable energy and concentration of P (colorimetry), K (flame photometry) and Ca and Mg (atomic absorption) in DM. All these last values were fitted to a linear function ($y = a + bx$).

RESULTS AND DISCUSSION

Dry matter accumulation and growth curves. Figure 1 shows that when the plants were allowed to grow from 1 May, the accumulation of DM was very low during winter and the growth became strong at the end of August. The maximum accumulation (> 6000 kg of DM ha^{-1}) was reached in December and the highest rate of growth (95 kg ha^{-1} day^{-1} of DM) was recorded at the beginning of October. When accumulation was recorded from a cut done on 12 August the maximum accumulation was registered at the same date of the first curve and the maximum rate of growth about 10 days after it. The following curves show how the maximum accumulation decreased and the date of highest rate of growth was reached later in the spring when the growth initiation was retarded until 25 October. These curves are consistent with the favourable environmental conditions for growth during the spring and would be in accordance with the leaf area index of swards in each set of plots. From the middle of December the available soil water decreased rapidly and the birdfoot trefoil DM accumulation from November was slower than before and could not be fitted to the logistic function. It reached 3000 kg ha^{-1} at the end of January. This last fact differs from the pattern of growth of annual species or perennial grasses (Acuña *et al* ,1984), when the plants die or become dormant and all their aerial parts are dried. Birdfoot trefoil, because of its deep root systems, can take up enough water for growing later in spring and in early summer, and the herbage accumulated during spring keeps its green colour until summer. The last two features support the advantages of birdfoot trefoil over subterranean clover and annual or perennial grasses. Lucerne (*Medicago sativa*) can play the same role of birdfoot trefoil but the cost of establishment is substancially higher because a greater rate of P application is necessary and 2 to 4 ton ha^{-1} of lime are required to improve the soil pH. To conclude, from these curves, which parameters are in Table 1, different cutting calendars can be derived attending to practical considerations to maximize annual yield to satisfy seasonal requirements such as summer green forage for grazing.

Herbage quality. The linear functions presented in Table 1, allow us to see the tendencies of each herbage quality descriptors. The crude protein decreased from values greater than 25%, recorded a few days after starting growth from August to October, to values between 10 to 5 % in summer. The highest percentages are similar to figures reported by Blumenthal *et al* (1993) which probably also came from young leafy material. The acid detergent fibre percentages increased from 20 to 30 in early stages of regrowth during spring until around 50 in herbage available for cutting or grazing in summer. Metabolisable energy values around 2.5 Mcal kg^{-1} of DM were recorded from August to October, then decreased until nearly 1.8 in mature stemmy material. The concentration of P,K, Ca and Mg in DM decreased when the number of days from the beginning of regrowth increased. Comparing the mineral composition with figures repported by Frame (1992) only P appears to have lower concentration in birdfoot trefoil DM than the ranges given as average for herbage. Potassium, Ca and Mg concentration measured in this experiment are within the referred ranges. The tendencies decribed above show the high quality of birdfoot trefoil herbage, particularly during spring. This additional information would allow more confidence to define programs of herbage utilisation taking in account animal requirements of production systems more intensive than those supported by the annual species.

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Table 1

Parameters of fitted functions. Dates show the growth initiation (x=0). A, is the higher accumulation observed value (kg of DM ha^{-1}) plus 1 kg, *P=Probability.

	A	a	b	R^2	P(*)
Accumulation of pure birdfoot trefoil, kg of DM/ha^{-1}					
1-May	6657	-0.05887	13521.75	0.85	<0.01
12-Aug	5399	-0.08167	490.68	0.96	<0.001
12-Sep	3662	-0.09033	76.71	0.99	<0.001
7-Oct	3467	-0.11136	140.04	0.97	<0.05
25-Oct	3552	-0.07677	7.13	0.75	0.13
Accumulation of total DM harvested, kg ha^{-1}					
1-May	7751	-0.06465	25676.65	0.93	<0.001
12-Aug	6876	-0.12734	5253.10	0.89	<0.05
12-Sep	5826	-0.17089	2040.28	0.95	0.06
7-Oct	3751	-0.11402	59.88	0.93	<0.05
25-Oct	3789	-0.08213	23.12	0.89	0.06
Crude Protein, % DM basis					
1-May	-	31.00	-0.07708	0.86	<0.001
12-Aug	-	30.28	-0.11980	0.93	<0.001
12-Sep	-	27.88	-0.12556	0.85	<0.01
7-Oct	-	25.25	-0.12495	0.91	<0.01
25-Oct	-	22.98	-0.13003	0.81	<0.05
Detergent-acid fibre, % DM basis					
1-May	-	8.48	0.15138	0.80	<0.01
12-Aug	-	27.27	0.13891	0.84	<0.01
12-Sep	-	27.61	0.14331	0.83	<0.01
7-Oct	-	39.95	0.07140	0.32	0.25
25-Oct	-	25.61	0.20446	0.74	0.06
Metabolisable energy, Mcal kg^{-1} of DM					
1-May	-	3.01	-0.00427	0.80	<0.001
12-Aug	-	2.49	-0.00404	0.84	<0.01
12-Sep	-	2.49	-0.00416	0.83	<0.01
7-Oct	-	2.13	-0.00209	0.32	0.24
25-Oct	-	2.54	-0.00594	0.75	0.06
Phosphorus, % DM basis					
1-May	-	0.31	-0.00080	0.86	<0.001
12-Aug	-	0.31	-0.00135	0.89	<0.001
12-Sep	-	0.31	-0.00159	0.78	<0.05
7-Oct	-	0.27	-0.00157	0.86	<0.05
25-Oct	-	0.20	-0.00124	0.77	<0.05
Potassium, % DM basis					
1-May	-	3.36	-0.00545	0.77	<0.01
12-Aug	-	3.23	-0.00773	0.68	<0.05
12-Sep	-	3.32	-0.01006	0.79	<0.01
7-Oct	-	4.02	-0.01659	0.91	<0.01
25-Oct	-	3.31	-0.01268	0.85	<0.05
Calcium, % DM basis					
1-May	-	1.68	-0.00361	0.54	<0.05
12-Aug	-	1.05	-0.00249	0.77	<0.01
12-Sep	-	0.90	-0.00140	0.73	<0.05
7-Oct	-	1.04	-0.00281	0.64	0.06
25-Oct	-	0.84	-0.00154	0.84	<0.05
Magnesium, % DM basis					
1-May	-	0.34	-0.00061	0.64	<0.01
12-Aug	-	0.26	-0.00064	0.93	<0.001
12-Sep	-	0.24	-0.00050	0.80	<0.01
7-Oct	-	0.25	-0.00076	0.95	<0.001
25-Oct	-	0.24	-0.00084	0.85	<0.05

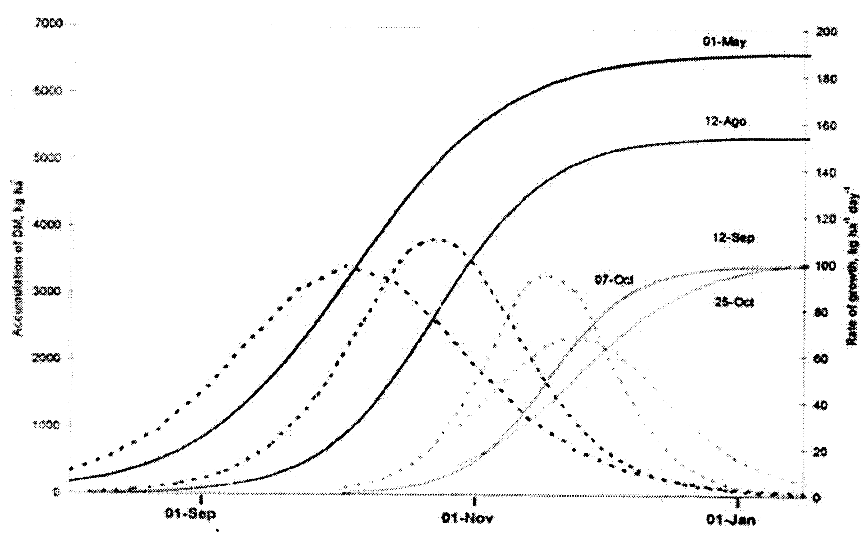

Figure 1

Dry matter accumulation and growth curves of birdfoot trefoil from different dates of regrowth initiation.