The effects of winter conditions on the nutritive value of Lotus pedunculatus cv. Grasslands Maku and Trifolium repens cv. Haifa

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The effects of winter conditions on the nutritive value of *Lotus pedunculatus* cv. Grasslands Maku and *Trifolium repens* cv. Haifa.

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Abstract

As part of an investigation into the adaptation of *Lotus pedunculatus* to the northern tablelands of New South Wales, a study was made of the effects of onset of winter conditions on the nutritive value of cv. Grasslands Maku lotus compared with *Trifolium repens* cv. Haifa (white clover). White clover maintained relatively constant levels of forage nitrogen, *in vitro* organic matter digestibility and structural fibre constituents from late May through July. By contrast, the levels of nitrogen and digestibility of lotus were depressed (42 to 32 g/kg N, 78 to 63% OMD), and these effects were associated with morphological changes induced by severe frosting. These effects on nutritive value limit the potential role of lotus on the northern tablelands of New South Wales.

Resumen

Como parte de una investigación sobre la adaptación de Lotus pedunculatus *(lotus) a la región norte de las altiplanicies de New South Wales, se condujo un estudio comparativo de los efectos de las condiciones invernales sobre el valor nutritivo del cv. Grasslands Maku lotus y* Trifolium repens *cv. Haifa (trébol blanco). Durante fines de Mayo a fines de Julio, el nivel de nitrógeno y la digestibilidad* in vitro *de la materia orgánica del trébol blanco se mantuvieron constantes; sin embargo, en lotus tales parámetros fueron reducidos (de 42 a 32 g/kg N, y de 78 a 63% DMO). Dicha reducción es asociada con cambios morfológicos causados por la intensa helada. Estos efectos en el valor nutritivo limitan la función potencial del lotus en la región norte de las altiplanicies de New South Wales.*

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Introduction

Lotus pedunculatus cv. Grasslands Maku is a summer growing pasture legume with adaptation to the northern tablelands of New South Wales (J.F. Ayres, unpublished data). It has an erect growth habit, shows some winter growth (Armstrong 1974) and is tolerant of high levels of aluminium, manganese and salinity (Strachtman and Kelman 1990). Feeding value of lotus at vegetative stages of maturity is high compared with red clover, lucerne and perennial ryegrass but lower than white clover (John and Lancashire 1981). Following defoliation of lotus, rhizome growth predominates and shoot growth slows; specialised grazing management is required for persistence (Sheath 1981). Despite this limitation, some 30 000 ha in eastern Australia was planted to Maku lotus by 1990 (Harris *et al.* 1992), principally on beef properties in coastal districts extending from temperate latitudes into the subtropics. A tolerance of acid and infertile soils, hard seededness under cold temperatures, compatibility with summer-growing grasses, winter activity and bloat safety (Kelman and Blumenthal 1992) are attributes which make lotus potentially useful for the northern tablelands.

The northern tablelands, by virtue of elevation (>800 m altitude), is a cold-temperate environment, albeit at a subtropical latitude, and frosting is severe. Based on 46 years (1945-1991) of climatic data, the frost period at Glen Innes extends on average over 192 days (April 21-October 30) and includes an average of 91

"potential frosts". A "potential frost" is defined as occurring where the Stevenson screen minimum air temperature falls below 2.2 °C (Foley 1945). The "white frost" period extends on average over 179 days (April 26–October 22) and includes 50 "white frosts".

Although Maku lotus possesses a degree of frost tolerance, preliminary observations (J.F. Ayres, unpublished data) indicated the occurrence of "frost-burn" and negative effects on nutritive value where frosting intensity is severe. The present study was undertaken to determine whether the nutritive value of lotus is significantly influenced by winter conditions in this environment and whether changes in nutrient constituents are associated with the intensity of frosting.

Materials and methods

Site

The experiment was located at the Agricultural Research and Advisory Station, Glen Innes (29 °42 'S, 151 °42 'E, altitude 1060 m) on the northern tablelands of New South Wales. The soil is a basaltic black earth with acid reaction (pH 5.0 in calcium chloride) and very low available phosphate status. Mean annual rainfall is 847 mm with 60 per cent incidence between October and March. Mean maximum and minimum temperatures in the warmest month (January) are 24.8 and 13.5 °C respectively, with corresponding temperatures for the coldest month (July) of 12.0 and 0.4 °C.

Climatic records

The trial plots were located in close proximity to a standard Australian Bureau of Meteorology weather station (Station 056013). Records for the duration of the sampling period (May 21–July 25, 1991) were examined and data abstracted for daily rainfall, overnight absolute minimum air temperature, terrestrial temperature, 10 and 20 cm soil temperatures, and incidence of "white frosts". Available soil moisture status was calculated after the method of Smith and Johns (1975).

Treatments and experimental design

Samples of forage were taken from May 21–July 25, 1991 from monoculture plots of *Maku lotus* and *Trifolium repens* cv. Haifa. The plots were established in autumn 1987 as part of a coordinated field investigation of the nutritive value of perennial legumes at subtropical sites in New South Wales. Plot size was 10 x 2 m with 3 replications in a randomised block design and the resident species were maintained without grazing.

Representative forage samples were obtained by randomly cutting 10 subsamples per plot to 2 cm height and compositing. The forage samples were dried in a dehydrator for 16 hours at 65 °C, ground in a Wily mill to pass a 1 mm screen and retained for chemical analysis. Initial and final samples were separated into leaf and stem fractions.

Chemical analyses

Analytical procedures complied with conventional methods:

Nitrogen (N,g/kg) — analysed using a Leco organic nitrogen determinator

Organic matter (OM,g/kg) — determined by ashing in a muffle furnace at 550 °C for 16 hours

In vitro OM digestibility (IVD,%) — a two step rumen fluid/pepsin assay using the Minson and McLeod (1972) modification of Tilley and Terry (1963)

Neutral detergent fibre (NDF,g/kg), *Acid detergent fibre* (ADF,g/kg) and *Lignin* (g/kg) — measured by the method of Goering and Van Soest (1970).

Results

Climate

During the period of forage sampling, there were 30 potential frosts, 25 white frosts, one light snowfall and 16 occasions when the terrestrial minimum fell below − 5 °C (Table 1). There were 7 consecutive days during July (July 16–July 22) when the terrestrial minimum was below − 5 °C. The absolute lowest terrestrial temperature recorded was − 10 °C on July 7 and this coincided with an air temperature (Stevenson screen) of − 5.2 °C. Soil moisture status exceeded 50% of field capacity throughout this period.

Table 1. Summary of climatic data for the 1991 autumn/winter period coinciding with forage sampling.

Month/ week	Potential frosts	White frosts	Absolute terrestrial minimum	Mean minimum soil temperature		Available soil moisture
				10 cm	20 cm	
			°C	°C	°C	%
May 3	0	0	6.0	13.2	13.5	53
4	0	0	1.0	12.1	13.1	66
June 1	3	2	−4.5	9.4	10.7	78
2	2	2	−3.5	9.4	10.7	79
3	3	2	−5.8	7.0	8.6	73
4	5	6	−7.8	6.2	7.6	64
July 1	4	3	−10.0	6.6	7.7	58
2	4	2	−6.0	6.4	7.4	81
3	7	6	−9.5	3.4	5.7	73
4	2	2	−7.0	5.0	6.3	86

Nutritive value constituents

The onset of winter conditions exerted marked effects on nutritive value and effects were substantially greater for lotus than white clover (Figure 1). White clover maintained high nutritive value with relatively constant N concentration, IVD and structural fibre constituents (NDF, ADF and lignin). By contrast, the levels of N and IVD for lotus declined and structural fibre increased progressively with the onset of winter conditions. These effects were most marked with the occurrence of severe frosting where the terrestrial minimum temperature fell below −5 °C from mid June.

Leaf:stem ratio

The onset of winter conditions had a different effect on the leafiness of the two species (Figure 2). At the beginning of winter, lotus had a higher leaf: stem ratio than white clover (3:1 cf. 1.8:1), but by mid-winter the leaf:stem ratio of white clover exceeded lotus (4.8:1 cf. 1.6:1).

Discussion

The potential role for lotus on the northern tablelands of New South Wales is to provide: (i) an early flush of vegetative growth in spring to sustain lambing and calving, (ii) high quality non-bloating leguminous forage over summer/autumn to finish lambs and grow out calves to weaning, and (iii) winter grazing of "held-over" autumn forage.

The present results confirm observations that, although lotus possesses sufficient frost tolerance for agronomic adaptation, the severe frosting intensity that characterises the northern tablelands is deleterious to forage quality in winter. At the beginning of winter, lotus was comparable with white clover in the constituents under study (Figure 1). However, by mid-winter, the *in vitro* digestibility of lotus had declined from 78% to 63% while the digestibility of white clover remained relatively constant at about 80%. Other data (J.F. Ayres, unpublished data) indicate that the digestibility of lotus declines further to about 50% by the end of winter. Similarly, while the N concentration of lotus declined sharply from 43 g/kg to 32 g/kg over the same period, the N concentration of white clover remained relatively constant at 45 g/kg (Figure 1). These reductions in digestibility and N concentration were associated with corresponding increases in NDF, ADF and lignin.

The observed decline in nutritive value of lotus was apparently due to morphological changes occurring with onset of winter conditions as evidenced by a substantial reduction in leaf/stem ratio (3:1 cf. 1.6:1 for late autumn and mid-winter respectively). Each occasion of severe frosting intensity induced desiccating "frost-burn" at the interface of the sward canopy and air surface and this phenomenon produced a progressive defoliation process. Moreover, in contrast to white clover where growing tips are located in the basal zone of the sward along stolons, the axillary buds on lotus are located on shoot tips (Sheath 1981) where frost damage is maximal, thereby further reducing the capacity of lotus to initiate new

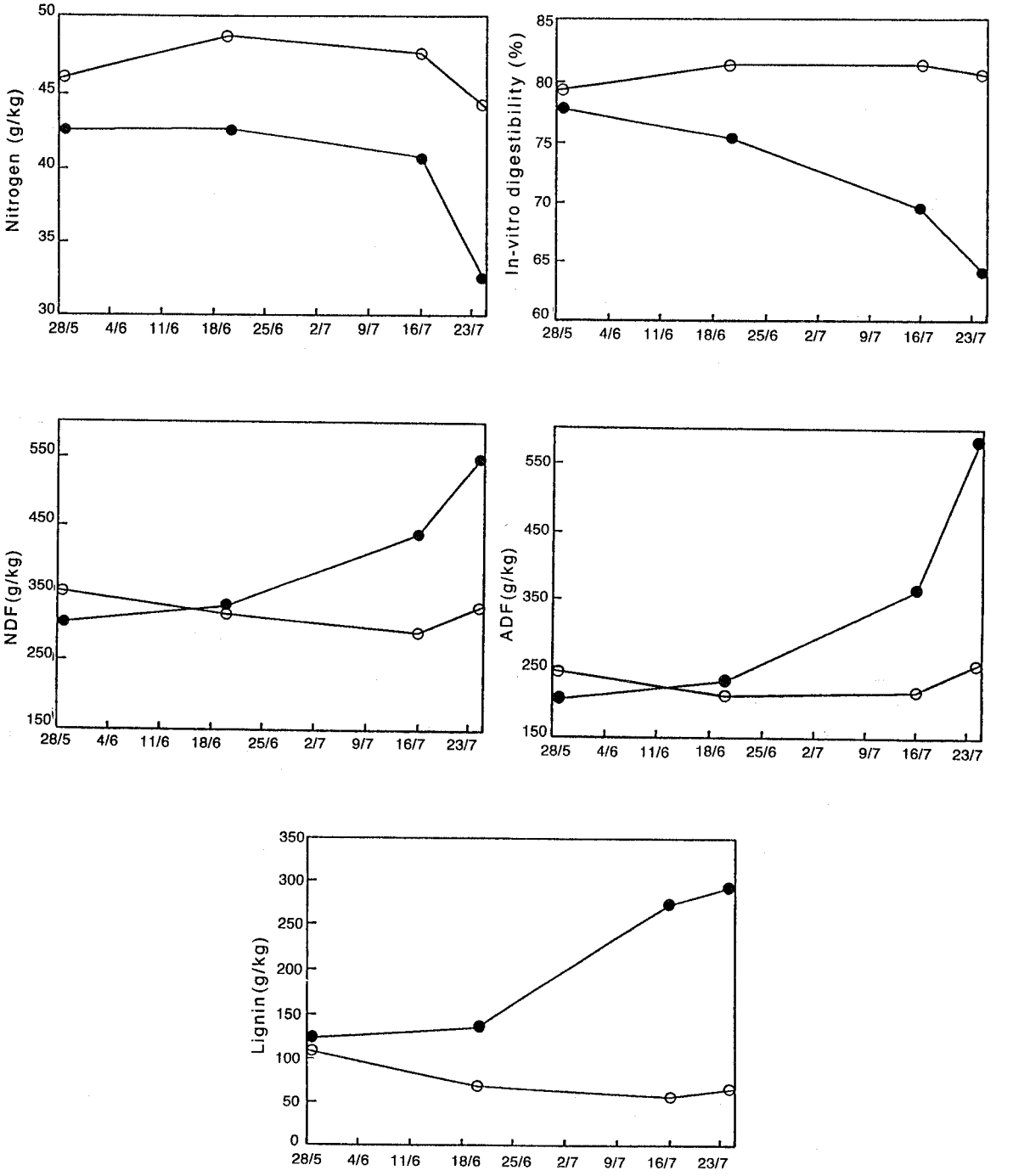

Figure 1. The influence of onset of winter conditions on the nutritive value of Haifa white clover (o) and Maku lotus (●).

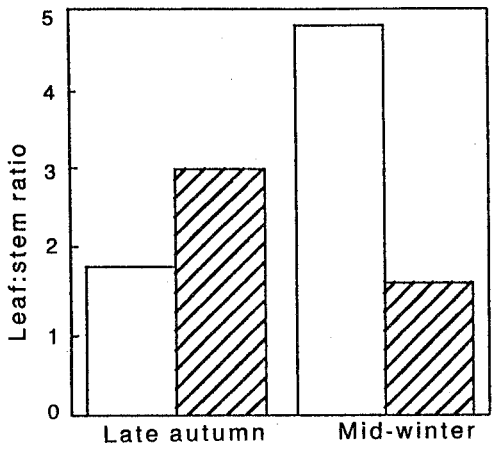

Figure 2. The influence of the onset of winter conditions on the leaf:stem ratio of Haifa white clover (□) and Maku lotus (▨).

shoots to offset loss of leaves. It is unlikely that phenological development affected nutritive value over winter because cold temperatures cause shoot growth to cease. However, physiological development of the rhizome system occurs during winter following rhizome extension in autumn (Sheath 1981); the rhizome network from the previous growth cycle fragments in the process of regeneration of new plant units. It is possible that translocation of assimilates between the shoot and root systems also occurred in conjunction with this regeneration process.

Regardless of the primary cause of the decline in nutrient constituents of lotus, the empiric result is a substantial decline in nutritive value over winter. This represents a limitation on the potential usefulness of lotus for northern tablelands pastures.

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