Dry Matter Production and Nutritive Value of Alfalfa (*Medicago sativa* L.) and Orchardgrass (*Dactylis glomerata* L.) under Different Light Regimes

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DRY MATTER PRODUCTION AND NUTRITIVE VALUE OF ALFALFA (*Medicago sativa* L.) AND ORCHARDGRASS (*Dactylis glomerata* L.) UNDER DIFFERENT LIGHT REGIMES.

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Abstract

Spring and summer alfalfa dry matter and nitrogen production rates were greater than orchardgrass in open pasture and under three shade levels. Ten years old *Pinus radiata* allowed 60% light transmissivity. The addition of artificial shade resulted in 45% and 25% transmissivity. Orchardgrass pastures were nitrogen deficient and water stressed. In contrast, alfalfa was not stressed and it was more light responsive than orchardgrass. Differences in nutritive value were relatively small between species and between light regimes. Sheep liveweight gain on alfalfa was greater than on orchardgrass. Orchardgrass demonstrated shade tolerance, but alfalfa was more productive even at 25% transmissivity. Conventional concepts of shade tolerance may not be appropriate when screening pasture species for silvipastoral systems.

Keywords: Crude protein, digestibility, shade, silvipastoral, slat, *Pinus radiata*.

Introduction

Photosynthetically, C_3 grasses and legumes respond similarly at low to moderate levels of radiation (Nelson and Moser, 1994). However, plant growth and morphology under shade can differ between temperate grasses and legumes (Davkota et al., 1997).

Orchardgrass is acknowledged for its ability to grow under shade (Joshi et al., 1999). In contrast, alfalfa is a light responsive forage (Nelson and Moser, 1994) that has been shown to produce more dry matter (DM) than orchardgrass in this silvipastoral experiment (Pollock et al., 1997). The concept of shade tolerance is usually associated with the relative growth performance of plants in shade compared with full sunlight (Wong, 1990). However, the concept of potential yield (the maximum yield that can be reached by a crop in a given environment) may be more appropriate when screening pasture species for shade tolerance (Evans and Fischer, 1999). The aim of this study was to quantify DM production and nutritive value of alfalfa and orchardgrass under a range of light regimes, which included wooden slat shade and tree canopy shade.

Material and Methods

The experiment at Lincoln University, Canterbury, New Zealand (48^{o} 38’00’’ S and 172^{o} 28’00’’ E) was located on a silt loam soil of variable depth (0.5 - 2.0m) over gravel. The 0.2 ha alfalfa plots under trees and 0.05 ha plots in full sunlight were sown on 1 March 1999 to establish 250 plants per m^2. Similar plots were sown in September 1990 with orchardgrass and clovers. The experiment was conducted from September 1999 to January 2000. The forest consisted of 200 ten year old *Pinus radiata* stems per hectare (sph) high pruned up to 6 m with 7 m between tree rows. Successive selective thinnings were carried out from 1000 sph in 1992 to a final population of 200 sph in 1996.

Four levels of light intensity were compared using a randomised block design with 3 replicates: full sunlight (100% photosynthetic photon flux density-PPFD), open + wooden slats (45% PPFD), trees (60% PPFD) and tree + slats (25% PPFD). The slat shade structure covered a 2.4 x 5.2 m area with 150 mm gaps between slats which were 150 mm wide. The slats were supported on an adjustable height frame to allow the shade source to be maintained at 0.3m above the alfalfa or orchardgrass canopy tops as they grew.

Light intensity was monitored from September 1999 to January 2000 with quantum sensors installed above and below the shade source, but above alfalfa or orchardgrass height. PPFD was recorded every 30 seconds. Proportions of red (660 nm) to far-red (730 nm) wavelengths were measured with a LI-COR spectroradiometer. The DM yield was measured prior to sheep grazing and a representative subsample was collected to measure components of yield and nutritive value. The alfalfa was rotationally grazed at the late bud stage by sheep for 7 ± 1 days grazing after 42 ± 5 days regrowth. Orchardgrass pasture was grazed for 7 days after 21 day regrowth periods. Because clover content was low (< 5%), the perennial grass was nitrogen deficient and green urine patches covered 20% of the pasture. Pasture samples were collected only in non-urine areas. Liveweight of sheep was measured at 30 day intervals from flocks grazing in the open and under trees.

Results and Discussion

Decreased light intensities had less effect on orchardgrass production than alfalfa (Figure 1). Orchardgrass DM production under trees (60% transmissivity) was typically lower than under open+slat (45% transmissivity). However, the red to far-red ratio did not change significantly (1.16 in the open, 1.07 under open+slat, 1.05 under trees and 0.96 under tree+slat). Therefore, it seems likely that orchardgrass production was also affected by tree root competition for soil nitrogen and moisture.

Alfalfa production was more sensitive than orchardgrass to increasing levels of shade. However, alfalfa produced more DM than orchardgrass at all light intensities (Figure 1). Under tree+slat (25% PPFD), the DM production rate of alfalfa was only 53% of full sunlight comparing with 72% for orchadgrass (Table 1). The greater productivity of the light responsive alfalfa in all levels of PPFD was presumably related to its deeper root system (drought tolerance) and ability to fix nitrogen.

Grass crude protein content (CP%) increased as PPFD declined. This may be attributed to either a decrease in photosynthates, with a consequent rise in the N% concentration, or to an increase in soil organic matter mineralisation under trees that provided greater nitrogen for grass uptake. In contrast, CP% in alfalfa was reduced under trees (Table 1), indicating tree competition may have reduced its nitrogen fixation. Shade had small effects on both alfalfa and orchardgrass organic matter digestibility (OMD). It is important to note that the alfalfa feeding value reported in Table 1 was for the whole plant (leaf + stem) whereas vegetative tillers were selected for orchardgrass chemical analysis. Mean OMD values for alfalfa leaf and stem were 80 and 62% and mean CP% were 28 and 14%, respectively.

The greater alfalfa pasture production and nutritive value resulted in greater sheep production. Higher stocking rates in alfalfa resulted in a liveweight gain of 32.1 kg/ha/day in the open and 20.6 kg/ha/day under trees compared with 16.0 and 8.9 kg/ha/day for orchardgrass.

Because alfalfa feeding value was superior to orchardgrass under trees and in the open, the concept of shade tolerance (Wong, 1990) may not be as appropriate as the concept of potential yield (Evans & Fischer, 1999) when screening pasture species for silvipastoral systems.

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Table 1 - Nutritive value, mean dry matter and nitrogen production rate of alfalfa and orchardgrass under different light regimes during spring and summer in Canterbury, New Zealand.

Treatments	CP [†]	OMD	Mean dry matter production rate [††]	Nitrogen production rate
	----%----	----%----	-----kg/ha/d-----	----kg/ha/day----
a)Alfalfa:				
Open (100%[§])	19.3	71.0	60.0	1.84
Open+Slat (45%)	22.3	72.0	38.0	1.34
Tree (60%)	17.5	68.2	49.0	1.38
Tree+Slat (25%)	20.4	66.2	32.0	1.03
b)Orchardgrass:				
Open (100%)	17.6	76.7	29.0	0.82
Open+Slat (45%)	21.0	79.2	28.0	0.93
Tree (60%)	20.1	78.9	24.0	0.76
Tree+Slat (25%)	23.0	78.1	21.0	0.78

[†] Crude protein (CP%= N% x 6.25) and organic matter digestibility (OMD%) of alfalfa shoot (leaf + stem) and orchardgrass vegetative tillers.

[††]42 ± 5 days regrowth for alfalfa and 21 days for orchardgrass. Averages from September 1999 to January 2000.

[§] Transmissivity in photosynthetic photon flux density (PPFD) compared with open.

Figure 1. Dry matter production rate of alfalfa (——) and orchardgrass (-----) under different light regimes: open (○), open+slat (Δ), tree (□) and tree+slat (◊) in Canterbury, New Zealand. Maximum SE of the mean for alfalfa: 9.82. Maximum SE of the mean for orchardgrass: 2.73.