Different Methods of Artificial Shade for Agro-Silvipastoral Research

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DIFFERENT METHODS OF ARTIFICIAL SHADE FOR AGRO-SILVIPASTORAL RESEARCH

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Abstract

Artificial shading sources are used to simulate silvipastoral light environments and study the effect of shade on pasture. Different sources of shade may not imitate normal forest light environment. An experiment was conducted to examine the light environment and effect on pasture yield components of two artificial shading materials. Alfalfa (*Medicago sativa* L.) pasture was submitted to three light regimes: full sunlight (100% transmissivity); black shade cloth (40%) and wooden slats (45%).

The pattern of light exposure for plants differed under slats and shade cloth, but light intensity and quality were similar. Alfalfa dry matter (DM) yield and leaf area index under shaded treatments were about 60% of the open pasture. Numbers of stems per m^2, number of nodes and plant height were also similar in both shaded treatments, but lower than in full sunlight. Plants under shade cloth and slats had a greater leaf to stem ratio, but leaf temperature was cooler under both shaded treatments than in full sunlight. This resulted in delayed alfalfa development. The results indicated that both slats and shade cloth can simulate the light environment under agroforestry, but they may not produce the same biological consequences.

Keywords: Alfalfa, cloth, slats, tree-pasture system.

Introduction

In agroforestry research, artificial shading is used to simulate tree shade on understorey vegetation (Devkota et al., 1997). The aims of this study were to quantify the light regime produced by a wooden slat structure and a black shade cloth and to determine the effects of both shading sources on alfalfa (*Medicago sativa* L.) production and morphology.

Modifications in the pattern of sunlight, light intensity and quality may be particularly important when plant morphology and production are concerned (Buxton and Fales, 1994). As sunlight passes through the tree canopy, its pattern, intensity and quality changes (Wilson and Ludlow, 1991). Under cloth, not only light intensity reduces, but spectral quality can alter when transmissivity is below 25% of the ambient sunlight (Gaskin, 1965). Shade cloth produces a continuous shading whereas slats produces alternating periods of shade and sun (Barden, 1977). The alternating light/dark pattern may more closely resemble an agroforestry system. In this investigation, alfalfa was used to indicate plant responses to these different light regimes.

Material and Methods

The experiment was located at the Lincoln University, Canterbury, New Zealand (48^{o} 38' 00'' S and 172^{o} 28' 00'' E) in a silt loam soil of variable depth. Alfalfa (*Medicago sativa* L.) plots (22 x 6.3 m) were sown on 1 November 1996. The experiment was conducted from January to June 1999 and plants were fully irrigated from November 1998 to March 1999.

The statistical design was a randomised complete block with three replicates. Treatments consisted of three light regimes: full sunlight, black shade cloth and wooden slats. The black shade cloth covered a 2.3 x 1.8m area and slats covered 2.4 x 5.2 m area with 150 mm wide

slats and 150 mm gaps between slats. The shade structures were supported horizontally on a vertically adjustable metal frame which allowed the shade sources to be maintained at 0.3 m above the alfalfa canopy. For the slatted shade structure, the objective was to create intervals of sunlight and shade similar to a nearby experimental radiata pine agroforestry area.

The light environment was monitored with quantum sensors installed above and below the shade source and the photosynthetic photon flux density (PPFD) was recorded by a datalogger. Proportions of red (660 nm) to far-red (730 nm) wavelengths were also measured with a LI-COR spectro-radiometer. Leaf temperature was measured with an infra-red thermometer (Everest Interscence model 110) on cloudless days at 12.00 pm. Leaf area index (LAI) was measured at 7-10 day intervals, using a LAI-2000 canopy analyser. Dry matter (DM) yield was measured using a 0.2 m^2 quadrat, prior to sheep grazing. A representative subsample was collected to estimate the average number of stems per m^2 and the leaf to stem ratio. Plant height and number of nodes per stem were measured weekly on five marked stems per plot.

Data presented in this paper are from the averages of the three replicates. Alfalfa was grazed by ewes for 5-7 days followed by a 35-42 day recovery period. Four grazing rotations were completed between January and June 1999.

Results and Discussion

The light regime experienced by plants differed with treatments. Compared with plants grown in the open, alfalfa under shade cloth received a uniform reduction in PPFD over the daylight hours with an average transmissivity of 40% (Figure 1). The mean transmissivity under the slats was 45%, but with alternating periods of full sunlight to shade. Proportions of red to far-red wavelengths were similar for all treatments at 1.16, 1.14 and 1.07 for full

sunlight, shade cloth and shade slats, respectively. Overcast conditions produced similar PPFD transmission, but without any spatial variation under the slats.

The bimodal appearance of the slatted treatment may be a closer representation of the light regime experienced by plants in an agroforestry system. Alternate periods of high and low radiation can be expected from the passage of sunlight between and behind tree crowns respectively, rather than a uniform shading pattern as experienced by plants under cloth. Despite the difference in light regimes under the shaded treatments, DM production and morphological changes were similar (Table 1). The DM production was about 60% of full sunlight treatment. The implication was that the reduction in DM production under the shaded treatments was mainly a consequence of the decrease in light intensity rather than the pattern of the light regime or light quality intercepted by plants. The lower PPFD resulted in fewer and shorter stems and a decrease in LAI. The relative differences in LAI, stems per m^2, plant height and number of nodes from full sunlight to cloth and slats were similar, but no changes were found in the internode length. Further, alfalfa under both shaded treatments increased the leaf to stem ratio, suggesting that plants may have responded to the lower stem population, and consequently lower intra-specific competition, by maximising their leaf area to harvest more light. This may account for the observation that transmissivity was about 40% in the shaded treatments, but total DM production was about 60% of that in the open.

The reduction in the number of nodes under cloth and slats was consistent with the measured reduction in leaf temperatures, indicating that the accumulation of thermal time was slower under shaded treatments. This resulted in slower alfalfa development (node appearance and time of flowering) under the cooler shaded treatments.

In conclusion, plants experienced markedly different light regimes under shade cloth and slats, but transmissivity and light quality were similar. In the short term, both artificial shade treatments produced similar effects on alfalfa. This indicates that either shade cloth or wooden

slats would be appropriate alternatives to investigate shade effects on plant morphology and yield. However, if the aim is to simulate tree shade and study plant physiological responses, slats may be more appropriate.

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Table 1 - Response of alfalfa to 3 light regimes in fully irrigated plots in Canterbury, New Zealand from January to 30 June 1999.

Treatment	DM† Yield	LAI††	Stems per m^2	Plant height	Nodes nº	Intern. length	L:S§ ratio	Leaf temp.
	--$kg.ha^{-1}$--			--cm--		--cm--		--^{o}C--
Open (100%)	10500 a§§	5.7 a	688 a	49.6 a	9.9 a	5.0 a	1.3 a	21.7 a
Cloth (40%)	6440 b	3.7 b	489 b	44.8 b	9.4 b	4.8 a	1.3 ab	20.4 b
Slats (45%)	5950 b	4.0 b	493 b	45.3 b	9.0 b	5.0 a	1.4 b	20.7 b
SE	315.0	0.08	44.2	0.63	0.11	0.07	0.04	0.25

† Accumulated dry matter yield.

†† Leaf area index.

§ Leaf to stem ratio.

§§ Means followed by the same letter in a column are not different using LSD tests at α=0.05%.

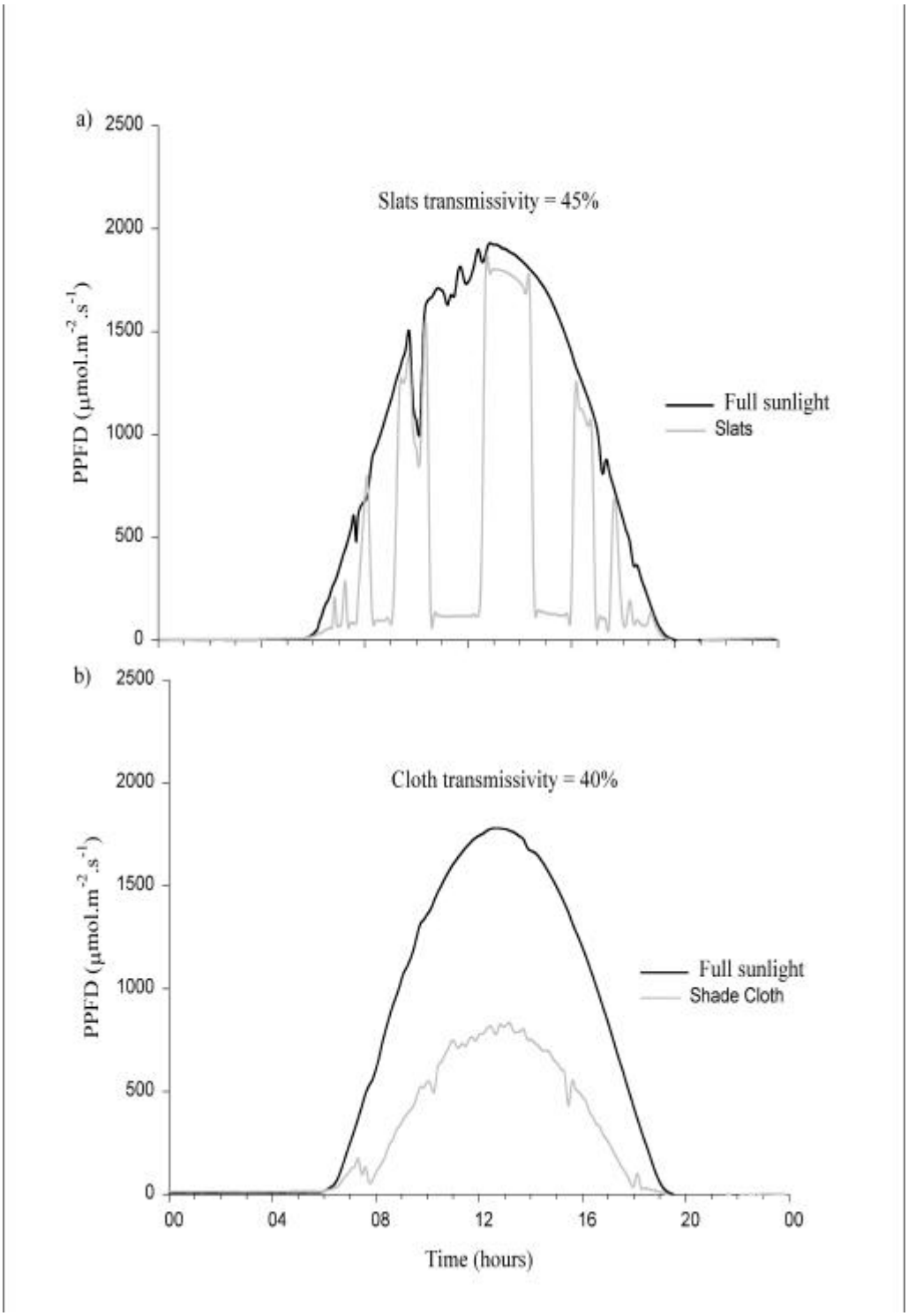

Figure 1 - Photosynthetic photon flux density (PPFD) in a typical sunny day for alfalfa in full sunlight, under wooden slats (1) and under shade cloth (1b). Data collected in February 1999, Canterbury, New Zealand