The Effects of Tree Density on Pasture Production Under Acacia Melanoxylon

B S. Thorrold
Whatawhata Research Centre, NZ

I L. Power
Whatawhata Research Centre, NZ

M B. Dodd
Whatawhata Research Centre, NZ

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B.S.Thorrold, I.L.Power and M.B.Dodd

AgResearch, Whatawhata Research Centre, Private Bag 3089, Hamilton, New Zealand

ABSTRACT

Silvi-pastoral systems could contribute to greater total productivity and more sustainable land management of grazed pastures in New Zealand. Despite this potential, little is known of the interactions of tree species and environment on pasture growth. In this paper we report the effects of tree density on pasture yield in an *Acacia melanoxylon* silvi-pastoral system. The results show decreasing pasture yield with increasing tree density, although the extent of the reduction is less than would be expected under *Pinus radiata*. Results suggest that shade is the dominant factor causing yield decline in this study, while reduced N availability is clearly implicated in previous studies with pine trees. This study will provide more data on which a mechanistic model of tree-pasture interactions can be based.

KEYWORDS

silvi-pastoral, nitrogen, *Acacia melanoxylon*, pasture, shade

INTRODUCTION

Study of silvi-pastoralism in New Zealand has focused on mixed timber-livestock systems through the planting of pine trees (*Pinus radiata*) into pasture (e.g. Percival and Knowles, 1988) and on the use of Poplar species for erosion control in unstable hill country (e.g. Hawley and Dymond, 1988). Silvipastoral systems have the potential to enhance sustainable management of grazing lands by combining protective and productive functions, yet there is little information available that would allow extrapolation of the results from individual studies to new sites or tree species. Study of tree-pasture interactions under *Acacia melanoxylon* allows the opportunity to assess the impacts of an N fixing tree on pasture yield. By detailed measurement of nutrient cycling, light environment and soil moisture we hope to be able to develop the predictive models required.

METHODS AND MATERIALS

Pasture dry matter measurements, light quantity measurements and soil moisture measurements were made under *A. melanoxylon* over a range of tree densities at two sites in the Central North Island, New Zealand (Table 1). The sites were planted in 1987 as part of a New Zealand Forest Research Institute nationwide regime trial. Trial design is an unreplicated factorial design (final tree density by thinning regime by pruning height) at each site. The trees were thinned in 1991 and 1993. We placed our measurement sites under the selected tree densities in 1993 after that year's pruning and thinning. Each site is grazed regularly, mainly by sheep with occasional cattle grazing.

Use of stems/ha or basal tree area as the predictor of pasture yield is not satisfactory in stands where thinning and pruning can change tree influence. Instead the effect of the trees is integrated as metres of green crown length/ha. This is calculated by multiplying tree stocking rate by the height of green crown on the trees, giving a measure of green crown length (m) per hectare. Table 1 shows the treatments at each site. At each site we chose plots to cover the range of tree densities, and also included an open pasture site in the trial area but away from the influence of the tree shade or roots. In each plot we placed three pasture measurement sites on a 15-20° slope. Pasture growth was measured under grazing exclusion cages using a double trim technique. Soil moisture was measured at 0-15 and 0-30 cm depths in each plot by time domain reflectrometry on a regular basis.

RESULTS AND DISCUSSION

The results show clearly that pasture production (as a fraction of open pasture yield) declines with an increase in tree density. The relationship is similar for both sites (Figure 1). The decrease in yield appears to be dominantly through a shading effect. Soil moisture results (Table 1) show that soil moisture is consistently higher under the trees than in the open pasture, and the difference increases with tree stocking density. There is a trend for the low tree density treatments to be higher yielding than the open pasture in the late summer autumn period when moisture stress in the open pasture is at its greatest. These results reinforce Australian experience (Scanlon and McKeon, 1993) which showed that the extent to which competition for moisture dominated tree-pastue interactions depended on rainfall distribution and soil depth. In our study it appears that net effect of the tree canopy has been to reduce evapotranspiration from the soil surface, such that moisture becomes less limiting under the trees than in open pasture. With an N fixing tree it is unlikely that there is severe competition for N (as occurs under pine trees), although we do not yet have the plant N content data to make more informed comment on this.

Comparisons of the pattern of yield decline under *A. melanoxylon* with that expected under *P. radiata* at similar densities are also shown in Figure 1. The predicted curve for *P. radiata* was taken from Percival and Knowles (1988). The results show that green crown length is a good predictor of pasture yield for both species, but the rate of pasture decline is much less under *A. melanoxylon* than *P. radiata*. Data from the Tikitere trial (Steele and Percival, 1984) indicate that severe N deficiency develops under the pine trees due to suppression of legume growth and a slowing of the N cycle by the trees. In addition the canopy density of the pine trees appears to reduce light more than *A. melanoxylon* at the same green crown length (I. Power; unpub data).

These results are interesting in their own right, indicating the potential for *A. melanoxylon* to produce more pasture in silvi-pastoral systems than *P. radiata*. More importantly they illustrate the importance of a mechanistic approach to tree-pasture interactions in order to develop a better ability to predict the interactions of tree species and environment on pasture yield.

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Table 1
Details of sites, treatments and soil moisture levels at one sampling

Site 1 Lake Okareka
Soil type = Rotomahana hill soil Vitric hapludand (USDA taxonomy)

Aspect	Rainfall (mm)	pH(H2O)	Olsen P
North	1600	5.9	9

Treatments

Stems/ha	Green crown/Tree (m)	Green crown length (m/ha)	Soil moisture (%v/v) 0-15 cm Autumn 1995	Relative yield Jan-May 1995
0	0	0	26.80	100.0
500	3	1500	33.10	84.84
800	3	2400	26.73	101.43
1700	1.5	2550	28.63	100.47
500	6	3000	24.00	96.44
800	6	4800	28.90	73.92
1700	3	5100	37.93	66.92
1700	6	10200	32.83	44.09

Site 2 Te Kuiti
Soil type = Te Kuiti sandy loam Typic hapludand (USDA taxonomy)

Aspect	Rainfall (mm)	pH(H2O)	Olsen P
West	1500	5.8	10

Treatments

Stems/ha (m)	Green crown/Tree length (m/ha)	Green crown 0-15 cm	Soil moisture (%v/v) Autumn 1995	Relative yield Feb-May 1995
0	0	0	23.67	100.0
200	3	600	28.3	82.34
425	1.5	637.5	24.63	95.88
800	1.5	1200	27.83	91.14
425	6	2550	24.97	87.32
1700	1.5	2550	30.47	70.39
1700	3	5100	31.17	58.65
1700	6	10200	31.05	50.89

Figure 1
The relationship between pasture yield and green crown length for the Sites 1 and 2 in comparison with results for *P. Radiata* from Percival and Knowles (1988).