TREE-PASTURE INTERACTIONS IN ALLEY FARMING SYSTEMS ESTABLISHED ON MILDLY SALINE LAND

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ABSTRACT

In the agricultural region of Western Australia alley farming systems are commonly established on saline land, or on land at risk of becoming saline, for groundwater recharge and watertable reduction purposes. At these sites a diverse range of trees and pastures have been established. Anecdotal evidence suggests that some tree species compete with neighbouring pastures more strongly for resources than other species. This study investigated interactions between three seven year old tree/shrub species, from different families (*Eucalyptus occidentalis, Casuarina obesa* and *Acacia saligna*), and neighbouring pasture. More pasture was produced under and adjacent to *Acacia saligna* and *Casuarina obesa* than under *Eucalyptus occidentalis*. Total nitrogen stored in the above ground biomass (excluding the tree themselves) was significantly higher (47 kg ha^{-1}) under the Acacia trees compared to the two other tree species (23 kg ha^{-1} C. obesa, 4 kg ha^{-1} E. occidentalis). The results suggest that the tree species used in alley farming need to be chosen carefully and that the hydrological and production implications of species selection need to be considered before establishment.

INTRODUCTION

Approximately 30 % of the WA wheatbelt has the potential to become salt affected (Anon 1999). Because large areas of agricultural land will become saline, under most recharge management scenarios, there needs to be an emphasis on "living with salinity" (Anon 2000). It is generally considered that there needs to be a larger focus on the uses and options for saline land and water. Saltland must be managed for economic and environmental outcomes but the range of perennials is limited; annuals and herbaceous perennials may perform better when integrated with salt tolerant woody perennials that control water tables, provide a more favourable growth environment for annual and herbaceous perennial forage crops, and may produce wood products on low value land.

Alley farming systems have developed as a means of making broad scale tree planting and agricultural production compatible (Knight et al 1998). In such systems, crops and or pastures are grown in the alleys (usually 10-300m wide) that are formed between belts of trees or shrubs. Alley farming can benefit agricultural systems through the: 1) provision of shelter to crops/pasture and livestock 2) provision of commercial products from the trees or shrubs, 3) reduced groundwater recharge and water table rise 4) provision of habitat for beneficial wildlife, 5) enhancement of farm aesthetics. Over the last twenty years Western Australian farmers have established alley-farming systems in order to lower or stabilise saline watertables on land that was salt affected or was at high risk of becoming saline. In certain circumstances there has been some hydrological success, however, pasture growth has often been relatively poor (Marcar et al 1995) due to resource competition particularly in narrow alleys located in low rainfall areas .

There is scant information available on pasture production under trees grown on land that has a shallow and saline watertable. On mildly saline land the authors have observed that annual pasture appears to be abundant under and adjacent to some mature *Acacia saligna* bushes whereas, pasture under and adjacent to *Eucalyptus species* appears to be sparse. Scott and Crossley (1996) noted from visual observations that some tree species such as *Casuarina obesa* did not reduce pasture production as markedly as some of the *Eucalyptus* species. The aim of this preliminary study was to determine the effect of tree species on pasture growth on land with a shallow saline watertable.

MATERIALS AND METHODS

Site and species description

In 1995 an alley farming trial was established adjacent to Toolibin Lake on land at risk of becoming saline. Lake Toolibin is listed under the ramsar convention as a wetland of international importance. The alley farming trial used nine tree species planted in different layouts. *Acacia saligna*, *Casuarina obesa* and *Eucalyptus occidentalis* were three of the species planted. C. obesa is a highly salt and waterlogging tolerant woody perennial, naturally occurring and widely planted (two WA two nurseries sold 190,000 C. obesa seedlings in 2000). C. obesa and A. saligna both have the capacity to fix atmospheric nitrogen. There are contrasting thoughts regarding the salt and waterlogging tolerance of Acacia saligna; Marcar et al (1995) describes it as being moderately tolerant of salinity and waterlogging, whereas, Bell (1999) classified the species as being mostly intolerant. Eucalyptus occidentalis is a tree of height range 10-20 m and has moderate to high tolerance of saline and waterlogged conditions (Marcar et al 1995, Bell 1999).

Soil salinity and groundwater levels.

Depth to groundwater was monitored by the Department of Conservation and Land Management (CALM) at Narrogin. Observation wells (down to 4 m) W91, W81 W 23 and W 35 were close to the study area and data provided by CALM was used for analysis.

Apparent soil salinity (ECa, Geonics EM38) was measured under each tree species and at 2, 10 and 20 m out from the tree belts. Electrical conductivity of a 1:5 soil:water (ECw) extract was also used to measure soil salinity. ECw was determined on soil samples collected from a depth of 0.1-0.2m at 10 m from the trees. To compare with the universally applicable soil salinity categories developed by the United Sates Salinity Laboratory (USSL 1954), ECw was converted to electrical conductivity of a saturated soil extract (ECe) using the following: ECe =(364xECw)/SP (Moore 1998)

Above ground biomass

The site was first visited on 26/10/2001, during which, pasture biomass underneath each tree species was estimated by harvesting above ground biomass within four randomly placed 0.1m2 quadrats. Tree leaves and twigs were removed from samples, then oven dried (80^{o}C for 7 days) and weighed.

On the 20/3/2002 and on the 14/8/2002 above ground biomass was estimated under each tree species and at 2, 10 and 20 m out from the tree belts. Biomass was estimated as above however, fallen tree leaves and twigs were included in samples collected on the 20/3/2002.

Nitrogen analyses.

Nitrogen in the topsoil (0-0.1 m) and in the above ground biomass (excluding living the living trees) was measured in late March 2002. The biomass samples harvested on the 20/3/2002 were ground into a fine powder and total nitrogen content measured by the chemistry centre, Western Australia.

Statistical Analyses

Genstat 5, release 4.1 (Rothamsted Experimental Station, Harpenden, UK) was used for all statistical analyses. Unless otherwise stated, a general analysis of variance was used, from which the least significant difference (LSD) at P = 0.05 was used to compare means.

RESULTS

Soil salinity and depth to groundwater.

The topsoil at most sampling sites was non saline. Mean soil salinity (ECe) at the site was 100 mS m^{-1}, which would be rated as non-saline by the USSL (1954) classification system. Two of the twelve sampling sites had a soil salinity of 200-250 mS m^{-1} and classified as slightly saline USSL (1954). The mean apparent salinity over the 0-1.0m range (as measured by EM 38 in vertical mode) at the study site was 81 mS m^{-1}.

Since the establishment of the alley farming trial a falling groundwater level has been observed at the study site. This may be partly due to water use by the trees but would also be due to below average summer and winter rainfall since the establishment of the alley farming trial. A shallow watertable (<1m) occurred at the site at times when rainfall has been in excess of the average (figure ??).

Annual pasture and above ground biomass

The annual pasture composition varied spatially at the experimental site, often over small distances of 5-10 m. The main grass pasture species were Hordeum marinum and Lolium sp.; major dicot pastures were Arctotheca calendula, Erodium sp and Trifolium sp.

At the end of the 2001 annual plant growing season there was significantly more pasture biomass under *Acacia saligna* (1.4t/ha) and *Casuarina obesa* (1.1t/ha) than under *Eucalyptus occidentalis* (0.2t/ha, Figure ?). A similar result was observed in March 2002, however, at this time the *Acacia saligna* trees had shed numerous leaves resulting in a total biomass (pasture + leaf litter) of 4.2 t/ha underneath this species. During the October 2001 sampling it was also visually apparent that the pasture under A. saligna was greener than that under and adjacent to C. obesa and E. ccidentalis which was dead or senescent.

Intensive pasture sampling in August 2002 showed that all three species reduced neighbouring pasture growth to some extent. Biomass under and 2 m from the trees was significantly greater under A. saligna and C. obesa than under E. occidentalis (Figure). Integration of the data shown in Figure ? suggests that A. saligna, C. obesa and E. occidentalis result in a 14, 22 and 40 % decrease in pasture production relative to a "no tree System" assuming an alley width of 50 m, a tree belt width of 7 m and that the yield at 20 m for each species is an approximate estimate of open field pasture yield.

Nitrogen

Tree species influenced the soil and biomass nitrogen pool. E. occidentalis had a profound negative influence on the nitrogen pool stored in the above ground biomass. This was due to a low total biomass and low nitrogen content of the biomass under and adjacent to E. occidentalis. A. saliga, in contrast to the eucalypts, significantly increased the biomass nitrogen pool, under and adjacent to them. Casuarinas did not significantly alter the total above ground nitrogen pool. Total soil nitrogen in March 2002 was slightly higher under A. saligna (0.117%) but not significantly different from C. obesa (0.108%) and E. occidentalis (0.103%)

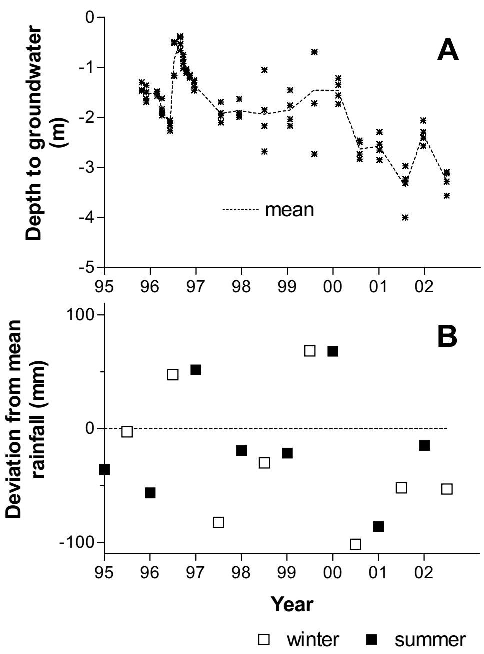

Figure 1 Depth to groundwater and deviation from average (1976-2001) rainfall at the Lake Toolibin alley-farming trial.

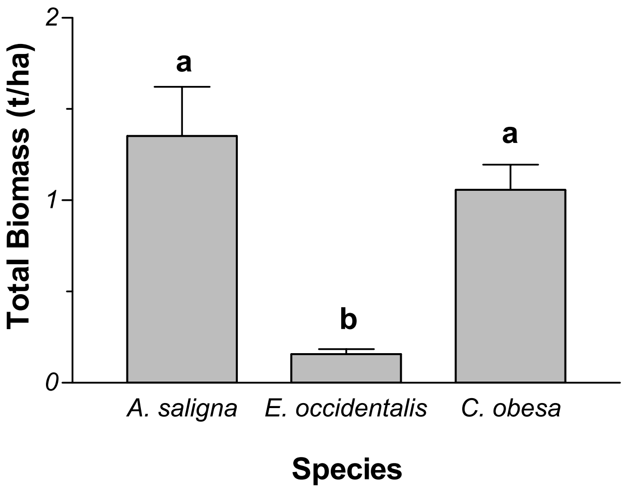

Figure 2 Pasture biomass harvested under three tree species, October 2001

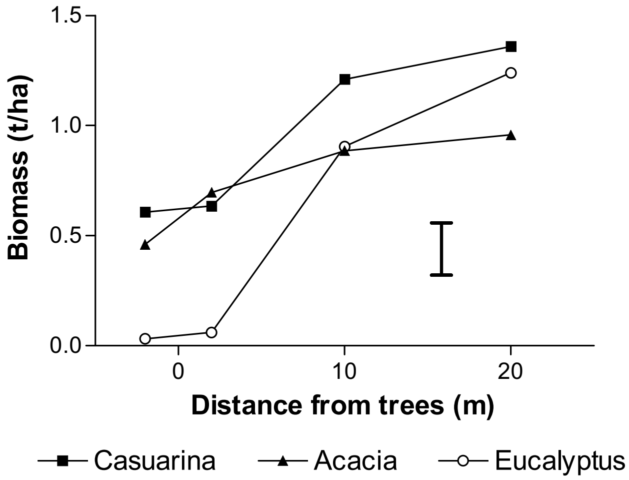

Figure 3 Pasture biomass at distance from three tree species, August 2002

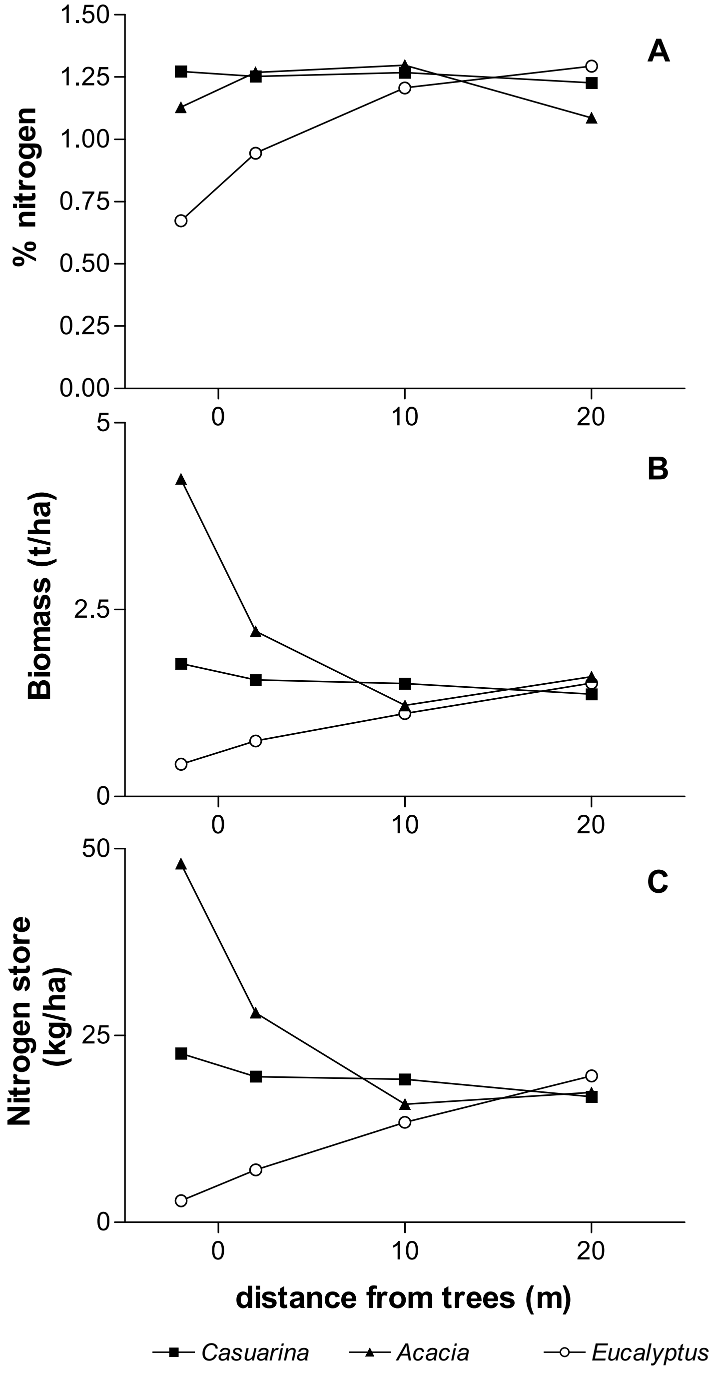

Figure 4 Nitrogen content, total biomass and total nitrogen stored in above ground biomass at distance from three tree species, March 2002.

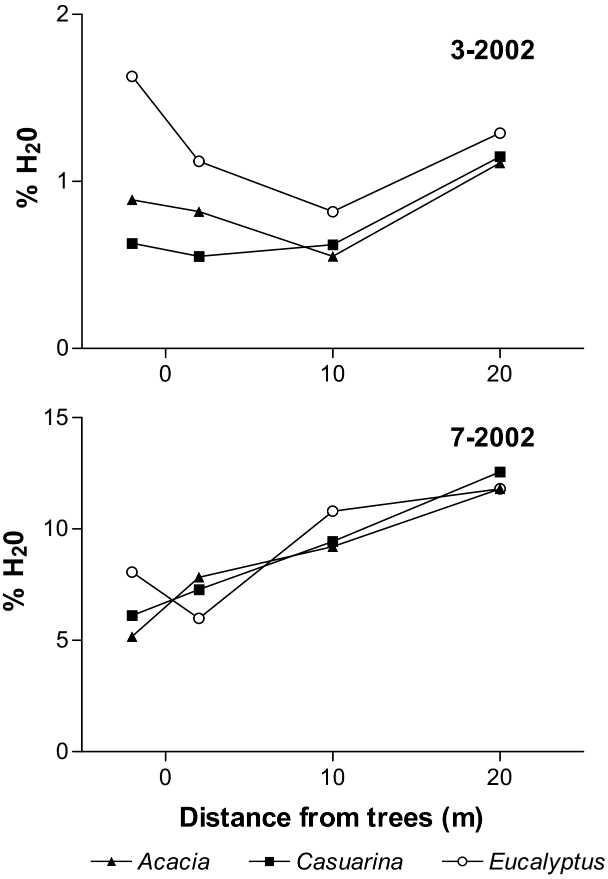

Figure 5 Summer and winter soil moisture content over soil depths of 0-0.1 m, at various distances from three tree species

DISCUSSION

All the species in this study competed with pasture for resources, the result of which was reduced pasture production under and adjacent to the trees. Introducing E. occidentalis into the farming system (7 m tree belts and 50 m alleys) generated a 40% reduction in pasture production. In contrast, the introduction of A. saliga or C. obesa or into a similar farming system resulted in only a 14 and 22% reduction in pasture production. For the economic cost of reduced pasture growth to be offset, an E. occidentalis alley-farming system would need to produce significantly more non pasture related revenue than an equivalent A. saligna or C. obesa system. C. obsea and E. occidentalis could, if managed, produce high value wood products. The forage value of A. saligna and the nitrogen it fixes would offset the pasture production cost of this species.

While this study has shown that more pasture can be produced under 7 year old A. saligna and C.obesa than under E. occidentalis, it has not determined why this situation exists. Trees and pastures compete for limited resources (light, water and nutrients) and the competitiveness of each species (for each resource) must be different. Southern Western Australia has a Mediterranean climate and is water limited during all but a few winter months. In this environment, studies have shown that water is the main resource that limits crop and pasture growth under and adjacent to trees. The pasture results may therefore be due to E. occidentalis drying out the soil to a greater extent, or for a longer part of the year, than the two other species studied. In contrast C. obesa is slower growing compared to the other species and may not currently reduce soil moisture to the same extent as the other two species. Because most alley farming systems in Western Australian have been established for groundwater recharge and water table control, the capacity of each species to allow pasture growth needs to be balanced with the species ability to manage recharge and watertables.

The management of the A. saligna at the study site and its phenological characteristics may provide a favourable moisture environment for winter pasture growth while also providing groundwater recharge control. A. saligna maintained a dense canopy during spring through to mid summer 2001-2002, which would dry the soil and buffer against groundwater recharge. During late summer and through autumn the trees shed numerous leaves, forming a considerable mulch under and adjacent to the trees. Water use is related to leaf area index (reference) and the reduction in A. saligna's leaf area in autumn may reduce tree water use and allow more moisture to accumulate in the soil. After the first germination of annual pasture the site is managed on a rotational grazing basis (Whites, pers comm), during the first grazing in autumn the lower leaves of A. saligna are removed by the sheep. This further reduction in A. saligna's leaf area in autumn may also allow additional moisture to accumulate in the soil. The considerable mulch layer under these trees would influence the soil water balance (Wallace 1996) and could result in a net soil moisture gain, dependent on the relative effects it has on evaporation and infiltration. The mulch may also provide a favourable germination environment for pasture species.

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