THE INFLUENCE OF ALLEY FARMING AND INTERCROPPING ON THE YIELD OF LUPINS

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Summary. Wide spaced rows of the forage shrubs *Acacia saligna* and tagasaste (*Chamaecytisus proliferus*) had a strongly directional influence on the yield of lupins (*Lupinus angustifolius* variety Gunguru) in the 1993 growing season with yield reduction being greater on the eastern side of north-south tree rows than on the western side. The yield of lupins was not significantly reduced by the presence of an understorey of the perennial summer active grass *Chloris gayana* variety Katamboora (rhodes grass) when compared to lupins grown in monoculture. While only one season's data is presented, it has implications for the integration of woody and herbaceous perennial plants into cropping systems given the current interest in developing high water use farming systems.

INTRODUCTION

Rising water tables and subsequent waterlogging and dryland salinity are major off-site effects of grain production on sandplain soils in Western Australia. Current agronomic practice is inadequate for soil water management as recharge is strongly influenced by large infrequent rainfall events outside the growing season, limiting the effectiveness of high water use cropping systems alone. Even optimal agronomic practices will not prevent water movement past the root zone of annuals (7). Wind erosion is a major on-site effect of grain production on sandplain soils. Despite improvements in stubble retention, current practice involves escaping rather than planning to avoid major wind erosion events.

These two side effects of current practice have suggested the need to incorporate deep rooted perennial species into sandplain farming systems. Alley farming, where crops are grown between widely spaced rows of trees or shrubs, presents a means of potentially increasing water use and protecting against wind erosion and this approach has been adopted by some farmers in WA (5). Increases in the yield of crops and pastures due to the shelter effects of windbreaks have been cited by several authors (1, 2, 3, 4) and this has been suggested as an additional benefit of broad-acre alley farming systems (5, 6).

As trees can have negative as well as positive effects on crop yield, it is necessary to quantify their net effect in order to fully evaluate the potential of alley farming. This paper describes the measurement of the yield of lupins grown in monoculture and intercropped with a winter dormant perennial grass in a commercial alley farming paddock. The potential positive and negative interactions between trees and crops in alley farming are then summarised in the form of a simple equation.

MATERIALS AND METHODS

The site was in a 40 ha alley farmed paddock on deep sand over gravel soil at Dowerin, 150 kilometres north-east of Perth. The forage shrubs *Acacia saligna* and tagasaste (*Chamaecytisus proliferus*) had been planted in 1989 in alternating three row belts orientated north south and spaced 30 m apart. In 1990, two alleys (3.6 ha) were sown to rhodes grass (*Chloris gayana* variety Katamboora). This spread rapidly by runners during spring and summer of 1991/92 following a poor initial establishment. The paddock remained in pasture until 1993 when a lupin crop was sown in the first week of May. Part of the rhodes grass area was burnt to reduce biomass prior to seeding. The crop was sown with a double-disc seeder using standard rates of knockdown and pre-emergent herbicides.

In November 1993, nine 20x30 m plots of lupins were harvested in the alleys being three replicates of three treatments; lupins in monoculture, lupins intercropped with rhodes grass without fire pre-seeding and lupins intercropped with rhodes grass with fire pre-seeding. Plots were harvested in strips parallel to the shrub rows with a 1.5 m wide plot harvester to produce continuous yield transects across the alleys. One open paddock plot away from the influence of the trees was also harvested. Following harvest, measurements were made of understorey edible dry matter (EDM) in the intercropped plots by removing all edible material within a 50x150 cm quadrant at six locations within each plot and sorting into crop residue, rhodes grass and annual understorey species.

RESULTS

Intercropping

Lupin yields were unaffected by the presence of a rhodes grass understorey in the 1993 season (Table 1). The yield of rhodes grass however was significantly reduced when fire was used to reduce grass biomass pre-seeding.

Table 1. Mean grain yield of lupins with and without rhodes grass intercrop and mean rhodes grass intercrop EDM with and without fire pre-seeding (t/ha).

Treatment	Lupin grain yield[a]	Rhodes grass EDM[a]
1. Lupin monoculture	1.36	
2. Lupins + rhodes grass	1.39	2.10
3. Lupins + rhodes grass + fire	1.35	0.36

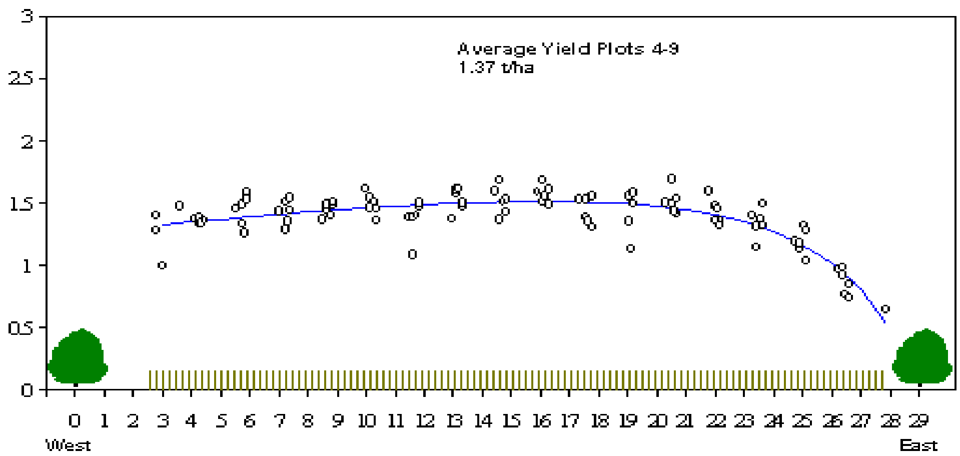
[a]lupin yields not significantly different; grass yields significantly different at $P \leq 0.05$

Alley farming

There was a strong directional trend in the influence of the trees on lupin yield as shown in Fig. 1 in which all the data points from treatments 1 and 3 have been grouped. Lupin yield was markedly lower in the eastern lee of trees than in the western lee. Half the data points in Fig. 1 are from plots that had tagasaste on the western side and acacia on the east and half from plots with the reverse. The net effect of the trees on lupin production at the paddock scale is shown in Fig. 2. While the open paddock yield in Fig. 2 cannot strictly be considered a control as different herbicide rates had been used in the alley farmed and open areas, it is shown to illustrate the principle that trade-offs are involved in alley farming.

DISCUSSION

It is likely that the high degree of compatibility between the lupins and the rhodes grass in the intercropped treatments was due to the atypically mild spring experienced in 1993, with late rain and a low incidence of hot dry easterly winds. This result suggests that the concept of intercropping is worth exploring through field experiments and modelling studies to indicate the likely frequency of such benefits. This could involve intercropping grain legumes with winter dormant perennial grasses or cereals with winter dormant perennial legumes as was sucessfully trialed in the WA wheatbelt in the 1940's (C. A. Parker, pers. commun.). In both cases, prevention of recharge from episodic events outside the wintergrowing season and the supply of out of season feed would be significant advantages.



Distance (metres)

Figure 1. The influence of trees on the yield of lupins across a 30 m alley (6 reps).

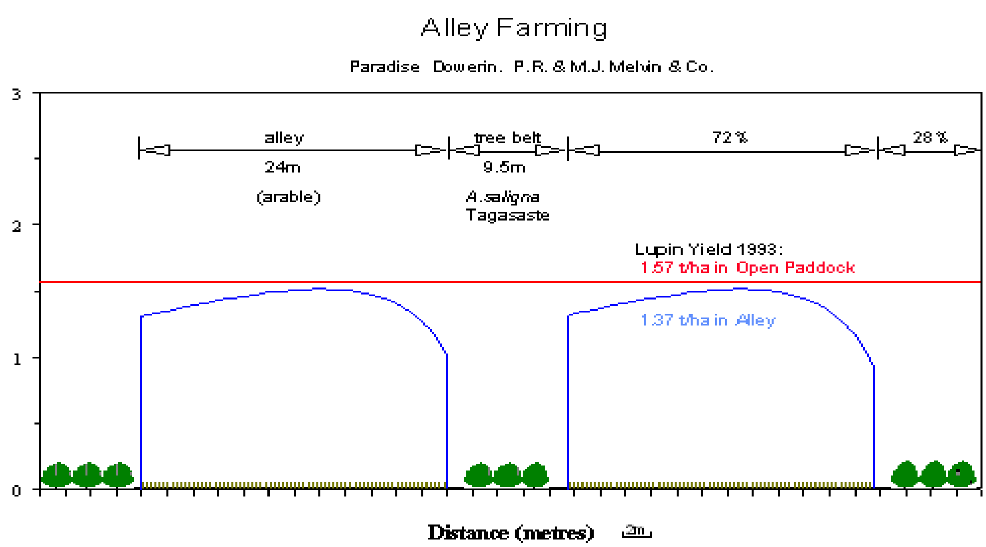


Figure 2. The influence of one alley farming design on lupin yield at the paddock scale.

The strongly directional trend in the effect of the trees on lupin yield was most likely due to frost damage. Frost damage was apparent in this and neighbouring lupin crops and it is possible that the trees restricted air movement across this paddock and exaggerated this effect, particularly in the eastern lee of the tree rows where temperatures would have remained low for a longer period after sunrise. The fact that this occurred in the eastern lee of both tagasaste and acacia rows suggests that this directional effect was not species dependent.

The yield depression in the alley illustrates the potentially negative effects of trees on crop yield and the need for long-term studies that cover a wide range of seasonal conditions. A study in Nebraska reported that over six consecutive years of measurement, shelter effects on wheat yield varied from a 100% increase to a 40% decrease, with an average net effect of +15% (2).

Even though this study lacked a satisfactory control, it is possible to derive from Fig. 2 a simple break even equation to illustrate the principles involved in the net commercial effect of alley farming. This can be expressed as $[Y_1 - Y_2] + T + L \geq D$, where Y_1 is the yield increase due to the trees, Y_2 the yield decrease due to the trees, T the net commercial value of the trees, L the long-term environmental benefits of the trees and D the value of the crop displaced by the trees. This equation emphasises the fact that the opportunity cost of the crop displaced by the trees (D) needs to be compensated by some combination of net yield benefit, the commercial value of the trees and their long-term environmental benefits. Assuming the open paddock yield in Fig. 2 did represent the control yield, the value of the trees as fodder and/or their long-term benefits would have to make up for a 63% decrease in harvested grain due to land taken up by the trees plus the yield decrease in the alleys, a net loss of $58/ha. For the trees to compensate in the short-term, tree fodder at the measured EDM yield of 2t/ha from the 11 ha of non-arable land would have to be worth $105/t net, some three times the cost of equivalent feed value from alternative sources.

This study highlights several factors critical to decisions about integrating trees into cropping systems. Firstly that trees can have negative effects on crop yield through competition and microclimatic influence and that measurements and modelling need to involve long time periods to reflect a wide range of seasonal conditions. Secondly that the design of alley farming systems has a big influence on profitability through the opportunity cost of the crop displaced. Thirdly it illustrates the importance of having reliable open paddock controls in the evaluation of such agroforestry systems.

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