Soil moisture and canola yield in an alley farming system

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ABSTRACT

Belts of *Acacia* and *Atriplex* spp. planted between narrow (45 m) and wide (90 m) spaced alleys, were used to estimate the impact of alley farming on water use and crop production in a dryland farming system in the central Victorian Mallee, Australia. Soil water content and crop yield were measured at a range of locations and distances from the belts. In 1999, three years after establishing the belts, soil water content between 2.5-5.5 m down the soil profile was significantly less under the shrub belt and out to 2 m from the edge of the shrub belt compared to under the adjoining annual cropping regime. The deep profile drying corresponded to significant canola yield reductions up to 4.5 m from the edge of the belt. The study is continuing with a focus on the impact of moisture competition from the belt and its potential shelter benefit on crop yields, over a number of seasons.

KEY WORDS

Alley farming, shrub belts, soil water, crop yields

INTRODUCTION

Deep drainage of water past the root zone of annual crops is causing rising saline water tables and increased salt loads in the Murray Darling Basin. It is estimated that by 2050 over 50% of the River Murray salinity increase will arise from the cleared dryland region of the Mallee zone of South Australia and Victoria (5). Since clearing of native vegetation, recharge rates are estimated to have increased from <0.1 mm year^{-1} under native eucalypts to 5-30mm year^{-1} under dryland cropping systems in the low rainfall area of the Murray Darling Basin (1, 6). Current agronomic practices based on shallow-rooted annual crops and pastures are inadequate for soil water management as recharge is strongly influenced by large infrequent rainfall events outside the growing season. This limits the effectiveness of high water use annual cropping systems alone (4). Alley farming, where crops are grown between widely spaced rows of deep rooted perennial trees or shrubs, offers a potential means of increasing water use, while providing fodder for livestock and wind protection for crops (4).

The aim of this research, supported by the Murray Darling Basin Commission, was to examine the potential for alley farming systems to reduce recharge under dryland farming systems. This paper describes soil water content and canola yield in a wide (90 m) and narrow (45 m) spaced *Atriplex* and *Acacia* alley farm.

MATERIALS AND METHODS

The experimental site was established in June 1996 at Walpeup (34^{o}12'S, 142^{o}20'E, 336 mm average annual rainfall) in the Central Victorian Mallee, Australia. The site is typical of a Central Mallee Land System dominated by east-west tending sand dunes separated by broad flat sandy loam swales. The 40 ha site was split into three 13.3 ha treatments with wide cropping alleys (90 m apart) and narrow cropping alleys (45 m apart) and two controls isolated from the impact of belt. About 12 000 trees/shrubs were planted into 10 m wide belts arranged in a curved layout N-S orientation, to provide a partial contour and off set damaging winds from the west (figure 1). The 10 m wide belts consisted of *Atriplex numularia* (Oldman saltbush), *Acacia saligna* (Golden wreath wattle), and *Atriplex amnicola* (River saltbush). Since establishment the paddock has been continuously cropped in winter with lupins (1996), triticale (1997), barley (1998) and canola (1999). Since 1998 sheep have grazed the belts and stubbles for approximately 1-2 months each summer and autumn.

In October 1996 six replicate transects of neutron moisture meter (NMM) access tubes were installed to a depth of 5.5 m, three in each of the alley treatments. Tubes were placed at 0, 5, 7, 10, 15 and 25 m from the centre of the belts. Five tubes were installed in each of the control areas to monitor water use away from the impact of the belts. Soil water was measured at 0.2 m intervals to a depth of 2 m then 0.5 m intervals to a depth of 5.5 m. The NMM was calibrated on-site and readings were taken approximately monthly between October 1996 and February 1999, and four times per year thereafter.

In November 1999, eight 1.4x 30 m plots of canola were direct harvested parallel to the belts at 2, 3.8, 5.6, 7.4, 9.2, 11, 15.8, and 20 m from the edge of the belts. Five plots were harvested in each of the controls.

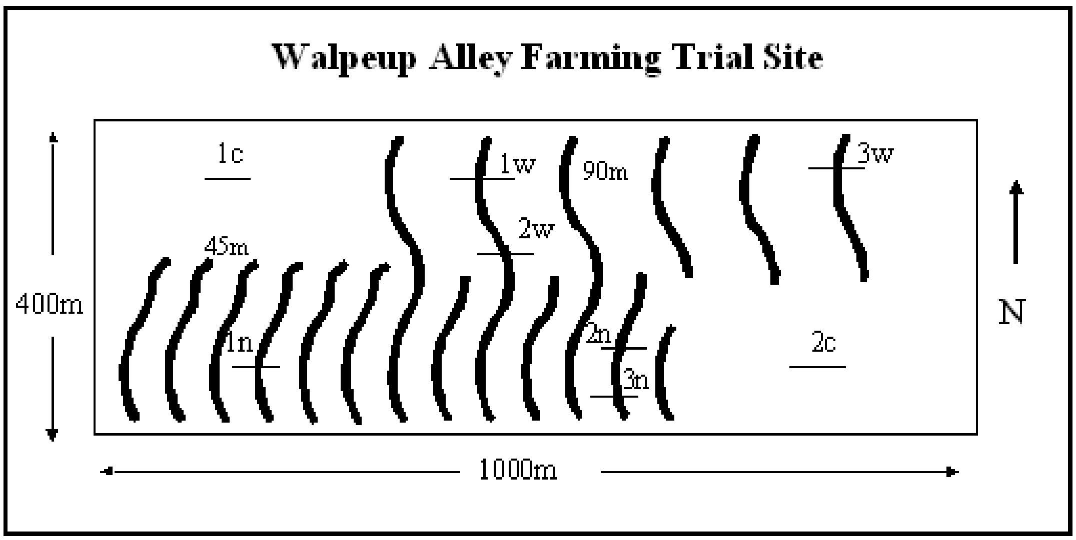


Figure 1. Walpeup alley farm trial layout

RESULTS AND DISCUSSION

Soil water

The pattern of deep (2.5- 5.5 m) soil water content across transects was similar in the wide and narrow alley treatments.

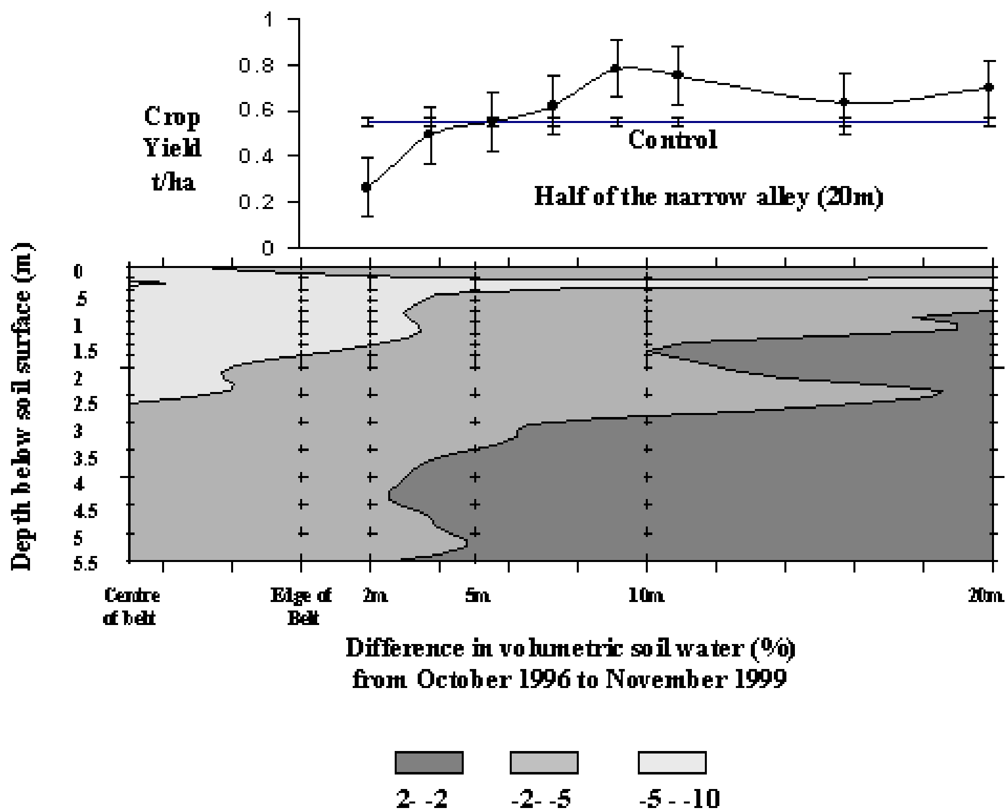
Figure 2 shows zones of drying (light) and of no change (dark) in soil water content beneath the belt and 20 m into the cropping alley, expressed as the difference in volumetric water content from October 1996 to November 1999. Underneath the belts drying was observed through the 5.5 m profile (possibly deeper) extending to 2 m laterally into the adjacent cropped areas. In the centre of the alley, there was little or no change in soil water down the profile, with drying only occurring in the first 2 m. It was assumed that water draining below 2.5 m (i.e. beyond the root-zone of the annual crops) had become 'potential recharge'.

The mean soil water content of the 2.5- 5.5 m zone under the belt decreased by 163 mm, significantly more than under the crop (4mm).

In the 40 months after establishment of the trial, the subsoil moisture in the wide alley system was 16% drier then the control (associated with a loss of arable cropping area of 11 %), and the narrow alley is 31% drier (22% less cropping area).

Figure 2. Change in soil water content over time and the impact of competition on crop yield.

The shaded chart at the bottom of the figure shows the (%) change in volumetric soil water content from October 96 when the belts were planted to November 99 when the belts were well developed.



Crop production

Average canola yield in the control plots was 0.55 t/ha compared to 0.64 t/ha over the arable area in the wide alleys, an increase of 15 %, and 0.59 t/ha in the narrow spaced alleys (an increase of 7 %). Canola yields in the wide alley spacing provided the greatest benefit for the 1999 season; although the belts displaced 11 % of the land, a 4 % overall increase in yield/ha was achieved. Although these differences were not statistically significant they indicate the potential for reductions in land area sown to crop to be offset by increases in grain yield (Table 1).

The influence of the belts on crop yield along transects was not significantly different between narrow and wide treatments.

Table 1. Canola yields in alley farming at Walpeup, 1999, expressed over the arable area in the alleys and as whole paddock yield (including the area occupied by the shrub belts).

	Yield over arable area[a]		Whole paddock yield including shrub belts	
Alley width	Average Yield (t/ha)	% Change	Average Yield	% Change

(% tree cover)			(t/ha)	
90 m (11 %)	0.64	15% increase	0.57	4% increase
45 m (22 %)	0.59	7% increase	0.46	16% decrease
Control (0 %)	0.55	-	0.55	-

[a]L.S.D (<0.05) n.s.

The 1999 cropping season at Walpeup had a dry finish. With sandy soil on the dunes limited moisture was more available to the crop. The majority of alley transects were located on the dune, which could explain some of the yield variation between treatments since the controls were on the heavier soils which had lower yields.

Prior to planting the alley system, the paddock was subject to high levels of wind erosion, which has since been substantially reduced. There is visual evidence on the eastern side of the belts of wind protection for the crop, which may have increased yield.

CONCLUSION

The *Atriplex* spp. and *Acacia* belts reduced soil water deeper in the profile than the annual crops. Drying zones in the alley crop system reflect the different rooting depth and activity periods of the annual crops compared to the perennial shrubs. The annual crops extracted significant quantities of water only in spring from near the soil surface, whereas the shrubs were able to extract water from a greater depth and for the whole year. The belts would also use summer rainfall while the crop land was in fallow. Recharge is therefore less likely to occur below the fodder belts. The decline in crop yield close to the belts reflects competition for moisture and nutrients.

Within three years of planting, the shrubs have used large amounts of soil moisture accumulated under the previous annual cropping/pasture rotations. Subsoil moisture was reduced by 31% for the narrow alleys with a decrease in canola yield of 16%. The wide alleys lowered subsoil water by 16% and had a yield increase of 4%.

The study highlights several factors critical to decisions about integrating belts into cropping systems. While recharge is an important issue to the Murray Darling Basin as a whole, unless rising ground water or wind blown sand damage to crops is directly affecting the farm, farmers will get little direct benefit from investing in an alley farming system. Changing landuse to alley farming requires modifications in behaviour to manage the new system and risks of unforeseen problems. Although it was shown that the area of crop displaced by belts can be recovered by increases in crop yields in the alleys, the cost of establishing the belts makes this system less profitable in the short term. The project is now focussing on quantifying the financial viability of alley farming systems.

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REFERENCES

1. Allison, G.B. and Hughes, 1983. *Journal of Hydrology* **60**, 157-173.

2. Bartel, B. and Knight, A. 2000. In: Oldman Saltbush, Farmers experiences in low rainfall farming systems. (Primary Industries and Resources South Australia)

3. Knight, A. 1999. Proceedings MDBC SI&E Forum. Canberra

4. Lefroy, E.C. and Melvin, D.P.C. 1996. *Proceedings 8th Australian Agronomy Conference*, Toowoomba. p 377-380.

5. Murray Darling Basin Commission. 1999. The Salinity Audit of the Murray Darling Basin. (Canberra) ISBN 1 875209 85 9.

6. O'Connell, M.G., O'Leary, G.J. and Thorne, R. 1996. In: Murray Darling Basin: Natural Resource Management Strategy Program.