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Alley farming: new vision for Western Australian farmland

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Alley farming is a system where crops and pastures are grown in the alleys between rows of trees and shrubs. The concept is new to Western Australia but one that is likely to become more familiar over the next few years. The objective is to use trees and shrubs to decrease the environmental side effects of agriculture, such as erosion and salinity, while increasing farm profit through the direct and indirect value of the trees.

This article describes some examples of alley farming in Western Australia and discusses the challenge of getting the right tree species and layout to maximise the benefits, while minimising competition with crops and pastures for water, nutrients and light.

Origins of alley farming

Alley farming originated in the tropics as a method of reducing erosion on sloping land and preventing decline in soil fertility. In tropical alley farming, nitrogen-fixing shrubs are planted on the contour to control soil erosion and provide mulch from cut branches for the benefit of inter-row crops such as maize and beans. Prunings from the trees are also fed to animals and used as firewood. The alleys are narrow, often only 5 to 10 metres wide, because of the steep slopes and cultivation by hand or draught animals.

In the South-West of Western Australia, similar farming systems have evolved quite independently over the past decade in response to a different set of problems. Responding to salinity, waterlogging, wind erosion, the lack of autumn stock feed and declining terms of trade in agriculture, farmers, foresters and agricultural scientists have been working together to develop solutions that combine trees and shrubs with conventional agricultural crops and pastures.

While the systems have some similarities with tropical alley farming, they differ in several important respects. The most obvious is that the alleys are much wider in order to accommodate machinery. The trees are often planted in straight parallel lines. This is common on sandplain where trees are planted at ninety degrees to the most damaging winds to provide the best protection. On sloping land, following the contour may become a higher priority.

Advantages of farming between trees

Protects the land

It is becoming increasingly obvious that more perennial vegetation is necessary in the agricultural landscape if we are to have any significant impact on salinity, waterlogging, soil erosion, the pollution of waterways and other side-effects of our current farming systems. One approach is to mimic, in a very basic sense, the structure of the original woodland, forest and heath ecosystems of the agricultural areas. This would mean:

• a higher proportion of deep-rooted plants able to draw on water deep in the soil
• a more permanent vegetation that protects the soil surface from erosion throughout the year
• greater diversity of both plant species and forms (such as trees and shrubs), increasing the resilience of our farming systems in the face of a variable and occasionally extreme climate.

Alley farming also means that trees are spread across the landscape rather than being concentrated in a few locations. This improves our chances of controlling large scale processes such as rising water tables, soil erosion and contamination of soil and water. Small blocks of trees alone will not do this.
Current types of alley farming
- Timberbelt alley farming in the high rainfall South-West
- Saline alley farming in the wheatbelt
- Sandplain alley farming on the light soils of the wheatbelt and coastal sandplains
- Mallee alleys for the experimental production of eucalyptus oil in the wheatbelt.

Each type has evolved in response to a different set of environmental problems and commercial opportunities. Because most of these examples are too recent for us to know their full impact on farm profit, and because very little is yet known about the degree of competition between the different trees and crops, the examples described represent prototypes only, not fully developed farming systems. With hindsight, they could probably all be improved using different layouts and better species selection. Despite this, they represent important steps towards farming systems that are highly productive and environmentally friendly.

Economic analysis shows that alley farming is very sensitive to the value of the land taken up by the trees. For instance, tree belts 5 metres wide at intervals of 60 metres take up 8 per cent of land. The value of the trees plus their effect on yield in the alley needs to be greater than 8 per cent of the former net value of production from that paddock for a commercial incentive to mix trees and crops in this way.

Doug French at Goomalling has used wide alleys separated by wattles and eucalypts on his sandplain.

Improves productivity
By mixing plants with different forms (such as deep and shallow root systems) and those whose main growth periods are at different times of the year, water and nutrients that are presently unused can be converted into extra plant and animal products. The mixture needs care, however, as there is a fine line between plants complementing and competing with each other. The challenge is to find mixtures that complement the production of wheat, wool, meat and other commodities fundamental to Western Australian agriculture.

Adds income
Adding trees and shrubs to our farming systems can bring commercial benefits in two ways. The first is a direct contribution where there is a new product from that land such as timber or fodder. The other commercial benefit is through a positive influence, where the physical presence of trees and shrubs results in increased yield of crops, pastures or animals. This positive influence on agricultural production can occur above the ground by sheltering plants and animals from weather extremes, and below the ground by improving the soil conditions for plant growth through lowering watertables and reducing waterlogging.

The commercial principle of alley farming is that the net value of the tree products, plus the net effect of the trees on agricultural yield in the alley, must be equal to or greater than the value of the crop or pasture that has been displaced by the trees.

$ TREES +$ YIELD ↑ - YIELD ↓ ≥ $ CROP DISPLACEMENT
Agroforestry is a general term for any combination of agriculture and tree production on the same land. Alley farming is one form of agroforestry. Other forms include farm plantations or blocks of trees, and wide-spaced (parkland) plantings of trees mixed with pasture.

The distinction between alley farming and other forms of agroforestry is the presence of the discrete alley, wide enough to allow conventional farming between the trees. This is important because it means that flexibility of land use is maintained. This flexibility to change crops or to move from crop to pasture in response to variations in commodity prices and seasonal condition has been a vital factor in the efficiency of agriculture in southern Australia.
Timberbelt alley farming

The first form of alley farming in Western Australia was developed from agroforestry experiments with wide-spaced trees (parkland) established in the late 1970s. This allows simultaneous production of high value trees and pasture. It has been used for centuries in southern Spain and Portugal for cork production and grazing, and more recently in New Zealand for timber and sheep production.

A disadvantage of this design is the long period from planting until the trees can withstand grazing. This means little or no income from the land for four or five years. Richard Moore, Department of Conservation and Land Management forester, saw the alley farming layout as a solution to this problem as it would allow income from cropping or hay production between the tree rows during those early years. In 1981, he planted an experimental area of pines (Pinus radiata), Sydney bluegum (Eucalyptus saligna) and powderbark wandoo (E. accedens) in four-row belts separated by 20 metre alleys near Darkan in the Collie River catchment. The tree rows were planted parallel and oriented north-south to minimise shading of the pasture.

The Land Equivalent Ratio

This is a means of determining if there is any advantage in growing plants in mixtures rather than monocultures. To calculate the Land Equivalent Ratio, divide the yield of each crop in the mixture by its yield in monoculture in the same environment and add these fractions.

The example below uses measurements from the Jenkins' timber alley farming taken at year six in a ten-year tree rotation:

\[
\frac{\text{Yield of trees in alley farming}}{\text{Yield of trees in plantation}} + \frac{\text{Yield of pasture in alley farming}}{\text{Yield of pasture in monoculture}} = \text{Land Equivalent Ratio}
\]

- Yield of trees in alley farming: 92 cubic metres/hectare
- Yield of trees in plantation: 118 cubic metres/hectare
- Yield of pasture in alley farming: 6.5 ewes/hectare/year (mean over 6 years)
- Yield of pasture in monoculture: 12.5 ewes/hectare/year
- Land Equivalent Ratio: \( \frac{92}{118} + \frac{6.5}{12.5} = 1.30 \)

The amount by which this ratio exceeds 1 indicates the percentage increase in land area necessary to produce the same amount in separate monocultures. In this case, it would take 30 per cent more land to grow the same amount of timber and pasture separately in monocultures.

When the ratio is greater than 1, it indicates that there is more efficient use of resources (light, water and nutrients) in the mixture, either because the crops are using different resources or drawing on the same resources at different times. This can occur if the plants have different structures (such as height and rooting depth), different growing seasons or different resource needs (such as legumes and non-legumes). In this case, it is due to the compatibility of the tall, deep-rooted summer-active eucalypts and the shallow-rooted, winter-active annual pastures in an environment with abundant water at depth.
Saline alley farming

Saline alley farming began with attempts to use trees as water pumps to lower saline water tables. The best documented example is at the Boundain property of Graeme Wilson, near Narrogin. This site receives about 500 mm of annual rainfall, and is one of several plantings of this type. Department of Agriculture researcher Ric Engel and adviser Tim Negus designed the planting at this site in 1981 to test the effectiveness of this simple concept. At the time, there was considerable scepticism that trees would even survive on these salt flats, let alone control water tables. These water tables were 1 to 3 metres below ground, with water quality of 500 to 3,000 milli-Siemens per metre, or between 10 and 60 per cent of the salinity of seawater. The experiment involved planting different species of salt-tolerant trees, the swamp oak (Casuarina obesa), flat-topped yate (Eucalyptus occidentalis), salt river gum (E. sargentii), York gum (E. loxophleba), Kondinin blackbutt (E. kondininensis), red river gum (E. camaldulensis), and the swamp mallet (E. spathulata). The trees were planted 5 metres apart in single rows at 25 and 12.5 metre alley widths. These two widths gave tree densities of 80 and 160 stems per hectare respectively.

Wettable monitoring bores placed in the alley farmed areas and an adjacent area without trees showed that watertable drawdown in the alleys began in the fourth year after planting. The rate was similar at both the low and high tree densities. Subterranean clover was successfully re-established in 1986 following leaching of salts from the soil surface, after the groundwater began to recede. After that however, the story was not so encouraging. The trees, particularly the flat-topped yate, competed so strongly that after a few years there was very little pasture in the alleys. Pruning the tree roots did result in doubling pasture production in the following season but it was still very low. Tree roots also made cultivation for cropping very difficult. The trees have fulfilled their role in terms of water use, but may have left the land with little commercial potential.

There are several possible solutions to this dilemma. One is to prune the tree roots from an early age by ripping. Another is to reduce competition by widening the alleys. Experiments are underway to determine which tree species are least competitive with pasture and the optimum tree spacing to give groundwater control and allow maximum pasture production. Changing the pasture species beneath the trees and using trees with direct commercial value would also help to make this system more profitable.
A combination of these improvements should result in systems of saline alley farming that are profitable as well as environmentally effective. Whether trees can lower groundwater on saline flats in all cases is also uncertain. This sort of treatment is only likely to be effective where there is little lateral movement of groundwater into an area, groundwater salinities are not too high and a sufficient area is planted to trees.

In ecological terms, saline alley farming involves mimicking the native salt-tolerant eucalypt woodlands and saltbush flats typically found in the valley floors of the wheatbelt. Several thousand hectares have been planted in the last few years on cropping land threatened by rising water tables in the wheatbelt.

**Sandplain alley farming**

The term alley farming was first used widely in Western Australia to describe the approach that Dowerin farmers, Dean, Sherren and Craig Melvin, developed in an attempt to eliminate wind erosion and increase returns on some of their poorer sandplain country. In 1989, the Melvins brought together the results of two separate pieces of research when they began planting widely spaced rows of fodder shrubs across some of their worst sandplain.

The first research was the work of Chris Oldham and his colleagues at the University of Western Australia who were assessing the value of the leguminous shrub tagasaste as a browse plant for sheep and cattle. They had shown that tagasaste could increase the carrying capacity of poor Badgingarra sandplain by a factor of six, from just over one, to eight dry sheep equivalents per hectare. Cattle grazing the same tagasaste plantations produced about 300 kg of liveweight per hectare per year.

The Melvins also drew on a windbreak study by Department of Agriculture adviser David Bicknell. On Gary and Jan English's farm at Esperance in 1988 and 1989, David recorded an increase in the yield of lupins and oats in the lee of a pine windbreak. That included allowing for the land taken up by the trees and the area of depressed yield caused by competition within one to two tree heights of the windbreak.

Influenced by these two experiences, the Melvins developed their alley farming system. They planted two to three rows of various fodder shrubs in north-south belts, initially with 30 metre wide alleys but more recently with alleys twice that width. The north-south orientation was to give protection against the most damaging winds, north-westerlies, south-westerlies and easterlies.

A neighbouring farmer, John Thomas, has used a spiral design to control wind erosion, increase feed supply and make cultivation easier in an irregularly shaped paddock. The alley width in both cases is based on multiples of the widest implement.

These paddocks, which normally could not produce a profitable wheat crop, have seen a marked increase in productivity. The Melvins have tripled sheep-carrying capacity while greatly reducing the erosion risk associated with autumn grazing. With this layout, they have also maintained the option to crop. This means a greatly reduced erosion risk with early lupin sowing and reduced spray drift, which in turn enables more timely crop spraying. A long-term benefit is likely to be a reduction in recharge and therefore in waterlogging and salinity down the slope.
Where cropping is the major land use, wider alleys would be preferable. This is because the benefits of shelter, such as reduced physical damage and drought stress, will probably outweigh competition effects only at wider spacings, and may only show in some seasons. The less direct benefits of trees, reduced topsoil loss and reduced recharge, are likely to take some years to appear. The key questions are whether these benefits to crops outweigh the competitive effects of the trees in the majority of seasons.

This form of alley farming represents a rough mimic of the heath and mallee vegetation that grew on these sandplain soils prior to clearing.

Mallee alleys
This new form of alley farming is being tried by some wheatbelt farmers in conjunction with the Department of Conservation and Land Management and the Department of Agriculture. The aim is to test the feasibility of combining wide-spaced rows of mallee trees for eucalyptus oil production with conventional crops and pastures. It is hoped that by spreading the trees across the landscape they will achieve faster and more uniform production and have a wider influence on water table lowering and wind and water erosion control than dense plantations. Beneficial shelter effects on the crops and pastures in the alleys are also possible.

The viability of eucalyptus oil is uncertain at this stage, but it may offer another incentive for putting more deep-rooted perennial plants into the wheatbelt landscape and a new source of income for the region. To assess oil yields and the practicality of this approach, a range of mallee species have been planted in various alley layouts at more than 30 sites from Morawa to Esperance.

Illustration of how agriculture can mimic the original native ecosystem by including deep-rooted perennial plants. These complement the shallow-rooted annual crops and pastures.

<table>
<thead>
<tr>
<th>Sandplain heath</th>
<th>Annual crops and pastures</th>
<th>Alley farming system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover: Permanent</td>
<td>Cover: Temporary</td>
<td>Cover: Permanent</td>
</tr>
<tr>
<td>Water use: Internal redistribution</td>
<td>Water use: Less than rainfall</td>
<td>Water use: Internal redistribution</td>
</tr>
<tr>
<td>Root depth: 10+ metres</td>
<td>Root depth: ≤ 2 metres</td>
<td>Root depth: 10+ metres</td>
</tr>
</tbody>
</table>
Further reading


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Alley farming has the potential to provide many environmental and commercial benefits. Just how attractive it proves to be will depend on how the following costs and benefits balance out:

- environmental benefits, such as water table control, soil erosion prevention, soil structural improvement, nutrient cycling and improved nature conservation values
- value of crop and pasture displaced by the trees and lost through competition with them
- more intensive management required
- gains in crop, pasture and animal productivity due to the influence of trees on micro-climate and soil conditions
- commercial value of the trees themselves.

While the costs are immediate, the benefits tend to be medium to long-term. For a strong commercial incentive, the value of the crop or pasture displaced by the trees and lost through competition with them needs to be compensated by tangible short-term returns. With tagasaste on the sandplain and timber species in the high rainfall areas, such incentive exists. However the high level of interest in alley farming outside these areas indicates that short-term commercial incentive is not the only driving force. The task ahead is to measure the net benefits to the environment and to farm profit of different combinations of trees, shrubs, crops and pastures. This is particularly necessary on the better cropping country.

If alley farming does find wider application, it will represent a significant step towards ensuring the persistence of agriculture in this environment.

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