Windbreaks may provide an effective way to incorporate trees into farming land, bringing both environmental and economic benefits, according to new research.

Wind erosion, waterlogging and dryland salinity are major causes of land degradation which may be reduced by planting tree windbreaks.

In preliminary trials researchers investigated wheat and oat yields around east-west and north-south oriented tree windbreaks in Victoria during one cropping season.

These studies found large yield gains in wheat crops of up to 25 per cent and oat crops of up to 47% grown in sheltered sides of windbreaks. The results provided the incentive for Rural Industries, Land and Water Resources and Forest and Wood Products Research and Development Corporation’s Joint Venture Agroforestry Programme (JVAP) to establish the National Windbreaks Programme (NWP).

The NWP was initiated to determine if these large gains in productivity were consistent and widespread. Over five years and at sites in Western Australia, South Australia, Queensland and Victoria, the programme performed extensive studies of windbreak effects on crop yields in wheat, barley, lupins, faba beans, canola, maize, potatoes and peanuts.

The NWP involved CSIRO researchers and scientists from State agricultural departments in Queensland, WA, Victoria and University of Adelaide, SA.

CSIRO research has shown windbreaks can help lift crop and pasture yields in some areas. Windbreaks lower the incidence of direct damage to crops by protecting them from wind erosion or reducing wind erosion in sandy soils.

**Crop yield response**

Compared with the large yield gains observed in earlier studies, four years of measurements of plant production and yield at sites across Australia showed the shelter impacts on plant growth and harvest yields were small. Two areas of crop and pasture response were found; a zone of reduced yields due to competition with the windbreak trees extending from 1–3 windbreak heights away from the windbreak and an area of unchanged or slightly increased yield stretching downwind from the competition zone out to about 20 windbreak heights (see Table 1).

High value crops such as potatoes and peanuts on Queensland’s Atherton Tableland benefit from windbreak protection as do lupin crops grown in sandy soils around Esperance, WA. The results show windbreaks do not reduce overall paddock yields and on many occasions the slight gains can offset the costs of establishing windbreaks.

**Microclimate and wind damage**

Windbreaks affect crop growth because they reduce the strength of the wind which lowers the likelihood of direct damage to the plant, through leaf tearing and stripping, plant lodging and sandblasting.

The calmer conditions on the sheltered side of a windbreak can also lead to a warmer and more humid microclimate for the growing crop.

Under conditions of very dry air, shelter from wind can also reduce the stress on the

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<td>Esperance, WA</td>
<td>Lupins</td>
<td>Yield gain</td>
<td>Canola</td>
<td>Slight yield gain</td>
<td>Barley</td>
<td>No yield response</td>
<td>Lupins</td>
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<td>Roseworthy, SA</td>
<td>Wheat, faba beans, canola</td>
<td>No yield increase due to shelter</td>
<td>Oats, faba beans</td>
<td>No yield increase due to shelter</td>
<td>Wheat More biomass but no yield response</td>
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<td>Rutherglen, Victoria</td>
<td>Confounded by soil variability — site abandoned</td>
<td>Wheat More biomass but no yield response</td>
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<td>Hamilton, Victoria</td>
<td>Grazed perennial pasture</td>
<td>Perennial pasture</td>
<td>Slight increase in dry matter production</td>
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<td>Hermitage Research Station, Warwick, Queensland</td>
<td>No response in dry matter production</td>
<td>Irrigated wheat</td>
<td>No yield response</td>
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<td>Atherton, Queensland</td>
<td>Maize. No yield response</td>
<td>Potatoes. Yield response</td>
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**in brief**

- The Joint Venture Agroforestry Programme’s National Windbreaks Programme research shows windbreaks can reduce the incidence of direct damage to crops by protecting high value crops from damage or reducing wind erosion in sandy soils.
- Crops and pastures grown in the lee of tree windbreaks grow larger and leafier, use less water and show improved yields as a result of shelter from the wind.
- Windbreaks may boost available soil moisture and reduce plant stress by shading and sheltering crops and pastures.

**Source:** CSIRO Land and Water.
FARMING FOR THE FUTURE

Shelter benefits...

growing plant (see Figure 1). As a result, plants will either increase their yield but use no more water or produce the same yield as if they were unsheltered but using less water. Shelter will only benefit productivity if it affects a factor that currently limits growth and productivity. For example, in the pasture growing areas of Victoria or the NSW Tablelands, consistent shelter in the cooler winter months could enhance pasture growth. Similarly, yield gains could result from reduced evaporation where the probability of dry times at flowering and grain filling is high. This includes the Darling Downs, Queensland and cereal growing areas of SA.

Water availability is probably one of the most important limits to plant growth in Australian agriculture but unfortunately shelter from wind does not always mean reduced evaporation so windbreaks cannot be relied on to improve yields by reducing this limiting factor.

Using a windbreak may reduce the factors limiting productivity and improve yields.

Crop type and climate

A computer model which simulates wheat and maize growth and final yields, developed by the Agricultural Production Systems Research Unit, Toowoomba, Queensland, was adapted to predict the effects of wind shelter on wheat and maize yields. Computer simulations at selected sites across Australia’s cereal growing areas show yield responses to shelter are always positive but are often small.

For a few sites where wind directions were available, these small yield gains became negligible when the variability of wind direction was included. This suggests windbreaks need to provide protection from winds blowing from several directions to maximise productivity gains. These simulations also showed crops such as wheat grown at Dalby, Queensland, and Minnipa, SA, which are characterised by consistent wind direction, very dry air and low soil water storage later during the growing season would be the most responsive to shelter.

These conclusions echo the results from the field and artificial windbreak sites in the NWP. Crops responded differently to shelter in the trials. There was no evidence of a significant shelter benefit in pasture, maize, wheat or barley.

Lupins, canola, mungbeans and faba beans showed larger yield responses, although with lupins this was more a response to reduced wind damage than shade. Yield gains were reported for lupin and canola crops grown at the Esperance, WA, field windbreak site and the irrigated mungbeans at the artificial shelter site at Hermitage Research Station, Queensland.

A high value horticultural crop such as potatoes was found to be sensitive to damage so the protection offered by shelter gave a large economic advantage even when potatoes were grown in rotation with cereals. The NWP trials also showed enhanced yields were more likely in dry years, especially with the risk of severe wind damage.

Wind protection

An extensive survey of windbreak sites in WA showed grain yields in sheltered crops increased with decreasing rainfall and found little yield response to shelter in years with

Windbreak design critical for optimising shelter

Careful windbreak planning and design is critical to maximise the productivity gains of establishing sheltered paddock areas.

The National Windbreak Programme project results have important implications for designing and managing windbreaks.

Choosing the right location

Orientation — Shelter amount and distance are highest when winds blow at an angle between perpendicular and 45 degrees to the windbreak. It is important to consider if a windbreak along one edge of the paddock will provide the best shelter in terms of distance and frequency. Windbreaks may need to be placed on more than one of the paddock boundaries to form a grid pattern.

Landscape — It is also important to consider the effects of topography on wind and shelter. Surrounding land cover such as scattered trees and other windbreaks may provide regional shelter benefits.

Optimum windbreak design

Windbreak height and porosity are the main factors affecting the amount of wind shelter. The amount of wind shelter and consequent changes in temperature and humidity are proportional to windbreak porosity or density. This means dense windbreaks will have a larger effect than porous windbreaks.

Careful selection of tree species is critical. To yield a large sheltered area choose fast growing tree species. Choose low level branching, bush habit for the outer row. Casuarina and pine species are good for intercepting off-target spray drift. Deciduous trees can reduce shading during winter.

A windbreak with a porosity of 10–70% can reduce wind speed which can significantly reduce wind erosion.

A dense windbreak is not necessary for wind shelter, but a highly porous windbreak is less useful for modifying temperature and humidity.

A very dense windbreak can be created to achieve large reduction in wind and it will not compromise the sheltered area.

A uniform porosity (length and height) is critical to protect soils, plants and animals.

Windbreak layout

A short windbreak with a length which is less than 20 windbreak heights can lead to erosion of the sheltered zone. As a general rule, a windbreak spacing of 10 windbreak heights will have microclimate benefits while a spacing of 20 windbreak heights will provide damage protection.

Another way to maximise windbreak height is to place the windbreak on a mound or ridge.

A windbreak grid can give shelter from all wind directions but increases crop and tree interaction and as a result limits competition.

Maintaining windbreaks

Reduce gaps by planting multiple rows and always replace dead trees. Use a range of species with different growth rates for multi-row windbreaks.

Limit stock access to the windbreak to prevent browsing of the lower branches.

Competition can be minimised by root pruning and using the zone for other purposes such as an access track.

Source: CSIRO Land and Water.

FIGURE 1 Windbreaks may reduce evaporation and increase soil moisture

-2 to + 2 windbreak height.
• Competition for light, water and nutrients.
• Risk of plant damage and soil erosion.

Bleed flow

Quiet zone
(2–8 windbreak height)
• Calmer, warmer and more humid.
• Reduced soil evaporation, evaporative demand (maybe).
• Increased growth and biomass production but not always yield.

Wake zone
(More than 8 windbreak height)
• Microclimate effects are small but shelter from wind reduces risk of soil erosion and plant damage.
The potential for windbreaks to improve productivity by reducing direct wind damage is a key result from this research. A direct wind effect on productivity is potentially more important than effects due to temperature and humidity.

Wind shelter occurs across a larger area of the paddock so windbreaks can be spaced farther apart to capture this benefit and adequate levels of wind protection are found even for a porous windbreak.

Multiple benefits

Windbreaks are economically viable for cereal crops if financial gains can be realised from one of the other multiple benefits of tree windbreaks or if damaging events are frequent. Trees on farms can bring multiple benefits including shade and shelter for growing crops, pasture and livestock, and timber and fodder to supplement farm income and stock feed. Trees add biodiversity to the landscape, reduce local waterlogging and improve aesthetic value.

Minimising the area taken up by the windbreak itself, and managing the competition zone through root pruning can improve the financial picture by reducing the cost of windbreaks. Crop and pasture growth in the rootzone of the windbreaks was reduced at all of the field sites during all years. The magnitude and extent of these losses varied from site to site and year to year.