HOW ARTIFICIAL WINDBREAKS HELP CITRUS GROWERS IN AUSTRALIA

ABSTRACT

Artificial windbreaks provide instant wind protection and improve the quality and yield of citrus. Investigations of skin blemish problems on the Central Coast of New South Wales have shown that wind is a major blemish producing agent, and that wind scarring can be minimised with artificial windbreaks.

Wind as a Horticultural Hazard

Many farmers accept wind as a normal day-to-day occurrence and take little or no action to manage this component of our environment.

That wind is a horticultural hazard has been proved many times in a large number of countries and the evidence is well documented. Some remarkable improvements in crop yield and quality, as well as plant growth, have occurred as a result of wind protection; and this applies to the majority of crops.

Wind possesses energy—and the stronger the wind the greater the amount of energy. It is this energy which causes the tree or plant to toss and sway, often resulting in substantial bruising or even breakage of plant parts—hardly ideal conditions for maximum growth and productivity.

Wind is a transport agent. It transports sand and dust which blast the crops, and heat and cold by a process called advection. In coastal regions salt is carried inland by onshore breezes. As a result of wind evaporation, transpiration and photo-synthesis are often adversely affected and growth and efficiency suffer. The end result is a smaller and less productive plant in which economic production is reduced.

Wind promotes evaporation of soil water causing a more rapid depletion of soil reserves. This also increases the soil’s vulnerability to erosion. Orchard spraying and sprinkler irrigation become difficult under windy conditions and the percentage of windfalls is likely to increase as wind velocity increases.

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Wind Damage to Citrus.

Young, in 1926 in California, reported a 20 per cent increase in pack-out to fancy and extra choice grades as a result of wind protection by natural windbreaks. In 1934, Blanchard, also in California, showed that protected trees were one third larger and produced better quality fruit than exposed trees. In addition, the protected trees were yielding seven times more fruit per acre than exposed trees (286 field boxes per acre compared with 43.6). Equally large yield differences have been recorded again in California by Platt (1967), and also in Australia by Campbell (1967). These are extreme cases but are by no means remote. A more indicative figure is given by Platt (1967) who recorded yield for 13 protected and 13 unprotected orchards. The average yield loss due to exposure was 20 per cent and the average downgrading into 3rd grade citrus was an additional 20 per cent.

The improvement in fruit quality by wind protection is due to a reduction in wind scarring by leaves and twigs. This injury occurs in the spring and early summer when the newly set fruitlets are very tender and quite susceptible to abrasion. Fig. 1 illustrates the type of injury that results from wind rub. This is often confused with thrips injury in South Africa and in some cases the thrips are falsely blamed for the injury. Scritothrips aurantii do not occur in Australia and no confusion results. In South Africa an average of 40 per cent of all

Figure 3

Plotting the distribution of winds likely to cause blemishes during the first four months in the life of the fruit.
fruit is culled from export due to wind scarring, and in bad wind years this figure can be much greater.

Campbell (1972) in South Australia demonstrated the depressing effect of wind on the growth and production of young citrus trees. Trees that were protected carried more fruits (up to 100 per cent) and grew longer shoots and larger leaves, the exposed trees having only 60 per cent of the height of the protected ones.

Orchards that are exposed to strong winds reflect their exposure by producing stunted, slow growing trees that produce low yields of poor quality fruit. Lesser exposed orchards suffer similar problems but to a lesser degree. It is in these orchards that average, or mediocre, growth and production fall the farmer into a false sense of security. In most cases, windbreaks should increase yield and packout by a minimum of 10 per cent. Just as we manage the soil, the water requirements and the nutrition of the tree, we can equally manage the wind that affects the tree adversely.

Artificial Windbreaks

The concept of artificial windbreaks was developed as a means of minimising citrus skin blemish at Gosford on the Central Coast of New South Wales. Natural windbreaks suffer disadvantages which lead to considerable reluctance by some farmers to plant trees for wind protection. Not only do natural windbreaks occupy up to 10 per cent of the arable land, but they compete for light, water and nutrients and provide homes for birds which may attack the crop. They are also slow growing and may be susceptible to herbicides. A suitable alternative which suffers none of these disadvantages may be found in artificial windbreaks.

The most recent concept involves the use of synthetic mesh, usually black polyethylene, supported by timber poles. The mesh needs to be perforated so that its permeability or air space is about 45 per cent. These holes allow some air through while most is displaced upwards. A windbreak that is too dense causes turbulence on the lee side and the zone of protection is reduced. Windbreaks that are insufficiently dense, such as wire netting, do not lower wind speeds sufficiently on the lee side to provide adequate protection. The advantage of using polyethylene mesh is that optimum permeability is provided and this remains fixed for the life of the windbreak. In the case of natural windbreaks the permeability is quite variable.

Fig. 2 shows a polyethylene windbreak used in current skin blemish trials. It is 18 feet (5.5 m) high supported by timber poles buried 5 feet (1.5 m) into the ground. No guy wires were necessary with this structure, which is sound and stable after 18 months exposure and having experienced winds in excess of 60 m.p.h. (90 k.p.h.). It was constructed in an exposed commercial orchard with a history of badly scarred fruit. The 1972 harvest provided excellent results. Trees that had been protected yielded up to 26 per cent more than the exposed trees and the overall average yield increase for the protected block was 20 per cent. This yield increase was due to an increase in both fruit size and fruit number. In addition there was an overall improvement in fruit quality—much higher quality pack-out resulting which was estimated to return an additional 50 cents per bushel. Tree health and vigour also responded most favourably.

ARTIFICIAL WINDBREAK CONSTRUCTION

1. Positioning the Windbreak

Windbreaks should be positioned to achieve the maximum protection of the crop with the minimum interference to normal orchard operation. The maximum protection is achieved by erecting the windbreak at right angles to the direction of the prevailing or most damaging winds. In order to achieve this, a sound knowledge of seasonal wind directions is important. In the case of skin blemishes of citrus, the scarring occurs in the first 12 weeks after petal fall and little or no wind rub occurs after this period. Windbreaks designed to minimise skin blemishes, therefore, should be orientated to achieve maximum protection from winds occurring within 12 weeks of petal fall. Long term records provide the most reliable information as to wind direction and force.

Fig. 3 illustrates the type of information that is required. The percentage of wind for each direction and greater than Force 4 during the 12-week period after petal fall was plotted out as shown. Most of the damaging winds were from the NW to SW sector and this coincided with skin blemish values, in which the greatest scarring occurred on the western side of the trees. A north-south windbreak was therefore warranted and this produced the superior yields and quality mentioned previously.

If at all possible, avoid gaps in the windbreak for orchard traffic. Gaps create a nozzle effect and wind will blow through at 120 per cent or more of its normal velocity. Where possible, have the barrier parallel to farm roads.
or tracks. It may be easier to change the patterns of orchard traffic movement rather than to lose windbreak efficiency.

2. Spacing of Parallel Windbreaks
   Where a series of parallel barriers may be required one needs to consider the best interval between them. On relatively flat ground, a general figure is 10H (H = height of windbreak). In other words, if the barriers are 20 feet (6 m) high, then they should be spaced 200 feet (60 m) apart. Experiments have shown that the best protection occurs up to 6H in the lee of a windbreak, although adequate response is achieved up to 10–12H. Sometimes a compromise is required in which economic factors, farm layout and the value of the crop, determine the best spacing.

   On rising ground the barriers should be spaced closer together and on falling ground a wider spacing is acceptable.

3. Height and Length
   The higher the windbreak, then, the greater the zone of protection. A 20 feet (6 m) high barrier will provide 200 feet (60 m) of protection while a 6 feet (1.8 m) barrier provides 60 feet (18 m) of protection. Successful windbreaks at Gosford have been 18–20 feet (5.5–6 m) high and construction has been relatively swift and simple. Windbreaks in excess of 20 feet (6 m) would be more difficult to erect and would require much stronger support poles. The labour costs of erecting such large windbreaks would be too high.

   With mature citrus trees, a minimum windbreak height should be 18–20 feet (5.5–6 m) to allow for the height of the trees. It would be difficult to protect citrus trees that were themselves 18–20 feet (5.5–6 m) high. However, research has shown that 18 feet (5.5 m) high barriers provide sufficient protection to 10H on citrus trees that were 12 feet (3.6 m) high.

   To be fully effective, a windbreak should be at least 20 times longer than it is high. Because winds will curl around the ends, a short windbreak would lose much of its advantage due to these "end effects". Where possible, the windbreak should extend past the crop on either end and could be angled in slightly to form deflecting wings.

4. Supports
   Research experience has shown that sturdy timber poles are preferable to steel as they can function without guy wires. The windbreak in Fig. 2 is using 25 feet (7.6 m) poles, 5 feet (1.5 m) of which is underground. Disused telegraph poles provide ideal supports and in Australia can be obtained at little or no cost.

   The poles should be spaced 20–25 feet (6–7.6 m) apart and the end poles reinforced with guys or bed logs to take the strain.

   Care should be taken to ensure that all poles are free from rough or sharp points that may tear or fray the mesh.

5. Attaching the Mesh
   (a) Horizontal support wires should be strained tightly and spaced about 4 inches (10 cm) less than the width of the rolls of mesh. If the mesh is 6 feet (180 cm) wide, then space the wires 5 feet 8 inches (173 cm) apart. This allows for an overlap and the seams are rolled around the wire before stapling. The top wire or support should preferably be light cable.

   (b) Once the wires are in position the bottom layer of mesh is rolled out. It is attached to the poles by wooden slats which are firmly nailed, with the nails being no more than 6 inches (15 cm) apart. (This prevents pulling in strong winds—the closer the nails, the less force acting on each point.) As each bay or section is rolled out, the mesh is pulled taught but not tight, before nailing. Mesh that is strained too tightly will break down rapidly. The three layers of mesh are attached in this way to give an 18 feet (5.5 m) high barrier.

   (c) The next step is to attach the mesh to the horizontal wires. The topmost wire or cable and the bottom wire hold the mesh which is folded, wrapped around, and stapled with a ringlock stapler, the interval between each staple being no more than 3 inches (76 cm). The two centre wires receive the mesh in the same manner except that the upper edge of the mesh is folded around the wire with the lower edge of the mesh in the next layer up.

   (d) To prevent bellowing in strong winds, diagonal cross wires should be placed in each bay between adjoining poles. It is important also that the mesh be attached on the windward side of the poles.

Economics
   A range of windbreak materials are now available at variable prices. Most of the fabrics are black polyethylene and may be woven or extruded. The life of the fabric varies from about three years for one brand to over five years for another. More expensive products will last for ten years assuming sound and proper construction.

   Costs have been estimated for two fabrics currently under test. Costing includes all materials and labour. The three-year fabric will cost $A233 per acre ($A93 per hectare) to install or $A65 per acre ($A26 per hectare) per year. The five-year fabric costs $A288 per acre ($A115 per hectare) to install or $A52 per acre ($A21 per hectare) per year. These costs are based on an

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the oil companies who stacked their profits away into various bank accounts throughout the world and now it was the Arabs—so what's the difference to us in the third world?

But Sir Kenneth did say that man needs crises of this sort (like a major war, for example), to get down to grass roots and make a plan.

**SLOW BOAT TO**

Now I wonder for a start whether we should not support the chaps at the University of Hamburg who have drawn up plans for a 121.9 m, 17 000 tonne sailing ship capable of an average speed of 12 to 16 knots and a top speed of 20 knots under ideal wind conditions?

At that speed you hardly need to cool the cargo.

**"SCATTERED SHOWERS"**

There are farmers in odd corners of the Transvaal who are complaining that the wonderful rains that we have received this summer have passed them by. It is true that the rainfall this year, though more frequent and much more plentiful than most of us can remember, seems to have been more "patchy" than usual and that some districts have had less than their average annual rainfall.

18–20 feet (5.5–6 m) high barrier with a 12H spacing.

A simple formula can be used to calculate the increased returns as a result of erecting windbreaks:

\[ IR = \frac{R(Y-y) + r(YP-yP)}{100} \]

where IR equals the increased return

P = price per bushel (or local equivalent) on the local market

Y = new yield with windbreak (bushels/acre)

y = old yield without windbreaks (bushels/acre)

r = price difference between export and non-export fruit

p = new packout (percentage)

% = old packout.

Example

Take the case of a grower in a moderately exposed situation who currently averages 600 bushels per acre and a packout to export of 60 per cent. The price he receives on the local market is $3.00 and for export fruit $3.50. Assume that by erecting a windbreak system he increases both yield and packout by 10 per cent.

**ARTIFICIAL WINDBREAKS**

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Then according to the above formula:

\[
R = 300
Y = 600 b/a
y = 600 b/a
r = 0.50
P = 70 per cent
p = 60 per cent
\]

Thus \[ IR = \frac{3(660-600) + 0.50}{100} \]

\[ = \frac{3 \times 60}{100} + \frac{60 \times 600}{60 \times 600} \]

\[ = $180 + 0.50(102) \]

\[ = $180 + $51 \]

Increased Value $231/acre

If he uses three-year material for an outlay of $233 per acre, then his increased returns will be $231 x 3 = $693 less the capital outlay $227, which means $466 per acre more over three years due to the windbreak.

If a five-year fabric is used, his increased profit will be $231 x 5 = 288 = $867 per acre.

Artificial windbreaks are used in Japan to protect citrus from cold winds, in Italy and Sicily, for the protection of citrus and pome fruits, and in a number of other countries successfully protecting vegetable and berry crops. The concept can be applied to many aspects of agricultural production with favourable responses. Farmers can now provide instant wind protection where it is needed most, and this imparts flexibility in the farm plan, maximum efficiency of land use and a greater opportunity for diversity—a situation not experienced with permanent stands of windbreak trees.

**REFERENCES**


