



## Guide to Windbreaks

# Capatex

**Horticultural & Agro-textiles**  
Protecting your growing assets

# Capatex Ltd

## Windbreaks for Horticulture a guide for the professional

### INTRODUCTION

Gales and storms can wreak havoc amongst many horticultural crops. Fresh and strong breezes can adversely affect some crops at certain times. They will reduce temperatures and affect germination, plant growth and fertilisation. Windbreaks, both living and artificial, offer ways of ameliorating the worst effects of wind. This leaflet discusses the principles involved in the siting of windbreaks and gives details of construction and maintenance.

Growers will find good practical advice, whilst students will be given an introduction of the needs of windbreaks. The leaflet stimulates, comments and questions.

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One of the earliest methods of improving the climate for growing crops must have been the use of windbreaks. They have an important part to play in horticulture today by providing shelter from the ill effects of wind on plants, soil, buildings and people.

Windbreaks may be grouped as:

*Living* - trees or shrubs which are semi-permanent  
-sown plants which give temporary shelter for specific short periods.

*Artificial*

### TYPES OF WIND

The strongest winds, particularly gusts-cause damage to the structure of buildings and plants. Deformed growth results from a mean annual wind speed of 4.5 metres /second (m/s). Serious deformation results where the wind speed is greater than 6.8 m/s.

Damaging winds - cause damage when plants are at a sensitive stage e.g. fruit blossom.

Prevailing winds - are not necessarily the most damaging winds. The name refers only to the direction from which the wind most frequently blows. In this country the prevailing winds come from the south and west. The greatest benefit may come from providing shelter from these prevailing winds, although in some situations protection from the cold winds from the north and east is more important. The local lie of the land (topography) can modify wind direction appreciably and must be taken into account.

# EFFECTS OF WIND IN COMMERCIAL HORTICULTURE

## Damage to plants

Wind frequently causes lesions and lacerations on leaf and stem surfaces and where this occurs, plants can easily be desiccated. By rocking plants it also damages roots. These all combine to stunt plant growth and therefore reduce yields, often by 10 per cent, while those of more sensitive crops may be reduced by 30 per cent or more. Leaves are often torn off, flowers are tattered, fruit is bruised or blown off and whole plants may be broken or blown over because of torn roots. Resistance to disease and herbicide damage is reduced

## Damage to buildings and structures

Considerable structural damage can be caused to buildings, but especially to glasshouses and plastic tunnel structures. Wind turbulence caused by the proximity of other buildings or solid barriers will increase the effects of gales. Hop wirework often collapses in late summer gales because of the load from wind on top of the already considerable crop load which forms a fairly impenetrable barrier to the wind.

## Damage to soil

Blowing sandy or light peaty soil particles, especially in areas of low rainfall, causes erosion. Soil compaction, in the form of an inverted cone around the necks of plants, can be caused by the rocking action in the wind. Plants may become waterlogged and die if the cone fills with water which is unable to seep away.

## Evaporation

Wind increases the rate of evaporation of water from plants and soil. It is sometimes necessary to dry the soil enough for land preparation, but too much evaporation can increase the need for irrigation, e.g. pre-sowing or pre-emergence of seed crops.

## Heat loss

Cold winds cause heat loss from plants, soil and buildings. This delays crop maturity, causes uneven plant growth in glasshouses and leads to considerably higher fuel bills.

The effect on plants of low temperatures from cold winds is to depress:

- Germination
- Plant Growth
- Flower Development
- Pollen transfer, through reduced insect activity
- Pollen tube growth
- Fertilisation, through flower damage
- Fruit ripening
- Crop yield
- Crop quality

## Wind as carrier

The wind itself may not be so important as what it brings with it e.g. salt, rain, hail or soil particles, or extremes of drying cold or heat.

# Management difficulties

Wind makes working conditions unpleasant, especially if accompanied by rain, hail or soil particles - so work rates are slower and expense increased. Spraying and irrigation become uneven, difficult or impossible.

All these factors impose limitations on management and may need additional expense to offset their effects. e.g. staking of trees.

## PRINCIPALS OF WINDBREAKS

The purpose of a windbreak is to reduce wind speed, not stop it.

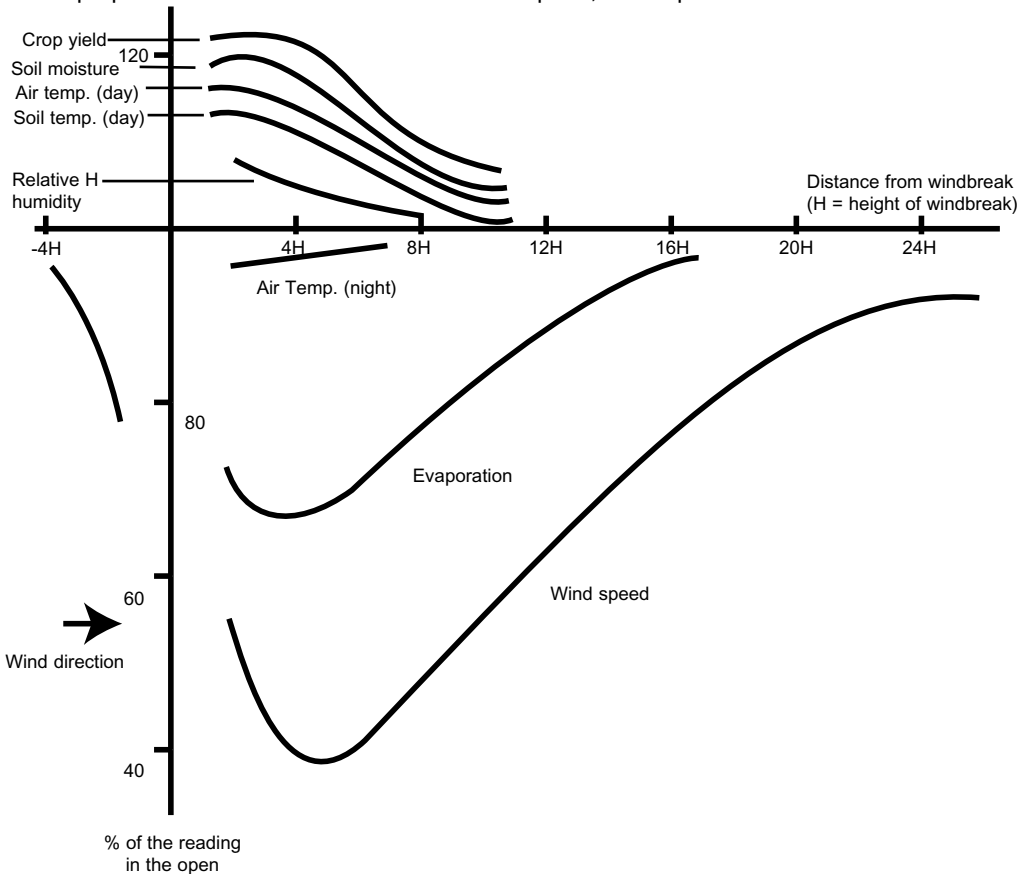


Fig.a Effect of shelter on microclimatic factors.

# Porosity

Dense windbreaks cause an upward deflection of the airstream, giving rise to an area of low pressure to the leeward of the barriers. The resulting suction draws down air currents and gives rise to intense turbulence on both the leeward and windward sides, which may cause more damage than the original wind (see fig.b i)

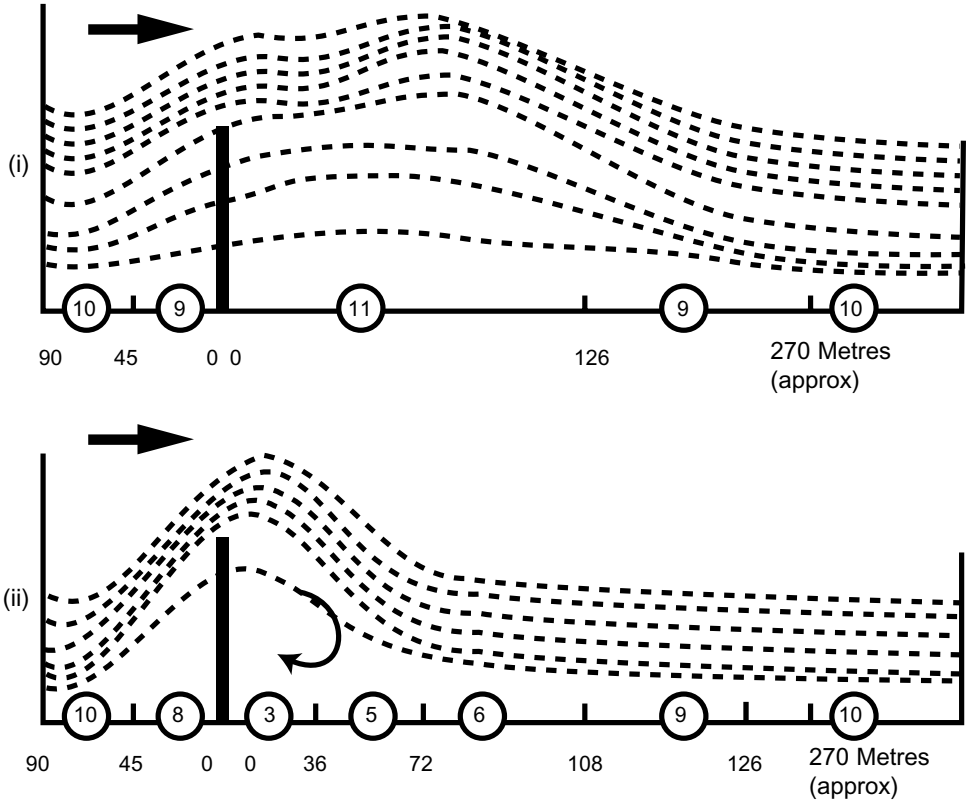


Fig.b Effect of (i) moderately penetrable and (ii) dense windbreaks on the flow of wind. Figures circled denote approximate wind speeds (metres/second) in the various sections. Horizontal distances (metres) refer to windbreaks 9m tall.

A badly constructed or poorly maintained windbreak is worse than useless e.g. gaps in the barrier cause wind funnelling at increased speed and if the windbreak is sparse or does not come fairly close to the ground, the result is local acceleration of wind.

A windbreak facing the prevailing wind (or at least 50 per cent of the prevailing wind) gives most protection. Even a thin windbreak will give a reduction in the destructive value of wind, but 50 per cent permeability as been found to be best, both experimentally and in practice.

## Distance between windbreaks

Reduction of wind speed occurs up to a distance of  $30H$  ( $H$  being equal to the height of the windbreak) to the leeward of a windbreak with 50 per cent permeability. At this distance the wind will have almost regained its original speed. Maximum benefit to crop yield occurs at a distance of up to  $10H$  from a windbreak (see fig.a)

Single rows of trees 7-9m high every 70-90m therefore provide a good shelter without making too much land unproductive. In very windy situations it may be necessary to use windbreaks much closer than this, or to use double staggered rows of one or more species.

## Length of windbreaks

The length of a windbreak is also important. If it is too short, wind is deflected around it, leading to increased wind speed at certain points. Since wind speed is never constant the ratio of length to height must be at least 12:1 to take full advantage of the protection given by the windbreak.

## Siting of windbreaks

The direction of the surface of the wind is influenced by the topography of the ground and funnelling is often very noticeable along valleys. Windbreaks across a valley have maximum effect as the wind is most likely to beat a right angle to the windbreak.

Windbreaks sited across slopes can impede air drainage on cold nights and so increase the risk of frost damage. This is particularly important at fruit blossom time and for sensitive crops such as runner beans. In such situations a gap of 0.3-0.6m should be kept open at the

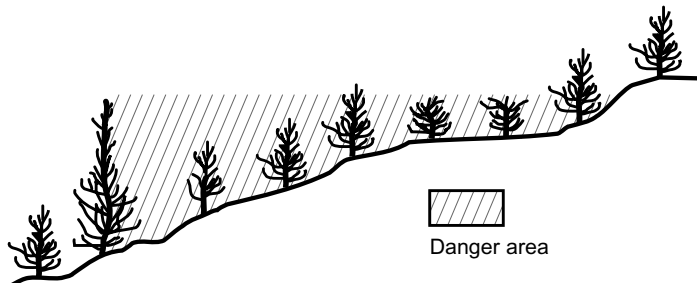


Fig.c Frost pocket created by a dense windbreak

Staggering or angling of windbreaks (see Fig.d) allows access and free drainage of cold air without leaving a 'wind funnel' gap. It prevents frost build-up and diverts the flow of cold air away from valuable crops. Damaging eddies of wind or frost build-up can occur near isolated barriers such as buildings, reservoir embankments etc.

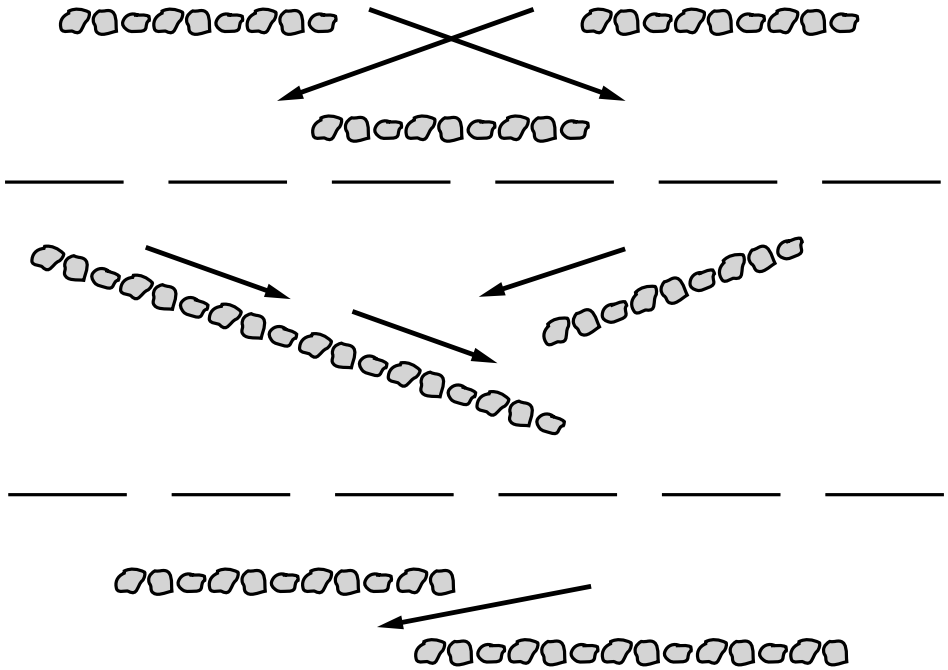


Fig.d Staggering or angling of windbreaks to allow free air drainage on sloping sites.

## BENEFITS FROM

The speed of the wind is reduced as it filters through a windbreak giving numerous beneficial effects, though many of them may go unseen. Although plant species react differently to wind protection because of their different forms, windbreaks generally give increased and earlier crop yields. Without a windbreak, leaf surface can be damaged sufficiently to reduce yields, but not enough for the damage to be noticed.

## Contributing benefits

1. Because plants may use water more slowly where sheltered, they are less likely to wilt in hot conditions and whilst stomata of the leaves remain open, photosynthesis continues effectively. This may not be the case with unprotected plants, subjected to greater atmospheric and internal water stress. There is no evidence of CO<sub>2</sub> shortage in the air above sheltered crops.
2. Windbreaks reduce wind velocity and therefore evaporation of water from the soil. This can be critical in a seed-bed.
3. The daytime temperature of soil is raised by as much as 3<sup>0</sup>C where shelter is provided by a windbreak. This can lead to fruit and vegetable crops maturing several days earlier than unsheltered crops.
4. Windbreaks provide a habitat for bumble-bees and for insect predators. The latter are likely to be of increasing importance for the development of integrated pest control in orchards.
5. By providing shelter from wind for pollinating insects, pollination is improved.
6. Windbreaks prevent or reduce soil erosion. This is especially important on fine sandy or organic soils. Where soil erosion is reduced, there is reduced risk of the spread of soil-borne diseases, e.g. Clubroot, Red Core of strawberries and other diseases caused by *Phytophthora* species.
7. Windbreaks reduce the risk of wind-borne disease spread, e.g. mildews, *Botrytis* and rusts. Reduced splash in autumn gales reduces the risk of infection by *Phytophthora* spp. in fruit at harvest time.
8. Spraying can be done when it may be impossible on more exposed sites. Both spraying and irrigation are more efficient where the site is protected by windbreaks.
9. Windbreaks reduce the risk of mechanical damage e.g. branch and root breakage in fruit trees, lodging of Brussels sprouts etc.
10. Windbreaks give better quality produce - especially of crops susceptible to wind damage e.g. container grown nursery stock which blows over, fruit, flower and vegetable crops such as runner beans, which are readily bruised.
11. Windbreaks lessen the risk of structural damage and reduce the heat loss from glasshouses and other buildings.
12. Near sea coasts, windbreaks protect crops from the worst effects of wind-blown salt spray, which can cause severe salt burn.

Most of these can be interpreted as effects of changes in the microclimate, which are summarised in fig.a

## ARTIFICIAL WIND BREAKS

Artificial windbreaks have the advantages of giving immediate protection with constant permeability and they take up little space. They do not compete with crops for water and nutrients and can be used either as temporary or permanent shelter. They are ideal for protecting units of container grown nursery stock. They are also useful for protecting crops and living windbreaks until the living windbreaks become established.

The most efficient materials are those with a hole area of about 50 percent. More dense materials reduce wind speed more markedly at first, but this effect extends over a much shorter distance downwind. Those with greater hole area give protection over a longer distance, but there is a smaller reduction in wind speed.

Capatex windbreak nettings are knitted to give an ideal wind permeability. They are produced with eyelets for ease of installation.

## SUPPORTS FOR ARTIFICIAL WINDBREAKS

These are normally round timber posts of Sweet chestnut, Larch or Douglas fir, placed at approximately three metre intervals. Although the methods of support are similar for most artificial windbreak materials, site exposure and prevailing wind speeds, height of the windbreak, soil type and method of anchorage must be considered when determining the size and length of supports.

Post size, i.e. the diameter of its thinnest end, is mainly determined by the height of the windbreak and exposure to wind. The depth of embedment in the soil is largely determined by the soil type and anchorage used. If the posts are embedded in concrete, a depth of 0.8 metres suits most situations shown in the example specifications for a 2 metre and a 3.5 metre high windbreak in Tables 1 and 1b.

When embedding in the soil, the type of soil and anchorage it affords greatly affects the depth of embedment required for stability of the windbreak. The soil types in Tables 1a and 1b are described in engineering terms - the nearest agricultural classification does not indicate the anchorage potential.

Table 1a Specification for erecting 2m high windbreak  
(distance between supports\*:3m)

Depth of embedment (m) in 3 soil types with either soil backfill or 450 or 600 mm concrete

Wind speed m/s	Post concrete dia. mm	Soil type1**		Soil type2		Soil type3	
		Soil bÖfill	concrete 450 or 600mm	Soil bÖfill	concrete 450 or 600mm	Soil bÖfill	concrete 450 or 600mm
40	110	0.8	0.8	1.0	0.8	1.5	0.8
42	110	0.8	0.8	1.0	0.8	1.6	0.8
44	115	0.8	0.8	1.1	0.8	1.7	0.8
46	120	0.9	0.8	1.1	0.8	1.8	0.8
48	120	0.9	0.8	1.2	0.8	1.9	0.8

Table 1b Specification for erecting 3.5m high windbreak  
(distance between supports\*:3m)

Depth of embedment (m) in 3 soil types with either soil backfill or 450 or 600 mm concrete

Wind speed m/s	Post concrete dia. mm	Soil type1**		Soil type2		Soil type3	
		Soil bÖfill	concrete 450 or 600mm	Soil bÖfill	concrete 450 or 600mm	Soil bÖfill	concrete 450 or 600mm
40	150	1.1	0.8   0.8	1.4	0.8   0.8	2.2	1.1   0.9
42	155	1.2	0.8   0.8	1.5	0.8   0.8	2.3	1.2   1.0
44	160	1.2	0.8   0.8	1.5	0.8   0.8	2.4	1.2   1.0
46	120	1.2	0.8   0.8	1.6	0.9   0.8	2.5	1.3   1.1
48	120	1.3	0.8   0.8	1.6	0.9   0.8	2.6	1.4   1.2

\* round timber posts of Sweet chestnut, Larch or Douglas fir.

\*\* see Table 2 for soil definition.

# WIND SPEED

Local wind speeds can be found in Fig e. These apply to open country with no obstructions. Ground surface unevenness will deflect wind and may cause gusts of wind of the height of the windbreak, which should be taken into account. Wind speeds of the area largely determine the size of the posts (see Table 1). Where anchorage is good, wind speed is a minor consideration in determining the depth of embedment.

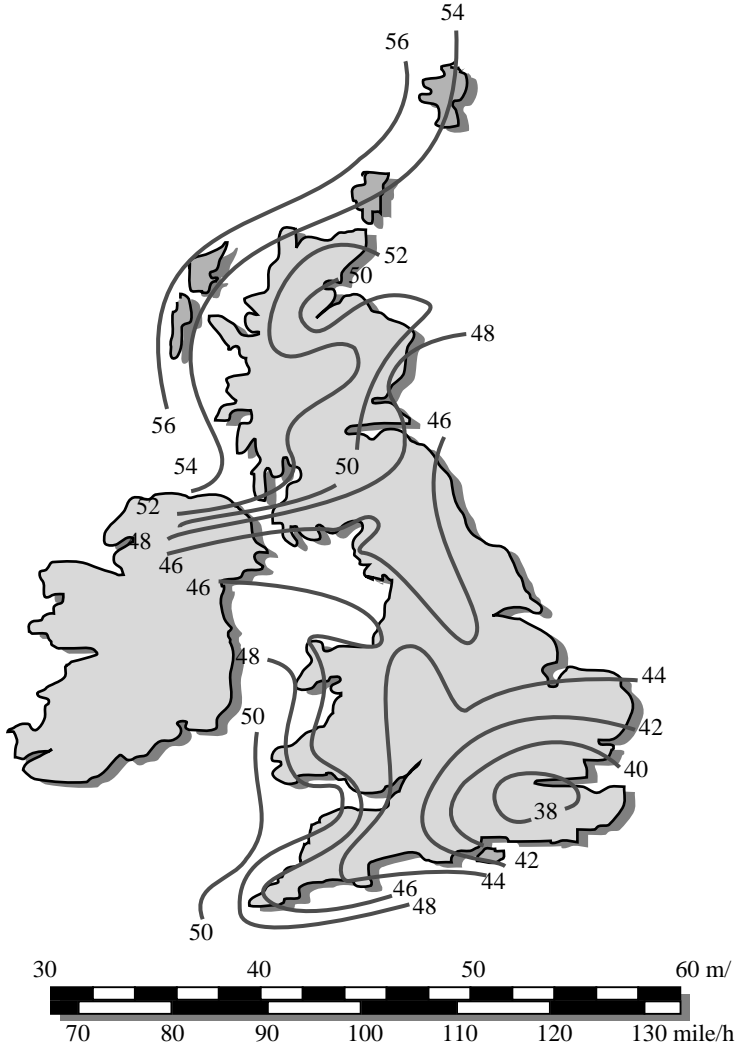


Fig e. Maximum gust speed (metres per second) likely to be exceeded on average only once in 50 years at 10m above the ground in open, level country.

## TYPE OF CROP

The type of crop being sheltered decides the space to be left from ground level to the bottom wire, e.g. for ground crops it should be 150mm.

## END SUPPORTS

Any calculations must assume that the end support is adequately braced along the line of the windbreak. Where driven posts with tapered butts are used, the depth of embedment should be increased by half the length of the taper.

For posts, longer than 3 metres, the bracing of the end support should consist of two guys splayed about  $60^\circ$  apart, at distances equal to the height from the ground of the anchor wire fixing on the pole, as in Fig f. For posts less than 3m long, a single guy is sufficient. Alternatively, the method depicted in Fig g. may be used.

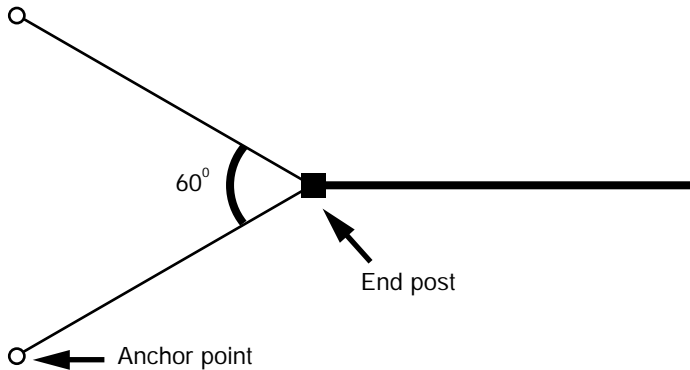


Fig f. Plan of bracing the end support for post

Fig g. Plan of bracing the end support for post

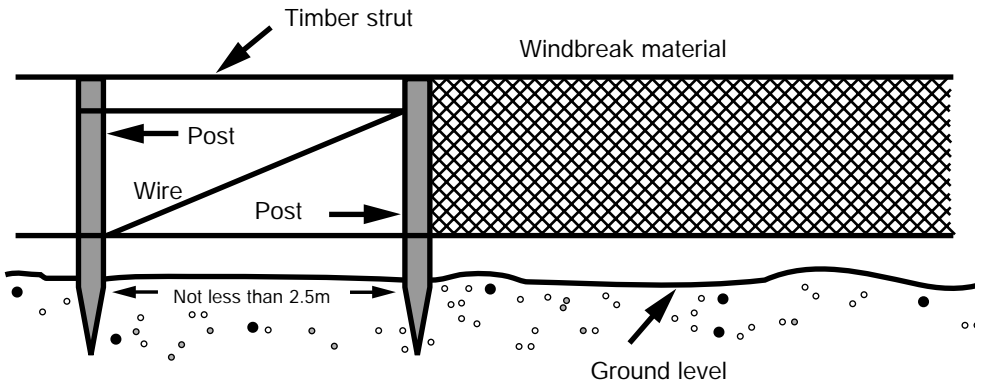


Fig g Method of bracing the end support for posts

Table 2. Definition of soil types for Tables 1a and 1b

<b>Soil grouping</b>	<b>Visual assessment</b>
<b>Type 1</b>	Compact, well graded sand and gravel. Well graded fine and course sand. Stiff clay. Stiff sandy clay. Should be well drained and in locations where water will not stand.
<b>Type 2 (Average)</b>	Compact fine sand. Loose course sand and gravel. Compact well drained sandy loams and loamy sands. Firm clay. Firm sandy clay. Should drain sufficiently well so that water does not stand on the surface.
<b>Type 3 (Poor)</b>	Loose sand. Soft clay. Clay loam. Loose clayey sand. Soft silty clays. Soft silty clay loam.
<b>Notes: Compact</b>	- Requires pick for excavations. 50 mm square peg hard to drive.
<b>Loose</b>	- Can be excavated by spade 50 mm square peg can be easily driven.
<b>Stiff</b>	- Difficult to mould by fingers requires pick for excavation.
<b>Firm</b>	- Can be moulded with strong finger pressure. Can be excavated by hand.
<b>Soft</b>	- Can be easily moulded with finger pressure. requires pick for excavation.
<b>Well-graded</b>	- Contains wide range of grain sizes well distributed.

For erection of windbreaks a tractor, trailer and a post hole borer of 600 mm diameter and/or post driver are needed. A fork-lift attachment with a bulk bin can be used as a platform: two people are usually needed. The marking out must be done carefully to be certain of the correct spacing between each support. The material of the windbreak should be attached to the sides of the posts facing the prevailing wind.

When using a lightweight material the position of the horizontal supporting wires must be marked on the uprights with care, as allowance has to be made for the material to fold round the top and bottom wires.

To fix the wires, the top wire is wrapped around one end support, then loosely attached to the other supports with staples. At the other end there should be sufficient wire left to tension it while driving home the staples in the intermediate posts, and again wrapping the wire around the end support. This is repeated for the bottom and middle wires. The wires are usually galvanised mild steel 3 to 4 mm (1 to 8 gauge), though high tensile wire of lighter gauge may be used. The screen material may be fixed with a batten or folded plastic fertiliser sacks to the supports, using large-headed, galvanised clout nails. The material is then fixed to the horizontal wires. Long gaps between the fixings puts more strain on the material in strong winds and is more likely to tear. Methods of fixing vary from galvanised split rings clamped into position, to stitching with polypropylene twine, using an over and over stitch or a short running stitch. When using webbing, the material must be strained so as to place the fastening in the correct position on the supports.

## WINDBREAKS IN PRACTICE

### WINDBREAKS FOR FRUIT

#### Orchard fruit

With the increasingly high capital investment involved in intensive orchard planting, it is only common sense to ensure that everything is done to encourage maximum early cropping. The need for windbreaks for orchard fruit can hardly be over-stressed.

#### Wind effects on russetting

Ice forms in the floral tissues at  $-2^{\circ}\text{C}$  and results in russetting and cracking and therefore poor quality fruit. Cold wind can also cause this kind of damage and it was particularly noticeable how quality was reduced by russetting in an apple orchard where part of the windbreak was removed on the north-east side.

#### Pollination

At temperatures below  $-2^{\circ}\text{C}$  the stigmas are damaged, so fertilisation is impossible and styles are killed at temperatures below  $-2.8^{\circ}\text{C}$ . Apple pollen will not germinate below  $3.9^{\circ}\text{C}$ . Even if stigmas and styles are not damaged, low temperatures may prevent fertilisation by slowing pollen growth. Mature pollen, may not be harmed by cold, but wind will desiccate it or blow it away. It may also dry the stigmas and styles so that the pollen cannot germinate, even if the temperature is sufficiently high. Plums flower so early in the year that protection from icy winds must be beneficial.

Reducing wind speed with windbreaks encourages greater insect activity, which results in better pollination. The warmer climate results in faster pollen tube growth, fertilisation and therefore fruit set. If shelter is too dense though, it can delay drying of flowers after rain and this can lead to poor pollination and fertilisation.

## Wind effects on fruitlets

Apple fruitlets are very sensitive to cold in the early stages, are easily killed and drop off. Partially pollinated fruit matures lop-sided, or, in the case of Conference pears, which are able to produce fruit parthenocarpically (i.e. without fertilisation), there are numerous sausage-shaped fruits.

## Wind effects on roots, leaves and stability

Exposure to strong winds causes root injury, which can have severe effects on both tree growth and yields. Pear trees are especially sensitive to this kind of wind damage. Growth of newly planted trees is limited and production delayed. Rocking of fruit laden trees in summer and autumn can cause damage to fruits and loss of crops. Unless trees are adequately staked they may lean over or break off, especially with weaker rootstocks.

Where trees rub against their stakes there is an increased risk of Canker, *Nectria galligena*, infection. Windbreaks may lessen the need for permanent staking on apple stocks, except M9 and M26 although some support will still be needed for the first few years. They also reduce the amount of branch breakage when plums are in full crop and Bacterial Canker infection in both plums and cherries.

Rocking in wet conditions often produces a smeared hole around the base of the tree. Collection of water in this hole can cause death of the trunk and roots through asphyxiation and death may be hastened by fungal infection.

Foliage, particularly that of pears, can be blackened and shredded in strong, cold winds of spring and early summer. Protection from winds is most important when temperatures below freezing result in wind-borne frosts. Even light winds markedly increase the chilling effect in frosty weather.

## Windbreaks for soft fruit

Soft fruit also benefits considerably from the shelter provided by windbreaks. The main wind damage to strawberries is the production of lesions on the upper and lower leaf surfaces and on the leaf stalk. These lesions reduce the area of leaf which is effective in the exchange of air and photosynthesis, with the result that overall vigour of the plant is reduced. Effects of wind on temperature and water stress are also implicated: strawberry pollen will not germinate below 11° C. Large increases in strawberry yields can be obtained by sheltering plants from the wind, especially on exposed sites. Work at the Scottish Crop Research Institute showed that strawberry crops can be increased by anything from 7-77 per cent by the provision of windbreaks and that most of this increase is related to protection from winds in September/October, when the flower initials are forming. Better shaped and therefore better quality fruit is produced where windbreaks encourage pollinating insects.

Average increase in parts of strawberry plants due to shelter was as follows.

Leaves	+	20%	Trusses	+	26%
Crowns	+	24%	Runners	+	25%

For strawberry runner production, windbreaks are not only useful for increasing the number of runners, but by preventing them blowing about, they allow runners to root more quickly and make bigger plants. Raspberries, especially those with long fruiting laterals such as Malling Admiral are susceptible to wind damage. The use of wind break netting in trials in Scotland has resulted in increased cane growth and yield.

New canes of blackberries and loganberries can be severely damaged in strong summer or autumn winds. At this time, southerly or south-westerly winds are the most likely to be the cause of damage.

It is equally important that black currants should be sheltered. Fruit is dependent on pollinating insects at an earlier time of the year and insects do not work well in cold, windy conditions. Bushes do not grow well in windy situations and leaf tattering is known to depress yields. Shelter from northerly or easterly winds is therefore recommended.

Vines need protection, especially from spring and autumn winds and the raised temperature in the sheltered area can make all the difference to the ripening of the crop.

## Windbreaks for hops

Hops are very susceptible to wind damage, both to the leaf and cone. In the spring, gardens exposed to the north-east are frequently checked during a spell of cold winds but normally they recover and the subsequent crop is not greatly affected. As the vines grow they are liable to be blown off the strings and expensive retraining is necessary. Later still, the heads may be snapped off at the top wire and the laterals are bruised and broken. The cones themselves become brown and tattered by wind bruising and this effect is always obvious around the edges of exposed gardens and in gateways. Structural damage to the posts and wirework frequently occurs in several autumn gales. The most effective natural shelter is provided by woodland, followed by tall hedges of broad-leaved trees such as *Populus* 'Balsam Spire' or *Alnus cordata*. However Poplar is a hungry feeder and liable to block drains. Evergreens are not suitable.

## WINDBREAKS FOR VEGETABLES

On light sandy or peaty soils wind causes, in succession:

- ¥ drying of the soil
- ¥ soil erosion
- ¥ possible total loss of crop
- ¥ damage to the waxy coating of crop leaf surfaces by the blowing of soil particles, leading to the danger of damage from post-emergence herbicides e.g. dinoseb amine

On all soils, wind interferes with the timing of herbicide spraying, which is frequently critical in vegetable production. Drying of the soil can be particularly harmful to germinating vegetable crops. Carrots which are slow to germinate, have been found to benefit from windbreaks, whereas cabbage, which is quick germinating, shows no such benefit. Shelter is especially beneficial where temperatures are nearer the minimum for germination, raising them by 0.5<sup>o</sup> C at night and by 1-3<sup>o</sup> C in the afternoon. These higher temperatures continue through the life of the crop and at the National Vegetable Research Station it was found that sheltered crops matured five days earlier than those on an unsheltered site.

Runner beans are particularly sensitive to wind damage and produce more flowers, are better pollinated (from increased insect activity) and suffer less physical damage where windbreaks are used. All these add up to considerably increased cropping and better quality.

To prevent wind erosion of soil, crops have been planted directly into stubble, but toxins from the rotting stubble, has caused damage to brassicas and other crops, especially when planting takes place immediately after the corn harvest. The practice cannot therefore be recommended. For large scale field vegetables, strips of corn or maize can be grown as windbreaks.

For more permanent windbreaks willows are often used. The importance of windbreaks as hosts for crop pests should not be forgotten when choosing living windbreaks. Willows, especially *Salix alba* and *Salix fragilis* act as hosts for the willow-carrot aphid, which transmits carrot motley dwarf virus. It is those surviving on over wintered carrot crops, however, that are of far greater importance. Similarly, the Lombardy and Black Poplars are hosts for the lettuce root aphid.

## WINDBREAKS FOR GLASSHOUSES AND PLASTIC

### Structural damage

Modern glasshouses are designed to withstand quite high wind loadings, but damage does occur, particularly in exposed situations or where wind eddies around solid structures. Even in a well designed and well built glasshouse, damage can start from the failure of a single sheet of glass or ventilator and its impact on others can set up a chain reaction of breakage.

The risk of wind damage increases as glasshouses weaken with age. As well as the cost of repairs, there may be direct crop losses from flying glass and subsequent weather damage. Cropping schedules may be delayed, resulting in consequential losses long after the original wind damage. Some, but not all of these losses can be covered by insurance.

Plastic structures have proved particularly vulnerable to wind damage. It is possible to reduce this risk of failure to a very low level by the provision of stronger structures, but this could prove to be too expensive on very exposed sites.

It is useful to note that the forces exerted on a structure by the wind are proportional to the square of the wind speed, so if wind speed is halved, the risk of damage is reduced by a factor of 4.

## Heat loss

The rate of heat loss from a glass house depends on

- (a) the difference in temperature between the inside and the outside of the glasshouse;
- (b) the speed in the wind;
- (c) the amount of air leakage from the glasshouse. (Increasing air leakage reduces the effectiveness of CO<sub>2</sub> enrichment).

The figures for fuel consumption in Table 3. show the relative importance of (a) and (b) in maintaining 21<sup>o</sup> C in average January conditions in a typical glasshouse near Birmingham. The estimated fuel use has been apportioned into the amounts which would have been used in differing combinations of wind and temperature. The amount used in frosty weather is much less than the amount used in windy weather because the latter goes on for much longer, whereas windy/frosty weather gives the lowest fuel consumption because the number of occasions when these two combine are very few.

Table 3. Percentage fuel consumption in an average January with varying weather conditions

Total	Light winds	Windy	Light winds	Windy
Frosty	Frosty	No Frost	No Frost	No Frost
100	16.4	7.6	33.2	42.8

light winds=4.5m/s or less

**Maximum** rates of heat loss occur at high wind speed, **not** at the lowest temperature. Heat loss doubles as the wind speed increases from 0-6.8 metres per second. Using this relationship and hourly records of winter temperature and wind speed over a five year period, an estimate has been made of the contribution of wind to glasshouse heat loss at three places in Ireland and three places in England. Of the total fuel consumption needed to maintain 15 °C in glasshouses on unsheltered sites during the months of November-March, the percentage accounted for by wind ranged from 38 per cent at Thorney Island, Sussex, to 51 per cent at Roche's Point, Co. Cork, a 13 per cent difference (see Table 4).

Table 4. Percentage increased fuel consumption due to wind

Site	Increased fuel(%)
Dublin Airport	47
Claremorris	41
Roche's Point, Co. Cork	51
Manchester Airport	40
London Airport	40
Thorney Island, Sussex	38

(Dr T.O 'Flaherty, Kinsealy Research Centre)

The use of a thermal screen will virtually eliminate the effect of wind speed on heat loss at night. Depending on the temperatures being maintained, some 60 per cent of heat loss may occur at night, so the use of a thermal screen would considerably reduce the benefit of a windbreak. Unfortunately, it is not practicable to install thermal screens in some existing glasshouses, but newly built heated glasshouses should be designed to accommodate them.

Heat loss is slightly less for plastic tunnel houses and much less for inflated double-skin houses. If glass is rated at 100, a plastic tunnel is 98 and a double-skin house 70-78 in relation to glass.

## Worry

The worry of being in or near a glasshouse with a gusty gale blowing, is considerably reduced by the use of windbreaks. While it is impossible to put a value on this benefit, it is very considerable, especially on a site where gale damage has already been experienced.

## The effect of a windbreak

A well placed windbreak can reduce the risk of damage and reduce heat loss from a glass house. Even unheated structures will benefit from a reduction in heat loss, particularly at night and in the winter months, but it is with heated houses that the greatest benefit is obtained. Calculations show that a saving of between three and six per cent of the total annual fuel bill may result from an effective windbreak.

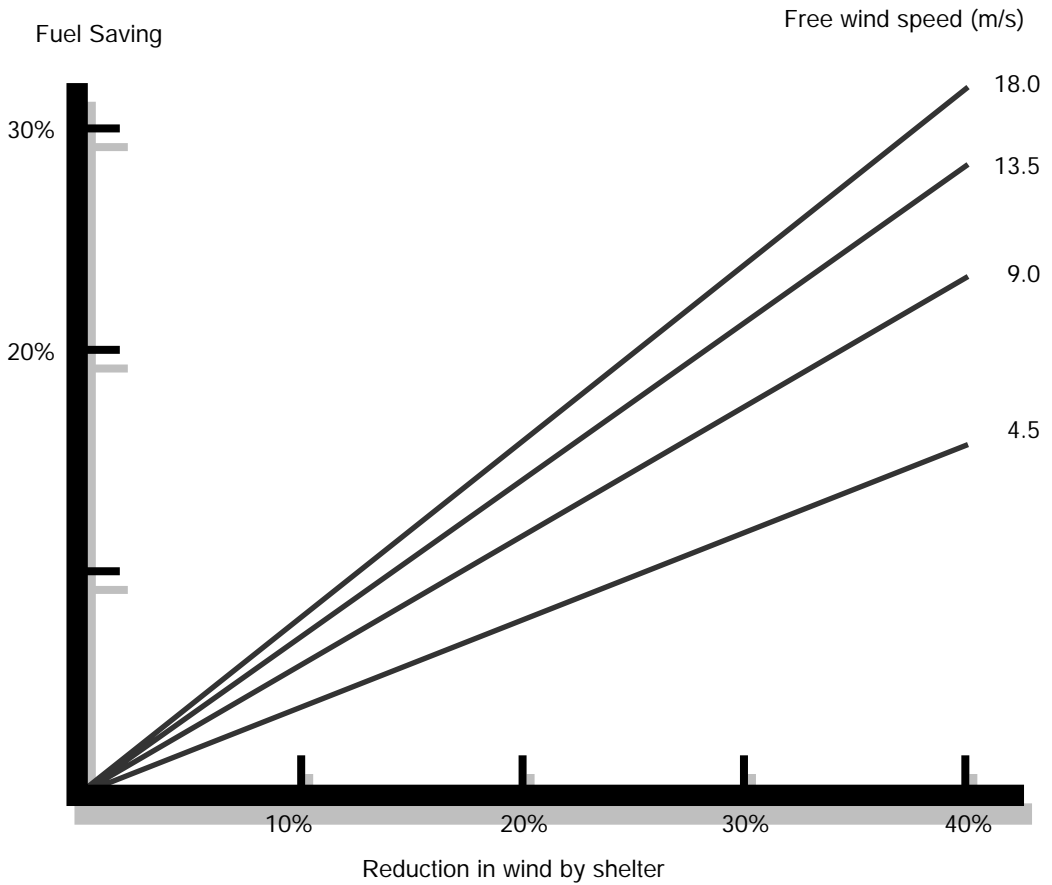


Fig h. Fuel saving from increasing reduction of windspeed by using a wind break. (Courtesy of the Horticultural Research Institute)

Fig i. shows the effect of a windbreak on wind speed. Although it does not show the modifying effect of the glasshouse on the wind run, it is clear that an overall reduction approaching 30 per cent can be achieved whenever the wind is blowing from the direction shown. On the exposed end of the glass house the wind speed is reduced to 70 per cent or less of its original speed. Since physical damage is proportional to the square of the wind speed, when the latter is reduced to 70 per cent the wind pressure is reduced to 49 per cent and the sheltering effect is quite pronounced.

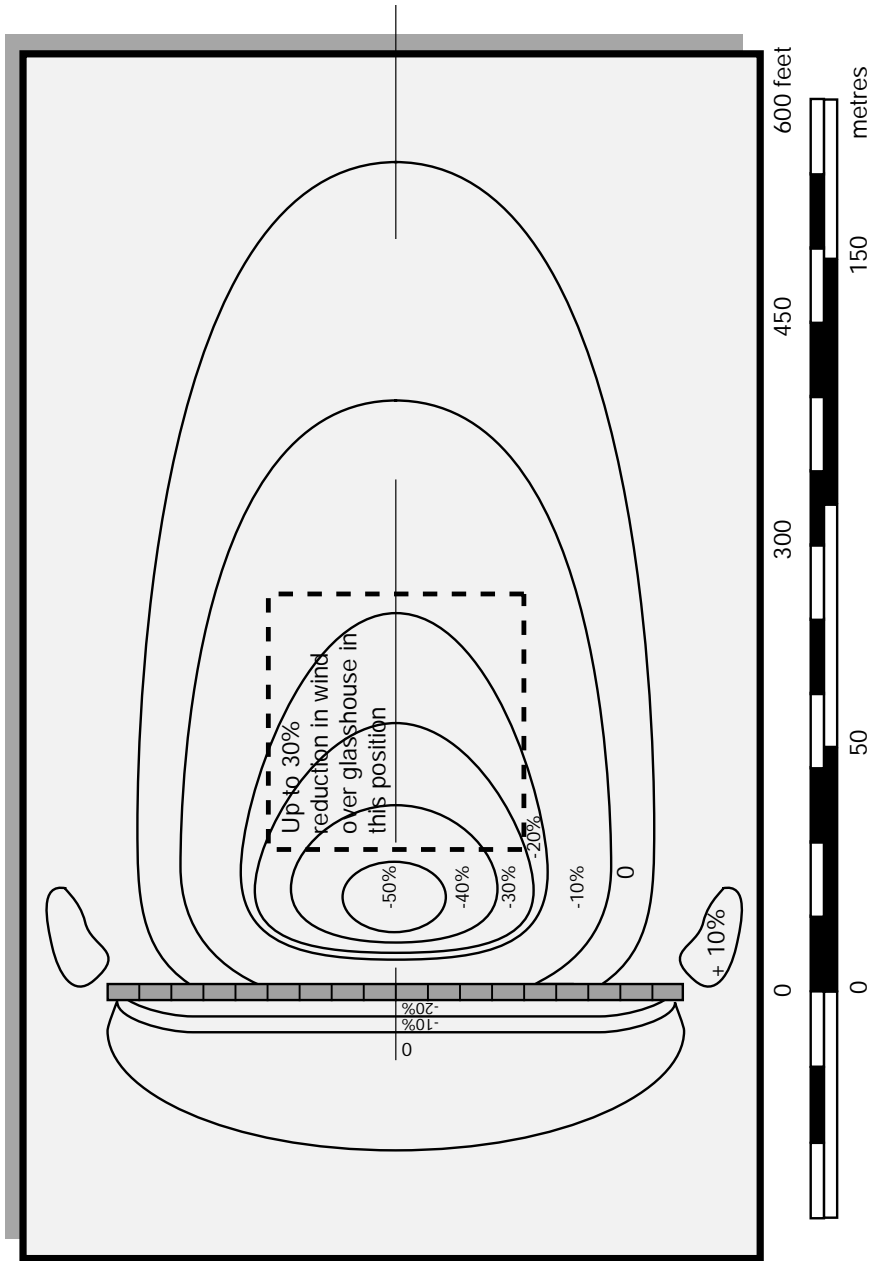


Fig i. Reduction of wind by a shelter belt 4.5 m high - moderately permeable. Measurements 3.6 m above level ground

A practical example was observed in Kent, where there was an average wind speed reduction of 34 per cent across a glasshouse block protected by 50 per cent permeable windbreaks. Although the windbreaks were closer to the glasshouse than recommended the tomato plants showed no apparent shading effect. Temperatures were more easily kept at 'Blueprint' levels and plant growth was even across the house, where previously there has been a history of uneven growth because of the difficulty of maintaining the correct temperatures at the extremities of the block in cold, windy weather. Fuel savings were significant and there was an increase of almost 3 per cent in crop marketed over the previous year.

## Orientation of Windbreaks

All-round shelter would be ideal, but is expensive, both in terms of material and space. Attention should first be given to the prevailing wind, which in most cases will be between south-west and west. It would be an advantage if the windbreak could also protect from the north-east and north-west. Winds which cause structural damage are most likely to be from the west or north-west.

## Design and layout

The windbreak should be nearly as high as the glasshouse - to a point at least half way between the gutter and ridge height. It would need to be higher than this to be effective over a large glasshouse block. Wire netting or plastic mesh material between individual glasshouses or between the gable ends of multi-span houses can help to prevent damage, even though it means some reduction in light.

For economy, a space of up to 1m may be left at the bottom of an artificial windbreak without much loss of efficiency. This space can soon be filled with shelter plants but gaps should be avoided. Where it is necessary to produce an opening, the wind should be prevented from blowing through it by staggering and overlapping the windbreaks.

Shading can be a major disadvantage of windbreaks for glasshouses, but this is now thought to be much less than previously supposed. A good compromise between loss of light and shelter efficiency is obtained when a 50 per cent permeable windbreak is sited 4 times its own height from the glasshouse. Where space makes this impossible, it may be worthwhile to site a windbreak closer than this but it would depend on individual site factors such as exposure, temperature to be maintained, size, age, and strength of the glasshouse to be protected.

## Types of windbreak suitable for glasshouses

A windbreak of trees may eventually take up a lot of space, which is not often available around glasshouses. Deciduous trees are leafless in winter, so give very little shelter when it is most needed. They need to be very twiggy to slow the wind speeds sufficiently at these times. Light penetrates them in winter, so their shading effect is little compared with conifers, but their leaves can block gutters.

Coniferous trees are too dense, so the risk of turbulence and damage is increased and they are also more likely to be blown over than deciduous trees, unless they are kept well thinned.

Where there is insufficient space for living windbreaks, artificial windbreaks are a good alternative as they are fully effective from the time of installation, have constant permeability, and occupy very little space.

## WINDBREAKS FOR NURSERY STOCK

Protection from wind is essential for nursery stock if good quality plants are to be produced. Cold northerly or easterly winds can damage young plants so that they become tattered and their growth rate is reduced. Newly transplanted stock can be desiccated by wind so that losses are high. Efford Experimental Horticultural Station have shown considerable increase in growth, and subsequent number of cuttings, from stock plants of camellia in a windbreak structure.

Where nursery stock is container grown, plants blow over and become misshapen unless they are righted quickly. With capillary irrigation, the base of the pot must be in contact with the bed, so fallen plants may dry out. Plants that have blown over dry out equally with overhead irrigation, as do those sheltered by fallen plants. In windy conditions overhead irrigation is uneven, so some plants can dry out and others could become waterlogged. Plant growth is poor and both time and money is wasted through righting plants.

Shelter gives better establishment of both container and open grown nursery stock and bigger, better quality plants. Living windbreaks can be useful as a source of material for propagation and for showing off stock, but they must be kept trimmed and consideration must be given to pests and diseases.

Artificial materials may be used where space is limited and for high value crops such as container grown nursery stock.

Many materials are also useful for the shading of shade-loving plants.

# APPENDIX A

## CONVERSION TABLES

### Wind Speed

Miles/hour (mph)	Metres/second (m/s)	Winds	Speed (m/s)
1	0.5		
2	0.9		
3	1.4		
4	1.8	light air	1.2-2.5
5	2.3		
6	2.7		
7	3.2		
8	3.6		
9	4.1	light breeze	3.4-5.0
10	4.5		
		Gentle breeze	5.9-8.4
20	9.0		
		Mod.breeze	9.2-13
30	13.5		
		Fresh breeze	14-18
40	18.1		
		Strong breeze	18-22
50	22.6		
		Near Gale	23-27
60	27.1		
		Gale	28-33
70	31.6		
		Strong Gale	34-39
80	36.1		
		Storm	40-46
90	40.6		
		Violent Storm	47-59
100	45.1		
		Hurricane	60-69

(1mph=0.45m/s)

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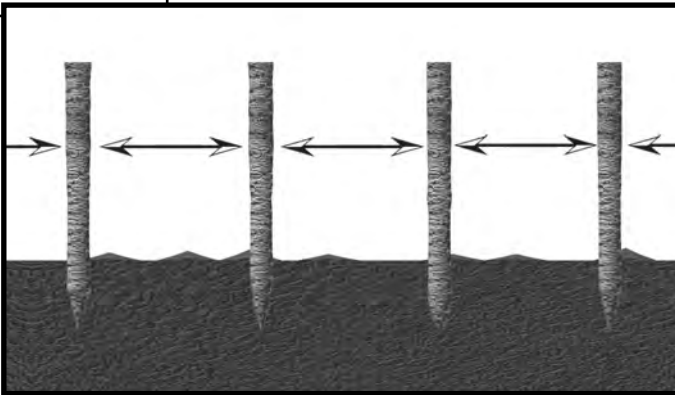
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## WINDBREAK INSTALLATION

We hope that these recommendations will help the professional grower when erecting windbreaks.

In agricultural applications windbreaks are generally mounted on wooden posts. Please note that rot-proofed or suitably treated wood should be used. This will ensure maximum service life of the installation.

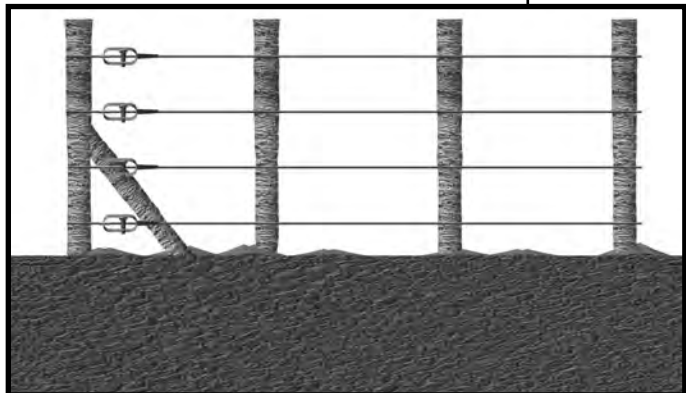
1



Spacing of posts:

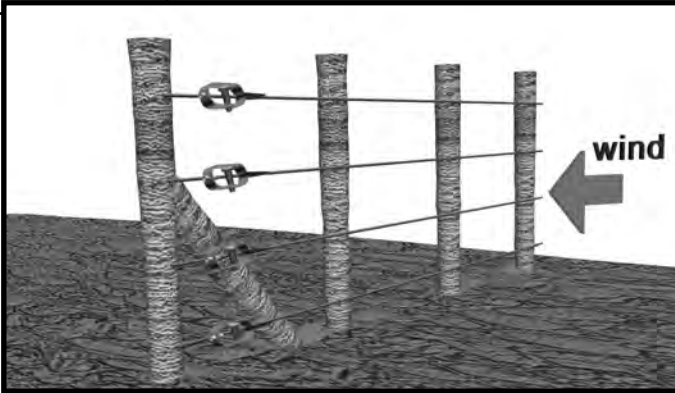
- Approx. 3 metres apart for heights of 2 - 2.5 metres.
- Approx. 2 metres apart for higher windbreaks.

2



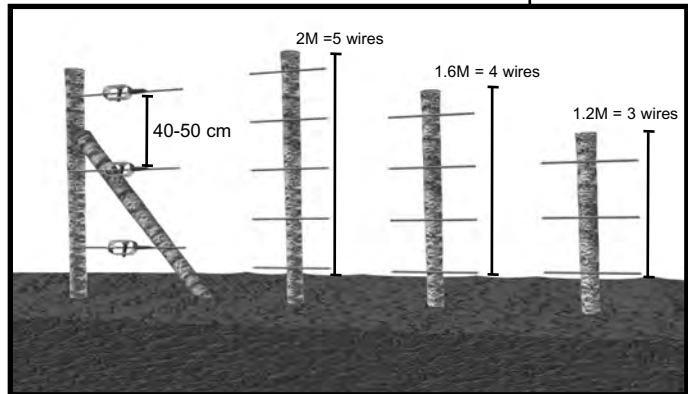
Use braced supports for end posts.  
It is recommended to set the end posts in concrete.

3



Locate the supporting wires on the side of the posts which face the prevailing wind.

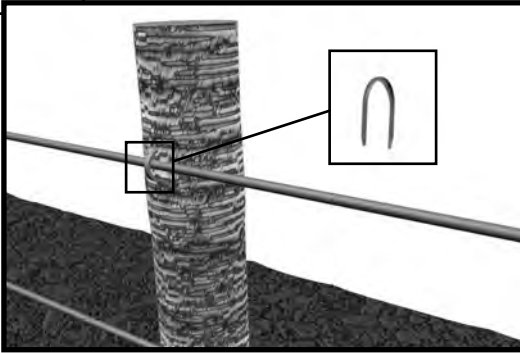
4



Vertical spacing between the support wires should be 40-50 cm.  
Tensioning devices should be used.  
End posts stabilised with inclined brace support.

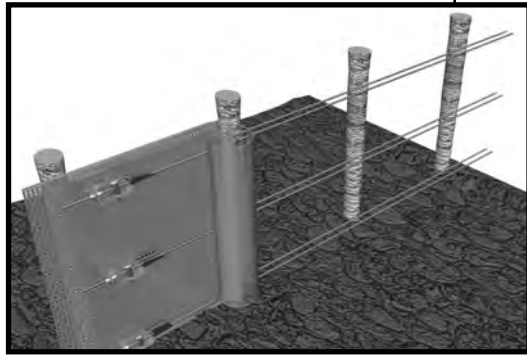
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5



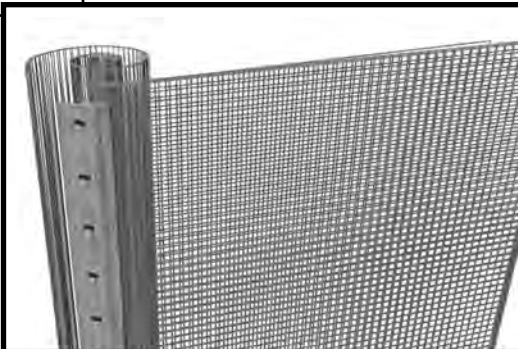
Fasten the support wires to the wooden posts using 30-40 mm staples.  
For metal post use cable ties.

6



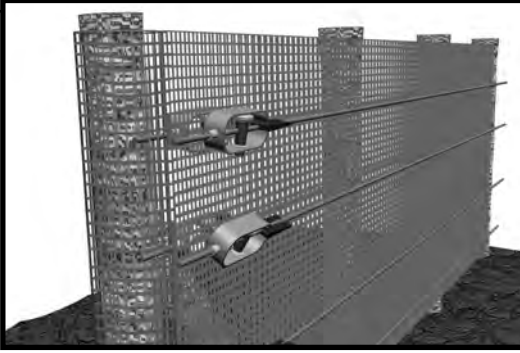
Starting at one end, unroll the windbreak and fix it temporarily on the tape tension wire using ring hooks at one metre intervals. Ensure that there is an overlap of 10 cm of windbreak above the top tension wire and that the windbreak is located parallel to the tension wire.

7



Attach the windbreak to the end posts using a wooden batten or cable tie to metal post.

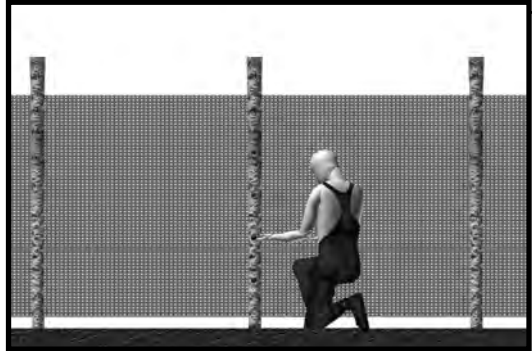
9



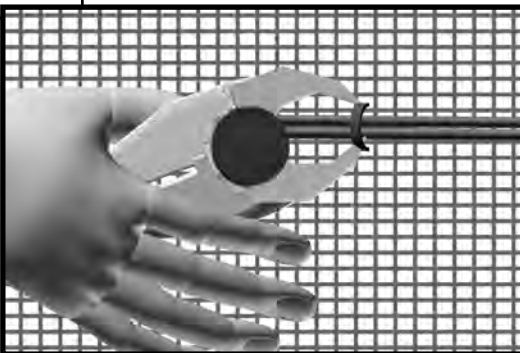
Fix a second set of support wires on the windward side of the windbreak. These should be located at the same height as the first set of tension wires. Take care not to over-tension the wire.

Starting at one end, tension the windbreak from post to post fixing it to the wooden posts using staples.

8



10



Using suitable pliers attach ring hooks around both sets of tension wires. Fit the hooks as shown in the diagram so that it holds the windbreak between the two sets of tension wires. Fit ring hooks at 40 cm intervals along the tension wires or cable ties. Fasten to end posts on windy sites. Thread a thin metal rod through the holes in the fabric and fasten this by cable ties to the metal post.

Capatex **CA125** can be fastened by this method.