Out of Season
Strawberry Production
Under Polythene

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Agriculture and Food Development Authority

Out of Season Strawberry Production Under Polythene

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INTRODUCTION

Out of season production of strawberries in walk-in-polythene tunnels is relatively new. It was first introduced in the Netherlands during the late 1980's. The objective was to provide an alternative source of income for the field strawberry producer. Although, the strawberry was here-to-fore seen as a mid-summer fruit, the availability at earlier and later periods of the season proved popular with the consumer.

Investigations in out of season strawberry production under polythene were started at the Soft Fruit and Beekeeping Research Centre, Clonroche in 1988. As a result of these investigations a system of production based on structure and container types, times of planting, nutrition and varieties have been developed. This is an account of our present state of knowledge. However, because the system is new, further technological advances will ensue in the years ahead.

There is an ever increasing demand by the consumer for wholesome, health-giving chemical-free fruit. EU and national legislation is narrowing the range of chemicals which can be used in strawberry production. In the future the emphasis will be on crops produced from runners in soil-less culture and on a short season of production where few or no chemicals are used.

Investigations at Clonroche have shown that a six to eight month crop is less vulnerable to disease and pest attack. Less fungicides, pesticides and fertilisers are required and the crop is less costly to produce and is therefore more profitable. Reducing the length of season of production also provides the opportunity to produce two crops per season using Elsanta or everbearing varieties. The two crop system allows the grower to recover the cost of the structure more quickly and to improve his income.

STRUCTURES

Five structure types are used for out-of-season strawberry production. These are:

- Walk-in tunnels
- Spanish tunnels
- Mobile tunnels
- Cloches or low tunnels
- Float film

Walk-in tunnels

Spanish tunnels

Mobile tunnels

Cloches or low tunnels

Float film

The period over which fruit is harvested under each of these structures is shown in Table 1. The dates of harvesting are approximate and vary from year to year according to the climate. When the weather is dull and cold harvesting is delayed by 5-10 days. Cloches have been in use for early production for many decades. Mobile tunnels were introduced in 1987. Production in walk-in tunnels began at Clonroche in 1988. Production under float film was first investigated in 1989. Spanish tunnels were first evaluated in 1998 and the information available is of a preliminary nature.

Table 1: Structures used for different production periods at Clonroche.

Structure	Period
Walk-in tunnels	May 5th - June 20th
Spanish tunnels	May 30th - July 7th
Mobiles	May 25th - July 4th
Cloches (Low tunnels)	June 1st - July 6th
Float film	June 3rd - July 8th
Field	June 18th - July 18th
Walk-in tunnels	July 19th - November 15th

Production Under Polythene

Production under polythene has many advantages. The type of advantage gained is dependent on the system chosen. These advantages are outlined in Table 2 and explained below.

Table 2: The advantages of strawberry production under protection.

Advantage	Walk- in Tunnels	Mobile +M	Mobile -M	Cloche +M	Cloche -M	Float Film +M	Float Film -M	Spanish Tunnels
Protection From Wind	+ + +	+ +	+ +	+ +	+ +	+	+	++
Protection From Rain	+ + +	+ +	+ +	+ +	+ +	+	+	++
Increased Temperature	+	+	+	+	+	+	+	+
Early Ripening	+ + +	+ +	+ +	+	+	+	+	++
Improved Quality	+ + +	+ +	+ +	+	+	+		+++
Reduced Chemical Inputs	+	+	-	+	-	+	-	+
Increased Yield/ Unit	+ + +	+ +	+	+ +	+	+ +	+	+ +
Protection for Pickers	+ +	+	+	-	-	-	-	++
Eye Level Picking	+	-	-	-	-	-	-	+

+++ Excellent ++ Good + Moderate - None

+ M Mulched with black polythene - M Not Mulched

Protection from wind and rain

Crops in walk-in tunnels are under permanent cover and receive all year around protection form wind and rain. Crops under Spanish tunnels, mobiles, cloches and float film are unprotected over the winter. These are covered from late February to mid-March onwards and are protected during the critical flowering and fruiting periods. Spanish tunnels have opened sides and provide only limited protection from wind. In windy weather the polythene cover is pushed upwards towards the apex of the ridge. When storms are forecast the polythene cover is folded down into the alleys between the tunnel spans.

Walk-in tunnel gives 10 years protection

Temperature and early ripening

All covered crops benefit from increases in temperature and ripening is earlier in all cases compared with the field crop. With polythene structures a high volume to surface area ratio results in smaller extremes in temperature. Cloches have a low volume to surface area ratio. Temperatures can build up rapidly under cloches during flowering.

Unless the polythene cover is removed under strong sun: pollination, fruit set and yield may be reduced. The risk of damage due to late frost is also greater under cloches. Conversely the volume to surface area ratio of walk-in tunnels is larger. Extremes are less likely to occur and fruit quality and yield are superior compared with mobiles and cloches.

Spanish tunnels are well ventilated and there is little risk of temperature build-up under these structure types. Temperatures are lower than average compared to walk-in or mobile tunnels and for this reason the date of harvest can be delayed by several weeks compared with walk-in tunnels and several days compared with mobiles.

Quality and reduced chemical inputs

Strawberries grown on suspended shelves or table tops do not make contact with cold soil so that the fruit ripens more uniformly. There is less moisture on the surface of the fruit and the risk of disease infection is reduced. Less chemicals are used. Herbicides are unnecessary. Lesser amounts of pesticides are required. Chemical inputs are also reduced when black polythene mulch is used under mobiles, cloches and float film. Shortening the period between planting and final harvest reduces the need for application of chemicals thus improving quality and reducing costs.

Increased yield per unit area.

With field grown strawberries the plant density is approximately three plants per m^2. The density under mobiles and cloches is increased to 6 plants per m^2. The density in walk-in tunnels is 9 to 12 plants/m^2. These higher plant densities give larger yields under cloches, mobiles, walk-in tunnels and Spanish tunnels. The density under Spanish tunnels is dependent on the system used. Over beds the density is 3 to 6 plants/m^2. Over tabletops the density is 9 to 12 plants/m^2.

Spanish tunnels (above) and mobile tunnel (below) give seasonal protection

Protection for pickers and ease of picking

Under protection pickers will harvest up to 30% faster than in the field. Pickers receive protection from the weather in walk-in tunnels, under mobiles and under Spanish tunnels. In these cases harvesting can proceed independent of the weather. When table tops are used the fruit is at eye level and because of the better visibility less damage is caused and the fruit quality is improved.

Mobile Tunnel

STRUCTURE COSTS

The cost of the different structures used for out of season strawberry production are given in Table 3. These are approximate basic costs and include VAT. Costs will vary depending on the source of the materials, hoop spacing, diameter and gauge of steel and extras purchased.

The capital cost of walk -in tunnels is large but the plant density in walk- in tunnels is 50 to 100 per cent greater than under cloches, float film, or mobile tunnels. When depreciated over time the extra cost of production is small. The cost of the supports for pots or modules are not included in the overall costs of the walk-in tunnels. These costs are shown in Table 4, page 21.

Mobile tunnels are re-erected annually and this adds considerably to the labour costs involved in production under mobiles. Mobiles are constructed over 3 to 5 drills of plants spaced at 0.85m centres or over 2 to 3 beds spaced at 1.5m centres. Cloches are erected over individual drills or beds and labour costs are high. Labour costs for the application of float film is relatively low. One sheet of standard width will cover 11 drills or 6-7 beds of plants.

Strawberries can be grown in modules, pots and trays

*Table 3: **Cost of different structures for out of season production.***

Structure	Cost/m^2 (£)
Walk-in tunnels	
9m x 30m double clad with motorised opening roof	31.00
7m x 35m single clad with side vents	7.98 - 14.50
9m x 35m single clad with roof vents	7.99 - 17.48
Spanish tunnels	
Span 6.5m x 40m	2.70 - 3.11
Mobile tunnels	
4 .5m x 36m	5.50 - 11.98
Cloches	0.63 - 1.06
Float film	0.42

Polythene Cladding

All polythene houses are supplied with 5-year polythene cladding. The gauge of cladding used is 600-800 gauge polythene.

WALK - IN TUNNELS

Production in walk-in tunnels is the most expensive of the four options for out of season production but has given the best financial returns. When considering the purchase of a walk-in tunnel the following should be taken into account.

Size and shape: The tunnel should be at least 7m wide and 3.5m high. With smaller tunnels head room especially at either side is limited and ease of movement is curtailed. The tunnel should be at least 30m long. Some modern tunnels have straight sides for approximately one metre from ground level and this adds to manoeuvrability within the tunnel.

Walk-in tunnel - heavy gauge steel

The greater the height to the arch the larger the ratio of the volume to surface area and the more stable the temperature and humidity within the tunnel. Increasing the height also increases the risk of wind damage.

Strength: Wind speed in Ireland is well above the European average and tunnel strength is of vital importance. Galvanised 50mm or 60mm hoops spaced at 1-1.5 metres apart are used. The risk of wind damage is much reduced when the polythene sheeting is adequately tensioned. In sheltered locations, galvanised 40mm hoops spaced at 1.5m have withstood wind speeds of up to 85 mph successfully. In the more modern tunnels the polythene is reinforced by steel wire and heavy gauge polythene bands.

Ventilation: Good ventilation is crucial to reduce the risk of temperature build-up in strong sunshine and to prevent the build-up of high relative humidity and disease infection. There are two options with regard to ventilation; side ventilation and roof ventilation. Roof ventilation makes rapid temperature control in warm weather possible but unless carefully controlled leads to lower temperatures within the house and this can delay maturity. With side vents the temperature in the section of the tunnel above the vents is reduced but at a slower rate than at below vent level.

Generally, the temperature within the tunnel at the level of the plants remains slightly above that of a tunnel with roof ventilation and fruit production may be 1-2 days earlier. Thermostatically controlled ventilation systems are available and should be considered at least in the long term. Ventilation and air movement is enhanced when multispan tunnels are used.

SPANISH TUNNELS

Spanish tunnels are multispan polythene structures which were developed in the Mediterranean region of Europe for the production of protected strawberry crops. Approximately 7000 ha are used for strawberry production in the Naples region of Italy and 5000 ha are used for strawberry production near Malaga in southern Spain. Approximately 250 hectares of strawberries are grown under similar tunnels in the south of Portugal. This particular design of tunnel was up to recently used only in these countries. For this reason the Spanish tunnel may more correctly be described a Mediterranean type tunnel.

The Spanish tunnel is a low cost structure which is placed over beds or tabletops used for the production of strawberries. The cost of the basic structure is low at £3.00/m^2. The low cost/m^2 is achieved by using light gauge narrow bore (3-3.5cm) steel uprights and hoops. The uprights are fitted with 3.5cm Y pieces into which are inserted the 3cm diameter steel hoops. The uprights with hoops are spaced at 2.2m apart. The multispan design increases the strength of the structure.

The light framework and wide hoop spacing together with the multispan design combine to reduce the cost while incorporating the extra strength. The uprights are fitted at the base with a 12cm diameter auger blade. The upright is rotated until the soil is penetrated to a depth of approximately 75cm over table tops and 50cm over beds. Units with a large number of spans provide a greater degree of mutual support. In Italy and Spain units with up to 30 spans are used.

Spanish tunnel made of lightweight steel

Venting

The structure can withstand moderate to strong winds. When very strong winds are forecast a venting tool is used to push the polythene upwards along the hoop towards the ridge to prevent damage to the cladding. The stronger the wind, the greater is the venting need. The tunnel ends are braced and tensioned using leg struts and clamps. The sides and ends of each unit are opened and this allows moving air to filter through so that strong wind pressures against the structures does not occur.

Ropes are used to secure the polythene and reduce wind flap and abrasion. The roping operation requires considerable skill and practice. The proper rope tension must be used to secure the polythene and this should be checked at regular intervals. Average wind speeds in Ireland are higher than those in southern Europe and the polythene cladding should be well secured when strong winds are forecast during the growing season. The cladding is removed and tied down in the alleyways between the spans when harvesting is completed.

For strawberries, production on tabletops is the least labour intensive option because it reduces the need to move the structures from one crop to another. With this system the growing medium is replaced each year and the build up of pests and diseases in the soil is avoided. The necessity for soil sterilisation is removed. The Spanish tunnel can also be used as a mobile moving the protection from one crop to another each year or biennially. A greater labour input is required but progress is fast when the team is well trained. A skilled group of 7 to 8 people can cover 0.8 ha of crop in one day.

The incidence of disease is reduced due to the excellent ventilation and the drier conditions in the tunnel. The date of harvesting is later than under conventional walk-in tunnels. Spanish tunnels are suitable for the production of a spring forced strawberry crop in May and June followed by an autumn crop of Elsanta or everbearers for August to November production. These crops can be fully

protected for the full growing season. Spanish tunnels are less suitable for 60 day production. The overwintered crop may be subjected to rain, frost and wind damage at times when the crop is uncovered during the winter. With tabletops the planting density used for Spanish tunnels is similar to that used in walk-in tunnels, i.e. 9-12 plants/m^2. With beds the standard density of 3-5 plant/m^2 is used. Crop nutrition is by fertigation using a drip-irrigation system.

Spanish tunnels should not be treated as an alternative to walk-in or mobile tunnels. The harvest under Spanish tunnels is later than under walk-in or mobile tunnels but the capital cost is less. Production under Spanish tunnels should be treated as successional to and complementary to production in walk-in and mobile tunnels.

MOBILE TUNNELS

Mobile tunnels are movable structures 4-5.5m in width which are built over strawberry crops in spring time to induce early fruit production. The tunnel length may be fixed to suit the location but should not exceed 50m. Temperature and relative humidity differentials show large increases with values being highest at the mid-point of the tunnel when the length exceeds 50m. Ventilation in the mid-morning reduces temperature and humidity build-up at the mid-point of the tunnel from mid-March onwards.

The height of the tunnel at the ridge apex has an influence on the ease of construction and on the yield and quality of the fruit. Tunnels with an apex height of 2.0 to 2.2m can be rapidly assembled as the ridge is accessible from the ground. Tunnels with an apex height of 2.3 - 2.6m are less rapidly assembled as the ridge may not be accessible from the ground and it may be necessary to use stools or step ladders during construction. During clear, dry, sunny weather in late March and April temperature control is more difficult in tunnels with a low ridge apex. High temperature during fruit set can reduce the yield and quality of the fruit in tunnels with a low ridge apex.

Investigations with time of covering have shown that the erection of the tunnel over the crop in early March has given early fruit yields comparable to those with crops covered in early and mid-February but delaying covering until mid-March or later has reduced earliness and yield. The tunnels should not be erected over the crop until early March as this reduces the risk of damage from storms which often occur in February.

Planting density

Crops grown under mobile tunnels are planted at 20cm apart in drills spaced at 85cm centres to give 6 plants/m^2 or are planted in double rows at 20cm apart on 1.0m beds covered with black polythene. The beds are spaced at 1.5m centres to give a density of 7 plants/m^2. Mobile tunnels are manufactured in varying widths and the tunnel width which is most suitable for the arrangement of drills or beds should be selected. Three beds or four drills are covered by a 4m wide tunnel. Four beds or six drills are covered by a 5.5m wide tunnel. Irrigation is applied by lines which are placed underneath the polythene cover. Liquid feed is applied through the irrigation lines.

At a density of 6 plants/ m^2 the cost/plant of liquid feeding at equivalent nutrient rates and at current prices is slightly less than that of broadcast fertiliser. Liquid feeding is a more flexible option in that the amounts of nutrients applied can be adjusted to the needs of the plant at the different stages of growth.

Crop yield

Planting for production in mobile tunnels is carried out using cold stored runners field planted during the period May to July or using current season runners lifted from the field during August to October. With cold stored runners a small crop may be harvested in the autumn. The revenue from this crop is used by the grower to cover the cost of the plants and the planting costs. A second crop is harvested from these plants in late May to July of the following year. Alternatively the plants may be deblossomed in the autumn and a full crop is harvested in late May to July. The harvesting of an

autumn and an early summer crop does not result in a larger yield per plant but yield is approximately similar to a full early summer crop. When large cold stored runners (15 mm+) are used the yield from those is 400-500g/plant. When field lifted runners are planted during the August to October period the yield in the following summer is 200 to 300 g/plant.

Although the cost/m^2 of mobile tunnels is low compared to that of walk-in tunnels the labour costs involved in erection and dismantling and the wear and tear and soiling of the polythene add considerably to the overall costs. Mobile tunnels are used in combination with walk-in tunnels in a successional strawberry production programme and are not treated as an alternative to walk-in tunnel production. Fruit production in mobile tunnels occurs 2-3 weeks later than in walk-in tunnels. Occasionally, when the early spring is extremely cold and the late spring has above average temperatures the production period in walk-in tunnels may be only marginally earlier than that of the mobile tunnels. This has occurred one year in eight at Clonroche.

When harvesting is completed the mobile tunnel is removed from the crop. Mobile tunnels are not placed over the same crop in the second year of production but are used over crops which were newly planted in the previous summer or autumn. In the second year of production the crowns are very large and each alternate plant is removed. This gives a spacing of 40cm between the plants and a density of three plants/m^2. Failure to reduce the density will result in competition between the plants and reduced fruit yields, fruit size and quality.

Frost can damage the flowers and fruit of the strawberry

LOW TUNNELS (Cloches)

Low tunnels (cloches) are movable structures which are built over strawberry crops in springtime to induce early fruit production. The tunnels are used to cover individual drills or beds. Low tunnels are 45cm to 100cm in height and are of varying widths depending on the width of the drill or bed to be covered.

The polythene cladding is supported by steel wire hoops which are placed at 1.0m apart over the drills or beds. Specialised equipment is available to enable the grower to manufacture the hoops. The polythene cladding is tensioned by polypropylene cord which is drawn over the cladding and fixed to eyelets at the base of each hoop.

From mid-March onwards ventilation is given in sunny weather by lifting the cladding from the surface of the soil to a height of 20-30cm. The increased ventilation reduces the risk of temperature build-up and damage to the foliage and flowers. This operation when required on a regular basis is labour intensive. The method of planting, irrigation and nutrition is similar to that used for cropping in mobile tunnels. Date of covering over the crop is also similar. During flowering ventilation is given daily to encourage fruit set. The polythene cladding is removed at the end of harvest. Alternate plants are removed in the autumn and the crop is left uncovered in the following year to be harvested as a main crop in the field.

FLOAT FILM

Float film is a perforated polythene film which is drawn over the crop during late February or early March in order to induce early fruit production. Production under float film is several days later than under low tunnels. The installation of irrigation is not essential for production under float film. Rain water percolates through the perforations in the film and in most seasons this source supply is sufficient for satisfactory crop growth.

The labour cost involved in production under float film is low. Due to the perforations the temperature build up under the float film is small and removal of the polythene from above the crop is not necessary until the beginning of harvest. Good shelter is essential for production under float film. When shelter is poor wind flap can cause severe damage to the foliage and flowers. For this reason the use of float film for large scale production of strawberries is not possible unless the site is very well sheltered.

The time of covering with float film is similar to that of mobile or low tunnels. The more dense planting (6-7 plants/m^2) is not necessary to justify the use of float film on an economic basis and very often float film is used to protect a field crop planted at the standard spacing of 40cm in the row located in a well sheltered area of the plantation.

METHODS OF PRODUCTION

Traditionally strawberries in walk-in tunnels were grown for the fresh market on drills or on raised soil beds mulched with black polythene. This method of production resulted in the build up of soil borne diseases in the crop making frequent applications of chemicals necessary. In the last 10 years or so production in pots, troughs, trays and modules has been introduced. Production in these containers has several advantages:

- The use of herbicides and soil sterilants is discontinued resulting in more environmentally friendly production and reduced chemical inputs.
- Soil borne pests and diseases are eliminated.
- Eye level harvesting leads to better fruit quality and cheaper picking.
- The introduction of drip fertigation systems results in better control of irrigation and nutrition.
- The use of pots, troughs, trays and modules (peat bags) enables growers to produce more than one crop in one season.

There are also some disadvantages:

(a) The introduction of supports for pots and modules adds to the capital costs.
(b) A higher level of skill is required for production in containers under protection.

On the basis of experience the advantages of production in containers in walk-in tunnels out weighs the disadvantages. In this publication the production system used in walk-in and Spanish tunnels are pots, troughs, trays or modules. The production system used under mobile tunnels, cloches and float film are beds or drills. Beds and drills are also used under Spanish tunnels.

CROP SUPPORT SYSTEMS

In walk-in tunnels the plants are containerised in pots, troughs, trays or in modules and the supports for the containers are additional to the cost of the structure. Since the structure costs are more or less fixed it is important that the costs of the supports are kept to a minimum. The containers can be supported in two ways, i.e. by:

Roof supports: Uprights which support rows of bars placed along the length of the house on cross tie supports within the house. The weight of pots or modules within a 300m^2 house is approximately 3.5 tonnes (12kg/m^2)and the uprights must be designed to support this weight.

Methods of support

Steel shelves

Wooden shelves

Hanging pots

Ground supports: Due to the high cost of supporting the superstructure alternative methods of support have been investigated. The cost of these supports is shown in Table 4.

Fixture in concrete: An alternative method to the use of uprights is to countersink the hoop ends of the structure in concrete. The use of concrete prevents splaying of the hoop ends under the weight of the containers and avoids roof collapse. The overall cost is similar to the cost of uprights but freedom of movement within the house is greater due to the absence of the uprights. In less stable soils a greater amount of concrete will be required and this will add to the cost.

Costs are normally depreciated over the life of the item costed. The life of the 70 x 50mm timber supports is an approximation. Costs will alter from time to time and are approximate. Only material costs are given. Labour costs are not included. Other types of supports include standard high tensile wire with tubular steel, suspended shelves and large plastic ducts which are adapted to hold pots, troughs, trays or modules.

All steel support system

It is anticipated that EU legislation will in future require collection and filtration of run-off from pots and modules to remove plant nutrients and to reduce the risk of environmental pollution. This will add to the cost of production.

Steel and wood combination support system

Table 4: Cost of supports for strawberry containers in walk-in tunnels.

Support type	Containers	Type	Cost (£)
Roof supports:			
60mm uprights under cross ties	Pots/modules/trays	Permanent	5.72
Hoop ends in concrete	Pots/modules/trays	Permanent	5.73
Ground supports:			
60mm tubular steel	Pots/ modules/trays	Permanent	5.71
30mm tubular steel	Pots/ modules/trays	Permanent	3.14
70' x 50mm timber	Pots/trays/modules	10 years	3.28
Straw bales (Not Wrapped)	Pots/modules	1 year	0.80
Straw bales (Wrapped)	Pots/modules	4 years	0.40

CONTAINERS

The main types of containers being used for strawberry production are pots, troughs, tray containers and modules (peat bags). Pots have a 5 litre (l) capacity. Modules are made in various sizes; 10 l, 18 l, 20 l, 30 l, and 40 l. The 20 - 30 l size is generally preferred for ease of handling. The standard tray container or trough has a capacity of 9 l. The density of plants which is generally recommended is 9 - 12 plants/m^2 of graded runners or 6 plants/m^2 of multicrown plants. Normally graded runners are used. The cost/plant using 5 l pots, trays and modules is given in Table 5. Most growers favour production in modules.

Table 5: The cost per plant of pots and modules.

Container type		Cost/m^2 (£)
5 l pots		0.25
Peat bags/modules	10 l, 20 l, 40 l	0.22
9 l tray containers		0.24

Production in 5 l pots, troughs and tray containers is more labour intensive than production in modules. The modules are ready for planting on delivery but the pots and trays must be filled manually. Some smaller growers find it convenient to produce in pots but the use of modules is more practical for larger producers who must complete the planting programme within a limited time scale. With modules, troughs and trays 2 - 3 fertigation drip units are inserted per module or tray but only one drip unit is inserted per pot. When blockages occur wilting is less likely in modules, troughs or trays due to the presence of several drip units. Pots, troughs and trays are re usable but modules must be disposed of when cropping is completed. Disposal of modules can become a problem especially for larger growers.

PLANTING MATERIAL

In Europe and the United States some virus and fungal diseases which have not been recorded in Ireland and the UK are endemic and plant material from these sources may be infected. When available, planting material should be sourced in Ireland or the UK to avoid importing these diseases.

Graded runners which are certified as disease and virus free are recommended for production in walk-in tunnels. The peat compost which is used for production in pots and modules is more or less free of disease organisms at delivery and the use of infected plants will result in the rapid spread of root diseases in the peat.

The various companies who market runners for production under polythene supply a range of grades and categories of planting materials. These include small, medium and large runners, single crown or multicrown plants and waiting bed plants

Large runners give large yields of good quality fruit

which are harvested in August to November and cold stored until planted. The various grades of runners are based on crown diameter but these grades are not standardised by regulations and the various commercial producers have a variety of methods for standardising the grades.

The yield of fruit obtained is dependent on the crown diameter of the runner at planting. The yields obtained with different runner grades of Elsanta planted in December to January at Clonroche are given in Table 6. The most commonly used runner grades have a crown diameter of 13mm + or 15mm +. Although multi crown and waiting bed plants give a large yield the average fruit size is smaller and the amount of grade II fruit produced is larger.

Table 6: Yields from different runner and plant grades.

Crown diameter	Yield (g/plant)
< 8 mm	125
8 - 10 mm	180
10 - 12 mm	275
13 - 15 mm	340
15 - 18 mm	476
18 mm + – Single crown	480
18 mm + – Multicrown	500
Waiting bed plants	521

PLANTING DENSITY

The planting density used is determined by the grade of runner. The 13-15mm graded runner is planted at a density of 11-12 plants per m^2. The 15-18mm plants are planted at a density of 9-10 plants per m^2 . The 18mm + plants are planted at 6-8 plants per m^2 . Closer planting will result in the production of smaller fruit size and an increase in grade II fruit. Varieties other than Elsanta normally require similar spacing. Some require a larger or smaller density for optimum yield and quality and this should be checked before planting.

METHOD OF PLANTING

Planting tool

Method of planting has an important influence on the fruit yield. Due to the high plant density it can be difficult to apply the correct planting method. There are several important guidelines which must be followed:

- The plant root should be placed in a straight downward position in the soil and the root tip should be bottommost in the container. Upturned root tips can cause death of the plant. Large runners and crown plants are more difficult to plant correctly than small runners. The correct method of planting is more difficult to achieve in modules than in pots or trays.

Planting tool is placed over the root tip

- The crown of the plant should be positioned just above soil level. Too deep planting may result in disease infection. The upper part of the root should be covered. Shallow planting may result in the plant being pushed upward from the compost when root growth begins. When planting, allowance should be made for settlement of the compost.

Runners is pushed down into module

- The compost should be pressed firmly about the plant root but excessive firmness should be avoided. More firm planting is required in coarse grade than in fine or medium grade peat.

- Planting tools for strawberries in modules are available and these should be used especially by those who are not skilled in planting in pots, trays and modules. The correct use of the tool can be demonstrated by an experienced person.

Planting in trays is easier

VARIETIES

There are two types of varieties used for out of season strawberry production. These are:

- June bearing varieties which require exposure to cold for some time in order to develop flower initials and produce good fruit yields.
- Everbearing or day neutral varieties which will continue to produce flowers and fruit throughout the season.

Elsanta is the most popular strawberry variety

Until recently all varieties grown in Ireland were June bearing varieties. Everbearing varieties were first introduced to Ireland about 12 years ago and only a limited amount are grown at present.

JUNE BEARING VARIETIES

These include the older varieties such as Royal Sovereign, Talisman, Huxley Giant, Gorella, Cambridge Favourite, Cambridge Vigour and Red Gauntlet. The newer varieties include Elsanta, Honeoye, Korona, Bagota, Pegasus, Totem, Pajaro, Melody, Tamella, Symphony, Kent, Polka, Elvira.

Elsanta has a large firm fruit

Elsanta is the most popular variety on the north-west European market due to its large fruit size, good fruit shape, attractive colour, good taste and long shelf life. The main weakness of this variety is its low level of

Elsanta is a heavy yielding variety

resistance to soil borne diseases. It is a heavy yielding variety. Due to the large fruit size and the firm flesh it is easily harvested and the output of the pickers is increased. Due to its popularity it is used as the main variety in all the out-of-season production programmes.

The variety Honeoye can produce fruit 5 to 7 days earlier than Elsanta and sells well on the market during this period. However as harvesting progresses the fruit colour darkens and this may affect its market value. Other varieties which have been assessed have not proved to be superior to Elsanta at Clonroche but can be used for slightly earlier and slightly later production. These include Emily (very early), Eros (mid-season), Florence (late) and Sophie (very late).

EVERBEARING VARIETIES

The first of the everbearing varieties which were introduced to Ireland were Selva and Rapella. The everbearing varieties Calypso and Tango were introduced in 1993. Evita was introduced in 1994 and Bolero was introduced in 1996. Everest is a new variety which was introduced in 1998. Everbearing varieties have had lower fruit yields and smaller fruit compared with Elsanta but the quality and yield of the more recently introduced varieties has improved.

Everbearing strawberry varieties are used exclusively for late season production in walk-in tunnels. Everbearing varieties are ideally suited for this purpose because the fruiting date can be determined in advance by removing the flowers until six weeks before the crop is required.

Six varieties; Selva, Rapella, Calypso, Tango, Evita and Bolero have been evaluated. The variety Rapella lacks firmness and is a poor keeper. The quality, taste, size, colour and shelf life is good but the yield is low and taste deteriorates in the later crops. Tango and Calypso have given good yields but fruit size is small particularly later in the season. In the most recent trials Evita and Bolero have given the largest yields and the best quality fruit.

COLD STORAGE FACILITIES

The provision of cold storage facilities is expensive and is not an economic option for most individual producers but it can be organised on a co-operative basis through group schemes. Cold storage facilities are used for the following purposes:

(1) To keep fruit in a marketable condition after harvest.

(2) To store bought in cold stored and fresh dug plants temporarily before planting up.

(3) Vernalization (cold treatment or chilling) of field dug graded runners to maximise quality and yield in the following spring.

Extending the season of production increases the cost of cold storage. Operational costs can be reduced by arranging for the delivery of cold stored material closer to the time of planting.

Large cold stored Elsanta give the best growth and yield

Insufficient winter chilling reduces yield and quality

CHILLING

Elsanta and other June bearing strawberry varieties require a period of low temperature in order to produce satisfactory fruit yields. In field crops this period of chilling occurs from the beginning of October to the end of March. Elsanta requires an accumulated total of 1000 cold units during this period to produce a full crop. (One cold unit = 1° below 7°C).

In some years the accumulative cold units do not exceed 700 in the open (Table 7) and cold stored rather than freshly dug runners should be used to guarantee a full crop. Cold storage at 2°C for 21 days is required for Elsanta. The temperature should not be allowed to drop below 1°C or exceed 2°C, otherwise the plant may be damaged or the cold treatment will not be fully effective

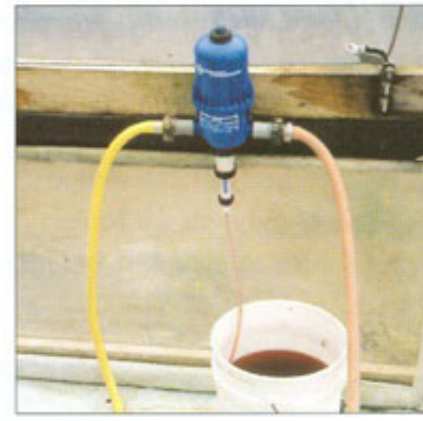
Table 7: Accumulated cold units (<7°C) at Clonroche.

YEAR	Cold units (°C)
1990 - 1991	829
1991 - 1992	546
1992 - 1993	735
1993 - 1994	787
1994 - 1995	635
1995 - 1996	689
1996 - 1997	700
1997 - 1998	611

IRRIGATION

Irrigation is given to containerised strawberries in walk-in tunnels primarily to supply moisture and plant nutrients to the crop. When used for the application of plant nutrients it is often described as fertigation. Fungicides may be applied through the irrigation system to control soil borne diseases. Runners and other planting material should be planted into a growing medium which has been watered to full container capacity. The quantity of irrigation given is dependent on the time of year and the growth of the plants.

Elsanta planted in December or January and watered to field capacity will not require further irrigation until approximately 3 weeks later. At that time approximately 180cc/ plant will be required to bring the compost to container capacity. Further irrigation of 270cc is required over the following three weeks. From early March when strong growth begins 150-200cc per plant is applied at approximately 5-7 day intervals. In April nutrients are included in the irrigation water when the fruit is set. During the rest of the season 300-400cc per plant is applied at 3-5 day intervals.



Irrigation and nutrients are essential under polythene

CROPPING PROGRAMMES

Growing strawberries in walk-in tunnels is a high cost method of production. Production must be confined to the period during which the returns are at a maximum to make the operation profitable.

The period of most profitable production is at the beginning and end of the season, i.e. late April to early June and August to November. Suitable cropping programmes which maximise returns and minimise costs need to be developed for this period. At Clonroche three cropping programmes have been developed. These are:

Programme 1.
Spring forced Elsanta and Everbearers.

A two crop system based on:

(a) December/January planting of a spring forced Elsanta crop using:-
  (i) Large cold stored Elsanta runners (15mm+) for cropping in May and June.
  (ii) Large cold stored waiting bed Elsanta plants.

(b) January to April planting of everbearers for cropping from mid-August to mid-November.

Programme 2.
Spring forced and summer planted Elsanta.

A two crop system based on:

(a) December/January planting of large (15mm+) cold stored Elsanta runners for cropping from May to July.

(b) June or July planting of large cold stored waiting bed Elsanta plants for cropping in August or September.

Honeoye and Emily produce fruit 3-7 days ahead of Elsanta

Programme 3. Double cropping sixty day Elsanta.

A single crop system based on:

(a) June/July planting of large (15mm+) cold stored Elsanta runners for cropping in August and September.

(b) Over wintering of the once cropped plants and removal of a second harvest from late April to July.

PROGRAMME 1

Elsanta is planted up from mid-December to mid-January in peat modules, pots or trays and is placed immediately after planting in the tunnel on tabletops or suspended shelves. Early planting results in larger yields (Table 8). Cold stored plants are recommended.

Table 8: Effect of time of planting on yield of Elsanta in walk-in tunnels.

Date of Planting	Yield (g/plant)	
	Runners (15mm+)	Waiting bed plants
28 December	342	504
18 February	254	390

Fresh plants can be used but when these are produced in frost free regions additional vernalization may be required. Large runners (15mm+) give good yields of top grade fruits. Waiting bed plants give larger yields but although the yield of top grade fruit may exceed that of the 15mm+ runners the production of second grade fruit is higher. Waiting bed plants are less available than 15mm runners and must be put on order early. The plants are removed from the tunnel and discarded in early July.

The everbearing varieties are planted up between January and April and are placed outside until the house is cleared of Elsanta in July. Time of planting is also important for everbearers. Yields are reduced when planting is delayed until after the month of April (Table 9). Flowering begins when the plants are stood outside in late April. The flowers are removed from the plants until six weeks before the planned cropping date. This coincides with the removal

of the Elsanta crop and the introduction of the everbearers into the tunnel. The everbearers are cropped from mid-August to mid-November.

Table 9: Effect of time of planting on the yield of everbearers in walk-in tunnels

Date of Planting	Yield (g/plant)			
	Tango	Selva	Rapella	Calypso
January	289.2	241.4	272.7	264.2
April	269.2	182.9	254.8	196.6
July	306.1	132.2	206.2	92.5

The yield of everbearers is also influenced by runner type and fertigation. Plug plants fertigated from March onwards have given larger yields than bare rooted types due to more rapid establishment and growth (Table 10.).

Table 10: Effect of runner type on yield of everbearing strawberries

Runner type	First Fertigation	Variety		
		Tango	Selva	Calypso
Cold stored plug plants	March 15	474.6	376.6	301.6
Cold stored runners	April 7	392.4	279.6	235.5

Planting density is determined by the grade of runner. Typical planting density - four runners per pot, 11 runners per module

PROGRAMME 2.

The time of planting and the grade of runner used in this programme is similar to that used for December/January planting of Elsanta in Programme 1. Fruit is ready for harvest in May and June. The second planting is carried out in early to late June using cold stored mother plants. The type of plant used and the time of planting affects yield and quality (Table 11). Early to mid-June planting gives the largest yield of fruit which is harvested during August and early September. Mid to late June planting gives a smaller yield but the crop is more valuable due to the later time of maturity.

Table 11: The effect of plant type and time of planting on the fruit yield of Elsanta.

Plant Type	Planting Date		
	June 10	June 20	June 30
Multicrown mother plant	230	259	-
Single crown mother plant	187	227	154

The larger the plant the greater the yield. However multicrown plants produce large numbers of flowers and the fruit is smaller especially later on in the season. Mother plants deteriorate rapidly in cold store after the third week in June and planting should be carried out before that date to avoid plant losses. The plants are discarded after harvesting. The spring crop from multicrown plants is poor and the plants are disgarded after the autumn harvest is completed.

PROGRAMME 3.

This system of production is commonly described as 60 day cropping. The Elsanta runners are planted in June or early July for cropping in Autumn and again in Spring. Time of planting and grade of runner affects fruit yield in Autumn and Spring. Mid to late June

planting gives a fruit yield of 150 to 250g per plant in August, the larger yield being obtained with 15mm+ runners.

Early July planting of larger runners also gives good yields in September when fruit prices are higher but the yield falls off rapidly with runners planted after mid-July. In most production areas the low temperatures required for chilling may not be achieved within the tunnel. When this occurs fruit yield and fruit size is very much reduced in the early summer crop. Light treatment can be used as a substitute for cold treatment. Light treatment is given by placing 100 watt incandescent lamps at 2m x 5m spacing within the house. The lamps are placed on a time switch to give 15 minutes per hour illumination from 2,300 hours to 600 hours (11 p.m. to 7 a.m.) from mid-February to April. Failure to provide light treatment especially in milder southern areas will result in combined autumn/spring yields of less than 400g/plant. The application of light treatment results in yields of 400 g+/plant.

With the 60 day production system the crop has a life of approximately 12 months and diseases and pests can build-up especially during the winter period. In order to reduce the risk of pest and disease infection larger chemical inputs are required compared with the spring forced crop. The incidence of winter damage is also greater in the 60 day crop.

GROWING MEDIA

Peat is the standard medium, which is used for strawberry production in pots and modules. Base fertiliser and lime is added to the peat to produce a suitable growing medium for strawberries. When 5 l pots, troughs or tray containers are used the peat may be purchased loose and the base fertiliser and lime may be incorporated on site. The growing medium can also be purchased in bulk ready mixed to save time and labour. Special modules suitable for strawberries are supplied by the commercial companies which manufacture the growing media. Pots or trays may be purchased from the appropriate source.

The investigations on growing media at Clonroche have shown that coarse or medium peat grades are the most suitable for strawberry production. Fine peat grades give a lower fruit yield. Home manufactured compost should be thoroughly mixed to ensure uniform distribution of the nutrients through the peat. The peat should be relatively dry (60-70% moisture) when the nutrients are being mixed. Mixing is carried out on a concrete floor or by concrete mixer. The ingredients are listed in Table 12.

Recent investigations on peat/sand mixtures have shown that the inclusion of various grades of grit and sand has no effect on fruit yield but the use of grit can result in earlier ripening of the fruit. Use of grit or sand also improves moisture absorbtion and rewetting. Strawberry modules are supplied with the lime and base fertiliser already incorporated. The commercial companies which supply these modules have specialised equipment for mixing. Growing media thus produced are usually superior to the home produced media.

Picked fruit should be immediately transferred to the cold store to extend shelf life

Table 12: Home manufactured compost mix for strawberries in pots.

Ingredient	Amount
Peat (Coarse or medium grade)	1000 l
Ground mineral limestone	8.0 kg
Osmocote plus (8-9 month) 16:8:12 + 2 Mg O)	1.0 kg

NUTRITION

In spring forced crops the fertiliser which is incorporated in the growing medium is sufficient to provide satisfactory growth up to the flowering and fruit set stage. Thereafter nutrition is given through the irrigation system. Flowering and fruit set takes place in spring forced crops in late March or early April and fertigation begins at this time.

In 60 day crops fertigation is delayed until 2-3 weeks after planting at which time the crop is fully established. In the spring fertigation is resumed when active growth begins in early March. The earlier application is necessary to replace the nutrients which have been used by the autumn crop. A well balanced programme of fertigation is essential for the production of strawberries in walk-in tunnels. Excellent results were obtained with the Kinsealy two tank drip feeding system over the past five years (Table 13). Two separate tanks are required for this system.

Plastic tanks are preferable to steel tanks. When steel tanks are used these should be coated with bitumen or a plastic based paint. Several commercial alternatives have become available in the past few years and three of these, Sangral, Kemira and Hortifeed (Darby Starter) have been evaluated at Clonroche. A 10% solution of each material is diluted at ratios of 1/100 to 1/200 and applied through the fertigation system. The feeds are more convenient to use, but are more expensive than the Kinsealy two tank feed. These commercial feeds are also fed through the drip system.

The strawberry feed should be a total one containing all the essential nutrients but a 1:3 N:K ratio should be maintained. High nitrogen applied during the rapid growth phase can lead to poor pollination, flower abortion and misshapen fruit. Later on the excessive leaf growth may cause shading of fruit, delayed ripening and reduced fruit size. High potassium encourages good fruit set, improves the fruit flavour and gives earlier fruit production.

Table 13: Kinsealy two-tank drip feeding system.

Chemical	kg/100 litres	
	Tank A	Tank B
Potassium nitrate	1.8	1.8
Calcium nitrate	6.0	
Magnesium sulphate		-
Mono-potassium phosphate	-	2.0
Ammonium sulphate	-	0.3
Iron chelate	1-60 cc	-
Trace element solution*	-	1000

*Trace element stock solution	
Chemical	**g/100 l**
Solubor (20% B)	2500
Manganese sulphate	2400
Copper sulphate	800
Zinc sulphate	3474
Ammonium molybdate	92

In the case of Elsanta which is planted in December/January and everbearing varieties which are planted in spring (Programme 1 and 2) fertigation is discontinued at the end of fruit production. In the case of 60 day crops (Programme 3) fertigation is continued after the completion of harvesting. The fertigation regime is altered to a high nitrogen feed (1:1:2 NPK) to encourage strong crown development for the early summer crop.

The response to fertigation is progressively reduced as the day length and temperature decreases and the frequency of fertigation must be progressively reduced also. Continued fertigation of crops into the dormant season will lead to an increase in the salt concentration to toxic levels. The salt concentration (SC) should be checked regularly towards the end of the growing season and it should not be allowed to rise above 200 siemens at any time.

POLLINATION

Pollination with bees is essential for early fruit

The strawberry flower is partly self pollinating and partly cross pollinating. In order to produce the maximum yield of well-shaped good quality fruit the conditions for both types of pollination must be good. To enhance self pollination good air movement and a temperature above 15°C is necessary. For this reason good ventilation is important. Strawberries which produce fruit in May are in full flower in April at a time when pollinating insects are not fully active. The polythene cover prevents good access for pollinating insects also. For satisfactory cross-pollination the insects must be placed within the house or at the entrance. The most common insects species which are introduced to enhance cross pollination are the honeybee and the bumblebee.

Honeybees: Honeybees may be kept by the producer or may be supplied by a beekeeper. The hive is placed at the entrance of the tunnel and is fitted with a double flight board at the front and rear of the hive. One hive with a strong bee colony will pollinate an area of 1000 sq. m. Honeybees are more efficient pollinators than bumblebees causing less damage to the flowers during nectar extraction. They are also less costly to introduce than bumblebees. They require a higher temperature than bumblebees (15°C+) but this is regularly achieved during the flowering period in April.

Bumblebees: Bumblebees are a more expensive method of pollinating strawberry crops. The hives are imported and their use increases the risk of introducing unwanted pests and disease of honeybees into the country. The useful life of a bumblebee hive is limited to 8-10 weeks after which a replacement must be purchased. The damage caused by bumblebees to the various flower parts can increase the number of mishapen fruit at harvest.

Varieties: Elsanta is particularly prone to poor pollination during cold, dull weather and particular attention must be paid to the conditions required for good pollination when this variety is grown.

PESTS AND DISEASES

LEAF AND FRUIT DISEASES

The main leaf and fruit diseases which occur in strawberries under polythene are grey mould (Botrytis) and powdery mildew.

Greymould: Greymould is by far the most common disease of protected strawberries. All crops grown under polythene will incur some level of infection. Infection can be minimised by good cultural practices and a limited chemical spray programme as follows:

1) Good ventilation to promote air movement. In houses with an area of greater than 300m^2 or greater than 50m in length a small fan can be used to create air movement in central parts of the structure.
2) Harvest all fruit when ripe and remove all infected leaf and stem tissue immediately.
3) Apply Rovral as recommended at flowering.

Mildew: Mildew does not occur commonly in early summer strawberry crops. Routine spraying is unnecessary. Crops should be inspected carefully and frequently. Sprays should be applied in the early stages of infection. Infection is much more common in late summer and autumn crops and is most serious in warm, dry weather. The everbearing variety Tango and autumn Elsanta crops are most susceptible. Adequate watering and good ventilation usually provides sufficient control in early summer crops but the application of Nimrod or Systane may be necessary in later crops.

ROOT DISEASES

The common root diseases are Redcore, Crown rot and Verticillium wilt.

Redcore root rot: Redcore attacks the strawberry root causing it to rot. The plants fail to grow and eventually begin to wilt and die. When the infected plant is lifted the roots are dark brown or black. The outer covering of the infected roots are loose and easily

removed showing a red or red-brown internal core.

Crown rot: Crown rot infection occurs in the crown and in the upper roots of the plant causing a brown or red brown discoloration. This disease occurs mainly in protected crops and can build up to a serious level in over wintered crops. It is a less serious disease in spring forced crops.

Verticillium wilt: This disease occurs in the upper roots and lower crown of the plant causing a brown discoloration of the tissue. The older leaves begin to die off as the disease progresses causing a 'halo' effect. Control of root diseases is most easily achieved by purchasing and planting disease free stock. It is important that plants be purchased from a reliable source where plants have been raised in disease free soil. Plug plants are produced in soilless culture and are less likely to be affected by root diseases. Application of Aliette or Ridomil with fertigation or as a drench following harvesting in autumn gives good control of redcore and crown rot.

PESTS

Red spider mite: Red spider mite emerges in spring and colonises the underside of the leaf causing damage by feeding on the sap. Populations build-up rapidly in warm weather. With heavy infestations silvery spots appear on the leaf surface. Later the leaf turns brown and withers. Control is achieved by the application of Childion early in the season and the use of biological control methods when temperatures rise above 15°C. Phytoselius persimilis has given good control at high temperatures. In recent investigations Ambyselius californicus has given better control but is more expensive than Phytoselius.

Aphids: A severe aphid attack can reduce crop vigour and can result in damage to young leaves in the centre of the crown in overwintered crops. Damage is less severe in spring forced crops. Aphids, also transmit Yellow Edge and Crinkle virus diseases but

these are not important in protected strawberries unless the crop is used for propagation. Recommended aphicides can be applied to control aphids in the crop. Biological methods are under investigation.

Vine weevil: Vine weevil is not a problem in spring forced crops. It may build up in modules, pots or troughs in 60 day crops in spring time. Vine weevil can cause severe damage to runners which are replanted in peat infected with vine weevil. The parasitic eelworm heterorabiditis meridis has given good control when applied as a spray or through fertigation at temperatures above 12°C.

CROP MANAGEMENT

Successful crop management involves not alone the routine operations necessary in the day to day care of the crop but also the good husbandry practices such as careful regulation of the nutrition of the crop. For example maintaining a K/N ratio of 3:1 avoids excessive leaf production and shading and delayed ripening of the fruit. Leaves should not be removed. The carbohydrates and sugars that form the fruit are manufactured in the leaves and leaf removal will result in a reduction of fruit yield.

Runners: Runners should be removed in the fruiting crop as soon as possible. Runner development takes place at the expense of fruit production.

Leaves: The leaves can be raised above the fruit trusses by running string along both sides of the pots or modules. String is preferable to wire which damages the leaf petiole more readily. This can lead to more uniform and faster ripening of the fruit, less botrytis and faster picking.

Fruit trusses: The fruit trusses are allowed to hang below the crop rows. Use of supports will result in 'kinking' of the truss stalks and small, unmarketable fruit. When pots or tray containers are used the growing medium should be filled to above the pot rim so that 'kinking' at the pot rim will not occur.

Fertigation: Check the fertigation lines during each watering to make sure that blockages do not occur. Wilting due to lack of water as a result of blockages in the fertigation nozzles is more common in the case of pots as only one nozzle per pot is used. Moisture shortages in peat modules, troughs or trays occurs over a longer period as 2-3 nozzles/bag are used. New improved fertigation systems have been developed in the last few years.

HARVESTING

Skilled pickers are required to achieve grade one fruit

Fruit is best picked in the cool of the evening before going to market or early the next morning. Transport to market is best done early in the morning when the fruit is cool so that it can be delivered in a fresh condition. Handling should be kept to a minimum. The fruit should be graded and placed in the final container during picking. Experienced pickers should be used so that finger marks and other types of damage is minimal. The calyx should be left with the fruit together with 3-5 mm of calyx stalk. When picked the fruit should be placed immediately in cold store. All ripe fruit of all grades should be totally removed during picking. Overripe fruit left on the plants encourages botrytis infection and leads to crop losses.

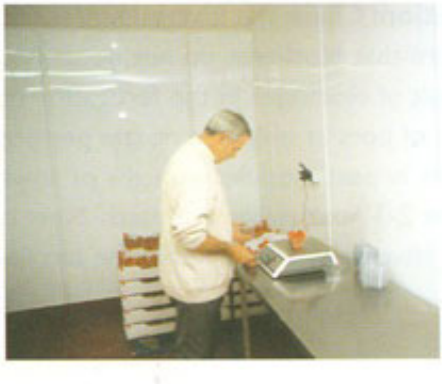
Packhouse

Standards used in the packhouse should conform to those issued by Bord Glas and the local health authorities. The packhouse should be designed in such a way that efficient hygienic packaging can be carried out. There should be easy access to the cold room. Equipment used should comply with the safety standards.

POST HARVEST TREATMENT

Spring forced crops

Elsanta which is planted in December/January and harvested from May to July or everbearers which are planted in February/March and harvested from August to November may be planted in the field after harvest or may



Standards in the packhouse should conform to the An Bord Glas Quality Assurance Scheme.

be discarded. Cropped plants of Elsanta which are field transplanted in July require irrigation for establishment. The yield of marketable fruit from such transplants is not as high as from the standard crop and is hardly justified on an economic basis.

Doubled cropped sixty day plants

Double cropped 60 day plants require careful treatment following removal of the autumn crop so as to achieve a satisfactory fruit yield in the following spring.

- Fertigation should be continued as outlined in the section on nutrition.
- Treatment with an appropriate fungicide is necessary to control crown and root diseases.
- The crop should be checked for the presence of aphids or white fly and treated as recommended.
- The crop should be trimmed and dead foliage removed at the appropriate time.

Trimming: After the autumn harvest the crowns are built up for production in the following spring. Therefore the leaf canopy should be retained for as long as possible to achieve this objective. Trimming of the foliage should be delayed until the leaves begin to die back in mid November. The young green leaves and shoots in the centre of the crowns are left untouched. Damage to this young tissue during removal of the older leaves will result in disease infection and plant death during the winter.

Trimming of the foliage is delayed until dieback in mid-November