Forcing Guide / The Iris

International Flower Bulb Centre

1. Introduction

Origins

The Iris genus belongs to the Iridaceae family, a family which also includes gladiolus, crocus and freesia. With approximately 200 genera, the Iridaceae family is extremely large. All these genera, containing several thousand species, are found in the northern hemisphere.
The name “iris” comes from the Greek meaning “rainbow”, indicating the rainbow of colors found in this genus. People were familiar with the iris even in ancient times; images of iris found in the Egyptian pyramids date back to approximately 1500 B.C.
Areas where Iridaceae are found in the wild include North Africa, Spain, Portugal, the Caucasus, Lebanon and Israel.

Classification

The genus can be divided into rhizomatous and bulbous iris.
The rhizomatous iris are grown as perennial plants in many gardens. Iris germanica, Iris siberica and Iris pseudocaris are the most familiar. The first of these species comes in many colors: white, blue, purple, red-purple, yellow, and in color combinations. Cultivars of the second species are almost all blue, violet, and sometimes white or yellow, while the last species is found only in yellow.
The bulbous iris contains only a small number of groups. For commercial flower production, however, these groups are extremely important. The Reticulata group comprises several dwarf garden species that flower early in the year. Two species in this group are the blue-violet Iris reticulata and the yellow Iris danfordiae. The Xiphium group includes all the Dutch, Spanish and English irises. Of these, the Dutch iris are the most important for flower production.
These Dutch iris include a vast number of cultivars of which ‘Blue Magic’ and ‘Prof. Blaauw’ are the most commonly cultivated. A practical classification of these iris into groups is done by color: purple, blue, white, yellow and white, yellow combined with other colors, and multicolored.

Production programming

As a result of extensive research and production trials, it is now possible to bring iris into flower throughout the year by applying special storage and preparation methods. To achieve good flower yields, a number of conditions relating to, for example, climate and cultivation requirements must be met.
These are described in detail in the following specification for Dutch iris flower production.

2. The greenhouse and its equipment

Greenhouse unit

It is possible to grow iris for flower production in all greenhouses. However the crop places specific demands on the greenhouse depending on the climate.
The iris is a light-sensitive plant and should be grown during periods when the minimum amount of daily sunlight ranges between 200 and 300 Joules/cm2 outside. During the winter months in temperate climate zones, the crop places high demands on the light transmission of the glass or plastic. Dirty glass, old and dirty plastic, and shadow-producing objects in and outside the greenhouse quickly reduce the amount of light reaching the plants.
During the summer and early autumn, the greenhouse will have to be well ventilated to minimize sharply rising temperatures.

Greenhouse equipment: Heating system

In many areas with temperatures below 5-8°C, a heating system is essential to maintain the cropping schedule. It also counteracts dull, damp weather by heating and permits the crop dry by means of ventilation. A heating system can also help maintain the proposed cropping plan.
For iris production the heating system must provide a heating capacity of appr. 220 Watt/square meters of greenhouse soil surface/hour. Pipe-heating is preferred because of its better distribution of heat and its climate control. Hot-air heating systems are also acceptable. With these systems, it is important to en-sure proper heat distribution, and combustion, and a leak-proof discharge of combustion gases. A heating system which is not properly adjusted can emit ethylene gas. If this enters the greenhouse it can cause flower bud blasting. A heating system using tubes or hoses in the beds can also be used and is recommended when the aim is to achieve a dry crop (to avoid Botrytis).
Make sure that the plants do not come into contact with heating pipes, which results in leaf scorch and flower blasting.

Greenhouse equipment: Soil heating and low level h

In areas with low ambient temperatures, soil heating during the winter is a good means of saving energy. With 4 tubilene hoses running through each bed at a depth of appr. 40 cm., a water temperature of 35°C, and a cover of plastic sheeting, a soil temperature of 14-16°C can be maintained for up to 4 weeks. During this period, space heating can be omitted.
Instead of soil heating, low level heating can be provided during the winter months. With this method, a heating hose is laid in each pathway following planting, and the soil is also covered with plastic sheeting. With a water temperature in the hoses of 35°C, a soil temperature of appr. 17°C is maintained. After appr. 4 weeks, the plastic is removed and heating is then by means of space heating. If earlier plantings of iris are in the greenhouse, a greenhouse temperature of 12-13°C is acceptable.
In addition to saving energy, water loss is also limited by the use of plastic sheeting, and the soil structure remains intact. Optimum rooting will result. If bulbs with shoots are planted, a fungicide should be applied to the crop before covering to prevent Botrytis.

Greenhouse equipment: Soil cooling

During periods of high soil temperatures, the soil can be kept to 17-18°C with the use of soil cooling, starting at planting to the end of root formation. Some of the same equipment used for soil heating can be used during warm periods for soil cooling.

Greenhouse equipment: Shading equipment

Use of shading equipment is recommended for environment control and energy saving during the winter. An adjustable shade that does not eliminate too much light in its open position is best. During sunny weather, especially during the spring and autumn, an adjustable shade will prevent soil temperatures becoming too high, while making the best possible advantage of the outside light during dull weather. A permanent screen, i.e. a chalk coating on the greenhouse roof or a shade cloth (preferably outside the greenhouse), can best be used when the light conditions remain continuously above the desired level at all times. It will therefore have to be removed promptly in the autumn.
During the first 3-4 weeks of production period, little light is needed. At this time, permanent shading can be applied or an adjustable shading system can be set to its closed position.
A moisture-permeable shade is preferable.
When using a shade, always have a ventilation flap open.

Greenhouse equipment: Watering system

The most important requirement of a watering system is the even distribution of water.
It is essential to check the irrigation circuit be-fore planting. A shortage or surplus of water leads to uneven and delayed plant emergence and development, a loss of length and flower bud blasting, and can encourage the development of Pythium.
A high level irrigation circuit over the crop provides even distribution and rinsing off the foliage if necessary. For this reason, this type is preferred.
Later in the growing period when the foliage is dense, use can be made of an low level irrigation system. This way, the foliage receives less water, or none at all, and the danger of a Botrytis attack is sharply reduced. Botrytis is a major problem, especially when growing in areas (or during periods of the year) with high relative humidity.

Technical specifications which an overhead irrigation system must meet include:

- pipe distance ranging from 1.60 to 2.15 m.
- distance between pipe outlets no greater than 1.00 m.
- provision of approximately 4 liters of water/ minute from each pipe outlet.
- a spray pressure of 1.5 - 2 bar (kg./cm2).
- filtration of irrigation water, 1 - 400 microns.

Due to the danger of damage to soil structure, the use of a flooding system is not advised.

3. Production site and preparation of the soil

Production site

Iris can be cultivated in the border soil of glass or plastic greenhouses as well as outside. A combination of outdoor planting and a temporary cover or mobile house, especially during the spring and autumn, is acceptable.
In choosing the best location for planting the bulbs, factors that should be considered first are: planting period in combination with the seasonal weather conditions during the initial production period, and the type of greenhouse.
For example, if the ambient temperatures during the production period are below 5°C for any length of time bulbs will have to be planted in a greenhouse. This is because the iris is susceptible to frost damage; these low temperatures halt growth! For the remainder of the year, planting can be done in the greenhouse if the temperature does not rise above 25°C for any length of time. Planting can be done outside if, during the production period, the ambient temperature does not drop for long below 5°C and/or the soil temperature does not remain long above 20°C.
Planting in a greenhouse has the advantage of reaching susceptibility to unfavorable weather conditions while providing ventilation and shading to maintain a more even day and night temperature and relative humidity. With the provision of a heating, the best possible production facilities are provided to improve the quality of the crop. In temperate climate zones, however, a crop grown outside during the summer produces a product of higher quality compared to production in poorly ventilated greenhouses.

Preparation of the soil: Soil

For iris flower production, practically any soil type is suitable as long as it is well drained, moisture-retentive, and free of compacted soil which might restrict growth. A good structure is essential because the relatively short production period for iris necessitates frequent cultivation of the greenhouse soil when a number of iris crops are grown.
With heavy soils, incorporating materials to improve soil structure, such as peat litter, vermiculite or coarse sand to a depth of 25 cm. is advisable.
The panning of soil susceptible to compaction can be prevented by applying a mulch consisting of rice hulls, straw, pine needles, upgraded black peat, and similar materials after planting. Soils that dry out quickly can also be covered with this type of mulch.

Preparation of the soil: Drainage

Surplus water should be able to drain off easily provided by a well-functioning drainage system. This also makes it possible to leach the greenhouse soil effectively with water. Such a treatment prevents an excessively high salt concentration after growing a heavily fertilized crop or after a crop period during which little water has been provided.

Preparation of the soil: Salt sensitivity

The iris is a salt-sensitive plant. If the salt concentration in the soil is too high, rooting can be delayed, or the roots can even be damaged. This restricts the plant's water absorption, and can lead to flower blasting.
To remove salt it is necessary to leach the soil thoroughly (200 to 400 mm. water per m2 of soil surface) before planting.
High salt concentrations occur following the production of crops heavily fertilized (chrysanthemum, rose, carnation and tomato) or after a production period during which little water was applied. High salt concentrations can also occur after growing a crop such as freesia in which the corms are lifted late. For these same reasons, excessive use of artificial fertilizers before or immediately after planting is not advised. In order, therefore, to obtain a reliable guide as to the amount of salt present soil sampling at least 6 weeks before planting is recommended. The following elements in the soil sample must not exceed the recommended levels:

Total salt (conductivity) 1.0-1.5 millimho at 25°C
Chlorine (common salt) 1.5-2.0 milli-equi-valents (MVAL)
Potash 0.8-1.5 milli-equivalents (MVAL)
Nitrogen 1.0-2.0 milli-equivalents (MVAL)
Magnesium 2.0 milli-equivalents(MVAL)
Phosphorus more than 5.0 milligrams P per liter of extract

The salt level (EC) of the irrigation water must not exceed 0.5 mS/cm. For use in greenhouses, the chlorine level must not exceed 50 mg./l; for use in the field, this level must not exceed 450 mg./l. If irrigation water does not meet these requirements, iris production should not be attempted! If, due to circumstances, irrigation is done with water exceeding the recommended salt concentrations, the soil must be kept constantly moist. This prevents an increase in salt concentration which might occur if the soil were to become dry.

Preparation of the soil: Nutrition

In general, using a base dressing before planting is not recommended as it increases the total salt concentration in the soil. This can cause a delay in iris root development.
It is essential to take a soil sample before planting to check if the right nutrient levels are present. It will have to be taken after the application of any soil treatment and leaching of the soil. At that time, any nutrient deficiency can still be corrected in the form of a straight fertilizer. Iris is sensitive to fluorine. For this reason, fertilizers that contain fluorine (phosphorus fertilizers) such as triphosphates are not recommended, where as those low in fluorine, such as diphosphates, are much to be preferred.

Preparation of the soil: Weed control

Flower production entails a fairly short cultivation period (8-12 weeks). If a soil treatment (such as steaming, inundation, ploughing) is applied to a clean soil, few problems with weeds will be experienced during crop growth.
After planting, weeding is preferable to the use of chemical weed control. Care in the use of chemicals is needed to prevent crop damage.
If weed control is necessary between planting and emergence to control existing weeds, use can be made of a herbicide only if the bulbs are planted sufficiently deep. Sprouted shoots must still be at least 2 cm. below the soil surface in order to avoid contact damage.
After crop emergence but before the spreading of the foliage, small weeds can be controlled in the greenhouse or in the field by spraying with a suitable herbicide. If a lot of annual meadow grass is present which is not adequately controlled by the herbicide, a combination of herbicides should be used. Always spray towards the evening on a dry crop using enough water to provide cover. The following morning rinse off the crop thoroughly with overhead irrigation. Because of the persistence of herbicides, keep the following points in mind: limit spraying frequency to no more than twice a year per site, only apply where necessary, and do not plant suspectable crops afterwards.
For more information concerning the use of recommended herbicides, we refer you to your local information service.

4. Purchase and planting operations

Purchase: Placing the order

After deciding upon the marketing strategy and organising a cropping programme, bulbs should be ordered from the supplier by cultivar and size. When dealing with iris in particular, this should be done far enough ahead so that the supplier can earmark suitable lots for export to Japan (Class I, Japan) on time and provide the proper temperature treatment. To be able to provide this treatment, the supplier should be kept informed of the following:

- desired planting period or flowering period
- site of cultivation (heated greenhouse, un-heated greenhouse, or outside)
- degree of latitude of the production site
- local climatic conditions

This information should be given on the order form so that the supplier can adjust the preparation of the bulbs according to the instructions received.

Purchase: Bulb size

With iris, it is normal to state the bulb size in terms of the circumference of the bulb as measured in centimeters. When someone speaks of sieve (or sieve size) 9/10, this means that all these bulbs have a circumference of 9 to 10 cm.
Just as with the other bulbous crops, a distinction is also made in iris as to the bulb sizes that are suitable for flower production (“saleable bulbs”) and those sizes only suitable for planting material. The difference between these two is not so clear as for example tulip. This is because some iris produce “large” bulbs and others produce “small” bulbs. This means that the saleable size for one cultivar can be much smaller than the saleable size for another. A distinction can be made as follows:

- bulbs that produce small sizes are saleable at 6/7, 7/8 and 8/up
- bulbs that produce large sizes are saleable at 8/9, 9/10 and 10/up

For flower production, it is important that the saleable bulbs come from plants that have not flowered in the previous growing season. These bulbs can be recognized by their oval-round shape and the fact that they are enclosed in 3 to 4 tunics. On the other hand, bulbs which have already flowered, have a flat shape and are covered by only 1 tunic. These latter bulbs are more easily damaged and dry out sooner.

Purchase: Receipt and storage

Bulbs intended for storage must be stored at 30°C after receipt.
Bulbs destined for flower production should be planted immediately after receipt. For this reason, it is important to have completed soil treatment well before the bulbs arrive.
If “planting immediately after receipt” is not possible, the bulbs must be stored at the correct temperature. This interim period will then form part of the temperature treatment received by the bulbs. In this case, it is important to contact the supplier to determine the temperature to be applied. If this is not done, maintaining a storage temperature of 2°C for no longer than 2-3 weeks is the best alternative. Higher temperatures extend the treatment and can have a negative effect on flowering results.
Unpack the bulbs immediately on receipt, and lay them carefully in a thin layer in containers, preferably ones with a mesh bottom. In addition to maintaining a storage temperature of 2°C, also ensure good air circulation between the containers in the store.

Lengthy storage of the bulbs after receipt by the grower is not advised as it has a negative effect on stem and leaf development and also increases the risk that the root crown will be infected by the fungus Penicillium.

Planting operations: Watering before planting

When growing iris for flower production, an adequate supply of moisture is especially important. Start by moistening the soil sufficiently several days before planting. This will ensure that the early stages of rooting progress quickly and successfully, and that no roots are damaged during planting.
The use of cold water, especially during periods of high soil temperatures, is advisable, as high temperatures make the crop develop too quickly leading to a reduction in quality. An increase in soil temperature can also be prevented before planting by choosing a planting site with cooler soils. A third possibility is to apply an insulating mulch before the onset of high temperatures as it prevents an excess of sun radiation from ente-ring the soil which will later be planted with bulbs.

Planting time and bulb size: Planting time

Autumn - Spring planting (newly harvested bulbs)
Bulbs of the cultivars 'Blue Diamond', 'Blue Sail', 'Ideal', 'Lovely Blue' and 'White Wedgewood' from the new harvest can be planted from mid-October. 'Apollo' 'Blue Magic' and 'Prof. Blaauw' (including sports) can be planted from early November. During and after planting, the soil temperature should be below 20°C.
As to the bulb size, the largest size (10/up) should be used to achieve a good crop. It is possible to use bulb size 9/10 starting on 1 December, although when using this smaller size, a lighter crop should be expected. The entire range can be planted in an unheated greenhouse or outside starting in November. Since iris are susceptible to frost damage, the soil should be covered with a mulch such as straw (100 kg./100 square meters). From 15 May, some cultivars such as 'Royal Yellow' and 'Yellow Queen' which cannot be stored for lengthy periods, can no longer be used. During the period previously described, all saleable bulb sizes can be used. In temperate zones, the entire range (cultivars with large and small bulbs) can be used for growing in a heated greenhouse starting on 1 January.

Summer planting
Iris production during the summer often entails a great deal of risk. The result will depend on the prevailing temperatures during the growing period. If average temperatures above 25°C are expected, production should not be abandoned, instead planting will have to take place earlier or later.

Autumn planting (retarded bulbs)
Depending on the soil temperature (preferably below 20°C), planting can start on 1 September, or earlier in areas with temperate climates using appropriate cultivars 'Blue Magic', 'Ideal' and 'Prof. Blaauw'.
For this period, only bulb sizes 9/10 and 10/up are considered appropriate.

Planting time and bulb size: Planting method

Iris are usually planted by hand pressing them into the soil with the thumb. Before this is done, the soil is worked and made fairly moist. Next, each bulb is planted by pressing most of it gently into the soil. This is called “thumbing in”. The aim of moistening the soil, working it, and taking care when pressing the bulbs into the soil is to avoid damage to the root crown, including any sprouted roots.
If frost is expected in cold greenhouses or in the field before crop emergence the planting method is adjusted by planting the bulbs in a raised bed. After planting, the soil is put back into the bed in such a way that a sufficient amount of soil covers the noses of the bulbs. This planting method is also used under warm conditions to prevent soil temperatures over 20°C at bulb depth.

Planting time and bulb size: Planting depth

The planting of iris bulbs needs to be done carefully. Especially when root growth has already started, root damage will need to be avoided as much as possible. When “thumbing in”, 3/4 of the bulb is carefully pressed into the soil. When planting in beds, a planting depth ranging from 7 to 10 cm. of soil covering the nose is recommended. In contrast to a shallower planting, this method prevents frost damage and also achieves a more even and lower soil temperature at bulb depth. Bulbs planted at shallower depths are also more quickly affected by the soil drying out and damage may arise from plants falling over due to strong winds. During warm periods of the year, the top soil can dry out quickly, leading to a lack of moisture available for the roots. For this reason, applying a soil cover (such as straw, rice hulls, or a shade cloth) after planting greatly limits the drying out of the soil.
The planting density/net m2 depends on the cultivar, bulb size, time of year, and production site. To maintain the correct planting distances, netting with 64 openings per square metre is often used. The planting densities given in this table apply only to the largest available bulb size for these cultivars.

Planting time and bulb size: Plant support

Depending on the growing period, climate and cultivar, it may be necessary to provide support for the plants during the growing period. It is recommended, for example, to provide support during the autumn when the growing period lengthens in temperate climate zones. During other months, especially in summer, this is also advised when growing cultivars taller than 80 cm. If the plants are pulled at picking instead of being cut, plant support can prevent the remaining plants from falling over. Chrysanthemum mesh is the usual type of support, as it deter-mines the planting density during planting and is then raised along with the plants as they develop.

5. Growing environment and miscellaneous cultivation operations

Growing environment: Growing temperature in the greenhouse

After planting the soil temperature is of greatest importance. It may range from a minimum of 5-8°C to a maximum of 20°C and has a direct effect on the shoot's rate of growth. Low soil temperatures, however, delay flowering. The optimum soil temperature is 16-18°C.
For greenhouse production, the optimum temperature is 15°C. To reduce the growing period, bulbs from the new harvest can be grown at a greenhouse temperature of 18°C for the first 4-3 weeks. This temperature can be maintained until 1 January, but results in a thinner crop. Growing temperatures of 13°C and below extend the growing period and give a heavier crop but the risk of flower blast increases. To encourage the flowers to open e.g. 'Blue Magic' it is sensible to lower the temperature to 13-15°C if high greenhouse temperatures have been maintained.
When growing in the autumn, especially in temperate climate zones under poor light conditions, the greenhouse temperature must be reduced to prevent flower blast. Depending on the amount of light available reduce to 13-10°C; for 'Blue Magic', the temperature should be reduced to 10-8-5°C. In any event keep the crop growing. If during any period the plants produce an excess of foliage, trimming part of the leaves should be considered.
The lowest possible temperature is 5°C and the highest possible average day and night temperature ranges from 20° to 23°C. In greenhouses with poor light transmission and high temperatures, there is a risk of flower blast due to lack of light.

As frost damage can result where frequent ground frosts occur, in such situations production must take place in greenhouses. The optimum growing temperatures also apply at night. For this reason, unheated greenhouses need to be closed early to keep the night temperature as close as possible to the desired level. By ventilating early enough during daytime, the risk of the greenhouse temperature rising above 18°C can be limited. Shading the greenhouse is also a good solution, although adequate light levels still need to be maintained.

Growing environment: Growing temperature in the field

The optimum growing temperature for field cultivation is 15-17°C. Here again, extended periods of high daytime temperatures can be prevented with the use of a shade cloth as it will limit direct sun radiation and the accompanying increase in temperature.
The lowest and highest possible temperatures for field cultivation are between 5 and 25°C. As for the soil temperature, the same values as indicated for greenhouse growing temperatures should be maintained.

Growing environment: Humidity

Relative humidity of 75-80% is ideal. What is important is that great fluctuations are avoided and that changes occur gradually. During mild, dull, still and/or humid weather, the relative humidity is often too high, and measures must be taken to reduce it by simultaneous heating and ventilation.

Growing environment: Ventilation

In terms of temperature control and reducing humidity, ventilation is extremely important. When ventilating, care must be taken that the humidity of the greenhouse air does not drop too rapidly, because a rapid drop in moisture can cause leaf scorch and a reduction in quality.

Growing environment: Shading

The temperature, humidity and light conditions in the greenhouse can be influenced by the use of shading. During months of high light intensity, the temperature in the greenhouse, in spite of ventilation, or outside can become too high (› 25°C). To prevent a loss of quality under such circumstances, shading should be done, combined with ventilation in a greenhouse situation.

Growing environment: CO2

In contrast to lilies, CO2 has no effect on the growth and flowering of iris.

Miscellaneous cultivation operation: Watering

As described under “Planting operations”, the soil must be watered before planting. The soil is then thoroughly moist during planting, which encourages rapid rooting.
The soil should also be kept thoroughly moist immediately and following planting during the entire growing period. A constant and adequate supply of moisture is extremely important for growing iris because a lack of moisture very quickly shows as a lack of height increase in the crop. Flower blasting can also result.
It is impossible to indicate a precise amount of irrigation. The amount depends on: the prevailing weather, the greenhouse climate, the soil type, the crop’s rate of growth, and the crop’s stage of development. A simple way to find out if the soil contains the right amount of moisture at the root zone is to take a sample of soil and squeeze it in your fist. If the sample holds the same shape after releasing it from your grain, the level of moisture is correct.
In such situations as poor air movement, accompanied by either dull, humid weather or humid, warm weather, excess water can cause damage. It is especially these conditions that promote the growth of bacteria and fungus diseases.
For the same reason, watering in the morning is recommended. The crop can then dry off during the day. During the harvesting period, watering must be done after picking the flowers to avoid the risk of botrytis spot.
A good overhead system which distributes a uniform supply of water is preferred.

Miscellaneous cultivation operation: Length of production

The length of time it takes to grow iris depends on the cultivar, the preparation treatment given to the bulbs, the production site (greenhouse or field) and the growing temperature. Because of these factors, it is difficult to indicate the exact
length of production for the various cultivars. In a heated greenhouse, the duration of cultivation, depending on the temperature maintained and the group of iris being grown, is in the order:
Ideal group : 50-60 days
Prof. Blaauw group : 60-80 days
Blue Magic group : 65-85 days
Tingitana group : 70-90 days
Small-bulb group : 65-85 days
Rest group : 55-75 days

The length of production for growing in unheated greenhouses and outside is entirely dependent on the prevailing temperature and is therefore impossible to predict.

Miscellaneous cultivation operation: Crop monitoring

A regular crop check, including the soil and other growing conditions, is exceptionally important. Attention should be given to:

soil: temperature, dry patches, EC, structure, weed growth
crop: condition, length of leaves with respect to available light, color, aphids, Botrytis, Pythium, bacteria rot.
growing location: climate, plant support.

6. Harvesting and preparation

Harvesting stage and preparation

The last phase of flower production is harvesting and preparation for sale. The correct operations taken from harvest ensure a good quality product. The correct harvesting stage is extremely important for the final keeping quality of the flowers. In the autumn, it is recommended to cut the flowers when the colored tip is 3 cm. in length; during the spring and summer, they can be cut when the tips are showing 1 cm. of color. What is meant by “tip” is the entire colored part of the flower bud. This means that picking will have to be done twice and sometimes three times a day. Doing so encourages flower uniformity. The flowers are picked by pulling up the plants. After picking, the flowers are bunched immediately. Alternately, if circumstances do not allow for this, they can be placed in the cold store to reduce the temperature of the product straightaway.

Preparation: Grading and bunching

If the letter, immediately after picking, or after having first placed the flowers in the cold store, the first job is removal of the bulbs from the stems with a bulb-removing machine, a bulb-removing comb, or pruning shears. The cultivation method and the soil type determine whether the bulb remains in situ or is pulled up with the flower.
Following this, grading and bunching are done. It is good practice to grade iris in groups varying in length by 5 centimeters up to a length of 70 cm. Iris longer than 70 cm. are grade in groups varying by 10 centimeters. Within the bunches, the greatest variance in stem length is limited to 3 cm.
Ten stems comprise one bunch; the tops of the flowers must be level with one another. The bunches can be held together with tape or rubber bands. “Bunching lines” are available for bunching and binding.

Preparation: Leaf tipping

This involves the removal of leaf tips which are too long or withered to a yellow-brown colour and disfigure the appearance of the bunch.
It is easiest to tip the leaves after bunching. It is often done with a knife but can also be done mechanically; equipment to do this is available in the trade.

Preparation: Storage

A cold store is indispensable when growing iris. As a general rule 10 m3 of storage area is needed for every 1000 m2 of production area. The storage temperature for harvested flowers ranges from 2°C - 5°C, but 2°C is optimum.
Iris that go straight into refrigeration after picking are pre-cooled to 2°C. If the flowers are not too closely packed together, the product temperature will quickly drop. This slows down the maturing process and extends keeping quality. Always place dry in the refrigerated room to prevent Botrytis attack.
The relative humidity in the room should be kept at a high level to prevent the product from drying out. Next, the flowers are taken from the refrigerated room and bunched.
During the autumn and winter months all bunches should be put in pre-chilled water (2°C) and placed in a refrigerated room (which is also set at 2°C) for at least 2 hours. The same treatment should be given at any time to bunches that feel limp.
The storage period for the flowers needs to be kept as short as possible as, however short, quality is always reduced.
During marketing of the flowers, it is preferable during the autumn and winter (periods without as much light) to transport the iris in water. This encourages them to open.

7. Crop protection and diseases

General soil treatment: Introduction

The soil should be free of pathogens that can infect the iris during its cultivation. This can be achieved by: a.) starting with fresh soil or using a sufficiently wide-spaced crop rotation. b.) maintaining the best possible growing conditions during cultivation. If the soil needs treatment, this can be done by means of an annual general soil treatment. Steaming, inundation or the use of a chemical soil sterilant are the main choices. Factors which determine the effectiveness of steaming, inundation and chemical soil treatment include: temperature, duration and concentration.

General soil treatment: Steaming

Steaming should be done down to a soil depth of 25-30 cm. at a temperature of 80°C for at least 1 hour. Steaming with under pressure produces a better control than steaming with over pressure. Almost all soil problems can be controlled this way except for Pythium for which this method is usually insufficient necessitating use of a specific fungicide. On silty soils with a low pH, manganese toxicity can result from steaming. Steaming for a short period in a porous, dry soil in which the pH has been increased by a previous application of lime will limit excess manganese.

General soil treatment: Inundation

The first step in this method of greenhouse soil disinfection is a May sowing of a sorghum crop, Sorghum bicolor Moench, var. dulcius culun Ohwi. Around mid-June, when the crop is appr. 50 cm. tall, it is ploughed under to a depth of 20 cm. along with the addition of 100 kg. $Ca(NO_3)$/1000 m2. At the end of July, the surface soil in the greenhouse is shaped into heaped-up strips, 60-70 cm. wide, which are then flooded. An extra layer of plastic foil is placed over the water. After 2 to 3 weeks of this treatment, the soil is worked with a rotary cultivator and then checked for pH and EC.

General soil treatment: Chemical soil treatment

If permitted, it is also possible to treat the soil with a fungicide or chemical sterilant. This should be applied when the soil temperature is at least 10-12°C, followed by covering soil with plastic foil. After 3 warm days (or 7-10 days if cool), the plastic can be removed. For more information concerning the agents to be used and the application method, we refer you to your local information service.

Additional soil treatment

Due to the rapid regrowth of the fungus Pythium, a general soil treatment applied once a year is not enough. To control this fungus the soil should have an additional fungicidal treatment immediately before each planting.
All fungicides should be mixed evenly through the top soil to a depth of 15-20 cm. To obtain a good distribution, wettable powders are mixed with sand and then applied by hand or mixed with lukewarm water and sprayed through a coarse nozzle. The treatment is then worked thoroughly into the top 15-20 cm. of soil. The solution can be sprayed through a fine nozzle. With soils susceptible to structural changes, working the fungicides initially through the soil manually and then lightly incorporating it with a rotary cultivator is recommended. For information concerning recommended fungicides and how much to apply, we refer you to your local information service.

Bulb treatment

The dipping of bulbs in fungicide immediately before planting is recommended for iris flower production. This can be done in various ways. The concentration of the fungicide in the dip solution should be adjusted to that given in the general advice on long immersion.

Once again, it must be stressed that crop protection against fungal diseases, etc., should be done in combination with the proper cultivation operations as described in this book.
For additional information concerning the proper bulb treatment for fungi, we refer you to your local information service or your supplier.

Diseases caused by fungi: Bulb rot

Seriously affected bulbs do not emerge from the soil, or do so very late, and form scarcely, if any, roots. In a less serious attack, the plants remain short and can also develop crookedly (see Fusarium disease). The diseased bulb tissue becomes dark or blue-grey in color starting at the root crown and is covered with a blue-green mass of spores. In comparison with a fusarium attack, the affected tissue is not shrunken and the division between healthy and diseased tissue is less clear.
There is no spread to healthy bulbs, and no long-lasting soil infection takes place.

Cause
The fungus Penicillium verrucosum var. corymbiferum shows as spores present on the bulbs and attacks tissue only through tiny wounds, chiefly those wounds that develop in the root crown where the roots emerge. This is why the disease is often a problem during prolonged transport or if there is a delay before planting occurs. An attack after planting only occurs if the soil is too dry.

Prevention
- Maintain a low (< 70%) relative humidity and positive air circulation between the bulbs during storage
- Give a bulb treatment immediately before planting (see above under “Bulb treatment”)
- Plant the bulbs immediately after receipt in a well-moistened soil. This treatment spends up rooting.

Diseases caused by fungi: Crown rot (Sclerotium rolfsii)

As a rule the bulbs grow normally at first. Later, the plants wilt in patches and collapse. The disease spreads quickly to neighbouring plants. On the underground parts and on the soil around the base of the plant are found many white fungal threads with 1-2 mm. round bodies (sclerotia) which are white and later turn light to dark brown. Eventually, the bulbs becomes completely soft and the plant which emerges is covered with white weft.

Cause
The disease is caused by the fungus known as Sclerotium rolfsii which occurs only in sub-tropical, warm-climate areas. No infection takes place in temperatures below 13°C, and the attack is heaviest at 20°C. The number of host plants is exceedingly high which means that care is required to prevent attack. Once soil is infected it remains so for a long time.

Prevention
- Do not plant any bulbs in soils that are known to be infected with Sclerotium rolfsii. If this is unavoidable, apply a general soil treatment and a bulb treatment aimed at controlling the fungus
- Carefully remove and destroy affected plants and surrounding soil.

Diseases caused by fungi: Fusarium

The disease starts at the base of the bulb and extends upward into the scales. The division between healthy and affected tissue is fairly clear. The affected tissue is soft, grey-brown in color, shrunken, and sometimes covered with a white weft. After planting, affected bulbs do not develop. If affected early, the part of the plant above the soil displays a crooked, weak shoot, the leaves turn yellow from the top downward and the plant dies prematurely. If the plant is affected later in its development, growth is halted and the flower bud desiccates. The bud can sometimes reach the harvesting stage but the flower colour is far too pale. The base of the flower stem inside the bulb remains intact for a long time and often has a characteristic corrugated surface.

Cause
Fusarium oxysporum affects healthy bulbs through spores or by direct contact with diseased bulbs. An attack through infected soil is a definite possibility. For this reason, the planting of diseased bulbs is dangerous, especially if the soil has just been disinfected. Iris, gladioli and freesias are all affected by the same fungus. Soil temperatures of 16°C and above encourage disease development, which advances more rapidly at higher temperatures.

Prevention
- Keep wide crop rotations for gladioli and freesias, or apply a general soil treatment once a year
- Give a bulb treatment immediately before planting (see Bulb treatment).

Diseases caused by fungi: Grey mould (Botrytis)

Plants affected with Botrytis can be found spread throughout the crop and also in patches. The growth of affected plants is retarded and the sheathed leaves, affected with wet rot, are covered from ground level with a white to grey spore-forming weft. Eventually, the plant falls over without the leaf tips becoming yellow.
The bulbs of affected plants become wettish, rotten and brown but do not produce an offensive odour. When the tunic is removed, a grey weft can be seen, with large black sclerotia appearing particularly on the top of the bulb. Roots and basal plate remain intact.
The foliage, except for damaged or desiccated leaves, is usually not affected. Irregular shaped white spots ("fire" spotting) can develop on the flowers as well, but only under humid conditions.

Cause
Grey mould is caused by the fungus known as Botrytis cinerea and occurs under continuous moist conditions. Especially in plants where the leaves have become damaged by overexposure to the sun, frost etc. Under these circumstances, the fungus affects a great many crops and plant remains.

Prevention
- Prevent the leaves from becoming damaged in any way
- Do not plant any bulbs with long above-ground shoots (5 cm. or longer) and especially not under plastic. This prevents overexposure to the sun
- Do not plant bulbs too densely, and keep the soil weed free during the growing period
- Keep the relative humidity in the greenhouse low, preferable 80 % or lower, and if necessary, give some heat while keeping a few ventilators open to keep the crop dry
- Water in the morning so that the crop is as dry as possible before night fall
- After leaf damage, apply a fungicide at an early stage according to the recommendations.

Diseases caused by fungi: Rhizoctonia disease

The extent of infection depends on the planting depth since an attack is heaviest at the soil surface. In a less serious attack, irregularly shaped black and brown spots can be found on the sheathed leaves with decayed leaf tissue (holes) in the centre.
With a heavier attack, the sheathed leaves (and later, the leaf bases and flower stems as well (become soft and grayish in color. The outermost leaves are the first to wilt; at a later stage, the entire plant will die off.
In the event of a heavy attack (deeply planted bulbs), the shoots will be completely rotten even before emergence. Deeply planted bulbs are the most susceptible to damage since the shoots takes a long time to emerge during which time they are liable to attack.
In infected bulbs, the affected tissue is soft and at first dull grayish white or sometimes purplish in color. At a later stage, the tissue becomes grey-brown in color. Many light brown hyphae, looking like a spider web and sometimes accumulated to form crusts, can be observed on the tunic and between the bulb scales. The roots are always sound, and the affected bulb does not smell bad.

Cause
The fungus Rhizoctonia solani affects the shoots and/or bulbs chiefly from the soil. Many crops (including tulips) can be affected by this fungus, even when the soil has never been used for flower bulbs before. Any soil type may be seriously affected even without a preceding susceptible crop. Rhizoctonia disease can develop at various soil temperatures, but the risk of infection is increased as the temperature rises.

Prevention

- With infected or possibly infected soils, apply a general soil treatment (see General soil treatment). During periods of high temperatures, there is a real possibility of a re-infection of soil. Prevent a re-infection by maintaining hygienic conditions and possibly by using an additional soil treatment (see below)
- If a general soil treatment has not been applied, and infection with Rhizoctonia is a possibility based on previous experience, treat the soil with an appropriate fungicide before planting. Work it into the soil with a rotary cultivator to a depth of 5-10 cm., depending on the planting depth. Always use this treatment in the summer if the soil temperature is over 16°C.
- When possible, plant bulbs shallowly.

Diseases caused by fungi: Root rot (Pythium)

If affected early, the crop's growth is severally retarded. The roots are either short with black tips or hardly visible; instead, only black root remnants can be seen. This condition looks like root scorch. The lateral roots that form later often appear sound. It is thought that this is a result of the plant's partially restored resistance to disease.

Cause
The Pythium ultimum fungus attacks the roots through the soil. It is found in all soil types and is difficult to control.
The susceptibility to Pythium differs according to cultivar.
When planted immediately after the soil has been steamed, the risk of an early infection is considerably greater as at this stage, antagonistic soil organisms have not yet recovered.

Prevention

- Maintain a wide crop rotation or else apply a general soil treatment once a year
- After a general soil treatment, or even where this is not done, give the soil a supplementary treatment
- Give a bulb treatment immediately before planting (see Bulb treatment)
- Ensure a proper soil structure
- Prevent wet areas by keeping a good soil structure and by using a proper watering system.

Diseases caused by bacteria: Soft rot

The shoot of affected plants is retarded starting shortly after planting. The sheathed leaves are often watery and therefore appear dark green at first, later becoming black in color. The shoot can easily be pulled from the bulb, and the affected tissue is soft and a dirty yellowish white color. Affected bulbs decay fairly suddenly into a mushy, soft mass with an extremely unpleasant odour. The roots, which at first emerge satisfactorily, sometimes also become glassy and yellow-green in color.

Cause
The disease is caused by the bacteria (Erwinia carotovora) and occurs almost only in the cultivar 'Prof. Blaauw'. High soil temperatures and moist growing conditions encourage the risk of infection.
Incorporating iris debris and other plant remains through the soil encourages the growth of the disease. Damaging the root tips during planting also increases the disease risk. Above ground the bacteria can easily be spread by water splash.

Prevention

- Do not work any plant remains into the soil
- Plant the bulbs in a soil which has been prepared for planting (including making it sufficiently moist) well ahead of time
- Avoid damaging the root tips during planting
- When planting in a greenhouse, keep the temperature within the optimum range (12-15°C) especially avoiding higher temperatures
- It is preferable to water, as needed, in the morning
- Prevent slaking of the soil.

Damage caused by pests: Root nematode (Pratylenchus penetrans)

Plant growth is retarded in patches, and the flower bud dries out. The root system displays many short, narrow black stripes. This symptom distinguishes the problem from root rot caused by Pythium since the narrow stripes do not change into large rotten spots.

Cause
This root rot is caused by an infestation of the root nematode Pratylenchus penetrans. Non-identified fungi and/or bacteria inhabit the wounds caused by the nematodes which can be found in any cultivated soil and infests many other plants (including chrysanthemum, rose, grasses).

Prevention

- Apply a general soil treatment annually.
- Grow a crop of marigolds (Tagetes patula or T. erecta) before growing iris.

Damage caused by pests: Root knot nematode (Meloidogyne)

From early in the growing period, weak plants occur in patches. With seriously infested plants, all the roots are destroyed. In less serious cases, the roots become severely swollen, crooked and branched. The bulbs themselves remain sound.

Cause
The problem is caused by the nematode Meloidogyne incognita which is found in soil and infests the roots of the plant. This nematode, which occurs only in warmer climates, has many different host plants (tomato, cucumber).

Prevention

- Apply a general soil treatment annually.

Diseases caused by viruses: Tomato Spotted Wilt Virus

This virus has two forms of symptoms in iris. In one the symptom shows in inner leaves that are entirely or partially light green to yellow in color. Often, the leaf tips remain green in color. On the outermost leaves, broad, yellow, light-green and sometimes brown-necrotic stripes can be seen. In the other yellow spots and stripes appear on the leaves, and sometimes oval-shaped ring spots accompanied by withering brown-colored spots and stripes. In both cases, the plants are retarded in growth and do not flower.

Cause

The disease is caused by the Tomato Spotted Wilt Virus (TSWV) or other Tospo viruses such as the Impatiens Necrotic Spot Virus (INSV). Transfer takes place via thrips, especially the California thrip (Frankliniella occidentalis). The disease has many host plants which include chrysanthemums, tomatoes, potatoes and many weeds. The virus is not carried over through the bulb and occurs only in Mediterranean climates. Pale flowers; flowers do not open and are lighter in color

Prevention

- Do not plant in greenhouses which have previously been used for growing crops susceptible to this virus
- Do not plant outside in the vicinity of susceptible crops to this virus
- Keep the crop free of weeds both outside and in the greenhouse
- Use thrip control, also for the previous crop.

Disorders of a nonparasitic nature: Pale flowers

The color of the flowers deviates from normal and is lighter. The flower does not desiccate but its keeping quality is definitely reduced.

Cause

This disorder develops as a result of poor transpiration caused by a high R.H. in the greenhouse.

Prevention

- During periods in which the R.H. in the greenhouse is high, maintain a greenhouse temperature of 2-3°C above the outside temperature
- If this is impossible to achieve because the out-side temperature is too high (15-16°C), heat the greenhouse in the mornings while keeping a ventilation flap open.

Disorders of a nonparasitic nature: Bud blasting

During the crop's development, the flower bud fails to grow. Ultimately, the top of the bract turns yellow and the flower bud becomes limp and dries out. Bud blasting often develops during the last weeks of the growing period. This disorder can occur during all phases of growth, but predominantly as the flower stem starts to leng-then. If it occurs at a very early stage, it is hard to see anything wrong with the plants. However the plants consist only of leaves.
Once the buds are visible, however, it is easy to see whether or not the flower is developing inside the sheathed leaves encasing it. If this development is insufficient, the damage has occurred.
In the case of late bud blasting, pale flowers often appear as well. Bud blasting can occur at any time until flowering.

Cause
This disorder is caused by insufficient light in combination with temperatures that are too high and/or a disruption of growth. It almost always occurs only in the winter months. This disorder is also caused by planting too closely or by a sudden drop in temperature as a result of frost. However bulbs slightly affected by Fusarium, in which fewer roots are formed, less moisture is absorbed, and less transpiration occurs, can also suffer from flower blasting.

Control
- Order the bulbs well ahead of planting time. The supplier is then able to give the treatment appropriate to the cultivation site and planting period (crop size, light) for which they are intended
- In the winter avoid too small bulb sizes
- In the winter months, plant only in well lit greenhouses, especially when the growing location is fairly north of the equator. Iris need to have enough light to flower well
- Provide the crop with a sufficient and regular water supply. A good root system, however, is required for this
- Reduce the greenhouse temperature during dull periods, especially during the period when the stem is lengthening, so that the growth rate is slowed. A too rapid growth rate which occurs in a period when the plant is producing (assimilating) little nutrition or is demanding a great deal of nutrition, will lead to bud blasting during excessively high temperatures. Keep the plant active, however, by heating combined with some ventilation
- Avoid excessive increases or decreases in the greenhouse temperature. In these situations, the plant's growth and transpiration can increase so quickly that the plants cannot "keep pace". This can result in a sudden increase in bud blasting
- Prevent damage from ground frost.

8. Cultivar selection

Choice of cultivar

Although the iris range is not especially large, choosing the right cultivar is not that simple for the flower producer. In addition, in recent years several new cultivars have been introduced which may still be unknown to the grower. This makes the provision of additional information concerning the current range useful.

In addition to color, the largest possible bulb size is indicated to give an idea of whether the cultivar belongs to a large-bulb or a small-bulb group.

Stem length is also given. This is an average length obtained by measuring flowers grown in a greenhouse, in the spring, under normal conditions. These factors also apply to the stem diameter, the amount of foliage and the rate of growth.