Department of Agriculture and Food
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Growing Cucumbers in Protected Cultivation in Western Australia

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General

There are over 20 growers who produce cucumbers under protected cultivation in Western Australia, ranging from Manjimup in the South-West to Geraldton and Carnarvon. They mainly grow these crops hydroponically in greenhouses. There is also some production under shadecloth and some crops are grown in soil.

There are two types of cucumbers grown under protected cultivation. The Continental or burpless cucumber is the main type of cucumber and has long fruit, whereas the Lebanese (mini) cucumber has shorter fruit. Compared with field cucumbers, these two types are seedless and do not require pollination to produce fruits. To ensure they are not pollinated, they must be kept apart from field crops of conventional cucumbers. Compared with field crops, protected cultivation cucumbers have flesh that has less total acids (0.11 per cent versus 0.17 per cent) and more sugars (3 per cent versus 2.8 per cent). They are smoother, greener and have a finer texture. The skin is more tender. They are not peeled and are easier to digest.

Figure1 Continental cucumbers with some powdery mildew on the leaves

There is now a larger production of protected cultivation cucumbers in Western Australia than field cucumbers. In 2005/2006, production of protected cultivation cucumbers was 1,735 t at Market City, Canning Vale, compared with 1,102 t of field cucumbers. This compares with a throughput of 960 t of protected cultivation cucumbers and 4,750 t of field cucumbers in 1992/1993. Production of Continental cucumbers and Lebanese cucumbers was 1,356 t and 379 t respectively in 2005/2006.

Plants are grown under protected cultivation in greenhouses in southern areas (planting for most of the year) and in Geraldton (April to June plantings). There is significant production in Geraldton from June to November, grown in soil. Plants may be grown in soil under shade cloth in Carnarvon, but production is small. Production in southern areas can be all year, if heating is used in winter, but this is expensive.

Varieties

Check with a seed supplier, as new varieties are regularly introduced. Continental cucumbers are 30 to 45 cm long, dark green, smooth skin slightly ribbed, and glossy. Lebanese or mini cucumbers are 14 to 20 cm long, green and glossy. They are quicker to harvest from flowering, with less bent fruit, especially in winter.

Figure 2 Lebanese cucumbers

Varieties may vary with yields and quality, tolerance to powdery mildew and cold tolerance. There are distinct warm season and cold-season varieties.

Greenhouse conditions

A polythene greenhouse should be selected with plenty of light and ventilation and preferably sited so that plants are grown in north-south facing rows. The height of the greenhouse to the gutters should preferably be over 4 m. A greenhouse with a twin skin polymer, with air pumped between the skins, is a cheap system commonly used in Western Australia. The polymer should be anti-condensate to prevent water dripping onto the plants and should last for 4 to 5 years. Temperatures should be similar to outside temperatures in summer in a twin polymer greenhouse, but the relative humidity should be higher.

With modern systems, computers control fertilising/watering, humidity, heating, ventilation and operation of thermal screens.

Carbon dioxide is not normally added to hydroponic systems in Australia, but is sometimes used in large, sophisticated, operations. Heating systems with gas often apply additional carbon dioxide in winter.

A white woven plastic weave material can be used on the ground to control weeds and reflect light.

A relative humidity of 85% is optimum. Use a hygrometer to check the relative humidities. High humidities increase leaf diseases such as botrytis and powdery mildew, and the plants can also be too bushy. Ventilation may be controlled by computer to adjust the vents to maintain optimum temperatures and humidities, especially in the afternoon. This will reduce diseases such as botrytis and increase the uptake of nutrients. Do not over-ventilate as this may reduce the relative humidity to a low level. This can reduce yields and fruit can have gummy ends. Fans can also be used for cooling and ventilation. Ensure that misters, if used, do not increase the relative humidities too high.

Cucumbers need light levels of about 50,000 lux. On clear days in summer, light levels are often above 100,000 lux and temperatures are too high. A thermal blanket over the crop can be used to automatically shade the plants at a selected temperature i.e. 32 °C.in hot weather and decrease day temperatures. If there is no thermal blanket, in the warmer months, whitewash is brushed on, rolled-on or sprayed (2 kg/5L per 40 m^2) on the polymer sheeting. More than one application may be needed. The whitewash needs to be washed off by manual brushing in autumn.

It is preferable to maintain the temperature above 14°C in winter by employing a double-skinned greenhouse, supplementary heating and use of thermal screens at night.

Optimum temperatures are 22 to 34ºC. Temperatures over 40^0C or less than 14°C are unfavourable to cucumber production. The absolute minimum temperature is 5^0C. If heating is used, usually by using LPG gas, keep the night temperatures above 14 to 16°C and keep the day temperatures at 21 to 23 °C. Supplementary heating may be applied through the air, or by passing warm water at 18 to 25°C through pipes on polystyrene blocks beneath the slabs. Five cm metal heating pipes can also be used in the path areas and are also used for carrying trolleys that are used for the harvesting containers and for workers attending to pruning and training the lower levels of plants . Cucumbers may receive higher prices in winter. However, heating costs are high and returns may not be profitable, especially if there are plentiful supplies from the mid-West.

If temperatures are too low in winter, such as inland areas of the South West, this will result in high heating costs and restrict cropping to the warmer months.

Seeding

Seed into sterilised, individually celled plastic seedling trays filled with fresh sterilised potting mix. Cover seeds with 5 to 10 mm of vermiculite or perlite. Seed may also be planted into peat blocks, 4 to 5 cm jiffy pots, or 4 to 8 cm rockwool blocks for 2 to 6 weeks before planting into the greenhouse. Plants can be transplanted at the 2 to4 leaf stage. The rockwool blocks are placed directly on top of the slabs. Some growers may seed directly into bags in summer and transplant in winter. Young plants may have poorer establishment in winter with unheated greenhouses.

Seed costs are high and growers may prefer to purchase plants from a commercial nursery, costing about 50 to 85 cents each.

Low temperatures give slow and uneven germination and plants of poor vigour. The optimum temperature for germination of cucumber seed is 27 °C, day and night. Bottom heating will be required for good germination in winter.

With old crops in slabs, the water is turned off for a few days. The plant is then cut off, leaving the old cube in the slab. New plants in rockwool–wrapped cubes are then placed next to the previous cubes and the drippers are transferred to the new cubes.

Spacing

Plant at 1.5 (winter) to 2.0 (summer) plants per square metre, with plants at 40 to 60 cm apart, with double rows on 2 m centres. Lebanese cucumbers can be planted slightly closer (up to 3 to 4 plants per square metre) than Continental cucumbers. Yields will decrease if too many plants are grown, due to insufficient light and a build-up of diseases.

Hydroponic Systems

The two main hydroponic systems are ‘Run to Waste’ and the Nutient Film Technique (NFT). The main system is the ‘Run to Waste’ system and different types of media are as follows:

Cocopeat slabs

This is the main system in Western Australia. Cocopeat consists of coir from coconut husks and contains some potassium, It is used as husk chips in bags, or slabs of 27 L size and 1.2m long and 18 cm wide. These may be used for 2 to 3 crops. There are four plants in each slab. These are easy to lay out and to remove. The slope for slabs should be 1:20. Cut drainage holes in the polythene that is lining the slabs. Cocopeat may also be placed into 10 L bags, with two Lebanese plants per bag or one Continental plant per bag. Waste slabs may be applied to the soil of field crops to supply organic matter.

Rockwool slabs

Rockwool is the main system used for growing cucumbers in the rest of the world. It is manufactured in Melbourne, Australia under the trade name 'Growool', and may also be imported as 'Grodan'.

Rockwool has excellent aeration and high water holding capacity. It is an inert volcanic fibre which is normally sold in 13 L slabs, 75 cm long by 30 cm wide and 7.5 cm thick, surrounded by a polythene liner. However, the cheapest system is for growers to buy unwrapped slabs and provide their own liners. There is a slit in the bottom to increase drainage. The slabs are placed end to end. Young plants can be propagated in small 10 cm rockwool cubes which are then placed on the slabs.

The rockwool slabs may be placed on polystyrene for better insulation and a hot water pipe on the polystyrene may also be used for heating the rockwool in winter.

There are three plants per slab and 3 to 4 crops may be grown before the rockwool becomes too soft and breaks down. Disposal of old rockwool slabs can be a problem.

Perlite bags

Perlite consists of potassium sodium aluminium silicate and is light with good water holding capacity and good aeration. As with rockwool, it neither contains or holds nutrients.

Perlite is available in 25 L bags and two cucumber plants can be grown per bag. Plants may be propagated in a rockwool cube and placed on top of the perlite. Slits may be placed on the side to leave a reservoir of nutrients in the bottom of the bag which is a safety valve during pumps' breakdowns.

The perlite bag should last for three crops and is readily disposable as an additive to nearby soils to improve moisture holding capacity.

Plants can also be grown in 10 L open bags containing perlite, with one plant per bag.

Sawchips

Sawchips are a cheap media and was the main system in Western Australia until the early 2000's, but is now difficult to obtain. Growers formerly used uncomposted pine sawchips, but jarrah sawdust may also be used. Sawchips of 5 to 7 mm grade are preferable, but the 2 to 4 mm and 9 mm sizes can also be used. The media will have poorer aeration if the sawchips are less than 5 mm in size.

One problem with sawchips is that bags are heavy and filling and emptying the bags involves much labour. Bags range from ordinary shopping bags to heavy duty black or white polythene bags or pots. The most common sizes are 10 L with one plant per bag. Providing there are no outbreaks of Pythium disease, a total of up to three crops can be grown on a batch of sawchips, following which this can be composted and applied as an organic matter addition to soil.

NFT

The nutrient film technique involves planting the cucumbers in a rockwool cube into a PVC channel and nutrients are recirculated 24 hours per day. This system has lost favour in Europe but it is still used in New Zealand. The main problem with NFT is that the cucumber roots have large roots and a high demand for oxygen. Roots can easily block the channels, raise the height of the nutrient solution and further deplete the supply of oxygen.

Cucumbers have been grown successfully on NFT in Western Australia, but attention must be given to the following points:

1. Grow crops for only a short period, ie 17 weeks.

2. Have a short run, ie 15 m.

3. Have a channel as wide as possible, ie 25 to 45 cm.

4. Place panda polythene film over the rows to reduce light and evaporation.

5. Increase ventilation by:

    a) having a long drop when the recirculating solution returns to the tank, or
    b) use a venturi, in the tank or
    c) add oxygen to the tank.

6. Ensure that there is only a thin film of nutrient solution passing over the roots at 0.5 to 0.75 L/minute.

To prevent leaching of nutrients into the groundwater, the trend with all crops in Holland is to move away from run to waste systems to recirculating systems. There are problems with using NFT in cucumbers, but the two systems are now being combined. The rockwool slabs

are placed over a channel, and the nutrients are recirculated with the nutrients adjusted for pH, nutrients, and often sterilised to control diseases.

With recirculating systems, every few weeks the old nutrient solutions are discarded and can be used to irrigate and fertilise fruit and vegetable crops grown in soil.

Soil

Soil fumigation with chloropicrin/DD is needed to control soil-borne diseases and nematodes after the second crop. The area is usually converted to hydroponics after a few crops due to a build-up of soil diseases and nematodes.

Figure 3 Continental cucumbers growing in soil in Geraldton

Cropping schedules

The best cropping periods for greenhouse cucumbers in the Perth area are from August to November and from April to May. Winter cropping is difficult because of low night

temperatures, and growers may use heating in winter to maintain good quality. Summer cropping is difficult if high temperatures occur in the greenhouse.

Greenhouse cucumbers can crop for 12 months when properly managed, but the normal picking period is much shorter. Growers often have three crops per year.

Irrigation/nutrient solution

Trickle irrigation with 2L/hour or 4L/hour drippers is the most suitable system for greenhouse cucumbers with one or two outlets per bag or slab. The trickle sub line can be tied onto a horizontal wire. Cucumbers do not tolerate salty water. Irrigation water must not contain more than 100 mg/L chloride. If the bore water is too salty (EC over 0.5 mS/cm or total soluble salts over 275 ppm), a reverse osmosis unit can be used to reduce the total soluble salts to a low level (0 to 20 ppm).

With 'Run to Waste' media systems, the nutrient solution is applied 3 to 5 times per day in winter and 10 to 15 times per day in summer, from sunrise to sunset. Measure the run-off with monitoring bags and water until there is a surcharge of 10 to 15 per cent from the bags. Light intensity sensors, or probes in a water bath can also be used to trigger watering. The trickle tube is placed into the cube first and then into the slab.

With the Nutrient Film Technique system, the nutrient solution is applied 24 hours per day.

Use an EC of 2 to 3 milliesiemens per centimetre (mS/cm), with the higher level during harvesting. An EC below 1.6 will have lower yields.

The need for water depends on the greenhouse design and the irrigation/nutrient system. In the Perth area, with a 'Run to Waste' system, greenhouse cucumbers use an average of 1L per plant per day in winter, 5 to 6 L per plant per day in summer and 3 L per plant per day throughout the year, or about 22,000 KL/ha/a. The system should be designed based on the maximum demand for water on the hottest days in summer.

Maintain the pH between 5.5 to 6.5 pH (by the water system of measurement), using either potassium hydroxide to raise the pH (make the solution more alkaline) and nitric or phosphoric acids to lower the pH (make the solution more acidic).

Misters can be used for cooling for a few minutes when temperatures exceed 35°C in summer and also to improve conditions for predatory mites against the two spotted mite.

Fertilisation

Cucumbers are supplied with 12 essential nutrients whenever the plants are watered. A commercial mix can be used from a proprietary company, or a grower can use his own formula.

Nutrients (see Table 1) are stored in two 200 L tanks. Tank A contains a soluble solution of four nutrients i.e. calcium nitrate, potassium nitrate and an iron chelate. Tank B contains a soluble solution of ten nutrients, excluding iron and calcium nutrients. The solutions from Tanks A and B are added together to a 10,000 to 40,000 L tank to feed and water the cucumbers. The EC can be adjusted twice per day.

Table 1 Available soluble fertilisers and nutrient concentrations in the solution (mg/L)

Nutrient	Available soluble fertilisers	Amount of nutrient in final solution (mg/L)
Nitrogen	Calcium nitrate. Mono ammonium phosphate. Potassium nitrate.	150-250
Phosphorus	Mono ammonium phosphate. Mono potassium phosphate	20-50
Potassium	Mono potassium phosphate. Potassium nitrate.	150-300
Magnesium	Magnesium sulphate	50
Calcium	Calcium nitrate	150-220

Sulphur	Applied in fertilisers with other nutrients	
Boron	Borax	0.3-0.5
Copper	Copper sulphate	0.1-0.2
Iron	Iron chelate	10
Manganese	Manganese sulphate	0.5-1.0
Molybdenum	Sodium molybdate	0.05
Zinc	Zinc sulphate	0.2-0.3

The use of the nutrients in Table 1 should result in a good supply of nutrients for the life of the crop. Test the leaves for a nutrient analyses to determine whether adjustments need to be made to the fertiliser program. Use the third youngest leaf at the early flowering stage. This is only a guide and analyses for some nutrients may not be reliable. Analyses for the older leaves can show lower levels than the younger leaves.

Table 2. Leaf tissue levels for continental cucumbers

Nutrient	Amount	Optimum	Deficiency	Toxicity
Nitrogen (N)	%	3.0 6.0	1.8	6
Phosphorus (P)	%	0.35 to 0.8	0.2	1
Potassium (K)	%	2.5 to 4	2.0	5.5
Calcium (Ca)	%	2 to 5	Results misleading	
Magnesium (Mg)	%	0.6 to 1.3	0.15	2.5
Sulphur	%	0.13- 0.30	Does not occur	
Manganese (Mn)	ppm	70 to 300	15-20	500
Copper (Cu)	ppm	5 to 20	3	30
Zinc (Zn)	ppm	40 to 100	15	300
Iron (Fe)	ppm	100 to 250	Results misleading	
Molybdenum (Mo)	ppm	0.8 to 3.3	0.3	
Boron (B)	ppm	30 to 100	20	150

If analysis shows that a certain nutrient is too high, this may require the adjustments of other nutrients to obtain a better balance, especially with potassium and nitrogen, calcium and magnesium ratios.

The plants can still show signs of nutrient deficiency (especially nitrogen, potassium, magnesium and boron) when they are under stress, during waterlogging, or if there is very heavy fruit production. There may also be problems with the mixture (manganese sulphate may have been applied by mistake in place of magnesium sulphate or vice versa). Plants can also show signs of a nutrient toxicity, especially if the nutrients in the bore water have not been analysed.

Many of the signs of deficiency or toxicity can be difficult to interpret. Deficiencies of nitrogen (pale yellow leaves) and magnesium (yellowing between the green veins of old leaves) are the easiest to identify. An excess of nitrogen can result in dark green leaves, marginal yellowing, too much vegetative growth and downward leaf curling. Marginal yellowing on the leaves can be caused by a number of problems, both deficiencies and toxicities.

Training, pruning and thinning

Train plants as follows:

- Tie polypropylene string to a 2 mm diameter support wire, 2.1 to 2.3 m above the ground. Tie the other end of the string to the base of the plant (when above 50 cm high), or to a horizontal wire, or under the potting bag, or into the potting mixture.

- As the plant grows, twist it around the string twice per week. Remove the flowers and fruit on the first 45 to 80 cm (more in the winter) of the main stem, or for the first 5 nodes (junction of the leaves and stems) with Lebanese cucumbers.
- Remove the side shoots and tendrils on the main stem.
- Thin to one fruit per two nodes for the Continental varieties, especially curled fruits which may be visible after a few days. The fruits may not be thinned alternately, as reject fruit are removed first. Some fruits will drop off naturally. Do not thin the Lebanese varieties, which may have more than one fruit on every node and up to 4 to 7 fruit per node. Tendrils may need to be removed if these wrap around the fruits.
- Place the plant over a hoop, or pipe, or plastic saddle at the top of the wire.
- Stop the plant by removing the growing point at the fourth leaf over the wire. Allow two laterals to grow. These will grow downwards. Stop growth just before they reach the ground.
- As plants mature, old or diseased leaves can be gradually removed, especially to allow better light into the plant.

Pests and diseases

Protected cultivation provides an environment which is different to field crops.

A specialist can check the crops and determine the need for biological or chemical control.

The best time to spray is in the evening.

The keys to controlling diseases in greenhouses are:

- strict hygiene - leave no leaf debris in the greenhouse; and
- maintaining greenhouse conditions favourable to the crop and not to diseases.

Applying pesticides in greenhouses presents special problems. Space is generally limited.

Pesticides applied to plants and other surfaces in greenhouses generally do not break down as rapidly as they do outside. This is due to reduced ventilation, no rainfall and the filtering out of ultraviolet light, which would normally contribute to the degradation of pesticides.

When spraying pesticides in a greenhouse, take the following precautions:

- Select the least hazardous chemical that will do the job.
- Use a full face respirator with appropriate filters and waterproof protective clothing. If possible, use automatic systems whereby the operator does not need to enter the greenhouse.
- Do not enter the greenhouse, or permit others to do so, until at least eight hours have passed, and only then after the greenhouse has been well ventilated. If someone needs to go in before then, they should wear a full face respirator with the appropriate canister filter.

Check the labels before you buy, as pesticides can be deregistered for use on a particular crop. Some pesticides can be used under permit and their usage is subject to change.

Diseases

Between crops, disinfect empty greenhouses with 1% chlorine (dilute sodium hypochlorite, as the 12.5% chlorine product, by 12.5 times).

Do not plant too closely. Practise good hygiene, such as removal of prunings, old leaves and reject fruit.

Angular leaf spot bacterium (Pseudomonas lachrymans)

Symptoms on leaves begin as small dark water spots which enlarge and become light brown and finally a pale bleached colour. The larger lesions are restricted by the leaf veins giving an angular appearance to them. Old lesions frequently become tattered and holes develop on the leaf. Yellow haloes may be seen around the lesions.

Fruit lesions are often slightly raised and corky and may produce a white crusty deposits. Under high humidity, there is often a bacterial gum exudate from the scabs.

Lesions caused by this disease do not contain the black fruiting bodies characteristic of gummy stem blight.

The bacteria are spread in water and are more common under overhead irrigation. It is worse in areas with high relative humidities.

The registered active ingredients, propineb and copper oxychloride, can be sprayed to control angular leaf spot.

Anthracnose (Colletotrichum orbiculare)

This attacks the stem at the base of the plant. It is favoured by high relative humidities and temperatures

The registered active ingredient, mancozeb, can be sprayed to control anthracnose.

Botrytis

Botrytis or grey mould is a disease which is one of the first problems encountered by the new hydroponic grower, mainly because of poor ventilation.

The disease is seen as a soft watery breakdown or rot on flowers, stems, leaves and fruit, and may also cause damping-off in seedlings. It will grow on debris on the greenhouse floor. The spores are borne on stalks and result in a grey furry appearance.

The disease often first affects the plant through pruning wounds and old flowers, and then spreads to the rest of the plant.

There are no registrations for chemical control.

Grey mould is most prevalent in cool moist climates and optimum temperatures are 18 to 23ºC. High relative humidities will increase the disease. Check the relative humidities with a hydrometer.

A most important means of control is to adopt good hygiene. Do not space plants too closely. Remove old leaves, prunings and debris from the greenhouse. Do not overwater.

The plants must be well ventilated especially in mid afternoon, so that moist air is removed. This will reduce humidities from 4.00 to 9.00 am, as high relative humidities at this time will result in high spore production. Botrytis will also be less prevalent in a tall greenhouse which has low relative humidities and where the polythene cover has good anti-condensate properties.
If necessary, use registered chemicals that contain the active ingredients chlorothalonil or mancozeb. If possible, spray immediately after removal of leaves and shoots and alternate different chemicals.

2: Gummy stem blight fungus (Didymella bryoniae or Mycosphaerella cucumis)

Symptoms on leaves begin as watersoaked areas and become light brown and irregular in outline. Stem symptoms may include cankers which can girdle the stem and cause total plant loss. These lesions may occur where leaves or fruit have been removed.

Symptoms also begin as water soaked areas, often at the blossom end, becoming brownish and exuding gum.

Lesions caused by this fungus are characterised usually by the abundant production of small black fruiting bodies.

Infection may be by water splash, but in the greenhouse it is more likely by aerial dispersion of spores. High relative humidities and condensation from the polymer roof plus low night temperatures will increase this disease.

The registered active ingredients, mancozeb or chlorothalonil, can be sprayed to control gummy stem blight.

Powdery mildew (Sphaerotheca fuligena)

Powdery mildew is seen as a white growth under the leaves and later attacks the whole leaf and the upper leaves. It is worse in autumn and winter.

Many varieties have some tolerance to powdery mildew, but may produce lower yields. Registered pesticides that contain the active ingredient triadimefon may be needed to control this disease. The relative humidity should also be not too high, and good ventilation is needed. Infection begins when surface moisture is present on the leaves, but then the fungus grows best under dry conditions.

Pythium root rot (various Pythium species)

Pythium root rot destroys fine feeder roots, so that the plant has difficulty obtaining water and nutrients. Plants wilt and appear nutrient deficient. Roots are yellow to brown and the base of the stem may rot.

Root rots are induced by overwatering and poor aeration.

Pythium may be controlled in hydroponic crops by using calcium hypochlorite at 1.5g/1000L (1 ppm) regularly in the water supply and nutrient solutions. Pythium can also be in the bore water and can be treated in a holding tank with a high rate of calcium hypochlorite (20 ppm chlorine) for one day before the water is applied to the cucumbers. Application of nutrients in warm water in winter may help to reduce the disease. Do not re-plant into slabs in which plants were infected with the disease.

Sclerotinia

Crops that are planted too close are often affected by *Sclerotinia* disease. This fungus causes a watery rot, usually at the base of the stem. Plants wilt. Reduce plant density and increase ventilation

Other

Alternaria, Fusarium oxysporum and Xanthomonas (bacterial spot) diseases occasionally occur.

Pests

The Mushroom/sciarid fly or fungus gnat is similar to a sand fly in appearance and has long legs. It may eat the roots of cucumbers planted in media such as cocopeat. It has also been found in cucumber grown on rockwool. Mushroom flies are worse in spring and autumn. The larvae normally feed on organic matter and fungi. They will also hollow out the stems of young seedlings at the base of the plant and cause plants to fall over. They also attack older plants. The pest has caused severe damage in some greenhouses and may also spread Pythium fungus disease. The fly lays its eggs in algae. If the trickle outlet is placed further down into the pot, the surface of the media may be drier and result in less algae. The active ingredient *Bacterial thuriengiensis israelensis* is an organic product (under permit) that can be used to control fungus gnats.

Whitefly is a small sucking pest which may build up to large numbers. It is favoured by warm temperatures and high relative humidities. It may be controlled by spraying with endosulphan. This has a one day withholding period. The predator *Encarsia formosa* will also help to control whitefly and may be purchased from the Eastern States.

Two-spotted or red spider mites (*Tetranychus urticae*) are a major problem in warm weather, especially where the relative humidities are low. Once two-spotted mites are well established in a crop, major yield loss is inevitable. Two-spotted mite, (*Tetranychus urticae)* also known as 'red spider' is a destructive pest and is usually found on the underside of the leaves. They are about 0.5 mm in size and are usually brown or brick red with dark spots on the back. In severe infestations, large numbers of mites and eggs occur on the leaves and are protected by webbing. The development from egg to adult varies from a fortnight in cool conditions, to five days during a heat wave. Two-spotted mites cause the leaves to become mottled, yellow and shrivelled. Two-spotted mite prefers hot and dry conditions and the use of overhead sprinklers during high temperatures may reduce populations and also cool the plants.

A predatory mite *(Phytoseiulus persimilis)* can help to reduce numbers of two spotted mite. These are fast, bright orange and the adults are a little larger than two-spotted mite. They are difficult to manage as they do not like cold or hot conditions, and it will take 6 to 8 weeks to control a well established population of two spotted mites. They must be introduced when the first two spotted mites are seen. It is best to introduce them in late winter/early spring and keep plants cool by misting in summer. Introduce 100 predators per 1,000 plants each week throughout the growing season. Optimum temperatures are 25 to 30°C, with high relative humidities. The predatory mite is tolerant to most fungicides, and some miticides and insecticides. Propargite (active ingredient) may be used in conjunction with predatory mite to control two spotted mite, especially in temperatures above 30°C, which is tolerated more by two spider mites than the predatory mite. Other pesticides may have a severe effect on predatory mites and should not be used.

Predatory mites are killed by some classes of pesticides such as synthetic pyrethroids. Avoid using these chemicals. A list of pesticides that do not harm the predators is available from the suppliers.

Predatory mites can be purchased from Hawkaid Integrated Pest Management Service, PO Box 415, Richmond, NSW 2753, (045) 701 331, or Bio-control Ltd., PO Box 515, Warwick, QLD 4370, (076) 614 488. Delivery time is one week.

If biological control is not used, spraying is necessary as soon as the mites appear on the leaves (1 to 2 per leaf). If the infestation is not noticed at an early stage, huge populations soon build up and are difficult to control. Applications of spray material must be thorough with both sides of the leaves wetted. The active ingredient abamectin (permit) and botanical oils (registered) can be used to control two spotted mites, but do not over-use the botanical oils.

Thrips are small insects that may cause bent fruits and scarring. They can be controlled with the biological agent, *Typhlodromips montorensis, which is a mite.* The active ingredients imidacloprid (permit) and spinosad (registered) can be used under permit to control thrips.

Whiteflies are small delicate insects that feed on the leaves and may cause curled fruit and black, sooty mould deposits on the leaves. They may be controlled with the pesticide buprofezin under permit. The biological agent, *Encarsia formosa* wasps are about 0.6 mm in size and they lay their eggs on the small whitefly nymphs.

Grubs can sometimes eat the fruit and leaves in summer. The use of good screens should prevent the entry of moths in enclosed greenhouses and eliminate grubs. Aphids and mealybug can attack the stems and leaves. The active ingredients imidacloprid (under permit), botanical oils (registered) and spinosad (registered) can be used to control aphids. Mice can eat the fruit.

Physiological disorders

Cracking can be caused by applying too much water.

Short periods of low temperatures can cause light coloured longitudinal surface scars on developing fruit.

Curled fruits can be up to 10 per cent of total fruit and can be caused by contact with leaves, stems, tendrils, strings and wires. Fruit should be allowed to hang freely. Crooked fruits are removed during thinning. Cold weather, waterlogging, poor nutrition and thrips can also result in bent fruit.

Fruit abortion is common. Flowers wither and immature fruits turn yellow and brown when 3 to 5 cm long.

Abortion is induced if plants suffer a heavy load of fruit from dryness, excess salts, overwatering, high temperatures or nutrient imbalances. Thinning of the Continental varieties should occur after it is obvious which fruit have aborted.

Scarring of the fruit can be caused by fruit touching leaves and stems, or by hot or cold temperatures, or by boron deficiency.

Tapering of fruit can be caused by cold weather.

Flowering

Cucumbers under protected cultivation produce fruit without pollination. However, pollination can take place from nearby field cucumbers which are monoecious (they have both male and female flowers). If flowers are pollinated, seeds form in the fruit and the fruit becomes bulbed, bitter and unsaleable.

Harvesting

The time from seeding to harvesting can be 4 to 6 weeks in summer and 11 weeks in winter.

In summer, fruit are ready for harvesting two weeks after flowering for the long varieties and 7 to 10 days after flowering for the Lebanese varieties.

Pick fruit in early morning. Cut fruit so that 1 to 2 cm of stalk remains at the end of the fruit. Small fruit wilt rapidly and are hard to sell. Over-mature fruit can be yellow at the stem end. Continental varieties may need picking every two days and Lebanese varieties may need daily picking.

Cucumbers should be handled carefully as they are easily marked.

There are normally three crops per year in the same area, but sometimes there are two crops per year, or one crop may be harvested in the warmer months for up to 8 months. Fruit are more plentiful and larger in summer. Pick for 10 to 15 weeks with 20 to 25 fruit in summer

and 10 fruit in winter. Long term crops in the warmer months may produce 30 to 40 fruit per plant. The average weight for Continental cucumbers is 500 to 600 g, but may weigh up to 1.4 kg. Average yields are about 500 to 550 t/ha/a, with about 80 to 90 fruit per square metre per year. Yields of Lebanese cucumbers may be higher than Continental cucumbers. Fruit may average 100 g each.

Quality

Good quality fruits should be dark green, and be firm, with good, crisp flavour.

Packing

Reject bent fruit and marked fruit. Wipe off sand and dust of Continental fruit. Wash Lebanese fruit and dip in a calcium hypochlorite solution which contains 2 ppm chlorine to prevent fruit breakdown. Remove old flower parts at the end of the fruit. Fruit are packed about three times per week.

To avoid condensation, cool the fruit to 7 to 13 °C before wrapping. Shrink-wrap fruit of Continental varieties individually in polythene film to increase their shelf life and enhance their appearance. A good operator can wrap 400 to 600 fruit in an hour. Some growers use shrink-wrap machines to wrap the fruit, which are expensive, but can wrap 600 per hour. A sticker can be placed over the wrapped fruit.

Continental cucumbers are sent to the Perth Metropolitan Markets in 22 L crates. There should be 10 to 15 fruit in a crate

Lebanese cucumbers do not need to be wrapped and are packed in 22 L (10-12 kg) crates inside a polyliner, or in 6 kg cartons, or on a 7 kg polystyrene tray which is wrapped. Packing the fruit takes twice as long as Continental cucumbers, but the individual fruit are not wrapped.

Storage

Wrapped Continental cucumbers should be kept at 10 to 15^0C and 95% relative humidity for 1 to 2 weeks. Unwrapped fruit have a storage life of only 2 to 3 days.

Do not store cucumbers with fruit that produce ethylene, such as mangoes and bananas. This will produce yellowing and spotting on the skins.

Marketing

Cucumbers are marketed in Western Australia and are sometimes sent to markets in the eastern States. The main market distributors in Western Australia are large wholesale distributors such as Coles and Woolworths, plus market agents at Market City, Canning Vale, Perth.

There is a large industry growing greenhouse cucumbers at Virginia, South Australia. When the eastern States markets are over-supplied, they send more fruit to West Australian markets. Imports must be certified free of European red mite or Queensland fruit fly.

Lebanese fruit are often more subject to over-supply than Continental cucumbers.

Removing plants

Old plants can be composted, but plastic strings should be removed as they will not rot in the compost.

WA Greenhouse Growers Association

This Association represents greenhouse growers, including cucumber growers.

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