

Greenhouse Vegetable Production



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Greenhouse vegetable production has traditionally been located near population centers, primarily in the northeastern United States. Improved transportation and high energy costs have forced the industry south. With light being one of the most important factors in greenhouse vegetable production, the Southwest has become an ideal area for future development of this industry, particularly in the winter months when tomato and cucumber prices are at a premium.

LOCATION OF GREENHOUSE

The ideal location for a greenhouse has high winter light intensity, moderate winter temperatures, low humidity, and easy access to markets. The easy availability of existing utilities will help reduce establishment costs and will affect ongoing fuel costs. Avoid trees or buildings that may shade the greenhouse, although windbreaks will help reduce heating costs if properly located. Be sure to leave sufficient room for future expansion and parking.

While superhighways have made transporting greenhouse-grown vegetables easier, locating greenhouse-grown tomatoes near large population areas is still important. High quality tomatoes should be vine ripened; as ripe tomatoes are hard to transport, the closer they are to the retail market the better.

Greenhouses using native soil for vegetable production should be constructed on level sites with deep, well-drained soils. Sandy loams are best. A source of good quality water also is important. High salt concentrations in either the soil or water can significantly reduce yields. Where soils are not suitable, growers may consider bringing in a better soil or using a soil-less production system.

GREENHOUSE CONSTRUCTION

When considering greenhouse designs, three major factors should be considered: load limitations, light penetration, and cost. The primary load considerations include snow and wind. Roof slopes of at least 28° and heated air in the greenhouse should prevent snow accumulation on the roof. Bracing along sides of the greenhouse and roof should be sufficient to withstand wind, particularly in the spring. Bracing along the roof also should be sufficient to withstand crop loads if tomato or cucumber vines are to be supported by twine attached to the bracing. A concrete footing is preferred for a permanent greenhouse. A wide door at one end of the greenhouse will ensure easy access for equipment.

Without sacrificing strength, support structures should be kept to a minimum to maximize light penetration. Glazing materials should be highly transparent. Overhead electrical lines, irrigation systems, and heating ducts should be kept to a minimum. Support structures should be painted with a reflective, light-colored material for maximum light reflection.

Most greenhouse crops grow best in light whose wavelengths range from 400 to 700 nanometers. This range of wavelengths is called *photosynthetically active radiation* (PAR). Most greenhouse coverings will accommodate these short waves of visible light. Polyethylene and fiberglass tend to scatter light, while acrylic and polycarbonate tend to allow radiation to pass through directly. Scattered or diffused light tends to benefit plants by reducing excess light on upper leaves and increasing reflected light to lower leaves.

Plastic glazed greenhouses have several advantages over glass greenhouses, the main advantage being cost. Plastic also is adapted to various greenhouse designs, generally resistant to breakage, lightweight, and relatively easy to apply.

Types of Plastic Coverings

- **Acrylic** is resistant to weathering and breakage and is very transparent. Its ultra-violet radiation absorption rate is higher than glass. Double-layer acrylic transmits about 83 percent of light and reduces heat loss 20–40 percent over single-layer. This material does not yellow. Its disadvantages are that it is flammable, very expensive, and easily scratched.
- **Polycarbonate** resists impact better and is more flexible, thinner, and less expensive than acrylic. Double-layer polycarbonate transmits about 75–80 percent of light and reduces heat loss 40 percent over single-layer. This material scratches easily, has a high expansion/contraction rate, and starts turning yellow and losing transparency within a year (although new varieties with UV inhibitors don't yellow as quickly).
- **Fiberglass** reinforced polyester (FRP) panels are durable, attractive, and moderately priced. Compared to glass, FRP panels are more resistant to impact, transmit slightly less light, and weathering over time reduces light transmission. This plastic is easy to cut and comes in corrugated or flat panels. It provides superior weatherability only when coated with Tedlar. Fiberglass has a high expansion/contraction rate.
- **Polyethylene film** is inexpensive but temporary, less attractive, and requires more maintenance than other plastics. It is easily destroyed by ultraviolet radiation (UV) from the sun, although film treated with UV inhibitors will last 12–24 months longer than untreated. Because it comes in wider sheets it requires fewer structural framing members for support, resulting in greater light transmission. Using a double layer of 6 mil polyethylene on the outside and 2 mil as an inner barrier will help conserve heat; this inner layer also will help reduce water condensation. The inner layer should be 1–4 inches from the outside layer with layers kept separated by a small fan (creating an insulating dead air space) or wood spacers. Two layers reduce heat loss 30–40 percent and transmit 75–87 percent of available light when new.
- **Polyvinyl chloride film** has very high emissivity for long-wave radiation, which creates slightly higher air temperatures in the greenhouse at night. UV inhibitors can increase the life of the film. It is more expensive than polyethylene film and tends to accumulate dirt, which must be washed off in winter for better light transmission.

TEMPERATURE CONTROL

Regulating air temperature in the greenhouse is important for both vegetative growth and fruiting. To determine heating requirements, it is essential to know the minimum temperature requirements for the crop, the lowest outdoor temperature that might be expected, and the surface area of the greenhouse. Heat loss also will be affected by wind and site exposure.

Most vegetable production greenhouses in New Mexico are heated by natural gas. Forced-air heaters installed in the ridge area of the greenhouse will take up a minimum of space. It is important to install a heater with sufficient BTU output to heat the greenhouse on the coldest day. Natural and compressed gas heaters should be vented for safety and to prevent crop damage. Thermostats should be located at plant level where plants are growing and where drafts or sunlight do not directly affect them.

Greenhouse cooling also is important. Evaporative cooling is the most efficient and economical way to reduce greenhouse temperatures in New Mexico. Proper ventilation also is important not only for temperature control, but also to replenish carbon dioxide and control relative humidity. Relative humidities above 90 percent will encourage disease problems. Roof ventilators are seldom used on plastic houses, which instead use side vents to provide both ventilation and cooling. Vents should be installed as high on the wall as possible. Shading may be required in the late spring or early fall if daytime temperatures become too high. Various shading materials that can be sprayed or brushed on are available from greenhouse supply companies. However, shade compounds must be removed when cool weather sets in. Shade cloths with various degrees of shading also are available.

Heating, cooling, and ventilation should be automated to save labor and to ensure proper temperature control. Polyethylene ventilation tubes with 3-inch perforation holes along the tube suspended in the peak of the house from one end to the other help evenly mix cooler air with warmer air, preventing drafts.

SOIL CULTURE

The easiest way to get started in greenhouse vegetable production is to use the existing soil on site, but soils must be well drained. Soils can be improved by applying ample quantities of well-rotted livestock manure, compost, or composted livestock manure. Apply all manures before fumigation. Soils should be fumigated or sterilized with steam at least two weeks before planting. If the soil is steamed, maintain a temperature of 180°F for at least four hours. Avoid deep tillage after sterilization to prevent reintroduction of weed seed and

disease organisms from below the sterilization or fumigation zone.

A soil test should be taken before planting to determine the amount of fertilizer to apply for each crop. All phosphorous and potassium fertilizers should be applied before planting and incorporated directly into the soil. Nitrogen fertilizers should be applied in split applications, part before planting and the rest as needed during the growing season. Nitrogen fertilizers can be applied as sidedressings or through a drip irrigation system. Secondary and minor fertilizer elements should be applied as needed.

HYDROPONIC CULTURE

Hydroponic culture of greenhouse vegetables involves the production of crops in sand, gravel, or artificial soil-less mixes in bags, tubes, tubs, tanks, or troughs designed to allow the circulation of nutrient media needed for crop growth. Unlike conventional soil culture, hydroponic culture of greenhouse vegetables is less forgiving and requires intense management. Although present automation systems can minimize fertilization and irrigation labor inputs, continuous monitoring of the system is important. Growers must be highly knowledgeable about plant growth, nutrient balances, cultural media characteristics, and plant physiology. Nevertheless, hydroponics allows the culture of greenhouse vegetables in areas where soils are not suitable for vegetable production.

CROPS AND CULTURE

Tomatoes are the most common vegetables grown in greenhouses, followed by cucumbers. Both are grown in the off-season (fall, winter, and spring) to take advantage of premium prices. Leaf and Bibb lettuces often are grown in the winter in cooler areas of the state. Other popular crops include bell peppers, eggplant, and herbs like basil.

CARBON DIOXIDE ENHANCEMENT

The introduction of supplementary carbon dioxide into the greenhouse has been found to significantly increase the yields of greenhouse tomatoes and other vegetables. Supplementary carbon dioxide is most effective on days when the greenhouse has been shut up for several days with no ventilation. Maximum results can be achieved by injecting 1000–1500 ppm CO₂ into the greenhouse using propane burners or other CO₂ generators.

INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) is a holistic approach to the management of pests. IPM does not exclude the use of pesticides in the greenhouse. Rather, pesticides are used in combination with cultural, natural, mechanical, and biological control as well as insect monitoring to maximize the effectiveness of control methods. Reduced use of pesticides under more effective timing schedules reduces not only the adverse effects of these chemicals on the environment and people, but also reduces the chance of pests developing resistance. For more information on pest control techniques, contact your local county Extension agent.

TOMATO

Planting

One or two tomato crops can be planted in the greenhouse during the year. Planting, transplanting, and harvest dates will vary depending on location. As most tomato varieties will begin to ripen 100 days after planting, seed should be planted so the fruit begin to ripen soon after first frost for fall crops.

In cooler areas of New Mexico, tomato crops are generally planted in early July and transplanted to greenhouse beds in mid-August. Harvest will begin in October and may continue until early March. Harvesting may be terminated at an earlier date if heating costs become extreme. Late spring harvest can be accomplished by delaying planting until late fall or early winter. Planting dates in southern New Mexico should be delayed until mid-August or later due to hot weather in mid-summer.

Plants are best started in individual containers (plastic pots, peat pots, or cubes) to reduce labor costs and reduce transplanting shock. Use of commercial sterile potting mixes will decrease the incidence of seedling disease problems. Custom soil mixes can be used, but must be pasteurized to eliminate insects, diseases, and weed seed. Heating the moist soil mixture to a temperature of 160°F for 30 minutes will kill most pests.

Sow two to three seeds per pot (1/4-inch deep) and water. Then cover pots with clear polyethylene and place in the shade (70°F) until seedlings emerge. Plastic should then be removed and the pots moved into full sun. Thin the seedlings to one plant per pot.

If possible, seedlings should be grown at daytime temperatures of 58–60°F (nighttime 52–56°F) for the first 10–14 days. This initial cold treatment should help seedlings develop larger cotyledons and thicker stems. Plants should also set more early fruit, increasing both early and total yields. Thereafter a daytime temperature of 70–75°F (nighttime 60–62°F) should be maintained.

After the initial cold treatment, temperatures should not fall below 55°F, which may cause rough, irregularly shaped fruit and stunted plant growth. Temperatures can be reduced slightly during cloudy days.

Irrigation water may have to be heated in the winter before use. Water less than 50°F will chill the roots, causing poor growth. Plants should be fertilized weekly with a starter solution (1/2 ounce of 21-53-0 per gallon of water) in the irrigation water. As plants become larger, feeding can be increased to twice a week.

Transplants should be established in the ground beds approximately four to six weeks after seeding. Set transplants in the soil 1 inch deeper than previously grown. Space plants 15–18 inches apart in rows 3–3.5 feet wide. Water immediately after transplanting.

Training

Plants should be trained as single (main) stems by removing all side shoots or suckers that develop between leaf petioles and the stems. Remove shoots by snapping them off, not cutting, as diseases can be transmitted on the knife blade. Vines can be supported by plastic or binder twine loosely anchored around the base of the plants (non-slip loop) and to overhead support wires (11- to 12-gauge) running the length of the row. Overhead wires should be at least 7 feet above the surface of the bed and be firmly anchored to support structures.

Twine should be wrapped clockwise around the vine as it develops, with one complete swirl every three leaves. The vine should be supported by the twine under the leaves, not the stems of the fruit clusters. Also wrap twine in the same direction, using clips or tape to keep vines from slipping down the twine. Do not try to wrap the twine around the growing tip because the tip may break.



Tie end of string loosely to base of stem using a non-slip loop.
Wrap string clockwise around vine.

When plants reach overhead supporting wires, untie the twine and lower vines and twine at least 3 feet. After lowering, vines should all lean in one direction in one row. Vines in adjacent rows should lean in the opposite direction. Retie twine with the vines to the support wire. Be sure to leave at least 4–5 feet of extra twine for this purpose when initially tying vines. Remove any leaves that lie on the soil.

About 40–45 days before terminating harvest, plants can be “topped” by pinching out the terminal growing tip. Keep two leaves above the top flower cluster. Topping vines will force remaining food reserves into maturing fruit already present on the vines. Continue to remove any suckers that develop.

As fruit mature on the lower part of the vine, pinch off older leaves below the fruit. This will provide better air circulation, which helps to reduce the incidence of disease and opens vines up for spraying and harvesting.

Growers should remove any deformed, immature fruit which will ultimately become culls. Removing excess fruit also will result in larger tomatoes at harvest that can be sold at a premium price.

Pollination

Mechanical pollination of tomato flowers is generally needed in the greenhouse due to limited air movement and high humidity. An electric or battery-powered vibrator can be used to vibrate flower clusters just above the area where they originate from the stem. The vibration will release pollen necessary for pollination. This can be done twice a day (around 10:00 am and 3:00 pm). If tobacco mosaic virus has been a problem, the vibrator should be wiped after each use with a clean cloth or sponge moistened in a 5 percent chlorine solution. Because all flowers on a cluster do not open at the same time, the same cluster will have to be vibrated again as new flowers open. Air from a mist-blower also has been found effective in pollinating tomatoes.

A number of factors can result in poor fruit set. The most common problem is temperature extremes (above 90°F during the daytime, above 75°F at night, or below 57°F at night). Other adverse conditions include high humidity, low light intensity, nutrient imbalances, pests, and water stress.

Plant Nutrition

Optimum soil pH for tomato production is 5.8–6.8. Depending on a soil analysis, phosphorous should be applied pre-plant incorporated at a rate of 200–400 lb/a of P₂O₅. Soils deficient in potassium may require similar quantities of potassium (K₂O). Both the phosphorous (treble-superphosphate) and potassium (potassium sulfate) should be incorporated to a depth of 8–12 inches. Approximately 50 lb/a of elemental nitrogen should be

applied before planting. Additional nitrogen can be applied as a sidedressing or through the irrigation system as needed. Leaf analysis is the best way to determine additional nutrient requirements. Plants exhibiting deficiencies of minor elements such as iron or zinc can be treated with foliar applications of iron or zinc sulfates or chelates.

Mulching

A mulch of clean straw can be placed around plants to a depth of 3–4 inches. Mulches will help conserve moisture and keep soil from compacting between plants. Mulches are most effective when used in combination with drip irrigation.

Harvesting

Fruit should remain on the vine for as long as possible for maximum quality. However, market specifications will determine whether fruit should be harvested earlier (light red stage). Plants are generally harvested two to three times a week. Fruit should be snapped from the plant leaving a small portion of the pedicel and green calyx bracts attached to the fruit, a distinct trademark for greenhouse-grown tomatoes.

Tomatoes should be graded using USDA standards. Most buyers prefer U.S. No. 1 fruit. The best market for greenhouse-grown tomatoes in New Mexico is between November and April.

Ripe fruit should be cooled to 55°F for maximum shelf life, but never allow the temperature to drop below 50°F. Light-colored fruit can be held at 70°F until the desired color is achieved.

Greenhouse tomatoes are generally marketed in 8- to 10-pound baskets or cartons. Some two-layered cartons may hold 16–20 pounds of fruit. Cartons should be sturdy enough to prevent mechanical damage when handling. Fruit and packaging should be distinctly labeled with decals or other identification to distinguish them as greenhouse-grown tomatoes.

Varieties

- 'Tropic' - very popular; very firm, large, red fruited type (8–9 oz); resistance¹ to Fusarium wilt (race 1), Verticillium wilt, early blight, gray leaf spot, and some leaf molds; tolerance¹ to blotching and some races of tobacco mosaic virus (TMV).
- 'Jumbo' - similar to 'Tropic'; excellent yields; more USDA #1 fruit (8 oz); resistance to Fusarium wilt (races 1 and 2) and Verticillium wilt; not resistant to TMV.

- 'Floradel' - 6-oz fruit; resistance to Fusarium wilt, gray leaf spot, and some leaf molds.
- 'Floralou' - excellent fruit quality and color; vigorous and productive plants; medium-size fruit; resistance to Fusarium wilt and gray leaf mold; resistance to fruit cracking.
- 'Vendor' - develops good red color; medium-large fruit (4–8 oz); uniform ripening fruit; moderately firm; resistance to TMV (race 1), Fusarium wilt, and several races of leaf mold; fruit resist cracking.
- 'Pole King' - 8- to 9-oz fruit; sturdy vines; resistance to Fusarium and Verticillium wilts.
- 'Michigan-Ohio' hybrid - medium-large fruit (8 oz); resistance to Fusarium and Verticillium wilts; adapted to low light conditions.
- 'Tuckcross O and V' - excellent fruit quality and color; very productive; small to medium-size fruit; minimal fruit cracking; resistance to leaf mold (one strain) and Fusarium wilt.
- 'Trend' - high yield potential; large, smooth, red fruit; good crack tolerance; resistant to Fusarium crown rot.
- 'Furon' - red, medium size, beef-steak type; good tolerance to cracking and russetting; resistant to Fusarium crown rot.
- 'Husky Cherry Gold' - golden-yellow cherry type; vigorous vines up to 6 ft long; more compact and larger fruit than other cherry varieties; resistance/tolerance to Verticillium and Fusarium wilts.

Pest Control

Diseases. Diseases are best controlled through prevention. Selecting a sunny site with a well-drained soil, sterilizing the soil, providing good air circulation, and monitoring your irrigation closely will help keep diseases to a minimum. Nevertheless, keep a good supply of recommended fungicides on hand with an appropriate sprayer that will effectively cover all plant surfaces.

Seedling diseases include seed rot (failure of seed to germinate due to fungi), stem rot, and pre- and post-emergence damping-off. Damping-off refers to the attack of seedlings before and after emergence from the soil. Symptoms include the development of dry or water-soaked lesions at the soil line, resulting in stem

¹Resistance - ability of plants to restrict the activities of a specific pest. Tolerance - ability of plants to endure a specific pest or adverse environmental condition and continue to grow and produce a crop.

constriction and plants toppling over. Seedling diseases are most commonly caused by soil-borne fungi like *Pythium* spp. and *Rhizoctonia solani*. Soil sterilization, seed treatment with appropriate fungicides, and good cultural practices are the most common control methods.

Root-knot nematodes cause plants to become stunted and wilt (diurnal wilting is common). Roots develop knots, galls, or swelling. Secondary symptoms of nutrient deficiencies may result from the inability of roots to take up the necessary nutrients. Soil sterilization is the most effective control measure.

Verticillium and Fusarium wilts cause leaves to become yellow along the margins and between veins. Plants become stunted and wilt severely during the day, but recover at night. Eventually the entire plant dies. Vascular tissue is streaked brown (streaking occurs high on the stem and into petiole scars with Fusarium wilt, and occurs on lower stems and is not evident in petiole scars with Verticillium wilt). For best control, use soil sterilization and plant resistant varieties.

Leaf mold (*Fulvia fulva* = *Cladosporium fulvum*) is the most common and destructive disease in greenhouse-grown tomatoes, and is particularly severe under conditions of high humidity. Lower leaves develop pale green spots on their upper surfaces and eventually turn yellow; spots become covered with patches of olive-green to brown mold on the bottoms of leaves. Maintaining humidity below 90 percent by providing good air circulation will help control this disease. Use appropriate fungicides, resistant varieties, and soil sterilization for maximum results.

Gray mold (*Botrytis cinerea*) is a grayish, powdery, moldy growth on fruit, leaves, and stems. Use similar control measures as for leaf mold; resistant varieties are unavailable.

Early blight (*Alternaria solani*), which may occur at any time in the season, causes collar rot of seedlings and spotting on leaves and fruit. Note that concentric rings on leaves create a target pattern. Use similar controls as for leaf mold.

Bacterial wilt (*Pseudomonas solanacearum*) causes diseased plants to wilt and die rapidly (with no yellowing or leaf necrosis). The pith in the stem near the soil line will become water-soaked and dark. Best controls include good sanitation and soil sterilization.

Tobacco mosaic virus (TMV) disease reduces fruit set and quality. A mosaic or mottled appearance of the leaves is the most common symptom. Plants infected as seedlings are usually stunted and slightly yellow; the leaves also may be curled, small, or deformed. Greenhouse workers should wash their hands carefully with soap and water after using tobacco products. Remove any diseased plants as they appear.

Fruit rots are caused by fungi like *Alternaria*, *Phytophthora*, and *Botrytis*. Maintaining optimum temperature and humidity are critical for good control. Use

of registered fungicides can help to reduce the incidence and severity of fruit rots as can good greenhouse sanitation. Handle fruit carefully to prevent bruising.

Physiological diseases that can cause problems with greenhouse-grown tomatoes are blossom-end rot and sunscald. Blossom-end rot occurs when tomatoes are stressed for water and calcium, resulting in the formation of a sunken, brown, leathery spot on the blossom-end of the fruit. Monitoring soil moisture and mulches will help prevent this problem. Over-exposure of the fruit to sun can result in sunscald. Training of vines and leaves to cover developing fruit should solve this problem.

Insects. Aphids are small, soft-bodied insects that insert piercing-sucking mouth parts into tomato plants to extract plant juices. Heavy populations can cause leaf curling and plant stunting. Aphids also serve as vectors for several plant diseases. Sticky honeydew produced by aphids may result in growth of black sooty mold.

Whitefly adults are small, winged, white insects 1/16" long. They suck juices from plants and, like aphids, whiteflies are vectors for some diseases. Honeydew produced by whiteflies also will support growth of black sooty mold.

Thrips are very small insects with piercing-sucking mouth parts that feed on plant juices. They can spread tomato spotted wilt viruses and cause premature blossom drop.

Spider mites are non-insect pests (related to spiders) that feed on plant juices on underside of leaves. Leaves may become stippled (gray) and covered with a fine web; defoliation can occur with heavy infestations. Mites are yellowish to greenish with a dark spot on either side.

Other insect and non-insect pests that can cause occasional problems include cutworms, earwigs, snails, slugs, and various caterpillars. Sanitation, soil sterilization, screens on ventilation fans, and appropriate insecticides should be used for maximum control of pests.

CUCUMBER

Planting

Cucumbers generally grow more rapidly than tomatoes and produce earlier. They also require higher temperatures, which means they are generally grown as a spring or early summer crop. Daytime temperatures should be 80–85°F (nighttime 65–75°F). Soil temperatures should be at least 65°F. Lower temperatures will delay plant growth and fruit development.

Cucumbers are heavy feeders requiring 300–400 lb/a of P₂O₅. Similar quantities of potassium are required. Weekly feedings with a balanced fertilizer (20-20-20)

will be required for maximum production. Never stress seedlings for water or nitrogen.

Plants are best started in individual containers. As seed are often very expensive, sow one seed per container (1/4 to 1/2 inch deep) in a sterile potting mix with the spiked end of the seed up (root will emerge facing down). Water, cover pots with clear polyethylene, and place in the shade. Plants will emerge in two to three days at 80–85°F. Remove plastic coverings when plants emerge and place them in full sun.

After plants have formed at least two true leaves, transplant them to their permanent location in the growing bed. Cucumbers will require 6–8 square feet of space per plant. Plants are generally spaced 2 feet apart in rows 3 to 4 feet apart.

Training

Cucumber vines can be trained on plastic twine supported from horizontal support wires running the length of the rows (7–8 feet above top of bed). The base of the string can be anchored loosely to the base of the stem with a non-slip noose.

As the stem develops, it can be fastened to the string with plastic clips. Allow one stem to develop, removing all laterals and tendrils as they develop. Fruit buds should be removed from the first five leaf nodes. Thereafter, fruit can be allowed to develop, but continue to remove all laterals and tendrils.

After the stem reaches the horizontal support wire, it can be trained along the wire and then down another string suspended from the horizontal wire between the two plants in the row. The stem is then allowed to follow the string downwards to within 18 inches of the bed. It is then trained back up the original string with the stem forming a circle. Remove old leaves on the older part of the stem ahead of the developing stem terminal.

Fruit should develop at each node. Remember to remove all laterals and tendrils to encourage fruit production. Fruit production should continue for approximately 60 days.

Varieties

Seedless (parthenocarpic) or all female (gynoecious) varieties are generally recommended for greenhouse cucumber production. These types generally produce higher yields and do not require bees for pollination. European seedless cucumbers are generally the most popular type of cucumber grown in the greenhouse. 'Mustang' is suitable for early or fall cropping and has potential for high total production. This variety has excellent fruit shelf life and color, with 12- to 14-inch fruit. 'Bronco' is suitable for very early spring or late fall cropping (low light conditions). It produces high quality

fruit 12–14 inches long. Other popular varieties that have performed well include 'Sandra', 'Boneva', 'Daleva', 'Padex', 'Fertila', 'Factum', 'Femspot', 'Femfrance', 'Toska 70', 'Farbio', 'Corona', 'Sweet Slice', 'Radja', 'Bella', and 'La Reine'.

Harvesting

With good management, each plant may produce as much as 20–30 pounds of fruit over a four-month period. European varieties are generally harvested when fruit are 12–16 inches long and 3/4–1 pound in size. Fruit are often shrink-wrapped to prevent softening from moisture loss. Store fruit at 55°F with 80–90 percent relative humidity.

Seedless European greenhouse cucumbers are distinctly different from traditional field-grown cucumbers. Because of consumer expectations for field-grown cucumbers, greenhouse cucumbers may require some market promotion. Excellent selling points include their seedlessness, dark green color, mild flavor, and thin, tender skins that require no peeling.

Pest Control

Diseases. Gummy stem blight (*Didymella bryoniae*) is a fungus that occurs on all above-ground parts of the plant causing extensive damage to leaves, stems, and fruit. Light brown to black lesions occur on leaves, at nodes, and in pruning wounds. Leaf lesions eventually dry and fall from leaves. Stem lesions can crack at the soil line, producing an amber-colored gummy ooze, and can girdle the plant resulting in death. This disease also can occur as grayish-green water-soaked lesions on fruit beginning at the blossom end and can develop on fruit after harvest. Control by using steam sterilization of soil, good sanitation, crop rotation, and good ventilation. Avoid night temperatures below 60°F and overhead irrigation. Use preventative fungicides.

Powdery mildew (*Sphaerotheca fuliginea* and *Erysiphe cichoracearum*) fungus first appears as pale yellow leaf spots. The spots rapidly enlarge to fine cottony growth on the leaf surface. The spots also can occur on the stems and fruit. The fungus causes severe stress on plants as leaves yellow and die. Powdery spores produced on the leaf surface spread from plant to plant by air currents. Control through good sanitation, preventative fungicides, and resistant varieties.

Other diseases that can occasionally cause problems include various viruses (cucumber mosaic and watermelon mosaic), gray mold (*Botrytis*), damping-off, and crooking. Crooking is a physiological disorder often caused by temperature extremes, excessive soil moisture, and nutrition imbalances. Fruit will become excessively curved, reducing its market value.

Insects. Insect pests include whitefly, thrip, leaf miner, and other non-insect pests like two-spotted mites. Insects can gain entrance into the greenhouse through vents, doorways, openings in the greenhouse, and even on clothing and equipment. Regular plant inspections are important for immediate and effective control.

LETTUCE

Lettuce is generally grown when light intensities are low and temperatures are cool. Plants prefer a daylight temperature of 60–65°F and a nighttime temperature of 50–55°F. High greenhouse temperatures will often result in spindly growth and seedstalk development in some varieties. A crop of lettuce can be scheduled between fall and spring tomato crops.

Lettuce usually takes about one month from seeding to transplanting. Days to harvest from seeding may vary from 12–15 weeks in mid-winter and from 8–10 weeks

in early spring. Under poor light intensities a 9 × 9-inch spacing may be used, while a 6 × 6-inch spacing can be used in the spring as light conditions improve.

Lettuce is a poor feeder, but requires a high level of nutrition. Apply a balanced fertilizer before planting with weekly nitrogen feedings as needed.

Leaf and Bibb lettuce varieties are the most common types grown in the greenhouse. Popular leaf lettuce varieties include ‘Waldmann’s Dark Green’, ‘Grand Rapids’, and ‘Ruby’. Bibb lettuce varieties include ‘Ostinata’ and ‘Salina’.

OTHER GREENHOUSE CROPS

Other crops that have done well under greenhouse conditions include sweet peppers, eggplant, and herbs like basil. Popular pepper varieties include ‘Cubico’ (red), ‘Locas’ (red), ‘Samanta’ (yellow), and ‘Doria’ (yellow).

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