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GREENHOUSE VEGETABLES - TOMATOES

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The tomato constitutes one of the two major vegetables grown under glass. The other crop is the cucumber. In contrast with the latter vegetable the tomato can be satisfactorily grown either as a spring and summer crop under glass or as a fall and early winter crop. The cucumber is rarely, if ever, grown as a fall crop. The rotation of crops in a vegetable greenhouse, then, is that of spring cucumbers followed by fall tomatoes or a spring and early summer crop of tomatoes followed by another crop in the fall and early winter.

Type of Greenhouse Desired. In view of the height of tomato plants as they are grown vertically under glass, it is desirable to have an even span greenhouse with an eave height of at least six feet or preferably higher (1). Ground beds are preferable to benches for in them the soil can be more economically prepared, the plants can be more readily maintained, and the fruit harvested with greater ease and economy. Likewise there will be greater consistency of soil moisture in the ground beds than in the benches, which are apt to lose water readily.

There are no necessary permanent walks in a tomato greenhouse, for such walks can be provided by temporary boards and runways between certain rows of plants.

Temperature Requirements. The tomato is a warm temperature plant and thrives under plenty of sunlight and a comparatively warm night temperature. Greenhouses should be piped with a sufficient number of hot water or steam pipes so that a night temperature of 60° - 65° F. can be maintained. Lower temperatures than these will decrease the growth rate of the plants and there is also danger of leaf disease occurring when night temperatures are cool and moisture condenses on the leaves. For greenhouses of moderate size, the gravity-circulation hot water system is suitable, but in some cases this system may be converted into a forced-circulation hot water system.

Piping requirements for a certain size of greenhouse can be provided by the writer of this circular.

The greenhouse should have continuous ventilators on either side of the roof at the ridge.

There must be an ample water supply for the purpose of providing water for the heating system and for the irrigation of the plants.

Planting Program. The spring crop of tomatoes is usually started from seed about December 1-15 and the bedding of these plants is usually done in February. This harvest extends from May 1 to August 1.

Somewhere in this planting program there should be time allowed for soil sterilization. After the summer crop is over the soil is warm and more readily heated to the desired temperature for sterilization (2).

Soils and Fertilizers. The soil for growing a greenhouse crop of tomatoes should be mellow, friable, deep, fertile, and disease-free. In such soil plants will make good clean roots with an ensuing satisfactory top growth. The soil type is often the natural soil over which the greenhouse is built with the addition of compost or well-rotted manure to provide organic matter and additional plant nutrients. If the original soil is too heavy it will have to be lightened by bringing in river loam or it might have to be almost entirely replaced by a soil mixture composted some months previously. It is rarely possible to frequently change the soil in the house where there are ground beds, so at the beginning of operations the soil must be of the right type, particularly in so far as friability and depth are concerned.

Where tiles are put in the soil for carrying steam for sterilization, the soil should be of the same uniform type down to the level of the tile.

Manure is always a good foundation fertilizer at the rate of 50 tons per acre applied in the fall or prior to the setting of the plants in August. In some cases where previous tomato plants have been heavily mulched such mulch may be sufficient to provide organic matter for the succeeding plants. For a spring crop of tomatoes one may apply to the area of the root zone, 1,000 to 1,500 pounds of 20 percent superphosphate together with 500 pounds of muriate of potash per acre. In fertilizing tomato plants, nitrogen should be provided in liberal supply in the spring and during the long sunny days of summer but it is required in relatively limited amounts during the short, usually dark days of late fall and winter.

In one state where large quantities of greenhouse tomatoes are grown, the program of soil fertilization consists of applying about 50 tons of manure to the acre in advance of the fall crop. Then, in preparing the soil for planting the spring crop 1,000 to 1,500 pounds of superphosphate and 750 to 1,000 pounds of muriate of potash are plowed into the soil.

The bearing of fruit by a tomato plant is a burden on the plant and in order that it may continue to make a satisfactory vegetative growth, as well as bear good clusters of fruit, it is desirable to make successive applications of fertilizer about every two weeks or so after the tomatoes have begun to set on the first three clusters. General recommendations are for semi-monthly applications of 100 pounds of ammonium nitrate with 100 pounds of muriate of potash, which would alternate between applications of ammonium nitrate 100 pounds. These are recommendations for the spring and early summer crop rather than for the fall plants, which in the shorter days would not be benefited by heavy applications of nitrogen. These fertilizer applications are spread uniformly between the rows and watered in. It takes strong plants of good stem diameter to encourage a good setting of fruit and proper size of the same. Weakly vegetative plants are usually associated with unfruitfulness. With the English varieties of tomatoes it is rare that the plants are too vigorously vegetative to induce unfruitfulness but this may occur with varieties of American origin.

Plant Growing Program. The spring crop of tomatoes is started from seed about December 1 to 15. The seed is sown in a greenhouse bench or in soil in a flat. It is advisable to disinfect the soil prior to seeding by heating it in an electric soil pasteurizer or by treating the soil with a solution of formaldehyde fourteen days or so before seeding (2).

Due to the short days of December when seeding is done the seed should be dropped comparatively thinly in the row, not more than eight seeds to the linear inch, with the rows two to three inches apart. This will prevent the plants from becoming too spindling before they are pricked out, preferably into three- or four-inch individual containers. Plants which are stocky and have good diameter of stem must have abundant light and space during the winter days of December to February when they are developing.

The setting of plants started in December is usually done in early February.

For a fall crop of tomatoes the seed should be sown in late June or early July so that the plants can be set in the greenhouse about August 15. It is imperative in the case of the fall and early winter crop that the fruit clusters be set on the plants before the arrival of the short-day period. This crop bears from October 15 to January 15.

Plants should be set in the permanent beds before they have become spindling. This is usually when they are about eight inches high. A short stocky plant is desirable for setting in the beds. The plants should be watered down several hours prior to being removed from the individual containers such as veneer bands, and thus there will be no root disturbance in the transplanting. The usual distances of planting are 16 to 18 inches apart in a row, 30 to 36 inches between rows. It is desirable to give the plants for the fall crop more room between the rows than the spring-grown plants.

Varieties. In the Northwest varieties of tomatoes generally grown under glass are of European origin, such as, Potentate, Best-of-All, etc., which produce fruit of medium size compared with the large fruited varieties of American origin, such as Globe and Bonny Best. The English varieties are characterized by having several to many flowers on the cluster, short pistils in the flowers, making for free setting of fruit, and the fruits themselves are smooth and of uniform red color. The plants are not naturally strongly vegetative, such as Bonny Best, and are benefited by fairly heavy feeding.

Some strains of tomatoes have been bred resistant to leaf mold, a serious disease of plants under glass (5). Certain individual growers of tomatoes have their own seed strain, maintained year by year, in which case it is important to save seed from healthy plants bearing fruit of a good type.

In the Northwest, the market demand for greenhouse tomatoes is for fruits of about four to the pound.

Trimming and Training. Most tomato growers grow single stem plants. The plants are supported by various means. Short stakes are put in the ground beside the plants and binder twine tied from them to a wire about six feet above. These wires must be supported by other wires because of the heavy weight of the crop on the vines. The vines are twisted around the twine. There is no tying necessary. Enough length of string should be tied to the top wire to permit a further tying of the top of the plant in case an unusually heavy crop of fruit is borne. In all cases the string must be tied tight enough from stake to wire to prevent sagging of the plants.

In some greenhouses stakes are used to support the plants but this is seldom seen in the Northwest.

All laterals at the axils of the permanent leaves and the main stem are removed when small. One should not handle laterals which incline to have any semblance of mosaic at the same time the laterals are removed from clean plants. (See discussion on diseases.)

A modification of trimming laterals has been recently presented by Hemphill and Murneek (3). Instead of a complete removal of all laterals, a method suggested was to cut the lateral back to a stub after it had produced two leaves. In other words, the growing tip was removed but the leaves were left on. The idea of the method is to provide more foliage or greater leaf area for exposure to light and manufacture of food that goes into the production of the tomato crop. One might leave one or two of these laterals and pinch out the remaining ones. Increased yields are reported by these investigators from plants so treated.

Plants are usually topped after they have borne six to eight clusters of fruit.

Pollination. As previously stated, the varieties of English origin set fruit readily. Some growers occasionally shake the plants or fruit clusters. Other growers do not touch the plants at all. Shaking the blossoms when fully opened or the blossom clusters takes little time and usually results in additional amounts of pollen being dislodged from the pollen sacks.

Some investigators (4) have found the use of hormone sprays effective in increasing the set of fruit on tomato plants grown under glass. However, the varieties used in most of these trials were those having longer pistils than those of the European varieties and it is doubtful, in the use of the free-setting varieties named in this circular, that hormone sprays are necessary.

Temperatures. Tomato plants should be grown under moderate night temperatures, 62-65° F., in order to prevent moisture condensation and prevalence of disease, mainly leaf mold. If possible, ventilation should be accomplished in such a way as to encourage circulation of air and prevent exposure of the plants to drafts (2). Full ventilation should be given in bright warm weather. In late spring and summer it is desirable to have some shading on the glass, using material which will readily wash off when the fall rains arrive and a full degree of light is required for the fall plants.

Watering. The use of water in supplying proper soil moisture is an important consideration and study. Two important diseases--leaf mold and blossom-end rot of fruit--may develop by improper watering. Most growers prefer to water early in the day. Application of water is made by the hose, by longitudinal sprinkling pipes with nozzles throwing horizontal streams of water close to the soil and sometimes by sub-irrigation. A consistent level of soil moisture provided by moderately frequent applications is considered superior to heavy applications at one time followed by a drier soil condition. It is especially necessary to maintain consistency of soil moisture in order that blossom-end rot of the fruit does not occur (8). During the earlier stages of blossom production there should not be heavy waterings; following fruit bearing on the earlier clusters, the amount of water applied at each irrigation should be increased. Sufficient water should be applied each time so that the root zone of the plant will be well wetted.

Mulching. A layer on the soil of some kind of organic material, such as strawy manure, baled alfalfa, manure with sawdust, etc., provides for a greater conservation and consistency of soil moisture as well as acting as a cushion for water applications.

The mulch tends to prevent soil packing in watering, to discourage weed growth, and when turned under the soil, following the completion of crop harvest, provides an addition to the supply of organic matter. Commercial fertilizer applications, applied periodically through the season, are spread on the mulching material and watered in.

Crop Ailments and Control. Periodical releases of cyanide fumigations are necessary to control white fly. This is the only major insect commonly present in the tomato greenhouse. The life cycle of the white fly is short; therefore, fumigations have to be made rather frequently (2).

Another insect not infrequently found in a tomato house is the climbing cutworm, which can be controlled by using cutworm bait applied at the base of the plants.

Damping-off of the young plants, which is a particularly common ailment during the winter days, can be prevented by soil disinfection with heat or chemicals prior to seeding (2).

Various diseases affect tomato plants under glass, including leaf mold, mosaic, root anthracnose, nematodes or root-knot, fusarium wilt and white mold. With the exception of the two first-named diseases, they can be kept under control by steaming the soil through tile laid in longitudinal rows lengthwise of the beds. If the greenhouse is heated by hot water a portable steam boiler will serve the purpose of providing steam for beds of reasonably small size. A number of growers having small ranges of glass utilize a portable boiler.

Practical control of leaf mold in some areas of the United States is being accomplished by the use of a leaf-mold-resistant strain of seed, such as the variety Bay State used in Massachusetts (5).

There are various forms of virus diseases of greenhouse tomato plants. Mild mosaic may be present in the greenhouse with comparatively little reduction in yield, but a virulent form of virus such as streak is likely to kill the plant. O. S. C. Station Circular of Information 257 (6) discusses suggestions for the control of tomato mosaic and streak.

Blossom-end rot, denoted by blackening and rotting of fruit at the base, is associated with inconsistencies of soil moisture. Keeping the plants supplied with a uniform soil moisture content usually prevents an outbreak of blossom-end rot (8).

Root-anthracnose is characterized by intermittent black markings on the roots, thus preventing their normal functioning.

Root-knot nematodes cause swollen knots on the roots, inducing a stunting of the plants and a greatly reduced yield. Because of the ready contagion of these minute eelworms, thorough sterilization in beds and walks is essential. All care should be taken to sterilize tools and to prevent carrying infected soil from one part of the greenhouse to the other.

Fusarium wilt clogs the water-bearing cells and is manifested in the plants by yellowish lower leaves, wilting of the plants even on a cloudy day and by a severe decrease in growth and yield of fruit. The stems of the plant, when sectioned, show a dark brown color between the bark and the pith. This is a soil-borne disease and must be controlled by sterilization.

Stem rot (*sclerotinia* sp.) manifests itself by wilting of the leaflets and the rotting of the main stem, which is covered at intervals from the ground upward with a white mold-like growth.

Fruit Handling. Hothouse tomatoes should have a good color in the container. If a few days elapse between the time the fruit is packed and the time of selling, then the fruit may be in the pink stage when crated. Under certain conditions tomatoes may develop blotchy ripening which may be induced by high temperatures. The fruit will color well from a pink stage to a good red if kept at about 60° F. or so. When picking, stems should be left on the plant rather than on the fruit. After harvesting, fruit should be graded for variance in color, size and blemishes. Only first-class, unblemished fruit of uniform color should be in grade 1. The variation in size may run from three to six ounces.

Two kinds of packages are in common use, a five-pound basket of veneer or cardboard, four of which make a crate, and a ten-pound wooden box. The five-pound basket accommodates two layers of tomatoes, usually 12 to a layer. The flare of the basket makes it possible to accommodate the larger sized fruit on the top layer. Moderately sized fruit, four to a pound, is desired as it is easier to sell. The tomatoes are packed firmly but not squeezed in such a way as to cause bruising.

Yields. Individual plants should produce about ten pounds of fruit in the spring and summer crop. The fall crop, ripening through the short, dull days, rarely yields more than about three-fifths of the spring total. In all cases a great deal depends on how free the plants are from disease and how well they have been fertilized.

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