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Growing Greenhouse Tomatoes

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Growing Greenhouse Tomatoes

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Do you dream about picking fresh tomatoes for a late fall or early spring treat from your own greenhouse plants? Or do you wonder about growing tomatoes in the "off-season" to sell at a profit? Whether you are a hobbyist or a potential commercial grower of greenhouse tomatoes, you must know some of the economics of cropping tomatoes. It's easy to grow tomatoes in the greenhouse but not everyone can grow them profitably. There is more to producing greenhouse tomatoes than just transplanting the plants and watching them grow.

Because plants growing in water are still a novelty to most of us, quite often the first thought a grower has is to grow tomatoes by the hydroponic or soilless culture method. This method has some attractive features, such as a degree of automation which cuts down on labor. But hydroponic culture does have problems, especially in identifying nutritional deficiencies. It also ties up a high initial investment for materials and installation; the cost is generally about \$25,000 or more for a 40 x 100 foot greenhouse. Diseases may also be a serious problem in hydroponics.

You'd be farther ahead to start growing tomatoes in a soil bed. After a few years of experience you can decide whether to continue with soil beds or convert to hydroponics. You won't have the high initial cost of materials and installation of hydroponic equipment, and it is easier for the beginner to control fertilizing and watering in soil beds.

Location and Placement of Greenhouse

Select your greenhouse site and plans with care, the greenhouse site should have good air circulation and water drainage. High humidity and still air encourage foliage diseases. Wind protection is always helpful in reducing the heating cost and protecting the greenhouse from damage. A north-south orientation of greenhouses provides a uniform distribution of sunlight for maximum production of tomatoes throughout the year and enables the construction of a headhouse at the north end of the range. Greenhouse plans are available in many places.

Soil

Although greenhouse tomatoes grow well in many types of soil, loam to silt loam is favored over the extremes of heavier or lighter soils. Unfavorable physical

conditions can be amended by incorporating an abundance of organic matter into the greenhouse soil. Well rotted animal manure should be applied in one application at the rate of 1 ton per 1,000 square feet of bed surface. Later on add organic matter to the greenhouse soil at every opportunity, especially between cropping.

One major advantage of a light soil is that you can correct cultural errors such as excessive water or fertilizer more readily than on heavier types of soils.

Lighter soil also has an advantage during the dark cloudy periods of late spring and early fall, but you can expect rapid drying out during the hot sunny days of late spring and early fall. Soil moisture content fluctuates more in lighter soil, which will reduce the yield of marketable fruit. Frequent, light applications of water and fertilizer are required on light soils during the hot season to reduce blossom end rot, cracking, splitting, and other physiological disorders. These same disorders are encouraged on heavier soils by overwatering and excessive fertilizer application.

Sterilization

The soil in the greenhouse should be sterilized before planting a crop. Harmful fungi live in the soil, and sterilization of the top 12-14 inches of soil by heat or chemical means is the best method of controlling these and ensuring a better crop.

Soil disinfectants such as Vorlex, Chloropicrin, Methylbromide, Vapan, and others are used to

control certain soil borne fungus diseases, nematodes and weeds. Chemical disinfectants are generally quite specific in disease control, while heat or steam kills a broader range of pathogenic fungi, viruses, bacteria, nematodes, and insects. Steam sterilization is more effective than chemical sterilization.

Soil steaming should follow the addition of manure and precede planting by 6 weeks to allow the soil to cool, dry, and to build up beneficial populations of microorganisms. Toxic levels of ammonia and manganese resulting from heating the soil can also escape, be broken down, or leached out during this time. Soil in the ground bed at the time of transplanting should be slightly moist. The soil temperature should also be close to the desired air temperature.

There are various methods of sterilizing by steam. Any one is good if the top 12-14 inches of soil are sterilized. The soil should reach 180° F at all points in the bed for half an hour. If chemicals are used for sterilization, be sure to follow the instructions very carefully.

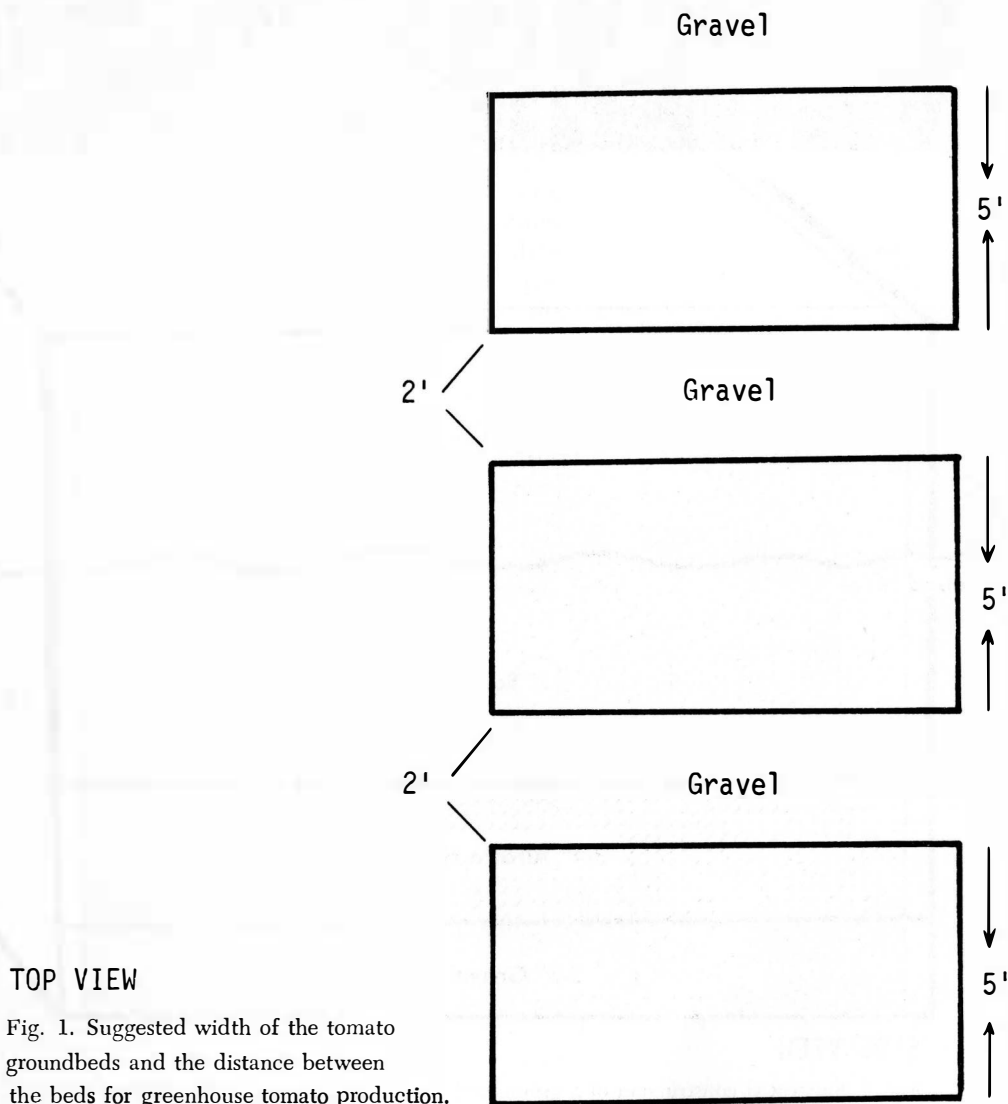
Ground Beds

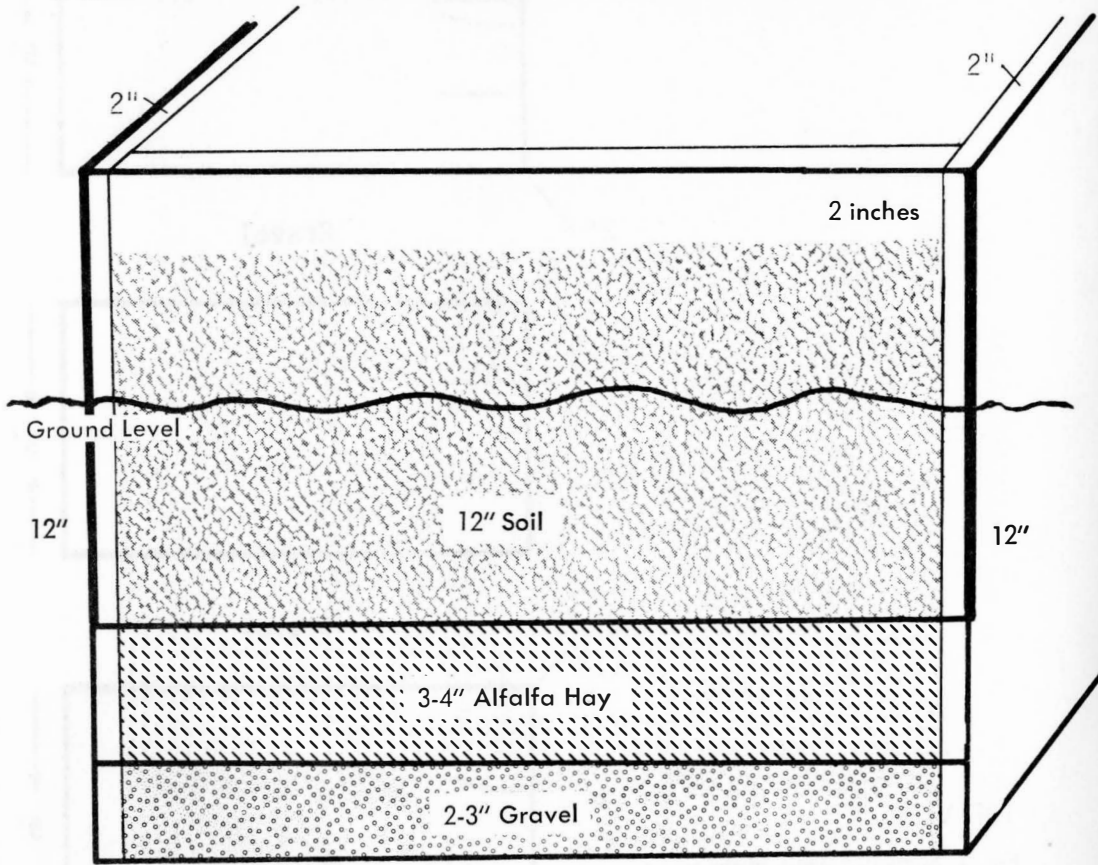
Do you want your tomatoes at ground level or on benches? A good crop of tomatoes can be grown at floor level in ground beds without any bottom heat. Ground beds have this advantage over raised benches: the soil is more easily prepared for planting, especially if you have a large greenhouse and power machinery. Greenhouse tomato plants are trained to be tall growing, and need 6 feet or more head room for

growth. Tomatoes growing in ground beds are easier to water, train, and harvest. You would also largely eliminate the cost of constructing and maintaining benches.

There is no general agreement among growers as to the most desirable length and width of ground plant beds. Figs. 1 and 2

show one method of constructing ground beds for tomato growing. The main advantages of this system are: 1) beds are not contaminated and packed by walking through them during cultural operations; 2) there is adequate walking space between the beds; and 3) plants are easy to prune, tie, and harvest.





SIDE VIEW

Fig. 2. Suggested construction of a groundbed for greenhouse tomato production.



Variety Selection

The variety you choose should be selected according to your growing conditions, market preference, and experience. It is advisable to grow two or three, depending on the size of your greenhouse. At the same time, try one or two others which you may be interested in for

the future or which are a novelty or popular on the market. It is not advisable to plant more than 20-25% of the area of your greenhouse in a new or untried variety.

Varieties differ greatly in their performance from season to season, locality to locality, and greenhouse to greenhouse.

Varietal performance also varies according to cultural methods. Some of the most commonly grown varieties are Michigan-Ohio hybrid, Ohio-Indiana hybrid, Super-M, Tucross 520, and Tucross 0.

After you have decided on the variety or varieties you want, you should start your own plants. Timing of the crop is critical if you want the best market prices. You need to start the seed in time so the plants will be at the right stage of growth when you want to plant a crop. If properly grown, you are assured of a supply of stocky plants of the desired age and variety, and the plants can be transferred to the permanent bed with the least shock.

Seed Germination

Seeds should be sown in flats of soil. Cover them with about $\frac{1}{4}$ inch finely screened soil or vermiculite and sprinkle lightly with water. Carefully sprinkle regularly until the seeds germinate. Common errors tomato growers make are sowing too thick and too shallow.

When the cotyledons are fully expanded and the first true leaves are visible, transplant the seedlings. Plants for the main spring crop are usually grown in 4-inch pots until near flowering. They are spaced progressively further apart as the plants grow. Crowding which results in touching or overlapping of the leaves of neighboring plants should be avoided. You can most conveniently manage this type of spacing if you use clay or plastic pots.

Some growers plant two or three tomato seeds per 4-inch pot. Later on, when the plants are established, they are thinned to one plant per pot. This reduces chances of tobacco mosaic transmission during transplanting.

Workers should not be allowed to smoke while planting seed, transplanting seedlings, and doing other cultural operations. They should wash their hands thoroughly with soap before starting to work with tomato plants in the greenhouse. This should reduce tobacco mosaic infection of the tomato plants.

Cold Treatment

Cold treatment of tomato seedlings is a useful tool for increasing the yield of the crop. Cold treatment means exposing tomato seedlings just after the leaves unfold to temperatures of 52-56° F for 10 days to 3 weeks, maintaining the temperatures both day and night. Ten days are sufficient in bright sunny weather, 3 weeks are necessary in cloudy, dark, or winter weather. Duration of the cold treatment is determined by the time required for leaves to develop to the two-leaf stage.

Carbon Dioxide Enrichment

Young tomato plants are especially responsive to extra carbon dioxide (CO_2) in the greenhouse atmosphere, having a higher optimum requirement of CO_2 than other plants. Growth rates can be increased by 50% and early flowering and fruiting accelerated by a week or 10 days

by CO₂ enrichment. Effects are carried into the fruiting.

The suggested level of enrichment of the greenhouse atmosphere by CO₂ is 1,000-1,500 parts per million. Carbon dioxide enrichment pays best dividends in the production of the spring crop of greenhouse tomatoes if done during the early growing period, that is, from the time the seedlings are first transplanted until the plants are in their permanent beds.

Planting and Cropping Schedule

Planting and cropping schedules are critical to the successful production of greenhouse tomatoes. It is difficult and usually economically unfeasible to produce tomatoes for harvest through December, January, February, and March in South Dakota. Sunlight intensity during these months is deficient and days are short. Fruit setting is low, ripening is slow, and fruit quality is poor. Fuel costs are often prohibitive and heating facilities overtaxed to meet the heat requirements.

The Two Crops Per Year System

Two crops per year are recommended for tomato culture in greenhouses but only if rigid disease control measures are practiced. This system allows maximum production and utilization of labor, and you can time plants to avoid high summer temperatures and low winter light intensities.

Seed for the spring crop is sown about the last week in December or first week in January. Plants are

set permanently about March 1st. Harvest begins in May and continues until July or until field grown tomatoes appear in the local market. Normally, 10-12 clusters of fruit should be harvested from each plant.

The fall crop is seeded about July 1st. Plants are set permanently by the second or third week of August. Harvest begins in October and continues until the first week of December. The plants are topped off in late October, and subsequently developing suckers are removed. Normally, 6-8 clusters of fruit from each plant should be harvested in the fall.

The two-crop system should result in a total yield of 15-17 pounds of marketable tomatoes per plant per year. Inexperienced as well as some experienced growers sometimes attempt to carry a fall crop which begins maturing in October through the winter months into the following spring and summer. This usually results in failure, discouragement, and financial losses. The technology isn't available yet to maintain a greenhouse tomato crop in South Dakota in which harvest begins in the fall and continues at a profitable level of productivity through the winter months.

Disease Prevention

Before a crop is planted in the greenhouse, spray the walls and floor thoroughly with a mixture of fungicide and insecticide to get rid of fungi spores and insects which are in the greenhouse. If this is not done, insects present in the greenhouse will spread diseases to the tomato plants.

Planting

The best spacing for greenhouse tomatoes is shown in Fig. 3, if ground beds are constructed as shown in Fig. 1. Should other ground bed arrangements be selected, the rows should be 42 inches apart and the plants 15-18 inches apart within the rows. This gives enough room for sunlight and other cultural operations.

Pruning

The single-stem method is a common method of pruning. Generally all shoots or suckers are removed when they are 2-4 inches long. (A sucker is a side branch that grows where a leaf is attached to the main stem.) A strong twine or string is tied close to the base of the tomato plant so that the plant can be trained and tied to this string during the growing season. Use the same cord or twine later to tie the plants. Cut strings 10-12 inches long for tying plants as shown in Fig. 4. Tie the twine securely to the string and tie under the leaf (not under the fruit cluster). Allow 3 inches of play between the tomato plant and the upright supporting cord to accommodate stem growth. Plants are usually supported by baler binder twine, and more recently by plastic twine. Plastic plant clips have recently been introduced on the market to tie tomato plants in the greenhouse. They may be used as an alternate to the cord used to attach the plant to the twine. Advantages in using the clips are a reduction in plant breakage if inexperienced help is used and elimination of the need for securing the twine to the base of the plant.

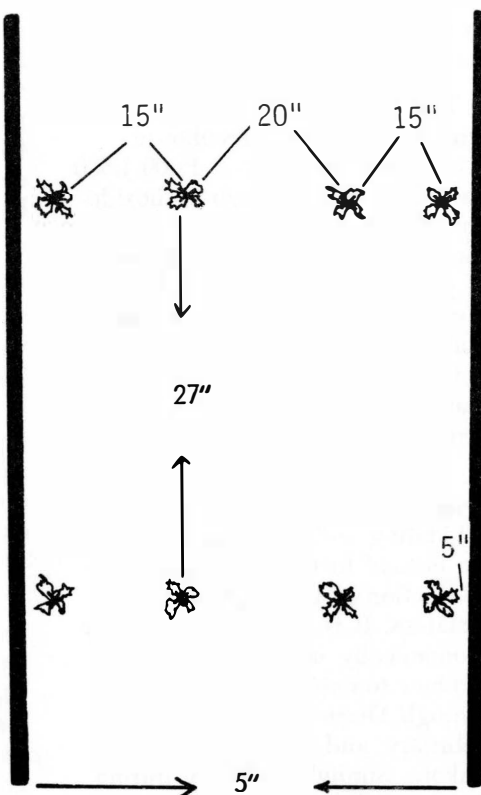


Fig. 3. Recommended distance between plants and rows if the tomato beds are constructed as suggested in Fig. 1 for tomato production.

Pruning and training are a necessity in greenhouse tomato production. These practices, however, often result in the rapid transmission of virus diseases from infected to healthy plants. When infected plants are discovered they should be removed immediately from the greenhouse.

Infected plants generally have pale green or yellowish mottling

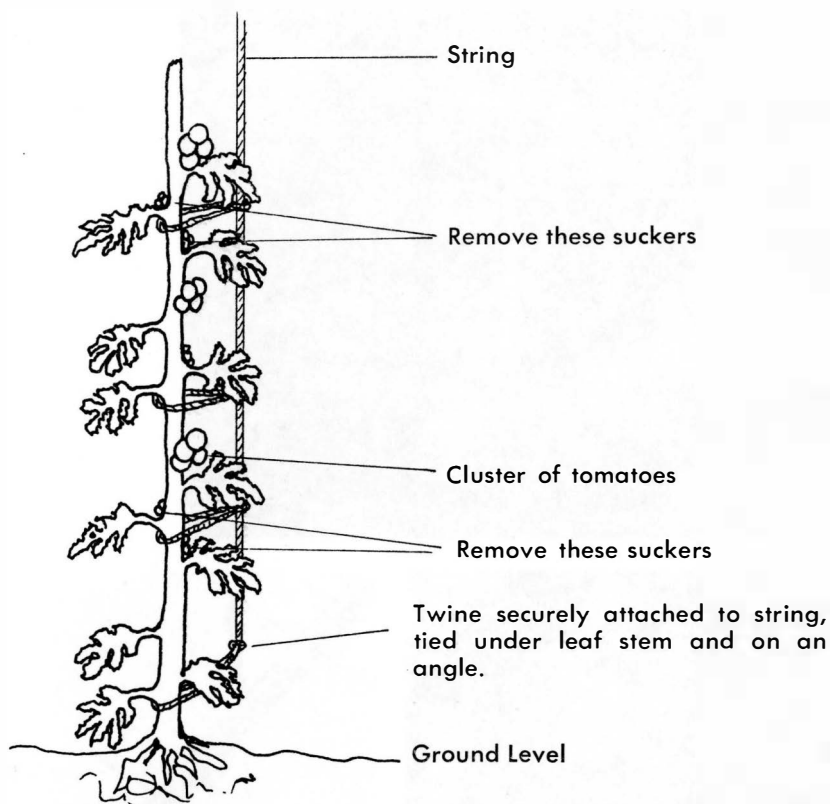
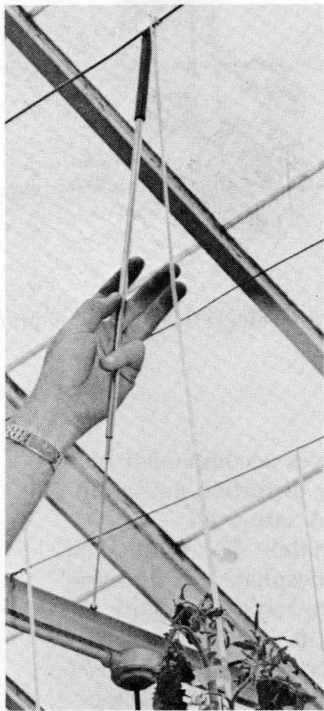
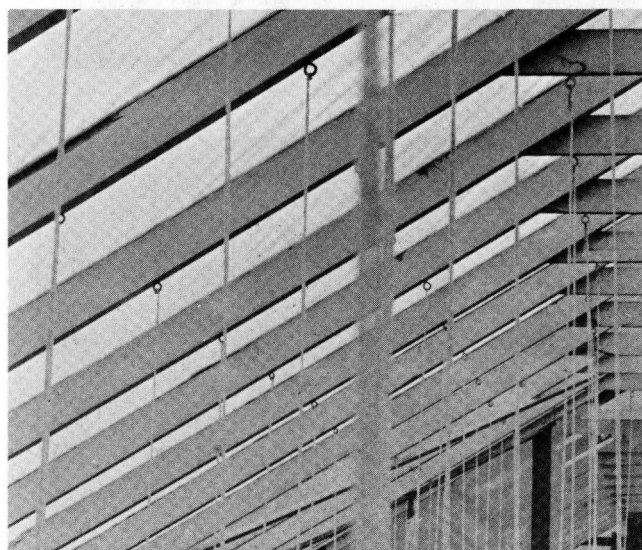
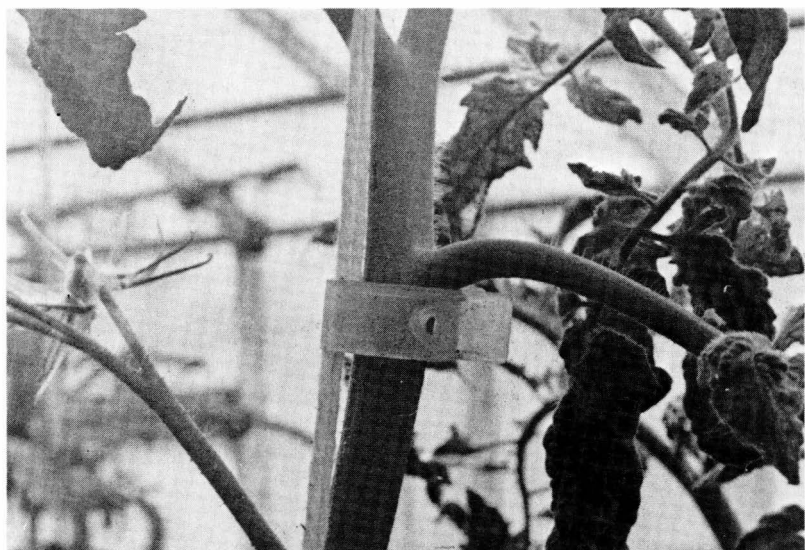


Fig. 4. Single stem method of pruning and tying tomato plants.

of the leaves accompanied by curling, or distortion and plant stunting. A saturated (approximately 3%) solution of sodium phosphate for cleaning greenhouse tools, especially the pollinator, is very effective in reducing transmission of tobacco mosaic virus. Using this solution at the end of each row will help to keep tobacco mosaic virus infection isolated.







Pollination

Vibrating tomato flower clusters increases fruit set even though the tomato is a self-pollinated crop. Clusters on the plant should be vibrated daily with an electric vibrator. For best results, vibrate between 11-1 o'clock at midday. Tapping the supporting wires to set fruit is a somewhat effective method of pollinating flowers if light and temperature are adequate, pollen is shedding and fruit clusters are 3 to 4 feet above the ground.

Watering

Too much water may ruin the crop when the plants are first set out. Many growers water with a hose for 4-6 weeks after setting the plants or until after the first clusters of fruit have begun to enlarge, taking care to wet the soil just down to the root zone. Special care in watering must be taken until after 2 or 3 fruit



clusters have set. The danger of overwatering in the spring crop may be avoided by watering only when the plants show signs of wilting.

Sometimes the spring crop will grow for 6 weeks or longer with only spot watering before general watering become necessary. Watering is often carelessly handled. A vast majority of greenhouse grown tomatoes suffer in late spring from lack of water. The plant requires nominal watering during the early stages of growth. As the plant increases in size, water requirements increase.

With a little experience you soon learn when to water the crop. Water must be applied when the plants need it. Whenever the moisture level falls below 50% at the root level the bed should be watered. Soil moisture can easily be determined by various types of instruments available on the market. Greater fluctuation of water encourages blossom end rot and fruit splitting. The best and easiest way to apply water is to place properly spaced perforated plastic hoses on the bed. Use black hose; clear hose encourages the growth of algae in the water.

Heat

Heat is often carelessly controlled in greenhouses. In a large greenhouse one side may be warmer than the other by as much as 10° F. Poorly controlled temperature can mean loss of the first and in some cases the second cluster of blossoms. This will reduce the early yield.

Temperatures play an important role in the shedding of pollen.

Below 65° F shedding is delayed. Optimum temperatures for pollen shedding are about 70° F.

While the crop is growing the temperature should be kept between 60-65° F during the night and between 70-75° F during the day if the sun is shining. On cloudy days the temperature should be kept around 65-68° F. When this temperature schedule is maintained the fruit bud should develop normally and the fruit should be smooth and of high quality. In no case should the night temperature be held below 58° during the fruit bud development as this may cause poorly formed blossoms which abort or produce misshaped fruit of poor quality.

Fertilization

Have a soil test taken in the tomato bed. Your soil should be high in nitrogen, potassium, and phosphorous. Soil very high in nitrogen encourages vegetative growth. The required amount of nitrogen, phosphorous, and potassium, as determined by soil tests, should be added to the soil and thoroughly mixed. Generally, additional potassium and phosphorous are not needed during the growing season, but a few applications of nitrogen are required in later stages of development of the plant.

Generally phosphorous and potassium levels in most established greenhouses are high. If the soil test indicates so, the recommended schedule of fertilization for 1000 square feet of soil bed is 4-6 pounds of 40% of superphosphate and 4-5 pounds of muriate of potash.

At the time of setting tomato plants in the bed use a starter solution high in phosphorus for irrigation. After transplanting to the ground bed, it is generally not necessary to apply any fertilizer until three clusters of fruit have set, as long as the plant color remains dark green and the stem diameter continues to increase. Apply the first nitrogen fertilizer as soon as three clusters have set on the plants. Subsequent applications of nitrogen are made approximately 2 weeks apart. The number of supplemental feedings of nitrogen fertilizer will depend on the nature and amount of organic matter in the soil. Usually three or four applications of nitrogen at the rate of 1 pound per 1000 square feet of area are made through the spring crop. For fall, one or two applications usually are sufficient. The fertilizer is broadcast between the rows and watered in, or liquid fertilizer can be applied through the watering system.

The required amount of nitrogen at any one time depends on the age of the plant and its condition with respect to fruit setting and fruit development. At first the amount required for a young plant will be relatively small, but as the plant develops you will need to add more fertilizer. As fruit continues to set on succeeding clusters, the nitrogen demand increases and probably reaches a maximum at the time when flowers of the fifth and sixth clusters have set fruit and harvest of the fruit of the first cluster is just starting. It appears that the time when the hazard of excessive nitrogen exists is from the time that the plant is

transplanted until the first five clusters have set fruit. Excessive nitrogen contributes to puffiness, cracking, blossom end rot, and blotchy ripening of the fruit.

Picking

There is a general tendency for the new grower to let the tomato fruits ripen on the vine before picking them. This is not desirable from the market point of view. The tomatoes should be picked as soon as they start turning color. It may not always be necessary to pick the fruit every day or even every other day.

During the peak of the season daily picking will be necessary. It usually takes 3-7 days for tomatoes to go through the various market channels before they reach the consumer. Picking times depend much upon the market and the method used for selling tomatoes.

Greenhouse tomatoes are expensive to produce and therefore deserve to be packed in attractive packages. This gives the tomatoes better eye appeal and will increase sales.

Ventilation

Greenhouse ventilation is essential for removing excessive heat and for bringing in fresh supplies of air. Heating and ventilation should be so regulated as to keep the air in the atmosphere of the greenhouse circulating.

Disease and Insect Control

Greenhouse tomatoes are not immune to diseases and insects. Be on the outlook for them and take proper prevention and control measures. A few of the common diseases and insects of greenhouse tomatoes are listed below.

Blossom End Rot

Blossom end rot is associated with water stress within the plant. Under moisture stress, water moves from the fruit to the leaves, and if moisture stress is prolonged, perhaps a few hours, the cells of the fruit will die and injury will develop. Blossom end rot may be caused by vigorous plant growth resulting from overfertilization with nitrogen, high salt concentrations in the soil which restrict water uptake in the plant, overwatering, wide fluctuations in soil moisture, and low soil temperatures.

Correct management of fertilizing, watering, and temperature will prevent many of the above conditions. There is a difference among varieties in susceptibility to blossom end rot.

Cracking

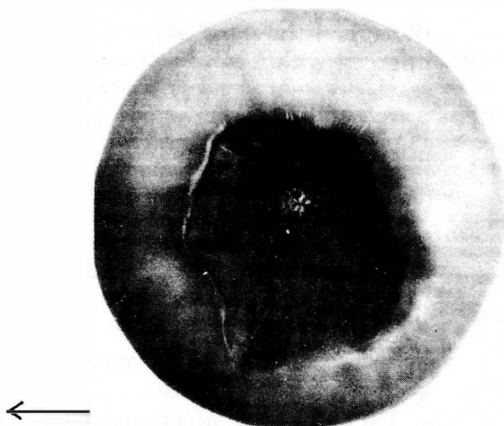
Varieties vary in their susceptibility to cracking. Unfortunately, none are immune to cracking. Correct plant nutrition, careful temperature control, good water management during periods of high temperatures, and harvesting during the early stages of ripening will aid greatly in reducing the severity of cracking.

Fruit Burst

Fruit bursting usually occurs when plants carrying ripe fruits are watered. It is usually severe in spring crops, but it can generally be prevented by frequent picking so that ripe fruits are not left on the plants, especially during watering.

Puffiness

Puffiness generally is a result of poor pollination. This could be due to inadequate vibration with a pollinator, low daytime



temperatures, excessive irrigation, excessive nitrogen or low potassium levels within the plant.

Tobacco Mosaic Virus (TMV)

TMV is the most common greenhouse disease of tomatoes in South Dakota. The effect of virus on plant growth often is not obvious, but fruit weight may be reduced up to 25%, depending upon



the age of the plant when it is infected with TMV. The virus also causes fruit bronzing, necrotic pitting, and mottle, which are objectionable to the buyer.

Sometimes the fruit is a total loss to the grower. Some strains cause severe leaf distortion and plant stunting. A pale green or yellowish mottling of the leaves, accompanied by curling or distortion, is the most common symptom of the disease.

TMV is highly infectious and readily transmitted by any means that introduces even a minute amount of juice from a mosaic infected plant to a slight wound in a healthy plant. The virus is most commonly transmitted by handling diseased and healthy plants during pruning and tying. Because of the necessity and frequency of these operations, most greenhouse tomato plants are infected before the end of the season. Clothes may remain contaminated for a number of years.

For all practical purposes the virus is not insect transmitted. The virus is systemic in the plant. Primary sources of the virus are usually infected seed, root debris, or trash from a previous greenhouse planting. Seed from infected fruits may carry the virus externally on the seed coat. When infection takes place several weeks after planting healthy seedlings, it is usually an indication that the virus was brought into the house by workers or was present on supporting wire, twine and clip supports.

Steam sterilization of the soil is one of the most important aids in controlling tobacco mosaic in the

greenhouse. Inspect and remove diseased plants. Wash hands in soap solution as often as possible when pruning tomato plants. Remove as much debris from the previous crop as possible, particularly thick roots, as virus inside them will withstand heat sterilization. Tools, wires, and other greenhouse structures should be thoroughly washed between crops. Do not reuse support wire or plastic clips.

No smoking should be allowed in the greenhouse. Workers must wash their hands with soap solution each time before handling the plants. They should clip their fingernails regularly.

Leaf Mold

Leaf mold is one of the most common foliage diseases of tomatoes in the spring. Pale yellowish patches develop on the upper surface of the leaves. The fungus spores are on the lower leaf surface and produce a grayish, olive green or pale brown, velvety mold growth. Later the patches become necrotic and the leaves dry out. The disease spreads rapidly under optimum conditions. Spores which are produced on the lower sides of the leaves are carried by air currents to healthy leaves where they germinate in the presence of water to start infection over again. The lower leaves are usually attacked first. The disease occurs only when the relative humidity is 90% or higher at the leaf surface. The disease is not troublesome unless the temperature is in excess of 75° F.

Disease can be controlled by adequate ventilation and by reducing humidity, especially during the night and early

morning. Spray with a recommended fungicide at the first sign of disease.

Botrytis Stem Rot

This can be a common disease in the greenhouse under conditions of high humidity and temperatures below 60° F. It is more prevalent when the house is cool and moist for prolonged periods. It is more common when the plants are set for spring crop as compared to the fall crop.

Invasion of the stem usually occurs through the petioles of the infected leaves or leaf scars. Sometimes leaves are removed from the base of the plant to aid in air circulation or stems are

removed in pruning. These scars are susceptible to infection during moist, cool weather. The lesions eventually girdle the stem and cause plant death. If the humidity remains high, a grayish-brown coating or fungus web develops over the infected, water soaked lesion.

The disease can be controlled by keeping night temperature above 60° F or by painting leaf scars with a paste compound of equal parts of copper sulphate, and hydrated lime. Since the fungus survives on plant debris, sanitation is an important control measure. Remove and dispose of all plant debris from the greenhouse.

