GREENHOUSE TOMATO

INSTRUCTIONAL

AND

PLANT CULTURE

MANUAL

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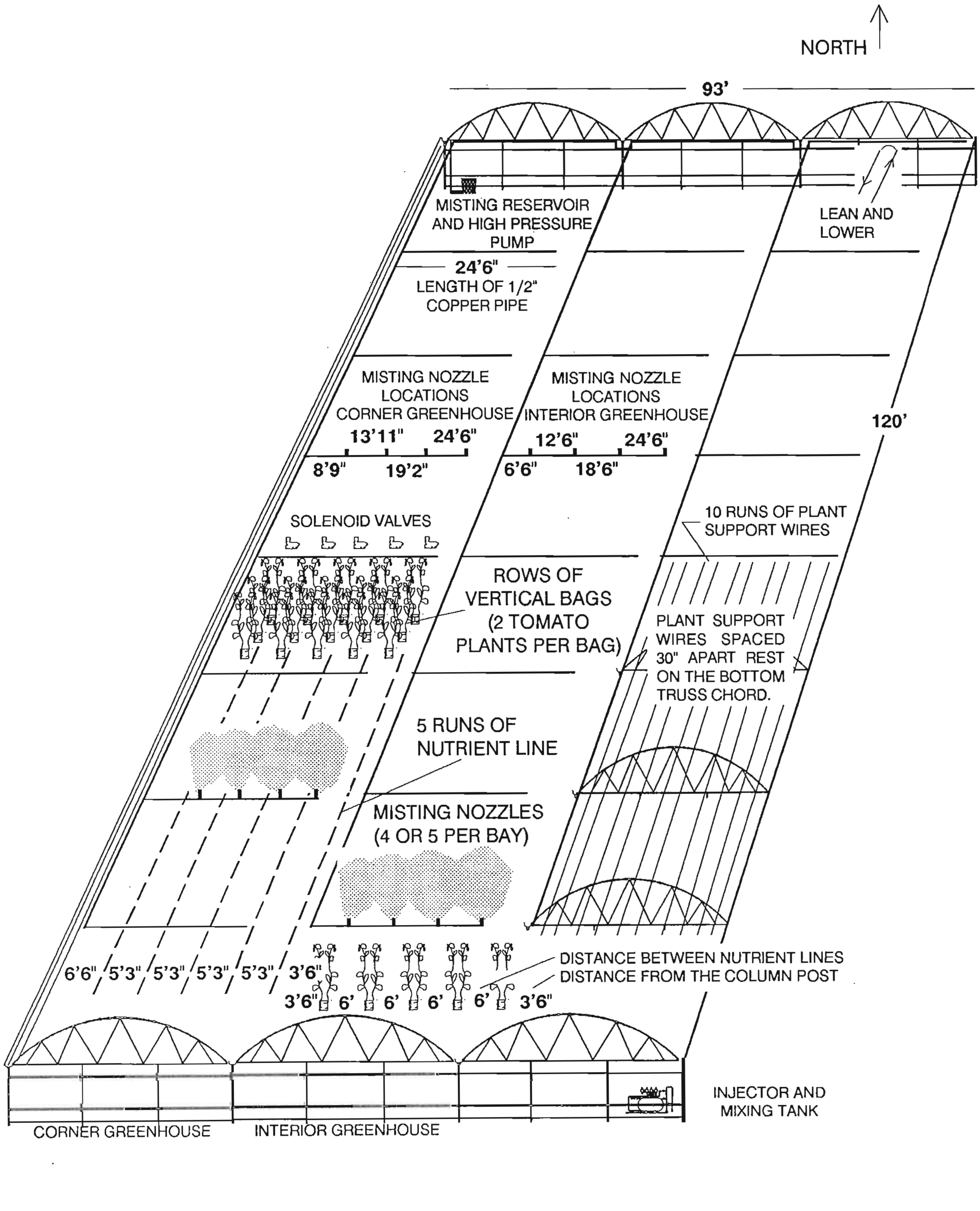
HYDRO-GARDENS, INC.

TOMATO GROWERS GUIDE

TYPICAL FINISHED GREENHOUSE



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I. INTRODUCTION

Tomatoes are the most commonly grown greenhouse vegetable. In recent years, some growers have shifted to other crops. Those gaining in popularity are seedless cucumbers, bell peppers, leaf crops, and herbs. The tomato continues to retain an important role as a popular crop that can also be used as a vehicle for establishing companion crops in the target market.

This manual will describe Hydro-Gardens' proven technique for growing tomatoes in the greenhouse utilizing the vertical bag system that was developed by Hydro-Gardens in the early 1970's. This method is now extensively used throughout the world, and continues to be the most popular development for hydroponic culture.

II. SELECTING A VARIETY

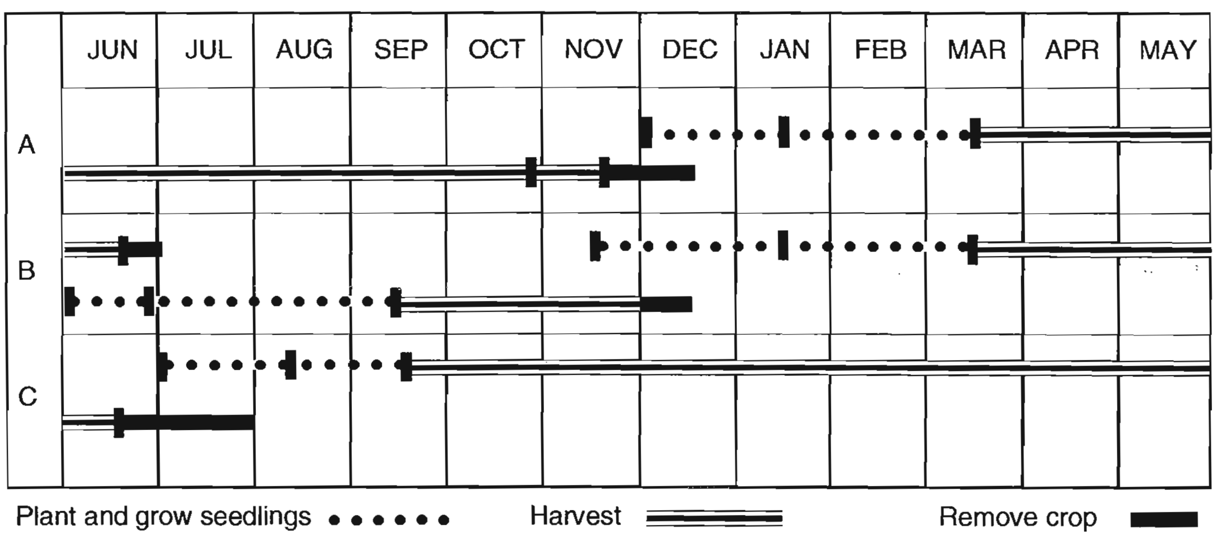
The greenhouse environment provides you with numerous advantages over field production. The most important is the greenhouse tomato you take to market can be truly "vine ripened". This will allow you to sell a tomato that tastes as if it were grown by your customer in their backyard garden. You will sell your tomatoes to a local market and can expect that a very high percentage of your tomatoes will reach the store shelf in excellent condition. A part of your marketing program should emphasize this quality throughout the levels of distribution so the final purchasers understand that they are buying a high quality, vine ripened tomato.

You should place a substantial emphasis on quality when selecting the tomato variety you will be growing. You will also want a variety that is resistant to as many pathogens as possible. Several current varieties (cultivars) are resistant to mosiac viruses, wilts, and bacterial related problems. The cultivar you want should also produce a high percentage of #1 fruit, be resistant to cracking, and not have a tendency toward greenback (green shoulders) if you are in a high temperature area. One extra fruit from a plant will more than pay for the difference in price of any seed.

III. PLANNING THE CROP

Proper scheduling of a tomato crop is of extreme importance and must be considered seriously if you expect to make money. You need to be familiar with the specifics of your local environment, and have a thorough understanding of the market demand, average retail selling price, and average wholesale selling price before planting the first seed. You should visit all of the retail stores in your projected market to determine which stores are already handling greenhosue/hydroponic tomatoes and which are not. Try to learn some of the specifics of the stores produce purchasing methods from the produce manager. You may need to be set up as a "vendor" before you can sell to some stores.

There have generally been two approaches to crop scheduling by commercial growers. They either grow one long crop for about 10 months, or two short crops that will also cover a 10 month time period. The law of supply and demand will help dictate your approach. The other factors will be local climate (amount and consistency of available sunshine), cost of utilities, and price pressure from field crops.



A. One long crop per year for Spring, Summer and Fall production:

Seed: Dec. 15th.	Transplant: Feb. 1st	First Pick: Apr. 1st - 10th
Top Out: Oct 15th - 30th	Remove Crop: Nov 30th - Dec. 15th	

B. Two crops per year for Spring, Summer and Fall production:

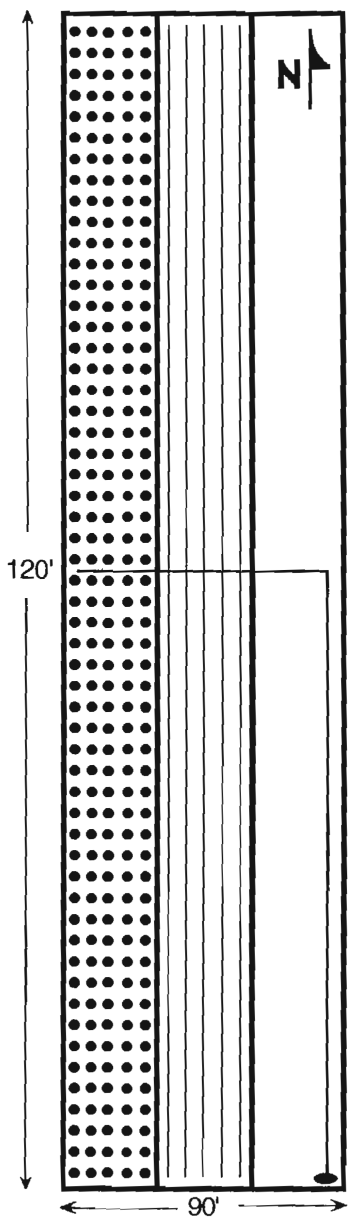
Seed: Nov. 20th	Transplant: Jan. 15th	First Pick: Mar. 15th - 30th
Top Out: May 1sr - June 1st	Remove Crop: June 15th - July 15th	
Seed: May 15th - June 15th	Transplant: June 20th - July 25th	First Pick: Sep. 1st - 30th
Top Out: Oct. 30th - Nov. 15th	Remove Crop: Dec. 15th - 30th	

C. One crop per year for Winter, Spring production:

Seed: July 1st	Transplant: Aug. 10th	First Pick: Sep. 15th - 30th
Top Out: June 1st - 15th	Remove Crop: July 15th - 30th	

Seeding and transplant dates may vary by one to two weeks. Harvest dates may also vary one to two weeks depending on available sunshine and transplant size. A nursery greenhouse is highly recommended to help you utilize these schedules. This will reduce your production costs since you will be heating a smaller space for the seedling stage. Good winter sunshine is very important to grow healthy, productive tomato plants. In certain unique areas, growers have successfully used schedule C to grow through the dead of winter. The weather pattern in most areas of the United States is such that 50% of your heating cost will occur during Dec., Jan., and Feb. To evaluate your situation, review your home heating bills for the previous 3 to 5 years.

The decision to continue a crop is primarily based on being able to pay for fuel costs and labor. If your sales don't exceed these two expenses, it makes sense to remove the crop. You should be able to estimate your picking 15 to 30 days in advance by counting the number of fruit that will ripen during that time. If your crop has been adversely affected by disease, insects, or other problems, the quantity and quality of fruit will probably indicate when to terminate.



IV. PLANNING THE VERTICAL BAG SYSTEM

Hydro-Gardens' developed the vertical bag system to grow tall crops in the early 70's. It has continued to gain in popularity since then, and has become, in one form or another, the most widely used "hydroponic" technique worldwide. The system is versatile enough to allow you to easily switch to other crops without changing any of the original equipment.

Calculating the tomato plant population in your area of the U.S.

Northeast Quonset 5.0 sq. ft. per plant	Southwest Quonset 4.8 sq. ft. per plant
Northeast Gutter Connect 4.8 sq. ft. per plant	Southwest Gutter Connect 4.5 sq. ft. per plant

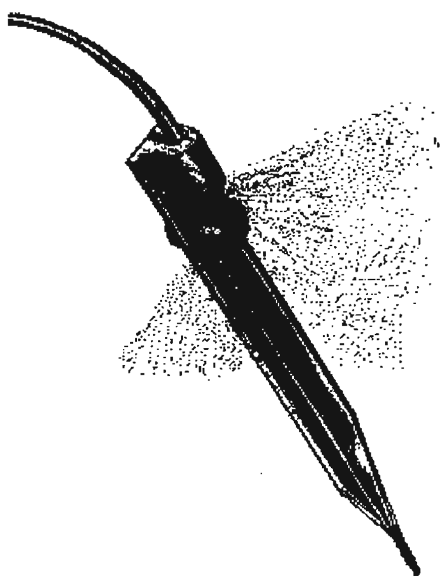
The spacing for tomato plants used to indicate 4.0 sq. ft. per plant, the newer varieties today will produce larger and higher quality fruit if they are given more space in the greenhouse. You will invest less into media, emitters, labor, etc. and should find that your yield per sq. ft of greenhouse space will be the same or greater than using the old spacing of 4.0 sq. ft. per plant.

If you have not yet purchased your system from Hydro-Gardens, you can easily determine the number of tomato plants you should put in your greenhosue. The figures for calculating the plant population are based on large greenhouse operations. Again, **available sunshine and daylength** are the limiting factors. You would not expect to grow a tomato crop through the winter in Anchorage, Alaska. By the same token, areas along the equator have the same day length every day of the year, and you would expect tomato plants to grow consistently day in and day out. The square foot per plant calculation takes into account the aisles in the front and rear of the greenhouse as well as those between the rows of plants. Studies have shown that 8,500 to 10,000 tomato plants per acre (43,560 square feet) are the minimum and maximum plant populations. Two tomato plants are grown in a 5 gallon vertical bag. Therefore you will need 1/2 as many 5 gallon bags and sprayers as the calculated number of tomato plants.

We recommend that the rows of plants run North and South to provide for maximum light to each plant during the shorter days of the year. The distance between rows of bags should be no less than 5 feet. A 30 foot wide greenhouse will provide the maximum growing area. For example, you have a gutter connected greenhosue that is 90' wide and 120' long (10,800 sq.ft.). Applying the formula (10,800 ft^{2} 5.0 sq. ft/plant = 2,160 tomato plants) indicates you need about 1,080 bags and sprayers. You will have 15 rows of bags in the greenhouse. Since 1,080 / 15 = 72 bags per row. You will need a 4' aisle in the front of the greenhouse, and a 4' aisle in the back. Thus the actual rows of bags are 112' (or 1,344") long. 1,344" / 72 bags puts the bags about 18.67" center to center down the length of the greenhouse.

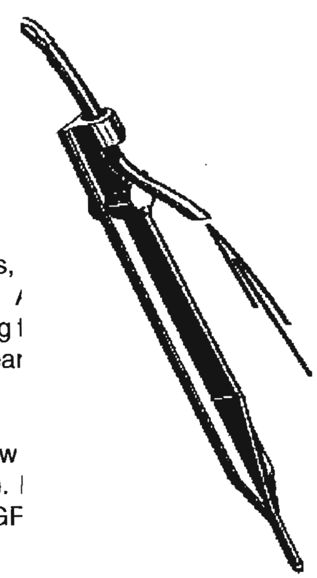
The spray stakes have a 24" leader.

The dripper stakes have an 18" leader.



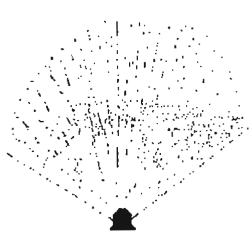
If you need to change the bag spacing at a later date, we have designed in a 4" to 6" fudge factor to allow you to move the bags either closer together or farther apart. The spray stake emits about .07 GPM (gallons per minute) of solution at 25 psi (pounds per square inch) pressure in a fan spray pattern. The dripper stake emits a small stream of solution at .035 GPM with 25 psi. Generally the spray stakes are used with vertical bags, and the dripper stakes with layflat bags. / small hole is cut in the top of the layflat bag 1 the tomato transplant, and the dripper streaı directed into this hole.

Still using the 120' greenhouse example, a row will require about 5.04 GPM flow (72 * .07). I injectors range from 10 to 100 GPM flow. A 10 GF can only handle one row of bags at a time.

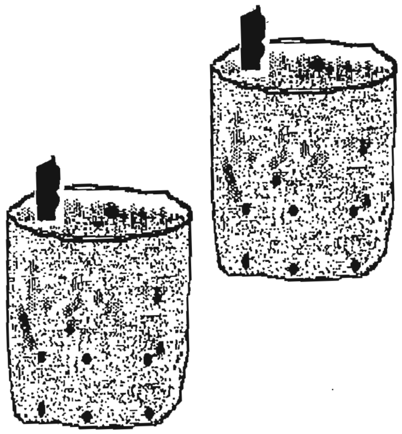


A 100 GPM injector can handle all 15 rows of bags at one time (100 / 5.04 GPM = 19 zones possible). However, your incoming water supply may not be 100 GPM. The watering system is divided into zones using 24V solenoid valves and a combination of timer and/or solar irrigation controller. We highly recommend purchasing an injector that will provide room for expansion. You will want to be able to complete a watering cycle for all rows of plants in one hour or less. You may also need to water the rows of plants for 60 seconds per row. Therefore, it will take 15 minutes to water all the rows in our example using the injector with a 10 GPM flow rate.

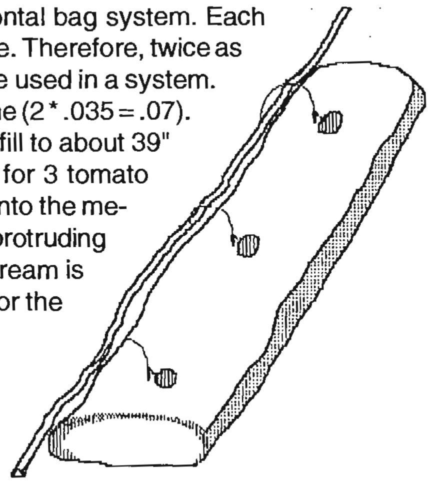
Your incoming water pressure should be maintained as close as possible to 40 psi. The solenoid valves will operate on as little as 8 psi, but the spray stake will not give a full pattern at this pressure. Injectors that use a water motor (Anderson) or valve technique (DOSMatic) to adjust the amount of nutrient concentrate that gets injected into the water stream operate accurately from as little as 15 psi to as much as 75 psi. The system functions best at 40 psi.



The spray stakes are pushed into the growing media until the top 1" of the stake is left protruding above the media. The stake is located between the two tomato plants about 2" from the edge of the bag. Angle the spray slightly downward to prevent the solution from overshooting the opposite side of the bag.



A dripper is used with the horizontal bag system. Each plant will have a dripper at its base. Therefore, twice as many drippers as sprayers will be used in a system. The GPM flow rate will be the same (2 * .035 = .07). Hydro-Gardens' horizontal bags fill to about 39" long and provide media volume for 3 tomato plants. The drippers are pushed into the media with the top 2" of dripper stake protruding above the media. The solution stream is directed into the hole you make for the tomato seedling.



V. CHOOSING THE GROWING MEDIA

You will want to consider several factors when picking the growing media you will use. Included are cost, availability, porosity, ion transfer capability, and weight. The media should be sterile and inert. It should contain no pathogens or weed seed (sterile), and have little or no fertilizer value (inert) in it. There are several companies that offer excellent grades of peatlite mixes that are a blend of Canadian sphagnum peat moss, perlite and vermiculite. The media is pH adjusted to about 6.4 and normally has a wetting agent blended in to help initial saturation of the peat moss. If you have the machinery, you can mix this with 50% aged lumber mill sawdust that is screened to 1" in particle size. This will substantially reduce media cost and not adversely affect its usefullness.

Other media examples are: Redwood sawdust, perlite/rockwool blends, rockwool slabs, peatlite/sand, coconut fiber, and bulk rockwool. Commercial growers have successfully used all of these materials and combinations. The results of years of media experimentation have been published in books and periodicals, and we suggest you read about this research from the list of publications found in our commercial growers catalog. Subscribing to the grower trade publications will also help you stay abreast of new developments as they occur.

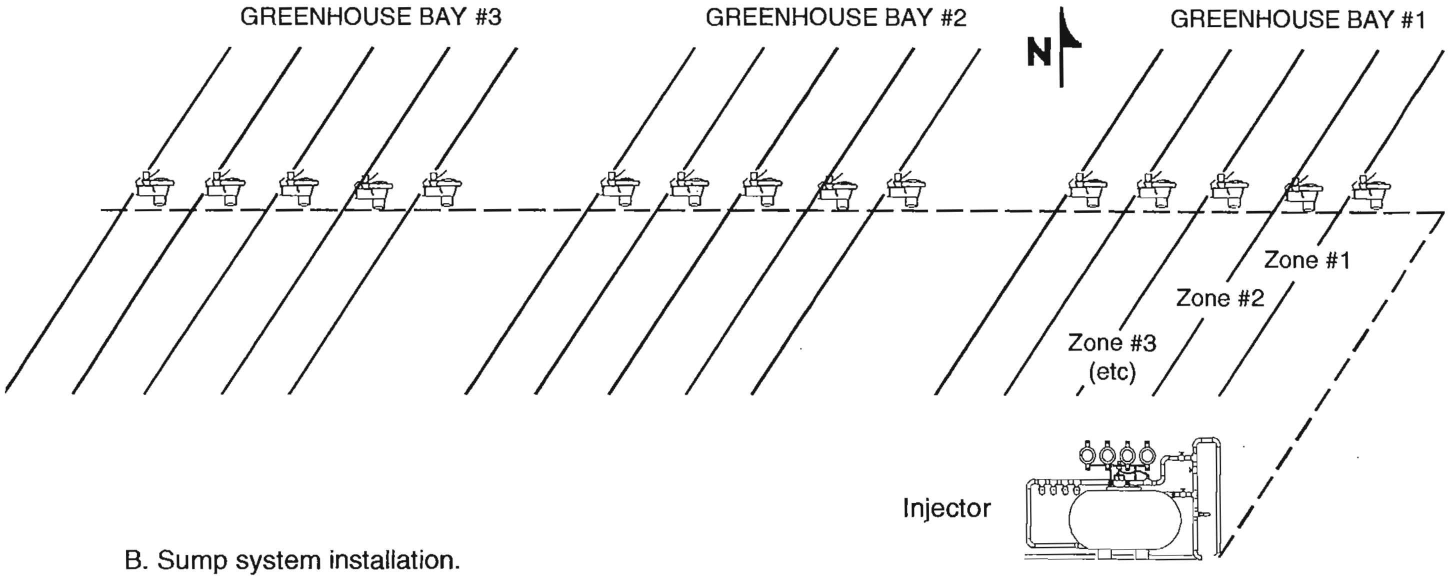
VI. GROWING SYSTEM LAYOUT AND INSTALLATION

Our suggested growing system layout depicted on page 2 assumes that the slope of the greenhouse floor does not exceed 1/2% (6" in 100'). The sprayers and drippers are **not** pressure compensating, and the plants at the lower end will get more water if they are a foot or more lower than those at the high end. If this is the case, you will want to move the solenoid valve location nearer the lower end and reduce the size of the poly pipe at the high end. The poly pipe in this system is "charged" with nutrient solution when the solenoid valve shuts off after a watering cycle. The solution left in the poly pipe will drain from the high end to the bags at the low end. Moving the valves to the low end will reduce this.

A. Injector system installation.

The injectors, concentrate tanks and related equipment should be placed in a convenient location near your greenhouse entry door. This equipment should be inspected daily. Your bagged fertilizers, pH testing equipment, conductivity meter and other similar items **should not** be stored in the greenhouse.

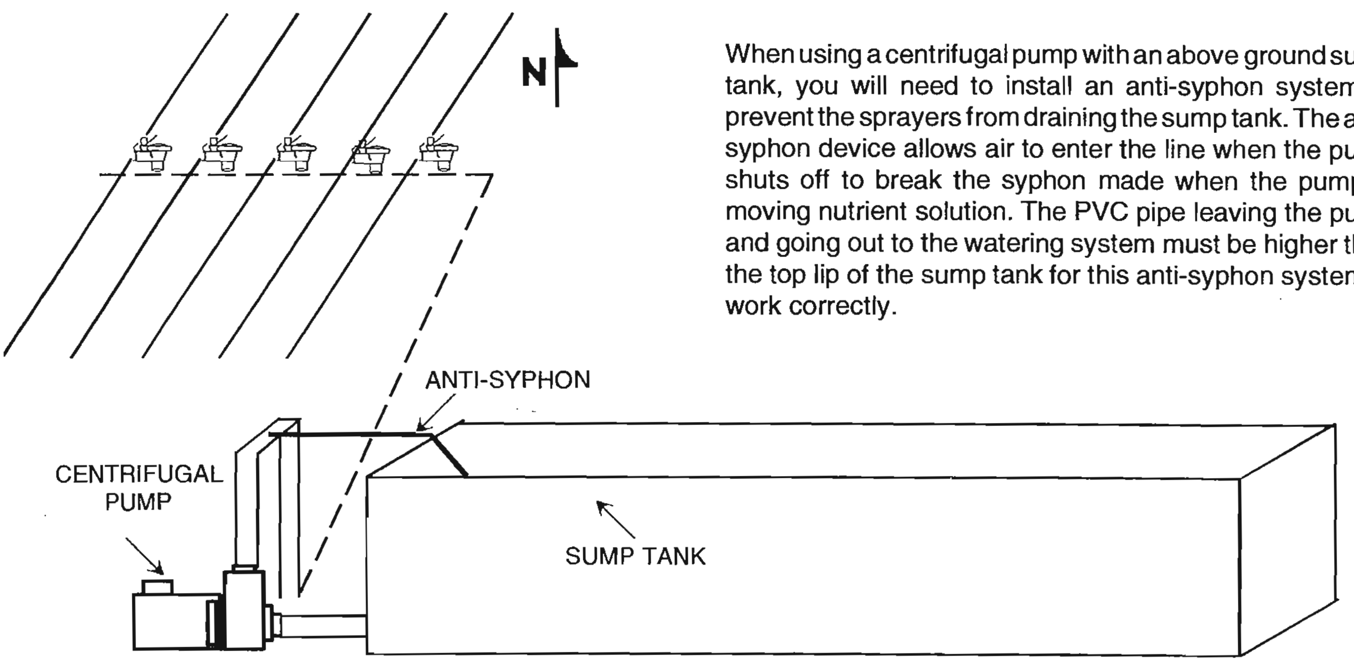
The PVC pipe main header should be buried 4" to 6" under ground after exiting the mixing tank. White PVC allows enough sunlight through its walls to provide a growing area inside for algae. If burying this pipe is not possible, paint the pipe black to prevent this algae growth, and then paint it white again to reduce heat gain which can distort the pipe. **Black** poly pipe nutrient line is used anytime water or nutrient solution is flowing above ground. Your injector size and number of sprayers in the system will determine if you can water more than one row at a time. The system should be designed so that one row or zone is less than your maximum water flow rate. If your incoming water source cannot provide the needed pressure and volume, you will need to install a water storage tank and centrifugal pump that will drive the system. Your incoming water line will supply the storage tank with "make-up" water, and the pump will provide the pressure. The storage tank, including the make-up flow, needs to hold enough of water to provide a minimum of 1/2 gallon per tomato plant per day, and 1/16th of a gallon per plant per watering cycle. You can calculate with our example of 72 bags (144 tomato plants) in a row (zone), that this capacity is about 75.6 gallons (72 bags * 15 rows * 1 minute * .07 GPM = 75.6). A float valve should be installed in the side of the tank that automatically fills the tank as the water is being removed by the pump. The flow rate of water from your source to this tank must be greater than the amount used by the system between the start of one watering cycle and the start of the next cycle..



B. Sump system installation.

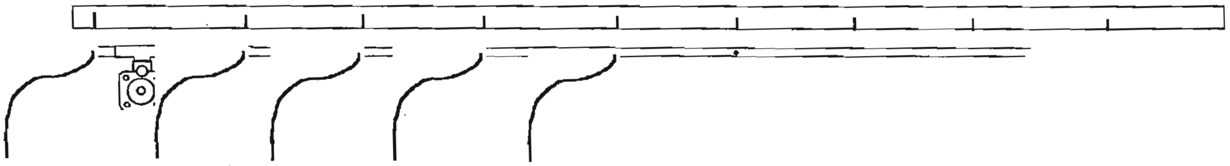
The best layout for a sump system is also running a header out to the center of the greenhouse, and running the poly pipe both directions down the length of the greenhouse. If you need to run your poly pipe from one end of your greenhouse to the other, you will need to use two or three sizes of poly pipe to restrict the volume as the poly pipe gets further from the nutrient pump. The sump tank needs to have a minimum capacity of 1 1/2 gallons per plant. An individual tomato plant could use at least one gallon of water every two days during peak growth. You will have to mix fertilizer every two or three days using a sump system. A one horsepower centrifugal pump will be able to water one bay of bags at a time. If you have more than one greenhouse bay, it is advisable to opt for an injector system.

When using a centrifugal pump with an above ground sump tank, you will need to install an anti-syphon system to prevent the sprayers from draining the sump tank. The anti-syphon device allows air to enter the line when the pump shuts off to break the syphon made when the pump is moving nutrient solution. The PVC pipe leaving the pump and going out to the watering system must be higher than the top lip of the sump tank for this anti-syphon system to work correctly.



C. Sprayer installation:

Now that the poly pipe is in place, it's time to install the spray lines. It is best to practice inserting a spray line several times with the punching tool on a scrap piece of poly pipe to familiarize yourself with this. Goof plugs are available that plug holes made in the wrong locations. You can use a 12' length of scrap lumber as a template for tubing installation. Place marks on the 2" x 4" for our example 18.67" apart. Begin installing tubing at the solenoid valve and work toward the ends of the greenhouse from there. This will compensate for any gain or loss in spacing. As indicated in the drawing, push the tubing into the hole made by the punching tool as soon as you pull the punching tool out of the pipe. The outside diameter of the tool is slightly greater than that of the tubing, but the hole made by the tool in the poly pipe is slightly less. The poly pipe will return to its original shape shortly after the hole is made, and grips the tubing tightly.



After all the spray lines have been installed, and before you install the end caps on the poly pipe, run your system for as long as it takes to flush the lines of any debris that may have collected during installation. This flushing should also be carried out periodically as a part of your maintenance program to keep the lines clear of any sediment that forms on the inside walls of the pipe. Be sure to bypass your injector so you are flushing with plain water and not wasting nutrient solution.

The bags should be filled with the media of your choice, and spread around the greenhouse with one bag for each sprayer. You should install one or two extra sprayers at the near end of the nutrient line(s). This sprayer will later be put inside a one gallon bottle to collect nutrient solution as if it were a bag being watered. You can use this bottle to daily monitor the quantity of solution being used, to measure the conductivity, and to measure pH. It can also be the nutrient solution you send off to the lab for analysis each month.

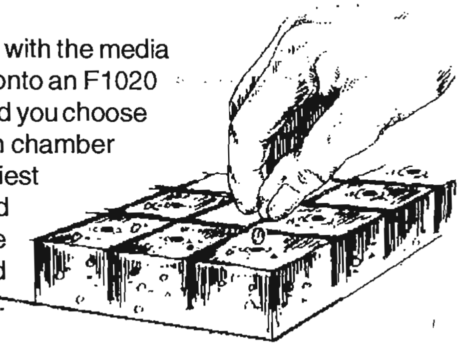
Several days before moving the seedlings into the bags, run your system with plain water. This is done to thoroughly wet the media prior to transplanting. It also gives you an opportunity to walk the rows of bags to insure that all sprayers are working properly. The bags should be filled to within 1" of the top lip of the bag. If the media level is too low, this lip may later fold over onto the media and redirect the spray out of the bag and onto the floor. The spray stake should extend out of the media about 1" and be directed slightly downward to keep the spray contained within the bag.

You must insure that during transplanting, the media in the bag is more wet than the media surrounding the tomato seedling root system. If not, the capillary action of the media will draw water away from the seedling root system causing severe wilting. It may be necessary to manually water two or three rows at a time just ahead of actual transplanting. Always handle the seedlings **by the pot** they are in; **not** by the stem of the plant.

VII. PLANTING THE SEED

A clean, sterile germination area is very important. All the equipment you will use should be cleaned and free of organic material that may harbor disease organisms. It is generally advisable to clean the area with common household bleach. A 1:9 ration of bleach to water is sufficient. Do not plant until the chlorine odor has disappeared.

Your tomato seed can be individually planted into Horticubes, net pots filled with the media you are using, or some other type container. They can also be "broadcast" onto an F1020 flat filled with vermiculite to be "pricked" out later into a container. The method you choose is not as important as doing the method correctly. If you have a germination chamber and seedling propagation greenhouse, you should be able to grow the healthiest seedlings possible. If you do not, you will need to refine the germination and seedling growth around the available space you do have. A simple technique to singulate tomato seed is to fold a 3" x 5" card in half, put several dozen seed in the fold, and scrape a seed out the end of the card with a pencil or toothpick. With some practice, this can be done quite quickly.



The proper technique using Horticubes or rockwool blocks is to wet them prior to dropping the seed. You will want to have some vermiculite or perlite on hand to fill in the hole in the block. After filling the hole, tamp down slightly and moisten this media. This practice serves two purposes: 1) It helps keep the seed evenly moist. 2) It applies force to the seedling causing it to shed the seed coat as it works up through the vermiculite.

If you use net pots filled with your growing media, slightly moisten the media first. This will keep the media in tact as you scoop it into the pot. It is not necessary nor advisable to firmly pack the pot with media. Packing too tightly can restrict the seedlings' root growth. Make a 1/4"+ depression in this media (this is called dibbling). Drop the seed and cover with vermiculite, perlite, or more of your media. Tamp this covering lightly and water.

You need to have enough flats available for all the seed you plan to germinate. Always seed at least 15% more blocks than seedlings you need. Germination rate for tomato seed will also vary so assume that, unless otherwise stated on the seed package, this rate will be 75%. Our example will need 2,250 good tomato plants. You have checked the variety and it has an 80% germination rate, so you you will drop 3,000 seed. This will allow you to discard those seedlings that don't appear as healthy as the rest. It makes a lot more sense to over plants by 25% to 30% rather than discover a week or two later that you don't have enough good tomato plants to fill the greenhouse, and must re-seed, causing you to have some seedlings that are 3 weeks behind.

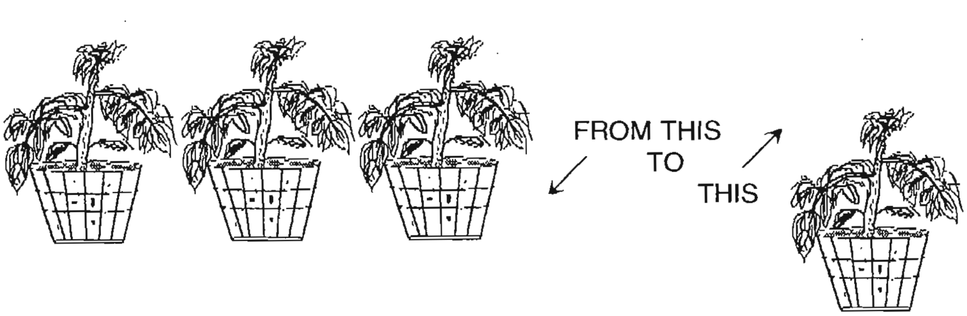
After placing seed in the pre-moistened media, it is wise to **cover the flats with newspaper**. This will help keep moisture in the media, shield the top of the media from direct light and excess heat, and allow you to water with a breaker nozzle and not "blow" the seed out of the media, or the media out of the flat. The ideal germination temperature is 78°, and the seed should germinate in 3 to 5 days. Inspect the seed daily for signs of germination. Once this begins, remove the newspaper cover to expose the plants to light (preferably sunshine).

VIII. GROWING A HEALTHY SEEDLING

Once the seed are up, the night temperature should be kept at 65°, and the day temperature at 78°. The young plants can tolerate temperatures that vary somewhat from these, but may not grow as effectively. If the plants are in your greenhouse during the summer, you may need to shade the area they're in to maintain the day temperature. Continuous air movement across the top of the media hastens evaporation. This causes the media to wick up solution to the top of the media. As the water continues to evaporate, fertilizer salt deposits may form on the top of the media, and this may injure the tender stem of these small plants. Always water seedlings from the top with a light, fine spray until 2 to 3 true leaves have formed.

Within 3 days of germination, begin watering your seedlings with 1/2 strength nutrient solution. The conductivity of this solution will ideally be 400 ppm to 600 ppm. It should not exceed 1100 ppm. Continue this practice until the plants are about 3 weeks old. With the proper environment and good light (preferably sunshine), your seedlings should be 3" to 4" tall and 3" to 4" across.

Your seedlings should be spaced apart as soon as the leaves of one begin crowding the leaves of its neighbor. If you have used Horticubes as your medium, you will have noticed that the root system has grown out of the block. You should transplant this block into a larger container. We prefer the 3 1/2" net pot, or something similar in size. This will automatically space the plants apart. Depending on your situation, you can continue potting the plants up into larger containers so long as they can be self supporting, or you can conveniently support them with a 30" bamboo stake. The main reason for "potting up" is to delay having to heat the greenhouse for as long as possible. The seedlings may also be moved into the 5 gallon bags as soon as the first two true leaves have formed.



At the 3 week stage, the seedlings will require a nutrient solution with more potassium, phosphorus and magnesium. This is accomplished by increasing the amount of Chem-Gro and magnesium sulfate ($MgSO_4$) you use while continuing to keep the quantity of calcium nitrate ($CaNO_3$) the same. Specific mixing instructions are found in Hydro-Gardens' catalog and the fertilizer appendix of this manual.

Tomato seedlings can be grown under light for the first 2 to 4 weeks. This technique is used by many northern growers duirng November and December. The daylength is short, and many days are extremely cloudy. This makes it very difficult to grow vigorous seedlings. You can use high intensity discharge (HID) lights, or standard cool white fluorescent lights. Seedlings do best at 1000+ footcandles, but can be grown with as little as 400 footcandles for 2 weeks. Fluorescent lights should be mounted side by side and as close together as the fixture will allow. They should be mounted so that they can be raised as the plants grow in height and be kept 2" to 4" above the tops of the plant. HID lights will need to be kept 8' above the plants.

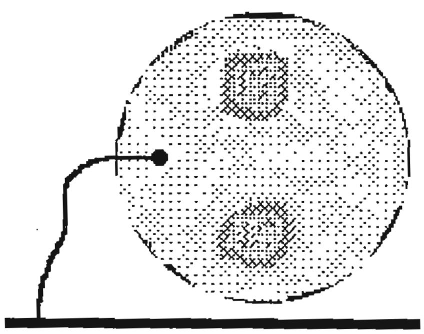
IX. TRANSPLANTING INTO THE VERTICAL BAG

Planting into the bags is generally done from the 4 week to 7 week growth stage. The timing is not crucial so long as you can conveniently manage to water the plants and keep them upright. The 5 gallon vertical bag should be nearly full of media that has been thoroughly moistened. Select two tomato plants that are similar in size, and scoop a hole for each on opposite sides of the bag about 3" in from the lip. If the seedlings are small (4 weeks old), and in Horticubes, they will not displace very much media. If the plants are larger and in 3 1/2" net pots, they will displace substantially more media, and the 5 gallon bag should be less full to accomodate this volume. Tomato plants can be successfully moved into the bags even after the first fruit cluster has begun forming.

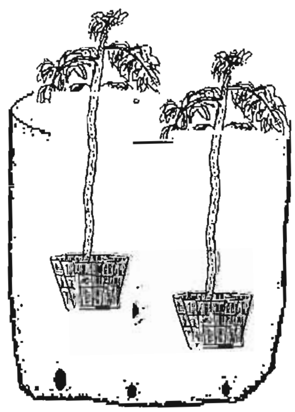
Insert the spray stake into the media leaving 1" exposed. Direct the sprayer slightly downward so that it will not over shoot the opposite side of the bag. You will probably need to "top off" some, many, or all the bags. Have a supply of moistened media nearby for this.

After one or two rows have been planted, it is beneficial to manually water these plants. This gives you another opportunity to observe that all sprayers are working properly, and will prevent the media from drying out the seedlings.

If you have not managed the seedlings well, they may be "leggy". This condition occurs when the plants have not been given enough light, and the temperatures have not been maintained. It is still possible to salvage these seedlings by planting them far enough into the vertical bag so that most of the stem is covered with media. This will require special care. If spindly plants are not planted deep, the stem diameter usually remains quite small and the mature plant will not be able to move enough water through this restriction for good growth later in the crop. You can bury the tomato stem all the way up to the 1st true leaf. Be sure to remove the seed leaves first. The stem of the plant will then become an integral part of the root system.



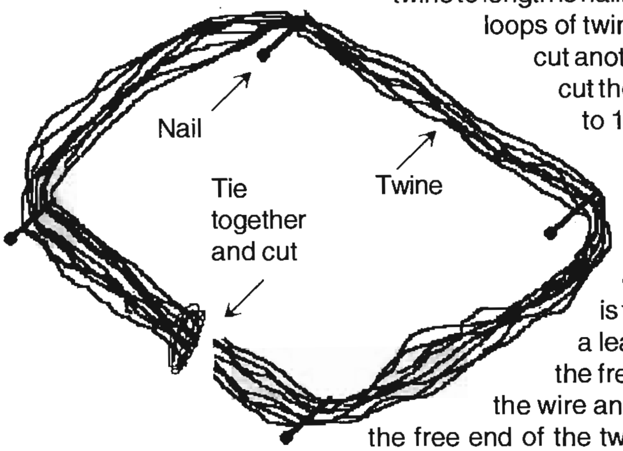
COMPACT PLANTS



LEGGY PLANTS

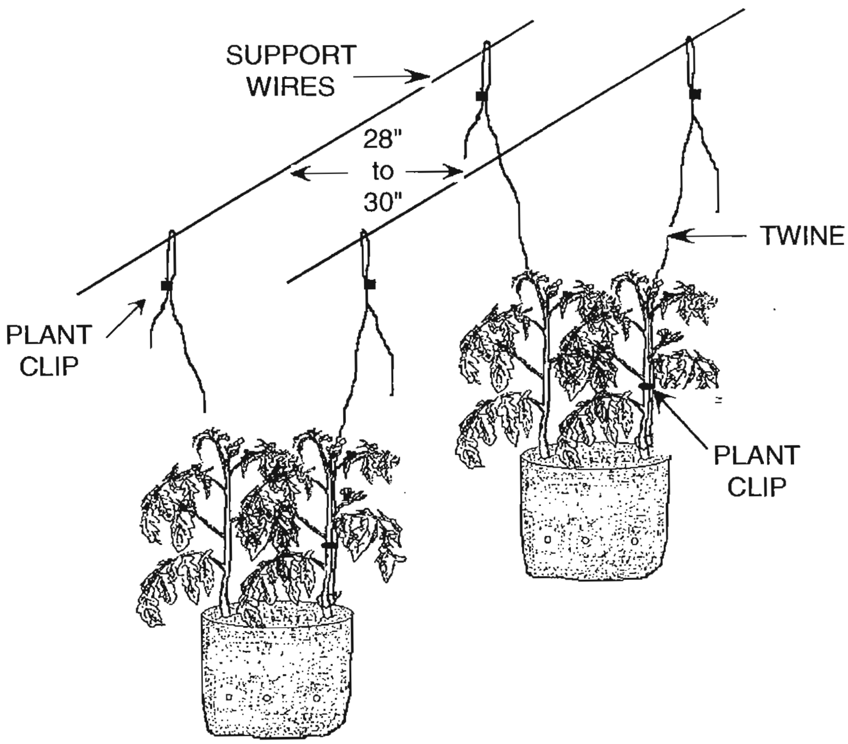
X. TYPING PLANTS TO SUPPORT WIRES

We recommend the use of Tomaholders or Tomahooks to attach your plants to the support wire. However, if you choose to not use them, the length of your monofilament tying twine should be several feet longer than the distance from the top of the bag to the overhead support wire. In most instances this will be 10' to 12'. A simple method we use to cut the twine to length is nailing four 16d nails 2 1/2' to 3' apart in a square, and wrapping several loops of twine around the nails. Once the nails are wrapped 20 to 30 times, cut another short length of twine, tie the lengths of twine in a bundle, and cut the bundle in half. This will give 20 to 30 pieces of twine that are 10' to 12' long.



With the plants in place in their vertical bags in the greenhouse, you will need to string them to the overhead wires. You can use one of three techniques to keep the lines in place on the overhead wires and close to the base of the plants. The quickest is to use a 3/4" plant clip snapped around the base of the plant under a leaf stem with the twine in the hinge, and a slip knot that attaches the free end of twine to the support wire. You can also tie a slip knot at the wire and tie an open loop to the base of the plant. Lastly, you can bury the free end of the twine in the media with the plant. This method is both the least desirable and least expensive. You may find that the free end wants to pull loose from the media, and time is spent shoving it back in.

Later in the crop, the stem of the plant may be 15' - 25' long or longer. You will have run out of twine during the course of lowering and leaning the plants. You will need to extend the length of twine by tying a 6' to 8' length of twine onto the free end of support twine with a square knot. At step 1 on the previous page, you could have separated the nails by 4' and had lengths of twine that are 16' long that may be long enough to last through a 6 month growing season. Thus you could avoid tying "pig tails" onto the shorter twine as explained here. The only problem with this method is that it is difficult to distinguish which length of twine is supporting the plant, and which length is the free end. Then when you lower the plants, it becomes a little more difficult to grab hold of the correct piece of twine.

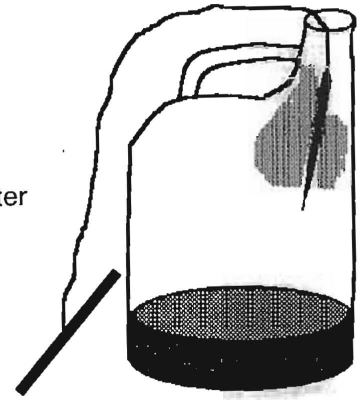


XI. PLANT MANAGEMENT

There are several jobs that you will need to learn. Some are done daily, some several times a week, and still others less often. The rate of growth of your tomato plants will dictate how often you perform some of these jobs. We have segregated these activities into the categories we consider daily, weekly and periodically.

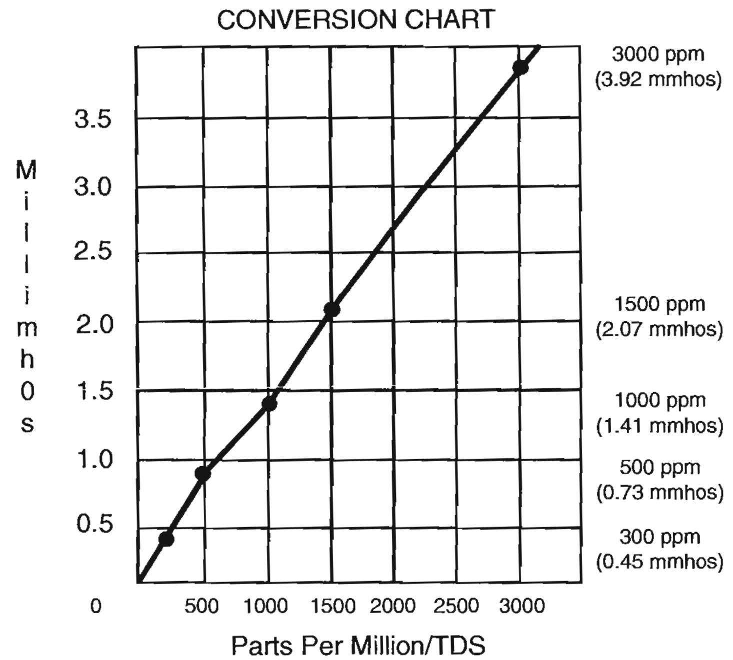
A. Daily activities.

1. Check conductivity, pH and empty the collection bottle.
2. Check the nutrient level in your concentrate tanks.
3. Inspect 1%+ of the plant population for insects.
4. Randomly lift some of the bags to check their weight.



1. Check conductivity and pH: You should carry your conductivity meter and pH tester to the greenhouse daily. Do not store these, or other items in the greenhouse that may be damaged by the high temperature and fluctuating humidity found in the greenhouse. You have connected a 1 gallon bottle to a spray device just to monitor the volume going to the plants each day, and for use in checking the conductivity and pH. You should keep a chart where you can record the daily water volume, conductivity and pH.

Conductivity is generally discussed as parts per million (ppm) or millimhos (mmhos). Millimhos is a reading based on how quickly electricity moves from point A to point B. Parts per million is a conversion from millimhos and is a comparative readout. Both are described as total dissolved salts (TDS). A meter reading of 1.41 mmho is about 1000 ppm. The comparison chart below shows the relationship between millimhos and parts per million. Other terms sometimes used to express conductivity are microsiemens and micromhos. Both terms are 1000 millimhos (i.e. 3.5 millimhos = 3500 micromhos). The acceptable conductivity range for tomato seedlings and young plants is 400 to 1500 ppm. For mature plants it is 1200 to 2500 ppm. This range attempts to take into account the conductivity of your source water. Source water conductivity can range from less than 200 ppm to as much as 1200 ppm and more. It is recommended that source water that ranges above 500 ppm be sent to a laboratory for analysis to determine which elements are in this water. Not all soluble salts found in water are harmful to plants growth. Generally, "hard" water contains elements that plants can use, and "soft" water has an adverse effect on healthy plant growth. Refer to the fertilizer index in the back of this book for more comparison information.



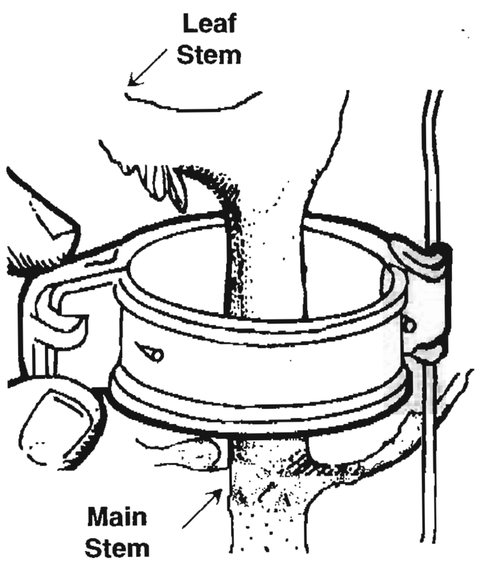
2. When checking your nutrient concentrate tanks, make a mental note of how much concentrate is being used daily. The levels in the tanks should be decreasing at the same rate. If not, you will want to check your injector heads to insure that they are working properly.

3. Inspect a sample of the plant population for insects. The most troublesome insects for greenhouse tomato growers are greenhouse whitefly (GHWF) and sweet potato whitelfy (SPWF). Others that can cause problems are thrips, aphids, spidermites, and russet mites. All of these pests live on the undersides of the leaves. They are also all extremely tiny, and are difficult to find the 1st time through. Hydro-Gardens' catalog has complete descriptions of pests and biological control techniques.

4. Lifting bags will give you an idea of how much a bag full of root system and fertilizer solution should weigh. If you notice that one or both plants in a bag are wilting, The first thing to check is the weight of the bag. If it is not as heavy as the non-wilting neighbors, the spray emitter may be plugged. A paperclip is a handy tool to clean emitters.

B. Weekly activities.

1. Train plants to twine.
2. Prune off suckers.
3. Pollinate.
4. Pick and pack tomatoes.
5. Prune off lower leaves.
6. Lean and lower.
7. Clean floors of debris.



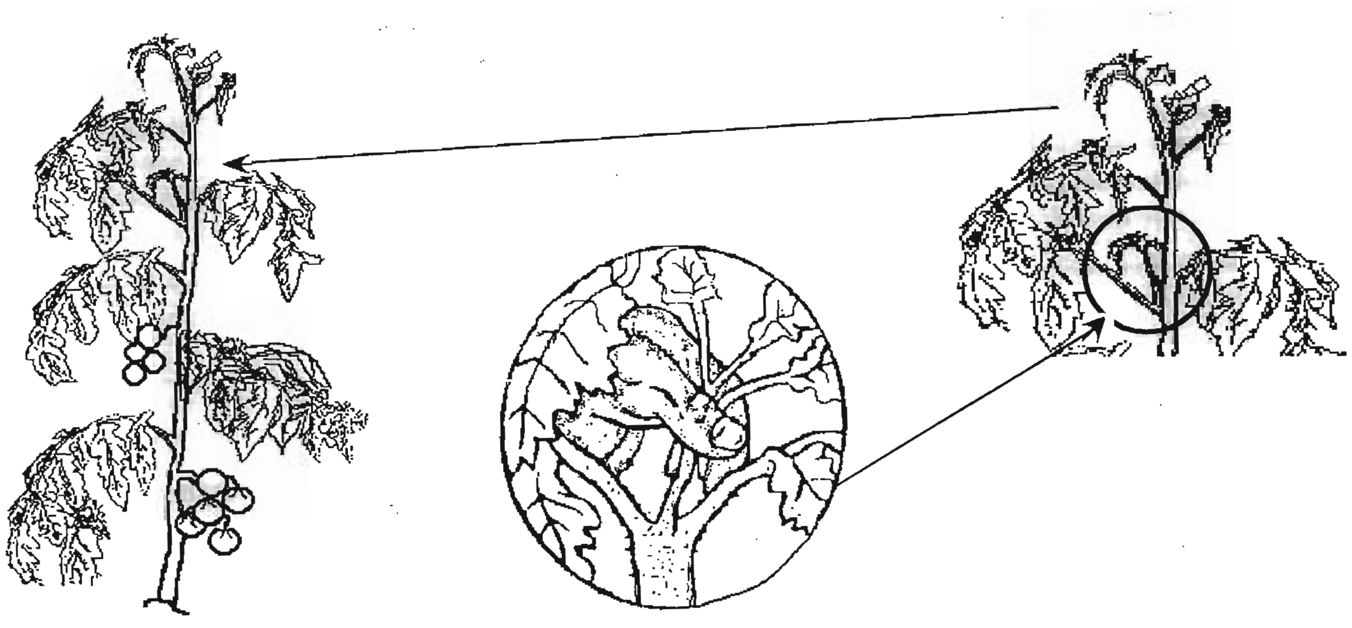
1. Plant clips have been used for many years to aid in "training" tomato plants to the twine. The Max tapener machine is a very useful tool for this training as well because it will reduce the number of clips you use, and is faster. It can be a lifesaver if you have fallen behind in your clipping and must quickly bring the stem back to the twine. Hot air stratifies just above the wires in the greenhouse. If the growing tip of the plant gets into this hotter air, it will wilt very quickly. If not fixed, the wilt can be severe enough to kill the growing tip, or at least, cause some serious damage. Temperatures above 90° F. can damage flowers.

You need to be careful about the twine you use for tying up your plants. Hydro-Gardens sells only the highest quality, UV stabilized plastic monofilament twine for this purpose. It is the correct diameter to fit behind the "nubs" of the hinged portion of the clip. Twine that is not UV stabilized may deteriorate before the end of the crop. Between clips, you can use tapener tape to keep the plant close to the twine. The tape is not a substitute for clips because the tape does not grasp the twine. The final caution about clipping is to be sure that the clip is attached to the twine on the underside of a leaf stem, and **not** under the clusters of fruit.

2. Suckers, or laterals, begin growing in the "notch" formed between the main stem and the leaf stem. They are occasionally seen growing out the end of a cluster (hand) of blossoms. If you closely inspect them, you will see that they look identical to the growing point at the top of the plant. Much like a tree, the plant has a natural tendency to branch out and form multiple tops. You will get the best quality and fruit size if you maintain a 1 to 1 ratio between root system and top growth, therefore this excess growth should be pruned from the plant and discarded. Some growers have tried to start a new tomato crop from these growths. No knowledgeable grower or expert in this field will recommend this practice. While true that these suckers will eventually have their own hands of blossoms that will become fruit, as the name implies, these suckers will drain energy from the plant and overall production will suffer if they are not removed..

Suckers should be pruned when they are 2" to 4" long. Be sure not to confuse a sucker with the active growing tip of the plant. When in doubt, wait a few days before removing them. If left on the vine too long, they will begin developing flower clusters of their own which take vitality from the main plant and create a large pruning wound. Suckering should be done when the plants are "crisp". This is usually in the morning.

The technique is also easily learned, and as shown, the sucker is firmly held between thumb and forefinger, and snapped off the stem with a quick motion. You will notice that the sucker will snap off cleanly where it connects to the main plant, and the scar left will heal quickly. We do not recommend using pruning shears for this activity. Pruning shears will smear the juices of one plant into the wound on the next plant. This could cause disease to spread. Also, the shears will leave a stub behind that may take several days to dry and shrivel. This will remain as an "open wound" that can be attacked by botrytis and other harmful organisms.

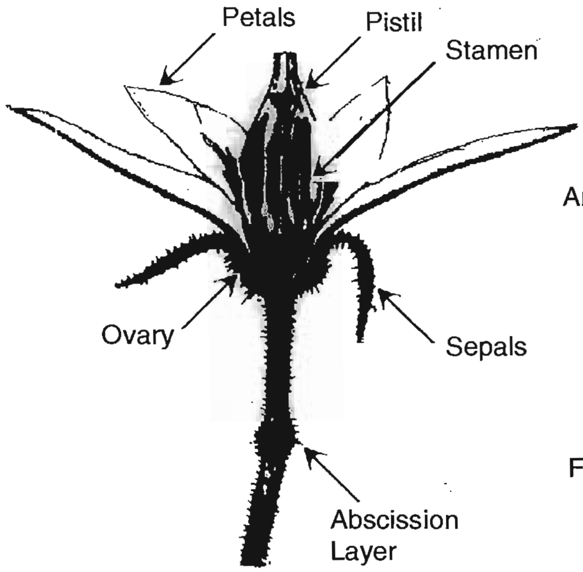


3. Pollinating is a very important part of maximizing production. The size fruit you get will be greatly influenced by the seed count found in the tomato. Each pollen grain that properly attaches to the stigma will become a seed. The fruit will gain size and weight by enveloping these seed with gel and meat.

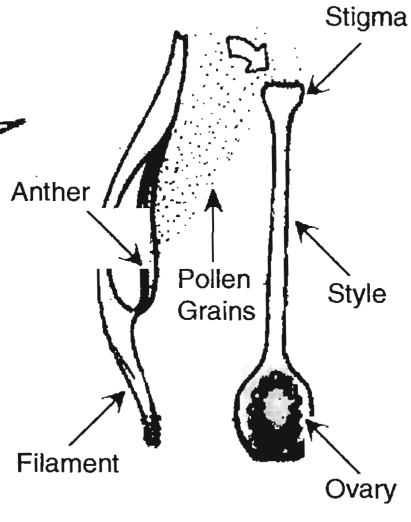
Sunlight, temperature and humidity in the flower are crucial for good pollination. Good sunshine causes the flower to open fully. It needs to be open to start the drying out process from the previous nights' humidity. If the flower is damp inside, the pollen will stick in clumps causing the fruit to be misshapen. Air that is too dry around the flower will let the pollen fly away from the pistil. If it doesn't stick, it won't become a seed. Studies by seed producers and others have indicated that the relative humidity in the greenhouse should be 60% to 70%, and that the temperature should range between 75° and 80°F.

The best pollination method is to use bumblebees. The bees know when the flowers are ready to be pollinated. When pollinating by hand, you should plan spending about 2 hours for every 1000 plants about 3 times a week. A battery powered pollinator can be found in our catalog. For about 1 second, the tip of the pollinator is lightly pressed against the main truss arm of the blossom cluster at its "knuckle". This will vibrate the entire cluster, and when done during the correct time of day, a small "puff" of yellow pollen can be seen bursting from the flowers that are ready. If you do not see pollen fly after touching a few clusters with fully open flowers, discontinue pollinating until the parameters described previously are met. A black card held behind a cluster of flowers will allow you to see the pollen more easily. Pollen grains are generally viable for about 72 hours, and must be shaken loose from the stamen at one point during these 3 days of fertility.

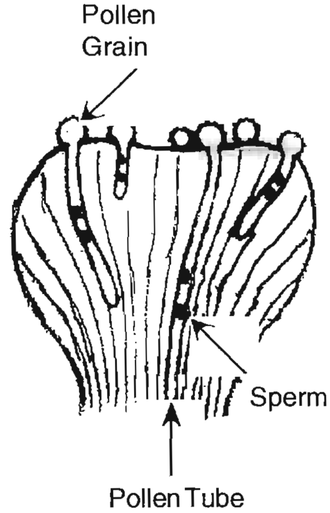
You will experience several consecutive days of cloudy weather sometime during your growing season. You will find that, because of these adverse outside conditions, you will need to force your greenhouse into the required humidity parameters. You will still need to pollinate. You can lower the relative humidity in a greenhouse by alternately heating and then exhausting the air within the building. Repeat several times before attempting to pollinate.



BLOSSOM



STAMEN and PISTIL



STIGMA

4. Growers generally pick and pack tomatoes 2 to 3 times a week depending on time of year and local market demand. Tomatoes will ripen on the vine much more quickly during long, warm summer days than short, cool winter days. Growers usually pick when the tomatoes begin to show some color during the summer. During the winter, most growers leave the fruit on the vine until it is a pink stage. the longer the fruit remains on the vine the better the flavor and vitamin content. However, the sooner the fruit is removed, the quicker the plant can begin devoting energy to younger fruit. A quality tomato should have a shelf life of 2 to 4 weeks when picked with some color. The standard practice is to pick with less color on Friday as opposed to Monday.

Picking is the first job of the day, when the fruit is cool and full of moisture. During a warm day, fruit can lose 1% - 3% in weight, due to heat stress. The actual picking technique is easily learned. Simply grasp the tomato, place your thumb on the abscission layer and lift upward. The fruit should snap off the plant at the abscission layer leaving the calyx (stem) attached to the fruit. The shears are then used to trim the stem near the tomato to prevent the stem of one tomato from punching a hole in another tomato.

Your market investigation should provide clues about how you can get the highest possible price for your tomatoes. This may mean that you need to put a sticker on each fruit to create customer awareness and recognition. You might also leave the calyx on the fruit. If you do this, prune the stem close to the tomato to prevent the stem of one fruit from puncturing the skin of another. Some customers recognize the calyx being attached as a sign of freshness.

Your main selling advantages will be the vine ripened flavor of your tomatoes, and the fact that they are grown locally. A tomato will take on its flavor characteristics as it ripens. Once picked, the fruit should be stored away from cucumbers and other crops that give off ethylene. This gas will increase ripening speed. It is not necessary nor desirable to refrigerate tomatoes below 55°F. You should try to deliver your crop within 3 days of harvest to provide the final consumer the longest shelf life possible.

Your produce can be packed into 10# or 20# boxes. They may be packed by size in the box, or packed with several sizes in the same box. Your buyers should be able to describe how they want you to pack your tomatoes. You should weigh the cost in labor and materials for a particular packing method against the revenue you get from this. There is no single "correct" way to pack your produce.

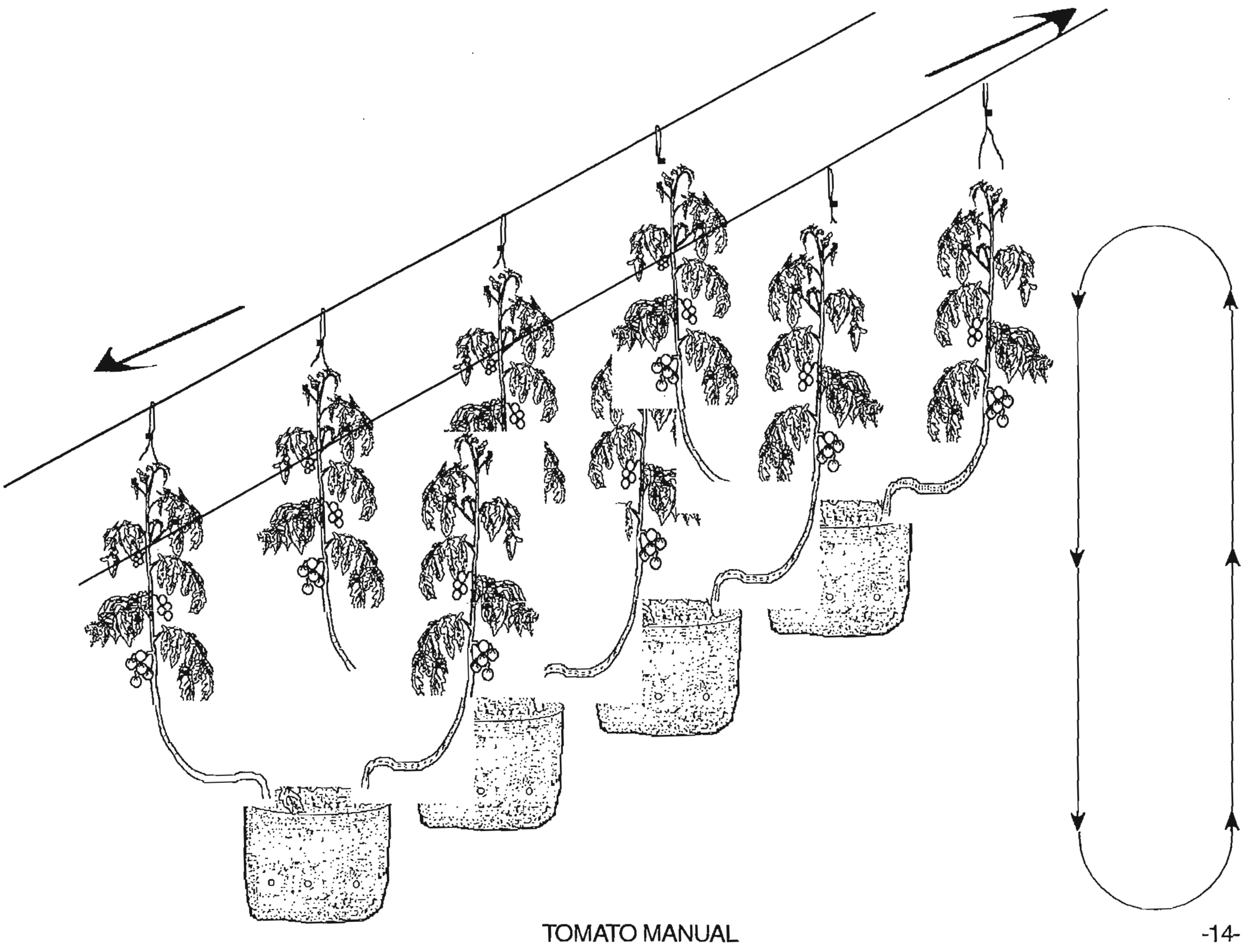
5. Once the plants have reached the wire, the 1st cluster of fruit should be ready to harvest if not already harvested. By this time, the lower leaves should have been removed up to the 1st cluster. This will "open up" the congested area near the floor and provide better air movement through the greenhouse.

It is not wise to prematurely prune the lower leaves unless they have been seriously damaged. The leaves are needed for photosynthesis and as shade for the maturing fruit. If leaves are pruned above a cluster of fruit, that cluster may get sun scald or ripen unevenly. If you have had to battle botrytis or an insect infestation that has severely damaged the lower leaves, it is best to prune them off even if this means exposing a cluster of fruit. Damaged leaves can no longer provide enough photosynthesis to be useful, and are a breeding ground for other ailments. Pruning several leaves at one time can also cause excessive moisture loss and shock to the plant. It is best to remove only 2 or possibly 3 leaves at one time.

6. Lowering plants is best done during the hotter part of the day. At this time, the plants are more limber and will not break as easily as when they are crisp. You should never lower the plants more than 6"-12" at a time. Trying to conserve time by lowering the plants too far is costly in the long run.

You will no doubt individualize the lowering and leaning method to suit your preference. The standard way is to grasp the tomato plant with one hand at a convenient height that will allow you to support the top of the plant. Flip one loop of twine from the Tomaholder or Tomahook. Slide the Tomaholder down the support wire and gently lean the plant over as you lower it. Do not drop the plant straight down. This can easily cause the stem to snap. While still holding the tomato plant, give a slight pull on the support twine to insure it is going to support the plant.

Each time you lower the plant, the Tomaholder will need to be repositioned 10" to 15" down the wire. Keep the Tomaholders positioned equidistant from each other. Each plant should be allowed its maximum share of sunlight. Your plants will need to be leaned during the lowering process to keep the main stem off the floor and out of the way. The question then is, what do I do with the plants that are at the end of the row. You will need to remove the Tomaholder from the wire the plant is on, and transfer it to the adjacent wire. Over the course of the crop life, this will, when viewed from above, create a circular pattern as depicted in the drawing.



You will find there are times when the plants need to be lowered, but not all the bottom fruit on the stem have reached the picking stage. If done properly, you will still be able to get the tops of the plants out of the hotter air that stratifies just above the wires, and also keep these tomatoes off the floor. It just takes a small amount of extra care.

One final activity related to lowering is pruning the emptied truss arms off the main stem. Unlike suckers and leaf stems that **can't** be snapped off the stem, these truss arms will need to be cut off with pruning shears. Be careful to snip this arm off as close as possible to the main stem. This will promote quick healing and not leave a stub that is prone to disease.

7. Cleanliness is mentioned in every text that discusses plant care. All organic material (plant debris) should be removed from the greenhouse daily. Decaying plant tissue is an excellent breeding ground for all the bad organisms that you built the greenhouse to protect your plants from. Leaving this material in the greenhouse doesn't make good sense. An excellent material found in Hydro-Gardens' catalog that will help you keep the floor clean is ground cover. This woven plastic will last many years and can be easily swept.

C. Periodic activities.

1. Leach bags with plain water.
2. Flush nutrient lines.
3. Clean out concentrate tanks.
4. Inspect injector system.
5. Blow out all water lines (winter preparation).

1. Your source water quality will, in part, dictate how often you should leach the media in your bags. The nature of your media is another determining factor. All fertilizers are composed of "salts". These compounds are left behind during evaporation, and the drying action ongoing in the media. Leaching is used to re-absorb and flush the salts towards the bottom, and out of the bag.

The most convenient method to use when leaching is to bypass your injector during a days' feeding schedule so that only source water is going to the bags. It may be necessary to either increase the number of waterings, or the length of the time each cycle is on to accomplish this process. An aid for determining the effectiveness of this is to place a plastic pan under several of the grow bags to collect the leachate. You can then measure the conductivity of this solution to determine the level of "salt" buildup in the media. An increase of 10% is normal, while an increase of 30% - 50% indicates a need to leach your media.

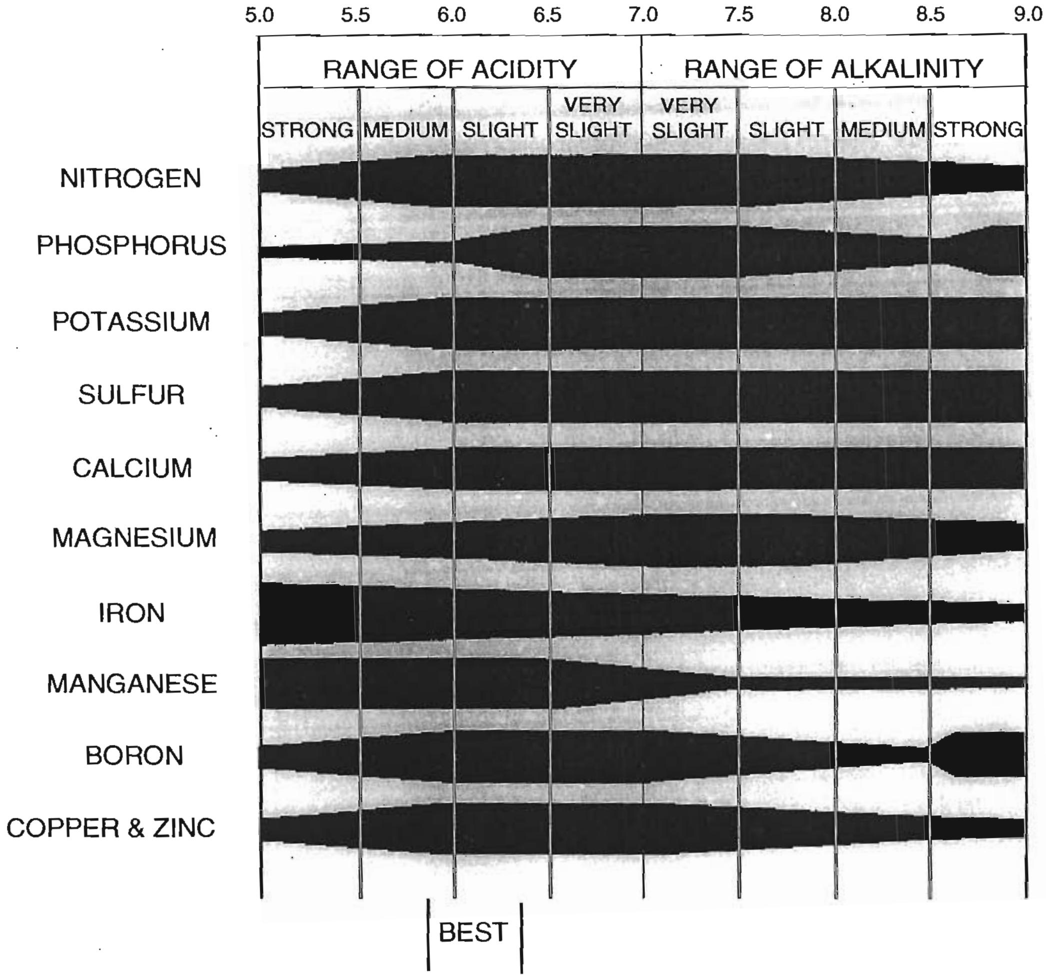
2. Nutrient lines need to be flushed of mineral buildup for some of the same reasons you flush your bags. Mineral deposits that are mostly calcium compounds stick to the walls of both the PVC and poly pipe. When the buildup gets heavy, it will break away from the pipe wall and plug the tubing of your sprayers/drippers. Often, sediment also forms in these lines after passing through your filter. This sediment can collect rather rapidly if you have source water that already has a lot of minerals (salts, fertilizers) in it. You should start your program by flushing the lines weekly. After several of these flushings, you will have a good idea of how quickly sediment and minerals are building up, and how often, as a regular maintenance program, you should flush your lines.

3. We recommend you clean your concentrate (or sump) tanks every time they are emptied. Sediment forms here because the raw materials used in making blended fertilizer have some impurities that will not dissolve. This does not have an adverse effect on the quality or usability of the fertilizer. As an example, some calcium nitrate is rolled in parafin wax. This is why it is small beads which liquify when you hold them in your hand, or expose calcium nitrate beads to the air. The wax doesn't totally dissolve, and leaves a scum in your tank.

We do not recommend stirring up the concentrate in the hopes of re-dissolving these impurities. You are simply moving them from the tank to your nutrient lines. If you have particularly poor quality water, you may get quite a bit of sediment from the reaction of the fertilizer with the minerals that are in your water. If this happens, you may want to purchase a Chem-Gro formula that is custom blended to account for these minerals. The "how to's" of this are discussed in our catalog.

4. You can be quite comfortable in the knowledge that your injector system is working properly if you have taken your daily conductivity and pH readings, and watched the level recede in your concentrate tanks. We still suggest that you periodically watch your injector in operation to confirm that it is functioning as intended. You may notice a problem with its mechanics even before your daily readings confirm an injector breakdown.

FERTILIZER ABSORPTION, TEMPERATURE AND pH:



There is an interrelationship between fertilizer, temperature and pH that must be maintained in proper balance for the plant to grow properly.

The fertilizer must be completely balanced for the crop being grown, with all the major and minor nutrients. The elements comprising this fertilizer must be derived from soluble chemicals that provide all of the essential elements in the proper proportions.

The temperature around the roots of the plants should be warm enough for the feeder roots to function properly, yet not so warm it would promote root diseases. If the root temperatures drop below 65°, the roots begin losing their ability to absorb some of the nutrients. This causes the plant to slow its vertical growth and instead, to develop a thicker stem and tougher leaves. This type of plant is called "bullish". If the root zone temperature is consistantly above 70°F., *pythium* and *fusarium* may multiply very rapidly.

The pH of your nutrient solution can change the flavor of your produce. It also can change the availability of different fertilizer elements to the plant. If the pH of the fertilizer solution is either too *acid* or too *alkaline*, many of the elements in the solution will become insoluble and cannot be absorbed by the plant. This will cause deficiency symptoms to appear in the plant even when plenty of each element is being supplied. The chart above shows the relationship between pH and the availability of various nutrients.

There is a maximum amount of water that any media is capable of holding. The term used to describe this moisture holding ability is "field capacity". Water applied in excess of field capacity will run off. A slight amount of run off will "leach" the excess fertilizer that might accumulate in the media. An excessive amount of drainage should be avoided. This excess will be wasted and may actually harm the root system of the plant by eliminating oxygen from the media. Most plants grow best in media with moisture levels that are 50% to 70% of field capacity.

MIXING CHEM-GRO™ FERTILIZER FORMULAS

READ THE INSTRUCTIONS IN THE CATALOG FOR THE FORMULA YOU ARE USING TO INSURE YOU ARE MIXING THE CORRECT FORMULA FOR THE STAGE OF THE SPECIFIC CROP AND VARIETY BEING GROWN.

DO NOT CHANGE THE PROCEDURE THAT IS DESCRIBED BELOW

There are a three ways to obtain dilute (plant usable) nutrient solution: (1) Mix the dry powder in a large capacity holding (sump) tank; (2) make nutrient concentrates that will be transferred to a holding tank; (3) make nutrient concentrates that will be diluted with a fertilizer injector. We believe the following instructions will clarify how to handle each situation.

MAKING DILUTE (PLANT USABLE) FERTILIZER IN A HOLDING (SUMP) TANK

1) Determine the volume of the holding tank (100, 500, 1,000 gallons, etc.) 1 cubic foot is 7.48 gallons.
2) Clean out the residue in the holding tank.
3) **Fill the holding tank with water.**
4) Use a submersible pump or other device and begin stirring the water.
5) Weigh out the correct amount of Chem-Gro™ fertilizer, Calcium Nitrate, and Magnesium Sulfate for each 100 gallons of water according to the instructions in the catalog for the crop you are growing.
6) Slowly add the Chem-Gro™ **powder** to the holding tank.
7) Slowly add the Calcium Nitrate beads to the holding tank.
8) Slowly add the Magnesium Sulfate to the holding tank.
9) Allow the stirring device to run another 1/2 hour and turn it off.
10) Check the pH and conductivity of the nutrient solution and adjust accordingly. Make a note of the adjustments made so you can duplicate the amounts.
11) Because of the complexity of fertilizer components needed to make Chem-Gro™ a complete nutrient, you may get some sediment each time you make nutrient. Source water composition and quality can also increase the amount of sediment. This sediment is **not** "lost" fertilizer, and it is **not** necessary to continuously stir the nutrient solution in the holding tank. That which has not dissolved will probably not dissolve. You should stir the tank for a few minutes each day to prevent fertilizer stratification. Then simply repeat step 2 as often as necessary to keep the holding tank relatively clean.

CHEM-GRO™ 10-8-22 CAN NOT BE MADE INTO A CONCENTRATE

THE QUALITY OF YOUR SOURCE WATER MAY REQUIRE MORE CONCENTRATE TANKS

MAKING CONCENTRATED FERTILIZER IN TWO CONCENTRATE TANKS

1) Determine the volume of the concentrate tank (5, 10, 50 gallons, etc.)
2) Clean out the residue in the concentrate tank.
3) **Fill the 1st concentrate tank 3/4ths full with water.**
4) Use a submersible pump or other device and begin stirring the water.
5) Weigh out a maximum of 1 lb. of Chem-Gro™ fertilizer for each gallon of water.
6) Slowly add the Chem-Gro™ **powder** to the concentrate tank.
7) Weigh out the correct amount of Magnesium Sulfate needed for each 100 gallons of water according to the instructions in the catalog for the fertilizer you are using. You should also take into account the magnesium content in your source water.
8) Slowly add the Magnesium Sulfate to the 1st concentrate tank.
9) Add enough water to fill the concentrate tank to the volume calculated in step 1.
10) Allow the stirring device to run another 10 minutes or until it appears that all of the fertilizer has dissolved.
11) Repeat steps 1 thru 4 for the **2nd concentrate tank**.
12) Weigh out 1 lb. of Calcium Nitrate for each gallon of water.
13) Slowly add the Calcium Nitrate to the concentrate tank.
14) Add enough water to fill the concentrate tank to the volume calculated in step 1.
15) Allow the stirring device to run another 10 minutes or until it appears that all the Calcium Nitrate has dissolved. (Some grades of Calcium Nitrate is coated with parafin wax. This may make a "scum" form in this tank. Skim this material off the top of the water.)
16) **You should only make enough concentrate to last 2 to 4 weeks. The concentrate tanks may require additional fertilizer adjustments during the life of the crop, and it is easier to do this with a "fresh" batch of concentrate.**

Fertilizer will dissolve more quickly in warm water than in cold. Do not exceed 90°F.

1/4th teaspoon of Chem-Gro dissolved in 1 gallon of distilled water will be about 300 ppm.

ANALYSIS PARAMETERS

		TOMATO TISSUE				TOMATO NUTRIENT SOLUTION			
		Young Plants		Mature Plants		Young Plants		Mature Plants	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Total Nitrogen	[N]	3.0	4.0	3.5	5.5	—	—	—	—
Nitrogen	[NO_3-N]	0.2	0.6[a]	0.6	1.3	70	90	90	200[b]
Phosphorus	[P]	0.7	1.5	0.6	1.2	60	80	40	60
Potash	[K]	2.5	5.0	3.5	6.0	150	180	180	300
Calcium	[Ca]	1.5	3.5	2.0	6.0	150	300	150	500
Magnesium	[Mg]	0.4	0.8	0.5	1.2	40	60	40	60
Sodium	[Na]	0.05	0.4	0.05	0.4	Trace	100	Trace	150
Chloride	[Cl]	0.05	0.8	0.5	0.8	Trace	100[c]	Trace	100[c]
Sulfur	[SO_4-S]	0.4	0.8	0.5	1.2	30	100	100	200
Iron	[Fe]	70	150	80	200	1.0	3.0	1.5	4.0
Manganese	[Mn]	70	150	100	250	0.5	1.0	0.8	1.2[d]
Zinc	[Z]	20	40	20	60	0.1	0.2	0.1	0.3
Copper	[Cu]	5	15	5	25	0.05	0.1	0.08	0.15
Boron	[B]	40	80	40	140	0.06	1.0	1.0	2.0
Molybdenum	[Mo]	1.0	5.0	1.0	5.0	0.05	0.1	0.05	0.1
					pH	6.2	6.8	5.8	6.4
					Conductivity [ppm]	400	1500	1500	2500[e]

a. Depends on tomato variety and season
b. May be higher if weather is warm and sunny in long day area.
c. Upper limit depends on sodium level.
d. Must be approximately twice this level in short day climates (winter), levels are dependent on pH.
e. Upper levels depend on source water PPM.

Young plants are defined as from the seedling stage to the fully formed 2nd flower cluster. Between the time it takes young plants to grow from the 2nd to the 4th flower cluster, on a weekly basis, you should gradually increase the strength of fertilizer concentrationyour conductivity by 10% to achieve a level of Chem-Gro and calcium nitrate that is equal to 1/2 lb. per 100 gallons of water of each, and 1/4 lb. of magnesium sulfate per 100 gallons of water.

ADJUSTING CHEM-GRO™ FERTILIZER FORMULAS FOR INJECTORS

DOSMATIC A30 ADJUSTABLE RATIO INJECTOR (1:200 - 1:100)

Follow the mixing instructions for making concentrated fertilizer in two concentrate tanks. Dissolve 1/2 lb. of Chem-Gro and 1/4 lb. of magnesium sulfate per gallon of water in the 1st injector concentrate tank. Dissolve 1/2 lb. of calcium nitrate per gallon of water in the concentrate tank for the 2nd injector. The 1st injector, containing the Chem-Gro, should be set to 1:100 ratio.

The 2nd injector, containing calcium nitrate, should be set to 1:200 ratio. This setting will be for seedlings. Use this setting until the tomato plants have fully formed their 2nd cluster of blossoms. At this time, begin gradually increasing the calcium nitrate from 1:200 to 1:100 as the plants grow to the 4th flower cluster. The dosmatics will now be injecting 1/2 lb. of concentrate for every 100 gallons of water. This is full strength nutrient solution.

FIXED RATIO INJECTORS - 1:128

Determine the quantity of the fertilizers you will need from the instruction page on that particular Chem-Gro™ formula. Plant fertilizer requirements change as the plant matures. A 1:128 injector will add 1 gallon of concentrate to 128 gallons of water (or 1 oz. per gallon). Therefore, each gallon of concentrate must contain sufficient fertilizer to make 128 gallons of plant useable fertilizer solution. To determine how much fertilizer will be dissolved in one gallon of CONCENTRATE, multiply 1.28 by the number of ounces of fertilizer required.

EXAMPLE: 4-18-38 for **seedling plants:**	1.28 x 8 oz. of 4-18-38 = 10.24 oz. per gallon
(A minimum of two tanks and	1.28 x 4 oz. of $CaNO_3$ = 5.12 oz. per gallon
two heads are required.)	1.28 x 4 oz. of $MgSO_4$ = 5.12 oz. per gallon

To determine the weight of each compound to add to the concentrate tank for any number of gallons of concentrate, multiply the amount per gallon listed above by the number of gallons you are going to make.

EXAMPLE: 20 gallons of concentrate:	10.24 oz. of 4-18-38 x 20 gallons =204.8 oz. =12.8 lbs.
(A minimum of two tanks and	5.12 oz. of $CaNO_3$ x 20 gallons = 102.4 oz. = 6.4 lbs.
two heads are required.)	5.12 oz. of $MgSO_4$ x 20 gallons = 102.4 oz. = 6.4 lbs.

Thus 20 gallons of concentrate will make 2,560 gallons of fertilizer for the plants (20 x 128 = 2,560). If you know how much is required each day by all the plants you have, you can determine how much concentrate to make based on how long you plan to use this particular strength of fertilizer solution.

ADJUSTABLE RATIO INJECTORS: (1:150; 1:190; etc.)

The injector ratio is given as the maximum amount the injector heads can deliver. These ratios can be adjusted down from this maximum. The normal plant useable solution strength of 4-18-38 is 1/2 lb. (8 oz.) per 100 gallons of water. The multiplier you will use is calculated by dividing the injector ratio by 100. This multiplier is used to determine the amount of fertilizer required in your concentrate solution to make the number of gallons of plant useable fertilizer as listed by the ratio of the injector. The second thing you need to know is how many pounds of fertilizer are in each GALLON of concentrate. If we assume you use a 50 gallon concentrate tank, and full bags of fertilizer, your concentrate tanks would contain:

2 @ 4-18-38 at 25 lbs. per bag in 50 gallons of water is 1 POUND PER GALLON.
2 @ $CaNO_3$ at 50 lbs. per bag in 50 gallons of water is 2 POUNDS PER GALLON.
2 @ $MgSO_4$ at 50 lbs per bag in 50 gallons of water is 2 POUNDS PER GALLON.

Again, using 4-18-38 as an example, the head settings will be:

1:150 RATIO - Three head injector

$\frac{\text{8 oz. of 4-18-38 x 1.5 multiplier}}{\text{16 oz. (1\#) in each gallon}}$ = 7.5 head setting

$\frac{\text{8 oz. of } CaNO_3 \text{ x 1.5 multiplier}}{\text{32 oz. (2\#) in each gallon}}$ = 4 head setting

$\frac{\text{5.33 oz. of } MgSO_4 \text{ x 1.5 multiplier}}{\text{32 oz. (2\#) in each gallon}}$ = 2.5 head setting

1:190 RATIO - Three head injector

$\frac{\text{8 oz. of 4-18-48 x 1.9 multiplier}}{\text{16 oz. (1\#) in each gallon}}$ = 9.5 head setting

$\frac{\text{8 oz of } CaNO_3 \text{ x 1.9 multiplier}}{\text{32 oz. (2\#) in each gallon}}$ = 4.8 head setting

$\frac{\text{5.33 oz. of } MgSO_4 \text{ x 1.9 multiplier}}{\text{32 oz. (2\#) in each gallon}}$ = 3.2 head setting

Understanding your crop

Tomato plants are very responsive to care. Maintaining all environmental elements in the proper balance can make a remarkable difference in your production. The elements necessary for proper tomato growth are:

Sunlight	Carbon Dioxide	Relative Humidity
Water	Temperature	Proper Pruning
Fertilizer	Pollination	Pest Control

Depending on time of year, it takes 5 - 8 weeks to grow a seedling until it is ready to transplant into your greenhouse. It will take another 7 - 10 weeks before fruit is ready for harvest. An interesting point, seed catalogs sometimes list "days to maturity" of different varieties. This "days to maturity" basically refers to the time it takes from flower pollination to fruit harvest during the late spring and the long days of summer. It does NOT include the time required to grow the seedling plant nor does it account for growing the plants "off season" during the shorter day-length times of the year. The total time required for a plant to grow from seed to "first harvest" can range from 12 to 18 weeks. However, it then only takes an additional 7 - 14 days to shift harvesting from one fruit cluster to the next fruit cluster.

In order to get the most yield from a tomato plant, each plant must produce leaves and flower clusters consistently. The flowers on each cluster must be pollinated and should produce #1 quality fruit. It is essential that each cluster of flowers receive the proper care in order to supply a continuing amount of maturing fruit as the plant grows.

There are constant subtle changes taking place that affect the growth of the plant. The plant's fruit-load changes. The seasons of the year are changing. The temperature, relative humidity, amount of sunlight and amount of carbon dioxide around the plant is constantly changing. The plant's need for water and fertilizer change as a result of these subtle changes. The better you can monitor, understand and control these subtle changes, the more potential yield you can get from your plants.

Sunlight

Plants need a regular and consistent supply of sunlight for photosynthesis. Mother Nature has designed tomato plants to grow during the longest days of the year in an area with no shade. Too little sunlight and the plants don't have the ability to collect enough energy for both fruit and foliage production. As plants load with fruit, the need for more sunlight increases. The accepted amount of sunlight necessary for proper growth is between 4,000 and 5,000 foot-candles. Plants can utilize higher amounts of sunlight, if the greenhouse can control the other elements in their proper balance.

Maintaining proper plant spacing allows each plant it's proper share of sunlight. The generally accepted spacing is 4.5 to 5 square feet of greenhouse space per plant. As an example, a 5,000 square foot greenhouse would hold 1,000 tomato plants if they were spaced at 5 square feet per plant. Crowding more plants into the greenhouse would increase the competition for light. Each plant would attempt to grow above its neighboring plants to get a greater share of the sunlight. This would cause the plants to become weak and spindly and the net result would be less production from the crop. White reflective floors can help bounce more light to the lower parts of the plant and help prevent heat build-up within the greenhouse. Condensation on the greenhouse roof can block as much as 20% of the available light. If your greenhouse can't properly control temperature and humidity, shading may be necessary during high light periods.

Water

Water is the most abundant element within a tomato plant. The plant uses water to transport nutrients to its various parts. Water is used as a primary building block within all of the plant's tissue. It is used as a method to cool the plant. Good quality water, in the proper balance, is important to the overall health of the plant.

A full sized tomato plant will use 30 - 50 ounces of water on a normal day. The amount of water used will change with light intensity, temperature and relative humidity. If light intensity is high, the plant will need more water than if the light intensity were low. If the temperature is high, the plant will need more water than if the temperature were low. If the relative humidity is low, the plant will need more water than if the relative humidity were high.

All of these factors change constantly around the plant. These changes determine the frequency that the plant must be watered. When all three of these factors (light, temperature and humidity) are combined, it is called Vapor Pressure Deficit or VPD. The more accurately a grower can anticipate the water needs of the plant, the more evenly the plant will grow. Attempting to monitor and control these factors manually can be a challenge. A computer can easily track these factors across the day and determine the appropriate time to water.

In addition to the amount of water needed by the plant for proper growth, 10% - 20% of the amount watered should leach out of the root zone to prevent a fertilizer buildup around the roots. Water evaporates from the root zone, but the fertilizer will remain. Without proper leaching, the fertilizer levels can gradually build up in the root zone. Watering too much not only wastes water and fertilizer, but may make the plants too soft and vegetative. Watering too little may cause an increase in the fertilizer levels around the roots. It may also inhibit the plant's ability to properly cool itself and can have a negative affect on fruit sizing. Monitoring the leachate both for volume and electrical conductivity (EC) will tell you if the correct amount of water is being applied each day.

Fertilizer

Fertilizer contains the nutrients needed by the plant to properly build all parts of the plant. Not enough fertilizer and the plant may become weak because it can't build these parts properly. Too much fertilizer and the plant's ability to take up water may be inhibited. The fertilizer and water must be in the proper balance to satisfy the needs of the plant. Both the balance and the quantity of fertilizer needed changes as the plant grows.

Electrical Conductivity or EC measures the amount of minerals in water. Distilled water contains no dissolved minerals and will not conduct electricity. As minerals are dissolved into water, its ability to conduct electricity increases. An EC meter allows the grower to measure the total amount of fertilizer being applied to the plants. Meters are available that can measure the amount of electricity that can be conducted between two points within the meter. The amount of electrical conductivity is then displayed on the meter as millimhos, micromhos, Parts Per Million (PPM), Total Dissolved Salts (TDS), microsiemans or Conductivity Factor (CF).

The grower can also measure the EC of the water draining out of the root zone or leachate. This tells the grower how much fertilizer is in the root zone. The EC in the leachate of a full sized plant should be 10% - 20% higher than the EC being given to the plants. If the EC of the leachate is greater than 20% higher than the feed EC, it indicates that the fertilizer levels are climbing in the root zone. This can be corrected by increasing the amount of leachate each day or by reducing the EC going to the plants. If the EC of the leachate is similar to the EC being given to the plants, it may indicate that the plants are being watered too much and that water and fertilizer is being wasted.

The fertilizer needs of the plants change as they grow. As the plant loads with fruit, the fertilizer required to support the plant changes. As the seasons of the year change the day-length, the average growing temperatures and humidity levels are constantly changing. There are subtle changes to the fertilizer needs of the plant. Adjustments should be made to the fertilizer to get the best performance from the plants. Getting a tissue analysis on a regular basis (usually monthly) can tell you if the nutrients within the plant are in the proper balance and at sufficient levels for the plant to grow properly. Reviewing the analysis from the same time last year will allow the grower to anticipate the needs of the plants as the seasons change and the crop matures.

Carbon Dioxide

The majority of the dry weight of plant tissue is carbon. Carbon is not fed to the plants as part of the fertilizer solution. Plants take in carbon dioxide (CO_2) from the air and through the process of photosynthesis the plant strips off the carbon molecule and returns the dioxide (Oxygen) to the air. It is important that a good supply of carbon dioxide be available around the leaf surfaces during periods when photosynthesis can occur. A shortage of carbon dioxide will cause all growth within the plant to slow down.

The normal amount of CO_2 in the atmosphere is about 360 PPM. On a bright day, in a closed greenhouse filled with mature plants, it can take less than one hour to reduce the CO_2 levels down to a point where photosynthesis can not continue at the proper rate. The plants need a constant fresh supply of CO_2 to continue growing properly. This can be accomplished by supplementing additional CO_2 or by ventilating the greenhouse. The only indication that plants are suffering from a lack of CO_2 is a slowing of the growth. The growth rate of plants may be increased when CO_2 levels are increased 2 - 3 times above the normal atmospheric levels.

Relative Humidity

Relative humidity is the measure of the amount of moisture that is contained in air at a given temperature. The amount of moisture that can potentially be held in air changes with the temperature. Therefore it is called "relative" humidity.

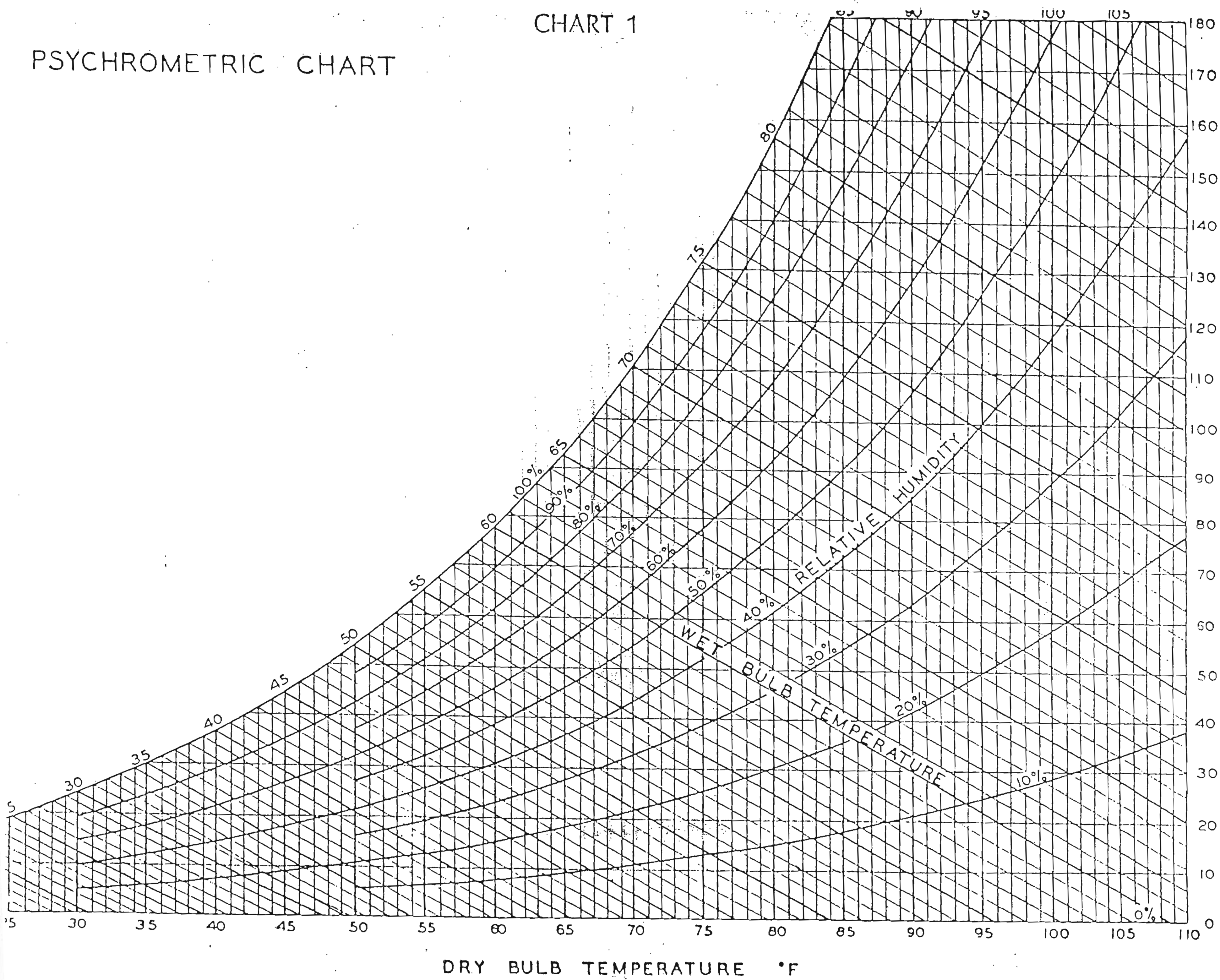
A Sling Psychometer is a device with two identical thermometers that are placed side by side so they should both read the same temperature. If you slip a damp sock over the bulb of one of the thermometers, they would still read the same temperature. If you were to sling both thermometers in the air for about one minute and then read the temperature on both thermometers, they would be different. The thermometer with the "dry bulb" should still read the same current air temperature. However, the thermometer with the "wet bulb" should read a lower temperature. This difference is used to calculate the relative humidity in the air. The difference in temperature between the two thermometers shows the cooling potential of an evaporative cooling system. In cold climates, this difference is called the "wind chill" temperature. In hot climates, this difference is used to calculate the "heat index".

Engineers have developed Psychometric Charts that show how the moisture holding capacity of air changes with temperature. By studying one of these charts, a grower can develop a better understanding of how exchanging air within a greenhouse can affect the environment around their plants. The bottom of the chart shows the "dry bulb" temperature and the vertical side shows the amount of water contained in a volume of air. Where these two lines intersect is the sloped line of "relative humidity". The diagonal line shows the "wet bulb" temperature.

As an example, let's say the outside air temperature is 95° F. Locate this number on the "Dry Bulb" line. Let's also say that the outside relative humidity is 20%. Follow the 95° F line up until it intersects the 20% relative humidity line. If you follow this intersection line across to the right, you will see that it contains 50 grains of moisture per pound of air. If you follow the "Wet Bulb Temperature" diagonal line up to the left until it reaches 100% relative humidity, you can see that the temperature would be 66° F. This is the theoretical maximum cooling potential of an evaporative cooling system. An evaporative cooling system probably won't provide the ability to

CHART 1

PSYCHROMETRIC CHART



increase the relative humidity to 100%, but if you follow this diagonal line down to 70% relative humidity, you can see that the temperature has been lowered to 73° F.

As a reverse example, let's say that the daytime air temperature in the greenhouse is 85° F. and there is a 50% relative humidity within the greenhouse. Locate 85° F. on the "Dry Bulb" line, the follow it up to 50% relative humidity. Reading across you can see that this air contains 90 grains of moisture per pound of air. As evening arrives, the greenhouse begins to cool down to 65° F. Locate 65° F. on the "Dry Bulb" line and follow it up until it intersects with 90 grains of moisture. You can see that the relative humidity now exceeds 95%.

Relative humidity affects the plant's ability to transpire moisture from its leaves. The plant utilities water to pull nutrients from the roots into the tissue with capillary action. The plant then moves some of the water onto its leaf surfaces where it should evaporate. This evaporation cools the leaf surface and allows the plant to regulate its internal temperature. As moisture is lost from the leaves, more water (and fertilizer) is pumped up from the roots to replace it. The grower needs to understand that the plants are constantly adding more humidity into the greenhouse atmosphere.

If the relative humidity around the leaf surface is too high, very little evaporation can take place. As a result, the transpiration process slows down. The plant struggles to pull fresh water and nutrients up from the roots. High humidity can cause nutrient deficiencies to appear in the plant even though there is plenty of fertilizer around the roots. Constant high humidity around the leaf surfaces sets up an environment for fungus to begin growing. Plants grown in constant high humidity environments usually show Calcium and Boron deficiencies even though there may be an abundant amount of these elements in the fertilizer solution.

If the relative humidity around the leaf surface is too low, evaporation takes place at a very high rate. As a result, the root system may not be able to replace moisture within the plant as fast as it is being lost. The plant starts to wilt. To slow this rapid loss of moisture, the stomata or pores in the leaves begin to close. When the stomata are closed, the plant then stops taking in CO_2 and the growth process slows down. More frequent watering during the heat of the day can help keep humidity levels higher and replaces water within the plant as it is being used.

One of the most overlooked parts of growing is the "micro" environment that exists around the leaf surfaces. Proper air movement within the plant canopy helps control the relative humidity around the leaf surfaces allowing the plants to grow properly. Understanding how the relative humidity can quickly change as the temperature within the greenhouse changes from day to night. Maintaining a relative humidity around the plants of 50% - 70% at all times is considered ideal. However, 50% relative humidity at 80° F. can become nearly 100% relative humidity as the temperature drops to 65° F. at night. The relative humidity inside the plant canopy is higher than it is in an aisle-way. A good grower understands the effect of rapidly changing temperature and how it can cause the relative humidity to change.

Temperature

The temperature within a greenhouse is monitored several ways. The minimum temperature at night and during the day is monitored. The maximum temperature at night and during the day is monitored. Also, the temperature should be monitored at the root zone and at the flower level. The average 24-hour temperature should be calculated.

Temperature affects the metabolism or growth rate of the plants. Generally, night temperatures of 65° F. and day temperatures of 77° F. are considered ideal. The two places where temperature can affect plant growth are in the root zone and the air temperature around the flowers. Plants need a day-night differential to shift from photosynthesis to processing accumulated energy. During the daytime, plants collect energy. At night, they process the stored energy and convert the energy into carbohydrates, sugars and other building blocks needed by the plant. These building blocks are then transported into the leaves, stems, flowers and fruit. The plant will move a higher percentage of these "building blocks" into the warmer parts of the plant. Fruit usually is the largest mass within the plant and takes longer to cool down at night. As a plant loads with fruit, more and more energy is transported into the fruit and the grower must be careful to maintain a temperature balance between the fruit and the flowers.

During a normal growth cycle, the leaves will appear slightly pale green in the morning. As energy is collected, the leaves change to a slightly blue-green color during the day. This shift in color indicates that energy is being collected and the plants are ready to process another batch of energy. Temperature helps determine what the plant should do with this energy. In a normal growth cycle, energy is distributed evenly between the development of fruit and foliage.

If the temperature is below normal, the plant will become more compact. There will be less distance between the leaves. The plant will send more energy into the existing fruit. Fruit will get larger, but the cooler temperatures may delay ripening. Less energy will be utilized for the development of the stem at the top of the plant.

If the temperature is above normal, the plant will send more energy into the leaves and stems. The plants will grow very rapidly. However, less energy will go into the flowers and fruit. Flowers will open later and pollination may be more difficult. Fruit does not develop size as quickly.

Having a portion of the greenhouse heating system on the floor has advantages. Because heat naturally rises, having the ability to control the root zone temperature also allows the grower to maintain proper temperatures around the fruit. Fruit ripens by temperature. Fruit stored at 55° F. will not ripen. Fruit stored at 70° F. will turn from "breaker stage" to red ripe in 7 days. When the root zone and lower parts of the plant are kept at an adequate temperature, ripening of fruit is not delayed. With bottom heating, the humidity level at the base of the plant is lower and the incidence of fungus decreases.

When the root zone is kept too warm, the fruit will ripen faster. More energy is pumped into the fruit than into the foliage. However, the long-term effects may yield a plant with fewer fruit and a spindly growing point. When the root zone is kept too cool, fruit ripens slower and the humidity level around the base of the plant can get too high. This can lead to fungus problems.

The flowers of a tomato plant are also sensitive to temperature. Temperatures above 90° F. or below 55° F. can damage the pollen within the flowers. Low temperatures increase the relative humidity within the flower and can make the pollen too moist to fall properly. High temperatures can make the pistil of the flower too dry and not allow the pollen to stick properly. Both of these conditions can affect the number of seeds that will develop within the fruit and may have an adverse effect on fruit size and shape. Therefore, it is important that the flower temperature be maintained in the proper range. As plants grow up to the support wires, the grower should be aware that the temperatures at the flower level can get too high.

Pruning

Pruning of leaves is necessary to maintain proper ventilation and light levels within the plant canopy. Pruning of suckers and fruit is necessary to control the growth of the plant and not allow it to waste energy growing plant parts or fruit that will be removed later. Pruning allows the grower to train the plants to grow and utilize the vertical space within the greenhouse as efficiently as possible.

Once a healthy tomato plant begins fruit production, it should produce a cluster of flowers, then three leaves and then another cluster of flowers. Each cluster of flowers will be pollinated and begin to develop fruit. Typically, you will be pollinating the 7th cluster of flowers before you begin harvesting fruit from the first cluster. If you count the mature leaves between the cluster of flowers being pollinated down to the cluster of fruit that is beginning to ripen, you should count 15 - 18 mature leaves. This is the normal amount of leaves on a mature plant. This number of leaves is sufficient to provide proper photosynthetic leaf surface for normal development of fruit and foliage on the plant.

As each new cluster of flowers begins to open at the top of the plant, three more new leaves will also begin developing. In order to maintain the proper leaf balance, three leaves should be removed from the bottom of the plant to maintain the leaf count at 15 - 18 on the plant. Normally, suckers will also start to grow where the new leaves connect to the main stem of the plant. These suckers should be removed before they get too large. The smaller they are when removed, the less energy they will have consumed and the smaller the wound will be when they are removed. Both leaves and suckers should be "snapped" off the plant rather than using pruning shears to remove them. If any portion of the leaf or sucker remains attached to the main stem, this stub will later die back and allow an entry point for fungus.

In nature, tomato plants normally grow along the ground. The main stem of the plant has a tendency to want to grow laterally rather than vertically. In a greenhouse, where you are trying to utilize the vertical space within the building, it is necessary to redirect the growing point of the plant along the support twine. This process is usually done before the stem begins to stiffen. It can be done by twisting the stem around the support twine and/or with the use of plant clips or tape. This "tying up" process should be done at the same time the new suckers are removed from the plant.

The amount of fruit that can properly develop on a tomato plant is dependent upon the plant's ability to collect energy. During the longer day-length periods of the year, the plant can usually support 4 fruit per cluster. During short day-length periods of the year, 3 fruit are usually allowed to develop on each cluster. During the short day-length periods, if 4 fruit are left on each cluster, the plant may not have enough energy to develop the fruit to the proper size. As mentioned earlier, a plant can support about 7 clusters of fruit, from those fruit that have just started to develop from flower down to the fruit that is about to be harvested. This means that during the long days a total of 28 fruit are developing on the plant at any given time. During the short day a total of 21 fruit are developing.

Normally, a cluster of flowers has 5 - 6 flowers on it. As each cluster of flowers is pollinated, small fruit begins to develop. Once this fruit has grown to 3/4" to 1" in size, it can be inspected and determined if it's shape will grow on the be a #1 quality fruit. If the fruit is distorted or misshapen, it should be removed and another fruit is allowed to develop on that cluster. Once the desired number of #1 quality fruit have begun to develop on a flower cluster, the remaining flowers or fruit on that cluster should be removed.

During the long day-length periods of the year, it will take about 6 weeks for fruit to mature from pollination to harvest. It may take 8 - 8 1/2 weeks for fruit to develop during the short day-length periods of the year. If a grower monitors a few plants, they can determine the number of new fruit set each week. With this information, they can predict the amount of production that will be expected from their crop in 6 - 8 1/2 weeks.

Keeping a consistent fruit-load on the plant will not only help to keep the energy distribution within the plant balanced, but it will also make your production and marketing more predictable. If a plant becomes overloaded with fruit, it may start aborting flowers until some of the fruit is removed from the plant. Also, the fruit on the plant may not develop to the proper size.

Pest Control

A greenhouse is an ideal environment for insect pests. With a controlled environment, all conditions are maintained at near ideal levels for pests to multiply quickly. There are no natural enemies to the pests within the greenhouse unless the grower introduces them. Most of the insects that can damage a tomato crop are very small. However, they can suck the moisture from the plants and can drain their energy. The plants can tolerate low levels of pest insects, but the grower must keep them under control. There are no sprays that are approved for use on food crops that will completely eliminate pests. A good grower attempts to manage the pest population and keep the pests at low levels so they do not cause economic damage to the crop.

We devote a large section of our catalog and our website to explaining the various pests and the ways to control them with beneficial insects. We also have a computer program that will make recommendations of not only when to release various beneficial insects into your crop, but also the quantity to release to keep the pest populations under control. This program is available to any grower at no charge.

Pests are easier to control if the grower attempts to exclude the majority of the pests from getting into the greenhouse. Insect barriers over the intake vents can dramatically reduce the number of pests coming into the greenhouse. However, if you can get into your greenhouse, so can insects. Many insect pests are attracted to the color yellow. Hanging yellow sticky traps every 50 - 60 ft^2 near the tops of the plants can help control pests. They can also give a grower an early indication of the presence of insects. Flagging a few of these yellow sticky traps and inspecting them weekly will give the grower a good indication if the pest population is under control.

Whiteflies are the most common pests in greenhouse tomatoes. These insects are small, 1/16" - 1/8" in length. They are pure white. They are usually found on the underside of the leaves. The larval stages and the adults feed on the sap of the plants. At normal greenhouse temperatures, nearly all of the eggs will hatch into female whiteflies. Each female can lay about 100 eggs within 10 days of hatching. These eggs will hatch and grow into another generation of adults in about 3 weeks.

The population of whiteflies can progress quickly in a greenhouse. One whitefly can become 100 whiteflies in 3 - 4 weeks. Three to four weeks later, the population could grow to 10,000 whiteflies. At 9 - 12 weeks, the uncontrolled population could exceed 1,000,000.

As these whiteflies suck the moisture from the leaves, they excrete sap, which falls to the next leaf below. In addition to draining the plant of fluids, as this sap (honeydew) builds up, the lower leaves become sticky. Black sooty mold begins to grow on the honeydew. The pores of the leaf become blocked and the plant has difficulty transpiring moisture and taking in carbon dioxide. Sunlight is also blocked from the leaf, so photosynthesis is reduced. Tomato plants can tolerate low levels of whiteflies without much effect on production. However, if whiteflies are not controlled, they can destroy a tomato crop in 3 - 4 months.

Two types of whiteflies can be found in greenhouses. *Trialerodes vaporarium* or "Greenhouse Whitefly" is the most common type of whitefly. However, in recent years, *bemisia tabaci* or "Silverleaf Whitefly" has become more common. It usually requires an examination of the whitefly larvae under a microscope to determine the specific type of whitefly. Not all biological controls for the Greenhouse Whitefly will work on the Silverleaf Whitefly. However, *encarsia formosa* Nile Delta will work against both types of whiteflies.

Aphids are somewhat unique in the insect world. At greenhouse temperatures, they are nearly all female. Rather than laying eggs, aphids bear live young. These young aphids are born pregnant and within 1 week of birth, can begin bearing young aphids of their own. An adult aphid can bear 3 - 6 young per day. In addition, because they feed on plant sap so heavily, aphids come with two excretion ports that stick out of their rear end like exhaust pipes on a car.

Aphids come in several colors. The most common color is green. This allows the aphids to blend with the color of the leaves and go unnoticed for some time. However, some varieties of aphids can be pink, red, brown or black. They can range in size from 1/16" to nearly 1/4" in length.

Normally, aphids are born without wings. The young aphids disperse on the same plant to new feeding sites. However, if there becomes too much competition for food in a particular area. The adult aphids will begin bearing a generation with wings. These "winged" aphids can then fly to other feeding sites and begin bearing "flightless" aphids again.

Damage to the plants from aphids is similar to the damage done by whiteflies. Aphids multiply at a rate of 20 - 40 per week. However, they can begin another generation each week. It only takes a few weeks of uncontrolled multiplication, and aphids can be found everywhere. Damage to the plants includes sticky leaves, honeydew, and black sooty mold. In addition, the loss of fluids within the plant, lack of photosynthesis, and reduction in the ability to properly transpire can all affect production. As aphids grow, they shed their skins. These whitish colored skins are found on the leaves and are sometimes confused to be whiteflies.

Fungus gnats and **Shore Flies** are commonly found near the base of plants. These small black flies normally feed on dead algae and are usually considered to be only a nuisance pest. They can be observed flying above the growing media or anywhere algae may be found. Occasionally they are caught on yellow sticky tapes. However, the larvae of some of these gnats can feed on the roots of your plants. The larvae are small white worms less than 1/4" in length, usually with black heads. The damage done by these larvae is usually not fatal to the plants. Instead, the ability of the root system to function properly is compromised and production from the plant may be affected. Because this damage occurs in the root zone, it may go undetected by the grower. Introduction of beneficial nematodes every 4 - 8 weeks usually controls all insects that spend a portion of their life cycle in the root zone.

Spidermites are a member of the spider family and have eight legs unlike insects, which only have six legs. They are very tiny, less than 1/32" in length. Like most spiders, spidermites trail a strand of silk behind them as they move about.

Spidermites like warm, dry areas of the plant and are usually found towards the tops of the plants. Spidermites can multiply very rapidly in warm temperatures. They can grow from egg to egg-laying adults in only two or three days. Although spidermites do not fly, they can spread by walking across leaf bridges from plant to plant. Workers can spread them on their hands and on their clothing.

Spidermites feed on plant sap. However, they do not produce honeydew. The observant grower can initially find them by noticing tiny yellow spots on the leaves. Examination of the bottom of the leaf will reveal the spidermite's feeding site. If left uncontrolled, the grower may not notice spidermites until yellow leaves are covered with silk. At this point, the leaves are damaged beyond recovery and can only be carefully removed from the greenhouse without spreading the spidermites to other plants.

Spidermites can hibernate in the greenhouse structure. They are very difficult to eliminate between crops. The grower should watch for the reappearance of spidermites in each new crop. Usually, the spidermites first appear in areas that were a problem in the previous crop. Regular introductions of beneficial predator mites that eat spidermites can usually control spidermite problems.

Thrips are small insects, usually less than 1/8" in length. They are tan in color and are difficult to see when hiding around the edge of a small tan spot on a leaf. Thrips feed by scrapping into a plant cell on the bottom side of the leaf and drinking the fluid. They continue to feed on adjacent plant cells and gradually form a tan spot on the leaf about the size of a pencil eraser. Thrips use the center of the tan spot as a restroom and the observant grower may notice tiny black spots in the center of the tan spot.

Thrips lay their eggs into the leaves. When the eggs hatch, the tiny, nearly clear larvae feed at random sites on the leaf until they have completed their larval stages. They usually then drop to the base of the plant and find a slightly moist location to pupate. After about 7 days, the next generation of adult emerges. The adult thrips then crawls or flies to it's feeding site and begins the process again.

Thrips usually do the majority of their damage to the lower leaves of a plant. However, if left uncontrolled, thrips will move higher and higher in the plants and can seriously affect the photosynthetic ability of the plants. On rare occasions, thrips can carry Tomato Spotted Wilt Virus. This virus can be fatal to the plant.

Fungus can grow on plants when the relative humidity within the crop is not properly controlled. There are various types of fungi that can grow on the stems, leaves and fruit of the plants. The spores are constantly present in the atmosphere and are seeking an ideal environment to start growing.

To grow most types of fungi, you need a relative humidity around the plant surface of 90% or higher. You also need moisture present for about 3 hours. This moisture could occur from condensation or from plant sap being excreted from pruning or a wound on the plant. The grower should be aware that the relative humidity within the plant canopy is usually higher than the relative humidity in the aisleways.

Proper spacing of the plants within the greenhouse can help prevent fungus. Over crowding the plants will usually result in crop loss from fungus. Pruning early in the day allows the plant to seal the wounds before evening. Providing proper air circulation within the greenhouse helps prevent high humidity. Controlling the relative humidity as the greenhouse cools from the day temperature down to the night temperature by exhausting air as the humidity builds within the greenhouse can help prevent fungus. Providing at least one air exchange per hour at night can help keep the relative humidity under control. Bottom heating systems help keep the fruit and the lower parts of the plant warm and dry. As warm air rises up through the plant, the moisture is carried away.

There are varieties of plants that have been bred to be resistant or tolerant to some types of fungus. There are sprays that can be used to help control an existing problem, but the best way to control fungus is to not provide the environment that is needed to grow fungus.