GREENHOUSE LETTUCE

INSTRUCTIONAL

AND

PLANT CULTURE

MANUAL

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Part # 9P099

HYDRO-GARDENS, INC.
LEAFCROP PRODUCTION PROCEDURES FOR LETTUCE

I. Selecting A Variety

In recent years salad crops of all kinds have become more and more popular with health conscious consumers. Our Nutrient Flow System (NFS) Leafcrop Production System enables the grower to be quite flexible in regard to the product that is chosen for the market. This manual will be directed towards the production of four types of lettuce (1) Bibb {Ostinata, Salina, Summer Bibb, et al.} (2) Leaf {Waldmann's Dark Green, Grand Rapids, Ruby et al.} (3) Romaine {COS, et al.} and loose head types {Montello}.

The primary factor that determines the type and variety of lettuce that is selected for production is the grower's intended market. It is up to the grower to study the market thoroughly prior to planting the first seed.

There are wide variances in geographic location and local environmental factors that figure prominently in the success of one variety or type over another. We will not attempt to provide a season by season varietal planting schedule in this text.

II. Planting The Seed

Although our NFS Leafcrop Production System will accommodate a wide variety of rooting materials, we have found after many performance trials that a net pot filled with PRO-MIX BX, horticultural rockwool; or rockwool cubes; or horticubes are preferred. PRO-MIX is composed of Canadian sphagnum peat, vermiculite and perlite.

PROCEDURE FOR FILLING NET POTS

A. Fill each pot to within 1/2" of the top with the appropriate growing media. Compress slightly with your fingers or with a dibble board.

B. Place one seed in each pot (seed an additional 10%>15% to allow for any seed that fail to germinate).

C. Top off the pots with 1/4" of growing media, and press firmly again. The seed needs to "struggle" through the media to shed the seed coat.

III. Producing A High Quality Seedling For Transplant

A. Place the seeded pots in the germination area and wet thoroughly with 65^0-75^0 F. water which has had the pH adjusted to 6.4-6.6. The pots need not stand in water, however they must remain uniformly moist at all times.

B. Air temperatures best suited for germination are 65^0 to 72^0 F. (unused lettuce seed should be stored in a sealed package in a refrigerator)

C. If the seedlings are produced under artificial light, install a time clock that will provide 16 hours of light per day with an eight hour period of darkness for each 24 hour cycle. The footcandle intensity desired is 500 to 2000. The seed should sprout within 3 days, and then you need light.

D. When the seedlings have emerged, establish the following temperature regime:

Northern Climates	Southern Climates
nights - $55^0 > 60^0$ F.	nights - $60^0 > 65^0$ F.
days - $65^0 > 75^0$ F.	days - $70^0 > 75^0$ F.

E. Once the plants have emerged, they should be fed with 1/4 strength nutrient solution made from CHEM-GRO 8-15-36 Lettuce Formula.

1. Use 4 ounces of 8-15-36 plus 2 ounces of epsom salt and 5 ources of calcium nitrate per 100 gallons of water.

2. Adjust the pH to 6.4 to 6.6 using either common battery acid (sulfuric) or phosphoric acid to lower the pH, and potassium hydroxide (caustic potash) or sodium hydroxide (caustic soda) to raise the pH.

What is pH?

The concept of pH is very important as it relates to the availability of plant nutrients in the root zone. Technically, pH is the negative log of the hydrogen ion concentration. It quantitavely describes the acidity of basicity of a substance or solution. The pH scale covers a range from 1 to 14, with 7 representing a neutral value. The portion of the range from 7 to 1 represents an increasing acidity, and from 7 to 14 indicates an increasing alkalinity. We have found that lettuce grows best in a nutrient solution that has a pH of 6.4 to 6.6. Avoid going above 7.0 and below 6.0.

Adjusting the pH

3. The pH of a liquid solution can be adjusted to the desired range by using two common chemicals; battery acid and/or potassium hydroxide. Since source water varies widely in its chemcial composition and resulting pH, no formula can be provided to determine how much adjustment chemical will be required. This is done by trial and error.

a. Take a water sample and test the pH using a pH kit supplied by Hydro-Gardens.

b. If the test indicates that the solution is too basic, then you know that some battery acid must be added to lower the pH to the desired range.

c. Record the volume of the solution that you are going to adjust and the pH prior to the addition of acid.

d. Measure out a small amount of acid and add it to your nutrient tank. As an example, you might use 1/2 teaspoon per 100 gallons.

e. Allow the solution to mix for 15 minutes or so and test the pH again.

f. Record the new pH value. If the pH is now in the desired range, then no further adjustments are necessary. If the pH is still too basic, continue adding the pre-determined volume of acid to the solution until the desired level is achieved. By adding up the number of ounces required to lower the pH the the correct range, you will have an approximation for the amount of acid needed to lower a given volume of solution to that pH range. The same method is used to increase the pH using potassium hydroxide.

You now have a balanced starter solution to feed your seedlings until it is time to transplant into the NFS system.

IV. Transplant to Harvest

One of the primary attractions of growing leaf crops is the fact that with careful scheduling the grower can harvest fresh produce as dictated by the local market. Bibb and leaf lettuce varieties can be grown to maturity in our system from seed within 4 > 8 weeks (local weather conditions may at times influence date to maturity). Therefore, it is a simple matter to design a seeding schedule to accomodate variations in harvest dates. The flexibility allowed by the variable spacing system simplifies cash flow greatly.

Once the seedlings have leaves that are 1" to 2" long they are ready to be transplanted into the NFS system. In general it will take 2 to 3 weeks to reach this size. During the summer months seedlings can be put into the trays within one week.

Simply take the net pot containing the seedling and place it in the production tray. Make certain that the pot is seated properly. In other words, be sure that the top most rim of each pot rests directly on the tray cover. The bottom of the pot will rest on the bottom of the NFS tray. This assures nutrient uptake for good root growth and plant vitality.

Use only the most vigorous seedlings of uniform development. Care should be exercised to avod damaging the plants during the transplant phase since injured plants are susceptible to disease.

A. Spacing.

Spacing lettuce depends on varieties grown and head size required. At Hydro-Gardens we use a unique system whereby the nursery section of the bench is approximately 33% of the total bench length. Plants in this section are on 3 1/2" x 7" centers. The balance of the bench space is devoted to maturing and mature lettuce plants. These are on 7" x 7" centers. This technique provides maximum output per square foot of bench area.

BIBB LETTUCE seedlings should be spaced so that they are on 6" to 7" centers within the individual trays. Furthermore, the spacing between each tray should also be on 6" to 7" centers depending on varieties and market requirements. To make the most of the available production

area, it is suggested that the plants be staggered, i.e. the first plants in the first tray is placed 3" in from the nutrient feed line. The plants in the tray adjacent to it is 6 1/2" in from the feed line. The illustration below should help you visualize this system of spacing and staggering the plants.

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Tray #1   X     X     X     X     X     X) -----feed line

Tray #2     X     X     X     X     X   ) -----feed line
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LEAF LETTUCE varieties require 7" to 8" on center spacing within the trays and 7" on center from tray to tray. Again, the plants should be staggered. NOTE: It is important to begin circulating the nutrient solution through the trays as soon as you begin filling the tray. If the seedling dries out during the transplant procedure, stunting may occur which increasess the time to maturity and may also effect quality. If larger heads are required and trays are in a fixed position on the bench, simply space the plants further apart in the trays.

B. Nutrient Solution Management

1. Each 12'3" tray should be supplied approximately 1 pint of solution per minute.
2. The temperature of the solution should be maintained at 60^0 to 65^0 F.
3. Ideally, the nutrient solution should be adjusted for pH and conductivity early in the morning and late in the evening.
4. Optimum pH is between 6.4 and 6.6.
5. Leaf crops in general are poor feeders, so a fairly high level of nutrition must be maintained. We have found that 1300 to 1600 PPM is satisfactory.
6. To maintain the balance of fertilizer ions in solution it will be necessary to pump out the reservoir every 14 days (depending on water quality and tank size) and recharge the nutrient tank with fresh nutrient solution at the target PPM level, pH range and temperature.

EXAMPLE OF HOW TO ADJUST A NUTRIENT SOLUTION

A sample of the nutrient solution is tested using the conductivity meter. The test indicates that the concentration of the recirculating solution is 1200 PPM and your target is 1600 PPM. The volume of your reservoir is 500 gallons. The volume of nutrient solution is down to 400 gallons from the original 500 gallons. If it took 2 1/2 pounds of Chem-Gro 8-15-36 plus 1 1/4 pounds of epsom salts plus 2 1/2 pounds of calcium nitrate to get 1600 PPM in 500 gallons of water, then 8 ounces of 8-15-36 plus 4 ounces of epsom salts plus 8 ounces of calcium nitrate will raise 100 gallons of water to 1600 PPM. Adding 1/2 ounce of 8-15-36 plus 1/4 ounce of epsom salts plus 1/2 ounce of calcium nitrate should raise 100 gallons by 100 PPM. Therefore, you should add 2 ounces of 8-15-36 plus 1 ounce of epsom salts plus 2 ounces of calcium nitrate to increase 400 gallons by 400 PPM.

Under warm dry conditions the solution may have a greater conductivity during the course of the day. This occurs as a result of an increase in the transpiration rate (the loss of water vapor from living plants is known as transpiration). The plant is giving up water vapor to cool itself, and fertilizer salts are left behind, hence the increase in solution conductivity.

In this instance, the nutrient solution in the reservoir must be diluted and re-adjusted for PPM and pH. Since your water differs from ours, it will be necessary for you to calculate the amount of source water required to dilute a given volume of nutrient solution contained in your reservoir. The procedure described earlier for pH adjustments should be employed to make this determination.

C. Air Temperatures (optimum)

Northern Climates	Southern Climates
nights - $55^0 > 58^0$ F.	nights - $58^0 > 62^0$ F.
days - $65^0 > 72^0$ F.	days - $75^0 > 80^0$ F.

D. Carbon Dioxide Enrichment

Of the commonly grown vegetable crops produced in greenhouses, lettuce is by far the most responsive to added carbon dioxide (CO_2). Carbon dioxide enrichment is especially important during the colder months when ventilation is reduced during the day. The air outside the greenhouse normally contains about 300 PPM CO_2. Although the CO_2 content builds up to some degree overnight by the respiration process, under normal light intensities in an unvented house, the CO_2 level falls rapidly. It has been demonstrated that CO_2 enrichment results in a rapid growth rate, earlier maturity (10 days +), and higher yields.

The CO_2 generator should be calibrated to supply a level of 1000 to 1200 PPM. It is suggested that the generator(s) be wired so that it will come on 1 hour before sunrise, turn off if an exhaust fan comes on, and run until 1 hour prior to sunset. If gas is not available, then one should consider using liquid carbon dioxide.

E. Harvest

The amount of time from transplant to harvest may vary due to seasonal changes, leafcrop type, and the environment that you provide the plants. During good weather, the heads will be ready to harvest within 4 weeks from transplant.

1. Harvest the heads early in the morning to avoid wilt prior to boxing and loss of shelf life due to heat build up in the plants.

2. Harvest one tray at a time.

3. Intermittently stop the flow of nutrient. The frequency depends on the variety and age. It also depends on the growing media used. i.e. peat-lite, rockwool cubes, etc.

4. Start at one end of the tray and remove the head by grasping the net pot and lifting it up out of the tray. be careful not to damage any of the leaves.

5. Trim away the pale and discolored leaves from the base of the plant. Cut away the roots from the basal portion of the head if you are selling un-bagged lettuce.

6. If the leaf margins have a bit of tip-burn, it might be acceptable to simply tear away the affected portion.

7. Package as dictated by the market that you will serve.

8. Use an ice water dip if necessary to increase shelf life. On a larger scale, a vacuum cooler or commercial water chiller may be needed. Refrigerate at 35^0 to 40^0 F as soon as the plants have been packaged.

It is advisable that you consult the buyer of your produce to determine the type of packaging that will be required. Some buyers will prefer to purchase strictly by the pound, in which case the grower need only cut and trim the heads prior to boxing. Other retailers may wish to promote your lettuce as "living lettuce", and in this case, the heads will be packaged individually in plastic bags with the roots left intact. Post harvest storage conditions, i.e. temperature and relative humidity, are extremely important considerations and again the buyer should be able to advise you on proper conditions. It is to your advantage to be in partnership with the individuals that will handle your produce prior to point of purchase.

F. Pests, Diseases and Disorders

The publications listed are valuable references and are available from Hydro-Gardens, Inc.

"Common-Sense Pest Control"
William Olkowski, Sheila Daar, Helga Olkowski
715 pages. Hardcover.

"Nutritional Disorders - Glasshouse Tomatoes, Cucumbers and Lettuce"
Eysinga and Smilde
80 color photos with descriptions. Hardcover.

Because of variances in state laws governing pesticide usage in greenhouses, we will not offer any suggestions on chemicals for insect, disease or fungus control. It is advised that the grower contact the local county extension office and request the list of state approved pesticides for greenhouses. Furthermore, it is strongly suggested that anyone that intends to use pesticides becoma a certified applicator. Your local agricultural extension agent can fill you in on all the details and arrange for your enrollment in a state supported program.

KNOW THE LAW. TREAT ALL CHEMICALS WITH RESPECT. PROTECT YOURSELF.

1. Pests

a. Aphids. Also known as plant lice, are small (average 0.1 inch) soft-bodied insects that feed on plants by sucking their fluid or sap. They pierce plant tissue with slim, needle sharp stylets in their beak. In abundance, aphids may cause leaves to curl or may stunt plant growth. Aphids expel from the end of their abdomen a sticky substance called honeydew on which sooty mold can grow. Even

small populations of aphids on lettuce are very objectionable to the customer. Aphids also introduce fungus, bacterial, and viral diseases that can be serious problems.

Control: Use suggested chemicals, raise seedlings in isolation, and eliminate weeds inside and outside the greenhouse that may harbor this pest. Refer to the biological control section of our catalog for predators and parasites.

b. Cabbageworks, Loopers and other Caterpillars. These are larvae of butterflies and moths. Several species feed on plants. Where infestations are severe, the lettuce is soon decimated and is unfit for sale. These pests are seldom a problem in greenhouse lettuce however.

Control: Use suggested chemicals to kill the adults as well as larval forms. Hand pick if only a few are present. Prevent entry of the worms by repairing holes in the covers, etc. Eliminate weeds in and around the greenhouse.

c. Slugs. Slugs are mollusks that sometimes feed on the foliage. The damage may be mistaken for the feeding of other insect pests. They usually feed at night and hide under leaves or debris during the day. Occasionally, slugs can be come a problem particularly where sanitation is not good.

Control: Clean up the greenhouse and seeding area and remove old seeding flats, etc. which provide hiding places. Nearby weeds and grass can also harbor slugs, so keep the inside and outside free from these plants. Commercial slug-control baits spread near, but not touching the plants, will give some measure of control.

d. Leaf Miners. Leaf miners are the larvae of certain moths, flies, beatles or sawflies. They feed between the epidermal layers of a leaf, causing blisters, blotches or tunnels. Leaf miners attack lettuce in two ways, rendering plant leaves unsightly and unsuitable for marketing. The pest usually attacks the very young lettuce plant, killing its primary leaves, and it attack the mature plant when the leaves are thick enough to be mined. Mined leaves are then susceptible to a bacterial leaf blight disease, Psuedomonas Marginalis, that causes the plant to decay in transit. Unfortunately, there is no known bactericide to control this decaying bacteria.

Control: Several chemicals are available for the control of adults and larvae. Make any repairs to prevent entry into the greenhouse. Eliminate weeds in and around the greenhouse.

2. Diseases

a. Botrytis or Gray Mold (Botrytis cinerea). This is one of the most serious diseases of lettuce. The spores of the fungus are always present in the air, but cannot attack healty tissue. It gains entry through wounds, dying leaves, leaves already damaged by Downy Mildew and Rhizoctonia, and as a resulf of damace caused by physiologic maladies (tipburn or flassiness). Botrytis favors humid conditions, and is active over a wide range of temperatures, up to 77^0 F., but low temperatures are especially favorable to the rapid spread of this disease. In plants approaching maturity, red-brown lesions are often seen on the outer leaves close to the base of the plant. Sudden wilting and characteristic masses of gray spores accompany extensive rotting.

Control: Several chemicals are available to protect healthy tissue. Avoid damaging the plants at all stages of growth which predispose the plant to attack. Any diseased plants must be removed from the population immediately. All trimmings, etc. should be hauled well away from the production facility.

b. Downy Mildew (Bremia lactuacae). On older plants, the symptoms are small areas on the leaves of a paler green, which become yellow. Underneath, the typical white fluffy growth can be seen. High humidity conditions favor the rapid spread of the disease. In order for the spores of the fungus to germinate, it is essential for there to be a film of water on the leaf, and for the temperature to be in the range of 50^0 to 74^0 F. Once inside the leaf tissue, the fungus will continue to develop while humidity is high.

Control: Avoid extreme fluctuations in temperature. The danger period is in the evening; as temperatures fall, relative humidity rises, and condensation on the leaves can occur. In autumn, particular care must be taken to ventilate freely on warm days to minimize the drop in temperature after sunset. Some greenhouse operations run a dehumidification cycle at this time to bring in cooler outside air and warm it up with the heating system. You can also utilize the fresh air system during the night to reduce humidity. Use resistant varieties. Treat the crop with suggested chemical compounds.

c. Rizoctonia solani (damping off). In seedlings, there can be seen a light brown constricted area on the stem, and later the seedling topples over. Damping off may occur anytime, especially during the first 10 to 14 days after the seedlings have emerged. Any type of unfavorable growing conditions, such as chilling, over watering, inadequate ventilation or rought handling may trigger an outbreak.

Control: Prevention of damping off is very dependent on good management. It is important to sterilize flats and pots and use only well sterilized media for growing seedlings. Growers who often run into problems should provide additional ventilation, and consider seed treatment and seedling sprays with a recommended fungicide.

d. Lettuce Mosaic virus. Although widespread in outdoor lettuce, particularly in late summer, infection in the greenhouse is not often seen. The virus can be carried on the seed, so this is uaually the primary source of infection. Symptoms are a mottling of the leaf, pale green or yellowish areas among the darker green of the rest of the leaf. Young plants are most affected. The become stunted or fail to form a head. Not only do lettuce plants themselves become infected. but also certain weeds become hosts for the virus. Aphids feeding on host plants within about 15 seconds become capable of infecting other plants.

Control: Control aphids as indicated earlier. Use cleen seed. Discard all unhealthy seedlings. Destroy weeds inside and outside the greenhouse. Outdoor lettuce crops should be grown as far away as possible and regularly sprayed with aphicides.

4. Disorders

a. Normal Tipburn and Marginal Tipburn

With both forms of tipburn, part of the leaf wilts and dries up. The damage is caused when the leaves are losing water into the air more rapidly than they can take ups water through the roots. Most tipburn damage is seen when the crop is mature and ready for harvest. It is most common in the spring.

With normal tipburn, the younger leaves at the center of the head are affected. The leaves wilt and the cells at the edge of the leaves are killed. Soft rots frequently develop on the dead tissue.

With Marginal tipburn, the older leaves are affected, but since air circulation is better, the tissue usually dries up and leaves a scorched appearance along the edges of the leaf. The most common cause of these tipburns is a sudden change in humidity due to exhausting the greenhouse too quickly in bright sunny weather. Any set of conditions that encourage rapid water loss by the plant can cause tipburn. Rapid water loss can be caused by:

1. High temperatures during sunny weather.
2. Low humidity and excessive air movement.
3. Too little solution passing through the root zone.
4. Cold nutrient temperature (below 45^0 F.).
5. Excessively high PPM levels in the nutrient solution.
6. Poorly developed root system.
7. A sunny day that follows one or more cloudy days.

Control: Ventilate early in the morning on bright, sunny days to prevent temperatures from rising too fast. If the relative himidity is too low (less than 50%) mist the leaves lightly or wet the floor area under the bench. Be certain that each tray receives an adequate amount of solution. Keep the ppm levels in the prescribed range. Check the root system for pests, diseases and nutrient volume.

b. Glassiness or Veinal Tipburn

This physiologic disorder is the exact opposite of normal and marginal tipburn. It is caused when leaves are unable to lose sufficient moisture into the air. The edges of the leaves are most affected and become suffused with fluid so they look translucent. Occasionally this condition is mistaken for frost damage because of the water soaked appearance.

The problem is most common in dull, misty or foggy conditions during November, December and January. The plant is taking water up via the roots, but is unable to do much transpiring because of the high humidity of the surrounding air.

Control: The relative humidity of the air must be reduced. On dull days a temperature boost will be necessary. Good air movement above the crop is essential. Make sure the leaves of the plants are dry by evening.

c. Low Temperature Injury

Injury due to low temperatures is commonly seen after very severe weather in heated greenhouses where the heating system only gives a small temperature lift. It is most pronounced when seedlings are suddenly subjected to low temperatures without having time to adapt themselves.

The symptoms are curling of the affected leaf or leaves. On the underneath side of the leaf will be seen a number of light brown markings, and further inspection with a hand lens will show how the tissue has become restricted and brittle. On the upper surface, the leaf looks crinkled. Normally, lettuce will grow away from the injury once normal temperatures are established.

Control: When severe weather is predicted, be sure that all heating units are operating efficiently and that minimum temperatures are maintained. Harden off seedlings prior to transplanting into the production unit.

Any factor which may reduce the quality or quantity of the lettuce that you are producing needs to be rectified quickly. We a Hydro-Gardens, Inc. are very anxious to see you succeed in your endeavor. If you encounter any problem, do not hesitate to contact our staff and we will do our best to help you eliminate the problem.

NFT LETTUCE SYSTEMS
PRODUCTION AND LABOR ESTIMATES
31' x 128'/132' GREENHOUSE

Lettuce plants, either bibb or leaf, are spaced on 6" x 3 1/2", or 7" x 3 1/2" centers in the initial stage - or approximately one-third of the bench. Each tray is 12'3" long and holds 24 or 20 lettuce plants. A 120' bench is used in a greenhouse this length, and the total plant population will range from 13,000 to 11,000. In the 1st stage, trays are placed on the bench so that they are touching, and the plants are on 6" or 7" centers down the length of the tray. During the finishing stage, the trays are separated to 6" or 7" centers, and the plants are in the same place within the tray. Theoretically, with a 4 week old plant (normally a 5 oz. to 7 oz. head), the production ranges from 2500 to 2100 plants per week once the cycle is in full swing. The plants are rotated from germination/small seedling to seedlings on the bench to mature plants on the bench on an as need basis. Harvesting is generally done twice a week.

The seed are planted by hand in growing blocks or net pots. This can be automated with a seeder, but then requires pelleted seed. These are germinated and grown in 10" x 20" flats that can hold 50 plants. This initial stage should be done in a separate building or greenhouse under lights. Each 50 plants will require about 1 1/2 sq. feet of area. They will remain in this stage for 10 to 16 days. When their leaves are touching, they should be transferred to the bench, or spaced out to prevent crowding. The initial planting should be 12% of the expected total plant population. If the total population has been calculated to be 13,000, then each planting will be 1,560. For example, plant 1,560 cubes (or pots) on Monday, and another 1,560 on Thursday. This should be repeated the following 4 to 6 weeks. By that time, harvesting should have begun, and you can adjust your planting to the harvesting schedule.

This germination/seedling area must have good environmental control. This includes good light with the appropriate temperature and humidity levels. The level should be at least 500 footcandles. The seedlings will grow faster and stronger with higher levels. This level of light can be obtained with fluorescent tubes if they are spaced closely together. The light bulbs should be replaced every 6 months for optimum seedling growth, and should be no more than 6" above the plants.

Once the seedlings are ready, they should be placed directly in the growing trays. It is important to keep the starter cube evenly moist, and this may mean that the nutrient solution will run constantly. You might experiment with an intermittent watering schedule to reduce algae buildup in the nfs trays and return gutter, but pay special attention to the new seedlings.

Total production will depend on the variety and size of head your market requires. Some locations can market 4 oz bibb, while others need an 8 oz head. Clearly, you will have a quicker turnaround and more production with the smaller heads, but the market price may be a lot less. Harvesting, including bagging and boxing should be done at the rate of 125 plants per man hour. It will thus take 25 man hours per week to harvest 2,500 plants per week. It will require about 8 man hours a week to transplant into, and space, the nfs trays. Another 7 man hours per week will be used for the balance of activities associated with growing a lettuce crop. These would include mixing and monitoring the nutrients solution, managing disease and insect control, and general maintenance of the nfs system. Therefore, 3,000 sq. ft. of bench can be handled with 40 man hours per week.

It will require 6 to 8 full time employees to operate an acre of greenhouse lettuce. Some of the many variables that determine the size of the labor force are: Size of head harvested, type of packaging required, type of equipment available for seeding, harvesting and packaging, and the material flow design of the greenhouse.

Projected yearly gross income can be obtained by multiplying weekly harvest by 52 weeks, and then by the expected selling price. As an example, 2,500 * 52 = 130,000 * $.60 = $78,000.00. The selling price is the net returned to you. If you use a produce wholesaler, the net back to you might be $.42 per head.

Marketing is an equally important function of greenhouse operations. Marketing is more than just selling your product. It involves promotion, packaging, and selling the product at the best possible price. It may be that a wholesaler can return a net amout to you that is greater than you can obtain by marketing to the end user directly. Marketing commissions are in the 15% to 30% range.

The decision to use a produce broker, professional salesman, or to do your own marketing is usually a function of the size of operation, and is an individual business decision. The important thing to do is sell all of the produce at the highest possible price with the least amount of effort and worry from you as the grower.

LETTUCE NUTRIENT RECOMMENDATIONS
8-15-36 LETTUCE FORMULA

MATURING PLANTS - FROM TRANSPLANT TO HARVEST
FOR 100 GALLONS OF PLANT USABLE NUTRIENT SOLUTION

A. 8 ounces (1/2 pound) Calcium Nitrate per 100 gallons of water.

Note 1: Calcium nitrate is very soluble and can easily be made into a very concentrated liquid. One pound of calcium nitrate per gallon of water is easy to dissolve. However, there will be some foam from the parafin wax that is used to coat the calcium nitrate. After one pound of calcium nitrate is dissolved in one gallon, then each gallon will make 200 gallons of nutrient solution (1/2 lb. per 100 gallons = 1/2 gallon per 100 gallons)

Note 2: Calcium is very important for lettuce and is mostly supplied from calcium nitrate. However, there are times when more calcium is needed but it would be a disadvantage to add more nitrogen. This usually happens in the winter. It is also possible when the source water contains little or no calcium. An optional source is calcium chloride. This compound adds chloride to total conductivity which is not a good idea. So a rule of thumb is to use no more than 1 ounce of calcium chloride per 100 gallons of water.

B. 5 ounces of Magnesium Sulfate (Epsom Salts) per 100 gallons of water.

Note 1: Magnesium sulfate is the most common form of magnesium. Lettuce requires a lot of magnesium. Magnesium sulfate also contains a high percentage of sulfate-sulfur. At times, the sulfate can build up to an excessive level because plants need a lot less than the other elements. This is especially true when the source water contains little or no magnesium.

Note 2: Another excellent source of magnesium is magnesium nitrate. The percentage of magnesium is the same as magnesium sulfate. Magnesium nitrate is sometimes called Magnisol. This compound can be used to supplement magnesium sulfate. Since it also contains nitrogen, it will not completely replace magnesium sulfate. It can be used for up to 10% of the magnesium in the winter, and 20% in the summer. It is an important compound to have on hand when there is a greater need for magnesium, but the sulfate content is already too high.

C. 8 ounces (1/2 pound) of Chem-Gro 8-15-36 per 100 gallons of water.

Note 1: Chem-Gro 8-15-36 is a specially formulated mixture containing all the necessary trace elements as well as Phosphorus, Potassium, and a large percentage of the Nitrogen needed in lettuce. This formula does not contain magnesium.

Note 2: Lettuce requires a large amount of potassium and uses the element at about the same rate or more than nitrogen. Potassium needs to be added most of the year and especially during long days. From about March 1 to late November, add 2 ounces of potassium nitrate per 100 gallons in addition to 8-15-36. From December 1 to about March 1, use potassium chloride instead of potassium nitrate.

Note 3: Chem-Gro 8-15-36 can be made into a concentrated liquid. Dissolve one pound per gallon and stir well. Each 1/2 gallon then contains the 8 ounces of 8-15-36 needed. One gallon of concentrate will make 200 gallons of nutrient. Since Chem-Gro contains quite a number of different compounds, it is not as soluble as calcium nitrate or magnesium sulfate. Acid, for pH control, is mixed with the Chem-Gro concentrate.

D. pH (6.5 - 6.8)

The pH of lettuce nutrient must be adjusted and controlled within the range of 6.5 to 6.8. Lettuce needs a large root mass in hydroponic systems. A pH that is too low reduces phosphorus, magnesium and calcium uptake. A pH over 7 reduces the uptake of several minerals, particularly iron and manganese.

Note 1: There are several acids that can be used to lower pH. Sulfuric, phosphoric, or nitric acids are commonly used. Nitric is usually the most expensive, then phosphoric, then sulfuric being the least expensive. Sulfuric and nitric are much more dangerous than phosphoric. Nitric is the most difficult to obtain. It is recommended that phosphoric acid be used for pH adjustment. There is no way to accurately calculate the amount of acid that will be needed. This is done by trial and error, and in a very short time, the required amount can be determined. **CAUTION** - All acids are dangerous!! Dilute acids carefully before allowing employees to handle them. **NEVER** add water to acid.

E. Conductivity (ppm, DS, Micromhos, Millimhos)

The conductivity of lettuce nutrient will vary considerably over the course of a day. Any recirculation system must be checked regularly. The nutrient conductivity (and pH) should be checked daily or monitored continually with an in-line conductivity and pH monitor. If you do not have a monitor, then use a standard portable conductivity meter, and a pH test kit.

The conductividy (DS) of a lettuce nutrient solution should be 1300 ppm +/- 5% during the winter. Water quality effects your total DS reading. The above ppm level is based on an average source water DS of 300 ppm. Your DS will be slightly higher when you are adding potassium nitrate or if your water is higher than 300 ppm. If your water conductivity is higher than 300 ppm, it is possible that a special formulation may be required. For example, if you have high sodium in your water, then you will need a higher level of potassium. If you have high calcium, then calcium nitrate can be reduced and potassium nitrate increased. Therefore, it is important to have a complete water analysi done at least twice a year, and a nutrient analysis done every two weeks.

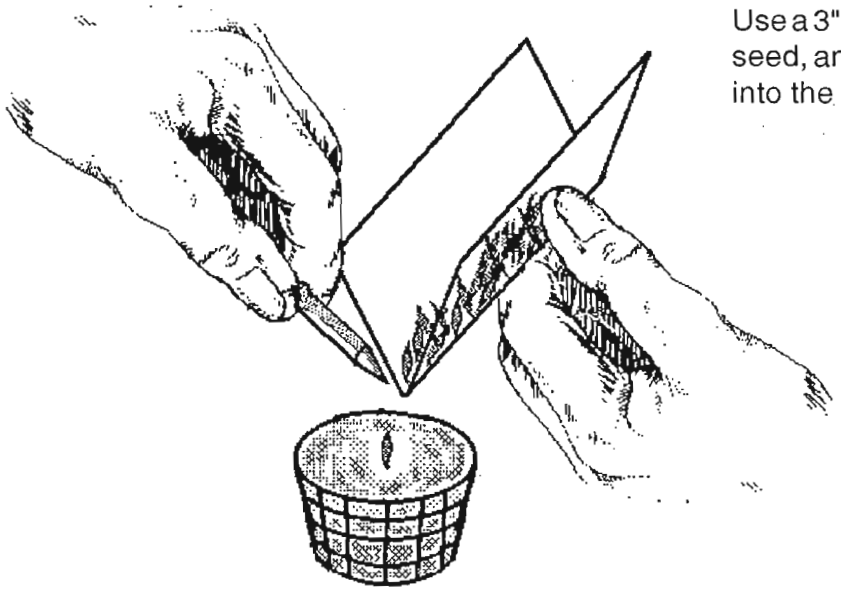
Note 1: Conductivity is measured in several different ways. The two most common measurements are ppm and millimhos. To convert from millimhos to ppm, simply multiply the millimho reading by 72o. For example, 2.1 millimnos is 1512 ppm. Also, 2.1 millimhos is the same as 2100 micromhos.

Note 2: Conductivity varies more in a system using small tanks than it does using large tanks. Therefore, the size of the tank effects how often you need to check and adjust DS and pH.

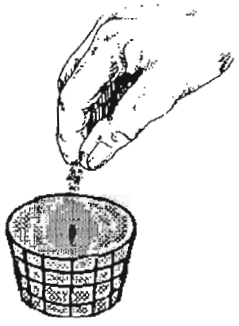
Note 3: If the weather changes rapidly, you need to adjust the conductivity accordingly. If the DS is too high when the plants are growing rapidly in full sun, then tip burn will be greater. This is especially true when the humidity is low and plant transpiration is high.

Note 4: Most lettuce varieties require about the same nutrient levels. Climate effects the growth rate more than any other factor if nutrition is adequate.

Note 5: Carbon dioxide is probably the most important nutrient and the most ignored. Plants cannot grow without it. If you do not have carbon dioxide equipment in your greenhoue, you need to seriously consider it. A carbon dioxide level of 1000 to 2000 ppm could increase lettuce production by as much as 25% under certain conditions.



Use a 3" x 5" card folded to hold the lettuce seed, and use a pencil to scrape the seed into the center of the net pot.

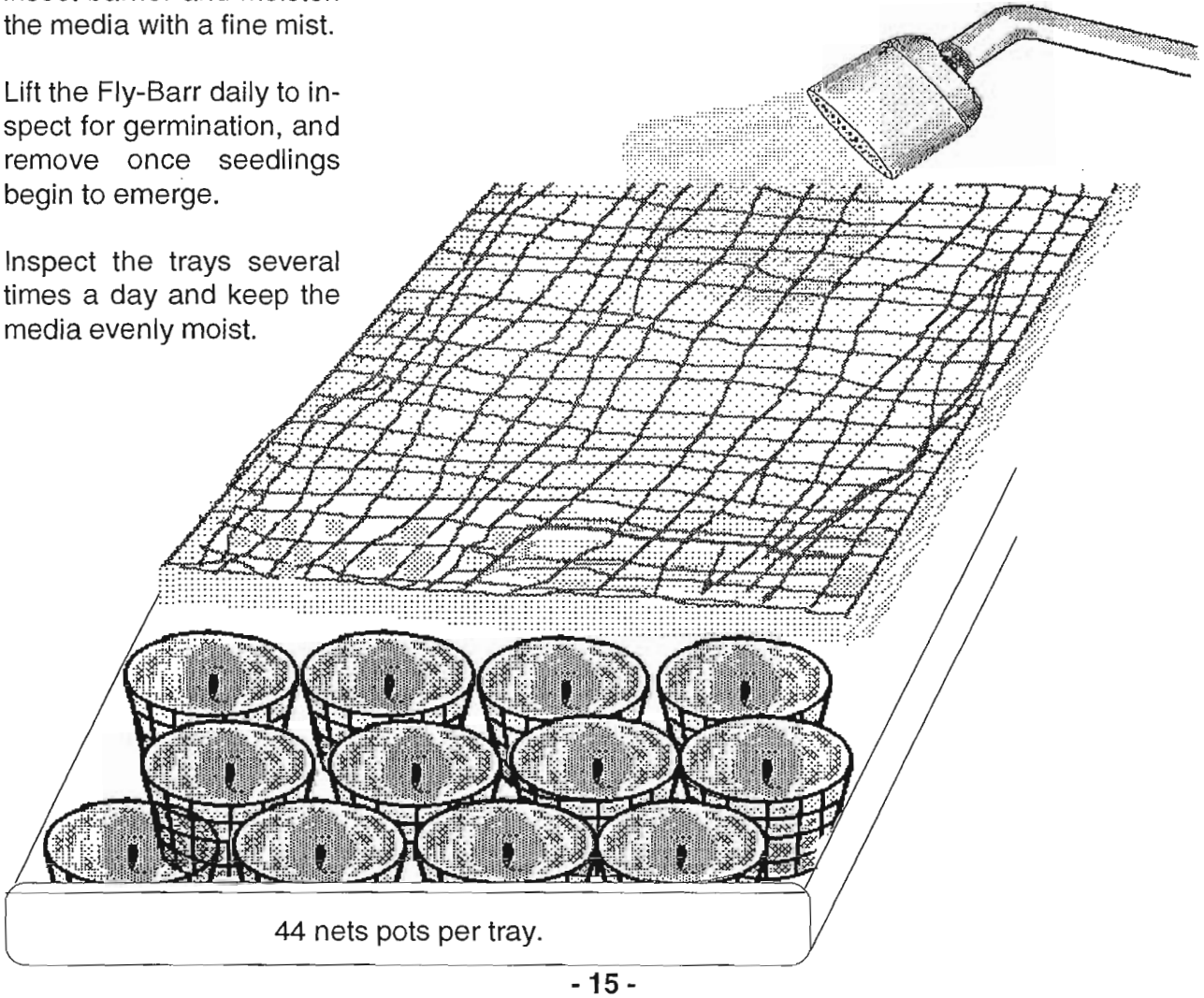


Press the seed 1/4" deep into the media and cover the seed with a small amount of vermiculite or the media used to fill the net pot.

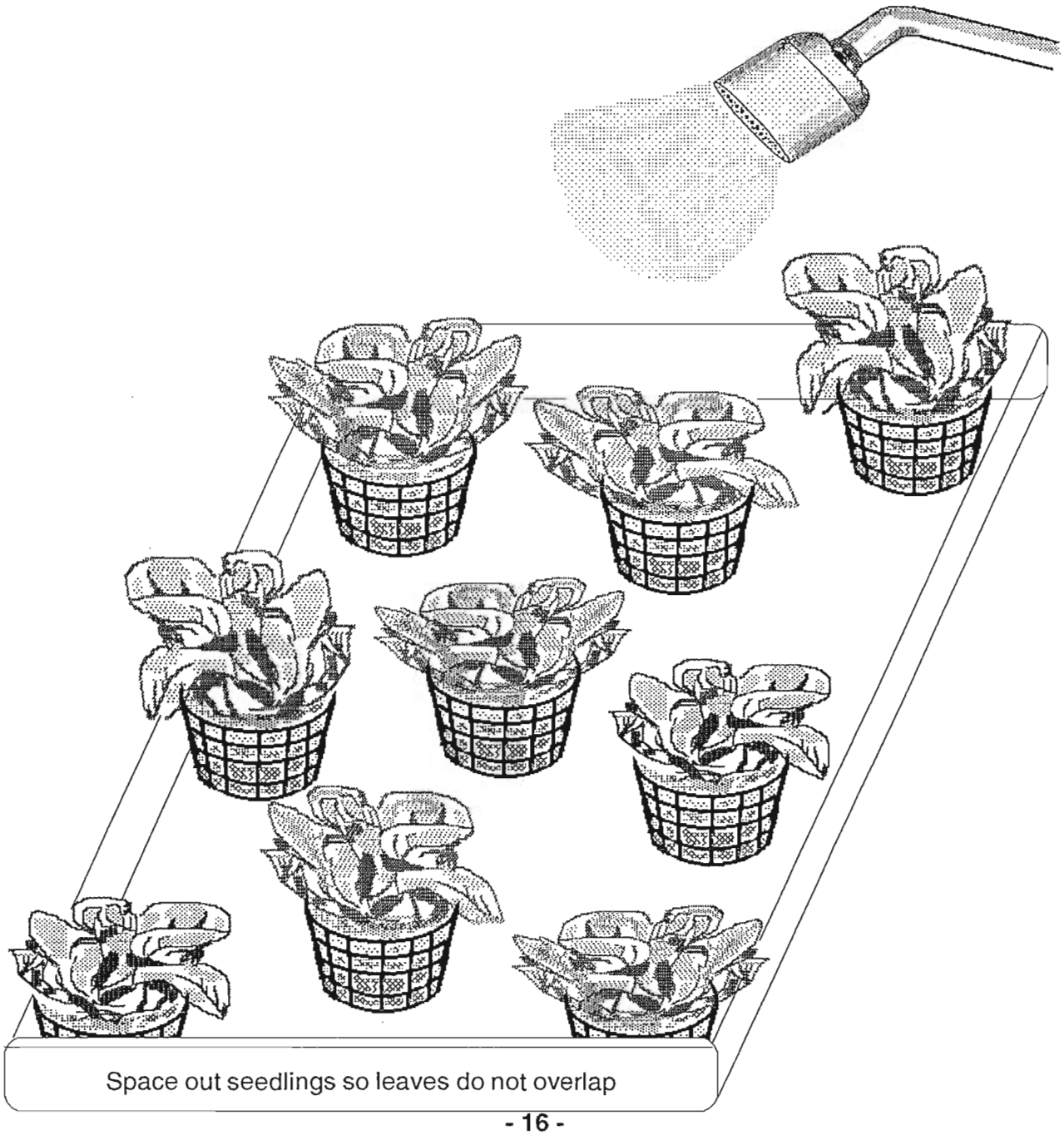
Cover the tray with Fly-Barr insect barrier and moisten the media with a fine mist.

Lift the Fly-Barr daily to inspect for germination, and remove once seedlings begin to emerge.

Inspect the trays several times a day and keep the media evenly moist.



44 nets pots per tray.


Space out seedlings so leaves do not overlap

ANALYSIS PARAMETERS

		LETTUCE TISSUE			LETTUCE NUTRIENT SOLUTION		
		Min.	Max.	Optimum	Min.	Max.	Optimum
Total Nitrogen	[N}	2.5	4.0	3.5[a,b]	80	160	130
Nitrogen	[NO_3-N]	0.3	0.6	0.5	---	---	---
Phosphorus	[P]	0.2	1.5	0.7	20	50	40
Potash	[K]	3.5	6.0	4.5	150	250	175
Calcium	[Ca]	1.3	4.0	2.5	100	300	150
Magnesium	[Mg]	0.3	0.8	o.6	35	60	43
Sodium	[Na]	0.05	0.6	0.5	Trace	200	Trace
Chloride	[Cl]	0.05	0.8	0.5[c]	Trace	100[c]	Trace
Sulfur	[SO_4-S]	0.4	0.8	0.5	30	100	100
Iron	[Fe]	100	400	150	1.0	3.0	2.0
Manganese	[Mn]	30	200	100	0.5	1.0	0.7
Zinc	[Z]	30	200	50	0.1	0.4	0.2
Copper	[Cu]	5	30	10	0.1	0.4	0.2
Boron	[B]	18	100	50	0.5	1.5	1.0
Molybdenum	[Mo]	0.5	1.5	0.8	0.04	1.2	0.08
				pH	6.4	6.6	
				Conductivity [ppm]	400	1400[d]	
				[mmhos]	0.6	2.0	

a. Depends on lettuce 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. Upper levels depend on source water PPM.

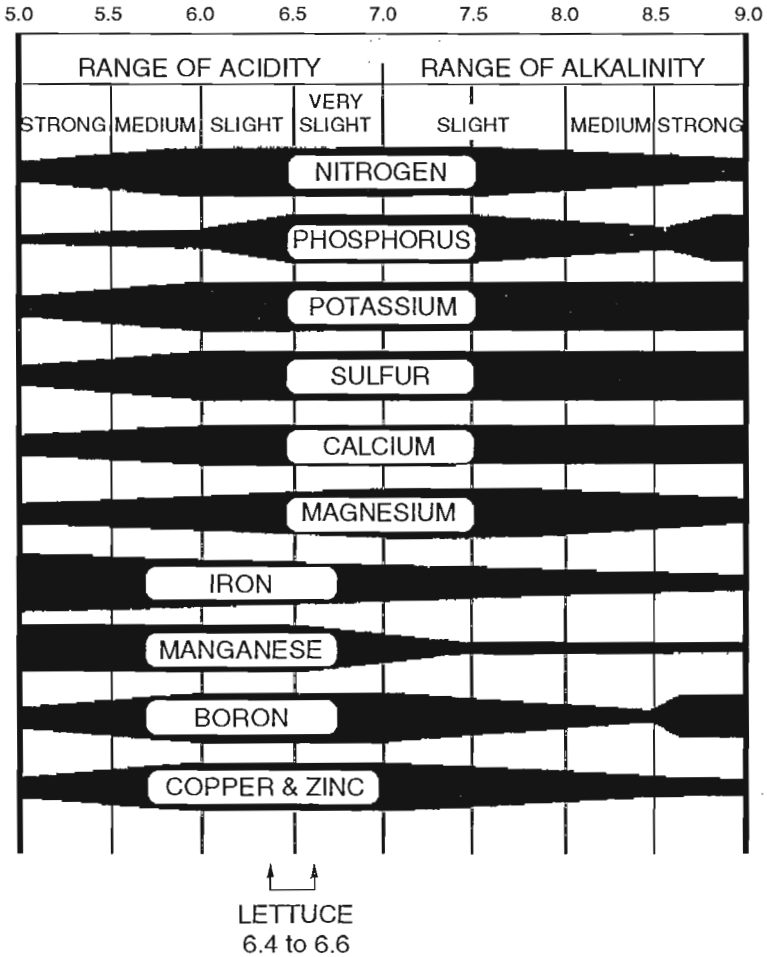
ADJUSTING CHEM-GRO FERTILIZER FORMULAS FOR INJECTORS

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

Follow the mixing instructions for making concentrated fertilizer in two concentrate tanks. Dissolve 1/2 lb. of calcium nitrate per gallon of water in the concentrate tank for the 1st injector. Dissolve 1/2 lb. of Chem-Gro and 1/4 lb. of magnesium sulfate per gallon of water in the 2nd injector concentrate tank. Put the 1:200 dosage rings on the dosage piston of both Dosmatics. The Dosmatic injectors will withdraw 1 gallon of concentrate for every 200 gallons of water flowing through the system. With 1/2 lb. dissolved in each gallon of water, 1/4 lb of concentrate will be delivered with 100 gallons of water. This is 1/2 strength nutrient solution and should be used on lettuce seedlings. When the lettuce plants are 1 to 3 weeks old, put the 1:100 dosage rings on the dosage piston. The dosmatics will now be injecting 1/2 lb. of concentrate for every 100 gallons of water. This is full strength nutrient solution.

This Dosmatic injector system can be used to continuously "top off" the nutrient storage tank used in the NFS system. It is advisable to pump the nutrient storage tank dry every two weeks. It can then be cleaned of sediment and debris, and filled with new nutrient solution. The reason for discarding the nutrient solution in this tank is that usage by the plants changes the concentration levels of the various elements. This creates an imbalance which can be harmful to the lettuce plants' growth.

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 macro and micro 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. If the root temperatures drop below 60°, the roots begin losing their ability to absorb some of the nutrients. This causes the plant to slow its vertical growth and instead, develop a thicker stem and tougher leaves. This type of plant is called "bullish".

The pH of your nutrient solution 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

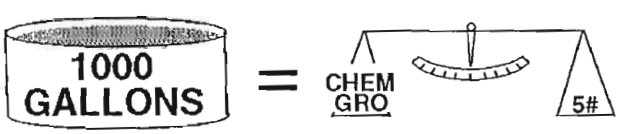
READ THE INSTRUCTIONS ON THE PAGE OF THE CATALOG OPPOSITE THE FORMULA YOU ARE USING TO INSURE YOU ARE MIXING THE CORRECT FORMULA FOR THE STAGE OF THE SPECIFIC CROP AND VARIETY BEING GROWN.

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 on the page opposite the fertilizer you are using 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.

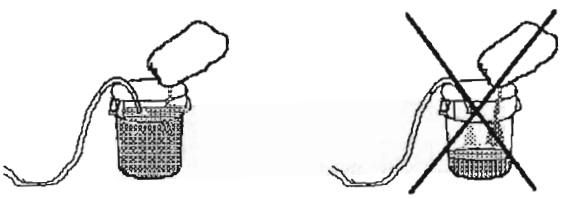


Fertilizer will dissolve more quickly in warm water than in cold. Do not exceed 70°F.

1/4th teaspoon of Chem-Gro dissolved in 1 gallon of distilled water will be about 500

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 on the page opposite 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. (Calcium Nitrate is in bead form because it 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.**