Calculating Fertilizer Rates

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When fertilizer is added to water, it is referred to as ***nutrient solution.*** A properly balanced nutrient solution contains the correct proportions of the major elements nitrogen, phosphorus, potassium, calcium, magnesium, sodium and sulfur plus the minor elements boron, chlorine, copper, iron, manganese, molybdenum and zinc. Plant growth will be reduced if the nutrient solution contains too little fertilizer or if one or more of these elements are missing. If too much fertilizer is added to the nutrient solution, plant growth will also be diminished.

The correct ratio of elements is a complicated subject. Some of the elements are needed in only minute amounts. Thus, many growers choose to purchase commercially prepared fertilizer formulations. Fertilizer companies may have different formulations for different crops and they also recommend different proportions of fertilizers for the various stages of crop growth. Many growers use these commercial fertilizers, but amend them somewhat for improved performance.

It is convenient to add a given amount of fertilizer to each gallon of water in the tank. Therefore, one must know how many gallons of water the tank contains. An easy way to determine the quantity of water in a tank is to use a water meter. Since this isn't practical for many growers, it is worthwhile to learn the following:

1 inch depth of water on 1 square foot of tank = 0.625 gal
Area of a rectangle = length x width
(area of an 8 ft. x 4 ft. tank = 32 square ft.)
Area of a circle = 3.14 x radius squared
(area of a 10 ft. diameter tank = 3.14 x 5 ft. x 5 ft. = 78.5 sq. ft.)

An 8 ft. x 4 ft. tank with 2 inches of water contains 40 gallons of water.

8 ft. x 4 ft. x 0.625 gal/in x 2 inches = 40 gallons

A 10 ft. diameter circular tank with 2 inches of water contains 98 gallons.

3.14 x 5 ft. x 5 ft. x 0.625 gal/in x 2 inches = 98 gallons

For Beginners - An Easy Way to Calculate Fertilizer Rates

Chem-Gro Universal Sump Tank Formula 10-8-22 is an all-in-one solid fertilizer which is suitable for beginners, home gardeners and student projects. This fertilizer works well for most garden crops, but it is somewhat low in calcium and magnesium and must be stored in a dry place or else it will gather moisture and become mushy.

The recommended rate of this fertilizer is 1 teaspoon per gallon of water. For example, 1 teaspoon of this fertilizer is added to a gallon of water and this is enough water and fertilizer to grow a head of leafy lettuce. Alternatively, one could add 1 tablespoon (1 tablespoon = 3 teaspoons) per 3 gallons of water or 1 lb per 100 gallons of water. (One lb of this fertilizer should be enough to grow about 100 heads of leaf lettuce.)

Therefore, a bucket with 4 gallons of water would receive 4 teaspoons of fertilizer. An 8 ft. x 4 ft. tank with 3 inches of water (60 gallons) would receive about 20 tablespoons or 60 teaspoons or 0.6 lb of Chem-Gro 10-8-22 fertilizer. Under most conditions, this should be enough water and fertilizer to grow 48 to 60 heads of lettuce in this tank. That's all there is to it!

For Intermediate Growers

Commercial growers demand improved yields and quality and are usually not satisfied with a general hydroponic fertilizer and prefer to use more specific fertilizers. These fertilizers usually have 2, 3 or 4 parts. Total-Gro Steiner Formula 8-5-16 has a white mix (calcium nitrate) and a blue mix (all of the other elements). The calcium is kept separate to prevent it from reacting with phosphorus and sulfates (precipitates would form). Chem-Gro and pht Formula 8-15-36 are lettuce fertilizers which contain all of the minor elements and some of the major elements, but they need to be supplemented with calcium, magnesium and nitrogen. Again, the calcium must be kept separate to prevent formation of precipitates. These manufacturers recommend that growers add calcium nitrate and magnesium sulfate. Thus, the Chem-Gro and pht fertilizers have 3 separate parts. Sometimes, potassium nitrate is also added, so this would result in a 4-part fertilizer.

These fertilizers are soluble. It is convenient to dissolve them in water and apply as liquids, because liquids can be accurately measured with simple measuring cups. Also, some growers use fertilizer injectors to mix nutrient solutions and these require liquids. Dry fertilizers often gather moisture after the bag has been opened and they become sticky and hard to handle.

When dry fertilizer is dissolved in a small amount of water, this is called a **stock solution**. Stock solutions are quite stable and will store for a long time, but they should be stirred before using. Liquid stock solutions are added to water in the growing tank. We will first discuss how to make a stock solution and then suggest how much of each stock solution should be added to the tank water.

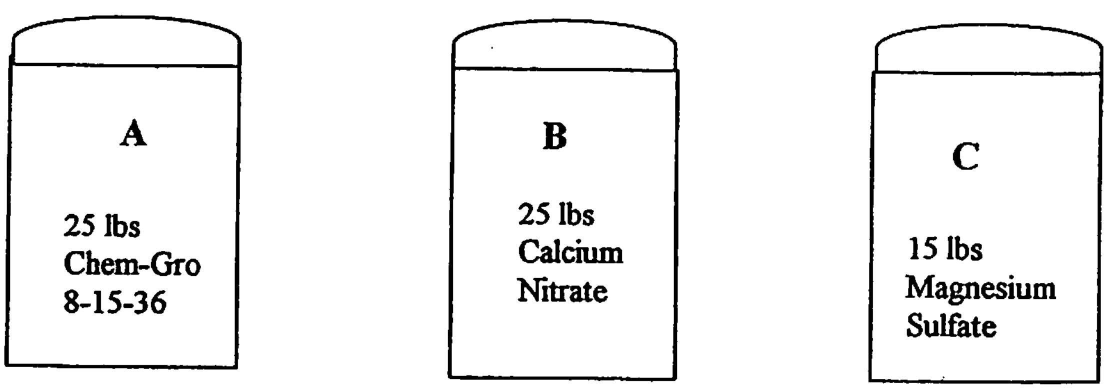
For illustration purposes, let's discuss how to make stock solutions based upon Hydro-Gardens Chem-Gro Lettuce Formula 8-15-36.

STOCK SOLUTIONS

A.) 1 lb of Chem-Gro 8-15-36 fertilizer per gallon of water or 25 lbs/25 gallons of water

B .) 1 lb of calcium nitrate (soluble type) per gallon of water or 25 lbs/25 gallons of water

C.) 0.6 lb magnesium sulfate per gallon of water or 15 lbs/25 gallons of water



Final volume of A, B and C = 25 gallons (Fertilizer + water)

Many growers like to make a 25 gallon batch because a large plastic trash container will hold 25 gallons of liquid. Since a bag of hydroponic fertilizer weighs 25 lbs, the whole bag may be used in one batch. Calcium nitrate comes in 50 lb bags, so one bag will be adequate for 2 batches.

Some growers choose to combine the contents of Stock Solutions A and C (ie. 25 lbs Chem-Gro 8-15-36 + 15 lbs magnesium sulfate in 25 gallons of final volume of liquid). Then, they only need 2 stock solutions (AC and B stock solutions).

If you are starting with only water in the growing tank, add 1/2 ounce (about 1 tablespoon) of all 3 stock solutions per gallon of water (ie. 1/2 oz of solution A + ½ oz of solution B + ½ oz of solution C). Thus, an 8' x 4' tank with 3 inches of water would contain 60 gallons of water and you would add 30 ounces of all 3 stock solutions in this tank (30 oz of solution A + 30 oz of solution B + 30 oz of solution C).

Place the stock solutions in different locations of the tank, because calcium will react with phosphorus and sulfate to form precipitates when in a concentrated form such as a stock solution. However, they do not react when in a diluted form in the growing tanks. This is the reason that calcium nitrate must be in a separate stock solution. In fact, it is recommended to have a separate stirring stick and a separate measuring cup for each stock solution.

Growers would like to measure and monitor nutrient solution strength quickly and inexpensively. A simple electrical conductivity tester costs about $60 and can measure the electrical conductivity (EC) of a liquid in about 10 seconds. The instrument measures total electrical conductivity of the ions in solution and does not distinguish between ions.

The instrument reads in millimhos/cm or mS (milli-siemens). One mS is equal to about 640 ppm of salt.

Assuming that a balanced fertilizer is applied to the water in the tank and that the water source is free of salts, a high reading indicates that more fertilizer is present and a low reading indicates that little fertilizer is present. Many growers aim for a range of 1.5 to 2.5 mS. If the reading is too low, add equal amounts of all 3 stock solutions until the target level has been achieved. (Actually, we recommend that you wait for 1 day after adding the stock solutions before measuring the electrical conductivity.) Plants may suffer salinity damage when the electrical conductivity is too high. If the electrical conductivity exceeds 2.5 mS, then dilute the nutrient solution with water. Tomato growers often use a 1.0 mS nutrient solution strength from transplanting until early fruit set after which the EC is increased to 2.0 - 2.5 mS. The initial EC for an exotic crop which originated from the rainforest should only be 0.5 mS and it may be increased by trial and error.

In the previous example of adding 1/2 ounce of all 3 stock solutions per gallon of water, the EC reading was 1.4 mS which is slightly low. A grower may wish to add about 30 per cent more stock solution or it might be left alone. The grower would rely on experience with the particular crop to make this management decision.

If the water source has high salinity, there will be a tendency for salinity to build up as more of this saline water is added to the tank. This is a real problem with tap water from the Kona area. Since the EC tester can't distinguish between non-usable salt ions and fertilizer ions, the EC reading will not provide a true indication of fertilizer nutrient content of the nutrient solution. In these cases, it would be prudent to partially drain the nutrient solution several times during the cropping season or else obtain a complete laboratory analysis of the nutrient solution from the UH CTAHR Agricultural Diagnostic Service Center.

For Semi-Advanced Growers

Let us base fertilizer application rates upon the projected removal of nutrient elements by the plants. A precise fertilizer recommendation would include calculations of nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, boron, copper, iron, manganese, molybdenum and zinc. This would be quite complicated.

A simplified approach would be to apply a complete fertilizer which is recommended by a reliable supplier and assume that all of the elemental levels decrease uniformly in the nutrient solution with uptake by the plants. (Of course, this will never be exactly true and this can lead to a complex discussion which we shall avoid in this paper. Also, some elements are taken up very quickly whereas others are taken up slowly.) Thus, if one only calculates the application rate for one element, and then the correct amounts of all of the other nutrients will be automatically applied. For example, if we add the correct amount of nitrogen, then the plants should receive adequate amounts of all the other nutrients.

If the 3 nutrient solutions were made correctly, one liter of the 8-15-36 nutrient solution would contain 9.6 grams of nitrogen; one liter of the calcium nitrate solution would contain 18.6 grams of nitrogen and one liter of the magnesium sulfate solution would not contain any nitrogen. Therefore, one liter of all 3 solutions would contain 28.2 grams of nitrogen.

1 lb dry fertilizer/gal of water = 454 g/3785 ml = 120 g/1000 ml
8% nitrogen (from 8-15-36) of 120 g = 9.6 g nitrogen/1000 ml
15.5% nitrogen from (calcium nitrate 15.5-0-0) = 18.6 g nitrogen/1000 ml
9.6 g nitrogen + 18.6 g nitrogen = 28.2 g nitrogen/1000 ml of all 3 stock solutions

A leafy lettuce plant contains approximately 4% dry matter and the dry matter contains about 4% nitrogen. Therefore a 200 gram head of lettuce contains 8 grams of dry matter and about 0.32 grams of nitrogen.

200 g wet wt. x 4% dry matter = 8 g dry matter x 4% nitrogen = 0.32 g nitrogen/plant

If an 8' by 4' tank had 60 heads of lettuce, the approximate nitrogen requirement would be 19.2 grams nitrogen.

60 heads x 0.32 g nitrogen = 19.2 grams nitrogen/60 heads

The correct fertilizer application rate would be 681 ml of all 3 stock solutions.

$$\frac{19.2 \text{ g nitrogen/60 heads}}{x \text{ ml}} = \frac{28.2 \text{ g nitrogen}}{1000 \text{ ml (1 liter)}}$$

x = 681 ml (0.68 liter) of all 3 nutrient solutions

It might be wise to add another 10% so the final amount should be 749 ml (0.75 liter).

681 ml x 1.1 = 749 ml (0.75 liter) of all 3 stock solutions.

Let's calculate the amount of stock solution needed for each head of lettuce. If 749 ml of stock solution are needed for 60 heads, then 12.5 ml are needed per head.

749 ml/60 heads = 12.5 ml/head

If a large tank has 200 heads, then 2.5 liters of each stock solution are needed.

200 heads x 12.5 ml/head = 2500 ml = 2.5 liters/tank

A lettuce growing method such as the net pot method requires that the full amount of water needed for the whole crop should be placed in the tank at planting time. The full amount of fertilizer is added to these tanks at planting time. However, methods such as the sub-irrigation pot method or methods for long-term crops such as tomatoes require considerable additions of water throughout the growing period. The full application of fertilizer to this tank at planting time would result in an excessively high electrical conductivity and likely cause injury to the plants. Generally, we don't like to exceed an electrical conductivity of 2.5 mS. Therefore, it would be prudent to add fertilizer in the same proportions as water is added to the tank. However, if the weather is hot, the plants may use more water, thus causing fertilizer to build up such that lower rates of stock solutions should be added.

Many growers do not discard the remaining nutrient solution after a crop is harvested. The new crop is the beneficiary of residual fertilizer in the tank. How do we calculate the amount of residual fertilizer? This will be difficult because all of the elements are not absorbed at the same rate. For example, nitrogen, phosphorus, potassium and manganese are usually taken up more rapidly than calcium and magnesium. One approach to this complex subject is to send a sample of the remaining solution to the UH CTAHR Agricultural Diagnostic Service Center for analysis and use this information to calculate the nutrients in the remaining nutrient solution. A less accurate, but practical approach is to simply add stock solutions to the refill water at the same rate as was added to the original solution and then to make a practice of dumping the tanks several times per year and start with fresh nutrient solution again.

Suppose you want to calculate how much fertilizer is needed per year, or how long the barrels of stock solutions will last? Our stock solutions consisted of dissolving 25 lbs of Chem-Gro 8-15-36, 25 lbs of calcium nitrate and 15 lbs of magnesium sulfate in a total of 25 gallons of solution which converts to 94,625 ml of solution (25 gal x 3785 ml/gal). Previously, we learned that lettuce required about 12.5 ml of all 3 stock solutions. Therefore, 25 gallons of all 3 stock solutions would be enough to grow 7570 lettuce plants.

94,625 ml/12.5 ml/plant = 7,570 plants

If you plant 500 plants per week then you would need to make a new batch of stock solutions every 15.1 weeks.

7570 plants/500 plants/week = 15.1 weeks

You would need 3.44 fertilizer batches/year.

52 weeks/15.1 weeks/batch = 3.44 batches/year

It is also possible to calculate the fertilizer cost per plant. Suppose 25 lbs of Chem-Gro cost $70, 25 lbs of calcium nitrate cost $17 and 15 lbs of magnesium sulfate cost $13. The total fertilizer cost for one batch of stock solutions is $100 (or 10,000 cents.) If we can grow 7570 plants from one batch, the fertilizer cost is 1.32 cents/plant.

$100/7570 plants = $0.0132 or 1.32 cents/plant

The fertilizer cost for the 60 heads in the 8' x 4' tank would be $0.79.

60 heads x $0.0132 = $0.79 or 79 cents

<u>Adding iron to nutrient solution.</u> Hydroponic researchers usually recommend 2 to 4 ppm (parts per million) of iron in the growing solution. There are situations where iron may be deficient either because the hydroponic fertilizer contained too low a rate of iron or because some of the iron reacted with other elements and became unavailable. One approach is to add 478 ml of iron metalosate to the 25 gallon calcium nitrate stock solution tank for every 1 ppm desired increase of iron in the growing tanks (in a

situation when 15 ml of stock solution is added per gallon of growing solution). The logic and calculations follow in the next paragraph.

Iron metalosate contains 5% iron or 5 grams per 100 ml (= 5000 mg/100 ml = 50 mg iron/ml of iron metalosate). Assume that 15 ml of the calcium nitrate/iron metalosate stock solution is added per gallon of growing solution. Then, a 25 gallon stock solution tank will treat 6308 gallons of growing solution (25 gallons x 3785 ml/gal = 94,625 ml/15 ml/gal of stock solution = 6308 gallons of growing solution). This calculates to 23,876 liters of growing solution (6308 gallons x 3.785 liters/gal = 23,876 liters). A 1 ppm solution may be defined as 1 g per million grams or 1 mg (milligram) of iron per liter of growing solution. Thus, 23,876 mg of iron should be added to the stock solution to increase the iron content of the growing solution by 1 ppm (23,786 liters of growing solution x 1 mg iron/liter of growing solution). The addition of 478 ml of iron metalosate to the 25 gallon calcium nitrate stock solution tank will raise the iron in 6308 gallons of growing solution by 1 ppm (23,876 mg of iron/50 mg iron/ml of iron metalosate = 478 ml of iron metalosate.)

<u>Adding silicon to nutrient solution</u>. Dr. Bruce Bugbee of Utah State University recommends adding 0.1 mM (millimolar) silicon to nutrient solution to help protect against insect and disease attack and to protect against the toxicity of metals. Dr. Emmanuel Epstein of The University of California-Davis wrote an extensive review on silicon and recommends a 0.25 mM silicate concentration in the growing solution. Adding 0.136 ml of Dyna-Gro potassium silicate to a gallon of growing solution (or 13.6 ml/100 gallons of growing solution) would achieve Dr. Bugbee's recommendation of 0.1 mM silicon. This should be added directly to the growing solution rather than to the stock solution, because potassium silicate raises solution pH and it is easier to correct in the growing solution. The calculations are contained in the following paragraph.

Dyna-Gro manufactures a potassium silicate product containing 7.8% silicon. Let us consider that 1 ml of this solution contains 0.078 g silicon (it actually is somewhat higher due to the higher density of potassium silicate). The molecular weight of silicon is 28; thus, a 1 molar solution would contain 28 g/liter. Following Dr. Bugbee's recommendation, a 0.1mM growing solution would contain 0.0028 g silicon/liter (0.1 mM = 1/10,000 of 1 M x 28 g = 0.0028 g) which is equivalent to 0.0106 g/gallon (0.0028 g/liter x 3.785 liters/gal = 0.0106 g/gallon) of nutrient solution. Adding 0.136 ml of the Dyna-Gro potassium silicate to a gallon of growing solution will give a

0.1mM silicon solution ([0.0106 g silicon/gal]/0.078 g/ml). Thus, the addition of 13.6 ml of Dyna-Gro potassium silicate to 100 gallons of growing solution would achieve Dr. Bugbee's recommendation of 0.1 mM silicon. A grower wishing to follow Dr. Epstein's recommendation of 0.25 mM silicon should add 34 ml (13.6 ml x 2.5 = 34 ml) of Dyna-Gro potassium silicate to 100 gallons of growing solution.

We find that the above methods of calculating fertilizer rates are a good starting point for many growers. However, there are more complicated and more precise ways of calculating fertilizer rates and growers are encouraged to explore these.

Mosquito Control

Mosquitoes breed in stagnant nutrient solution in non-circulating hydroponic tanks and become a major nuisance as well as a health hazard. Here are 3 methods for mosquito control in nutrient solution.

Screening

The open sides of the greenhouse should be screened to prevent mosquitoes from flying in. Window screen may be draped in a tank such that the initial nutrient solution level is higher than the screen because the containers holding the growing medium and plants must be immersed at seeding or transplanting time. Roots extend through the screen as the crop grows and the nutrient solution level drops below the screen, thus trapping newly hatched mosquitoes under the screen where they eventually die.

Fish

Fish which eat mosquito larvae may be placed in hydroponic tanks. Tanks should be somewhat deeper than normal to insure that there is at least several inches of nutrient solution in the tank at the end of the crop or else the fish will die. Some fish can not tolerate the salinity of the nutrient solution and die. Fish caught from a brackish pond are usually tolerant to the hydroponic solution. Nevertheless, it is wise to place some fish in a bucket of nutrient solution for a few days to determine if they can tolerate the hydroponic solution.

Insecticide

Pyronyl Crop Spray is registered for use with hydroponically grown vegetables in the water system to control diptera larvae. Tests conducted by a UHH agriculture student indicated that a 1 ppm (part per million) rate of the commercial formulation of Pyronyl killed mosquito larvae within 36 hours and a 2 ppm rate killed the mosquito larvae within 2.3 hours.

Consider that 1 gram or 1 ml of Pyronyl in 1,000,000 ml of water = 1ppm.
100 gal water = 378,500 ml.
1 ppm in 378,500 ml = 0.3785 ml of Pyronyl

Since 0.3785 ml of Pyronyl is too small to measure, one suggestion is to make a 1% Pyronyl solution by adding 10 ml of the commercial Pyronyl formulation in 1 liter (1000 ml) of final solution (10 ml Pyronyl + 990 ml water = 1000 ml). Then, each ml of the 1% dilution will contain 0.01 ml of Pyronyl.

A grower would then add 38 ml of the 1% pyronyl dilution to 100 gallons of water (38 ml of 0.01 ml Pyronyl/ml = 0.38 ml of Pyronyl).
The following amounts of 1 % Pyronyl could be added to the nutrient solution:

Gallons nutrient solution	ml 1% Pyronyl solution
10	4
20	8
40	15
60	23
80	30
100	38

Harvesting and Marketing

Early morning is the best time for harvesting. Lettuce may wilt when it is harvested in mid-day. Tomato and cucumber fruits are cooler when harvested early in the day. Thus, less energy is needed to cool them when they are refrigerated.

Lettuce should be misted lightly with plain water before harvesting or immediately after harvesting. This helps to prevent wilting.

You should always wash your hands well before harvesting or use clean gloves. Make sure that you wash your hands well after going to the toilet.

Harvesting containers should be cleaned regularly.

A convenient way to place lettuce in a plastic produce bag is to place your hand in the bag, grasp the head of lettuce and pull the bag over the head.

Consider making 'mixed bags' of lettuce by placing several kinds of lettuce in the same bag.

When packing lettuce or fruits in a box, place cardboard between layers because this will help to prevent crushing and bruising.

Protect your product during transport to the market. For example, don't place lettuce in open boxes on a truck bed in full sun.

Availability, quality and price are the three most import aspects of marketing. Availability means that you must be able to grow your product consistently. Chefs will value you as a supplier if you can deliver your product quickly if they suddenly run short.

When selling to a hotel or chef, make up sample boxes of your product and be prepared to discuss availability and price. Ask how and when you will be paid. Be prepared to deliver an invoice with the product.

Don't be afraid to set your price. Look for niche markets. Make sales calls during slow times. For example, don't try to interrupt a chef in the middle of the lunch or dinner rush.

One pricing strategy is to divide your customers into 2 or more classes. For example, the price is $2/lb for *customer A* and $1/lb for *customer B*. However, *customer A* gets the best quality product plus all the product he needs when and where he wants it and *customer B* gets what is left over. Unfortunately, you may lose *customer B* when you are short of product and all of it goes to *customer A*.

Germinating Seeds and Raising Seedlings

Seed germination occurs when the seeds imbibe water after being moistened and life processes begin. Roots and shoots emerge from seeds and seedlings develop and these eventually grow into mature plants. Not all seeds germinate, but there are simple techniques which can greatly improve the germination percentage.

Seed germination and vigor (energy or strength of the seedlings) is greatly reduced by high temperatures, high humidity and age. Certain seeds can tolerate these conditions more than others.

Purchasing seed.

Ideally, one should purchase fresh seed which has been vacuum packed or packaged in air-tight foil packages and stored at low temperatures. The seed package should have a packaging date and a percentage germination at that date. Poor germination results from seed packaged in paper envelopes which have been sitting in a store without air-conditioning and from seed which is several years old.

Upon purchasing the seed, keep it as cool and dry as possible. Don't leave it in a car parked in the sun with the windows up.

When you arrive at home, separate the seed into a '*mother batch*' and a '*working batch*'. The mother batch should be placed in a sealed plastic bag and remain in the refrigerator (preferably frost-free) except for brief periods when it must be taken out to refill the working batch container. A plastic photographic film container is excellent for storing working batches.

Working batches remain in the refrigerator except for one hour periods or less when they are taken to the seeding area. For this reason, it is recommended that the seeding area is located near the home such as in the garage or a seedling greenhouse near the home. If you must take the working batches to the field area for an extended period, keep the seeds cool by placing them in an ice chest or keeping them in a cool or shady location.

The late afternoon or evening is best for seeding, because this allows the germination process to start during the cool night. The mid-day heat may cause thermodormancy (the seeds do not germinate due to high temperature) in some crops such as lettuce and it may cause damage to the working batches of seeds.

Germinating the seed.

Method 1. A simple germination method is to place tissue paper or a paper towel in the bottom of a cup, a tupperware dish or a recycled clamshell container from a bento lunch or fast food sandwich. Wet the paper with water and drain so that there are only a few drops of free water in the container. Spread seed uniformly in the container. Place a lid over the container. For example, place a saucer over the cup or close the clamshell container. This now becomes a germination chamber. Place the germination chamber in a dark place at room temperature such as in a drawer. Check the germination chamber every day to see if the seeds are germinating.

When the seeds are germinating, transfer them to pots, trays or containers filled with moist growing medium. First, make a small hole (¼ to ½ inch deep) in the medium with a pencil or dibble and then transplant the germinated seeds by hand or with a forceps. After transplanting these small seedlings, lightly close the planting holes.

Method 2. Fill seedling trays or net pots or containers with moist growing medium. Make ¼ to ½ inch deep holes in the growing medium with a pencil or dibble. Cut the top side and right side from an ordinary envelope. Place seeds in the envelope. Notice that the bottom crease forces the seeds to line up in a single file formation. Use a pen or pencil or sharpened stick to guide the seeds into the seedling containers. You may choose to plant 1 or 2 seeds in each cell or container.

Mist the seeds with water either with a spray/mist bottle or with a mist head . Lightly cover the seeds with additional fine growing medium or lightly close the planting holes. Cover the containers with a one inch thick sheet of polystyrene sheet for 24 hours. Do not place the freshly seeded containers in the hot sun. A cool shady place is preferred. The polystyrene sheet provides insulation from heat and prevents the growing medium from drying out.

After the seeds begin to germinate (this may be 24 hours for lettuce or several days for tomatoes), remove the polystyrene sheet and place the seedling containers on a bench, preferably in a small greenhouse. They should be misted at least twice daily for several minutes. Watering with a sprinkling can tends to erode the growing medium and may ruin the tender seedlings. Mist systems can be automated with an automatic timer and a solenoid device for less than $100. After 1 to 2 weeks, the seedlings may be taken to the growing area and transplanted.