Fertilizing Greenhouse Vegetables

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GREENHOUSE CROPS require a very high level of soil fertility for maximum yields. Fertilization of the soil to reach these high levels of fertility is a necessary part of every greenhouse growing program, even though it is only a minor part of the cost involved in producing high-quality crops such as lettuce and tomatoes.

The objective of the grower's fertilizer program should be to reach and maintain the soil fertility level that is necessary for maximum yields. When a soil is brought up to a high state of fertility, only limited applications of fertilizer will be needed to maintain an available nutrient supply. In fact, excess amounts are likely to decrease yields.

Plant tissue can contain as many as 40 different elements, and 16 of these are considered essential for plant growth. Three of the essential elements — carbon, oxygen, and hydrogen — constitute approximately 90 percent of the dry weight of plants, and are derived from air and water. The remaining 13 mineral elements are primarily obtained from the soil solution. The soils of Illinois have insufficient quantities of nitrogen, phosphorous, and potassium for greenhouse crop production, and are often low in calcium and magnesium as well. These nutrients, with the exception of nitrogen, are considered immobile in the soil, so fertilizers containing them should be uniformly incorporated into the soil mixture. For maximum benefit add these materials prior to planting. Nitrogen, regardless of the fertilizer source, may be sidedressed and watered in. It is important to avoid getting concentrated fertilizer (especially urea) on the plant leaves and stems.

This guide for fertilizing greenhouse vegetables is based on Illinois soil tests, and therefore is not appropriate for other test methods. (For information on growing and fertilizing transplants see Illinois Cir. 884, *Growing Vegetable Transplants.* Single copies are available from your farm adviser, or by writing to the Agricultural Information Office, University of Illinois, 112 Mumford Hall, Urbana, Illinois 61801.)

SOIL TESTS

Soil tests measure the relative amounts of plant nutrients in the soil and are useful for planning the fertilizer program. Soil tests should be obtained prior to planting each crop, but test results are no better than the sample that is sent to the laboratory. Each sample for testing should be made up of a thorough mixture of 8 to 10 cores of soil taken from the surface in several areas of the greenhouse at a depth of 10 to 12 inches. Remove the top inch of soil and the mulch before taking the sample. Problem areas and different greenhouses should be sampled separately. One-half to one pint of soil is needed by the laboratory. Crumble the soil and air-dry before shipping.

The University of Illinois tests soil samples for a charge of $1.00 per sample. Make checks payable to the University of Illinois, and send the following information:

1. Crop to be planted.
2. Previous crop.
3. Last time manure and limestone were applied, and amounts applied.
4. Any unsatisfactory condition such as foliage color, burn, fruit problems, etc.
5. Name, address, and telephone.

Send the samples to the Soil Testing Laboratory, S-412 Turner Hall, University of Illinois, Urbana, Illinois 61801. Allow a minimum of three weeks for the laboratory to complete the analysis.

SOIL TEST INTERPRETATIONS AND CROP REQUIREMENTS

SOIL pH

The soil pH should be 6.5 to 7.0 for tomatoes and lettuce. If the pH test shows an extremely acid condition (pH below 5.8), hydrated lime can be applied at two-thirds of the rate recommended for agricultural limestone when a more rapid change in soil reaction is desired.

Limestone Needed to Correct Soil Reaction of Greenhouse Soils[a]

pH test	Pounds of limestone per 1,000 square feet[b]	
	Dolomitic[c]	Agricultural[d]
6.5–7.0	0	0
6.2–6.4	56	72
5.8–6.1	85	109
5.4–5.7	142	158

[a] Adapted from University of Illinois Cir. 721, *When, Where, How to Apply Limestone for More Profitable Farming.*
[b] Based on fineness of 90 percent through 8-mesh, 60 percent through 30-mesh, and 30 percent through 60-mesh screen.
[c] Calcium carbonate equivalent (neutralizing power) of 100 percent.
[d] Calcium carbonate equivalent of 90 percent.

SOLUBLE SALTS

The soluble salt test, measured on a Sol-U-Bridge,[1] is an overall measure of the total concentration of all salt materials in the soil solution. These salts are reported in parts per million (p.p.m.), and include nitrates, sulfates, chlorides, sodium, potassium, and other materials. Under greenhouse conditions, salts, especially undesirable chlorides, may accumulate in the soil over a period of time. Manure, inorganic and organic fertilizers, and irrigation water all contribute to the salt problem.

To prevent soluble salt problems, develop a fertilizer program based on soil tests, and avoid using more fertilizer than needed. Avoid fertilizers with a high salt index, especially when large amounts are to be used. Avoid using fresh manures that may contain a high salt content. No mixed or other fertilizers containing muriate of potash (KCl) should be used in the greenhouse. If the phosphorus and potassium levels are very high, it may be well to use only nitrogen fertilizers as long as yields are satisfactory.

To correct a soluble salt problem, the soil should be leached if adequate drainage permits. Leaching is most effective if the soil is watered heavily, allowed to soak for a few hours to bring as many salts into solution as possible, and watered heavily again. If poor drainage makes leaching unfeasible, the soil can be allowed to dry thoroughly, and the top inch or two of the soil removed and thrown away. The movement of water to the surface will bring some salts to the surface. This process can be repeated if necessary. In extreme cases, the soil may have to be replaced. If the soluble salts are caused by high levels of nitrate, the incorporation of materials such as corn cobs and straw will tend to reduce the nitrate level.

[1] Growers can test their own soil for soluble salts with a Sol-U-Bridge soil tester. The test is simple and accurate. The machine is available from Industrial Instruments, Inc., 89 Commerce Road, Cedar Grove, Michigan.

Interpretation of Sol-U-Bridge Readings (Illinois Test: 1 Part Soil to 5 Parts Water)

Sol-U-Bridge reading	p.p.m.	Interpretation
0–25	0–950	Low.
25–80	950–3,040	Satisfactory range for established plants, but upper range (2,500 to 3,000 p.p.m.) may be too high for seedlings.
80–100	3,040–3,800	Higher than desirable. Plants may grow satisfactorily but they can be injured if the soil becomes dry, or if fertilizer is applied. Critical for seed germination.
100–150	3,800–5,700	Plants usually injured. Sensitive plants may be killed.
150+	5,700+	Most tolerant plants often severely stunted. Crop failure likely.

Testing Water Samples. If well water is suspected as a source of soluble salts, it can be tested by the Illinois State Water Survey, 605 East Springfield, Urbana, Illinois. There is no charge, but the Water Survey requires you to do the following: (1) Send 1 quart of water in a clean jar. (2) Give the depth of the well and the *exact* location, *referring to two township section lines.* (3) State the uses of the water. The water will be tested for total mineral content, chlorides, alkalinity, boron, and hardness.

NITROGEN

The inherent composition of a soil, the light intensity, and stage of plant growth will materially influence the nitrogen requirements. Furthermore, the nitrate test will fluctuate from week to week depending on the time of year, watering, and the kind of mulch used. Therefore, the soil test can only be used as a rough estimate of the nitrate situation.

The organic matter in the soil forms a reservoir for release of nitrogen. For this reason, it is well to maintain high organic matter levels by turning under well-decomposed manure or other organic materials (straw mulch, peat, corncobs). Do not apply a large quantity

Interpretation of Nitrate Test

Spurway nitrate test, p.p.m.	Rating	Good level for
0–5	Low	
8–12	Medium	Starting spring tomatoes (Jan.-Feb.)
15–25	High	Starting fall lettuce or tomatoes
25–40	Very high	Finishing spring tomatoes (June)
50+	Excess	

of manure at one time. From 10 to 20 tons per acre, prior to planting, is usually sufficient.

Nitrogen fertilizer is best used in sidedressing applications for tomatoes varying with plant vigor and time of year. Excessive nitrogen when tomato plants are small, especially in mid-winter, may result in poor fruit set. Nitrogen should be applied in limited quantities before planting.

For the fall tomato crop, a sidedress application of ½ to 1 pound of actual nitrogen per 1,000 square feet may be needed after a good fruit crop is set. Three or four sidedress applications may be required. Medium (8 to 12 p.p.m.) nitrogen levels should be maintained during the period of short days and low light intensities, from late fall to early spring.

Tomato plants need greater amounts of nitrogen under prolonged periods of high light intensity and good fruit set in early spring. Sidedress applications can begin, if needed, in late February or early March, after fruit are set on the first two clusters. As a good fruit load develops, as much as 1 pound of actual nitrogen per 1,000 square feet may be needed every 10 to 14 days.

The total amount of nitrogen needed and the frequency of application for a tomato crop will vary according to the basic soil fertility, the season (fall or spring), fruit load, and soil conditions. Growers applying frequent sidedressings should take one or two soil samples during development of the crop to check on soluble salt levels. If potassium levels are on the low side, potassium nitrate fertilizer can be used for every other sidedress application. Fertilizer should be used with restraint near the end of the crop, whether fall or spring, to prevent a carryover of both high salt and high nitrogen levels to the next crop.

Maintenance applications of 1 to 1.5 pounds of actual nitrogen per 1,000 square feet are suggested between lettuce crops. It may be advantageous under some conditions to obtain a portion of this nitrogen from potassium nitrate.

Some nitrogen-source fertilizers and the amounts of them necessary to supply 1 pound of actual nitrogen per 1,000 square feet are shown in the following table:

Nitrogen fertilizer	Pounds needed to supply 1 pound of actual N
Ammonium nitrate	3.0
Ammonium sulfate	5.0
Calcium nitrate	6.5
Potassium nitrate	7.5

PHOSPHORUS

The Illinois P_1 test is used to determine the availability of phosphorus in the soil. Unlike nitrogen, phosphorus is immobile in the soil. Only a small proportion of the phosphorus in the soil may be used by a single crop and, therefore, high levels of soil phosphorus are necessary for good crop development. A guide for application of phosphorus fertilizer prior to planting is found in the table below. A water-soluble starter-fertilizer high in phosphorus such as 10-62-0, 10-52-17, or 10-50-10 should be used at transplanting time. Mix 3 pounds in 50 gallons of water and apply 1 pint of the solution per plant.

Guide for Use of Phosphorus Fertilizer

Illinois P_1 soil test	Soil test rating	Pounds of elemental P per 1,000 square feet	Pounds of P_2O_5 per 1,000 square feet[a]
0–40	Low	6.6	15.0
41–80	Medium	4.4	10.0
81–120	High	2.2	5.0
120–160	Maintenance	1.1	2.5[b]
200+	Very high	0	0

[a] If these values are multiplied by 2.2, they will give the amount to be applied as treble superphosphate, 0-45-0.
[b] Assuming that two crops are grown each year, this amount could be doubled and applied once a year.

POTASSIUM

Relatively large amounts of potassium are needed for maximum production and for uniform ripening and development of tomato fruit. One-half of the maintenance rate for tomatoes is suggested for application between lettuce crops.

Potassium nitrate (13-0-44), potassium sulfate (0-0-50), and potassium phosphate (0-52-34) fertilizers are suggested as sources of potassium. Do not use muriate of potash (KCl) or fertilizers containing KCl.

Guide for Use of Potassium Fertilizer

K soil test	Soil test rating	Pounds of elemental K per 1,000 square feet	Pounds of K_2O per 1,000 square feet[a]
0–150	Extremely low	8.3	10
151–300	Low	6.6	8
301–400	Medium high	5.0	6
401–500	Maintenance	3.3	4
500+	Very high	0	0

[a] Multiplying these values by 2 will indicate the amount of potassium sulfate to use.

CALCIUM

Calcium deficiency is not thought to be a problem if limestone is added in amounts large enough to keep the pH in the proper range. Calcium levels should be maintained at 150 to 175 p.p.m. Gypsum can be applied at 50 pounds per 1,000 square feet if lime is not required and the calcium test shows a rating in the low or medium range.

Interpretation of Calcium Test

p.p.m.	Rating
100	Low
125	Medium
150–175	Optimum
200+	Very high

MAGNESIUM

The usual range of magnesium for greenhouse soils in Illinois is 5 to 8 p.p.m. (Spurway test). If magnesium levels are lower than 5 p.p.m., deficiency symptoms may occur.[1] The use of dolomitic limestone should prevent magnesium problems. If limestone is not needed or dolomitic is not available, apply 5 to 10 pounds of magnesium sulfate (epsom salts) per 1,000 square feet and incorporate prior to planting. If magnesium sulfate is sidedressed, apply 2 to 3 pounds per 1,000 square feet. Foliage sprays of 5 pounds per 100 gallons of water may also be beneficial.

[1] Write to the Department of Horticulture, University of Illinois, for a "Key to Nutrient Deficiency Symptoms on Tomato Plants."

MICRONUTRIENTS

Micronutrients are sufficient in most Illinois soils. Growers should not make general application of these materials since small amounts can be toxic. They should be used only when a deficiency is diagnosed.

Suggested Fertilizers for Greenhouse Use

Fertilizer	Elemental	Oxides	Salt index
NITROGEN		(percent)	
ammonium nitrate, 33.5-0-0	33.5		104.7
mono-ammonium phosphate, 12-61-0	12.0		34.2
ammonium sulfate, 20.5-0-0	20.5		69.0
diammonium phosphate, 21-53-0	21.0		29.9
calcium nitrate, 15.5-0-0	15.5		52.5
potassium nitrate, 13-0-44	13.0		73.6
urea, 45-0-0	45.0		75.4
PHOSPHORUS		P_2O_5	
ammonium phosphate, 11-48.8-0	21.5	48.8	26.9
diammonium phosphate, 21-53-0	23.3	53.0	29.9
super phosphate, 0-20-0	8.8	20.0	7.8
triple super phosphate, 0-45-0	19.8	45.0	10.1
mono calcium phosphate, 0-55-0	24.2	55.0	15.4
potassium phosphate, 0-52-34	22.9	52.0	....
POTASSIUM		K_2O	
potassium nitrate, 13-0-44	36.5	44.0	73.6
potassium sulfate, 0-0-50	41.5	50.0	46.1
potassium phosphate, 0-52-34	28.2	34.0	....
sulfate of potash-magnesia, 0-0-21	17.4	21.0	43.2
CALCIUM		CaO	
calcium nitrate, 15.5-0-0		27.0	52.5
calcium sulfate (gypsum), 18 percent sulfur		27.5	8.1
limestone, agricultural, 1–5 percent MgO		56.0	4.7
limestone, dolomitic, 33 percent MgO		50.0	.8
hydrated lime		75.0	....
MAGNESIUM		MgO	
limestone, dolomitic, 50 percent CaO		33.0	.8
magnesium sulfate (Epsom salts)		30.0	....
sulfate of potash — magnesia		18.0	43.2

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