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BASIC FERTILIZATION OF GREENHOUSE PLANTS*

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Proper fertilization is necessary to obtain top-quality growth of plants in the shortest time possible. It is especially important in greenhouses because (1) foliage as well as flower quality is important, (2) crops timed for a holiday may be worthless if they mature a week late, (3) the cost of operation per square foot is high and (4) the plants are grown in limited soil volume.

We know that at least 15 elements are essential to plant growth. They are carbon, hydrogen, oxygen, iron, boron, manganese, zinc, copper, molybdenum, sulfur, calcium, magnesium, nitrogen, phosphorus and potassium. Vitamins and hormones need not be added in most instances, as green plants are capable of supplying their own requirements in this regard.

If the needs of plants are known, why does confusion as to the best method of fertilization often exist? One reason is that there are many ways to fertilize plants and get the desired results. The primary objective is to supply the plants with the proper quantities of essential nutrients, not so little as to cause a deficiency or so much as to cause injury or unbalanced growth.

Factors influencing the amount of fertilizer to apply include time of year, soil type, growing temperatures, watering methods, use of mulches and the amount of sunshine or dark weather. Research work at Rutgers University has shown that roses and carnations require approximately half as much fertilizer between November 1 and March 1 as they do in any equivalent period during the remainder of the year. This variation in nutrient requirements may be even greater in Minnesota than in New Jersey, because the winter days are shorter and the sun is farther away. Silty-clay and clay soils require less frequent fertilization than do sandy soils, probably because of the greater loss of nutrients through leaching in a sandy soil. Crops grown at higher temperatures usually require more fertilizer than do crops grown at lower temperatures, because of a faster growth rate and more frequent watering. Some growers water heavily enough to have a little water run out of the bottom of the bench while others attempt to avoid this condition. Although watering heavily will require more frequent fertilization, it is preferable as it helps prevent the accumulation of soluble salts in the soil. Less fertilizer need be applied where sub-irrigation is practiced. Less fertilizer need be applied where mulches are applied because less frequent watering is required and as a result less leaching occurs. Some mulches such as manure and corn cobs provide nutrients to the soil once decomposition has started. The nutrient requirements will decline during a prolonged cloudy period in the spring or fall and it may also increase during prolonged or continuous sunny periods.

An equally important factor is the amount of fertilizer and organic matter in the starting soil. A soil which contains a moderately high supply of nutrients to start may require no additional fertilization for several months.

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The discussion which follows is designed to provide a little better understanding of the fertilization of greenhouse crops. Such fertilization need not be confusing if a little thought is given to the procedure.

Carbon is obtained by the plant from carbon dioxide in the air and is rarely deficient.

Hydrogen is obtained from water which is always present if growth is to take place.

Oxygen

Oxygen is obtained from air which usually contains 21 percent oxygen. Roots as well as plant tops require oxygen and limited growth may occur if the soil is kept too wet, is highly compacted or is too heavy. Research work at Cornell University with roses showed that plants supplied with 9.3 percent oxygen in the soil produced 46.3 cm. of growth while the plants with 4.7 percent oxygen in the soil produced 16.1 cm. of growth. Surprisingly, the color was good on both groups of plants and if a comparison had not been made, visual observations would have indicated that the plants growing in the soil with the lower oxygen concentration were making satisfactory growth. It cannot be overemphasized that proper soil preparation is an economy, not a luxury, when subsequent production is considered.

Incorporation of at least 25 percent by volume sphagnum peat moss in your starting soil will provide better soil aeration and water-holding capacity. Sphagnum peat moss is also known as German or Canadian peat moss and numerous bogs of it are present in Minnesota. The quality may vary from bog to bog, however, and local supplies should be checked carefully before using. Better quality peat moss decomposes slowly and its effect on soil improvement is long lasting. Since sphagnum peat moss is quite acid, the incorporation of a four-inch potful of pulverized limestone per wheelbarrow (two and one half cubic feet) of peat moss will avoid any changes in soil pH.

Although manure is a good source of nutrients including trace elements, it is not a preferred source of organic matter because it may bring about a more poorly aerated rather than a better aerated soil. Fine particles of manure appear to wash down inbetween the soil particles as the manure decays. Plugging of the soil "pores" and increased activity of soil organisms which require oxygen are responsible for the poor soil aeration.

Trace Elements

Although trace elements such as boron, manganese, zinc, copper and molybdenum are not generally deficient in greenhouse soils in Minnesota, it is possible that deficiencies may be more common in the future. Why? Because greenhouse soil is now steam sterilized and reused year after year, and because sphagnum peat moss which is replacing manure to a greater extent each year is very low in nutrient content. Bear in mind that while trace elements are essential to normal growth, they are required by plants only in very small or trace amounts. As a result, slight excesses may injure the plant and just a little more may kill the plant. Specific applications of individual trace elements are usually inadvisable because a slight error can result in serious trouble. Some complete fertilizer mixtures contain trace elements and the application of such a mixture two or three times a year will usually prevent the appearance of trace or minor element deficiency symptoms. Iron is an exception to the rule in that iron deficiency in the plant (chlorosis while the main veins remain green) is relatively common. Iron chlorosis is effectively controlled by applying a solution of chelated iron to the soil. Contrary to some recommendations for stronger rates, it is preferable to use chelated iron (12 percent iron) at the rate of one ounce in 25 gallons of water.

Calcium is usually, although not always, present in the soil in adequate quantities if the pH is 6.0 or above. If both the pH and the calcium levels must be raised, lime should be added. Unless a very quick response is required, pulverized limestone is preferable to hydrated lime because it influences the soil pH over a longer period of time. Dolomitic pulverized limestone contains both calcium and magnesium and should be used whenever limestone is needed. In this manner the magnesium requirements of the plant will usually be satisfied.

Calcium sulfate (gypsum) may be used when it is advisable to raise the calcium level without altering the pH.

Phosphorus

The application of phosphorus is usually necessary because some of it is fixed or tied up in the soil and much of the remainder is removed from the soil by plants. Phosphorus is not very mobile and does not leach readily from the soil. Dry phosphorus fertilizers applied to the soil surface do not penetrate to the root area very well, but soluble phosphate fertilizers applied in solution will. Soluble phosphate fertilizers are relatively expensive and it is usually preferable to mix superphosphate (0-20-0) in the soil before planting. In new soil it may be added at the rate of four to five pounds per 100 square feet or two and one-half pounds per cubic yard. In old soil which already contains some available phosphorus the superphosphate may be added at one-half the aforementioned rates. These quantities should normally supply adequate phosphorus for the entire crop. Although it is difficult to apply an excess of phosphorus if other nutrients are present in adequate quantities, there is no point in applying great excesses of phosphorus either. Observations in rose ranges have indicated that chlorosis may result from high phosphorus levels.

Superphosphate is one half gypsum and in addition to furnishing phosphorus it contains 20 percent calcium and 11 percent sulfur.

Sulfur is usually supplied in adequate amounts with other fertilizers and no special applications are necessary.

Nitrogen and Potassium

Nitrogen leaches out of the soil quite readily and is used in appreciable quantities by plants. As a result, nitrogen levels in the soil tend to fluctuate quite freely.

Potassium also leaches out of the soil but not as readily as does nitrogen, nor does it fluctuate as much as nitrogen.

If phosphorus is mixed in the starting soil in adequate amounts, only nitrogen and potash need be added at regular intervals. One method is to apply a nitrogen and potash fertilizer, followed by two applications of a nitrogen carrier. Every third application combines nitrogen and potash. The soil pH may be controlled by choosing the proper nitrogen fertilizer. For example, using calcium nitrate or sodium nitrate will raise the pH, while ammonium sulfate or ammonium nitrate will bring about a lowering of the pH.

If soluble salts are a problem, use potassium nitrate or ammonium nitrate or like materials which do not leave unnecessary salts such as chlorides or sulfates in the soil. The use of mulches such as corn cobs or sawdust require the addition of nitrogen when the mulch is first applied to satisfy the needs of microorganisms which bring about decomposition. If a limited supply of nitrogen is present in the soil, the microorganisms will take this nitrogen and the plants will go wanting, unless the supplemental application is made. The nitrogen will be returned to the soil later as the decomposition of the mulch advances.

When phosphorus is mixed in the starting soil and the application of a complete fertilizer is preferred after the plants are actively growing, avoid the use of mixtures high in phosphorus such as 5-10-5 or 15-30-15. A ratio such as a 1-1-1, 2-1-1 or 2-1-2 as may be noted in a 10-10-10, 20-10-10 or 20-10-20 fertilizer is preferable. Constant use of a high phosphorus fertilizer will tend to tie up the available calcium, magnesium, iron and manganese in the soil.

The use of organic fertilizers or synthetic fertilizers such as ureaform and fritted potash which are slowly available will greatly reduce the fluctuation of nitrogen and potash levels in the soil. Such fertilizers are usually higher in price, but a saving in labor may result as infrequent applications are necessary. They are especially useful for pot plant crops grown at high temperatures. At low temperatures the nitrogen may not become available quickly enough to keep up with plant needs. Such materials are applied to the soil surface or preferably mixed in the starting soil.

Is liquid or dry fertilization preferred? The answer lies in part with the crop grown and the equipment available. Liquid application of fertilizer to pot plants is the only economical, quick way of getting a uniform application, unless the dry materials are mixed in the potting soil. More frequent application is needed with liquid than with dry fertilizers. The use of dry fertilizers is not as risky on bench crops as it is on pot plant crops.

Recently many growers in the area have turned to the use of a proportioner which permits them to apply a weak fertilizer solution every time they water. Results with this method appear to be good, but there may be occasions where the same fertilizer is not satisfactory for all crops grown. A fertilizer containing phosphorus would be highly desirable for pink hydrangeas and undesirable for blue hydrangeas or Croft Easter lilies. Poinsettias and stock require more potash than do snapdragons.

U. C. Mix

The University of California has proposed the U. C. mix for growing plants in containers. The U. C. mix is in reality a mixture of sphagnum (acid) peat moss and fine sand which is combined in several different ratios depending on the crop grown. An advantage of this system is that a standard soil is used and fertilizer recommendations may be standardized accordingly. Weather conditions, growing temperatures, methods of watering and time of year will still influence the nutrient needs of the plant, but the U. C. mix is certainly worth a trial on a limited basis to determine its effectiveness under your growing conditions.

Other Considerations

Regardless of the method of fertilization used, certain considerations should be kept in mind.

Start and finish the crop with low nutrient levels in the soil. Rooted cuttings and seedlings "take hold" much quicker if planted in a soil low in nutrient content. Remember that plants will take up more nutrients than they require. Larger flowers will often result if the nutrient level is moderately low (not deficient) when the blooms are opening. In the case of bench crops, it is especially important that the crop finish with low soil nutrient levels. The soil is usually steam sterilized before being planted to the next crop and steam sterilizing increases the level of available nutrients in the soil. It is easier to leach the soil when the old crop is still in the bench than it is when the bench is empty and waiting to be planted, because a bench with plants in it will dry out much more quickly following leaching.

Fertilizer Materials

Material	Analysis	Bench Crops lbs. per 100 sq. ft.	Potted Plants tsp. per 6" pot	Liquid oz. per 5 gal.	Potting Soil Amount per 3 bushels	Relative Availability
Nitrogen Fertilizers (acid reaction)						
Ammonium nitrate	33-0-0	½	¼	1	----	Rapid
Ammonium sulfate	20-0-0	1	½	2½	----	Rapid
Urea (neutral)	46-0-0	½	¼	3/4	----	Rapid
Dried Blood	9 to 14-0-0	2	1	--	2½ potful	Med. Rapid
Nitrogen Fertilizers (alkaline reaction)						
Calcium nitrate	16-0-0	1	½	2½	----	Rapid
Sodium nitrate	16-0-0	1	½	2½	----	Rapid
Nitrogen Fertilizers (neutral)						
Potassium nitrate	13-0-44	1	½	2½	----	Rapid
Phosphorus Fertilizers (acid)						
Mono-ammonium phosphate	11-48-0	1	-	2½	7 tblsp.	Rapid
Di-ammonium phosphate	21-53-0	½	-	1	----	Rapid
Phosphorus Fertilizers (neutral)						
Superphosphate	0-20-0	5	-	--	4" potful	Slow
Treble superphosphate	0-45-0	3	-	--	3" potful	Slow
Steamed bone	2-25-0	6	-	--	3" potful	Slow Medium
Potassium Fertilizers (acid)						
Potassium sulfate	0-0-48	1	½	2½	----	Rapid
Potassium Fertilizers (neutral)						
Muriate of potash	0-0-50	1	½	2½	----	Rapid
Muriate of potash	0-0-60	1	½	2½	----	Rapid
Potassium nitrate	13-0-44	1	½	2½	----	Rapid

Material	Analysis	Bench Crops lbs. per 100 sq. ft.	Potted Plants tsp. per 6" pot	Liquid oz. per 5 gal.	Potting Soil Amount per 3 bushels	Relative Availability
		Calcium (neutral)				
Gypsum (calcium sulfate)	calcium	3-5	-	--	3-4" potful	
		Complete Fertilizers (dry application)				
5-10-5	5-10-5	2-3	1¼	—	3" potful	----
5-5-10	5-5-10	2-3	1¼	—	" "	----
6-10-4	6-10-4	2-3	1¼	—	" "	----
0-12-12	0-12-12	2-3	1¼	—	" "	----
7-7-7	7-7-7	2-3	1¼	—	3" potful	----
		Complete Fertilizers (liquid application)				
10-10-10	10-10-10	1½-2	3/4	3	7 tblsp.	Rapid
13-26-13	13-26-13	3/4-1	-	2¼	----	Rapid
15-30-15	15-30-15	3/4-1	-	2	----	Rapid
20-10-20	20-10-20	½-3/4	-	1½	----	Rapid
20-20-20	20-20-20	½-3/4	-	1½	----	Rapid
30-10-10	30-10-10	½	-	1	----	Rapid
		Soil Acidifiers				
		lbs.		oz.		
Sulfur (fine dusting)	sulfur	3/4	1/3	--	2½" potful	Slow
Iron sulfate (ferrous sulfate)	iron	1	-	2½		Rapid
Ferric ammonium citrate	iron	--	-	2½		

Soils levels that should be altered or corrected prior to planting include pH, phosphorus and calcium as well as organic matter content.

Do not sterilize soil more than a week or so before planting. Stock piling of sterilized soil for extended periods of time can result in an excessive build-up of fertilizer salts and in addition there is no guarantee that the soil will not become reinoculated with disease organisms in the intervening period.

The incorporation of organic or other slowly released fertilizers such as ureaform and fritted potash in the soil long before use may result in a build-up of excessive quantities of nutrients in the soil.

How often should fertilizer be applied? Here again the answer is dependent on many factors. One way of determining the answer could be to have the soil analyzed monthly, especially with bench crops. If the same soil, growing methods and crops are used, less frequent analysis may be necessary the second year. An alert grower will combine past nutrient level trends with observation of his plants to determine when to fertilize. In a sense, plants talk and they inform the grower of their needs if the grower watches them carefully. For example, a plant may slow down in growth rate or flower production before it shows any other signs of a lack or an excess of nutrients. Soil type, amount of water applied and concentration and nature of fertilizers applied also determine how often to fertilize. Keep a written record of all fertilizer applications, soil analysis reports and pertinent notes in the greenhouse where the record and the crop may be observed at the same time.

Foliar feeding can support good plant growth, but it is not practical under ordinary conditions for the commercial grower. In order to be effective, frequent applications must be made necessitating excessive labor costs. In addition, the possibility of foliage burn or injury is always present if conditions should be unfavorable or a slight error is made in mixing the solution used.