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G90-945 A Gardener's Guide for Soil and Nutrient Management in Growing Vegetables

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A Gardener's Guide for Soil and Nutrient Management in Growing Vegetables

How to manage soil and nutrients when growing vegetables is discussed here, as is soil testing, soil pH, organic matter, and the use of commercial fertilizers.

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Using fertilizers as nutrient sources in growing vegetables is one cultural practice that can improve production if done correctly. This means using the right fertilizer material, applying it at the correct rate and time, and using the proper method of application.

Fertilizer needs for vegetables depend on the kind of vegetable grown, chemical properties of the soil, previous cropping history, and adequate water for plant growth. Guidelines here are based on soil chemical properties and the kinds of vegetables grown. It is assumed adequate moisture is available either from rainfall or irrigation.

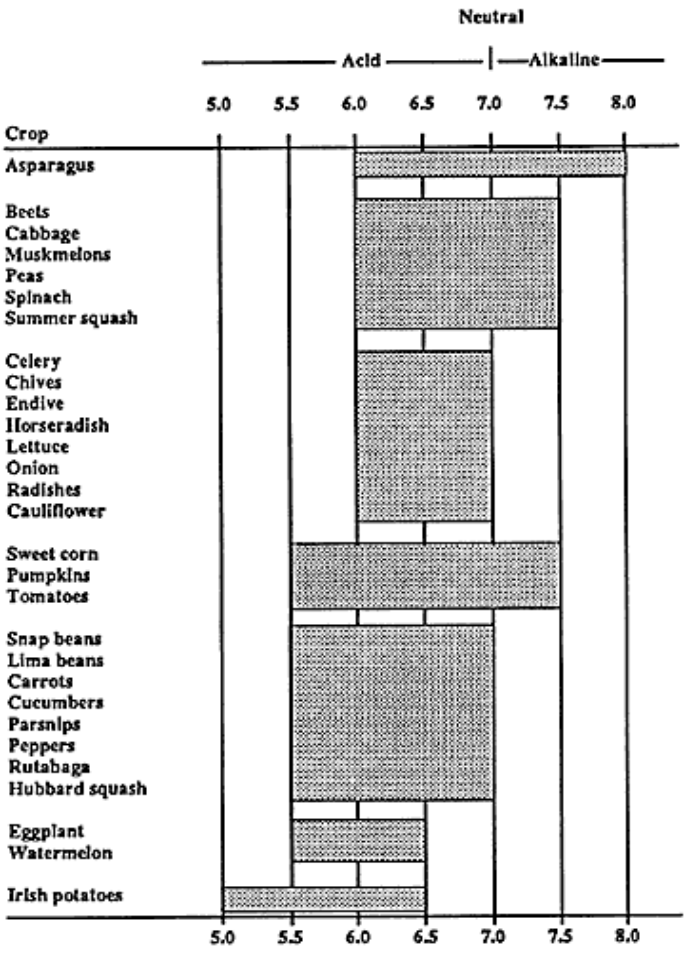
Problems with insects, diseases, herbicide injury, and weather conditions may be difficult to distinguish from soil fertility problems, and can occur at the same time.

Although 16 elements are needed for plant growth, only nitrogen (N), phosphorus (P), potassium (K),

sulfur (S), iron (Fe), and zinc (Zn) may need to be added to Nebraska soils.

Soil Sampling and Testing

Figure 1. Optimum soil pH range for vegetable crops. (Information reprinted from "Growing Vegetables" by G.W. Ware and J.P. McCollum.)



Fertilizer is used to add plant nutrients not adequately supplied by the soil. A soil test tells which nutrients to add. A soil test also indicates if a soil amendment such as lime or organic matter is needed.

Soils do not need to be tested every year. A good test every fifth year should be adequate unless a major soil amendment was added since the last test

One soil sample consisting of 10-15 cores collected randomly in the garden area usually is adequate, unless there are obvious soil differences in the garden. For large areas, such as commercial gardens or vegetable farms, more than one sample is needed.

Divide the area according to soil types and past cropping history. A "Soil Sample Information Sheet" and soil containers are available at County Extension Offices. The form should be submitted with the soil sample. On the back of the form are some general guidelines for taking soil samples.The most common and useful soil tests include pH, organic matter, phosphorus and potassium.

Soil pH

The pH of a soil is a measure of acidity or alkalinity. The numbers reported from a soil test generally range from 5.0 to 8.5. A pH of 7.0 is neutral. Those below 7.0 are acidic and those above 7.0 are alkaline. *Figure 1* shows the best pH ranges for vegetable crops. A pH of 6.5 is ideal; the range from pH 6.0 to 7.0 is good for vegetables. The growth of most vegetables will not be hindered if the soil pH is between 5.5 and 7.5. Below 5.5 and above 7.5, soil treatment or modification often is necessary.

Lime for Acid Soils

Apply lime to soils with a pH below 5.5. The rate required to raise the soil pH to 6.5 is determined by using a soil test called the "Buffer pH" test. The soil test shows the amount of lime to apply per 1,000 square feet.

Different kinds of lime can be used. Some change the soil pH more than others. *Table I* lists some of the materials available, and gives the value of each.

For example, if a soil test calls for 100 pounds of lime per 1,000 square feet and slake lime (also called builders lime) is used, then 100 + 1.36 = 74 pounds of slake lime per 1,000 square feet is needed.

Do not over-lime. Apply lime according to soil test. Excess lime is likely to result in iron chlorosis of plants.

Table I. Liming materials and their neutralizing equivalents

Material	Chemical composition	Neutralizing equivalent*	Factor to divide by
Crushed Limestone	Calcium carbonate ($CaCO_3$)	100	1.00
Dolomite	Calcium-magnesium carbonate ($CaCO_3$--$MgCO_{3)}$	108	1.08
Burned or Quick Lime	Calcium oxide (CaO)	179	1.79
Hydrated or Slake Lime	Calcium hydroxide ($Ca(OH)_2$)	136	1.36
*Neutralizing equivalent based on calcium carbonate being 100 percent. Soil test recommendation is based on finely crushed limestone.			

Lowering Soil pH

If soil pH is higher than 7.5, which is common in western Nebraska, it may be desirable to lower the soil pH. This generally is not practical for large areas because of cost, but it may be feasible on small garden plots or when the crop to be grown requires a low soil pH, and economic return is high.

Amendments such as elemental sulfur, aluminum sulfate, or sulfuric acid can be used. Powdered elemental sulfur is available for purchase and is most commonly used. *Table II* shows the amount of sulfur to add depending on the texture and the pH of the soil. The amount shown is the approximate quantity to apply.

The reaction of sulfur in soil is slow and may take a year or more to start a change in soil pH. A soil test should be done again one or two years after sulfur is applied to determine if more sulfur is needed.

Table II. Amount of elemental sulfur needed to lower the soil pH to 6.5

	Broadcast and mixed with 6 inch layer of soil		
Soil pH			
	Sandy soils	Loamy soils	Clayey soils
	- - - - - - - Pounds per 1,000 square feet - - - - - - -		
7.5	10-15	15-20	20-25
8.0	25-30	30-40	40-50
8.5	40-50	50-60	60-75

Organic Matter

Many garden soils are low in organic matter because they contain less than 5 percent organic matter. Soils that contain more than 20-28 percent clay (clay loams) and are low in organic matter tend to be hard when dry and sticky when wet. Soils high in organic matter are mellow (plant roots can penetrate easily) and absorb water more readily than soils low in organic matter.

The addition of organic materials (compost, manure, grass clippings, leaves, etc.) improves the physical properties of soils. As organic materials decompose in the soil, essential plant nutrients are made available for plant use, also.

The use of organic mulch is a good practice in vegetable gardens. Mulches suppress weed growth, conserve soil water, and keep the soil cooler. A one to two inch thick layer of chopped leaves or straw, grass clippings, or compost is effective.

When this mulch is mixed into the soil at the end of the growing season, the organic matter content of the soil increases slightly. It is not practical to increase the organic matter content of soil with one treatment, but after 5-10 years the incorporation of organic mulches raises the organic matter content.

Organic Fertilizers

The use of organic fertilizers appeals to many home gardeners. Organic fertilizers are naturally occurring, non-manufactured materials that contain plant nutrients. They are effective, but it is difficult to supply needed plant nutrients without sometimes applying other nutrients in excess.

Organic fertilizers must be used at higher rates of material than manufactured chemical fertilizers because nutrient content is lower in these materials. One approach is to apply organic materials to supply part of the nutrient requirements and add the rest of the needed nutrients with manufactured chemical fertilizers.

All nutrients must be in the ionic form to be dissolved in soil water and usable by plants, so organic fertilizer materials must decompose before plants can use the nutrients. In terms of plant use, it does not make any difference whether the nutrients come from organic or manufactured forms of fertilizer. Both are changed to the same form in the soil.

Manure

Applying manure to soils for vegetable production is a good practice. Manure supplies part of the needed soil nutrients and provides added organic matter. *Table III* gives suggested rates of manure application. These rates supply part of the nitrogen needed and most other nutrient needs. Avoid using more than the amounts given in *Table III*.

Applying too much manure results in a soil nutrient content that is more than plants can use, and in excessive soluble salts that can damage plant roots.

Rotted or composted manure is preferred to minimize odor and reduce the risk of applying some weed seeds commonly found in uncomposted manure.

Table III. Guide for manure use on gardens

Type of manure	Tons/acre	Lbs./1000 sq. ft.
Rotted barnyard manure with bedding	8	400*
Poultry and sheep manure with bedding	4	200
Feedlot manure without bedding	4	200
Composted manure	2	100
*Approximately 10 bushels (80 gallons) of material		

Commercial Fertilizers

Many different commercial fertilizers are available. They differ in grade or analysis. State law requires that the label of all fertilizers sold in Nebraska show a guarantee of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O). A fertilizer grade of 10-20-10 means it is guaranteed to contain 10 percent N, 20 percent P_2O_5, and 10 percent K_2O.

The content of other nutrients, such as sulfur, iron or zinc, also must be listed if the fertilizer manufacturer wants to guarantee the amount.

The rate of fertilizer application depends on the grade of the fertilizer and the amount of nutrient to be applied.

If one pound of nitrogen per 1,000 square feet is needed and a material with a grade of 10-20-10 is used, it is necessary to apply 10 pounds of 10-20-10 per 1,000 square feet to get one pound of nitrogen. This 10 pound rate of 10-20-10 fertilizer results in the application of 1 pound of nitrogen, 2 pounds of phosphorus (P_2O_5), and 1 pound of potassium (K_2O).

Table IV lists some of the common basic fertilizer materials available. Also shown is the amount of fertilizer material needed to supply one pound of the major nutrient each material contains. Many other products are available.

Most garden fertilizers purchased in small amounts are a mixture of the materials listed in *Table IV*. It is important to consider the fertility needs of the plants and the nutrients present in the soil, and buy the grade of material that supplies the needed nutrients.

Fertilizers designed for use on lawns can be used for vegetables if they provide the needed nutrients and do not contain other materials, such as herbicides or insecticides. If the fertilizer does contain other products, they must be specifically labeled for garden use.

Table IV. Common fertilizer materials

Nitrogen sources	***Analysis***	***Amount to supply 1 pound of nutrient, lbs.***	
Ammonium nitrate	34-0-0	2.9	(46 oz.)
Ammonium sulfate	21-0-0	4.8	(77 oz.)
Urea	46-0-0	2.2	(35 oz.)
Phosphorus sources			

Triple super phosphate	0-46-0	2.2	(35 oz.)
Monoammonium phosphate	11-48-0*	2.1**	(34 oz.)
Diammonium phosphate	18-46-0	2.2***	(35 oz.)
Potassium sources			
Potassium chloride	0-0-60	1.7	(27 oz.)
Potassium sulfate	0-0-50	2.0	(32 oz.)

* 1 pound P_2O_5 , 0.48 = 2.1 pounds.
** 2.1 pounds X 0.11 = 0.2 pounds N.
*** Supplies 0.4 pounds of nitrogen.

Nitrogen

The nutrient plants need from the soil in the largest quantity is nitrogen. When organic matter is decomposed in the soil, nitrogen is available for plant use. The nitrogen from organic matter usually is not adequate to meet the demands of many vegetables, so additional nitrogen from fertilizer is needed.

Suggested guidelines for nitrogen use are given in *Table V*. The preplant application rate of nitrogen is based on the estimated nitrogen level in the soil. For soils low in nitrogen and organic matter to which no manure has been applied, application of nitrogen is suggested before planting (preplant).

If the organic matter level is high or manure *has* been applied, the only added nitrogen fertilizer needed is for those vegetables that benefit from high levels of nitrogen.

Vegetables that need high levels of nitrogen include sweet corn, the cole crops, and leafy green vegetables. For these, one or two applications of nitrogen as a sidedressing after planting are recommended at specific growth stages as shown in *Table V*.

Onions also benefit from additional nitrogen. By delaying the application until after emergence, the crop benefits and weed stimulation is reduced.

Potatoes and tomatoes also respond to added nitrogen. Delaying the application improves tuber set of potatoes and reduces excessive vine growth of potatoes and tomatoes.

It is important *not* to stimulate excessive vine growth for tuber or fruit type vegetables. Excessive vine growth of these crops usually results in poor crop yields due to a lower number of tubers or fruits.

Table V. Guide for nitrogen fertilizer use on gardens

Nitrogen requirement	**Nitrogen (N) to apply**	
Preplant Application	***lbs./acre***	***lbs./1000 sq. ft.****
Low nitrogen soils	80	2
Medium nitrogen soils	40	1
High nitrogen soils or manure applied	0	0
Sidedress Application		

Sweet corn (12" tall)	80*	2*
Broccoli, cabbage and cauliflower (2 weeks after transplanting)	80*	2*
Leafy green vegetable (lettuce and spinach)	40	1
Onion (3-4 weeks after emergence)	40	1
Potatoes (beginning bloom)	40	1
Tomato, pepper, and eggplant (first fruits 1" in diameter)	40	1
Asparagus (at end of harvest)	80**	2**

*Application can be split. Apply at one-half rate with another application one month later.
**Application can be split. Apply at one-half rate in early spring and one-half rate at end of harvest.
***An area 20 feet by 50 feet, 25 feet by 40 feet, or 30 feet X 33.3 feet is 1,000 square feet.

Phosphorus

Phosphorus may be deficient in some Nebraska soils. The need for phosphorus fertilizer is best determined by a soil test. *Table VI* gives the suggested rates of phosphorus application based on a soil test.

For soils high in phosphorus (25 ppm or higher), no phosphorus fertilizer is suggested. Crop yield is not likely to be improved by additional phosphorus on high phosphorus soils, so there is no benefit from its use.

The use of a starter fertilizer (fertilizer high in phosphorus and applied in a band beside the row at planting) often stimulates early growth of sweet corn or popcorn, but seldom increases the yield on high phosphorus soils.

Table VI. Guide for phosphorus fertilizer use on gardens

Phosphorus soil test level			**Phosphorus (P_2O_5) to apply**	
ppm P			***lbs./acre***	***lbs./1000 sq. ft.***
0 to 5	(0-3)	Very low (VL)	120	3
6 to 15	(4-7)	Low (L)	120	3
16 to 24	(8-14)	Medium (M)	80	2
25+	(15+)	High (H)	0	0
Phosphorus test: Bray & Kurtz P_1, Sodium Bicarbonate P in parenthesis.				

Other Nutrients

- **Potassium** is usually high in Nebraska soils, but occasionally a soil test may indicate a lower level. The suggested rate of potassium to apply, based on soil test, is given in *Table VII*.

- **Sulfur** deficiency can occur on very sandy, low organic matter soils, particularly in north central

Nebraska. The application of organic materials, such as manure, will correct the problem. Using ammonium sulfate as the nitrogen fertilizer source (*Table II*) supplies more than adequate amounts of sulfur.

- **Iron** chlorosis may occur in some soils that contain excess lime and are compacted and poorly drained. Beans and tomatoes are two crops that may show iron chlorosis.

  Iron chlorosis can be identified by the interveinal yellowing of leaves. The veins are green and the tissue between the veins is yellow. At a distance of several feet, chlorotic plants look very yellow.

  Problems with chlorosis can be reduced by lowering the pH in high lime soils as was discussed earlier, but the simplest approach may be to apply an iron-containing fertilizer. Several products are available. Follow directions on the container for proper use.

  Where chlorosis is severe, iron chelates often are more effective than other forms of iron. The application of manure can be helpful by supplying iron and improving soil tilth.

- **Zinc** deficiency occasionally occurs when soils contain excess lime and are low in organic matter. Sweet corn and beans are the most likely crops to be affected.

  If zinc deficiency is suspected, the level of zinc in the soil can be determined by a soil test.If the zinc level is low, the application of two to four ounces of zinc per 1,000 square feet will correct the problem. The application of barnyard manure is helpful.

Other nutrients needed from the soil (calcium, magnesium, boron, chlorine, copper, manganese, and molybdenum) are not known to be deficient in Nebraska soils, and are not of concern in producing vegetable crops.

Low calcium transport in a plant appears to be associated with blossom end rot of tomatoes.

Nebraska soils are well supplied with calcium, so the application of additional calcium will not prevent the problem. Blossom end rot is best prevented by maintaining an optimum soil moisture level and avoiding excessive amounts of nitrogen.

Table VII. Guide for potassium fertilizer use on gardens

Potassium soil test level		**Potassium (K_2O) to apply**	
ppm K		***lbs./acre***	***lbs./1000 sq. ft.***
0 - 39	Very low (VL)	120	3
40 - 74	Low (L)	120	3
75 - 124	Medium (M)	40	1
125+	High (H)	0	0
Potassium test: Exchangeable K			

Time and Method of Application

The timing and method of fertilizer application is important to obtain optimum plant growth.

- **Nitrogen** is a mobile nutrient in soil; it can be applied whenever needed. Nitrogen can be broadcast on the soil and incorporated pre-plant by tillage. It can be applied in a band along the row or around a hill of established plants. Nitrogen fertilizer can be covered with soil or incorporated with water. Nitrogen fertilizer should not be placed in contact with seeds or growing plants because injury is likely.

- **Phosphorus** is a non-mobile nutrient in the soil; it must be applied prior to or at planting. Phosphorus fertilizer can be broadcast on the soil and incorporated by tillage or it can be applied beside the seed row at the time of planting. Row-applied fertilizer should not be placed in the seed row in direct contact with the seed.

  Small amounts of phosphorus can be applied as a transplant starter; this usually is not necessary if an adequate amount of phosphorus is present in the soil.

- **Potassium** and **zinc**, if needed, are best applied prior to tillage. **Sulfur**, when needed, can be applied with nitrogen using ammonium sulfate. **Iron** can be applied as needed according to the instructions on the package.

- **Iron** and **zinc** can be applied as a foliar spray if needed. Foliar application of these micronutrients can be effective if they are applied properly. It is important to follow the directions on the container.

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