Fertilizing Commercial Vegetables

Dean McCraw
Extension Horticulturist-Vegetables

J. E. Motes
Extension Vegetable Specialist

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Producing commercial vegetables successfully requires a grower to make maximum use of all available resources. One of the most important and necessary resources is fertilizer, which provides the nutrients needed by plants to grow properly and yield a quality product. Inadequate fertility starves plants. Excess fertility is wasted and can cause physical injury or death to plants. The most successful vegetable growers are careful to properly use the most economical fertilizer to meet the plant's nutritional needs.

Important factors to consider in determining the fertilizer program include the cropping history of the field, the soil type, and, probably most importantly, the crop to be grown.

Vegetables are generally heavy users of nutrients in comparison to most field crops. Fields planted repeatedly to vegetables may need more attention to fertilization than fields rotated into pasture or other agronomic crops. Fields previously planted to legume crops, (clover, alfalfa, peanuts, etc.) may need less fertilization.

Sandy soils usually require lower rates of fertilizer more frequently than fine textured soils. Indiscriminate application of fertilizer, especially nitrogen, to sandy soils can result in loss of nutrients to leaching by rainfall and a corresponding decrease in fertilizer efficiency.

The final determinant in a fertilizer program is the crop to be grown. Most vegetables are relatively high value crops with corresponding high production cost. Fertilizer is only one of the inputs that must be supplied, but can be the limiting factor preventing realization of maximum benefit from other supplied inputs, e.g. irrigation, pest control, and harvesting. From this standpoint, proper fertilization can be considered an investment, which can pay substantial dividends, when used as part of a total management program.

Determining Fertilizer Need

Soil Sampling

The starting point from crop fertilization is knowing the inherent and residual fertility available in the soil, which should be determined by a soil test. A properly utilized soil test is an inexpensive management tool. Sample fields properly. The test results are no better than the sample submitted. Fact sheet PSS-2207 explains soil sampling techniques.

The Soil Test

The OSU Soil Test Laboratory performs soil tests on a custom basis. County Extension offices throughout Oklahoma have guidelines and materials for sending soil samples to the OSU Soil Test Laboratory. Turn-around time varies with season, but is usually 14 days or less. The standard test includes soil reaction (pH), nitrogen, phosphorus, and potassium. Micronutrients (trace elements) can be tested if specified.

Soil reaction (pH) is a measure of the acidity/alkalinity of the soil. On the pH scale 7.0 is neutral, less than 7.0 is acidic and above 7.0 is alkaline. The major influence of pH is on nutrient availability. Most plant nutrients, particularly phosphorous, are most available in mildly acid soils, i.e. those with a pH between 6.0 and 7.0. Agricultural soils tend to become more acid over time. Excess acidity is corrected through lime applications to the soil. The nature of the soil determines the amount of lime needed to adjust pH. The OSU soil test report lists the soil pH and buffer index (BI), which is a measure of the soil's ability to resist pH changes. Lime is applied in accordance with BI (Table 1). Refer to Fact Sheet PSS-2229 for a detailed discussion of soil pH and BI as well as liming.

Table 1. Tons of ECCE. Lime Required to Raise Soil pH of a 6-7 Inch Furrow Slice to pH 6.8 or 6.4

	Lime required	
Buffer Index	**pH 6.8**	**pH 6.4**
over 7.1	none	none
7.1	0.5	none
7 0	0.7	none
6.9	1.0	none
6.8	1.2	0.7
6.7	1.4	1.2
6.6	1.9	1.7
6.5	2.5	2.2
6.4	3.1	2.7
6.3	3.7	3.2
6.2	4.2	3.7

*Effective calcium carbonate equivalent guaranteed by lime vendor

$$\text{Tons material required} = \frac{\text{Tons ECCE required}}{\text{percent ECCE}} \times 100$$

The various vegetables differ in ability to take up nutrients at a given pH. An effort should be made to pair a crop to soils with appropriate pH. Table 2 classifies vegetables according to their tolerance to soil acidity.

Table 2. Relative Tolerance of Vegetable Crops to Soil Acidity

Slightly Tolerant **(pH 6.8-6.0)**	Moderately Tolerant **(pH 6.8-5.5)**	Very Tolerant **(pH 6.8-5.0)**
Asparagus	Bean	Potato
Beet	Bean, Lima	Rhubarb
Broccoli	Brussels sprouts	Shallot
Cabbage	Carrot	Sweet potato
Cantaloupe	Collard	Watermelon
Cauliflower	Cucumber	
Celery	Eggplant	
Chinese Cabbage	Garlic	
Lettuce	Kale	
Okra	Kohirabi	
Onion	Mustard	
Spinach	Parsley	
	Pea	
	Pepper	
	Pumpkin	
	Radish	
	Squash	
	Sweet Corn	
	Tomato	
	Turnip	

Source: Knott's Handbook for Vegetable Growers.

Many vegetables can be grown successfully on alkaline soils. Some do well at pH 7.6 or higher in some cases if there is no deficiency of essential nutrients. Vegetables in the very tolerant group can be grown satisfactorily at a soil pH as low as 5.0. However, even the most tolerant crops grow better at pH 6.0-6.8 than in more acid soils. Cantaloupe will exhibit a distinct "acid yellows" or yellowing of leaves and stunting if grown at pH below 5.5. Calcium, phosphorus, potassium, magnesium, and molybdenum are the nutrients most likely to be deficient in acid soils.

Tissue Testing

Soil testing is the best method to determine fertilizer needs prior to planting. After the crop is planted and growing, plants can be observed for visual signs of nutrient deficiency or plant tissue can be tested for fertilizer nutrient content. Areas of the field not included in the soil sample, varying soil characteristics, and rainfall during the season can result in unpredicted growth response and nutrient deficiency during the season. The tissue test in comparison to the soil test is more expensive, but can more accurately reflect the nutritional status of the plant if done properly. Proper diagnosis is very important. Nutrient deficiency symptoms in some cases can be confused with disease or insect damage or other environmental causes, e.g. wind. The tissue sample must be collected in accordance with the procedures of the laboratory performing the analysis. Many commercial laboratories are available to do tissue analysis. Contact the laboratory prior to the growing season and get the following information:

1. Sampling procedure and submission guidelines.
2. Elements that can be tested.
3. Turn-around time.

The Nutrients

Plants require a total of 16 elements in differing quantities to grow and mature properly. The nutrients are classified on the basis of relative quantity of each required. Three of the 16, carbon, hydrogen, and oxygen, make up about 95% of the plant and are supplied by air and water. The remaining 13 must be supplied to the plant by the soil solution. See Table 3.

Methods of Application and Placement

Preplant fertilizer is applied to the soil in accordance with soil test requirements prior to planting the crop. It may be broadcast over the soil surface and mixed with the soil, applied in a strip and mixed with the soil in the row, or applied in a band beside the seed or transplant line.

Broadcasting is a good method for applying large quantities of fertilizer without plant damage or when speed of application is important. A broadcast application can be plowed or disked in during soil preparation. Broadcasting is generally an inefficient method for widely spaced crops (watermelon), or for application of large amounts of nitrogen on sandy soil (lost through leaching) or phosphorus (tied up by soil).

Band application near the seed or plant is an efficient placement method. The usual method is 2 to 3 inches beside and 2 to 3 inches below the seed or plant The amount of fertilizer that can be placed in a band is limited due to the possibility of salt injury to seedlings. This is particularly true for nitrogen and potassium. A general rule to follow is the total N and K_2O in a band should not exceed 100 lbs/A in a 3 foot between-row spacing, e.g. 40 lbs N + 60 lbs K_2O. In a 6 foot between-row spacing the total N and K_2O in a band should not exceed 50 lbs/A. Phosphorous is generally not injurious compared to nitrogen or potassium.

Sidedress fertilizer is placed beside a growing plant. This method is used to supplement preplant fertilizers. Most vegetables benefit from sidedress application of nitrogen, since preplant application of the total N requirement is generally impractical or detrimental due to seedling injury, potential loss through leaching, or reduced fruit set. Sidedress fertilizer can be applied with a shank or knife and should be applied far enough from the plant to avoid root injury to the crop.

Topdressing refers to application of fertilizer to a growing crop without disturbing the soil. It is effective on bed planted crops such as spinach and those with surface irrigation available to move the fertilizer into the root zone. High salt dry fertilizers such as ammonium nitrate can damage plant foliage if applied as a top dressing. Urea is generally less injurious as a topdressing N source. Urea applied to a hot, moist soil surface must be followed by irrigation or incorporation if possible to reduce loss of N to the atmosphere. Urea applied to dry soil is stable for 10 days or more.

Starter fertilizer is a dilute rate applied at transplanting through transplant water. It generally consists of a soluble low N, high P analysis. The element of importance is P. The N tends to improve P uptake particularly during spring trans-

Table 3. Classification, Characteristics and Deficiency Symptoms of Essential Nutrients.

Nutrient	Characteristic	Deficiency Symptom
Primary		
Nitrogen (N)	All converts to nitrate. Nitrate can leach from soil. Ammonium held to soil. Plants use mostly nitrate, some ammonium.	1. Slow growth, stunted plants 2. Yellow-green color 3. Firing of older leaf tips
Phosphorous (P)	Easily tied up by soil and made unavailable to plants. Availability reduced at high or low pH and soil temperature below 50°F. Form for plant use varies with soil pH.	1. Slow, stunted growth 2. Purplish color to leaves/stems 3. Delayed maturity 4. Dark green, dead leaf tips 5. Poor fruit/seed development
Potassium (K)	Increases size and quality of fruit. Adequate quantities available in most western Oklahoma soils.	1. Tip and marginal burn on older leaves 2. Weak stems, lodging 3. Small fruit, shriveled seeds 4. Slow growth
Secondary		
Calcium (Ca)	Major component of cell wall. Does not move within plant. Deficiency related to blossom end rot of tomato and others. Can be deficient in acid soils, but corrected by liming.	1. Death to growing points of top and root 2. Unusually dark green foliage, which fails to unfurl 3. Premature blossom/bud shed 4. Weak stems
Magnesium (Mg)	Deficiency may show on sandy, acid soils. Can be corrected with dolomitic limestone during pH adjustment.	1. Yellowing between older leaf veins 2. Leaves curl up along margins 3. Marginal yellowing with "Christmas tree" shape along midrib
Sulfur (S)	Can be deficient in acid soils.	1. Pale green/yellow color to young leaves initially 2. Small weak plants 3. Retarded growth, slow maturity 4. Yellow between veins of corn leaves
Micronutrients (trace elements)		
Zinc (Zn)	Terminal growth areas affected first. Deficiency can be caused by excess phosphorous.	1. Decreased stem length, rosetteing terminals 2. Reduced fruit bud formation 3. Mottled leaves 4. Stripping or banding of corn leaves
Iron (Fe)	Deficiency can be induced by high manganese at low pH. Usually associated with high pH soil or excess liming.	1. Yellowing between dark green veins of young leaves
Manganese (Mn)	Excess may induce iron deficiency at low pH.	1. Yellowing between veins of young leaves. Not as distinct as with iron
Copper (Cu)	Not usually deficient. May be linked to fruit cracking in tomato.	1. Stunted growth 2. Poor color 3. Wilting and death of leaf tips
Boron (B)	Does not move within plant. Deficient occasionally on cole crops.	1. Soft, dead spots on fruit or tubers 2. Reduced flowering and pollination 3. Thick, curled, wilted, yellow leaves
Molybdenum (Mo)	Essential for N fixation by legumes. May be applied with seed inoculation. Deficiency often corrected with liming.	1. Stunted, unvigorous plants 2. "Whiptail" of cauliflower 3. Cupping or rolling of leaves

planting in cold soils. Three pounds of 15-30-15 or 10-52-17 in 50 gal water, 1 cup per plant, is adequate for most transplants.

The term **"pop up"** fertilizer refers to placement in the seed drill. Information on the benefit of pop up fertilizer in Oklahoma is inconclusive. Guidelines from other states suggest that when soil temperature is 50°F or less use of a high phosphate (e.g. 6-18-6) liquid, such that the total N and K_2O does not exceed 10 lbs/A, may be beneficial.

Foliar spray is most effective for correcting special fertility problems as they develop, e. g. trace element deficiencies. It is generally not a good method for applying major elements, e.g. nitrogen, since the amount that can be applied is relatively small due to the danger of foliage burning. The upper limit for N, for example, is about 5 pounds per acre per application in a foliar spray. Under peak growth some crops may require $^1/_2$ to $1^1/_2$ pounds per acre per day. If 50% of the spray actually hits the leaves and is then absorbed into the plant, this would meet only half the crop requirements for 2 to 7 days. Some growers add foliar feed to pesticide applications as "insurance." The real value may be questionable.

Fertigation is the practice of applying fertilizer to a growing crop through the irrigation water. Drip, furrow, or sprinkle irrigation can be used. Material selection is important for fertigation to obtain adequate solubility and distribution to the crop.

Injection of fertilizer through a drip system, particularly for small plantings, can be easily accomplished as illustrated in Figure 1. The water soluble fertilizer source is attached across a pressure drop, e.g. control valve, by means of supply tubing.

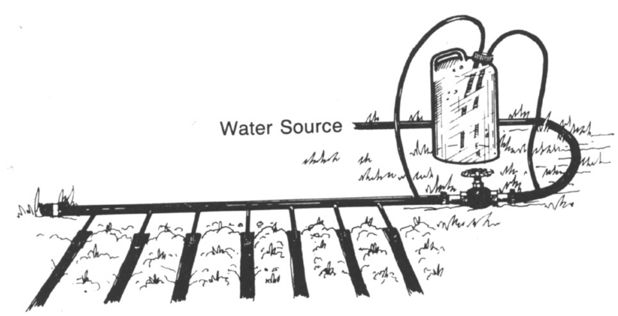

Figure 1. Fertilizer Injection Method for Small Scale Drip Systems.

Water circulates through the source and injects the fertilizer into the system. The amount of fertilizer to use is based on the area being drip irrigated and the desired application rate.

Fertigation is usually more beneficial on coarse textured sandy soils than on fine textured soils. This is especially true for N fertilizers, which leach easily. Fertigation is a specialized, inexpensive means of topdress fertilization. Water quality is important for fertigation. Excess calcium in water in combination with some fertilizer sources can plug irrigation lines or block the soil's ability to take up water. Ask the county Extension agent for more information on fertigation.

Fertilizer Sources

The source of fertilizer used is a major consideration in fertilizer economy. The kind of fertilizer must be paired with the crop and application method at the most economical price. Some terms must be understood:

- **Grade or analysis** refers to the minimum guarantee of the percentage of available nitrogen (N), available phosphoric acid (P_2O_5), and water soluble potash (K_2O) in the fertilizer. For example, 100 lbs of 10-20-10 contains 10 lbs N, 20 lbs P_2O_5 and 10 lbs K_2O plus any other nutrients listed on the tag. The remainder of the material in the bag is carrier.
- **Ratio** is the grade reduced to its simplest terms. A 10-20-10 or 5-10-5 analysis fertilizer is a 1-2-1 ratio.
- **Formula** is the pound or percentage composition of the ingredients mixed together to make a ton of fertilizer. The formula may or may not be listed on the bag.
- **Unit** is 1% of 1 ton or 20 lbs of nutrient. On a ton basis the units per ton equal the percentage composition or lbs/100 lb. For example ammonium nitrate contains 34% N. One ton of ammonium nitrate supplies 680 lbs N (2000 lbs x .34 = 680) or 34 units of N (20 lbs/unit x 34 units = 680).

Generally higher analysis fertilizers are less expensive per pound of nutrient. Calculate the cost per pound as follows:

$$\frac{\text{\$/ton}}{2000 \times \text{\% nutrient content}} = \frac{\text{\$/2000 lbs}}{\text{lbs nutrient}} = \text{\$/lb nutrient}$$

example: ammonium nitrate 34% N @ $180/ton
vs. urea 46% N @ $200/ton

$$\frac{\$180}{2000 \times .34} = \frac{\$180}{680 \text{ lbs N}} = \text{\$.26/lb of N from ammonium nitrate}$$

$$\frac{\$200}{2000 \times .46} = \frac{\$200}{880 \text{ lbs N}} = \text{\$.22/lb of N from urea}$$

Liquid fertilizer may be more expensive than dry, but in many cases it is easier to handle and apply. The amount of nutrient in liquid fertilizer is calculated from the weight of the material per gallon. For example, N32 (32-0-0) weighs about 11 lbs/gal. Each gallon provides 11 x .32 or 3.5 lbs of N. Ten gal/A provides 35 lbs N.

Nitrate N is readily available to plants, but is easily leached, especially from sandy soils. Ammonium forms convert to nitrate in the soil. The time required varies, but is usually 3 to 4 days. Lower soil temperature is one factor that reduces the rate of conversion. N from ammonium sources may be available over a longer period than from nitrate sources.

Some common fertilizer sources with descriptive information are listed in Table 4. Local fertilizer distributors can usually blend other fertilizers to meet your needs.

Cottonseed meal, peanut meal, etc., are organic fertilizer sources. Organic fertilizers are usually good sources, but their cost per pound of nutrient is usually very high. Table 5 lists the average composition of some common organic materials. In some cases some materials, e.g. gin trash are available at no cost. If the nitrogen content is less then 1.5%, additional N will be needed to prevent temporary N shortage to the vegetable crop. In these cases, about 20 lbs of additional N are required per ton of dry matter. It is often advisable to limit large applications of low nitrogen materials such as straw and gin trash to land that will be fallow the succeeding season.

Vegetable Fertilizer Recommendations for Oklahoma

Phosphate-phosphorous and potash-potassium recommendations for commonly grown Oklahoma vegetables are listed in Tables 6 and 7 respectively. The OSU soil test reports available nitrate-nitrogen, and an index of available P and K in lbs/A. The recommendations are in pounds of N, P_2O_5, and K_2O per acre as listed on the fertilizer analysis. The surface NO_3-nitrogen listed on the soil test report should be subtracted from the recommended amount, e.g. if a tomato soil test shows 10 lbs NO_3-nitrogen, preplant apply only 40 lbs N (50-10 = 40), since tomatoes require a total of 50 lbs preplant N. This conversion is built in to the phosphorous and potash charts, e.g. if a soil test for snap beans shows 0 to 19 lbs P/acre, 50 lbs P_2O_5 should be added. If the same test shows 0-59 lbs K/A, 150 lbs K_2O should be added.

Table 4. Characteristics of Some Common Fertilizer Sources.

Inorganic Sources	Analysis	Advantage/Disadvantage
Anhydrous Ammonia	82-0-0	Easy to apply irrigation water, no residue, little leaching, some loss in irrigation water, or if dry injected, can't be used with sprinklers
Ammonium Nitrate	34-0-0	High pH, little loss to volatilization, low acid residue, subject to leaching
Ammonium Sulfate	21-0-0 (24S)	High acid residue good for alkaline soil, minimal volatilization loss, sulfur content/not for acid soil
Calcium Nitrate	15.5-0-0	Ca content, immediate availability, very soluble, no volatilization loss/leaches, clumps when moist, high cost/N
Urea	46-0-0	Acid residue similar to ammonium nitrate/toxic in high amounts, high volatilization loss if not incorporated; greatest loss on wet high pH soil followed by good drying conditions
UN 32 (liquid)	32-0-0	Same as urea and ammonium nitrate
Normal Superphosphate	0-20-0	
Conc. Superphosphate	0-46-0	
Mono Ammonium Phosphate	11-48-0	
Diammonium Phosphate	16-48-0 or 18-46-0	
Ammonium Phosphate (liquid)	10-34-0 11-37-0	
Muriate of Potash	0-0-60	
Sulfate of Potash	0-0-52	

Table 5. Approximate Composition of Some Common Organic Materials.

		N		P_2O_5		K_2O	
Material	% **Moisture**	%	**lbs/ton**	%	**lbs/ton**	%	**lbs/ton**
Bone Meal, raw	0	3.0	60	22.0	440	—	—
Cottonseed Meal	0	6.0	120	3.0	60	1.5	30
Peanut Meal	0	7.0	140	1.5	30	1.2	24
Soybean Meal	0	7.0	140	1.2	24	1.5	30
Feedlot Manure, beef	68	0.7	14	0.64	12.8	0.89	17.8
Poultry Manure (no litter)	54	1.6	31	0.92	18.4	0.42	8.4
Alfalfa Hay	10	2.5	50	0.50	11	2.5	50
Oat Straw	10	0.65	13	0.20	5	0.02	40
Wheat Straw	8	0.60	12	0.15	3	0.95	19
Cotton Gin trash	0	0.70	14	0.18	3.6	1.2	24

Source: Knott's Handbook for Vegetable Growers and Western Fertilizer Handbook

Following are general nitrogen recommendations for Oklahoma vegetables. See vegetable crop production fact sheets for additional details on individual crop fertilization.

Asparagus (crown nursery bed or new planting)—Plow down 50 lbs/A N along with needed P_2O_5 and K_2O. For a new planting apply an additional 50 lbs/A of P_2O_5 in the bottom of the planting trench. About two months after planting, topdress with 30 lbs/A of N during cultivation.

Asparagus and Rhubarb (established planting)—Topdress 70 lbs/A of N each year near the end of the harvest period. Every third or fourth year soil test and topdress recommended N, P_2O_5, K_2O, and lime, if needed.

Beans and Peas —Apply 25 lbs/A N at planting or preplant. Topdress or sidedress an additional 30 lbs/A N between the 3-leaf stage and flowering if foliage is light green.

Carrots, Table Beets, and Parsnips—Apply 50 lbs/A N preplant. Topdress with 50 lbs/A N when plants are well established.

Cabbage, Broccoli, Cauliflower, and Brussels Sprouts—Apply 50 lbs/A N preplant. Use a starter solution for transplants. Sidedress or topdress 50 lbs/A N 3 weeks after transplanting. Seeded plantings should receive 50 lbs/A N sidedressed or topdressed 3 to 4 weeks after emergence. Sidedress cauliflower with an additional 30 lbs/A N 3 weeks later.

Cucumbers and Cantaloupes—Apply 50 lbs/A N preplant. When vines tip over and begin to run topdress or sidedress with an additional 50 lbs/A N.

Okra—Apply 30 lbs/A N preplant. Topdress or sidedress an additional 20 lbs/A N when plants begin to bloom.

Onions, Green—Apply 50 lbs/A N preplant. Topdress with 40 lbs/A N 4 weeks after emergence.

Potatoes—Apply 75 lbs/A N preplant. Topdress or sidedress with an additional 30 lbs/A N 3 weeks after emergence and 30 additional lbs/A N when tubers begin to form.

Radish and Turnips—Apply 50 lbs/A N preplant.

Table 6. Phosphate-Phosphorus Recommendations for Irrigated Vegetable Crops.* Based on OSU Soil Test Results.

Tested Available Soil Phosphorus—pounds of P per acre				Apply lbs/A P_2O_5
			0-19	150
		0-19	20-39	100
	0-19	20-39	40-69	75
0-19	20-39	40-69	70-99	50
20-39	40-69			25
40+	70+	70+	100+	0
Asparagus (25)** (old beds) Bean, Lima (15) Bean, Snap (54) Okra (90) Rhubarb Southern Pea (34) Turnip, root (200)	Carrot (220) Greens (160) Collard Kale Mustard Turnip Lettuce (160) Parsnip (200) Pumpkin (200) Radish Spinach (100) Squash (160) Sweet Corn (90) Sweet Potato (150) Watermelon (160)	Asparagus (crowns/new bed) Beet (160) Broccoli (90) Brussels Sprouts Cabbage (225) Cantaloupe (140) Cauliflower (100) Cucumber (180) Eggplant (200) Pepper (120)	Market garden Onion (300) Potato, Irish (220) Tomato (200)	

To use this table, look for the crop to be grown. Then find the position of the soil test range in the overlying column of figures. To determine the phosphate (P_2O_5) needed, follow dashed line to the appropriate column on the right side.
EXAMPLE: Crop to be grown — Sweet corn
Soil test — 28 pounds of P/A
Recommendation — 50 pounds of P_2O_5/A

*Vegetables grown without irrigation can utilize less fertilizer. Reduce the listed amount by 1/3 for dry land production.
**Figure in parenthesis estimated yield potential in cwt (100 lbs) per acre.

Table 7. Potash—Potassium Recommendations for Irrigated Vegetable Crops.* Based on OSU Soil Test Results.

Tested Available Soil Potassium—pounds of K per acre				**Apply lbs/A K_2O**
			0-59	300
		0-59	60-99	250
	0-59	60-99	100-149	200
0-59	60-99	100-149	150-199	150
60-99	100-149	150-199	200-249	100
100-149	150-199	200-249	250-299	50
150-199	200-249			25
200 +	250 +	250 +	300 +	0
Asparagus (25)** (old beds) Bean, Lima (15) Bean, Snap (54) Okra (90) Pumpkin (200) Radish Rhubarb Southern Pea (34) Squash (160) Turnip, root (200)	Asparagus (crowns/new beds) Carrot (220) Lettuce (160) Rhubarb Sweet Corn (90) Watermelon (160)	Beet (160) Cabbage (225) Cantaloupe (140) Cucumber (180) Eggplant (200) Greens (160) Collard Kale Mustard Turnip Pepper (120) Spinach (100) Sweet Potato (150)	Broccoli (90) Brussels Sprouts Cauliflower (100) Market garden Onion (300) Potato, Irish (220) Tomato (200)	

To use this table, look for the crop to be grown. Then find the position of the soil test range in the overlying column of figures. To determine the phosphate (K_2O) needed, follow dashed line to the appropriate column on the right side.
EXAMPLE: Crop to be grown — Sweet corn
Soil test — 160 pounds of K/A
Recommendation — 50 pounds of K_2O/A

*Vegetables grown without irrigation can utilize less fertilizer. Reduce the listed amount by 1/3 for dry land production.
**Figure in parenthesis is estimated yield potential in cwt (100 lbs) per acre.

Southern Pea—Apply 20 Ibs/A N preplant.

Spinach, Lettuce, Turnip, Mustard, Collard, and Kale—Apply 75 Ibs/A N preplant. Topdress with an additional 50 Ibs/A N 3 weeks after emergence. Additional N may be needed for desirable color or rapid growth after harvest.

Sweet Corn—Apply 50 Ibs/A N preplant or at planting. Sidedress or topdress with 60 Ibs/A N when plants are 1 foot high.

Sweet Potatoes—Apply 30 Ibs/A N before transplanting. Use starter solution when transplanting. Sidedress 20 Ibs/A N 3 to 4 weeks after transplanting.

Tomatoes, Peppers, and Eggplants—Apply 50 Ibs/A N preplant. Use starter solution for transplants. When first fruits are set and the size of a half dollar, topdress or sidedress with 50 Ibs/A N.

Watermelons, Squash, and Pumpkins—Apply 40 Ibs/A N preplant. For extended harvest of summer squash an additional 30 Ibs/A N may be needed.

Market Garden—Apply 50 Ibs/A of N preplant along with the P_2O_5 and K_2O rate recommended. Topdress and sidedress with additional N depending upon each particular crop grown.

Some Conversion Factors

For special application situations, growers often have difficulty figuring how much fertilizer to use. Some equivalent values are:

- 1 acre is equal to 43,560 square feet.
- 1 gallon of concentrated liquid fertilizer weighs about 11 pounds.
- 1 pint of water or dry fertilizer weighs about 1 pound.
- 1 pint is equal to 2 cups or 32 tablespoons.
- 1 tablespoon is equal to 3 teaspoons.
- 1 ppm means 1 part per million.
- 2 ppm means parts per 2 million.
- An acre of mineral soil turned to a depth of 6 $^2/_3$ inches weighs about 2 million pounds.
- 0.1 ounce or 2.8 grams of fertilizer per bushel equals about 100 pounds per acre.
- 1 pound of fertilizer per cubic yard is equal to 800 pounds per acre.
- 20 bushels of soil mix equals about 1 cubic yard.
- 1 ounce or 28 grams per gallon is equivalent to 3 pounds per 48 gallons.
- 1 ounce of fertilizer per 200 gallons makes a salt solution of 75 ppm.
- 1 bushel of manure weighs about 50 pounds.

Some Equivalent Rates

Pounds per acre desired	Amount Fertilizer Needed: One sq. ft.	cubic yard	1,000 sq. ft. (33' x 30')
100	—	2 oz.	2.3 lb.
500	1 tsp.	10 oz.	11.5 lb.
1000	2 tsp.	1.3 lb.	23 lb.

The following OSU Fact Sheets are referenced in this publication:

PSS-2207 How to Get a Good Soil Sample

PSS-2229 OSU Soil Test Interpretations: 1. pH and Buffer Index

They are available at the local county Extension office. Pick up a copy for your production notebook.

Calibration of Fertilizer Drills

Determine amount of fertilizer needed. Set drill at opening estimated to give the desired rate of application. Mark level of the fertilizer in the hopper. Operate the drill for 100 ft. Weigh a pail full of fertilizer. Refill hopper to marked level and again weigh pail. The difference is the pounds of fertilizer used in 100 ft. Table 8 can be used as an aid in calibration. Consult the column under the appropriate row spacing. The left-hand column opposite the amount of fertilizer dropped/100 ft. will then show the rate in pounds per acre at which the fertilizer has been applied. Adjust setting on the drill if necessary and recheck.

Table 8. Amount of fertilizer required/1000 ft of row at various rate/row space combinations.

Distance between Rows (ft):	1.5	2	2.5	3	4	6
Rate (lb/acre)	Approximate Amount of Fertilizer (lb/1000 ft of Row).					
250	8.7	10	12.5	15	20	30
500	12.5	20	25	35	45	70
750	25	30	37.5	45	70	90
1000	30	45	57.5	70	90	140
1500	50	65	85	105	140	210

*Divide these figures by 10 for 100' row length

Table 9. Amount of dry fertilizer needed to supply various amounts of nutrients/A.

% Nutrient in Carrier	Nutrients needed (lb/acre) 20	40	60	80	100	120	160	200
	Carrier Needed (lb)							
8	250	500	750	1000	1250	1500	2000	2500
9	222	444	667	889	1111	1333	1778	2222
10	200	400	600	800	1000	1200	1600	2000
11	182	364	545	727	909	1091	1455	1818
12	166	333	500	666	833	1000	1333	1666
13	154	308	462	615	769	923	1231	1538
15	133	267	400	533	667	800	1067	1333
16	125	250	375	500	625	750	1000	1250
18	111	222	333	444	555	666	888	1111
20	100	200	300	400	500	600	800	1000
21	95	190	286	381	476	571	762	952
25	80	160	240	320	400	480	640	800
30	67	133	200	267	333	400	533	667
34	59	118	177	235	294	353	471	588
42	48	95	143	190	238	286	381	476
45	44	89	133	178	222	267	356	444
48	42	83	125	167	208	250	333	417
50	40	80	120	160	200	240	320	400
60	33	67	100	133	167	200	267	333

This table can be used in determining the acre rate for applying a material in order to supply a certain number of pounds of a nutrient.
Example: A carrier provides 34% of a nutrient. To get 200 lb of the nutrient, 588 lb of the material are needed; and for 60 lb of the nutrient, 177 lb of carrier are required.

Table 10. Amount of liquid fertilizer solution needed to supply various amounts of nutrient/acre.

Nutrient needed (lb/acre)	Solution Needed (gal/acre) 21% Solution	32% Solution	41% Solution
20	8.9	5.6	5.1
25	11.1	7.1	6.4
30	13.3	8.5	7.7
35	15.6	9.9	9.0
40	17.8	11.3	10.3
45	20.0	12.7	11.5
50	22.2	14.1	12.8
55	24.4	15.5	14.1
60	26.7	16.5	15 4
65	28.9	18.4	16.7
70	31.1	19.8	17.9
75	33.3	21.2	19.2
80	35.6	22.6	20.5
85	37 8	24.0	21.8
90	40.0	25.4	23.1
95	42.2	26.8	24.4
100	44.4	28.2	25.6

Adapted from C.W. Gandt, W.C. Hulburt, and H.D. Brown, Hose pump for applying nitrogen solutions, USDA Farmer's Bulletin 2096 (1956).

Some Useful Formulas for Determining Fertilizer Application

Amount of dry carrier needed/acre to supply given amount of nutrient.

Formula 1. $\frac{\text{nutrient needed lb/A}}{\text{\% nutrient in source}} \times 100$ = lbs os source needed/A

e.g. How much urea (46% N) must be broadcast to supply 30 lbs N/A?

$$\frac{\text{30 lbs/A}}{\text{46\%}} \times 100 = \text{65.2 lbs urea/A}$$

Note: Table 9 lists some common dry fertilizer nurtient/rate combinations.

Amount of liquid solution needed/A to supply a given amount of nutrient.

Formula 2. $\frac{\text{lbs of source needed/A}}{\text{wt/gal of source}}$ = gallons of source needed/A

e.g. How much UN 32 (32%N, 11 lbs/gal) is needed to supply 50 lbs N/A?

$$\frac{\text{50 lbs/A}}{\text{32\%}} \times 100 = \text{156.25 lbs/A} \qquad \frac{\text{156 lbs/A}}{\text{11 lbs/gal}} = \text{14.2 gal/A}$$

Note: Table 10 lists some common liquid fertilizer nutrient/rate combinations.

Amount of dry fertilizer to apply in band application.

Formula 3. $\frac{\text{43560 sq ft/A}}{\text{row spacing (ft)}}$ = ft of row/A

Formula 4. $\frac{\text{fertilizer rate/A x 1000 ft}}{\text{ft of row/A}}$ = fert rate/1000 ft of row

e.g. How much fertilizer must be band applied/1000' of row to supply 500 lbs/A in a 6' row spacing?

$$\frac{\text{43560 sq ft/A}}{\text{6 ft spacing}} = \text{7260 ft of row/A}$$

$$\frac{\text{500 lbs/A x 1000 ft}}{\text{7260 ft/A}} = \text{68.9 lbs/1000 ft}$$

Problem: How much concentrated superphosphate (46% P_2O_5) must be banded/1000 ft of row to supply 100 lbs P_2O_5/A to bell pepper plants in 3 ft rows?

Step 1. Determine amount of fertilizer needed/A (use formula 1).

$$\frac{\text{100 lbs } P_2O_5\text{/A}}{\text{46\% } P_2O_5} = 100 = \text{217.4 lbs conc. superphosphate}$$

Step 2. Determine feet of row/A (use formula 3)

$$\frac{\text{43560 sq ft/A}}{\text{3 ft row spacing}} = \text{14520 ft of row/A}$$

Note: 217.4 lbs of concentrated superphosphate (0-46-0) banded in 14520 ft of row provides 100 lbs P_2O_5/A

Table 8 lists some fertilizer rate/row space combinations.

Step 3. determine amount/1000 ft of row

$$\frac{\text{217.4 lbs/A x 1000 ft}}{\text{14520 ft/A}} = \text{14.9 (15) lbs/1000 ft}$$

Note: 15 lbs of 0-46-0/1000 ft of row (3 ft spacing) provides 100 lbs P_2O_5/A.

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