Statement of Purpose

The management practices, products, and cultivars discussed in this publication are the research- and experience-based recommendations of the institutions associated with the contributing editors and authors. These recommendations are not exhaustive and other practices and products not mentioned in this guide might also be effective. *Read and follow label instructions before using any pesticide product.*

What's New in 2014?

Highlights of Changes in This Edition

Disease Management

- The watermelon variety resistance to Fusarium wilt table has been updated with new varieties — see Cucurbit Crops chapter.
- A new table (pollenizer watermelon resistance to anthracnose) was added to the Cucurbit Crops chapter.
- Luna Privilege® has been labeled for several diseases of watermelon — see Cucurbit Crops chapter.

Weed Management

- Prowl H2O® is now labeled for use between rows of melons (see the Cucurbit Crops chapter) and green onions (see the Dry Bulb and Green Bunching Onion, Garlic, and Leek chapter).
- Dual Magnum® was added for several crops.
- Anthem® and Anthem ATZ® are now labeled for preemergence and postemergence weed control in sweet corn. Both herbicides provide preemergence control of many grass and broadleaf weeds and postemergence control of many broadleaves. Anthem® is a mixture of pyroxasulfone (Zidua®) and fluthiacet (Cadet®). Anthem ATZ® is a mixture of atrazine, pyroxasulfone (Zidua®), and fluthiacet (Cadet®). These herbicides have an 18-month replant restriction for all other crops except corn.

Insect Management

- Closer® was added to the recommendations for control of aphids, whiteflies, and plant bugs on several crop groups.
- Blackhawk® was added to the recommendations for control of caterpillars and Colorado potato beetles on several crop groups.
- The threat from the invasive brown marmorated stink bug was specifically addressed for several crop groups.

Watermelon seedlings being grown as transplants in a commercial greenhouse.

Soil Testing

Soil tests aid vegetable growers with their crop management, rotation, and fertilizer application programs. Soil tests are most useful when growers keep accurate records for each field that include the amount of fertilizers and other soil amendments they applied, crop yields, and rotations. These records allow growers to discover trends in soil fertility and crop response to applied fertilizers over several years.

Efficient vegetable production relies on growers adjusting their lime and fertilizer applications to their soils' existing fertility levels. Growers can increase their net returns if they maintain proper soil fertility, which can reduce crop losses from physiological disorders. Applying nutrients based on crop needs and existing soil levels also reduces the movement of nutrients into groundwater and surface waters.

Take soil samples at the same time each year, preferably in the fall or early spring. Soil pH varies seasonally, so comparing winter and summer samples is difficult. A typical soil test for plants usually determines pH, lime index (also called buffer pH), available Bray P1 phosphorus (P), exchangeable potassium (K), calcium (Ca), magnesium (Mg), and cation exchange capacity. It also includes and the percent base saturation of Ca, Mg, and K.

In addition to the routine pH test, growers should test soils that are susceptible to large variations in soil pH for salt pH. The salt pH provides a more accurate estimate of the true acidity in these soil types by simulating the effects of fertilizer salts on soil pH.

There are also tests to determine organic matter and other nutrients, including sulfur (S), manganese (Mn), boron (B), and zinc (Zn). Some labs test for microbial activity and water-soluble carbon, which can predict the release of nitrogen and phosphorus from organic sources.

Your land-grant university or extension service can provide you with a list of soil testing labs in your area.

Soilless Growing Media

Test soilless growing media used in transplant or crop production for pH and total soluble salts before using it. Request a test specifically for "soilless media" from the lab. If the crop will be grown in soilless media more than a month, regularly test the media or plant tissue to catch any nutrient imbalances that may affect crop growth and yield.

Interpretation of Standard Soil Test Results

- **Soil pH** (sometimes called active soil acidity) is based on the pH scale, which measures the acidic or basic reaction of the soil. A pH less than 7 is acidic; a pH greater than 7 is alkaline. When soil pH is too low for good crop growth, adding lime will raise the pH. Natural processes and agricultural practices tend to lower pH over time, so it is important to measure it every year or two.
- **Lime index** (sometimes called "buffer pH") measures reserve soil acidity. The lime index is used to make limestone recommendations. It usually takes lime four to six months to correct soil acidity. Your land-grant university or extension service can provide you with liming recommendations specific your state.
- **Phosphorus** may be reported as P (phosphorus) or P_2O_5 (phosphate). The units for P and other nutrient values may be given as parts per million (ppm) or pounds per acre. The value is an estimate of the amount of phosophorus in the soil that the plant can use for growth. Applying P_2O_5 fertilizer at 100 pounds per acre will increase the soil P test level by about 10 pounds per acre.
- **Potassium** may be reported as K (potassium) or K_2O (potash). The test value estimates the amount of K available per acre. About 50 percent of the potassium applied in fertilizers is fixed in the soil and is not immediately available to plants — this can vary by soil type and clay content. Soil K declines due crop removal, leaching, and soil erosion.
- **Calcium (Ca) and magnesium (Mg)** soil test values represent the amount of Ca and Mg available in the soil. Ca and Mg values generally are low when soils are acidic. Levels are usually sufficient when pH and the lime test index are at proper levels.

- **Cation exchange capacity (CEC)** is a measure of the soil's ability to hold exchangeable cations such as hydrogen (H), Ca, Mg, K, sodium (Na), iron (Fe), and aluminum (Al). CEC is measured in terms of milliequivalents (meq) per 100 grams of soil. Soil type and soil organic matter determine CEC. Clay-, silt- and loam-type soils generally have a higher CEC than sandy soils because they have many more exchange sites to hold cations. High-CEC soils generally hold nutrients better than low-CEC soils. Low-CEC also lose smaller amounts of nutrients due to leaching.

  Here are the typical CEC ranges of various soil types:

Soil Texture	CEC Range
Sands	5-15
Silts	8-30
Clays	25-50
Organic soils	50+

- **Base saturation** is the percentage of the total CEC occupied by basic cations such as Ca, Mg, and K. Base saturation is related to soil pH and soil fertility. On acid soils, the percent base saturation of Ca and Mg is low. The saturation of the different cations is important because plants take up some cations more easily than others. The base saturation for Ca should be 60 percent or more; Mg should range between 10 and 15 percent; K should range from 1 to 5 percent. Excess levels of one cation can reduce the uptake of another. Some soil scientists believe that there should be specific Ca:Mg ratios and Mg:K ratios (2:1). Most horticulturists believe that if base saturation levels are at the minimum levels suggested here, then it is not important to maintain specific proportions or ratios.

Macronutrients or Primary Nutrients

Nitrogen (N), phosphorus (P), and potassium (K) are macronutrients or primary nutrients and most commonly applied in fertilizers for field vegetable production. Plant nutrient recommendations are often given as pounds of N, pounds of phosphate (P_2O_5) and pounds of potash (K_2O) per acre.

It is up to growers to figure how much fertilizer or product they must apply to meet the suggested recommendations. This can be tricky, because growers may need more than one kind of fertilizer product to meet the recommendations.

Fertilizer products are required to list the percent N, P_2O_5, and K_2O equivalent they contain — and the products are listed in the order: N-P-K. For example, a fertilizer labled 10-10-10 contains the equivalent of 10 percent N, 10 percent P_2O_5, and 10 percent K_2O. So a pound of this fertilizer would contain 0.1 pound each of N, P_2O_5, and K_2O.Urea labeled 46-0-0 contains 46 percent N, 0 percent P_2O_5, and 0 percent K_2O. Potassium chloride (muriate of potash) labeled 0-0-60 contains 0 percent N, 0 percent P_2O_5, and 60 percent K_2O. Organic fertilizers are also labeled this way — a 3-2-2 product contains 3 percent N, 2 percent P_2O_5, and 2 percent K_2O. It's important to note that some of the N and P in organic fertilizers require warm, moist soil and microbial activity before it is available to plants.

Let's say a nutrient recommendation calls for 100 pounds of N and 100 pounds of K_2O per acre.

A grower could meet that recommendation by using 217 pounds of urea (217 pounds of urea X 0.46 N = 100 pounds of N) and 167 pounds of potassium chloride (167 pounds of potassium chloride X 0.60 K_2O = 100 pounds of K_2O).

A grower could also meet that recommendation by using 1,000 pounds of premixed 10-10-10 fertilizer (1,000 pounds of fertilizer X 0.10 N = 100 pounds of N; 1,000 pounds of fertilizer X 0.10 K_2O = 100 pounds of K_2O). But that same fertilizer would also supply 100 pounds of P_2O_5 that is not needed. So using such a fertilizer could be a waste of money and could pollute surface or ground water.

If you choose a premixed fertilizer, select the ratio of nutrients that comes closest to the amount of recommended nutrients. It is not necessary to be exact as long as any differences are reasonable. If you can't get to the recommended nutrient application using premixed fertilizers, it is fine to first make a base application using a standard fertilizer ratio, and then apply individual elements to reach the recommended nutrient levels.

For example, you can supply extra N with urea or urea ammonium nitrate solution; you can supply extra K with muriate of potash. Custom-blended fertilizers can be made to almost any desired ratio.

Nitrogen (N)

Standard soil tests aren't very useful for predicting how much N fertilizer you need to apply to optimize yield and qualilty. N fertilizer recommendations account for the soil type, amount of organic matter in the soil, field history, and crop. The recommendations in this guide are based on data from relevant field trials. Adjust these recommendations according to experience, soil type, cropping history, additions of organic matter, and crop culture system.

For example, suppose your vegetable crop is following soybeans, alfalfa, or a grass-legume hay crop. If your soils have more than 3 percent organic matter, you may not need to add any sidedressed N. If your soils that have less than 3 percent organic matter, then half the total N can be applied preplant and the other half sidedressed early in the crop growth cycle.

Now suppose your vegetable crop is following corn, rye, oats, wheat, or a previous vegetable crop. There may be no residual soil N available, so the crop may benefit from additional sidedress N. It may be useful to test the soil for nitrate-N shortly before sidedressing to assess whether the crop will benefit from the application.

Phosphorus (P)

P recommendations for vegetables are based on the soil test value, the type of crop, and estimates of crop removal. On mineral soils, most vegetables will benefit from P fertilization if the soil test is less than 35-40 ppm P using the Bray-Kurtz P1 extraction method.

If the soil test on a mineral soil is more than 80 ppm P, then no additional P is recommended for most vegetables. P does not move readily in the soil and applied P easily reacts with soil minerals so that it is unavailable to the plant. That's why P fertilizer is applied in bands near the crop when possible, and starter solutions that are high in P are recommended for transplants.

Potassium (K)

K recommendations for vegetables are based on the soil test value, the soil CEC, the type of crop, and estimates of crop removal.

Vegetables usually benefit from K fertilization if the soil test is:

- Less than 85 ppm K on a soil with low CEC (4 meq/100 g).
- Less than 115 ppm K on a soil with medium CEC (16 meq/100 g).

The maximum annual K recommendation for most vegteables is 300 pounds of K_2O per acre. K fertilization is not usually recommended if the soil test is more than 135 ppm K on a soil with low CEC, or more than 165 ppm K on a soil with medium CEC.

Petiole Sap Testing

Petiole sap analysis is a rapid diagnostic method you can use to monitor nutrient levels in a variety of vegetable crops during the growing season. Sap testing is most common for checking N, although you can also monitor K levels. Sap tests do not supply any information you cannot get through standard plant tissue testing.

But sap tests can be done on the farm, are less expensive, and eliminate the delay between the time a sample is collected and laboratory results are available. These factors can be critically important when you suspect a nutrient deficiency, or you are preparing to fertigate or to make a sidedress fertilizer application and you want to know what rate to use. Plant nutrient levels can change quickly, especially during rapid growth phases.

Sap tests measure the nutrient concentrations in plant sap that has been squeezed from leaf petioles. Two of the most popular sap-testing equipment are Horiba® and Cardy® meters. The meters are hand-held, battery-operated, and have ion-selective electrodes for testing nitrate-nitrogen or potassium. They have flat sensors that require a small sample volume and give a direct readout of concentration.

Sufficient nutrient levels for many vegetable crops have been developed in Florida and California. On-farm surveys and research on a few crops, including pepper, tomato, and cantaloupe, have found those recommendations useful in the Midwest as well. Midwest growers should consider the values from Florida in Table 1 as initial guidelines. Keep records of sap tests and fertilizer applications, and adapt the Florida guidelines as necessary to fit your conditions and management system.

The advantages of petiole sap tests are that they are relatively simple, give immediate results, and are particularly useful for making timely adjustments in fertilizer application rates when using fertigation. They are designed as an on-farm crop management tool and are meant to supplement, not replace, standard soil testing and nutrient management programs. Sap tests are not as precise as laboratory analyses, but if used carefully, they are reasonably accurate and sufficiently precise to distinguish between adequate and deficient plant nutrient levels.

In short, they are accurate enough to help growers make decisions that can increase the efficiency of their fertilizer appliations. Growers may improve yield or quality by more closely matching nutrient rates and timing with plant needs. They may also reduce or eliminate unnecessary fertilizer applications, which can save money and reduce the potential harm to the environment from leaching or runoff.

Procedures for Sap Testing

To collect a sample for sap testing:

- Obtain a representative sample.
- Sample at a consistent time of day — sampling time may affect N results.
- Sample the uppermost, recently matured leaves.
- Remove the petiole or "leafstalk."
- Collect about 25-30 petioles per sample.
- Avoid damaged, diseased leaves.
- Collect separate samples for different:
    - Varieties, planting dates, and areas with deficiency symptoms.
    - Cultural practices, soil types, and irrigation sections.

After collecting a sample for sap testing, follow these handling guidelines:

- Do not allow petioles to lose moisture after picking.
- Strip leaf blades from petioles soon after picking.
- Place samples in closed plastic bags and store them in a cooler on ice.
- Do not store expressed sap for long periods (unless frozen).
- You can store petioles for 1 or 2 hours at moderate temperatures, somewhat longer on ice.

A garlic press may be used to extract sap for petiole testing.

Extension Vegetable Crop Production Websites

Illinois Fruit & Vegetable News
www.ipm.uiuc.edu/ifvn

Iowa State University
www.extension.iastate.edu/vegetablelab

K-State Plant Pathology Extension
www.plantpath.k-state.edu/DesktopDefault.aspx?tabid=49

K-State Horticulture Extension
www.hfrr.ksu.edu/DesktopDefault.aspx?tabid=931

Minnesota VegEdge
www.vegedge.umn.edu

Ohio VegNet
vegnet.osu.edu

Purdue Fruit and Vegetable Connection
www.hort.purdue.edu/fruitveg/

Radcliffe's IPM World Textbook
ipmworld.umn.edu

University of Missouri
www.plantsci.missouri.edu