MONTANA STATE UNIVERSITY EXTENSION

Feeding the Vegetable Garden

by Clain Jones, Montana State University Extension Soil Fertility Specialist, and Kathrin Olson-Rutz, Research Associate

Knowing about garden soil can lead to healthy plants, efficient resource use, and protection of ground and surface water.

Soil nutrients and organic matter are important for a healthy garden. If plants aren't thriving, soil nutrients could be lacking, out of balance or even too high. Adding fertilizer, compost or manure may not solve the problem, and may actually make the problem worse if nutrients are in excess.

A good starting point is with a soil test. Early spring is the best time to sample because the results best represent what is available the coming growing season. Plus there is time to make adjustments before the plants need the nutrients. Collect 6 inch deep cores (a tulip bulb planter works) from about 10 locations throughout the garden space. Mix them in a bucket and take a subsample from this mix to submit to an accredited lab. Areas with very different soils or past history can be submitted as a separate sample. Soil test reports generally provide recommended fertilization rates. If not, tables 1 and 2 give general guidelines for nitrogen (N), phosphorus (P) and potassium (K) fertilization based on soil test results.

Some nutrient imbalances can be detected by observing plant growth (Table 3). Gardeners are known to over fertilize. Excess fertilizer can burn the plant roots and leaves and the salt build up blocks uptake of other nutrients such as zinc (Zn) and K. Deficiency and toxicity symptoms are not always consistent and can be caused by a combination of nutrient imbalances. Beware of pseudo-deficiencies caused by herbicides, disease, insects, salinity, or moisture stress that look like nutrient deficiency symptoms.

Other soil properties to consider, aside from nutrient levels, are soil pH, cation exchange capacity (CEC) and soil organic matter (SOM). Most Montana soils are high in pH (greater than pH 7). Although vegetables generally prefer pH levels between 6 and 7, they grow fine in high pH soil. This is good, because little can be done to lower soil pH. Elemental sulfur lowers pH, but at a high cost and at the risk of increasing sulfate and soil salts to harmful levels. If soil pH is below 6, liming effectively increases soil pH.

Cation exchange capacity is a measure of the soil's ability to hold onto and supply positive ions [e.g., ammonium (NH_4^+), K^+, Zn^{+2}] to a plant. High CEC indicates a fertile soil. Clay has high CEC, and holds water well; however it can lack porosity (air space) to be a good growth medium. In contrast, sand has high porosity for good water drainage, but low CEC, so it doesn't supply or hold nutrients well. Soil organic matter is the key ingredient to turn sand or clay into a better garden soil.

Soil organic matter has high surface area which increases CEC. It helps hold water in sandy soils, yet adds air space for better drainage of clay soils. It also provides nutrients as it decomposes. Yet, if the organic matter is manure or food compost, a garden can accumulate too much of a good thing. One inch of composted manure adds more than 10 times the N and K annually removed by vegetable harvest, and 50 times the P. Not only is it easy to apply too much N, the ratio of P to N is four times higher in manure than in vegetables resulting in soil P accumulation if manure is added to meet N needs. Excess nutrients, whether from organic material or conventional fertilizer, can be unhealthy for the plants and contaminate water.

If soil P is high, consider adding organic matter high in carbon, such as straw, dry leaves, wood-shavings, or peat moss. However, these can tie up N for a few months, leaving insufficient amounts for the plants. Use high N sources such as urea or blood meal to supply about 0.5 lb N/1000 sq. feet extra N. Or increase soil N by growing legumes (e.g., beans, peas). Rotating these N-fixing plants with heavy feeders (e.g., broccoli, corn, lettuce, and potatoes) can help manage soil N and ensure efficient nutrient use throughout the garden.

Unlike conventional fertilizers, compost supplies a diversity of nutrients at relatively low, unknown concentrations. Lab analysis can determine nutrient concentrations, but not with the same confidence as the label on a bag of pelleted fertilizer. A concern with compost is the potential for residual herbicides. If in doubt, conduct a simple test by comparing beans, peas or tomatoes grown in pots with and without the compost. If plants don't germinate, have abnormal growth, or die young, the compost is likely contaminated.

Compost slowly decomposes and supplies nutrients, so it should be applied and turned into the soil in the fall. It can be used as very thin topdressing during the growing season. Liquid or pelleted fertilizers release their nutrients quickly and can be incorporated right before seeding, to the side of the seed row, or between plants early to mid-growing season.

The foundation of a healthy garden is a healthy soil. Understanding soils leads to wise nutrient use, promotes maximum plant health and yields, and protects our water and air.

For more information and references:

Growing Tomatoes in Montana at http://msuextension.org/publications/YardandGarden/MT199217AG.pdf

Home Garden Soil Testing and Fertilizer Guidelines under "Extension Publications" at http://landresources.montana.edu/soilfertility

Nutrient Management Module 9: Plant Nutrient Functions and Deficiency and Toxicity Symptoms at http://landresources.montana.edu/NM/

MSU Extension Yard & Garden at http://www.msuextension.org/category.cfm?Cid=5

Table 1. Nitrogen fertilizer guidelines (lb N/1000 sq ft) for garden soils based on 6-inch soil test results and organic matter level.

Soil Test Nitrate-N	Organic Matter (%)		
(lb/acre)	<1.5	1.5-3.0	>3.0
<20	4	3	3
20-40	2	2	2
40-80	1	1	0.5
>80	0	0	0

Table 2. Phosphorus and potassium guidelines for garden soils based on 6-inch soil tests.

Phosphorus (P_2O_5)	Olsen P (ppm)					
	<4	4-8	8-12	12-16	16-30	>30
(lb/1000 sq ft)	5	4	3	2	1	0

Potassium (K_2O)	Soil Test K (ppm)			
	<75	75-150	150-250	250-500
(lb/1000 sq ft)	3	2	1	0

Table 3. Plant symptoms that indicate potential nutrient deficiency or excess.

Nutrient	Nutrient Supply	Location on Plant	Appearance	Plant Structure
Calcium	Deficient	Upper, young leaves	Dark green distorted leaves, leaf tips dry and brittle, blossom end rot in tomatoes[a] and peppers	Poor germination, weak stems
	Excess	—	—	—
Iron	Deficient	Upper, young leaves	Sharp distinction between green veins and yellow between veins	Stunted under severe deficiency
	Excess	—	—	—
Nitrogen	Deficient	Low, older leaves	Leaves small and yellow	Weak stunted plants
	Excess	Low, older leaves	Burned leaf tips	Much dark green foliage but limited blossoms, or weak straggly plants, 'hairy' carrots
Phosphorus	Deficient	Low, older leaves, stems and veins, especially on underside	Dark green to purple, mottled or bronze as mature	Young leaves unusually small, possible very thin stems, or very lush and healthy but no flowers
	Excess	Upper, young leaves	Yellowing between veins	—
Potassium	Deficient	Low, older leaves	Grey-green, mottled, yellow, scorched leaf edge	Plant wilted, stunted, lacking vigor, small misshapen fruit
	Excess	Low, older leaves	Yellowing between veins	Fruit coarse and poorly colored
Sulfur	Deficient	Upper, young leaves	Light green to yellow	Small thin stems, delayed maturity
	Excess	—	Salt damaged, burned leaf tips	Inhibited flowering, limited seed germination

a. Refer to *Growing Tomatoes in Montana* (MT199217AG)

MONTANA STATE UNIVERSITY | EXTENSION

The U.S. Department of Agriculture (USDA), Montana State University and Montana State University Extension prohibit discrimination in all of their programs and activities on the basis of race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, and marital and family status. Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Jeff Bader, Director of Extension, Montana State University, Bozeman, MT 59717.