Urban Garden Soils: Testing and Management

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This fact sheet provides step-by-step instructions on selecting appropriate soil tests, sampling, and interpreting results. Soil tests measure plant nutrient needs and soil contamination, both important aspects of sustainable urban gardening. Although many garden centers sell home soil test kits, these tests are not recommended because they were developed outside of the Intermountain West with soils that have nearly opposite conditions. Soil tests conducted in local labs may cost more initially, but will provide results specific to Utah soils and management recommendations that balance long-term soil productivity, human health, and environmental sustainability. The Utah State University Analytical Labs (USUAL) is an excellent resource for the Intermountain West.

Deciding which soil test(s) to select depends on your intent. For example, if creating a garden on land with no prior history of fertilizer or amendment (compost or manure) use, then request an **Initial Urban Soil Test** for soil texture, salinity, and pH. In established gardens with a history of soil amendment additions, a **Routine Soil Test** for salinity, pH, phosphorus, and potassium is appropriate. Lastly, if heavy metal contamination is a concern, we recommend the **Total Elemental Composition (EPA 3050) Soil Test**.

Soil Texture, Salinity, and pH

For new garden locations, start with the Initial Urban Soil Test that includes soil texture, salinity, and pH. Soil texture describes how much sand, silt, and clay are in the soil, which is important for determining site suitability, as well as irrigation and nutrient management. Generally, soils with greater than 30% clay can be challenging to garden and may require selecting another location or installing raised beds. Knowing salinity and pH is important for maintaining soil and plant health—a low soil salinity (<2 dS/m) and pH near neutral (7) are ideal for most garden crops. Salinity and pH trend high in Utah and can easily increase, so these are important factors to check. Generally, soils with salinity >4 dS/m or pH greater than 8.5 are more challenging to garden. The soil lab will also provide a starter fertilizer recommendation for nitrogen, phosphorus, and potassium with this test.

Soil Fertility

There are 14 mineral nutrients in the soil that are essential for plant growth. Both deficient or excessive levels can lead to stunted plants and decreased yield (Figure 1). Fortunately, most nutrients are typically sufficient in Utah, and do not require regular testing.

Figure 1. *(Left) Dahlias with a nitrogen deficiency. (Right) Dahlias with sufficient nitrogen.*

The three most important nutrients to manage are the **primary macronutrients**: nitrogen (N), phosphorus (P), and potassium (K). Plants require more N than any other nutrient. Therefore, N generally needs to be added to the soil each year based on crop-specific recommendations. N is not regularly tested, but if soil N levels are desired we recommend sampling in spring and requesting the S8a soil nitrate test (also known as plant available nitrogen) from USUAL.

Unlike N, regular soil tests *are* recommended for P and K because these nutrients are needed in lesser amounts than N, can excessively accumulate in Utah soils, P can contaminate water resources, and K can increase soil salinity. We recommend USUAL's Routine Soil Test for first-time gardens that have had fertilizer, compost, or manure additions. This test includes P, K, soil texture, pH, and salinity. When retesting your soil in subsequent years, you can reorder the Routine Soil Test package, or select individual tests.

Though less common, other soil nutrient deficiencies may occur, necessitating additional testing. The micronutrients iron (Fe), zinc (Zn), copper (Cu), and manganese (Mn) can be deficient in soil with a high pH (>7.5). If you suspect plant nutrient deficiencies and a Routine Soil Test shows a higher pH with sufficient macronutrients, we recommend testing for micronutrients (S9a soil test) next.

Soil Contaminants

Soil testing for contaminants, such as heavy metals, is important in urban areas at risk for exposure. While low levels of metals naturally occur in most soils, levels can increase with certain property histories and locations.

Heavy metals pose a hazard to human health when soil test levels are high in areas where there will be *repeated* exposure over time (e.g., bare soils, gardens, and children's play areas). Growing edibles in contaminated soils can also add risk for exposure. Lead and arsenic, two common heavy metals in urban areas, accumulate near the soil surface and stay in the soil for a long time. See Table 1 for a list of locations and land histories that can elevate contaminant levels.

If your site may be at risk for heavy metal exposure, we recommend the S19 Elemental Composition (EPA 3050) Test. This test is also recommended when bringing in new fill or topsoil from unknown sources.

Guidelines for Urban Soil Sampling

1. Zone your property. Each zone gets its own soil test. The main goal of soil sampling is to submit a sample to the lab that represents your soil and returns accurate results. Different crop types, unique management practices, underperforming areas, and natural variations in the land can all affect soil test results. Therefore, group your gardens and yard into separate management "zones" so that unique areas have their own representative soil test (see Figure 3 for an example). Here are some considerations for creating zones unique to your property:

Crop type. If you are growing different types of plants, consider different zones for each planting category, such as separate zones for perennials and annuals, or grouping according to heavy and light feeders. Heavy feeders are crops that demand greater amounts of nutrients, such as corn, potatoes, and onions; light feeders demand fewer nutrients, such as lettuce, radish, and beans.

History and management. Isolate land that has been used or treated differently. For example, areas that use secondary water could be separated from those on

Table 1. *List of land histories that can elevate risk of soil contaminants.*

Property History or Feature	Reason for Potential Soil Contamination
Home built before 1978	Soil surrounding the house could have elevated lead levels from lead-based paint chips, particularly older homes with siding
Parked cars/vehicles	Leakage of oil, gasoline, or other chemicals
Near a highway	Deposition of leaded gasoline (phased down in the 1980s and banned in 1996) from motor vehicle exhaust
On an old orchard	Soil could have elevated lead and arsenic levels because lead arsenate was a common pesticide used from 1892–1940s (banned in 1988)
Mining history in the area	Concentrations of heavy metals and severely low pH
On or near a former industrial site	Prior storage and potential leaking of chemicals, and deposition from coal burning

Figure 2. *Old peeling paint accumulates on the soil surface.*

culinary, those under no-tillage from those in tillage, or those previously in pasture from those that were not. Other considerations may be differences in fertilizer, compost, or manure application practices. We recommend keeping areas of possible contamination isolated, such as a potentially lead-exposed garden next to an old house (Figure 2) versus a garden more than 20 feet away and likely out of a contamination zone.

Intuition. Isolate areas that are underperforming or just seem different. You can also learn more about the soil on your property by visiting this national soil database and zooming to your location to determine potential differences in soil properties. A separate soil test for these locations will help detect specific issues.

Figure 3. *Urban zoning example. The colored dots represent places to collect soil subsamples. There are four zones:* ***Pink****: old orchard (potential lead and arsenic exposure) on secondary water (potentially salinity).* ***Orange****: vegetable garden and seasonal chicken run (potential for high P, K, and salinity).* ***Blue****: flower bed adjacent to house (potential lead paint exposure).* ***Green****: vegetable garden with no manure application.*

2. Plan to collect multiple subsamples in each zone.

It is important that the soil sample you submit to the lab is composed of several samples taken across the zone, or "subsamples." Depending on the size of the zone, collect and combine 4 to 6 subsamples, mix well, and send in 2 cups of the composite to the lab (Figure 3). This helps ensure that the submitted soil sample represents the entire zone and provides an average of the zone's conditions. If only one soil sample is collected per zone, the results may be skewed. For example, perhaps the single sample was collected from a location where an animal urinated—results from that sample would have artificially high salinity levels.

3. Collect the soil samples.

Sample from the surface to a 6–8" depth, or the depth of a typical shovel blade. It is easiest to sample soils that are not extremely dry or wet. Watering the day prior can make sampling easier. Some circumstances require sampling deeper (one foot deep or more), such as for nitrate and some soil salinity testing.

To collect a soil sample, point your shovel straight down and shovel down to the desired depth (Figure 4). Alternatively, local Natural Resources Conservation Service (NRCS) offices lend soil corers for sampling (Figure 4) that are faster to use and cause less soil disturbance—a consideration when working with perennials.

As each of the zone's subsamples are collected, place them in a bucket. When all of the zone's subsamples have been collected, mix and break up any clods. If the soil is very wet, let the sample dry before bagging. Repeat these steps for each zone.

4. Send in your sample for analysis.

Samples can be hand delivered to the USUAL lab or mailed. Detailed mailing instructions are available here.

Figure 4. *Collecting soil samples for soil testing with a shovel (left) or soil corer (right).*

How frequently should I plan to soil test? When is the best time of year to sample?

For routine tests, we recommend resampling every 1 to 2 years for annual crops and every 3 years for perennials. Testing each zone can be costly, so it can be efficient to work in a rotation across zones, submitting one zone for testing each year. If certain zones yield similar results and will have similar management going forward, it may make sense to combine these zones in future years. Contaminants are only tested once, unless reclamation efforts are made or new fill is brought in.

The best time of year to sample is in spring or fall. Sampling in the fall at the end of the growing season has several benefits: there is more time to sample as the garden activities have ended, there is plenty of time allow the soil test to be processed by the lab, and having the soil tests completed in the fall maximizes planning time during winter. Soil testing in spring is best if you plan to test for nitrates, which can be lost from the soil during the winter. For spring soil tests, allow plenty of time for both the lab to process the sample (at least two weeks) and subsequent planning.

Understanding a Soil Test

A soil test is only useful if the information it provides is understood and used to make informed management decisions. Your soil test report will include a result for each category you had tested (texture, salinity, pH, P, K, etc.), an interpretation of the result (low, adequate, high), and a recommendation (amount of nutrient to incorporate). A brief description of the most commonly tested categories follows. For a detailed description of each category included in a soil test, click here.

Soil Test Results

Phosphorus (P) and Potassium (K) – reported in units of parts per million (ppm). P values between 21–30 ppm and K values between 126–300 ppm are optimal for most garden crops. See Table 2 to interpret your value and see a full list of P and K fertility recommendations. If your soil is low or very low, additional P or K must be applied to prevent deficiency. If the soil test indicated your nutrient levels are adequate, high, or very high, do NOT apply P or K and avoid manures and manure-based composts.

Nitrate – reported in units of parts per million. Nitrate values >25 are optimal. See Table 2 to interpret your value and find a full list of N recommendations.

pH – ranges from 1–14. Most Utah soils are around 7.5 to 8, which is on the high side for many crops. Avoiding excessive use of composts and manures, as well as never using lime or wood ash, can help keep pH from increasing. pH affects plant availability of some nutrients and is difficult to decrease after it becomes high in Utah. Awareness of pH and preventative management are key.

Salinity – reported as the amount of soluble salt in the soil in dS/m. Many fruits, vegetables, and flowers experience toxicity at 2 dS/m. Seedlings are more sensitive with a toxicity threshold of 0.75 dS/m. See Table 3 for a list of toxicity thresholds by crop. Utah soils have naturally higher salinity because of the state's drier climate; salts accumulate when not washed away by rainfall. Manures and manure-based composts also contain salt and can further elevate soil levels. In fact, these amendments are the most common reason for excessively high salinities in urban Utah gardens (click here for salinity values of Utah manures and composts). Like pH, salinity can be challenging and expensive to reduce after it becomes high. Awareness and preventative management are key.

Table 2. *Soil test values and fertilizer recommendations for nitrogen, phosphorus, and potassium. Recommendations are for a 100 ft^2 garden plot.*

Test Category	NITROGEN (N)		PHOSPHORUS (P_2O_5)		POTASSIUM (K_2O)	
	Test Result	Fertilizer Recommendation	Test Result	Fertilizer Recommendation	Test Result	Fertilizer Recommendation
Very Low	<10	Add 0.3 lbs N	0–10	Add 0.3 lbs P_2O_5	0–70	Add 0.4 lbs K_2O
Low	10–25	Add 0.2 lbs N	11–20	Add 0.2 lbs P_2O_5	70–125	Add 0.2 lbs K_2O
Adequate	>25	NONE	21–30	NONE	126-300	NONE
High	-	NONE	>31–60	NONE	>300	NONE

Table 3. Salinity thresholds and the ideal pH for crops. Salinity thresholds indicate the tolerance level of different crops. At salinities greater than the threshold, yield begins to decline.

Crop Type	Ideal pH[1]	Salinity Threshold [dS/m]
Apple	5.5–6.5	1.4
Artichoke	6.5–7.0	6.1
Blackberry	5.5–7.0	1.5
Corn	5.5–7.5	1.7
Bean, green	6.0–7.0	1.0
Beet	6.5–8.0	4.0
Broccoli	6.0–6.5[3]	2.8
Carrot	6.0–7.0	1.0
Cucumber	5.5–7.0	2.5
Garlic	6.2–7.0	3.9
Grape	5.5–7.0	1.5
Lettuce	6.0–7.0	1.3
Onion	6.0–7.0	1.2
Pea	6.0–7.5	3.4
Peach	6.0–7.0[4]	1.7
Pepper	5.5–7.0	1.5
Plum	6.8–8.5	2.6
Potato	4.8–6.5	1.7
Spinach	6.0–7.5	2.0
Strawberry	5.5–6.5	1.0
Sunflower	6.5–7.5[5]	4.8
Tomato	5.5–7.5	2.5
Zucchini	6.0–7.0	4.9

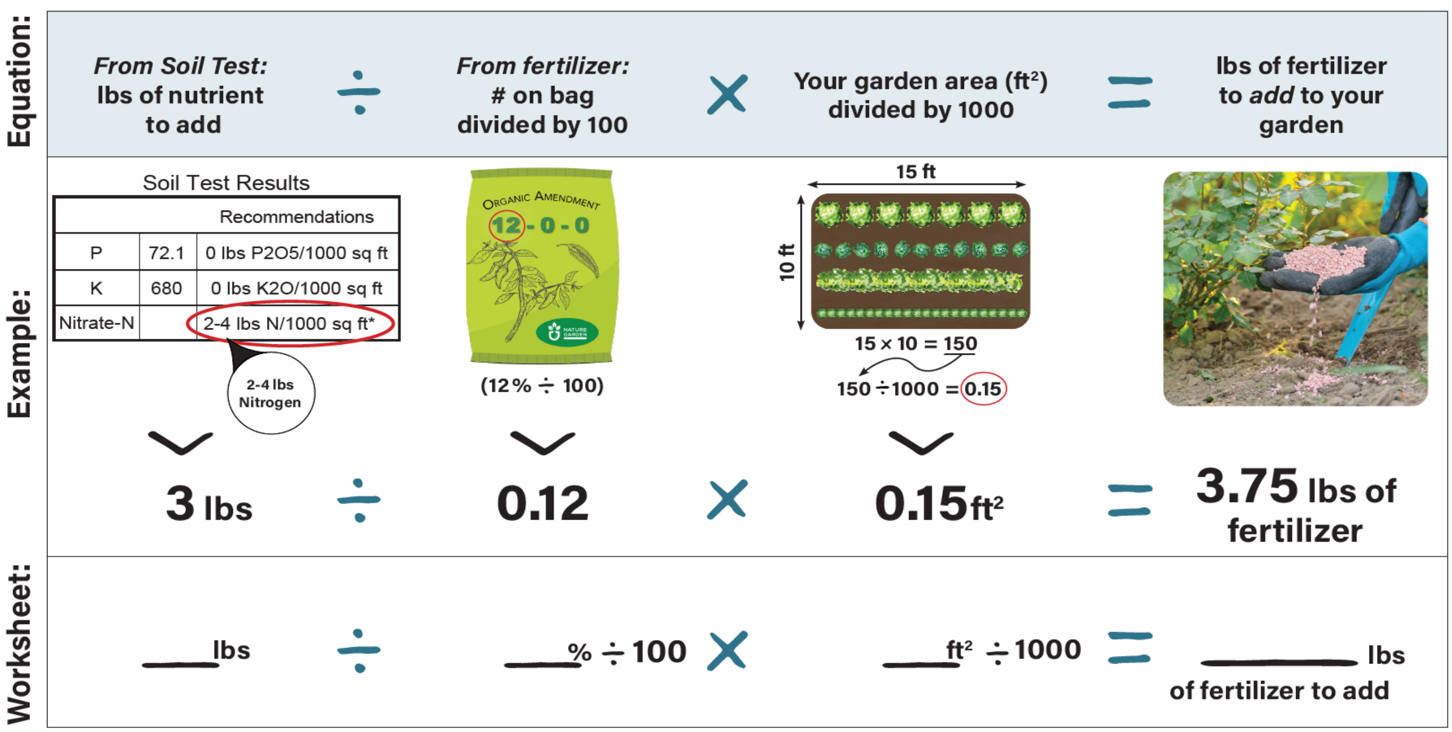
[1]Ideal pH ranges from Perry, 2003 unless otherwise noted.
[2]Salinity threshold table values from Tanji and Kielen, 2003, Table A1.1 [3]Lyon, 2017; [4]DuPont, 2020; [5]Berglund, 2007

Managing Soil Nutrients

When the soil test recommends applying fertilizer, the next step is to pick a fertilizer and determine how much of it to add. Every fertilizer has three numbers on its package: the first number is the percentage of nitrogen in the fertilizer, the second number is the percentage of phosphorus (as P_2O_5), and the third number is the percentage of potassium (as K_2O). When a soil test recommends pounds (lbs) of N, P_2O_5, or K_2O to add to your garden, use the worksheet at the bottom of this page to calculate the amount of fertilizer to apply.

Contaminants Soil Test

The S19 Total Elemental Test reports 18 elements in the soil, including both plant nutrients and heavy metal contaminants. Lead is a ubiquitous heavy metal in many urban environments. Per the EPA, bare garden soils and children's play areas should not exceed 400 ppm. If your soil test is flagged for heavy metals, there may still be options for growing crops in the space. Planting ornamentals (e.g., perennial flowers) and mulching the soil surface, or adding raised beds for food crops are two of the safest options. However, it is difficult for many garden plants to take up heavy metals and it is even more difficult for the metals to reach a plant's fruit. This means growing crops with edible parts above ground (tomatoes, corn, raspberries, etc.) is safer than growing leafy crops (lettuces, herbs) or root crops (potatoes, carrots, turnips).



Be sure to wash all produce with cold running water and peel roots crops prior to consumption. It is also important to wear gloves and closed-toed shoes in the garden, and wash your hands afterward. If children will be playing in the area, plant a perennial ground cover, like turf, to minimize their exposure to the bare soil.

Conclusion

Soil testing is critical for making informed management decisions for your garden, especially when starting to grow plants on a new site. Dividing your garden into zones based on crop type, previous management practices, and differences in performance ensures reliable and useful lab results. Regular testing provides information for sustainable nutrient amendment and identifies new problems. For urban sites, initial testing for contaminants is important, particularly for sites at risk. For additional help with soil testing or interpreting your soil test results, contact your local Extension office.

Additional Resources

Berglund, D.R. 2007. Sunflower production. North Dakota Agricultural Extension Service. A1331.

Cardon, G. E. Fertilizers. Chapter 4 in USU Extension Master Gardener Manual. P 4-1 to 4-10.

Cardon, G.E., J. Kotuby-Amacher, P. Hole and R. Koenig. 2008. Understanding your soil test report. Utah State University Extension. AG/Soils/2008-01pr.

DuPont, T. D. Granatstein and B. Sallato. 2020. Soil health in orchards. Washington State University Extension. Link

Hood, E. 2006. The apple bites back: claiming old orchards for residential development. Environmental Health Perspectives.

Koenig, R. and M. Johnson. 2011. Selecting and Using Organic Fertilizers. Paper 173.

Lyon, E. 2017. Growing broccoli in the home garden. Ohio State University Extension.

Oregon State University. 2016. Should I worry about heavy metals in my garden soil? OSU Extension Service. Link

Perry, L. 2003. pH for the Garden. University of Vermont Extension. OH 34

Saunders, O. 2017. Soil testing for environmental contaminants – Interpreting your heavy metals test results. University of new Hampshire Cooperative Extension.

Stock, M., T. Maughan, and R. Miller. 2019. Sustainable manure and compost application: Garden and micro farm guidelines. Horticulture/Soils/2019-01pr

Tanji, K.K. and N.C. Kielen. 2003. Agricultural drainage water management in arid and semi-arid areas. FAO Irrigation and drainage paper 61. Annex 1.

US Environmental Protection Agency. January 29, 1996. EPA takes final step in phaseout of leaded gasoline [Press release]. Retrieved from https://archive.epa.gov/epa/aboutepa/epa-takes-final-step-phaseout-leaded-gasoline.html

US Environmental Protection Agency. ND. Protect your family from exposures to lead. Retrieved from https://www.epa.gov/lead/protect-your-family-exposures-lead

Disclaimers

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