



Turf Technical Bulletins





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Turf

! IS PART OF WHO WE ARE.

In 1967, Harris Laboratories became the first agricultural laboratory to focus on the unique needs of golf course superintendents, turf growers and horticulturists. Through laboratory acquisitions, Harris Laboratories has now become AgSource Laboratories. While today we have a new name and look, the same service, dedication and quality analyses stands firm and rooted in the turf market.

Our specialized reports, analyses and procedures for soil, plant tissue and irrigation water were developed with the turf industry in mind. This includes customizable reporting in multiple formats, including PDF, CSV, and Excel, and are available via email, through our online portal, or mailed as a hard copy. We also offer free sampling supplies, including bags, submission forms, shipping labels, etc., to make sample submission as convenient as possible. AgSource Laboratories' dedicated turf experts will work with you to develop a custom testing plan based on your needs and goals.

Let our results drive your turf management decisions. Knowledge is Power.



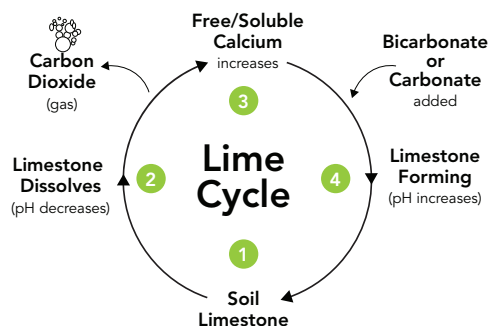
Alkaline Soils

Soils with a pH greater than 7.0 are considered alkaline. Alkaline soils often occur in arid regions that receive less than 25 inches of rain per year. Geographically, a combination of acid and alkaline soils exists between the Mississippi and Missouri Rivers, and the majority of the soils west of the Missouri River are alkaline. Soil alkalinity is caused by limestone that naturally exists in these arid soils. The effect of limestone and the interaction of irrigation water minerals on soil pH and soil productivity are discussed below.

Lime Cycle

Understanding the lime cycle is an essential beginning for understanding soil pH in alkaline soils.

Figure 1. Lime Cycle



- Beginning at the bottom of the cycle, soils can contain up to 60 percent limestone. In other words, an acre furrow slice of soil (2 million pounds) can contain up to 1.2 million pounds of limestone. However, most arid soils contain around 2 to 10 percent limestone (40,000 to 200,000 pounds).
- Chemically, limestone is calcium carbonate (CaCO_3), and as this compound dissolves, the soil pH decreases or becomes more acidic. A product of this reaction is free calcium and carbon dioxide, which is given off as a gas. This can be demonstrated by adding vinegar (acid) to many alkaline soils. You will note a violent effervescence of carbon-dioxide gas as the limestone is dissolved by the acid.
- As free or soluble levels of soil calcium increase, soil pH will be lowered (7.3 to 7.8). The soil pH will not drop below 7.3 until all of the limestone in the soil has been dissolved.
- When bicarbonate or carbonate is added to the soil (i.e., irrigation water), limestone is formed. In this process, free calcium levels in the soil are decreased and the pH increases.

Managing alkaline soil pH is best done by maintaining high levels of free calcium in the soil. This is why gypsum is added to soils with high soil pH (>8.0). It is an excellent and inexpensive source of soluble calcium. The soluble calcium removes carbonate from the soil by forming limestone. Elemental sulfur can also be used to lower pH - it reacts with soil limestone creating gypsum.

Irrigation Water Quality

Arid soils often require irrigation for crop production. Poor quality water can result in a build-up of soil salts and high soil pH. The chief minerals in irrigation water are chloride, sulfate, bicarbonate, sodium, calcium, and magnesium. Sodium, bicarbonate, and chloride are the three minerals that contribute most to soil salinity and alkalinity.

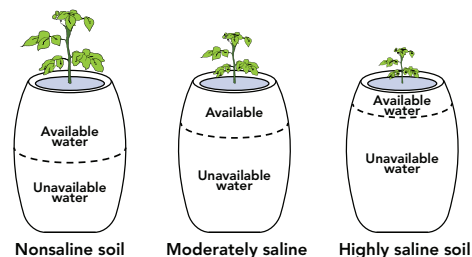
Continued irrigation with sodium-rich water will result in the soil "plugging up" because high sodium concentrations make the soil's clay and organic matter particles repel each other. This repulsion (dispersion) makes the clay break up and behave as an individual clay particle. Small, individual clay particles can then pack themselves in the small soil pores and plug them up.

Calcium has the opposite effect on soil clay. Calcium makes the clay particles flocculate, or come together, behaving as a larger soil particle. This encourages good drainage. Obviously, clay dispersion is not a problem for sandy textured soils with low clay content.

Bicarbonate in the water, as previously discussed in the lime cycle, will result in soil calcium forming limestone. After repeated use of waters high in carbonate and bicarbonate, soil calcium (both exchangeable and soluble) will be low and bicarbonate levels in the soil will be high because there is no more calcium in the soil to bind with and form limestone. Soil pH levels can be greater than 8.5 when water with bicarbonate is used.

Chloride-containing irrigation waters nearly always have high sodium also. Chloride affects soil productivity by reducing the amount of water available to the crop. The effect of salt build-up in the soil on the amount of available water is depicted in Figure 2.

Figure 2. Effects of salt build-up on available water



More frequent irrigation becomes necessary to keep up with increasing soil salinity levels. Many agronomic crops are most sensitive to saline soils during germination. Leaching and/or drainage must be carried out to flush the salt levels below the root zone. Once established, many crops can tolerate higher soil salinity.

Conclusion

Limestone is responsible for alkaline soil pH (7.0-8.5). Soil pH values above 8.5 are the result of irrigation waters containing bicarbonate. Irrigation waters containing high amounts of sodium result in poor drainage of medium and fine textured soils. Salt build-up is common with waters containing sodium chloride. A soluble source of calcium such as gypsum is the best way to reclaim these soils.

Lime Management

When using intense turf management practices, and carefully applying the correct type and amount of fertilizer, it's easy to see and measure the positive effects of an application. This is not the case when applying lime. Plant responses to lime are slow, of long duration and not easily spotted. However, when soil pH drops below pH 5, in order to achieve maximum fertilizer efficiency, lime must be applied before the fertilizer dressing. On acid soils, lime applications will improve the growing vigor for most turf grasses. A lime application will continue to neutralize acidity anywhere from two to three years. In this article, we will discuss the reasons and benefits of making lime applications.

Soil Acidity

Soil acidity, and its effect on nutrient availability, results from a lack of exchangeable metallic cations (Ca, Mg, K, Na) in the soil. The soil has an inherent capacity to absorb cations, called the cation exchange capacity (CEC), that varies with clay and organic matter content. The quantity of the adsorbed basic cations (Ca, Mg, K, Na) expressed as the percent of base saturation directly determines the hydrogen (H) concentration in the soil. (Example: Ca 60% – Mg 25% – K 3% – Na 2% of cation exchange capacity; this soil would be 90% base saturated, or contain 10% hydrogen.) As a result, adding suitable quantities of one or more of the above cations displaces H and attains an increase in soil pH. Calcium and magnesium are the two best suited; they are plentiful, widespread and relatively inexpensive. In addition, they have a desired effect on the soil's physical conditions.

Most grasses thrive best on slightly acidic soils (pH values of 5.8-6.5). At this range the best balance of available nutrients is achieved. Refer to **Figure 1**.

Changes to the Soil from Lime Applications

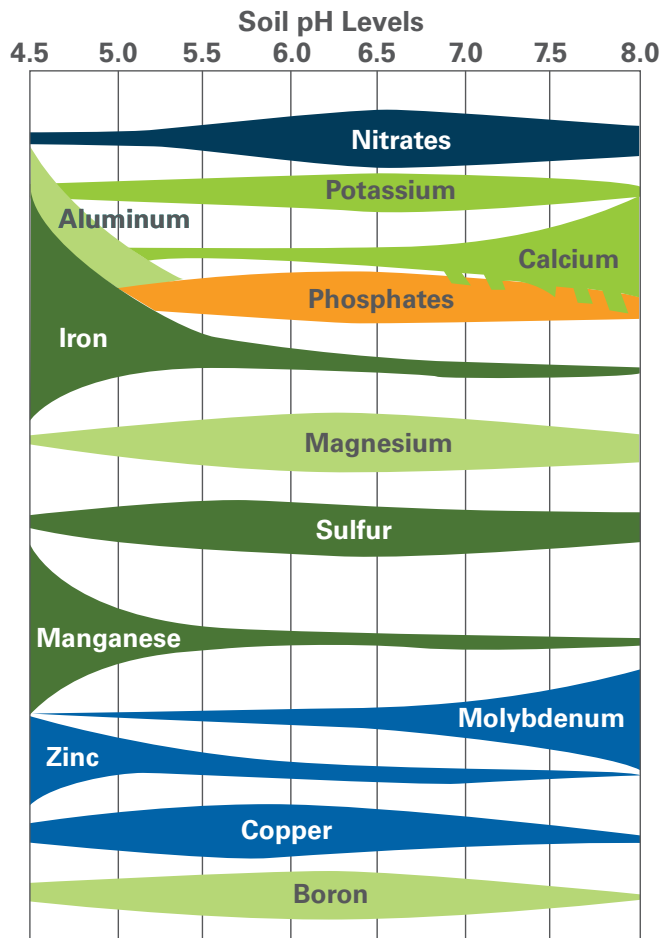
When applied to the soil, limestone undergoes several changes, the first of which is calcium and magnesium go into the soil solution with the help of carbon dioxide. Next, the acid dominated clay mineral adsorbs the calcium and magnesium ions from the soil solution. This can be diagrammed as follows:

Reaction with CO₂

When lime is applied to the soil it reacts with the carbon dioxide in the soil air and forms bicarbonates.



Figure 1. This bar graph is interpreted as the thicker the graph the greater the availability of the particular element.



Reaction with the Soil Clay

As the reaction of limestone proceeds, carbon dioxide is released, calcium and magnesium are adsorbed onto the clay mineral and the hydrogen reacts with oxygen to form water. The result is an increase in the soil pH.

Effects of Lime on the Soil

Basically, lime affects the soil in three ways: physically, chemically and biologically.

Managing Saline & Alkaline Soil: Soil Diagnosis

Managing saline and alkaline soil requires monitoring the salinity content in both the irrigation water and soil. In the 'Managing Saline & Alkaline Soil: Irrigation Water Quality' bulletin we discuss the measurements of water quality that impact the soil and crop growth. In this bulletin, we will discuss the analysis of soils as it relates to determining salt concentration and salt type.

Salt Concentration: Total Soluble Salts

As the salt concentration in the soil increases, plants must exert increasingly more effort to extract water from the soil. At some point, the soil will hold onto the water more tightly than the plant roots can extract it. As a result, the soil's ability to supply usable moisture is reduced. If the salt concentration continues to increase, drought conditions will occur.

Total soluble salt is usually reported as electrical conductivity. As the salt load in the soil increases, the value for electrical conductivity will also increase. Typically, AgSource Laboratories performs two different tests. The first test is a fast and simple procedure. A slurry of soil is made using a 1:1 ratio of soil to water. This procedure is best for determining if the soil has a high salt concentration and monitoring its level from one year to the next. It answers the question, "Is the salt concentration increasing or decreasing over time?"

The second test is the saturated-paste method. This involves adding only enough water to saturate the soil. A coarsely textured soil will need less water than a heavy clay. As a result, this method is more "truly" calibrated to the salt concentration encountered by plant roots. Therefore, the saturated-paste method is best for determining potential crop injury.

When looking at interpretations of salt concentrations in the soil, it is important to know which method is being used. Many tables will only state the salt concentration without stipulating the method. As you can see in the table below, the 1:1 Slurry values are less than half of values under Saturation Paste method.

Slurry 1:1 Extract (mmhos/cm)	Saturation Paste E _{ce} (mmhos/cm)	Saline Classification
0.01 to 0.45	0.01 to 2.00	Salt sensitive plants can be grown
0.46 to 1.50	2.01 to 4.00	Sensitive plants can be affected
1.51 to 2.90	4.01 to 8.00	Medium tolerant plants can be affected
2.91 to 8.50	8.01 to 16.00	Most plants will be affected
> 8.50	> 16.00	Severe saline conditions

Salt-concentration tolerances, based on saturated-paste method, for commonly grown crops based on maximum acceptable yield losses are shown below:

Maximum Acceptable Yield Loss

Crop	0%	10%	25%	50%	100%
Maximum E _{ce} Concentration (mmhos/cm)					
Bermuda grass	6.9	8.5	10.8	14.7	22.5
Barley	8.0	10.0	13.0	18.0	28.0
Alfalfa	2.0	3.4	5.4	8.8	15.5
Corn	1.7	2.5	3.8	5.9	10.0
Soybeans	1.0	1.5	2.3	3.6	6.5
Wheat	6.0	7.4	9.5	13.0	20.0
Oranges	1.7	2.3	3.2	4.8	8.0
Grapes	1.5	2.5	4.1	6.7	12.0

Note: Salt tolerance is much less during germination for many salt-tolerant crops. Salt-tolerant crops require E_{ce} less than 3.0 mmhos/cm during germination.

This table of maximum salt concentrations and corresponding yield losses assumes average soil moisture conditions are maintained throughout the growing season. If soil moisture conditions are higher than average, yield loss will be less than that stated in the table. On the other hand, as soil dries out, salt concentration increases along with salt injury. On average, salt concentration doubles as the soil dries from saturation to field capacity. It doubles again as it dries to wilting point. For example, a saturated-paste salt concentration of 3.0 mmhos/cm would be about 6.0 mmhos/cm at field capacity and 12.0 mmhos/cm at permanent wilting point.

Type of Salt

The three main soil salts are calcium, magnesium, and sodium in combination with chloride, sulfate, and bicarbonate. The most important salt is sodium because of its potential to destroy soil structure and reduce water infiltration. As the proportion of sodium absorbed in the clay increases, the soil tends to disperse or "run together," bringing about reduced rates of water penetration. However, soil sodium alone provides little information about the potential effect on soil structure and water infiltration. The dangers of soil sodium are best expressed as a ratio to calcium plus magnesium. Based on this concept, the sodium absorption ratio (SAR) was developed to express the soil sodium danger. SAR above 15 is expected to be more of a problem for a heavy textured soil versus a sandy soil because heavy textured soils have low infiltration rates under good conditions.

Soil boron concentrations are rather low in comparison to the other salts, but are important to mention from a toxicity standpoint. Soil boron concentrations below 0.7 ppm are safe for sensitive plants, 0.7 to 1.5 ppm is marginal, and more than 1.5 ppm is toxic to many crops.

Conclusion

Soil salinity and alkalinity are best managed by knowing soil salt concentrations and salt type. Interpretation tables for salt concentration and salt type are based on the saturated-paste extract. Soil salinity E_{ce} values less than 2.0 mmhos/cm are safe for most crops. With E_{ce} values above 2.0 mmhos/cm, yield loss is highly crop specific depending on crop-salt sensitivity. Salts that contain sodium are dangerous to soil structure and water infiltration. The ratio of sodium to calcium plus magnesium (SAR) reflects the true soil-sodium danger. Soil with SAR above 15 is prone to drainage problems.

Turf Nutrient Guide

Major, Secondary and Minor Elements

Mineral nutrients are classified as major, secondary and minor elements. This classification describes the relative amounts of each element present in plants, but is not intended to reflect its importance to the plant. All of the essential elements are necessary for proper plant growth, but the major and secondary elements are needed in greater quantities than the minor elements.

No one essential nutrient is of greater or lesser importance than another. Following is a list of the major, secondary and minor elements. Each has its own special role in the proper growth of turf grass.

Major Elements

- + **Nitrogen** (in fertilizer stated as N). An essential part of all living matter. Nitrogen-containing compounds make up about half of the living and reproductive substance of plant cells. Nitrogen is the basis for amino acids that combine to form proteins. Nitrogen is associated with vegetative growth and density of turf, as well as its deep green color.
 - **Nitrogen deficiency** is noticed in turf that has turned light green or yellow. When a deficiency occurs, it is first noticed on the older leaves or blades since nitrogen is easily moved (mobile) from the older to the newer growth. The blades start dying at the tip and progress along the midrib (center of the blade) until the entire leaf is dead.
- + **Phosphorus** (in fertilizer stated as available P_2O_5). It is the key nutrient in seedling development since it contributes so much to initial root development and seed formation. It is directly related to the vital growth processes; without it, there is a marked reduction in growth of established turf.
 - **Phosphorus deficiency** is most likely to be observed in seedling growth when new seedlings are slow to develop. On established plants, the blades may appear dull green and tend to turn purple in cold weather. These symptoms are first noticed on the older blades since phosphorus is so mobile within the plant.
- + **Potassium** (in fertilizer stated as exchangeable potash or K_2O) is found in all plants in relatively large quantities. It is involved in various biochemical reactions, including the production of sugars and starches. Potassium also plays a role in maintaining turgor pressure, which is associated with disease resistance, strengthening cell walls, increasing winter hardiness, and drought resistance.
 - **Potassium deficiency** first appears on the older leaves since potassium is a mobile element. The blades become streaked with yellow, turn brown at the tips and eventually die. Susceptibility to disease and winter injury is also increased.

Secondary Elements

- + **Calcium** is an important constituent of plant cell walls, thereby giving overall strength to the grass plant. Calcium is also essential for good root development and may serve to neutralize some toxic compounds present in the plant.
 - **Calcium deficiency** first shows on the younger new growth since this element is not readily moved within the plant. Symptoms are generally noticed as blades develop reddish brown leaf margins that may curl and die. However, these symptoms are sometimes difficult to observe and many times are completely lacking.
- + **Magnesium** is an integral part of the chlorophyll molecule, which means it is essential for photo-synthesis. Magnesium is also associated with phosphorus uptake and utilization within the plant.
 - **Magnesium deficiency** is first noticed on older leaves since this element is mobile. Green or yellow-green strips turn to bright red, and the turf becomes more susceptible to winter injury.
- + **Sulfur** is an integral part of certain amino acids and, therefore, proteins as well. Together with nitrogen, this element makes new protoplasm for plant cells.
 - **Sulfur deficiency** has symptoms that resemble those of a nitrogen deficiency since the two elements are so closely associated. Since sulfur is rather immobile, the younger leaves exhibit a light-green or yellowing. Eventually, the leaf tips turn brown and curl. Deficiencies are almost always associated with soils low in organic matter.

Phosphorus in Turf Grasses

Like nitrogen and potassium, phosphorus is one of the three major plant nutrients required for healthy growth. Phosphorus is used by plants to form nucleic acids (DNA and RNA) and other vital compounds. It is also used in storage and energy transfer (ATP and ADP). Compared to nitrogen and potassium, plants only need one-tenth as much phosphorus. Because phosphorus stimulates early season growth and root formation, fertilization is required to stimulate: cool season growth, correct limited root growth and development, and enable fast growth production.

Symptoms of Deficiencies

Symptoms of phosphorous deficiencies in turf grasses include:

- Slow growth and/or stunted plants
- Purplish coloration of foliage
- Dark green coloration with browning of leaf tips
- Poor seed development (if growing for seed)

Typically, in turf grass, deficiencies are described as a dark green color progressing to a purplish to reddish purple color, most apparent on the older leaves. Overall, stand appears as wilted and can be confused with the onset of drought stress.

Total soil phosphorus concentrations usually range from 200 to 5,000 ppm. These figures can be deceptive, however, because the available soil phosphorus may be only 1 percent or less of the total amount present. Think of an iceberg. All we see is the tip; more than 95 percent of the iceberg is below the water. So it is with phosphorus. Just as it is difficult to estimate the size of the iceberg by looking at the tip, it is difficult to estimate the amount of phosphorus reserves in the soil just by measuring extractable phosphorus using the Bray, Olsen or Mehlich methods.

Though estimation is difficult, these reserves are very important. On the average, 70-90 percent of the phosphorus used by the plant comes from the phosphorus reserves in the soil, while only 10 to 30 percent of the phosphorus fertilizer applied in a given year will be utilized by the turf. Therefore, even with an aggressive fertilizer program, plants depend primarily upon pre-existing phosphorus reserves for their phosphorus needs.

Phosphorus Cycle

It is important to understand the phosphorus cycle and its role in making phosphorus reserves available (See [Figure 1](#)). Phosphorus exists in the soil in three different forms:

- 1 Organic matter compounds
- 2 Inorganic mineral compounds
- 3 Soluble soil solution

Soil solution phosphorus exists in equilibrium with soil organic matter and mineral forms. Equilibrium means that phosphorus is being released from the organic and inorganic compounds and removed from the solution simultaneously. This movement, from soil solution to organic and inorganic forms, is indicated by the solid arrows in [Figure 1](#).

As a result of the equilibrium, phosphate anion concentrations in the soil solutions are created. Phosphorus is absorbed by the plant directly from the soil solution, in the forms of H_2PO_4 , HPO_4 or PO_4 . Thus, soil solution phosphorus is actually the source of phosphorus for plants even though the bulk of the reserve is found in the soil organic matter and mineral forms. The concentration of the soil solution increases if there is more released than removed. Conversely, the concentration decreases if there is more removed than released.

The release of phosphorus is generally due to weather, microbial activity and soil conditions.

- Certain weather conditions are responsible for releasing phosphate anions from the low-solubility compounds (calcium, magnesium, iron and aluminum phosphates).
- Microbial activity is responsible for soil organic matter release and/or tie-up of phosphorus.
- Various soil conditions influence the release of phosphorus from mineral and organic forms to the soil solution. These conditions include pH, temperature, moisture and amount of organic matter.

On the other hand, removal is almost solely related to the concentration of phosphorus in the soil solution. Plants absorb what is readily available, thus, the equilibrium noted in [Figure 1](#) is the controlling factor in phosphorus absorption. Plants cannot absorb that which is not present.

Release and removal are key to phosphorus turnover. Concentrations in the soil solution are very low, frequently ranging from 0.01 to 0.06 ppm. In order to replenish the phosphorus concentration, the phosphorus in the reserves must be released and simultaneously removed a number of times. For example, during periods of rapid growth, phosphorus in the soil solution may be replaced ten times or more per day. That translates to 450 times during one typical growing season. Continual phosphorus turnover must happen for the plant to absorb the proper amount of phosphorus.

Soil Phosphorus Reactions

As mentioned, phosphorus is required by the plant to form vital compounds and to store and transfer energy for growth. However, soil minerals and organic matter react quickly with soluble phosphorus fertilizer to create compounds with very low solubility. Because soil compounds and conditions significantly affect the amount of phosphorus available, the ability to estimate soil phosphorus is crucial. Your challenge is to manage these reactions so that turf grasses have adequate supplies of available phosphorus.

Reclamation of Saline and Sodic Soils

Saline and sodic soil conditions can be caused by many factors: high salt content in the parent material, poor internal drainage conditions, a high water table carrying salt to the soil surface, and high amounts of salt being applied, usually with poor quality irrigation water. Before a reclamation system can be established, the causal factor must be reduced or eliminated

Drainage

When deciding whether reclamation will be effective, it is important to consider soil drainage conditions. The ability to leach water through the soil profile is dependent upon good internal drainage. In fact, the overall effectiveness of a reclamation system is dependent upon leaching. Leaching carries the salts down through the soil profile and out of the rooting zone. Without it, salts will accumulate regardless of any applied soil amendments.

If natural drainage is low (or poor) then a tile drain should be considered. When properly installed, they are highly effective at carrying away the leached salts. Tile can only drain water if it is placed below the zone of saturation. For installation and or consultation, a professional should be contacted.

Another problem in turf areas is when two different soil types occur in the top foot of soil, inhibiting the downward movement of water. This can happen when top dress sand is applied to native soils (push-up greens) or when two different sand grades are used for top dressing. This creates a “perched” water table. Again, this condition needs to be reduced or eliminated for leaching of salts to occur. Radical deep tine aerification can help in most cases, but not all. If left uncorrected, “black layer” can occur, causing additional problems, resulting in decreased rooting. A professional should be contacted for consultation.

Leaching and Reclaiming Saline Soils

Saline soils cannot be reclaimed by fertilizers and/or soil amendments. However, they are relatively easy to reclaim if adequate amounts of low-salt irrigation water is available and internal drainage has been established. Reclamation consists of applying enough high-quality water to leach through the soil. Generally, about 6 inches of water are required to remove 70 to 80 percent of salt for each 6 inches of soil.

To ensure salt accumulation does not reoccur, an excess amount of water must be added, so the amount of salt added is equal to the amount of salt leaving the root zone.

Reclaiming Sodic and Saline-Sodic Soils

A sodic soil is one high in sodium. Sodium causes the clay in the soil to disperse, resulting in the loss of soil structure. As a result, internal drainage can be severely decreased. In addition, sodium also increases the soil pH value and adds to the total soil salinity content. A soil amendment is required to re-establish internal drainage and then leaching is required to remove the sodium.

The sodium in the soil needs to be replaced with calcium. Calcium flocculates the clay minerals resulting in improved soil structure, which in turn improves internal drainage. Calcium can be supplied by native gypsum (already in the soil), calcium in irrigation water, or with commercial amendments

Table 1. Amendment for soil and water, and their relative effectiveness in supplying calcium.

Amendment	Suitable for	Tons equivalent to one ton of 100% Gypsum
Gypsum	Soil & Water	1.00
Sulfur	Soil	0.19
Sulfuric Acide	Soil & Water	0.61
Ferric Sulfate	Soil	1.09
Lime Sulfur	Soil & Water	0.78
Calcium Chloride	Soil & Water	0.86
Calcium Nitrate	Soil & Water	1.06

Soil pH

Soil pH is one of the driving forces affecting overall soil fertility and the management of turf grass. It directly and indirectly affects the ability of plants to utilize soil nutrients. Understanding what causes soil acidity, and how to correct it, is essential to a successful nutrient management program.

Soil pH measures the relative amount of acidity or alkalinity in the soil by measuring the concentration of hydrogen ions (H+) in a suspension of soil in water. The alkalinity, or concentration of hydroxyl ions (OH-), is always in relative balance with the acidity. The pH scale ranges from 0 to 14. As diagramed in **Figure 1**, 0 is extremely acidic, and 14 is extremely alkaline. Soil with a pH of 7.0 is neutral.

It is interesting to note, each number on a pH scale represents 10 times the value of the previous number. For example, a pH of 6.0 is 10 times more acidic than a pH of 7.0. Thus, using the substances listed in **Figure 1**, battery acid is 10 million times more acidic than distilled water. Using this analogy, it is easy to understand why soil pH is so important.

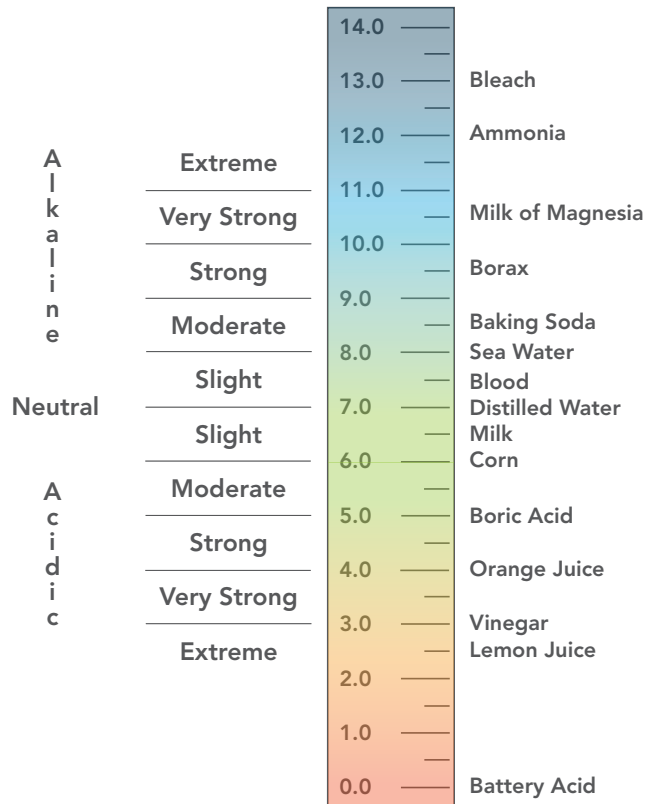
In extreme soil situations, pH can be as low as 3.0 and as high as 9.5. Normally, it ranges between 5.0 and 8.5, and values below 5.0 or greater than 8.5 represent severe growing conditions.

Soil pH Effects on Nutrient Availability and Toxicity

Managing the soil pH maximizes the effectiveness of the nutrients in the soil. For example, availability of nutrients such as nitrogen, potassium, and phosphorus is optimum from 6.5 to 7.5. Conversely, phosphorus availability decreases at pH levels lower than 6.0, because of aluminum and iron tie-up, and at pH levels higher than 7.5, because of calcium tie-up.

7.5. Conversely, phosphorus availability decreases at pH levels lower than 6.0, because of aluminum and iron tie-up, and at pH levels higher than 7.5, because of calcium tie-up.

Figure 1. Examples of pH values for several common items.



Zinc in Turf Grass

Zinc is a plant essential nutrient. It is necessary for plant growth and is taken up by the plant in the form of a cation, Zn^{++} . It is utilized in the following processes: activation of enzymes, chlorophyll formation, growth hormone regulation, cell growth and seed formation. Since zinc is immobile in the plant, visual deficiency symptoms (interveinal yellowing) will be most prominent in newly emerged tissue.

Factors Affecting Zinc Availability

Soil pH—The solubility and availability of zinc is directly related to soil pH. In alkaline soil, solubility is low and increases as the soil becomes more acidic. The table below predicts zinc concentration at various pH levels. For every one pH unit change, there is a tenfold change in the soil zinc concentration.

Soil pH	Soil Zn Solubility
4.0	4.12 ppm
5.0	0.412 ppm
6.0	0.0412 ppm
7.0	0.00412 ppm
8.0	0.000412 ppm

Organic Matter—Zinc deficiencies are frequently associated with soil low in organic matter. Soil organic matter behaves much like a chelate in holding zinc in the soil. The chelating nature of organic matter protects zinc from reacting with other soil minerals that contribute to zinc "tie-up," and causes zinc to accumulate in topsoil. Because of this, areas with a high degree of dirt work (cutting and filling) or heavy erosion are most prone to zinc deficiencies. This is further exaggerated when the newly exposed subsoil is alkaline.

Constructed sand-based soils are, by design, low in organic matter. Generally, the organic material used in an 80:20 mix is organic residue, not fully decomposed organic matter. Meaning, that without continued applications of organic residue, the reactivity remains very low and will be short lived (depending on geography, up to 3 years) in the soil.

Total Zinc Content—The original minerals present during soil formation determine the total zinc concentration in the soil. The total zinc content of the soil (available plus unavailable) can range from 10 to 300 ppm with an average of 50 ppm. The total zinc acts like a reservoir of potentially available zinc. The availability of the reservoir is dependent on the pH and organic matter. Most zinc minerals are contained in the silt and clay fraction of the soil. Therefore, medium and fine textured soils usually have higher levels of zinc and are less prone to zinc deficiency than sandy textured, or sand constructed soils.

Phosphorus—Research has shown that phosphorus fertilizer can induce zinc deficiencies, although, this only occurs when soil test levels are low to marginal (< 1.0 ppm Zn). With these low levels, high phosphorus applications will intensify a zinc deficiency. If zinc levels are greater than 1.0 ppm, phosphorus induced zinc deficiency will not occur.

Soil Temperature and Moisture—Cold, wet soil reduces root growth, zinc uptake, zinc solubility and the amount of zinc released from soil organic matter. As a result, the most severe zinc deficiencies occur in cold, wet and poorly drained soil.

Diagnosing Deficiencies

Soil Analysis—The extract most commonly used for zinc is DTPA, which is a chelate. The critical level for DTPA extractable zinc is approximately 1.0 to 5.0 ppm. A value less than 1.0 ppm would be considered deficient. The process of interpreting a zinc soil test can be improved when other factors that affect zinc availability, including the factors mentioned above, are taken into account. For example, a soil-test level of 1.0 ppm would be adequate in a slightly acidic, medium textured soil, with an organic matter level of 2 percent. However, a 1.0 ppm zinc level would definitely be deficient in an alkaline sandy soil with an organic matter level of less than 1 percent.

Application rates of zinc will be determined by the types and grades of fertilizer materials used. If needed, buy a fertilizer material containing zinc and follow the label for the correct rate. Zinc should be applied with the first application of the growing season, when soil temperatures are cool.

Plant Analysis—Since many factors can affect zinc availability, a plant tissue sample is an excellent diagnostic tool to complete a fertility monitoring program. This tool allows you to observe the actual zinc concentration in the plant, if the plant is getting enough zinc, or if too much zinc is present in the soil. Critical zinc levels for some turf grasses:

- Bermudagrass: 50 – 80 ppm
- Bluegrass: 40 – 60 ppm
- Bentgrass: 80 – 120 ppm

Soil Sampling Guide

Proper Sampling Equipment

Equipment should allow for monitoring and control of the sampling depth. A stainless steel sampling probe works best.

Composite samples should be collected in a plastic bucket for thorough mixing. Metal buckets can contain traces of some micronutrients (particularly zinc), which can contaminate samples.

Soil sample bags should be either plastic or plastic lined. These can be supplied by AgSource.

Sampling Procedures

Identify the areas to be sampled and note their locations for easy future reference. This is particularly important for fairways. Sample each unique area separately: mixing subsamples from different greens or fairways is not recommended.

Each sample should consist of a composite of many subsamples. About 10 to 15 subsamples are needed to supply the laboratory with enough soil for a nutrient analysis. The soil volume needed is roughly one cup (or approximately one pound).

Most importantly, keep sampling depth consistent. Golf greens should be sampled to a depth of three inches. For other turf samples, three to four inches is adequate.

It is advisable to include the thatch layer in your sample since it is a biologically active site. Keep in mind that this residue may contain fertilizer granules not yet dissolved or other materials which will affect the nutrient levels. Therefore, wait a minimum of two weeks after an application to collect soil samples.

Avoid any unusual areas in your routine sampling. These should be analyzed separately. An example would be poorly drained areas.

Clearly identify the sample (example: GRN#1) on each bag and submission form. Sample submission forms are available on our website.

Paperwork and Shipping Instructions

Please be sure all essential information is completed. The following information is required:

Samples Submitted By – This will be the account name and address, as well as who will receive the results and invoice.

Submitted For – The name and address for the golf course being tested.

Turf Type – This is expressed in broad categories: Greens, Fairways, Tee Boxes, etc.]

Note: Be sure the sample identification on the sample submission form matches the identification labeled on the soil sample bag(s).



Specify the desired analytical test packages to be performed

Pack samples very tightly in a strong shipping box. Use packing material so the bag(s) will not shift in the box. Tape the box completely and securely.

If possible, collect and ship samples on the same day. Visit our website or call your local AgSource laboratory to order your free sampling supplies.

Understanding a Soil Analysis

Soil pH

Soil pH is a measurement of the concentration of hydrogen ions. The level of concentration determines whether the soil is acidic or alkaline. Acid soils require limestone to raise the pH, whereas alkaline soils may need acid applications (elemental sulfur) to reduce soil pH. Most soils have a pH range from 4.0 to 8.5, with slightly acidic conditions being most productive. However, different grass species vary in their ability to tolerate pH conditions.

Grass Species	Minimum pH	Maximum pH
Fescue	5.0	8.5
Bentgrass	5.0	7.5
Creeping bentgrass	5.0	7.5
Bluegrass	5.0	8.4
Bermuda grass	5.0	8.0
Perennial ryegrass	5.2	7.5
St. Augustine grass	6.5	7.5
Salt grass	6.4	10.5

Because soil pH measures the active hydrogen, its value can be variable from one season to the next. This variability makes it difficult to predict the amount of lime needed to increase pH to an optimum value.

Buffer pH (or Buffer Index)

This index was developed to measure the total hydrogen (acid) content in the soil, which needs to be neutralized by limestone applications. As this Buffer pH decreases, the percentage of hydrogen in the soil increases.

As a result, greater amounts of limestone are required to neutralize the measured acidity. Because Buffer pH is only used to predict the quantity of lime, it is only analyzed when the soil pH is less than 6.5.

A generalized table of limestone applications for buffer pH values is listed below.

Buffer pH	Limestone (lbs./1,000 sq. ft.)
7.3	0
7.2	20
7.1	20
7.0	25
6.9	30
6.8	35
6.7	60
6.6	75
6.5	95

Limestone guidelines are assuming 100% CaCO₃, with a 6" incorporation. On established turf, do not apply more than 50 pounds in any one application.

Excess Carbonate

This quick test measures the amount of free limestone in the soil. It is reported as very low, low, medium, high or very high. As this rating increases, so does the amount of free carbonate. This quantity has a direct effect on availability of plant nutrients, particularly with manganese, iron, zinc, and phosphorus. As it increases, so do nutrient fixation rates. Excess carbonate can be neutralized with acid materials (elemental sulfur); however, the quantity required can be so large, it may become toxic to turf grasses.

Soluble Salt

Soluble Salt is a measure of the ability of a soil and water mixture to conduct electricity, expressed in millimhos per centimeter (mmhos/cm). The more electricity conducted, the higher the salt content in the soil. These salts are mobile in the soil solution and will move up and down with the soil water. Generally, high salt levels are associated with soils that have poor drainage conditions, and salt accumulates at the soil surface rather than leaching down through the soil profile. This salt load can only be reduced by leaching it below the rooting zone. Salt in irrigation water can also contribute to this problem. On this report, soluble salt is analyzed as a 1:1 soil to water mixture.

Test Unit: mmhos/cm	Optimum Range	Warning Range
Soluble salt	<0.60	>1.0

Cation Exchange Capacity (CEC)

CEC establishes the rate at which nutrients (cations) will be stored and released. It is an estimated value, based on the extracted cations: calcium Ca⁺⁺, magnesium Mg⁺⁺, potassium K⁺, sodium Na⁺ and hydrogen H⁺. Since the clay and organic sites in the soil have a negative charge, the positively charged cations bond with these sites. Therefore, CEC can be closely related to soil texture.

CEC Value	Estimated Texture
1-8	Sand
9-12	Loamy Sand
13-20	Sandy or Silty Loam
21-28	Loam
29-40	Clay or Clay Loam

Percent of Base Saturation

The base saturation is expressed as a percentage and is calculated by dividing each individual cation (Ca, Mg, Na, K, H) by the total CEC.

Below is a table representing the optimum percentage of the five major soil cations.

Cation	CEC Range				
	3-7	8-15	16-25	26-36	>36
	Optimum Percent Base Saturation				
Hydrogen	<30	<30	<20	<20	<20
Sodium	<10	<8	<5	<5	<5
Magnesium	10-20	10-20	10-20	10-20	10-20
Calcium	50-75	50-75	60-75	60-75	60-75
Potassium	3.3-7.7	1.5-4.3	1.0-2.2	0.7-1.3	0.5-1.3

Sodium (Na)

Sodium content provides information related to reclaiming saline and/or alkaline soils. When its base saturation exceeds five percent, water infiltration rates can become reduced because sodium causes the clay particles to be dispersed. This may not be the case with sand-based greens, where sand size (not soil structure) promotes infiltration. When correcting soils with high sodium, check and amend the soil drainage conditions. Corrections to high sodium content can be made by applying an amendment to replace the sodium and then leaching it below the rooting zone. If appropriate, select one of these soil amendments: gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), epsom salts (MgSO_4) or elemental sulfur (S).

Organic Matter (OM)

Soil organic matter is the result of the decay process of organic residues. The result of this process is a stable humus compound that has active cation-holding sites. These sites serve as a storehouse for plant nutrients and also improve soil structure in heavy soils. Undecomposed organic residue (thatch build-up) is not organic matter.

In most productive soils, the topsoil contains between 1.0 to 10.0 percent OM. In golf course construction, the top soil is commonly buried or stripped away, causing the loss of a valuable nutrient source. In addition, sand-based greens may contain 0 to less than 0.5 percent OM, resulting in high leach rates, low water holding abilities and low nutrient content.

Nitrate-Nitrogen

Nitrate-nitrogen is a measure of the available nitrogen present in the soil at the time the soil sample was taken. Due to solubility, it can leach rapidly out of the root zone, particularly on sand greens. This mobility makes it difficult to predict how much nitrogen will be present throughout the growing season.

Potassium (K)

The potassium extracted by ammonium acetate is readily available for plant uptake. Potassium is contained in the plant cells and tissues; therefore, it is removed in large quantities when vegetative growth is removed (removal of clippings).

The following table provides a generalized interpretation of optimal ranges for K and other cations. As noted earlier, soil texture influences CEC and nutrient availability. Sandy textures do not have enough holding sites, resulting in high leaching rates. Heavier textures will hold onto increasing amounts of K. As a result, high application rates are not advisable on sand-based greens, but can be successful on heavier-textured fairways.

Magnesium (Mg)

Magnesium can be deficient in sandy soils with low organic matter. Amendments can include: epsom salts, dolomitic limestone, and other soluble forms of Mg.

Calcium (Ca)

Calcium is rarely deficient as a plant nutrient and is usually applied as a soil amendment. Limestone (CaCO_3) is used to increase soil pH, gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) is used to dislodge sodium from soil particles; this releases calcium, but does not affect pH.

	Soil Cation Exchange Capacity (CEC)			
	5	10	15	20
	Optimum Range (ppm)			
Potassium	91-120	121-160	151-200	181-240
Magnesium	60-119	120-239	180-359	240-479
Calcium	600-1199	1200-2399	1800-3599	2400-4799

Phosphorus (P)

Two types of phosphorus extractions are used in this report: if soil pH \leq 7.1 Bray I; if soil pH \geq 7.2, Olsen P. In the plant, phosphorus stimulates early growth and root formation. Its primary usage is storage and transfer of energy throughout the plant.

Rating	pH \leq 7.1	pH \geq 7.2
	Bray P ppm	Olsen P ppm
Low	<15	<9
Adequate	16-25	10-15
Optimum	26-40	16-24
High	>40	>24

Zinc-Manganese-Copper-Iron

These four micronutrients are extracted from the soil with DTPA solution. As a general rule, soils which are high in pH, low in organic matter, and have a low Cation Exchange Capacity (CEC), are often deficient in these trace elements.

Zinc (Zn)

On areas with new construction and/or extensive dirt work, zinc levels can start out as deficient. But over time, areas with high management (golf greens) can achieve a build-up to very high levels. In turf grass, toxic levels have not been reported; however, monitoring is advisable.

Manganese (Mn)

Nutrient release from organic matter is the primary source of manganese; therefore, sand-based greens are usually deficient in Mn. In addition, Mn is highly reactive with soil pH. In soils with a pH greater than 8.0, plant response to Mn applications can be highly variable due to the very high fixation rates.

Copper (Cu)

Copper is similar to Zn in that it can start out as low in new construction, and be built to very high levels within several years. Monitoring is important; if a build-up occurs, check for a Cu source. Some soil-applied fungicides contain high concentrations of Cu. Toxicities have not been established in turf grasses; however, levels greater than 10 ppm would be a concern.

Iron (Fe)

Iron is similar to Mn in that it is highly reactive with pH. Soils with a pH greater than 8.0 can be sensitive to Fe deficiencies. In these soils, iron fertilizer fixation rates can be high, so multiple applications will be necessary each season.

Nutrient	Optimum Range (ppm)	Very High Range (ppm)
Zinc	1.5-5.0	>10.0
Manganese	5.0-15.0	>30.0
Copper	0.5-2.0	>5.0
Iron	5.0-30.0	>90.0

Soil Analysis



Submitted by **8888888**
AgSource Test Account
300 Speedway Circle, Unit 2
Lincoln, NE 68502

Submitted for
AgSource HARRISTURFELITE

Laboratory Sample #
DG27672 - DG27679
 Information Sheet #
TEST_20200923

Date Received
1-Jan-2026

Date Reported
03-Jan-2026

Field
TESTFIELD 1

Sample Identification	Phosphorus			Potassium	Calcium	Magnesium	Zinc	Manganese	Copper	Iron
	Bray I	Olsen	Mehlich							
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Test13	73			73	862	116	2.9	0.7	4.7	99.8
Test14	51			55	789	114	2.3	0.5	4.2	67.3
Test15	68			67	881	114	4.2	1.5	5.8	136.1
Test16	55			67	900	120	3.4	1.4	5.4	89.2
Test17	22			57	883	191	3.3	0.9	2.5	72.9
Test18	19			66	791	201	0.9	0.6	1.0	32.6
Test19	13			49	793	196	1.9	0.6	0.9	48.0
Test20	11			47	921	158	1.2	0.3	1.4	43.7
Optimum Levels Greens	25 - 45			125 - 150	747 - 862	140 - 250	1.0 - 3.0	5.0 - 15.0	0.5 - 1.5	4.0 - 20.0

Sample Identification	Soil pH	Sodium	Soluble Salts	Organic Matter	Cation Exchange	Percent Base Saturation				
						Hydrogen	Sodium	Potassium	Calcium	Magnesium
		ppm	mmhos/cm	%	meq/100g	%	%	%	%	%
Test13	6.5	65.0	0.2	1.9	5.7		4.9	3.2	75.0	16.9
Test14	6.4	57.0	0.2	1.5	6.0	12.4	4.1	2.3	65.3	15.8
Test15	6.1	66.0	0.4	1.8	6.8	14.4	4.2	2.5	64.8	14.0
Test16	6.6	71.0	0.2	1.9	6.0		5.1	2.9	75.2	16.7
Test17	6.3	49.0	0.2	2.2	7.7	17.7	2.8	1.9	57.1	20.6
Test18	6.3	59.0	0.2	1.3	7.0	13.6	3.7	2.4	56.5	23.9
Test19	6.8	78.0	0.2	2.6	6.1		5.6	2.1	65.4	26.9
Test20	6.7	63.0	0.2	1.6	6.3		4.3	1.9	73.0	20.8
Optimum Levels Greens	5.9 - 6.5	20 - 120	0.1 - 1.0	1.0 - 3.0		< 5.0	2.0 - 7.0	65 - 75	15 - 25	

Sample Identification	Boron	Sulfur	Nitrate	Ammonium	Chloride	Aluminum	Particle Size Analysis			
							Sand	Silt	Clay	Soil Texture
	ppm	ppm	ppm	ppm	ppm	ppm	%	%	%	
Test13	0.2	19.9	5.5							
Test14	0.1	26.0	3.7							
Test15	0.2	72.9	4.0							
Test16	0.2	15.3	5.6							
Test17	0.1	8.2	9.7							
Test18	0.1	5.3	21.1							
Test19	0.1	5.7	8.9							
Test20	0.1	17.6	12.4							
Optimum Levels Greens	0.5 - 1.0	8.0 - 20.0	5.0 - 25.0							

DISCLAIMER: Data and information in this report are intended solely for the individual(s) for whom samples were submitted. Reproduction of this report must be in its entirety. Levels listed are guidelines only. Data was reported based on standard laboratory procedures and deviations.

Soil Analysis



Submitted by **8888888**
AgSource Test Account
 300 Speedway Circle, Unit 2
 Lincoln, NE 68502

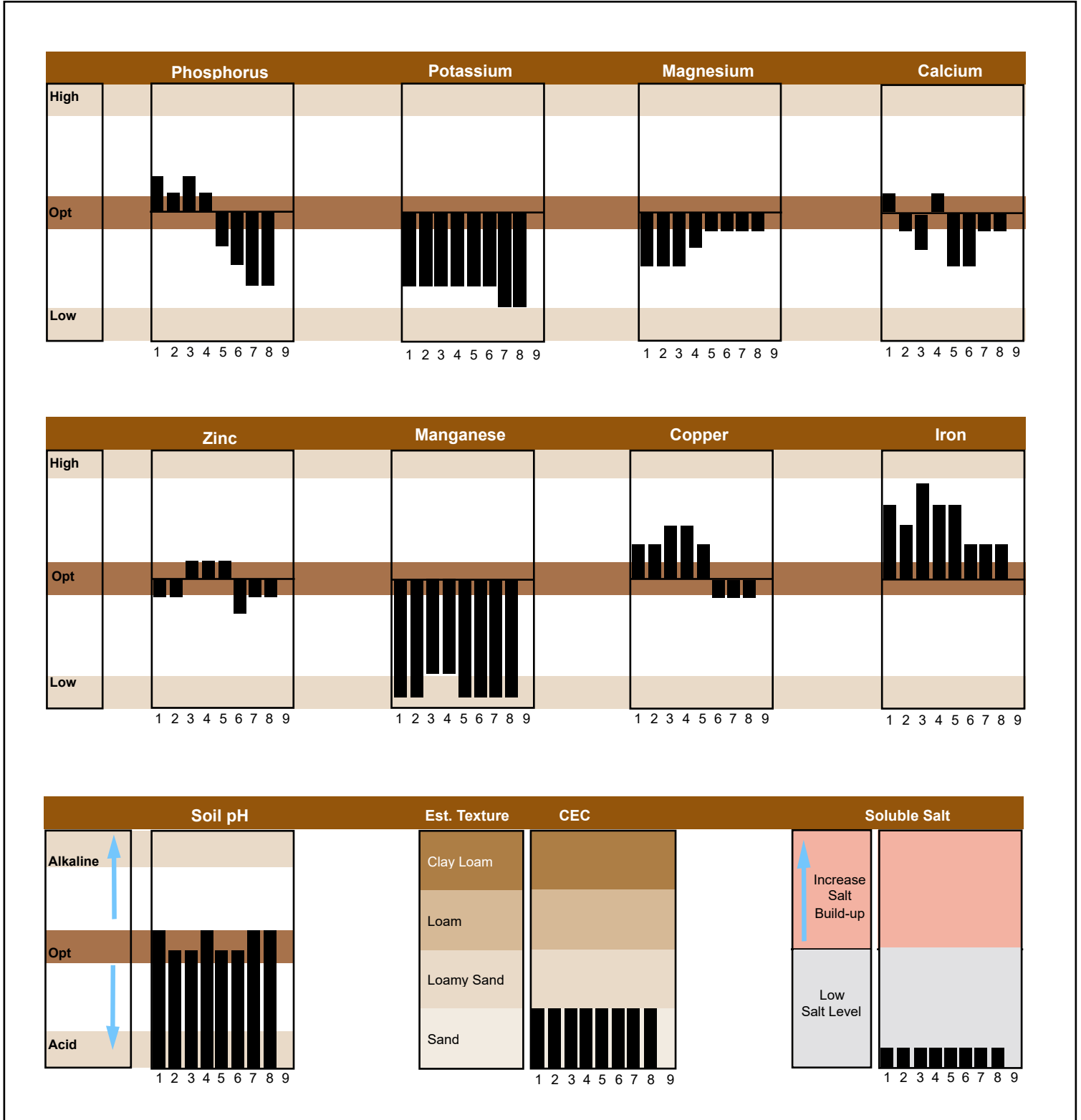
Submitted for
AgSource HARRISTURFELITE

Laboratory Sample #
DG27672 - DG27679
 Information Sheet #
TEST_20200923

Date Received
1-Jan-2026

Date Reported
03-Jan-2026

Field
TESTFIELD 1



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Soil Analysis



Submitted by **8888888**
AgSource Test Account
300 Speedway Circle, Unit 2
Lincoln, NE 68502

Submitted for
AgSource HARRISTURFELITE

Laboratory Sample #
DG27672 - DG27679
 Information Sheet #
TEST_20200923

Date Received
1-Jan-2026

Date Reported
03-Jan-2026

Field
TESTFIELD 1

Product Recommendation is Lbs./1,000 Square Feet

Sample Identification	Nitrogen N	Phosphorus P2O5	Potassium K2O	Magnesium Mg	Soil Amendment application			
					Limestone	Gypsum	Sulfur	Epsom
Test13	3.9	0.0	4.2	0.3	0.0	0.0	0.0	0.0
Test14	4.1	0.0	4.4	0.3	0.0	0.0	0.0	0.0
Test15	4.0	0.0	4.3	0.3	0.0	0.0	0.0	0.0
Test16	3.9	0.0	4.2	0.3	0.0	0.0	0.0	0.0
Test17	3.6	1.5	4.4	0.0	0.0	7.4	0.0	0.0
Test18	3.3	1.8	4.3	0.0	0.0	11.9	0.0	0.0
Test19	3.6	2.5	4.4	0.0	0.0	11.9	0.0	0.0
Test20	3.6	2.7	4.5	0.0	0.0	0.0	0.0	0.0

Plant food recommendations are for the entire growing season being presently grown.

Do not apply more than 1.0 lb/1,000 sf of Nitrogen any one application, if slow release N is used, more N can be applied, but no more than 3.0 lb/1,000 sf.

Product Recommendation is Lbs./Acre

Sample Identification	Zinc Zn	Manganese Mn	Copper Cu	Iron Fe	Sulfur S	Boron B
Test13	0.0	0.1	0.0	0.0	0.0	0.0
Test14	0.0	0.1	0.0	0.0	0.0	0.0
Test15	0.0	0.1	0.0	0.0	0.0	0.0
Test16	0.0	0.1	0.0	0.0	0.0	0.0
Test17	0.0	0.1	0.0	0.0	0.3	0.0
Test18	0.1	0.1	0.0	0.0	0.3	0.0
Test19	0.0	0.1	0.0	0.0	0.3	0.0
Test20	0.1	0.1	0.0	0.0	0.0	0.0



SOIL ANALYSIS

Submitted by **8888888**
AgSource Test Account
300 Speedway Circle, Unit 2
Lincoln, NE 68502

Submitted for
AgSource SUMMARY



Laboratory Sample #
DG25408 - DG25413
 Information Sheet #
TEST_20200923

Date Received
1-Jan-2026

Date Reported
03-Jan-2026

Laboratory Turnaround **2 Days**

Samples Will Be Stored Until **16-Jan-2026**

Field **TESTFIELD 1**

SUMMARY REPORT OF ANALYTICAL RESULTS													
Sample Number	% Organic Matter	Nitrate N ppm	Phosphorus IF pH < 7.1	Phosphorus IF pH > 7.1	Potassium ppm	Magnesium ppm	Calcium ppm	Sulfur ppm	Zinc ppm	Manganese ppm	Copper ppm	Iron ppm	Boron ppm
Test54	1.4	5.1	16	----	105	119	680	12.1	2.5	2.8	2.3	84.8	0.2
Test55	1.6	4.9	16	----	95	121	732	12.8	2.7	2.8	2.7	108.2	0.2
Test56	1.8	4.6	14	----	104	118	754	10.4	2.6	2.7	2.4	86.8	0.2
Test57	1.5	3.8	13	----	111	112	717	10.6	2.3	2.4	2.0	74.9	0.2
Test58	1.7	5.5	17	----	106	122	791	14.1	2.8	2.7	2.3	96.2	0.2
Test59	1.4	2.9	----	3	115	148	1549	30.5	2.3	2.4	1.7	62.8	0.3
Average	1.6	4.5	15	3	106	123	870	15.1	2.5	2.6	2.2	85.6	0.2

SUMMARY OF ANALYTICAL RESULTS							CATION EXCHANGE CAPACITY					
Sample Number	Soil pH	Buffer Index	Excess Carbonate	Soluble Salts mmhos/cm	Sodium ppm	Bulk Density	ACTUAL % OF TOTAL CEC					Total CEC
							% K	% Mg	% Ca	% Na	% H	
Test54	6.4	7.3	L - 0.1%	0.17	39	1.32	4.7	17.2	58.9	2.9	16.4	5.8
Test55	6.4	7.2	L - 0.1%	0.18	40	1.29	3.9	16.2	58.8	2.8	18.3	6.2
Test56	6.6	----	L - 0.1%	0.16	37	1.32	5.1	18.9	72.8	3.1	0.0	5.2
Test57	6.7	----	L - 0.1%	0.15	35	1.29	5.7	18.9	72.3	3.1	0.0	5.0
Test58	6.6	----	L - 0.1%	0.18	42	1.30	5.0	18.7	72.9	3.3	0.0	5.4
Test59	7.2	----	M - 1.4%	0.26	47	1.30	3.1	13.0	81.8	2.1	0.0	9.5
Average	6.7	7.3	L - 0.3%	0.18	40	1.30	4.6	17.2	69.6	2.9	17.4	6.2

SOIL ANALYSIS

Submitted by **8888888**
AgSource Test Account
300 Speedway Circle, Unit 2
Lincoln, NE 68502

Submitted for
AgSource SUMMARY



Laboratory Sample #
DG25408 - DG25413
 Information Sheet #
TEST_20200923

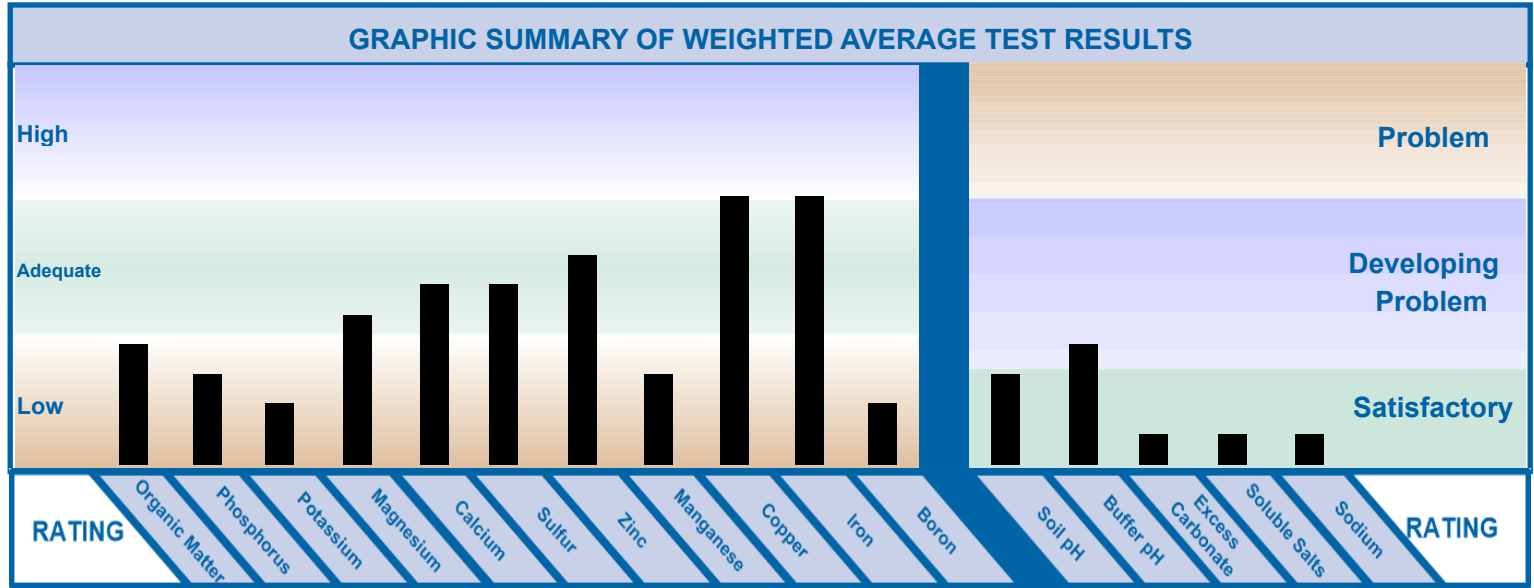
Date Received
1-Jan-2026

Date Reported
03-Jan-2026

Laboratory Turnaround **2 Days**

Samples Will Be Stored Until **16-Jan-2026**

Field **TESTFIELD 1**



SUMMARY OF SOIL FERTILITY AND PLANT NUTRIENT GUIDELINES

Sample Number	Crop Yield or Turf/Ornamental Code	Lime Gypsum Sulfur	PLANT FOOD NEED IN: Lbs/1000 sq ft									
			N	P ₂ O ₅	K ₂ O	MgO	S	Zn	Mn	Cu	Fe	B
Test54	Greens	Lime 0	4.0	2.2	3.6	0.3	0	0	0.1	0	0	0.0
Test55	Greens	Lime 0	4.0	2.2	3.8	0.3	0	0	0.1	0	0	0.0
Test56	Greens	Lime 0	4.0	2.4	3.6	0.3	0.1	0	0.1	0	0	0.0
Test57	Greens	Lime 0	4.1	2.5	3.5	0.3	0.1	0	0.1	0	0	0.0
Test58	Greens	Lime 0	4.0	2.0	3.6	0.3	0	0	0.1	0	0	0.0
Test59	Greens	Lime 0	4.1	2.9	3.4	0.3	0	0	0.1	0	0	0.0
Average	Greens		4.0	2.4	3.6	0.3	0.0	0.0	0.1	0.0	0.0	0.0

Submitted for AgSource SUMMARY

Field TESTFIELD 1

Additional Tests

Sample Number	Test54	Test55	Test56	Test57	Test58	Test59
Salinity Ammonium Nitrogen ppm	3.9	3.9	2.8	3.5	3.8	2.8
Salinity Bicarbonate ppm	31.73	37.83	42.10	39.66	62.24	230.64
Salinity Boron ppm	0.04	0.05	0.05	0.04	0.05	0.08
Salinity Calcium meq/L	1.86	2.04	1.55	1.46	2.20	5.70
Salinity Chloride ppm	93.6	87.2	40.1	53.2	73.4	57.8
Salinity Copper ppm	0.14	0.14	0.12	0.12	0.14	0.13
Salinity ECE mmhos/cm	0.65	0.62	0.44	0.48	0.61	1.03
Salinity Iron ppm	1.8	2.2	1.6	1.4	1.6	0.6
Salinity Magnesium meq/L	1.24	1.29	0.96	0.89	1.36	3.40
Salinity Manganese ppm	0.26	0.21	0.12	0.10	0.13	0.13
Salinity Moisture %	53.35	53.10	46.29	51.61	53.81	56.80
Salinity Nitrate Nitrogen ppm	11.4	9.0	8.1	5.5	8.5	6.3
Salinity PO4 ppm	2.37	2.16	2.27	1.96	1.75	0.72
Salinity Potassium meq/L	0.46	0.49	0.31	0.34	0.51	0.77
Salinity SAR	0.64	0.67	0.71	0.64	0.70	0.72
Salinity Silicon ppm	9.0	9.9	9.2	7.8	9.0	7.0
Salinity SO4 ppm	62.0	60.5	50.0	48.5	62.4	204.1
Salinity Sodium meq/L	0.8	0.9	0.8	0.7	0.9	1.5
Salinity Zinc ppm	0.04	0.05	0.04	0.03	0.03	0.06

Three Components of Soil Health

The NRCS defines soil health as “The continued capacity of soil to function as a vital living ecosystem that sustains plants, animals and humans.”

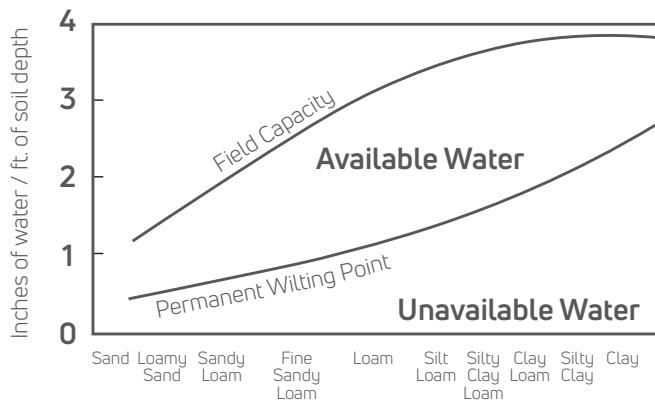
But what exactly does that mean? Let’s start by looking at the three components of soil: physical, chemical and biological.

Physical

The physical characteristics of soil include size and distribution of the mineral particles in combinations of sand, silt and clay.

While sand helps to keep the soil loose and increases internal drainage, small clay particles provide more surface area to retain water and nutrients within the soil. Natural physical and chemical bonds between these particles creates internal soil structure and small clumps called aggregates. This aggregation reduces soil compaction while increasing the space for roots to penetrate, thus supporting better plant growth. Other features such as surface slope and internal drainage also contribute to the physical properties of soil.

Figure 1. Soil texture and water availability



Chemical

The qualities of the soil considered to be chemical characteristics are already familiar to us through soil testing provided by laboratory services. Typical soil test results include pH, phosphorus, potassium and organic matter. Testing also looks for other nutrients necessary for plant production, such as sulfur and zinc. Recommendations for fertilizer and other additions to the soil are based on the measurable levels of these factors.

Chemical testing can also help to determine soil management practices that are needed to improve soil characteristics. For example, liming to raise pH to a favorable level, or adding gypsum to counteract high sodium levels, are two applications of inputs other than plant nutrients that enhance plant growth.

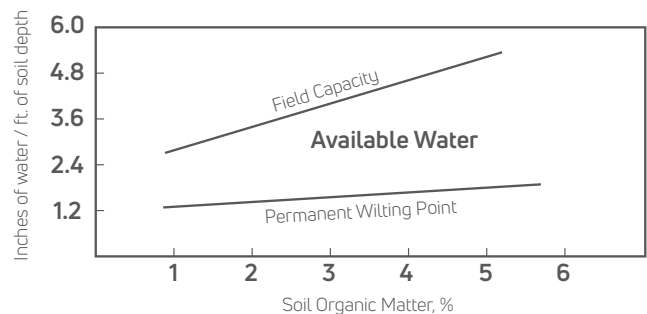
Biological

Biological characteristics of the soil are a function of the size and diversity of the microbiological population. It is estimated that in one gram of soil (enough to fit on top of a nickel) there are one billion living organisms, consisting of roughly ten thousand species. Most of those are single-celled bacteria, but the population is very diverse.

These billion organisms carry out countless biological transformations, depending on the blend of nutrients available and the physical characteristics of their environment such as temperature, aeration and moisture. These organisms compete with plants to utilize available nutrients in the soil. There are also beneficial bacteria and fungi that provide nutrient elements to plant roots while obtaining carbon from the plant as an energy source for growth.

Biological activity enhances water retention and soil absorbency, and reduces water runoff by increasing the organic matter content in the soil. Increasing the soil organic matter by one percent increases the retention of available water by one acre inch, or up to ten percent of the soil’s water holding capacity.

Figure 2. Water holding capacity as influenced by organic matter



Biological activity in the soil is beneficial in retaining nutrients for later release through decomposition. The nutrients present in decomposing plant residues, especially nitrogen and carbon, control the rate of microbial growth. When there is an abundant energy source (carbon) with readily available nutrients (such as nitrogen) there is a high rate of microbial activity and nutrients in the organic material are made available. But if carbon or nitrogen are limiting, this turnover is slower.

When thinking about soil health, look at the entire picture and see how all three components interact. For example, soil compaction (physical) limits the drainage of water through the soil which increases nitrogen losses (chemical) through microbiological reduction of nitrogen in the soil’s organic material (biological). Soil testing laboratories can provide tests that will measure most of these characteristics.

Understanding Soil Health - Turf

A Soil Health Assessment provides a reference point to use in gauging the current quality of a soil and the impact of any management steps taken to improve that quality.

Soil health testing combines the chemical and physical analyses of traditional soil testing with biological assessments of microbial activity to provide a measure of the quality of the soil. The microorganisms present in soil benefit turfgrass through decomposition of grass residues and nutrient cycling, but they also compete with plants for available nutrients. Knowing how actively soil microorganisms react to the availability of nutrients helps to understand plant requirements.

AgSource Laboratories' Soil Health Assessment includes a standard soil analysis. This focuses on the chemical characteristics of soil fertility. The parameters measured include pH, nutrients extracted using traditional methods and cation exchange capacity (CEC). The bulk density of the sample is also determined, along with the organic matter percentage, and can be used to infer the soil's ability to provide water to plants over the growing season (see Figure 1).

The results from these tests are used to provide fertilizer guidelines and management practices for the desired turfgrass type. For more information on a standard soil test, refer to the Understanding a Soil Analysis technical bulletin, available at agsource.com.

Three Soil Health Options: Basic, Routine and Complete.

All of the assessments include a measure of the biological activity in the soil, done by rehydrating a dry soil and measuring the carbon dioxide generated from microbial respiration. A water extraction is also used to determine the soluble forms of carbon and nitrogen. These two nutrients, in this form, most directly influence bacterial growth in the soil.

The Basic Assessment package includes the following:

Soil Health Score

The **Soil Health Score** is calculated from measurements of the rate of microbial respiration and the availability of soluble carbon and nitrogen. Combining these into a simple number that ranges from a low of zero up to 50 gives a quick evaluation of health. Increasing this score indicates an improvement in soil health. Scores below 10 are low, 10 to 29 are moderate and above 29 are classified as high. A score above 20 can be considered as very good. Higher respiration rates, or lower C:N ratios, increase the score. This score can be improved by adding easily decomposable organic material.

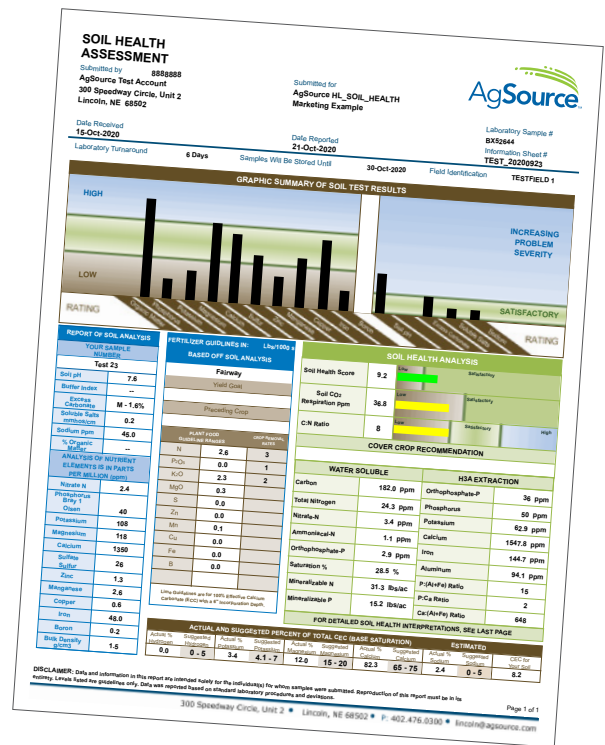
SOIL HEALTH ANALYSIS			
Soil Health Score	9.2	Low	Satisfactory
Soil CO ₂ Respiration ppm	36.8	Low	Satisfactory
C:N Ratio	8	Low	Satisfactory High
COVER CROP RECOMMENDATION			

CO₂ Respiration

CO₂ Respiration measures the respiration rate of the soil microorganisms. A dry sample is allowed to slowly absorb water and is kept in a sealed chamber to capture all the carbon dioxide evolved in a 24-hour period. The microorganism activity is briefly enhanced with this technique because the water stimulates their growth after the dry soil conditions. This one-day measurement reliably predicts the respiration rate in the soil under normal conditions. Respiration rates vary depending on the density and diversity of the population, as well as on the nutrient supply. An adequate rate of microbial respiration would yield CO₂ values from 60 to 300 ppm. Increasing respiration values are a sign of vigorous microbial growth. Respiration could be improved by stimulating microbes with the addition of organic matter, readily available nutrients, or biological products.

C:N Ratio

C:N Ratio is a measurement of the availability of two of the most important nutrients for microorganisms in the soil. Carbon is used as an energy source and nitrogen is a requirement for building proteins and enzymes. A desired C:N ratio for a soil with three to five percent organic matter would be around 10 or 12. The right balance of carbon and nitrogen is important. A high number is not better in this case! If the C:N ratio is too high (above 17), nitrogen limits the growth of the organisms and they will compete with plants for any available source of N.



Submitted for **AgSource SUMMARY**

Field **TESTFIELD 1**

SOIL HEALTH ASSESSMENT

SAMPLE ID: Test59	
Soil Health Score	7.3
CO2 Respiration	66.8
Water Soluble Organic C:N	32
Water Soluble Total Carbon ppm	43.6
Water Soluble Total Nitrogen ppm	5.1
Water Soluble Organic Nitrogen ppm	1.4
Mineralizable N Lbs/acre	0.0
Mineralizable P Lbs/acre	31.6

Soil Health Score

Calculated from the rate of microbial respiration, water extractable carbon and the organic nitrogen content to provide a simple number between 0 to 50. Measuring organic nitrogen corresponds to the long term growth potential of micro-organisms, independent of applied fertilizer N. Increasing numbers indicate improving soil health and values above 20 are considered very good.

CO2 Respiration

Measures the respiration rate of the soil micro-organisms. A dry sample is allowed to absorb water and is kept in a sealed chamber for 24 hours. This one-day soil CO2 respiration measurement predicts the average respiration rate in the soil under normal conditions. Increasing respiration values are a sign of vigorous microbial growth. Respiration could be improved by the addition of organic matter, or readily available nutrients.

Organic C:N Ratio

Measures the availability of the two most important nutrients for micro-organisms. Carbon is used as an energy source and nitrogen is a requirement for building proteins and enzymes. Since inorganic nitrogen (nitrate and ammonium) fluctuate with fertilizer use the measure of organic nitrogen gives a more stable assessment. A desired Organic C:N ratio would be between 10 and 15. A high number is not better in this case! Ratios can be raised by adding decomposable carbon or lowered with nitrogen.

Total Carbon

Used in determining the C:N ratio, soluble carbon is the energy source that stimulates biological activity in the soil. These sugars and carbohydrates that are secreted from plant roots are readily used by micro-organisms for growth when these populations die, the larger carbon compounds remain as part of the organic matter.

Total Organic Nitrogen

Used in determining the C:N ratio, this water extraction includes organic nitrogen such as, soluble organic matter, proteins and decomposition by-products as well as inorganic nitrate and ammonium. This soluble nitrogen is readily used by plants and micro-organisms but can be leached from the soil as water moves, or converted to gas if the soil is saturated. Organic forms of nitrogen are converted to inorganic forms as by-products of natural soil biologic processes.

Mineralizable Nitrogen and Phosphorus

Estimates the potential release of nitrogen and phosphorus from sources in the soil. Mineralizable N comes from the easily decomposable organic material such as the microbial biomass, plant residues or added manure. When the respiration rate increases and there is adequate organic nitrogen in solution the the potential mineralization increases as well. Mineralizable P increases in the same way but predicting the amount of the available P requires an extraction with the Haney H3A solution. Fertilizer amounts predicted in this way can be deducted from applications in the following growing season.

SAMPLE ID: Test60	
Soil Health Score	6.6
CO2 Respiration	59.7
Water Soluble Organic C:N	21
Water Soluble Total Carbon ppm	44.4
Water Soluble Total Nitrogen ppm	7.1
Water Soluble Organic Nitrogen ppm	2.1
Mineralizable N Lbs/acre	17.2
Mineralizable P Lbs/acre	31.1

SAMPLE ID: Test01	
Soil Health Score	7.1
CO2 Respiration	60.8
Water Soluble Organic C:N	16
Water Soluble Total Carbon ppm	65.7
Water Soluble Total Nitrogen ppm	8.8
Water Soluble Organic Nitrogen ppm	4.1
Mineralizable N Lbs/acre	22.7
Mineralizable P Lbs/acre	21.6

Graph Legend

	optimal
	outside of optimal range

Plant Tissue Sampling Guide

Steps for Collecting and Shipping Tissue Samples

- 1 Plant part to sample: Leaf Blade. Most turf samples are collected from mower clippings. Keep in mind that soil and fertilizer material can also be picked up by the mower and can contaminate the sample.

For best results, wait at least two weeks (if possible) from the last top dress application (fertilizer, fungicide or sand top dress).
- 2 Samples should be collected on actively growing turf. Do not sample drought or severely diseased areas.
- 3 If growth patterns (yellow to lighter green color) are apparent, sample separately from "normal" growing areas.

- 4 Collect approximately one cup of fresh clippings.
- 5 Because of the moist nature of turf clippings, molding and degradation are a concern. Samples should be shipped in paper or cloth bags and loosely packed in the shipping box. If possible, let samples dry overnight to remove excess moisture.

DO NOT ship in plastic containers. Contact AgSource and ask about complimentary sampling supplies.

- 6 Complete laboratory paperwork. Sample submission forms are available at www.agsources.com. Include the following information with samples:
 - Client Name
 - Turf Type
 - Sample Identification
 - Specific Concerns
- 7 Ship samples to the laboratory as soon as possible. If overnight drying is not possible, samples should be shipped by express delivery.



Understanding a Plant Tissue Analysis

A plant tissue analysis offers a precise measurement of the nutritional status of a plant at the time the sample was collected – a snapshot in time. This information allows a manager to determine if a specific nutrient is lacking, before a deficiency symptom becomes apparent. It also provides information on the relative health of the turf grass and interrelationships between all essential plant nutrients. When tissue testing is used in conjunction with a soil analysis, it can provide information on which nutrient levels are most critical, and how best to correct them. For example, if soil pH is high, causing an iron deficiency, a foliar application of an iron compound might be preferable to a soil application.

Because a tissue analysis is not predictive, collecting multiple samples throughout the growing season is recommended. This will allow the charting of plant nutrients, and can help you determine when a specific nutrient should be applied. At the very least, it can be used to better prepare a fertilizer plan for the next growing season. In the case of manganese for example, a soil analysis is a weak tool for evaluating actual needs. In this situation, if a tissue sample was tracked over the growing season and consistently tested as low, then the chances of getting a positive response to manganese next year will be high.

Keep in mind that a plant analysis can be only as good as the sample that is collected. In most situations, samples are taken from the clippings during regular mowing cycles. While this type of sampling will work, it is important that samples be devoid of fertilizer, lime and sand contamination. It is suggested to wait a minimum of two weeks after an actual application before samples are collected. For more specific information on how to collect an appropriate sample, please refer to the plant sampling instructions on the web, agsource.com.

On each report, a sufficiency range is printed for each essential nutrient. To interpret a tissue report, compare the result of a specific nutrient to the nutrient's sufficiency range. If the comparison is in the optimum or high range, then the uptake for that specific nutrient is in adequate supply (at that point in time). An illustration of this would be potassium levels for Bentgrass greens. The optimum range for potassium is 2.2 to 3.5 percent. If the value printed on your report is 3.7%, you would interpret potassium as adequate. For your convenience AgSource Laboratories provides a graphic display of how data compares to the optimum range.

Optimum Nutrient Ranges for Various Turf Grasses

	Bent-grass	Bermuda Grass	Blue-grass	Fescue Grass	Bahia-grass
Nitrogen %	4.0 – 5.0	2.5 – 3.5	4.0 – 4.5	3.4 – 4.5	1.5 – 2.5
Phosphorus %	0.3 – 0.6	0.2 – 0.5	0.3 – 0.5	0.3 – 0.5	0.2 – 0.5
Potassium %	2.2 – 3.5	1.0 – 3.0	2.5 – 3.5	2.6 – 4.0	1.0 – 3.0
Magnesium %	0.2 – 0.4	0.2 – 0.5	0.2 – 0.5	0.2 – 0.3	0.2 – 0.5
Calcium %	0.2 – 0.8	0.5 – 1.0	0.4 – 0.8	0.4 – 0.8	0.5 – 1.0
Sulfur %	0.2 – 1.0	0.2 – 0.5	0.2 – 0.4	0.2 – 0.4	0.2 – 0.5
Zinc ppm	20 – 70	20 – 125	40 – 60	40 – 60	20 – 125
Manganese ppm	25 – 100	25 – 100	30 – 200	30 – 200	25 – 100
Copper ppm	5 – 15	5 – 30	14 – 30	5 – 20	5 – 30
Iron ppm	30 – 300	20 – 250	50 – 300	50 – 300	20 – 250
Boron ppm	3 – 20	5 – 20	5-15	5-15	5 – 20

Mineral nutrients are classified as major, secondary and minor elements. This classification describes the relative amounts of each element present in plants. It is not intended to reflect its importance. No one essential nutrient is more or less important than any other. All essential elements are necessary for proper turf grass growth; major and secondary elements are just needed in greater quantities than minor elements.

Following is a list of essential elements and the special role each plays in plant nutrition.

Nitrogen is an essential part of all living matter. Compounds containing nitrogen make up about half of the substances in plant cells. It is the basis for amino acids, which combine to form proteins. Nitrogen is associated with vegetative growth and density of turf, as well as its deep green color. Nitrogen deficiency is noticed in turf that has turned a light green or yellow - the blades start dying at the tip until the entire leaf is necrotic. When deficiency occurs, it is first noticed on the older blades, since nitrogen is easily moved from the older to the newer growth.

Phosphorus is the key nutrient in seedling development as it contributes so much to initial root and seed formation. It provides the plant with a mechanism for using and transforming energy. Phosphorus aids in the transformation of sugars and starches, as well as nutrient movement within the plant. Deficiency symptoms appear as dull green with a purple shade; leaf blades are narrower and have a tendency to roll. The reddish tinge or purple color is an indication that the plant has ample food supplies (sugars) but not enough energy to convert it into proteins. Phosphorus is mobile in tissue, so older blades are the first to be affected.

Potassium is required by the plant in relatively large quantities. Plant tissue may contain up to four to five percent. Its role is that of a regulator of plant processes because 46 enzymes require potassium to function properly. Contrary to some statements, it is not directly used in cell wall or plant strength development. A likely function is that it affects the shape of enzyme proteins, which has a direct effect on enzyme functionality. Some of the 46 enzymes affect carbohydrate form and storage, while others regulate the use of nitrogen in its role of reforming proteins. Potassium is a mobile nutrient; as a result, deficiency symptoms will appear first on older tissue; resulting in leaf tip burn and a gradual thinning of the turf stand. A light chlorosis (yellow color) may also be apparent.

Calcium is an important constituent of plant cell walls. It is the cement that binds the adjacent cells together, giving rigidity to the plant. It is also essential for root development and may serve to neutralize some toxic compounds present in the plant. Calcium is immobile in the plant, meaning that it is not transported from one plant part to another. As a result, deficiency symptoms will be detected in the newer leaf blades as deformed, chlorotic and eventually necrotic leaves. In addition, root growth and development are also affected. The end results are slow growth and patchy dead spots of turf.

Sulfur is an integral part of certain amino acids, proteins and chlorophyll. As both nitrogen and sulfur are associated with chlorophyll, deficiency symptoms resemble each other. The difference is that sulfur will not produce the firing of the leaf tip back to the leaf collar. Instead, because sulfur is immobile, younger leaves will exhibit a light-green color, eventually turning brown and curling up. Deficiencies are almost always associated with soils low in organic matter.

Zinc is used primarily as a catalyst for oxidation processes in cells and for the utilization of carbohydrates. These processes regulate energy production of chlorophyll, formation of auxin (growth hormone) and promote the absorption of water. Zinc is a non-mobile compound, so deficiency symptoms will appear in new leaf blades, first as chlorosis, eventually progressing to necrosis. Because zinc is involved with growth hormones, deficient plants may exhibit a rosetting effect on new tissue.

Magnesium is an integral part of the chlorophyll molecule, which means it is essential for the process of photosynthesis. It also serves as a catalyst for several enzyme reactions essential for the phosphorus energy transfer. Magnesium is mobile in plant tissue; deficiencies will develop in the older tissue and move to the young immature leaves. Because chlorophyll is affected, symptoms will begin as pale green leaves and advance to interveinal chlorosis from the edge to center of the leaf.

Manganese, as with most of the micro-nutrients, is mainly used as a catalyst (it is needed to activate a chemical process). Its use is in the oxidation of carbohydrates into carbon dioxide and water (plant respiration). Other enzymatic processes affected include the metabolism of nutrients and synthesis of chlorophyll. Manganese is immobile; deficiency will first appear in the youngest leaves. Deficiency symptoms appear as graying blotches near the base of the leaf blade, progressing to a yellow, and then to a bright yellow-orange color.

Copper increases oxidase activity to influence metabolic reactions, including the formation of iron porphyrin, needed for chlorophyll. Essentially, it is needed for the formation of chlorophyll, but is not part of the chlorophyll molecule. Severe deficiencies for copper are extremely rare, but will appear as yellowing of the youngest leaf blades.

Iron also acts as a catalyst, and is essential for the formation of the chlorophyll molecule. In addition, it is an activating element in enzymes known as coenzymes. This coenzyme is used as an oxygen carrier for plant respiration. Iron is mainly immobile, so chlorotic mottling will appear on the youngest leaf tissue.

Boron's function in plant development is not fully understood, but is recognized to be involved with protein metabolism, water regulation, and the plant's energy producing mechanism (ATP). In addition, it is essential for proper development of apical growing points (active cell division). Deficiency symptoms are varied, but are usually described as stunted and misshaped/distorted plants. Symptoms also include leaf tip dieback and necrosis of the entire leaf.

Submitted by

Submitted for

Laboratory Sample #

Plant Tissue - Summary Report

Date Received

10/03/2017

Date Reported

10/04/2017

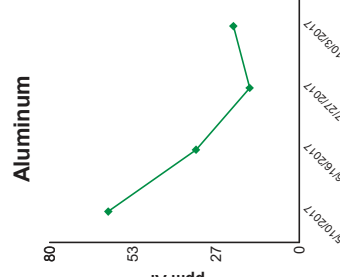
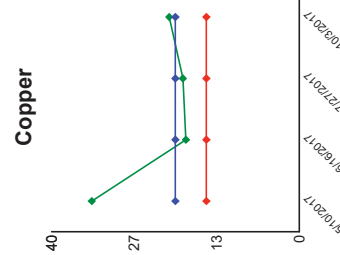
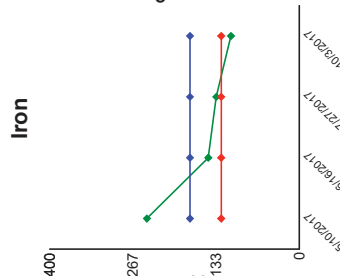
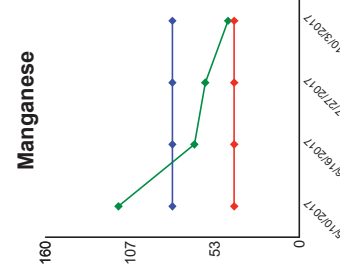
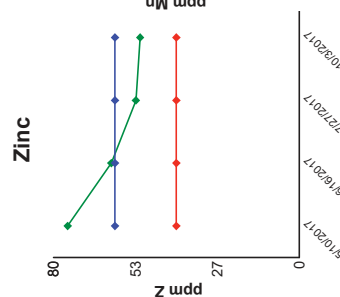
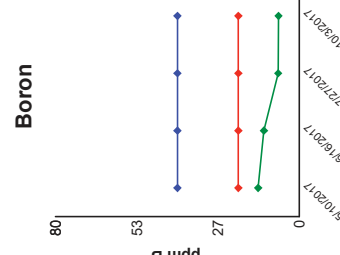
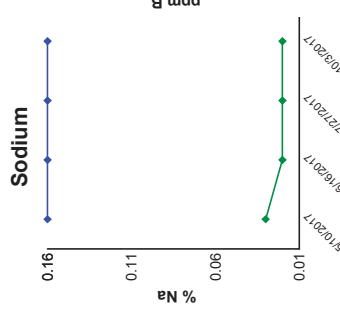
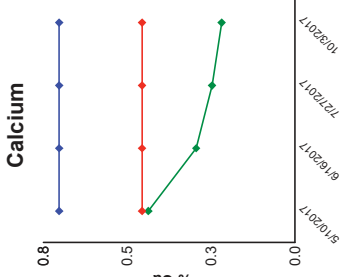
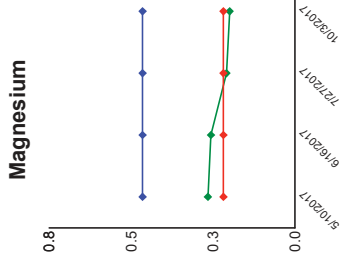
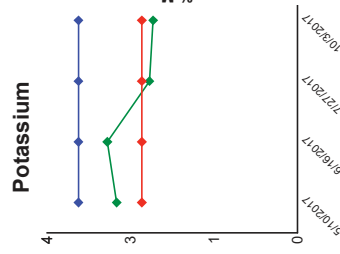
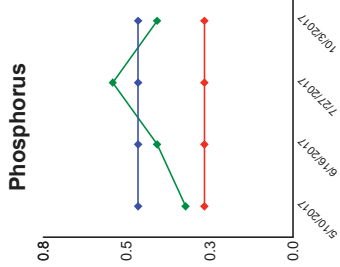
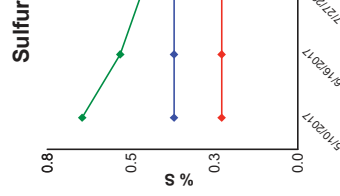
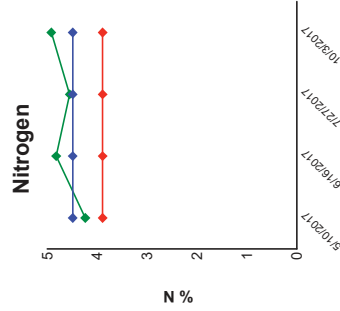
Information Sheet #

Plant Type: TURF

Summary Report

Graph Legend:
— Normal Range Top
— Normal Range Bottom
— Analysis Result

Sample Date	Laboratory Sample #	Sample Id	Nitrogen %	Nitrate-N ppm	Sulfur %	Phosphorus %	Potassium %	Magnesium %	Calcium %	Sodium %	Boron ppm	Zinc ppm	Manganese ppm	Iron ppm	Copper ppm	Aluminum ppm
5/10/17	BA90532	Iron Forge	4.25		0.69	0.35	2.89	0.29	0.47	0.03	13.5	75.4	114.0	244.0	33.5	61.2
6/16/17	BB46246	Iron Forge	4.83		0.57	0.44	3.04	0.28	0.32	0.02	11.6	61.2	66.1	145.6	18.3	33.1
7/27/17	BC00728	Iron Forge	4.56		0.50	0.58	2.37	0.23	0.27	0.02	6.9	53.2	59.3	132.8	18.8	15.9
10/3/17	BC60354	Iron Forge	4.93		0.52	0.44	2.31	0.22	0.24	0.02	6.8	51.82	44.9	109.3	21.0	21.1
Normal Ranges			3.9 to 4.5		0.25 to 0.4	0.29 to 0.5	2.49 to 3.5	0.24 to 0.5	0.49 to 0.75	0 to 0.16	20 to 40	40 to 60	41 to 80	125 to 175	15 to 20	N/A to N/A





Plant Analysis

Submitted by **8888888**
AgSource Test Account
300 Speedway Circle, Unit 2
Lincoln, NE 68502

Submitted for
AgSource HARRISPLANT_LEAF



Laboratory Sample #
DH06548
 Information Sheet #
TEST_20200923

Date Received
1-Jan-2026

Date Reported
03-Jan-2026

Laboratory Turnaround: **2 Days**
 Sample Marked: **Test02**

Samples Will Be Stored Until: **16-Jan-26**
 Crop: **TURF**

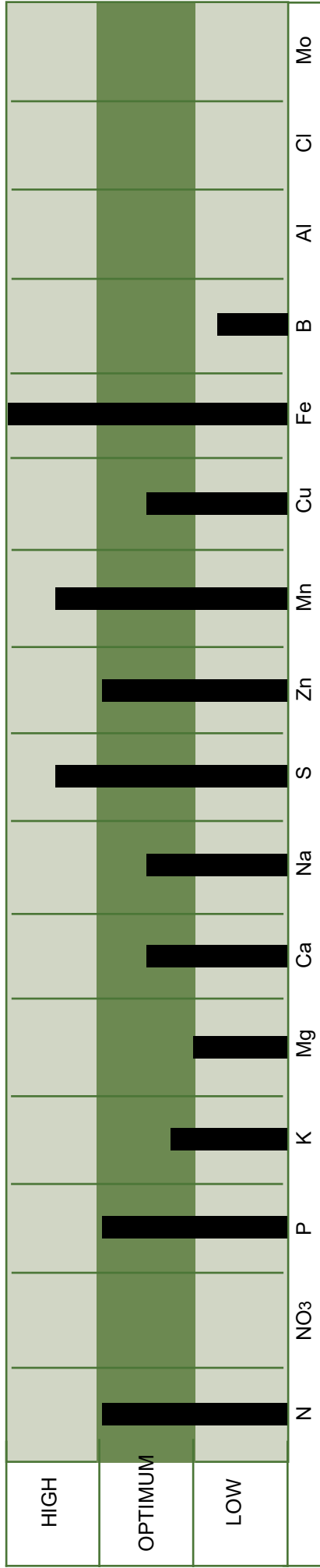
Field Identification: **TESTFIELD 1**
 Plant Part: **LEAF**

Results of Laboratory Analysis

Laboratory Analysis	4.68		0.55	2.62	0.21	0.59	0.07	0.51	57.94	105.0	17.0	1811.5	10.8	144.6		
	% Nitrogen	ppm Nitrate	% Phosphorus	% Potassium	% Magnesium	% Calcium	% Sodium	% Sulfur	ppm Zinc	ppm Manganese	ppm Copper	ppm Iron	ppm Boron	ppm Aluminum	% Chloride	ppm Molybdenum

Graphic Rating of Results Compared to Normal Ranges

Normal Ranges	3.9 to 4.5		0.29 to 0.5	2.49 to 3.5	0.24 to 0.5	0.49 to 0.75	0 to 0.16	0.25 to 0.4	40 to 60	41 to 80	15 to 20	125 to 175	20 to 40	N/A to N/A		
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DISCLAIMER: Data and information in this report are intended solely for the individual(s) for whom samples were submitted. Reproduction of this report must be in its entirety. Levels listed are guidelines only. Data was reported based on standard laboratory procedures and deviations.

Irrigation Water Sampling Guide

Irrigation Suitability Analysis Includes:

- Water pH
- Hardness
- Bicarbonate
- Carbonate
- Nitrate
- Total Dissolved Solids
- Sodium
- Chloride
- Boron
- Sulfate
- Electrical Conductivity (ECw)
- Phosphorus
- Potassium
- Magnesium
- Calcium
- Sodium Absorption Ratio
- Manganese
- Iron

Steps for Collecting and Shipping Water Samples

- 1 Use a clean plastic container. Rinse the bottle (including the lid) several times with the water to be tested. AgSource provides complimentary sampling supplies, including clean plastic bottles. Please call the laboratory directly or visit our website to order yours.
- 2 To reflect the water quality at the time of application, collect sample from the pumping station or within the irrigation system.
- 3 If a system of irrigation wells (ground water) is being used, sample each well separately and identify each sample's source. This will qualify the water specifically from each well. (This is important if pumping into a holding pond.)
- 4 When collecting a sample from the irrigation system, let the water run for two to three minutes before collecting the sample. (This will purge static water from the system.)
- 5 When sampling from a pond, collect water from the pumping station, if possible. Remember to let the pumping station water run for two to three minutes before collecting the sample. Do not collect the water from the side of the irrigation pond. Sediment will act as a contaminant.
- 6 Fill the bottle and eliminate all head space. Be sure the lid is tight so that samples do not leak during transit. The laboratory needs at least 125 ml (about 4 ounces) of water.
- 7 **DO NOT** use glass containers.
- 8 If possible, collect and ship sample(s) the same day.
- 9 Clearly identify all bottles and complete necessary paperwork before shipping. Sample submission forms are available on our website or by calling the laboratory directly.



Understanding Water Quality

Monitoring of irrigation water for salt content is an important component of an overall turf management program. Irrigation water can create saline and/or alkaline soil, depending on the quantity and type of salt dissolved in the water. High salt concentrations in irrigation water will reduce the available soil moisture, which limits plant growth.

Total Dissolved Salts

Chemically pure water does not conduct electricity, but water with dissolved salt does. The total salt content of a water sample is measured by electrical conductivity (ECw), reported as millimhos per centimeter (mmhos/cm). A more tangible unit of measurement is parts per million (ppm) or pounds of salt per acre foot. The ECw can be converted to these units as follows:

$$\text{ECw} \times 640 = \text{ppm}$$

$$\text{ppm} \times 2.72 = \text{lbs/acre foot}$$

Example: ECw of 2.0 mmhos/cm equals 1,280 ppm of dissolved salt or 3,481 pounds of salt for every foot of water applied. If over the irrigation season 24 inches of water is applied, the final annual total of salt is 6,962 pounds. From this example, it is easy to understand how salts in irrigation water can quickly increase the salinity level in the soil.

The following table is a quick rating of irrigation water quality based on the ECw:

Water Classification	Dissolved Salts Expressed As:		
	ECw (mmhos/cm)	Dissolved Solids (ppm)	Total Salt (lbs./acre ft.)
Low Salinity	<0.25	<160	<435
Medium Salinity	0.25-0.75	160-480	435-1306
High Salinity	0.76-2.25	481-1440	1307-3917
Very High Salinity	>2.25	>1440	>3917

Measured electrical conductivity is an indicator of the potential problems in plant growth associated with increasing quantities of salt. Ultimately, the effect of using irrigation water with varying levels of salt is dependent upon the soil's ability to percolate water.

Degree of problems associated with increasing quantities of salt:

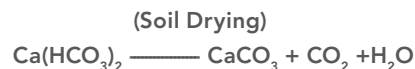
ECw (mmhos/cm)	ECw (mmhos/cm)
<0.75	Little/no plant growth problems associated with normal irrigation
0.75-2.25	Potential plant growth problems with salt sensitive plants
>2.25	Severe plant growth problems; select only salt-tolerant plants

Types of Salt: Sodium Absorption Ratio (SAR)

The major types of salts dissolved in water are: calcium, magnesium and sodium in combination with chloride, sulfate and bicarbonate. Trace amounts of iron, manganese, boron, nitrate, silicate, potassium, lithium and phosphorus are usually present as well, but with natural water sources, they contribute very little to the overall salinity concentration. Effluent water (or water spiked with fertilizers) may be the exception; even with low concentration, one needs to be aware of potential toxicities of boron and lithium, and leaf burning from sodium and chloride.

The most common problem associated with high salt concentrations is the degradation of soil structure. This process (deflocculation) is the breaking up of soil particles into the individual soil texture components (sand, silt and clay). The effect is a decreasing rate of water infiltration. As infiltration decreases, salt concentrations increase at the soil surface. The cation most responsible for this process is sodium. However, the measurement of sodium alone provides little information about water quality and its effect. Water with high sodium can be usable, provided the calcium and magnesium levels are also high. Because of this, the sodium absorption ratio (SAR) was developed. This calculation expresses the sodium in comparison with the calcium plus magnesium.

The SAR measurement has been further revised by correcting for bicarbonate (HCO₃) levels in the water. High bicarbonates will enhance a sodium problem. This calculated value is referred to as SARadj. A correction is necessary because sodium in the irrigation water increases in concentration during soil drying, while calcium levels in the soil decrease due to a reaction with bicarbonate. The calcium will precipitate out in the soil as calcium carbonate (free lime), resulting in increased soil SAR and pH values.



Degree of Problems Associated with Increasing SAR Values:

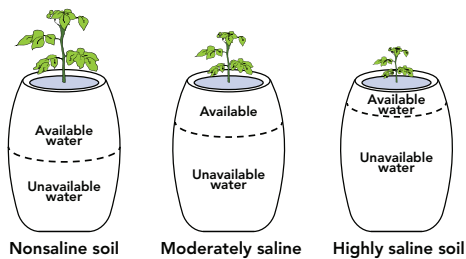
SAR	Potential Problems
1.0-9.0	Low Sodium: may be used with little harmful effect
10.0-18.0	Medium Sodium: problem with buildup on fine textured soils
19.0-26.0	High Sodium: sodium buildup on most soil types, high leaching rate needed
>26.0	Very High Sodium: unsuitable for most uses



Soil Drainage

The salt and minerals dissolved in irrigation water are often left in the soil as the water evaporates. This results in the salinity and SAR values of the soil increasing by up to 1.5 to 3 times higher than the SAR and salinity content in the irrigation water. However, if the soil has poor internal drainage conditions, both soil salinity and SAR could increase by up to a factor of ten. Therefore, it is important to remember that strategies for managing irrigation water that contains dissolved salts depend on the soil's internal drainage. More frequent irrigations also become necessary to keep up with the reduced water availability as soil salinity levels increase.

Figure 1. Effects of salt build-up on available water



Conclusion

Monitoring the quality of irrigation water is a vital component in managing plant health. The measurement of salt concentrations and the type of dissolved salt within the water determine irrigation water quality. When salt concentration increases, plant available moisture decreases, resulting in restricted plant growth. The problems associated with high sodium levels are best expressed as a ratio of sodium to calcium plus magnesium (SAR). As the SAR level increases, soil structure is diminished and water infiltration rates are reduced, leading to even higher levels of salt and accumulation in the soil.



WATER ANALYSIS

Submitted by **8888888**
AgSource Test Account
300 Speedway Circle, Unit 2
Lincoln, NE 68502

Submitted for
AgSource HARRISWATERANALYSIS_IRR



Laboratory Sample #
DG32091

Date Received
1-Jan-2026

Date Reported
03-Jan-2026

Information Sheet #
TEST_20200923

SAMPLE MARKED Test57

ANALYSIS OF CHEMICAL PROPERTIES		YOUR RESULTS			RATING OF YOUR RESULTS		
		UNIT OF MEASURE	RESULT	LBS/ ACRE FOOT	SATISFACTORY	POSSIBLE PROBLEM	PROBABLE PROBLEM
WATER CHARACTERISTICS	pH	-- --	7.26	-- --			
	Hardness	ppm	210.46	-- --			
	Bicarbonate	ppm	195.69	532.28			
	Carbonate	ppm	0.24	0.65			
IMPACT ON GENERAL PLANT GROWTH	Electrical Conductivity (ECw)	mmhos/cm	0.41	-- --			
	Total Soluble Salts	ppm	263.04	715.47			
IMPACT FROM ROOT CONTACT	Sodium Chloride	meq/l	0.15	-- --			
	Boron	ppm	1.89	5.14			
	Boron	ppm	0.02	0.05			
IMPACT FROM FOLIAGE CONTACT	Sodium Chloride	ppm	3.55	9.66			
	Sodium Chloride	ppm	1.89	5.14			
IMPACT ON SOIL STRUCTURE	Sodium Absorption Ratio Adj		0.22	-- --			
	Electrical Conductivity (ECw)	mmhos/cm	0.41	-- --			
	Total Soluble Salts	ppm	263.04	715.47			
To maintain good soil structure in arid regions, irrigation water should have the capacity to replace the soluble salts being dissolved. If the salts being dissolved are not replaced, a decrease in permeability may occur.					No anticipated difficulty with most crops.	Some difficulty for sensitive & moderately sensitive crops.	Significant difficulty for most crops.

ANALYSIS OF NUTRIENTS						
PLANT NUTRIENTS AS NORMALLY REPORTED IN WATER ANALYSIS	RESULTS AS PPM	NUTRIENTS CONVERTED TO BASIC FERTILIZER MATERIAL FORMS	RESULTS LB/ACRE FOOT		MEQ / LITER	
NITRATE (NO ₃ -N)	1.00	NITROGEN (N)	2.72	CATIONS	K+	0.06
PHOSPHATE (PO ₄)	0.01	PHOSPHATE (P ₂ O ₅)	0.02		Na+	0.15
POTASSIUM (K)	2.36	POTASH (K ₂ O)	7.65		Ca+	2.42
MAGNESIUM (Mg)	21.77	MAGNESIUM OXIDE (MgO)	97.96		Mg++	1.81
CALCIUM (Ca)	48.48	CALCIUM (Ca)	131.87	ANIONS	Cl-	0.05
SULFATE (SO ₄)	57.60	SULFUR (S)	51.84		SO ₄ --	1.20
MANGANESE (Mn)	0.01	MANGANESE (Mn)	0.03		HCO ₃ -	3.21
IRON (Fe)	0.01	IRON (Fe)	0.03		CO ₃ --	0.01
BORON (B)	0.02	BORON (B)	0.05		PO ₄ --	0.0
					NO ₃ -	0.07
					pHc	7.37
					Total Cations	4.44
					Total Anions	4.54
					SAR	0.10

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**IRRIGATION
SUITABILITY
INTERPRETATION**

ANALYSIS	UNIT	SATISFACTORY	POSSIBLE PROBLEM	PROBABLE PROBLEM
WATER CHARACTERISTICS				
Water pH		-----	-----	-----
Hardness		0 - 125	126 - 245	> 245
Bicarbonate	ppm	0 - 111	112 - 525	> 525
Carbonate	ppm	0 - 12	13 - 62	> 62
IMPACT ON GENERAL PLANT GROWTH				
Electrical Conductivity	mmhos/cm	0 - .75	.76 - 3.0	> 3.0
Total Soluble Salt	ppm	0 - 480	481 - 1950	> 1950
IMPACT FROM ROOT CONTACT				
Sodium	meq/l	0 - 2.9	3.0 - 9.0	> 9.0
Chloride	ppm	0 - 140	141 - 360	> 360
Boron	ppm	0 - 0.5	0.6 - 2.0	> 2.0
IMPACT FROM FOLIAGE CONTACT				
Sodium	ppm	0 - 70	71 - 210	> 210
Chloride	ppm	0 - 100	101 - 350	> 350
IMPACT ON SOIL STRUCTURE				
Sodium Absorption Ratio Adj.		0 - 6.0	6.1 - 9.0	> 9.0
Electrical Conductivity	mmhos/cm	> 0.5	< 0.5	

Understanding a Media Analysis Report

The purpose of a Media Analysis is to determine the availability of nutrients in the growing media that are required for healthy plant growth and to identify any fertility concerns that could constrain that growth.

Saturated Media Extraction

In this method a portion of the sample, as collected by the grower, is saturated with distilled water and allowed to equilibrate. The resulting solution is drawn off as the saturation extract. The available soluble plant nutrients in the sample are then analyzed and reported in the Media Report.

For convenience, a reference of the normal range of the nutrients is also shown on the report based on over 31,000 samples analyzed. Below is an explanation of the different test elements.

pH

In general, the target pH range will be crop dependent. Acidity, which is indicated by pH, determines nutrient availability so having a pH outside of the recommended range means you may have either too much of a certain nutrient (toxicity) or not enough of a nutrient available, depending on the pH and the nutrient in question. Lime can be added to raise pH – to reduce pH, a combination of nitrogen and sulfur are added.

Soluble Salts

The most common soluble salts in media come from commercial fertilizers, animal manure, organic matter, and compost. The salts usually found in growing media are forms of calcium, magnesium and sodium, in combination with chloride, sulfate and bicarbonate. Exposure to high soluble salt concentrations for a long period can cause injury to roots and, or, leaf margin burning. To reduce the amount of salt in the root zone you may need to adjust the amount and schedule of fertilizer applications. It may also be necessary to saturate the media with water to try to flush some of the salts from the root zone. Monitoring soluble salts can help with over fertilizing (unnecessary costs) as well as groundwater contamination due to leaching.

Soluble salt is measured as Electrical Conductivity (EC). This part of the test measures the concentration of soluble salts in the growing media by measuring the ability of the solution to conduct an electrical current. As the salt level increases the solution becomes a better conductor of electricity therefore, the EC increases.

Nutrients

The nutrients identified as essential for plant growth are listed in the top section of the report. This is used to determine the nutrients contained in the substrate that will become available for plant uptake. If your results are outside of the normal range, it does not necessarily mean you have an issue. However, it is certainly a good place to start looking.

N-P-K Fertilizer Values

The fertilizer values are the amount of total nutrients that the material contains. These values represent nutrients that are in the solution and readily available as well as nutrients that will become available over time as the material breaks down.

Total Nitrogen % - the sum of Organic Nitrogen and ammonium

Total P (as P₂O₅) % - The total amount of phosphorus as P₂O₅

Total K (as K₂O) % - The total amount of potassium as K₂O

Compost Maturity

Compost Maturity is used in determining if the compost material is stable enough for use in nurseries. It gives you an idea of how decomposed the raw material has become by measuring the amount of carbon, ammonia and respiration going on in the compost. If the compost is deemed unstable it will use nitrogen from the media or soil. This can cause a nitrogen deficiency for the desired crops and inhibit plant growth. Stable compost delivers nutrients slowly to the media or soil, providing valuable nutrients to the growing plants.

C/N Ratio

Measures the availability of the two most important nutrients for microorganisms in the soil. Carbon is used as an energy source and nitrogen is a requirement for building proteins and enzymes. This ratio is used as the first step in determining whether a sample is mature enough to be used as a soil amendment. An adequate ratio is equal to or less than 25:1.

Total Carbon % (AS)

Used in determining the C/N Ratio. Carbon is used as an energy source by microorganisms. Reported on an as received (AS) basis.

Total Nitrogen % (AS)

Used in determining the C/N Ratio. This value includes the organic forms of nitrogen found in soluble organic matter, proteins, and other by-products of decomposition as well as inorganic ammonium nitrogen. These soluble forms of nitrogen are easily leached from the soil with water movement or can be converted to gas if the soil is saturated with water. Reported on an as received (AS) basis.

Organic Matter % (DB)

Organic Matter is broken down as an important nutrient supply source for crops. The two main nutrients coming from organic matter are nitrogen and sulfur. As soil microbes break down OM it supplies the plant with these and other nutrients. This release is dependent on several factors such as the OM composition, temperature, moisture and management factors. OM is calculated using the Loss on Ignition method and reported on an as received (AS) basis.

Respiration %

Respiration percentage is used to determine maturity of the compost by measuring carbon dioxide released from a moist sample under controlled incubation conditions.

Test Your Water

You should also submit a water sample if you aren't sure of your water quality. pH, EC, alkalinity, and nutrients levels can all affect media differently so it's important to have a starting point on how this is going to affect your final growing media.

MEDIA ANALYSIS

Submitted by **8888888**
AgSource Test Account
300 Speedway Circle, Unit 2
Lincoln, NE 68502

Submitted for
AgSource HL_MEDIA_COMPLETE

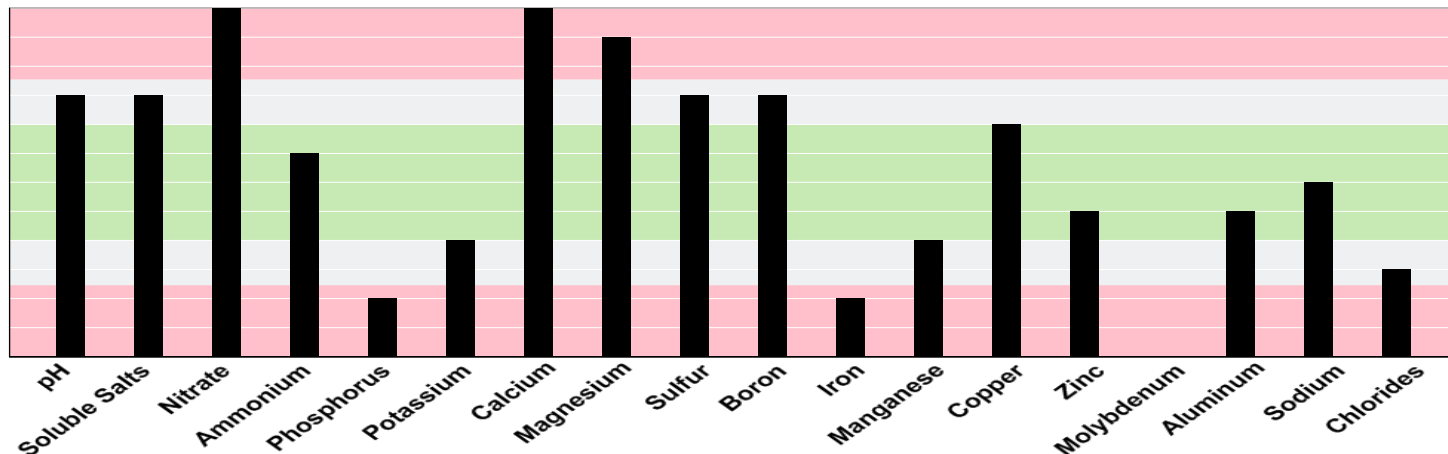


Laboratory Sample #
DH37889 - DH37893
 Information Sheet #
TEST_20200923

Date Received
01/01/2026

Date Reported
01/03/2026

Laboratory Turnaround **2 Days** Samples Stored Until **16-Jan-2026** Client Sample ID **Test47**



Report of Analytical Results and Interpretation for: **POTTING MIX/SOIL**

Analysis Type (AS)	Results		Normal Ranges
pH	7.0	H	5.3 - 6.4
Soluble Salts mmhos/cm (EC)	3.6	H	1.46 - 3.25
Nitrate ppm NO3-N	324.0	H	13.0 - 189.0
Ammonium ppm NH4-N	76.0		13.6 - 94.1
Phosphorus ppm	5.9	L	14.5 - 55.1
Potassium ppm	135.7	L	145.5 - 337.8
Calcium ppm	405.8	H	40.2 - 114.2
Magnesium ppm	83.0	H	18.8 - 66.2
Sulfur ppm	61.8	H	21.8 - 52.7
Boron ppm	0.26	H	0.10 - 0.22
Iron ppm	0.10	L	0.28 - 1.04
Manganese ppm	0.10	L	0.12 - 0.59
Copper ppm	0.10		0.10 - 0.10
Zinc ppm	0.10		0.10 - 0.20
Molybdenum ppm	0.12	L	N/A - N/A
Aluminum ppm	0.49		0.40 - 1.54
Sodium ppm	42.3		23.5 - 68.5
Chlorides ppm	23.7	L	44.6 - 207.0

H - levels higher than the normal range L - levels lower than the normal range
 High and Low levels do not necessarily indicate a problem.

Compost Maturity

Total Carbon % (AS)	9.15
Total Nitrogen % (AS)	0.62
C/N Ratio	14.80
Organic Matter % (DB)	17.80
Respiration ppm	494.80

N-P-K Fertilizer Analysis

Total Nitrogen % (AS)	0.62	12.4 Lbs/Ton
Total P % (as P2O5) (AS)	0.29	5.8 Lbs/Ton
Total K % (as K2O) (AS)	0.09	1.8 Lbs/Ton
Moisture %	11.37	

AS: Reported on an as is basis

DB: Reported on a dry weight basis

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AgSource Laboratories Testing Methods

Lincoln, Nebraska

Testing Methodologies and Procedures used at AgSource Laboratories Lincoln, Nebraska lab location

When comparing results from one laboratory to the next, it is important to determine the following:

1. Laboratory method used for each analysis
2. Units reported for each analysis
3. Any conversion or calculation used for specific tests

There is no perfect method for determining how much or little of an essential nutrient is available for plant uptake. Availability is affected by: soil moisture, temperature, soil pH, clay/organic matter content, soil drainage, physical barriers and many other factors. As these factors change, the availability of nutrients also change. What a soil test measures is the degree of fertility; be it low, medium or high.

Analysis	Unit	Method of Analysis
SOIL ANALYSIS		
Soil pH	N/A	1:1 Soil/Water Slurry
Soluble Salt	mmhos/cm	1:1 Soil/Water Slurry
Buffer pH	N/A	Sikora Buffer Solution
Cations Ca-Mg-K-Na	ppm	Ammonium Acetate Extraction
Phosphorus If pH < 7.2	ppm	Bray I Extraction
Phosphorus If pH > 7.1	ppm	Olson Extraction
Traces Zn-Mn-Fe-Cu	ppm	DTPA Extraction
Sulfur	ppm	Monocalcium Phosphate (ICP Determination)
Boron	ppm	Hot Water Extraction (ICP Determination)
Nitrate-N	ppm	Cadmium Reduction
Particle Size Analysis (Sand-Silt-Clay)	%	Hydrometer Measurement
Salinity Evaluation	mmhos/cm	Saturated Paste Extraction
Other Methods Available		Pertains to country of origin
Extractable Soil Ammonium	ppm	KCl extraction
Extractable Chloride in Soil	ppm	Calcium Nitrate Extraction
Soil Moisture	%	Loss of Drying
Organic Matter	%	Loss of Ignition
Extractable Aluminum	ppm	Cesium Chloride Extraction
Extractable Molybdenum	ppm	Ammonium Oxalate
PLANT ANALYSIS		
Nitrate-Nitrogen	ppm	2% Acetic Acid digestion
Phosphate-Phosphorus	ppm	2% Acetic Acid digestion

Quality Assurance and Control Procedures

AgSource Laboratories utilizes a rigorous Quality Assurance and Quality Control (QA/QC) program supported by an experienced, full-time analytical team. The quality assurance program for each area of testing is defined in specific Standard Operating Procedure (SOP) documents. These SOP's dictate the steps taken in the following processes:

- Sample receiving, handling and storage prior to analysis, including sub-sampling.
- Preparation of sub-samples for analysis including any extraction or digestion required, filtering or dilution, and presentation of processed samples for each analytical method.
- Recording the preparation of analytical methods including the first use and expiration dates for standards, extracting or digesting solutions and analytical reagents.
- Documenting instrument set up, calibration and maintenance in instrument or method logs.
- Including Quality Control (QC) samples such as known samples, standard check solutions, blanks, spiked samples or duplicates along with all unknown samples. The acceptance criteria for all the QC results are detailed for each testing method.
- Review, recording, and transfer of all analytical data, and final reporting of accepted results.

Overview of Quality Control for Soil Testing

The specific requirements of the QA/QC program are detailed in the specific SOPs for each analytical method. The general criteria for compliance are described below.

Sample Preparation

- When samples are received at the laboratory, sample bags and information sheets are matched and numbered with a unique identification number. The samples are transferred to trays for drying in a specific, consistent order.
- Soil samples are air-dried below 110°F and ground in automatically controlled grinders to provide a uniform grinding process. Ground samples are collected in small boxes and ordered in trays of 50 or 60.

Quality Control (QC) Samples

- In each tray of samples there are at least two known QC samples that are processed along with the soil samples for every test.
- The QC samples are inserted in a predetermined order in the tray and the box at that position is occupied with a marker to identify the location of the QC.
- The QC sample is a premixed bulk sample that is sub-sampled for each analytical run.

Recognized Analytical Methods

- Standardized sub-samples are then measured (scooped) from each soil sample or from the QC sample for each test.
- These sub-samples are prepared for analysis according to the recognized methods of the North Central region of states (NCERA-13) and according to state certification requirements.

Instrument Calibration and Control

- Each instrument used in the analysis of the soil samples is calibrated against a set of standards. The standard calibration curve must have a high correlation coefficient

(typically >0.995) and a check solution must read back with expected values before sample analysis begins.

- The check solution is analyzed after every 10 - 20 samples, depending on the instrument set-up, and if it fails (does not read as expected) the instrument is recalibrated before proceeding. The previously analyzed set of samples are re-tested if the instrument drift is greater than 15%.

QC Sample Review

- During the analytical run the technician can observe the values of the QC samples and evaluate the quality of the data against expected ranges for the QC samples.
- If the QC sample results fall outside these ranges, the technician will reject the accompanying sample results and notify the QC Manager to determine what corrective steps to take. These steps could be to:
 - recalibrate the instrument and read the sample tray again,
 - or have the tray re-scooped and re-extracted for another analysis.
- All the data for each analysis are reviewed by the technician and by the QC Manager for quality control compliance before being passed on for reporting. (see below)

Sample Reporting

- Sample results are identified by a unique sample ID in Labworks, the Laboratory Information Management System (LIMS) used in all AgSource Laboratories.
- When all the required analytical data is entered the LIMS performs any calculations and reporting routines before generating the PDF and electronic file reports that are automatically sent to the clients.
- Clients that submit samples also provide email addresses or digital transfer details maintained under the client account to ensure that the reports are securely distributed.

QC Data Analysis and Acceptance Criteria

The laboratory maintains a complete record of all supporting QC data for each analytical method. The data are statistically reviewed for average and standard deviation and these values are regularly updated in the AgSource LIMS system.

When data are reviewed in the LIMS for approval and reporting they are compared against the range of standard deviations around the mean.

- If a QC sample result falls outside two standard deviations from the mean it is flagged with a 'Warning'.
- If two consecutive QC samples in an analytical run receive a 'Warning' the QCs are considered as having failed and the associated sample results are rejected.
- If a QC sample result falls outside three standard deviations from the mean it is flagged as 'Failed' and the associated sample results are rejected.
- Rejected sample results are the samples that fall in the group between the prior passing QC sample and the next passing QC sample.
- Rejected samples are re-scooped and processed for analysis.
- The same QC criteria are applied to these re-tested samples when being reviewed.

All QC results are compiled and plotted over the course of the time that the QC sample is in use. By graphing this data it is possible to pick up trends in the results that are not apparent on a daily basis. These trends include rising or falling average values that may indicate deterioration of instrument sensitivity, electrode quality or stability of a reagent used in the analytical processes.