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These e-Updates are a regular weekly item from K-State Extension Agronomy and Kathy Gehl, Agronomy eUpdate Editor. All of the Research and Extension faculty in Agronomy will be involved as sources from time to time. If you have any questions or suggestions for topics you'd like to have us address in this weekly update, contact Kathy Gehl, 785-532-3354 kgehl@ksu.edu, or Dalas Peterson, Extension Agronomy State Leader and Weed Management Specialist 785-532-0405 dpeterso@ksu.edu.

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1. Considerations for fall applications of anhydrous ammonia

Soils across Kansas are still running above 50°F at the 4-inch depth in most locations (Figure 1). It is best to delay application of anhydrous ammonia until soil temperatures drop below this threshold. Applying anhydrous ammonia in the fall ahead of the next corn crop has some appeal to producers. For one thing, fall fertilizer application spreads out the workload so there's more time to focus on corn planting in the spring. Secondly, wet conditions in the spring sometimes prevents producers from applying lower-cost anhydrous ammonia ahead of corn planting, and forces them to apply more expensive sources after planting. Equally important for many producers have been issues with anhydrous ammonia availability at times in the spring.

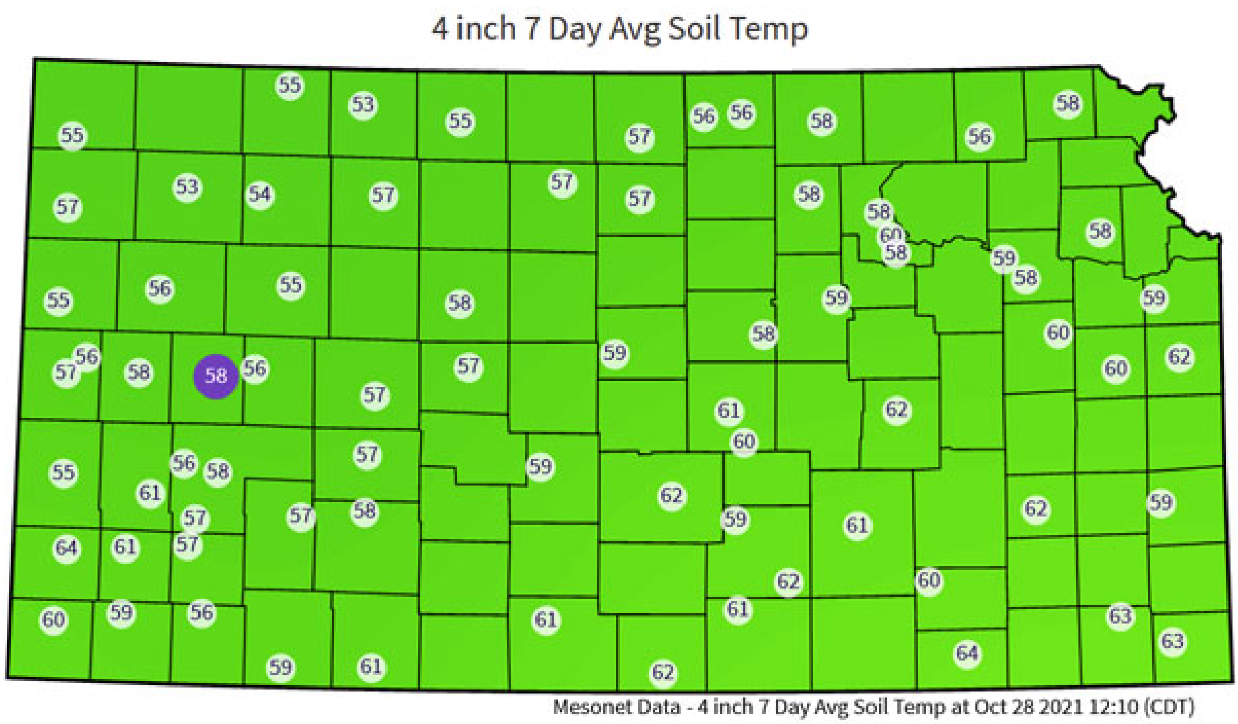

Figure 1. Average soil temperature (°F) at 4 inches for the 7-day period ending on October 28, 2021. Soil temperatures in individual fields in any given area will vary with differences in vegetative cover, soil texture, soil moisture, and other factors. (Kansas Mesonet)

Despite those advantages, producers should be aware that there is potential for higher nitrogen (N) loss in the spring following a fall application, as a result of nitrification of the ammonium during late winter and very early spring and subsequent leaching, or denitrification.

Reactions of anhydrous ammonia in the soil

When anhydrous ammonia is applied to the soil, a large portion of the ammonia is converted to ammonium (NH_4^+), and can be bound to clay and organic matter particles within the soil. As long as the nitrogen remains in the ammonium form, it can be retained on the clay and organic matter, and does not readily move in most soils except sandy soils with very low CEC, so leaching is not an issue.

At soil temperatures above freezing, nitrification occurs - ammonium is converted by specific soil microbes into nitrate-N (NO_3^-). Since this is a microbial reaction, it is very strongly influenced by soil temperatures. The higher the temperature, the quicker the conversion will occur. Depending on soil temperature, pH, and moisture content, it can take 2-3 months or longer to convert all the ammonia applied in the fall to nitrate.

By delaying application until cold weather, most of the applied N can enter the winter as ammonium, and over-winter losses of the applied N will be minimal.

Producers should wait until soil temperatures are less than 50 °F at a depth of 4 inches before applying ammonia in the fall or early winter. Nitrification does not cease below 50 °F, but rather soils will likely become cold enough to limit the nitrification process. In many areas of Kansas, soils may stay warmer than 50 degrees well into late-fall and only freeze for short periods during the winter.

The use of a nitrification inhibitor can help reduce N losses from fall N applications under specific conditions, particularly during periods when soil temperatures warm back up for a period after application.

One should also consider soil physical properties when considering fall application. Fall applications of N for corn should not be made on sandy soils prone to leaching, particularly those over shallow, unprotected aquifers. Rather, fall N applications should focus on deep, medium- to heavy-textured soils where water movement through the profile is slower.

When is nitrogen lost?

When considering fall application of N, keep in mind that loss of N during the fall and winter is not normally a problem in Kansas. The conversion of "protected" ammonium to "loss prone" nitrate during the fall and winter can be minimized by waiting to make applications until soils have cooled, and by using products such as nitrification inhibitors. The fact that essentially all the N may remain in the soil as ammonium all winter, coupled with our dry winters, means minimal N is likely to be lost over winter.

However, soils often warm up early in the spring and allow nitrification to get started well before corn planting. Generally, if the wheat is greening up, nitrification has begun! Thus, one of the potential downsides of fall application is that nitrification can begin in early March, and essentially be complete by late May and June.

Summary

If anhydrous ammonia is to be applied in the fall, there are a number of factors that must be considered, including soil texture, temperature, and soil moisture. Consider the following guidelines:

- Do not apply anhydrous ammonia in the fall on sandy soils.
- On silt loam or heavier-textured soils, wait to apply anhydrous ammonia until soil temperatures at the 4-inch depth are below 50 °F. Grass covered 2-inch depth typically reaches the 50 mark around the 20th of November in central Kansas (Figure 2). You can expect the 4-inch depth to lag behind that date depending on soil type and earlier if the ground is

bare.
- Use a nitrification inhibitor with anhydrous ammonia to help reduce fall nitrification.
- To check the soil temperature in your area, visit the K-State Research and Extension Weather Data Library at: http://mesonet.k-state.edu/agriculture/soiltemp/

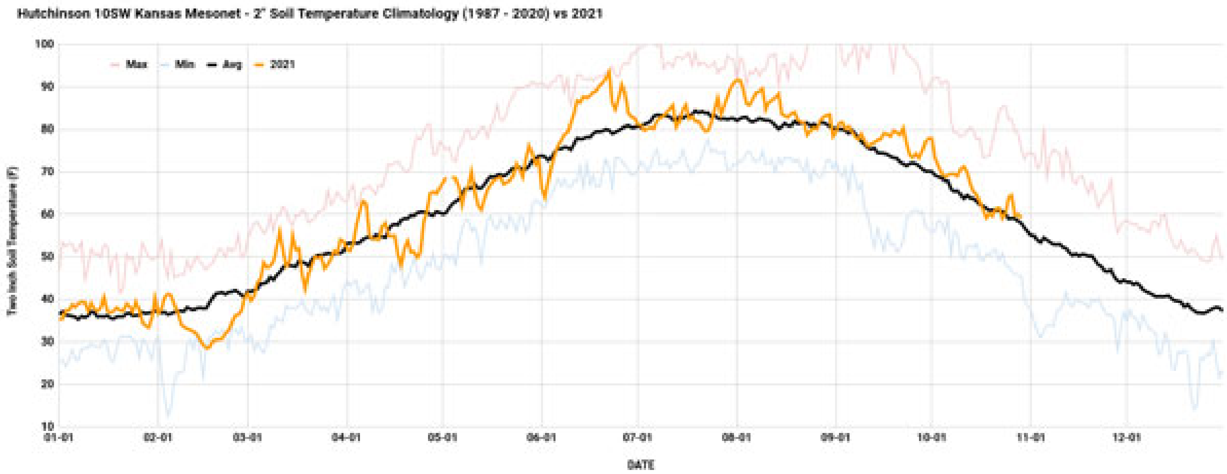

Figure 2. Hutchinson 10SW Mesonet station 2021 2-inch soil temperature compared to climatology under grass cover. Soil temperatures in individual fields in any given area will vary with differences in vegetative cover, soil texture, soil moisture, and other factors. (Kansas Mesonet)

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2. Saline and sodic soils: Understanding the basics

In Kansas, salt-affected soils and related problems occur statewide but often on small areas. Field-wide problems often are due to poor quality irrigation water and/or excessive manure applications. Some areas of the state where salt mining occurs have soils naturally high in sodium and soluble salts. Drilling activity causing high-salt water to escape to the soil surface, spills, or natural causes may result in spotty problems. Landowners with questions or concerns about brine spills that may have occurred on land leased for oil and gas leases should contact their appropriate Kansas Corporation Commission district office (http://www.kcc.state.ks.us/contact.htm).

Ions most commonly associated with soil salinity include:

- anions: chloride (Cl^-), sulfate (SO_4^{2-}), carbonate (HCO_3^-), and sometimes nitrate (NO_3^-)
- cations: sodium (Na^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), and sometimes potassium (K^+).

Salt-affected soils have been called white alkali, black alkali, gumbo, slick spots and other descriptive names. These names are associated with soil appearances caused by salt accumulation. The term alkali often refers to soils light in color and prone to surface crusting and implies that affected soils are high in exchangeable sodium (Figure 1).

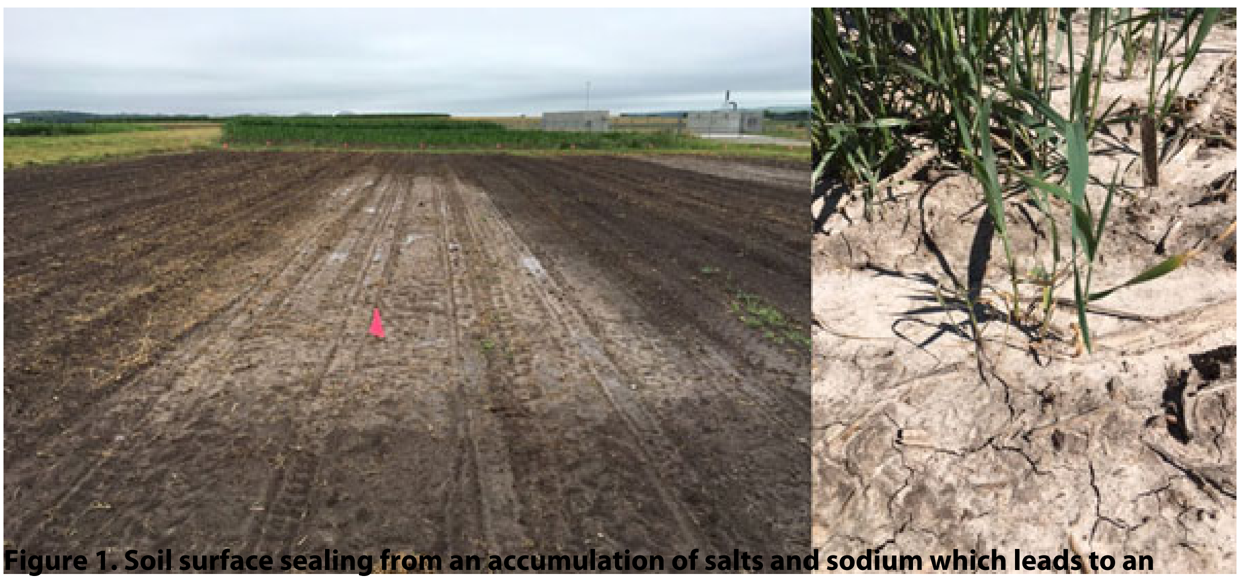

Figure 1. Soil surface sealing from an accumulation of salts and sodium which leads to an increase in runoff and reduced water infiltration (left photo). Plants often show drought-related injuries due to a lack of available soil moisture with poor water infiltration as well as osmotic effect on plant water uptake due to high salt content in the soil (right photo). Photos by Dorivar Ruiz Diaz, K-State Research and Extension.

Figure 2. Poor wheat emergence on an induced saline-sodic soil wheat plot. Photo by Dorivar Ruiz Diaz, K-State Research and Extension.

Characterization of saline and sodic soils

Salt-affected soils are divided into three groups depending on the amounts and kinds of salts present. Electrical conductivity (EC), is the ability of a soil solution to carry electrical current, and salts increase this ability. Classification depends on total soluble salts (measured by electrical conductivity), soil pH, and exchangeable sodium percentage (Table 1).

Saline soils - All soils contain some water-soluble salts, but when these salts occur in amounts that are harmful to germination of seeds and plant growth, they are called saline. Saline soils are the easiest of the salt-affected soils to reclaim if good quality water is available and the site is well drained. Saline soils often are in normal physical condition with good structure and permeability. They are characterized by irregular plant growth and salty white crusts on the soil surface. These salts are mostly sulfates and/or chlorides of calcium and magnesium.

Sodic soils - Sodic soils are low in total salts but high in exchangeable sodium percentage, abbreviated ESP. The combination of high levels of sodium and low total salts tends to disperse soil particles, making sodic soils of poor tilth. Sodium causes soil clays to swell and that squeezes out soil pores (which is useful when trying to seal the bottom of a pond or wastewater lagoon). Sodic soils are sticky when wet, nearly impermeable to water and have a slick look. As they dry, they become hard, cloddy and crusty.

Sodic soils are detrimental to growth of most plants. They can be reclaimed, but it may be slow and expensive due to the lack of a stable soil structure and low porosity, which slows water drainage.

Saline-Sodic Soils - These soils contain large amounts of total soluble salts and greater than 15 percent exchangeable sodium. The pH is generally less than 8.5. Physical properties of these soils are good as long as an excess of soluble salts is present. In other words, even though there is high sodium which normally causes the clays to swell, the calcium and magnesium in the soil helps keeps the soil pores open—so another way to put it is that the calcium and magnesium helps to counteract the sodium.

Table 1. Salt-Affected Soil Classification

Classification	Electrical Conductivity (mS/cm)	Soil pH	Exchangeable Sodium Percentage	Soil Physical Condition
Saline	> 4.0	< 8.5	< 15	Normal
Sodic (alkali)	< 4.0	> 8.5	> 15	Poor
Saline-sodic	> 4.0	< 8.5	> 15	Normal
> = greater than, < = less than				

For more information, please see the KSRE publication MF1022 "Management of Saline and Sodic Soils" at: https://www.bookstore.ksre.ksu.edu/pubs/MF1022.pdf

A companion article in this eUpdate discusses the use of soil testing to identify saline and sodic soils, along with management recommendations.

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3. Saline and sodic soils: Identification and management

An analysis of the soil for soluble salts and sodium accumulation will identify the specific problem and its severity. To see if a problem exists, take a composite sample of several soil cores, 6 to 8 inches deep, from the affected area, with a final sample volume of at least a pint of soil. In many cases, comparison soil samples from the affected area and surrounding area with a normal appearance will be beneficial. If a saltwater spill occurred and the water stood on the area for several weeks or a natural seep exists, depth increment samples to 3 feet should be taken to assess the depth of salinity. Profile information will help in planning a reclamation program. If you are unsure how to sample, consult the lab where you're submitting the samples or your county Extension agricultural and natural resources agent.

Lab analysis methods vary, but most labs that run a specific salt-alkali test use about the same methods. The methods and interpretation presented here are used in the KSU Soil Testing Lab. Before applying these interpretations to other lab results, you should be certain similar methods were used.

The amount of soluble salts present is measured by determining the electrical conductivity (mS/cm). The electrical conductivity of a solution is proportional to its soluble salt content. The general interpretation of the results is found in Table 1.

A second important measure is the amount of exchangeable sodium. The results of this extraction must be corrected for soluble sodium measured but not exchangeable. Once this correction is made, the results are expressed as percent exchangeable sodium. The general interpretation used by the KSU Soil Testing Lab is found in Table 2.

Table 1. Interpretation of Electrical Conductivity

Saturation Extract (mS/cm)	Salt Rank	Interpretation
0-2	Low	Very little chance of injury on all plants.
2-4	Moderate	Sensitive plants and seedlings of others may show injury.
4-8	High	Most non-salt tolerant plants will show injury; salt-sensitive plants will show severe injury.
8-16	Excessive	Salt-tolerant plants will grow; most others show severe injury.
16+	Very Excessive	Very few plants will tolerate and grow.

Table 2. Interpretation of Exchangeable Sodium Percentage

Exchangeable Sodium (%)	Alkali Rank	Interpretation
0-10	Low	No adverse effect on soil is likely.
10+	Excessive	Soil dispersion resulting in poor soil physical condition and plant

		growth is likely.

Detrimental effects of excess exchangeable sodium on plant growth occur because of poor soil physical condition. Some plants, however, begin to show some injury at levels as low as 5 percent exchangeable sodium. The commonly grown agronomic crops in Kansas are not among those sensitive to sodium. In the general discussion of a sodic soil, greater than 15 percent is the level of exchangeable sodium for poor physical condition to develop. To alert land owners of a potential problem, the KSU Soil Testing Lab interprets anything above 10 percent exchangeable sodium as excessive. Most well-drained, normal soils in Kansas will have less than 1 to 2 percent.

The occurrence of sodic or saline-sodic soil problems on a field basis nearly always can be traced to irrigation with marginal or poor quality water. Irrigators should determine the potential salinity and sodium hazard of their water. Irrigation water quality tests are available through the KSU Soil Testing Lab. In addition to the results, the KSU Soil Testing Lab report shows how to interpret the irrigation water test results for overall salinity and sodium hazard.

Salt effects on plant growth

Crops differ in the ability to tolerate salt accumulation in soils, but if levels are high enough, (> 16 mS/cm) only tolerant plants will survive.

Crop selection can be a good management tool for moderately saline soils. The following list serves as a general guide of salt tolerance ratings for crops, realizing that management practices, irrigation water quality, environment, and crop variety also affect tolerance.

- *Highly tolerant*: barley, rye, bermudagrass, crested wheatgrass, asparagus
- *Tolerant*: wheat, oats, triticale, sunflower, alfalfa, tall fescue, sweet clovers
- *Moderately tolerant*: corn, grain sorghum, soybean, bromegrass, sudangrass, sorghum-sudan
- *Sensitive*: field beans (dry), clover (red, ladino, alsike), strawberry, onion, pea, carrot, lettuce, pepper

Crops differ in their ability to tolerate sodic soil, but if sodium levels are high enough, all crops can be affected. Generally, soybeans are quite sensitive, corn and grain sorghum are intermediate and wheat and alfalfa are more tolerant. Crested and tall wheatgrass and a few sorghum-sudan hybrids are very tolerant and are able to grow on soils with exchangeable sodium percentages above 50 percent.

Reclamation of soils summary*

Abbreviated step-by-step procedure for reclamation:

Step 1. Collect a soil sample and submit to a soil testing laboratory for a salt-alkali soil test to determine the specific problem.

Step 2. Identify source/cause of the problem.

Step 3. Eliminate the source of salt contamination if possible and establish drainage if necessary.

Step 4. Add chemical amendment (gypsum) to sodic or saline/sodic soils.

Step 5. Incorporate residue to improve water intake.

Step 6. Apply irrigation water (if available).

Step 7. Allow time for leaching and consider planting tolerant crops.

*For detailed information on the reclamation process of saline, sodic, and saline-sodic soils, please see the full publication, MF1022: Management of Saline and Sodic Soils, on the KSRE Bookstore website.

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4. Save the Date for the 2022 Corn Schools

The Department of Agronomy and K-State Research and Extension, in partnership with Kansas Corn, are planning to host several Corn Schools in 2022. Please save the date for the location nearest you. Details on speakers and topics will be coming soon. Stay tuned to future eUpdates for more information!

2022 Kansas Corn Schools

- **January 7 – Oakley**
- **January 14 – Salina**
- **January 18 – Parsons**
- **February 3 – Virtual**
- **February 24 – Hiawatha**

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