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eUpdate

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These e-Updates are a regular weekly item from K-State Extension Agronomy and Steve Watson, Agronomy e-Update 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 Steve Watson, 785-532-7105 swatson@ksu.edu, or Curtis Thompson, Extension Agronomy State Leader and Weed Management Specialist 785-532-3444 cthompso@ksu.edu.

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1. Pre-harvest weed control in hail-thinned stands of wheat

Recent hail storms have affected wheat stands in some areas of Kansas. The resulting thin stands in some areas, along with the abundant rains in May, have caused weeds to start showing up in many wheat fields -- especially in fields not treated earlier. When broadleaf weeds are given the opportunity to grow rapidly in wheat fields because of wet weather and open canopies at the end of the growing season, these weeds flourish and often grow above the wheat canopy.

This raises several potential concerns, including harvest difficulties, dockage problems, weed seed production, and soil water depletion. No one wants to spend extra money on a below-average crop, but it may be necessary.



Figure 1. Weeds in wheat near harvest time. Photo by Dallas Peterson, K-State Research and Extension.

Unfortunately, there aren't many good options at this point in time. There are also a lot of questions about which herbicides are approved and the "use guidelines and restrictions" for pre-harvest treatments in wheat. Listed below are the various herbicide options producers can use as pre-harvest aids in wheat. There are differences in how quickly they act to control the weeds, the interval requirement between application and grain harvest, and the level or length of control achieved. All

of them will require good thorough spray coverage to be most effective.

Please note that the 2,4-D rate approved for pre-harvest weed control in wheat has been reduced to a maximum of 0.5 lb/acre, which is equal to 1 pt of a 4-lb formulation or 2/3 pt of a 6-lb material. 2,4-D also has a 14-day pre-harvest requirement.

Another herbicide that is sometimes mentioned as a possible pre-harvest treatment is paraquat. **Paraquat is not labeled for pre-harvest treatment in wheat.** Application of paraquat to wheat is an illegal treatment and can result in a quarantine and destruction of the harvested grain, along with severe fines.

Product and rate	Advantages	Disadvantages	Comments
Aim EC (1 to 2 oz)	Acts quickly, usually within 3 days. Short waiting interval before harvest – 3 days.	Controls only broadleaf weeds. Regrowth of weeds may occur after 2-3 weeks or more, depending on the rate used.	Apply after wheat is mature. Always apply with 1% v/v crop oil concentrate in a minimum spray volume of 5 gal/acre for aerial application and 10 gal/acre for ground applications. Do not apply more than 2 oz of Aim during the growing season.
Dicamba (0.5 pt)	Controls many broadleaf weeds.	A waiting period of 7 days is required before harvest. Acts slowly to kill the weeds. Controls only broadleaf weeds. High potential for spray drift to susceptible crops.	Apply when the wheat is in the hard dough stage and green color is gone from the nodes of the stem. Do not use treated wheat for seed unless a germination test results in 95% or greater seed germination.
Glyphosate (1 qt of 3 lb ae/gal product, or 22 fl oz of Roundup PowerMax or WeatherMax)	Provides control of both grasses and susceptible broadleaf weeds.	Acts slowly. May take up to 2 weeks to completely kill weeds and grasses. Cannot harvest grain until 7 days after	Apply when wheat is in the hard dough stage (30% or less grain moisture). Consult label for

		application. Kochia, pigweeds, and marestail may be resistant.	recommended adjuvants. Not recommended for wheat being harvested for use as seed.
Metsulfuron (0.1 oz)	Provides control of susceptible broadleaf weeds.	Acts slowly. Cannot harvest grain until 10 days after application. Controls only susceptible broadleaf weeds. Kochia, pigweeds, and marestail may be resistant.	Apply when wheat is in the dough stage. Always apply with a nonionic surfactant at 0.25 to 0.5% v/v. Generally recommended in combination with glyphosate or 2,4-D. Do not use on soils with a pH greater than 7.9. Weeds growing under limited moisture may not be controlled. Do not use treated straw for livestock feed.
2,4-D LVE (1 pt of 4lb/gal product or 2/3 pt 6 lb/gal product)	Provides control of susceptible broadleaf weeds.	Acts slowly. Weak on kochia and wild buckwheat. Cannot harvest grain until 14 days after application.	Apply when wheat is in the hard dough stage to control large, actively growing broadleaf weeds. Weeds under drought stress may not be controlled. Do not use treated straw for livestock feed.

It is very difficult to estimate the value of preharvest weed treatments as it will depend in part on the differences a treatment would have on harvest efficiency and dockage. It may not pay to treat wheat with lower weed densities unless harvest is delayed. If the weeds are about to set seed, a preharvest treatment can go a long way toward reducing weed problems in future years by preventing seed production.

In the coming weeks, we will address the issues of controlling weeds and volunteer wheat shortly after harvest this year, especially where there has been widespread hail injury.

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2. Plant analysis for testing nutrient levels in corn

Plant analysis is an excellent “quality control” tool for growers interested in high-yield crop production. It can be especially valuable for managing secondary and micronutrients that don’t have high quality, reliable soil tests available, and for providing insight into how efficiently you are using applied nutrients.

Plant analysis can be used by Kansas farmers in two basic ways: for diagnostic purposes, and for monitoring nutrient levels at a common growth stage. Diagnostics can be done any time, and is especially valuable early in the season when corrective actions can easily be taken. Monitoring is generally done at the beginning of reproductive growth.

Diagnostic sampling

Plant analysis is an excellent diagnostic tool to help understand some of the variation among corn plants in the field. When using plant analysis to diagnose field problems, try to take comparison samples from both good/normal areas of the field, and problem spots. Don't wait for tasseling or silking to sample.

When sampling for diagnostic purposes, collecting specific plant parts is less important than obtaining comparison samples from good and bad areas of the field. As a general rule, if plants are less than 12 inches tall, collect the whole plant. Cut off the plant at ground level. With plants more than 12 inches tall and until reproductive growth begins, collect the top fully developed leaves (those which show leaf collars). Once reproductive growth starts, collect the same plant parts indicated for monitoring purposes, described below.

Along with taking plant tissue samples, it is also helpful to collect a soil sample from both good and bad areas when doing diagnostics. Define your areas, and collect both soil and plant tissue from areas that represent good and bad areas of plant growth. Soil samples can help define why a problem may be occurring. The soil sample may find certain nutrient levels are very low in the soil, helping to explain why a deficiency is occurring. But other factors can also cause nutrient problems. Soil compaction, or saturation of soils for example, often limits the uptake of nutrients, especially potassium, which are otherwise present in adequate amounts in the soil.

Plant analysis for nutrient monitoring

For general monitoring or quality control purposes, plant leaves should be collected as the plant enters reproductive growth. Sampling under stress conditions for monitoring purposes can give misleading results, and is not recommended. Stresses such as drought or saturated soils will generally limit nutrient uptake, and result in a general reduction in nutrient content in the plant.

In the case of corn, 15-20 ear leaves, or the first leaf below and opposite the ear, should be collected at random from the field at silk emergence, before pollination, and before the silks turning brown.

Handling and shipping plant sample

How should you handle samples, and where should you send the samples? The collected leaves should be allowed to wilt over night to remove excess moisture, placed in a paper bag or mailing

envelope, and shipped to a lab for analysis. Do not place the leaves in a plastic bag or other tightly sealed container, as the leaves will begin to rot and decompose during transport, and the sample won't be usable. Most of the soil testing labs working in the region provide plant analysis services, including the K-State lab. Make sure to label things clearly for the lab.

What nutrients should be included in the plant analysis?

In Kansas, nitrogen (N), phosphorus (P), potassium (K), sulfur (S), zinc (Zn), chloride (Cl), and iron (Fe) are the nutrients most likely to be found deficient. Recently questions have been raised by consultants and others concerning copper (Cu), manganese (Mn), and molybdenum (Mo), though widespread deficiencies of those micronutrients have not been found in the state. Many labs can analyze for these nutrients also. Normally the best values are the "bundles" or "packages" of tests offered through many of the labs. They can be as simple as N, P and K, or can be all of the 14 mineral elements considered essential to plants. K-State offers a package which includes N, P, K, Ca, Mg, S, Fe, Cu, Zn, and Mn for \$23.75.

What will you get back from the lab?

The data returned from the lab will be reported as the concentration of nutrient elements, or potentially toxic elements, in the plants. Units reported will normally be in "percent" for the primary and secondary nutrients (N, P, K, Ca, Mg, S, and Cl) and "ppm," or parts per million, for most of the micronutrients (Zn, Cu, Fe, Mn, B, Mo, and Al).

Most labs/agronomists compare plant nutrient concentrations to published sufficiency ranges. A sufficiency range is simply the range of concentrations normally found in healthy, productive plants during surveys. It can be thought of as the range of values optimum for plant growth. The medical profession uses a similar range of normal values to evaluate blood work. The sufficiency ranges change with plant age (generally being higher in young plants), vary between plant parts, and can differ between hybrids. So a value slightly below the sufficiency range does not always mean the plant is deficient in that nutrient. It is an indication that the nutrient is relatively low. Values on the low end of the range are common in extremely high-yielding crops. However, if that nutrient is significantly below the sufficiency range, you should ask some serious questions about the availability and supply of that nutrient.

Keep in mind also that any plant stress (drought, heat, soil compaction, saturated soils etc.) can have a serious impact on nutrient uptake and plant tissue nutrient concentrations. So a low value of a nutrient in the plant doesn't always mean the nutrient is low in the soil and the plant will respond to fertilizer. It may be that the nutrient is present in adequate amounts in the soil, but is either not available or not being taken up by the plant for a variety of reasons. Two examples are drought, which can reduce plant uptake of nutrients and cause low nutrient values in the plant; and high-pH soils, which can cause low iron availability.

On the other extreme, levels above "sufficiency" can also indicate problems. High values might indicate over-fertilization and luxury consumption of nutrients. Plants will also sometimes try to compensate for a shortage of one nutrient by loading up on another. This occurs at times with nutrients such as iron, zinc, and manganese. Plants will load up on iron at times in an attempt to compensate for low zinc. In some situations, very high levels of a required nutrient can lead to toxicity. Manganese is an example of an essential nutrient that can be toxic when present in excess. This can occur at very low soil pH levels, generally well below 5.

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The following table gives the range of nutrient contents considered to be “normal” or “sufficient” for corn seedlings below 12” tall, and for the ear leaf of corn at silking. Keep in mind that these are the ranges normally found in healthy, productive crops.

Range of nutrient contents considered “normal” or “sufficient” at two growth stages in corn			
Nutrient	Units	Whole Plant <12” tall	Corn Ear Leaf at Green Silk
Nitrogen	%	3.5-5.0	2.75-3.50
Phosphorus	%	0.3-0.5	0.25-0.45
Potassium	%	2.5-4.0	1.75-2.25
Calcium	%	0.3-0.7	0.25-0.50
Magnesium	%	0.15-0.45	0.16-0.60
Sulfur	%	0.20-0.50	0.15-0.50
Chloride	%	Not established	0.18-0.60
Copper	ppm	5-20	5-25
Iron	ppm	50-250	20-200
Manganese	ppm	20-150	20-150
Zinc	ppm	20-60	15-70
Boron	ppm	5-25	4-25
Molybdenum	ppm	0.1-10	0.1-3.0
Aluminum	ppm	<400	<200

Summary

In summary, plant analysis is a good tool to monitor the effectiveness of your fertilizer and lime program, and a very effective diagnostic tool. Consider adding this to your toolbox.

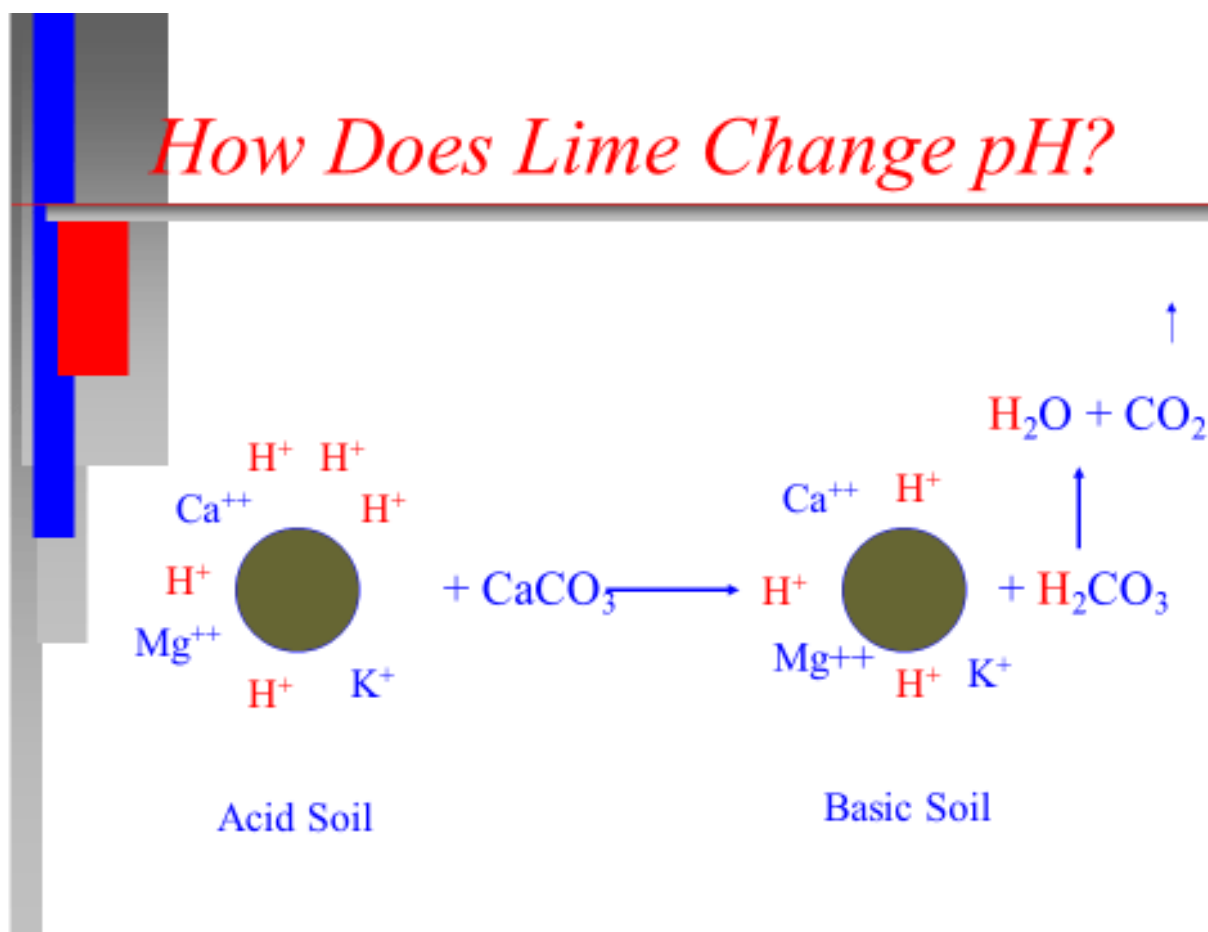
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3. Soil pH and liming in Kansas: Part 3 -- Selecting liming materials

In [Part 1](#) and [Part 2](#) of this series of articles in the Agronomy eUpdate we discussed the basic concept of pH and acidity in soils, why pH control is important in crop production, and how to make lime recommendations. This third and final article will discuss what reactions must occur in soil to change pH and selecting an appropriate and cost-effective liming material.

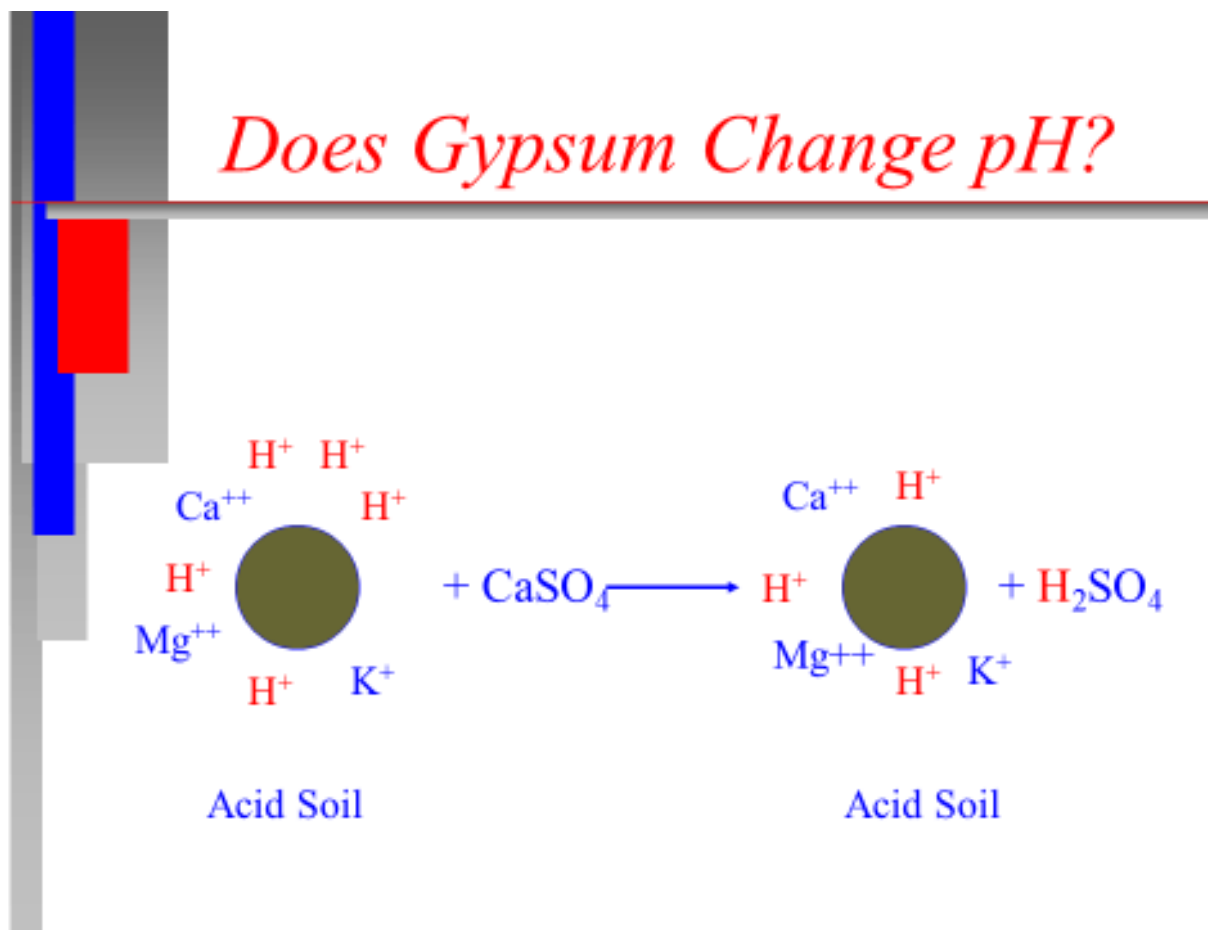
The "lime reaction"

The process of adding a material to raise soil pH, commonly referred to as liming, removes hydrogen (H^+) from the soil cation exchange capacity and replaces the H^+ with a basic cation such as calcium (Ca^{+2}) and/or magnesium (Mg^{+2}). But to complete the liming process, the hydrogen removed from the CEC must be neutralized and removed from the soil solution. The most commonly used liming product which both replaces exchangeable H^+ with Ca^{+2} and neutralizes the replaced H^+ is aglime. The chemical reaction explaining this reaction is given below:



Lime, calcium carbonate ($CaCO_3$), reacts with an acid soil replacing some of the exchangeable H^+ with Ca^{+2} , and forming carbonic acid, H_2CO_3 in the soil solution. Carbonic acid is what gives a soda the fizz, and is very unstable. The carbonic acid breaks down quickly to CO_2 and water. The CO_2 bubbles off to the atmosphere, and the H^+ is neutralized to form water. So the soil pH is raised by reducing the H^+ in the soil solution.

Compare this reaction to what happens when gypsum, calcium sulfate CaSO_4 , is added to soil:



Gypsum is the salt of a strong acid, and dissolves to form Ca^{+2} and sulfate SO_4^{-2} in the soil solution. The Ca^{+2} replaces some of the H^+ on the CEC, and sulfuric acid, H_2SO_4 , a strong acid, is formed in the soil solution. There is no way to neutralize that acid. The net effect is that little or no change in pH occurs when the salt of a strong acid, such as CaSO_4 or KCl (potash), is added to the soil.

The bottom line is that there must be some reaction to neutralize the replaced exchangeable H^+ , for a material to be an effective liming tool and increase soil pH.

Liming sources available

The most commonly used liming material is ground limestone. Several liming materials are marketed, and it is important to recognize differences among them.

Ground aglime (dry). Limestone rock is crushed and ground into a material known by several

names, including aglime, agrilime, ag stone, ground agricultural limestone, and lime. Ground aglime is the most widely used liming material in the U.S., as it is easy to transport and apply. The calcium in limestone is in the carbonate form and most Kansas limestones also contain some magnesium carbonate. Calcium content ranges from 15 to 40% and magnesium content normally ranges from 0 to 15%. Limestone with less than 5% magnesium is designated as "calclitic limestone." Limestone with more than 5% magnesium is referred to as "dolomitic limestone."

Fluid lime (liquid lime). In recent years a product called fluid lime or liquid lime has been marketed in some areas. This product is prepared by mixing very finely ground aglime (100% passing a 100 mesh sieve and 80-90% passing a 200 mesh sieve) with water along with a suspending agent (attapulgitic clay). The material is then applied with a liquid fertilizer applicator. The aglime content of liquid lime is normally around 50% by weight.

The main advantage for liquid lime is that a more uniform application can be made in the suspension form. Claims are also made that liquid lime will raise the soil pH faster than standard dry aglime and that much less material is needed because it is very finely ground. Both statements are partially true. For the first few months after application, the soil pH will rise faster where liquid lime is applied due to the extremely fine size of the lime particles. But, within a year or so, changes in soil pH will normally be equal for liquid and dry sources applied at equivalent rates of ECC.

The relative speed at which a lime particle reacts is a function of its surface area. The smaller the individual particles, the greater the relative surface area, and the faster the particle will react and change pH. Particles that are smaller than 60 mesh are considered to be 100% available and will be effective in changing soil pH within a year of application. Grinding particles finer than 60 mesh may speed the rate of reaction, but it will not alter the overall effectiveness of the lime.

Higher cost is the main disadvantage of liquid lime. This is primarily due to the additional cost of grinding the material fine enough to keep it in suspension, the cost of the suspending agent, and transportation costs for the water used in the suspension. A common application rate is 1,000 pounds per acre -- 500 pounds water and 500 pounds aglime. This rate would be adequate for a maintenance program to offset acidity caused by N fertilization, but it would not normally be economical as a corrective remedy where lime recommendations are 2 tons per acre or greater.

Pelletized lime (pel lime). To avoid the dust and distribution problems associated with spreading very fine particles, finely ground aglime can be compressed into pellets or granulated using a binding agent. The resulting product can then be spread similar to dry fertilizers. Individual pellets are readily dispersible in water and like liquid lime, will react very quickly in soil. Application rates can also be reduced one-third to one-half because of the fineness of the particles used to make the granule. Claims that a few hundred pounds can substitute for a ton of aglime have not been substantiated by land grant university research. Likewise, the practice of banding 200 to 400 pounds per acre of pelletized lime in the row as a starter fertilizer may be a means of supplying calcium or magnesium to the crop, but would have no effect on other key processes controlled by soil pH, and has only a limited potential for creating a yield increase capable of paying for the product.

While pelletized lime is an excellent product and has a high ECC, often approaching 1,800 to 2,000 pounds ECC per ton, like liquid lime, cost is often a use-limiting factor.

Marl. This is soft, unconsolidated lime material made up of marine shell fragments and calcium carbonate and found under many shallow organic soils in the Great Lakes region of the U.S. Marl also

commonly contains clay and organic matter as impurities and is mined wet and sold by the cubic yard because of the high moisture content. As a general rule, two cubic yards of marl has a neutralizing value equivalent to one ton of aglime. Uniform spreading is difficult unless the material is dried and ground, which increases the cost of the product. Use is generally confined to local areas very near marl deposits. Since marl contains no magnesium, repeated applications of marl may result in soils deficient in magnesium. Deficiencies can be prevented by occasional reliming using dolomitic limestone.

Burned lime (quicklime). Limestone rock is heated at high temperatures to drive off carbon dioxide to produce calcium oxide, CaO. It is a fast-acting liming material, but is also corrosive, disagreeable to handle and more expensive than aglime. It is usually used for special non-ag purposes.

Slacked lime (hydrated lime). This is produced by adding water to burned lime to produce calcium hydroxide, Ca(OH)₂. It has many of the same characteristics and limitations as burned lime.

Evaluating the relative value of liming materials

How effective a liming material will be in correcting soil acidity depends on two primary factors: chemical purity and fineness. Many states have lime laws which vary from labeling laws, like Kansas, specifying strict minimum purity and fineness standards to qualify for sale.

Chemical purity. Liming materials vary in their composition and thus in their capacity to neutralize acidity. Calcium carbonate equivalence (CCE) is the standard for measuring purity. Pure calcium carbonate has a CCE of 100%, while high magnesium dolomite has a CCE of 108%. Most aglime contains both calcium and magnesium carbonates along with varying levels of other impurities. The CCE of most midwestern limestone generally ranges between 85 and 107%. A suggested minimum CCE in many states is 80%.

Fineness. This refers to particle size and is important as mentioned earlier, because it governs how quickly the lime will dissolve and react to neutralize acidity. Most liming materials contain a mixture of particle sizes, from dust to fine-gravel. Small particles dissolve rapidly and react quickly due to their high surface area. Coarse particles react very slowly and are of little value in correcting an acidity problem due to low surface area.

Fineness of aglime is determined by passing the material over a set of sieves (screens) of different sizes. Sieve size is expressed in terms of the number of openings per linear inch; an 8 mesh sieve has 8 openings per inch (64 per square inch). The required screen sizes used and the number of screens required to quantify neutralizing value will vary across states. In Kansas, 8 and 60 mesh sieves are used to determine fineness. Table 1 shows the relative effectiveness of different size particles at changing pH over an extended period. It is suggested as a general recommendation in some states that a minimum of 80% pass an 8 mesh sieve and 25% pass a 60 mesh sieve for good lime performance and economics, since transportation and spreading costs are often greater than the cost of the lime at a quarry.

Particle size	Percent dissolving in		
	1 year	4 years	8 years
Larger than 8 mesh	5	15	15
Pass 8 mesh, held on 30	20	45	75

mesh			
Pass 30 mesh, held on 60 mesh	50	100	100
Smaller than 60 mesh	100	100	100

A series of efficiency factors based on the relationship between partial size and rate of reaction have been developed. An example of these factors as used in Kansas are listed in Table 2 below:

Table 2. Efficiency factors used to determine the effect of lime particle size on Effective Calcium Carbonate (ECC) content of lime	
Particle size	Efficiency factor
> 8 mesh	0
8-60 mesh	0.5
< 60 mesh	1.0

The concept of ECC. The ultimate effectiveness of aglime is determined by the interaction of chemical purity and particle fineness. Since both fineness and purity vary from one lime producer to another, there have been several systems devised to compare limes for the purpose of economics and adjustment of recommended rates for quality. In Kansas, lime quality is determined by measuring the chemical neutralizing capacity of the lime product, CCE, and by determining the fineness of the product by measuring the percent of the product which passes through both an 8 mesh and a 60 mesh sieve. A typical lime analysis report will give the sieving analysis as the weight or percent of lime retained on the 8 mesh sieve, the percent retained on the 60 mesh sieve, and the percent passing through the 60 mesh sieve. This is then used to calculate the fineness score or fineness factor. The fineness score or factor is calculated as follows using the efficiency factors given in Table 2 above:

Percent retained on 8 mesh sieve x 0
 + Percent passing 8 mesh sieve but retained on 60 mesh sieve x 0.5
 + Percent passing through a 60 mesh sieve x 1.0
 = Fineness factor or score

An example for a typical average quality aglime would be:

Weight or percent on 8 mesh sieve = 19% x 0 = 0
 Weight passing through 8 mesh but retained on 60 mesh sieve = 40% x 0.5 = 20
Weight or percent passing through a 60 mesh sieve = 41% x 1.0 = 41
 = Fineness score (FF) = 61

Using the chemical purity expressed as a Calcium Carbonate Equivalent, CCE, together with the fineness score, the percent Effective Calcium Carbonate, sometimes referred to as the percent lime, is calculated as follows:

(Fineness factor x CCE)/100 = percent effective calcium carbonate, % ECC, or % lime

An example of the calculation for a typical aglime would be:

$$[(FF) 61 \times (CCE) 90]/100 = 54.9\% \text{ ECC}$$

To calculate the pounds of ECC per ton of lime, one simply multiplies the percent ECC x 2000. For example using the values above:

$$(54.9\% \text{ ECC} \times 2000)/100 = 1,098 \text{ pounds ECC per ton}$$

Impact of moisture. Lime is often stored in piles outside and is impacted by weather. Thus to standardize the value of a ton of lime, results of lime analysis are often reported on a dry weight basis, much like grain moisture can vary and is adjusted to a standard moisture content. Lime moisture content will vary from 3 to 10% moisture depending on recent rainfall patterns.

Industrial byproducts as lime sources

A number of industrial byproducts or coproducts have been used successfully as liming materials. Key factors to evaluate when considering the use of these products include cost, transportation, ease of spreading, and neutralizing value. In many states the state EPA or Department of Environmental Management regulates the land application of these products. Always check that the material is properly registered or permitted before using these products.

Lime sludge. Some water treatment plants produce a soft lime sludge containing fine lime particles. Lime sludges vary in their calcium carbonate equivalent (CCE) and water content, which will influence the amount of sludge needed to equal dry aglime. Since the particles are very fine, it reacts quickly in soils. Lime sludge is often used to produce liquid lime products. It also can be stacked for extended periods and “dewatered” to allow for spreading with manure spreaders. Unfortunately, distribution can be an issue if the material is not well dried and chunks broken up with the spreading equipment.

Fluid-bed ash, fly ash, and stack dust. Modern electrical generating plants mix limestone into ground coal as a means of controlling burn rates and enhancing efficiency of operation. Much of the ash produced in these fluidized or plasma bed generators contains large quantities of calcium oxide and has neutralizing value. Ashes and dust collected from smoke stacks and cement kilns also can have lime value, though the neutralizing value can vary widely. Many of these products can also contain heavy metals and other environmental contaminants. Thus, these products are closely regulated and application rates can be limited by metal content. Make sure to check with your state department of environmental management before using one of these products to ensure the product is safe and legal for use.

Agricultural slags. One of the steel industry by-products is a magnesium silicate or slag. Air-cooled slag must be ground the same as limestone when used as a liming material. Water-cooled slag is a porous granular material produced by applying water to the hot slag. Usually it is screened and the fines are used as a liming material.

Summary

Soil acidity and low soil pH are a growing problem in many parts of Kansas. The widespread use of nitrogen fertilizers has lowered soil pH statewide. Appropriate soil testing programs to monitor pH and liming practices to maintain pH in the appropriate range for the crops you grow is critical for high yields, effective chemical weed control, and long-term soil health and sustainability.

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4. Kansas climate basics: Part 3 -- Precipitation trends over the last 121 years

(Editor's note: The following article is one in a series of articles in the Agronomy eUpdate that examines the historical record of temperature and precipitation in Kansas. The methods used to do this analysis of temperature trends in Kansas is explained in the [introductory article](#) in this series, from eUpdate No. 571, May 20, 2016. – Steve Watson)

Precipitation trends in Kansas

Precipitation in Kansas is highly variable from year to year, with the statewide annual average from a low of 17.3 inches in 1956 to a high of 43.7 inches in 1951 (Fig. 1). From the western third to the eastern third of Kansas, long-term mean annual precipitation totals (over the last 121 years) were 20.2 inches, 26.0 inches, and 37.2 inches (Fig. 1). Over the last two decades, annual amounts of precipitation have increased. Due to larger year-to-year variability, however, the long-term annual precipitation does not show any statistically significant increase or decrease at the 95% confidence levels.

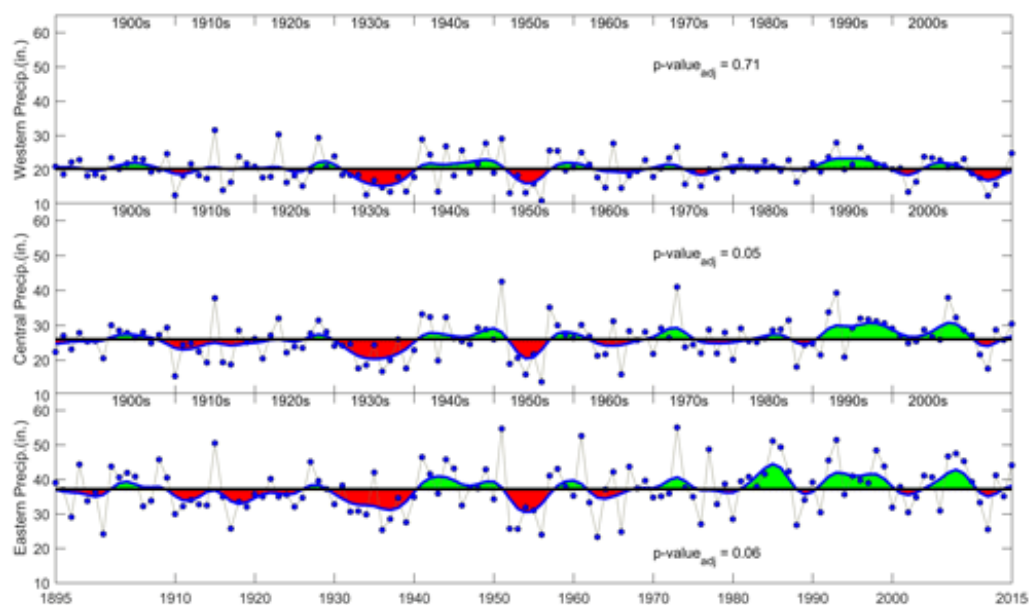


Figure 1. Kansas annual precipitation time series over 1895 to 2015: Western Kansas (top panel); Central Kansas (middle); and Eastern Kansas precipitation variations (bottom). The black lines are period-of-record mean over 1895 to 2015 (inclusive). A 9-point moving average was used to provide an indication of multi-year trends (blue lines). When trends are statistically significant the trend rates are displayed. All adjusted p values are shown.

For the state as a whole, the seasonal means of precipitation are nearly 20 inches during spring (March-April-May) and summer (June-July-August) seasons combined. The fall (September-October-November) and winter (December-January-February) seasons only contribute about 9.5 inches (Fig. 2). The winter season's mean is less than 2.8 inches, with small year-to-year variations.

There were no statistically significant trends in any of seasons at 95% confidence level. Precipitation rates did show statistically significant increases in eastern and central Kansas, however, at the 90% confidence level. Seasonally, only spring precipitations showed a statistically significant increase rate at the 90% confidence level.

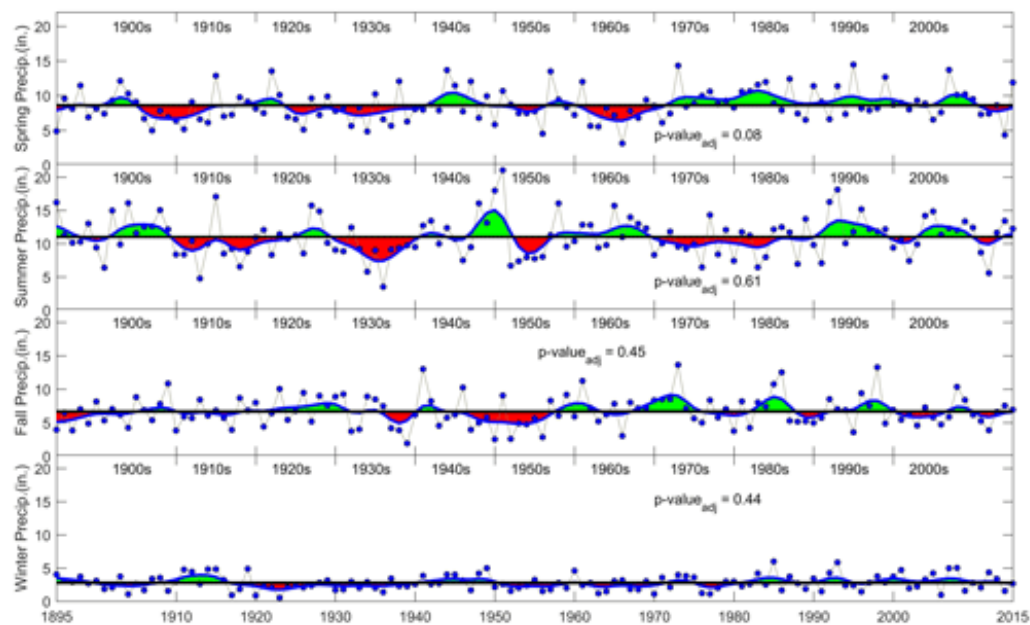


Figure 2. Kansas seasonal precipitation time series over 1895 to 2015, from top to bottom panels: Spring, summer, fall, and winter precipitation variations. The black lines are period-of-record means over 1895 to 2015 (inclusive). A 9-point moving average was used to provide an indication of multi-year trends (blue lines). When trends are statistically significant the trend rates are displayed. All adjusted p values are shown.

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5. White heads in wheat: Possible causes

White heads have been appearing in some wheat fields around the state this year, especially in south central and north central Kansas (Figure 1). Sometimes the white heads are just single tillers scattered throughout part or all of a field, and sometimes they occur in small to large patches. Heads might be completely white starting from the stem, or may just have a few spikelets showing the discoloration.



Figure 1. White heads showing up on wheat towards the end of the grain filling stage. When wheat is infected with head scab, heads of red-chaffed varieties, such as the one in the photo, may turn a dark red instead of white. Photo by Romulo Lollato, K-State Research and Extension.

There are many causes of white heads. Here are some of the most common causes and their diagnosis.

- **Premature dying** (drowning, hot dry winds, etc.). As wheat begins to mature, plants in some areas of the field may have an off-white color similar to take-all. This is premature dying could be due to drowning, hot dry winds, or some other stress. The pattern of off-colored heads will often follow soil types or topography, and may occur in large patches. The grain will be shriveled and have low test weight. Due to the recent rainfall events from mid-April through the end of May, many fields across Kansas are showing drowning symptoms on poorly drained areas.
- **Freeze injury to stem or crown.** Depending on the stage of growth at the time of a late spring freeze, parts or all of the heads may die and turn white.

In years when the freeze occurs about the boot stage or a little earlier, there can be injury to the lower stem, which then cuts off water and nutrients to the developing head. In years when the wheat is in the early heading stage at the time of the freeze, the freeze can damage the heads directly.

Often, wheat on north-facing slopes, on ridge tops, or in low-lying areas will be most affected by freeze injury. But freeze injury can also be so severe that it occurs throughout the fields, in no particular pattern. Crown rot is another potential problem that can be traced back to freeze injury.

When the crown is damaged by cold temperatures or a freeze, part or all of the tillers can die. If the tiller from a damaged crown forms a head, this head will almost always be white. The crown will have internal browning, and stands will usually be thinner than normal.

- **Hail.** Hail can occasionally damage just a portion of a head, and cause that damaged portion to turn white. The hail impact to the heads may also remove spikelets and expose the rachis (Figure 2).



Figure 2. The heads in this photo have had a few spikelets removed due to hail impact and have their rachis exposed. Photo by Romulo Lollato, K-State Research and Extension.

- **Dryland root rot (also known as dryland foot rot).** This disease, caused by the *Fusarium* fungus, causes white heads and often turns the base of the plants pinkish. As with take-all, dryland root rot causes all the tillers on an infected plant to have white heads. This disease is usually most common under drought stress conditions, and is often mistaken for either drought stress or take-all.

- **Head scab.** When there are periods of rainy weather while the wheat is flowering, as seen across most of Kansas this growing season, some heads may become infected with *Fusarium* head blight and turn white (or dark red in red-chaffed varieties). Symptoms of head scab include large brown or tan lesions that encompass entire spikelets or large sections of the head. When infection occurs in the middle of the head the upper half or the entire head might be affected because the fungus reduces the flow of water and nutrients within the rachis (Figure 3). Head scab can be identified by looking for pink spores of the *Fusarium* fungi, as well as by a dark discoloration to the rachis.



Figure 3. Wheat heads affected by head scab or *Fusarium* head blight. Symptoms may cover one or two spikelets or may affect the entire head. Photo by Romulo Lollato, K-State Research and Extension.

- **Take-all.** This disease often causes patches of white heads scattered throughout the field. It occurs most frequently in continuous wheat, and where there is a moderate to high level of surface residue. Take-all is also favored by high pH soils, so a recently limed field might also show symptoms. To diagnose take-all, pull up a plant and scrape back the leaf sheaths at the base of a tiller. If the base of the tiller is shiny and either black or dark brown, it is most likely take-all. All tillers on a plant infected with take-all will have white heads. Plants will pull up easily because the roots are often severely damaged by the disease.

- **Sharp eyespot.** This disease is common in Kansas, but rarely causes significant yield loss. Sharp eyespot causes lesions with light tan centers and dark brown margins on the lower stems. The ends of the lesions are typically pointed. If the stems are girdled by the fungus, the tiller may be stunted with a white head. Each tiller on a plant may be affected differently.

- **Wheat stem maggot.** Wheat stem maggot damage is common every year in Kansas, but rarely

results in significant yield loss. It usually causes a single white head on a tiller, scattered more or less randomly through part or all of a field. If you can grab the head and pull the stem up easily just above the uppermost node, the tiller has probably been infested with wheat stem maggot. Scout for symptoms of chewing close to the base of the plants, which could indicate that the head has died as function of wheat stem maggot.

Romulo Lollato, Wheat and Forages Specialist

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Erick DeWolf, Extension Plant Pathologist

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6. K-State wheat plot tours for June 7 - 9

The week of June 7 to 9 offers another exciting lineup of wheat plot tours! Producers willing to learn about the different varieties can choose to attend one (or several) plot tours in their county or agricultural district.

The plot tours generally include a discussion of wheat conditions across the state, as well as tips on what to look for when selecting wheat varieties for one operation. New and upcoming varieties are discussed, as well as older and more established ones and a discussion of how all these varieties are responding to this growing season's conditions.

For the week of June 7 to 9, the schedule plot tour locations include:

Tuesday, 6/07/2016, 9:00 a.m.

Location: Nemaha/Brown Co., Sabetha

Contact: David Hallauer, 785-863-2212, dhallaue@ksu.edu

Cooperator: Doug and Leonard Edelman

Directions: Southwest of T and 192 intersection, 4 miles west of Sabetha

Tuesday, 6/07/2016, 4:00 p.m. (MDT)

Location: Sherman Co., Kanorado

Contact: Jeanne Falk Jones, 785-462-6281, jfalkjones@ksu.edu

Cooperator: Truman Hooker, 4-H wheat plot tour

Directions: Go into Kanorado and after the railroad tracks turn west. Go to Locust Street and turn north. Continue north until the road ends.

Tuesday, 6/07/2016, 5:30 p.m. (MDT)

Location: Sherman Co., Goodland

Contact: Jeanne Falk Jones, 785-462-6281, jfalkjones@ksu.edu

Cooperator: F&J Farms

Directions: From Goodland, go 10 miles north on Hwy 27. Plot is east of the scalehouse.

Tuesday, 6/07/2016, 6:00 p.m.

Location: Scott Co., Scott City

Contact: John Beckman, 620-214-2151, jbeckman@ksu.edu.

Cooperator: Jon and Jeff Buehler

Directions: 4 miles east on Hwy 96 from the intersection of Hwy 96 and 83. Turn north on Pawnee Road and drive for ¼ mile. Plot is located on the east side of Pawnee Road.

Tuesday, 6/07/2016, 7:30 a.m.

Location: Thomas Co., Levant

Contact: Kurt Sexton, 785-460-4582, kclarson@ksu.edu.

Cooperator: Solomon Creek Farms

Directions: 10 miles south of Levant 1-70 interchange.

Tuesday, 6/07/2016, 1:00 p.m.

Location: Marshall Co., Centralia

Contact: Anastasia Johnson, 785-562-3531, anastasia@ksu.edu.

Cooperator: The Matson Family

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Directions: 2 miles north of Centralia, at the corner of Hwy 187 and 96th Road

Wednesday, 6/08/2016, 7:30 a.m. (MDT)

Location: Wallace Co., Sharon Springs

Contact: Jeanne Falk Jones, 785-462-6281, jfalkjones@ksu.edu

Cooperator: Mai Farms

Directions: From Sharon Springs, go 9 miles south on Hwy 27 to Field Rd. Go east 4 miles and south ½ mile

Wednesday, 6/08/2016, 7:30 a.m. (MDT)

Location: Wallace Co., Weskan

Contact: Jeanne Falk Jones, 785-462-6281, jfalkjones@ksu.edu

Cooperator: E&H Farms

Directions: From Weskan, go 3 miles west on Hwy 40 to Rd 3. Go 5 miles south.

Wednesday, 6/08/2016, 7:30 a.m.

Location: Clay Co., Wakefield

Contact: Kim Larson, 785-243-8185, kclarson@ksu.edu.

Cooperator: Zoe Auld 4-H plot

Directions: 3rd and Utah Road, south of Wakefield. 1 mile west, 4 miles south, then 2 miles east from Wakefield.

Wednesday, 6/08/2016, 9:30 a.m.

Location: Clay Co., Clay Center

Contact: Kim Larson, 785-243-8185, kclarson@ksu.edu.

Cooperator: Hayden Heigele 4-H plot

Directions: 12th and Kiowa Rd., south of Clay Center. 5 miles south and 2 ¾ miles west of Clay Center.

Wednesday, 6/08/2016, 12:00 p.m.

Location: Republic Co., Cuba

Contact: Kim Larson, 785-243-8185, kclarson@ksu.edu.

Cooperator: Republic County High School FFA plot

Directions: 1.25 miles west of Cuba on P Road

Wednesday, 6/08/2016, 6:00 p.m.

Location: Republic Co., Belleville

Contact: Kim Larson, 785-243-8185, kclarson@ksu.edu.

Cooperator: Polansky Seed

Directions: Seed facility east of Belleville on Hwy 36.

Thursday, 6/09/2016, 8:00 a.m.

Location: Logan Co., Winona

Contact: Candice Fitch-Deitz, 785-938-4480, cfitchdeitz@ksu.edu.

Cooperator: Ward Taylor Farm

Directions: From Winona, head west on Old Hwy 40 for ½ mile to Road 220, then turn south for 3 miles to Vista.

Thursday, 6/09/2016, 5:30 p.m. (MDT)

Location: Cheyenne Co., Wheeler

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Contact: Jeanne Falk Jones, 785-462-6281, jfalkjones@ksu.edu

Cooperator: Sunny Crest Farms

Directions: From Wheeler go south 4 miles on Hwy 27 to Road J. Plot is ¼ mile west.

Thursday, 6/09/2016, 5:30 p.m.

Location: Rawlins Co., Atwood

Contact: JoEllyn Argabright, 785-626-3192, joargabright@ksu.edu.

Cooperator 1: Wolters Farms

Directions: From the intersection of Hwy 36 and Hwy 25 in Atwood, go north on Hwy 25 4 miles. Plot is on west side of the road at Surefire Ag Systems.

Cooperator 2: Kastens Farms.

Directions: From Hwy 25, go north to where the highway curves. Go east on County Road Y to CR 31.5. Turn left and go one mile north. Head ¼ mile west to the tank batteries.

Romulo Lollato, Extension Wheat Specialist

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Erick DeWolf, Extension Wheat Pathologist

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7. K-State field pea plot tours, June 6 and 17

K-State Research and Extension will be hosting a series of field pea plot tours on June 6 and 17.

Topics will include variety selection, herbicide options, production practices, producer experiences, and pea plant growth and development.

Gove County, Monday June 6 at 9 a.m.

- Performance test with 13 entries, seeding rate study, in-furrow fertilizer study, and seeding rate strips
- Faba bean and lentil seeding rate studies

Directions: From Grainfield/Hoxie exit on I-70 go $\frac{3}{4}$ miles south on Road 50, 1 mile east on Road BB, 1 mile south on Road 52, 1 mile east on Road AA, $\frac{1}{4}$ mile south on Road 54.

Rawlins County, Friday, June 17 at 8 a.m.

- Field pea seeding rate study and variety performance test with 18 entries
- Lentil variety and seeding rate study
- Demonstration strips of flax, Austrian winter pea, faba beans, and spring forage pea

Directions: From the intersection of Hwy US 36 and K-25 in Atwood go 6 miles north on K-25, 1 $\frac{1}{2}$ miles east on Road X, South 1 $\frac{1}{4}$ miles on Road 22. Refreshments provided.

K-State Northwest Research-Extension Center, Friday, June 17 at 10:30 a.m.

- Field pea variety performance test with 22 entries, seeding rate study, and in-furrow fertilizer study
- Lentil seeding rate, variety, and date of planting study

Directions: 105 Experiment Farm Road, Colby, KS. Come in the main drive and follow the signs.

For questions or more information please contact:

Lucas Haag, K-State Northwest Area Agronomist (785) 462-6281, LHaag@ksu.edu

Rawlins County Extension office (785) 626-3192

Golden Prairie Extension District office (785) 938-4480

8. Dryland Ag Day, June 15, Tribune

Dryland Ag Day is scheduled for June 15 at the Southwest Research-Extension Center Tribune location, 1 mile west of Tribune on Highway 96. Registration is at 8:30 a.m. (MDT) and the field tours begin at 9 a.m.

Field tours will feature:

- Wheat Varieties
- In-furrow Nitrogen on Wheat
- Update on Solid Stem Wheat Varieties
- Wheat Seeding Rates
- Tillage in Dryland Systems
- Dryland Crop Rotations (wheat, corn, and grain sorghum)
- Rainfall Simulator Demonstration

Indoor seminars will start at 11:15 a.m., and feature:

- Soil Test Trends in Western Kansas
- Weed Management Update

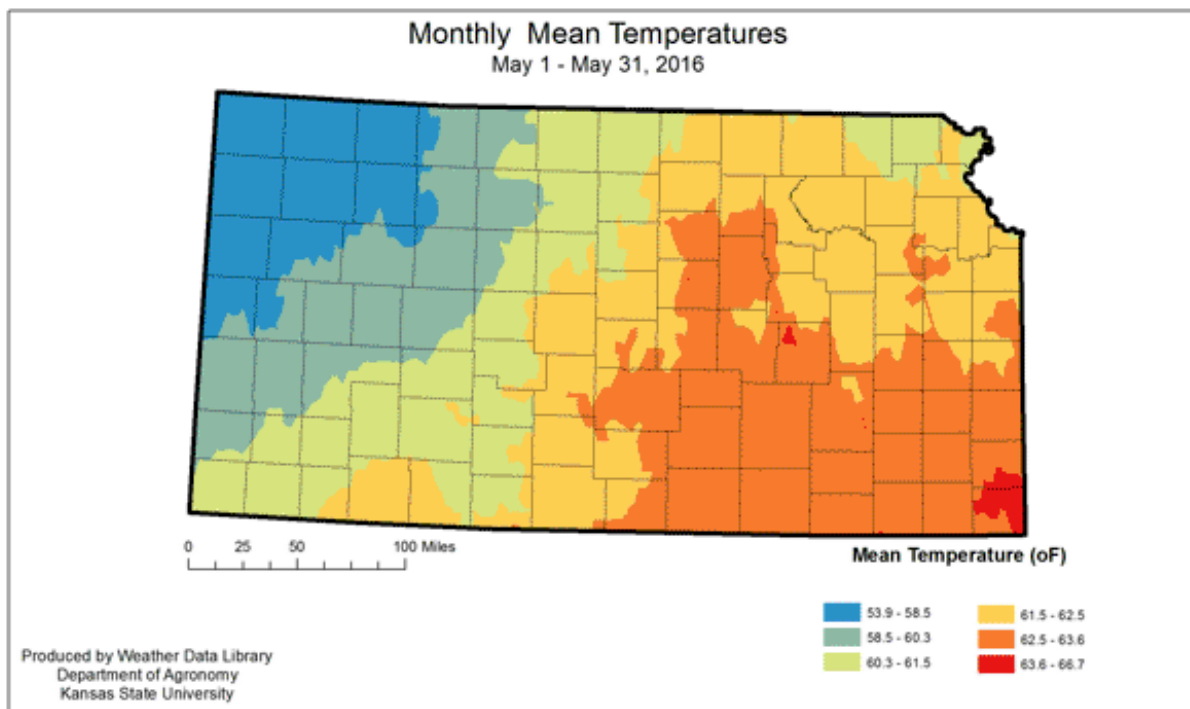
Presenters include:

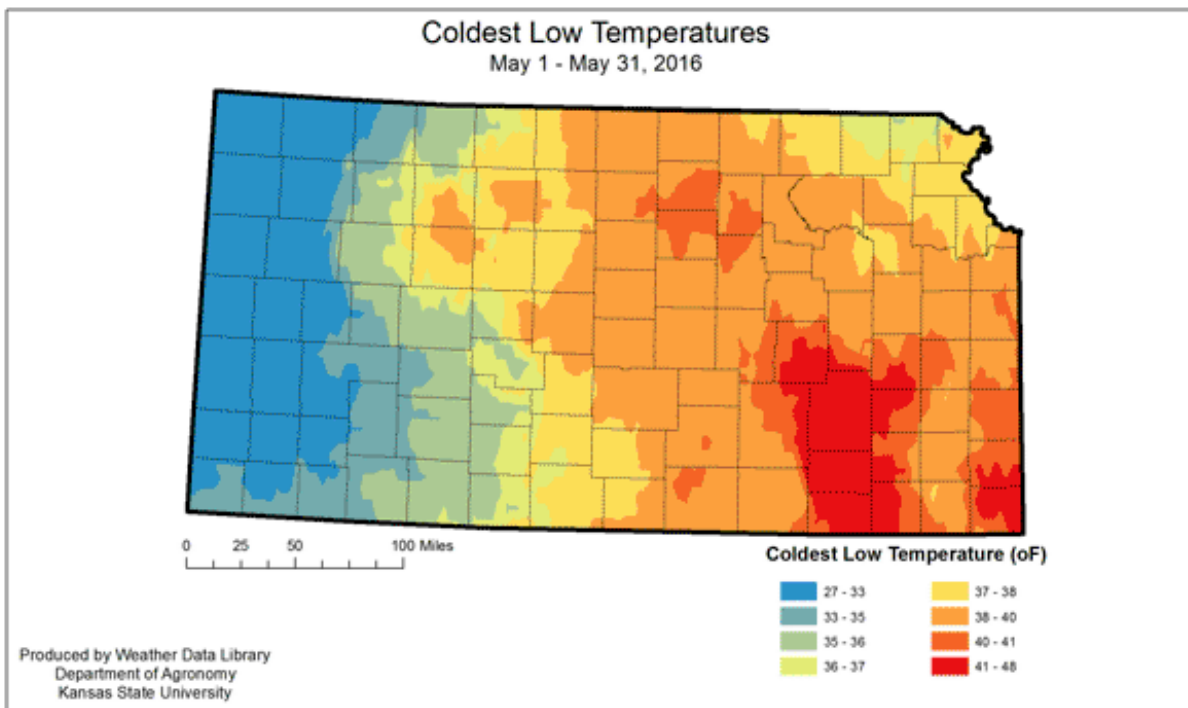
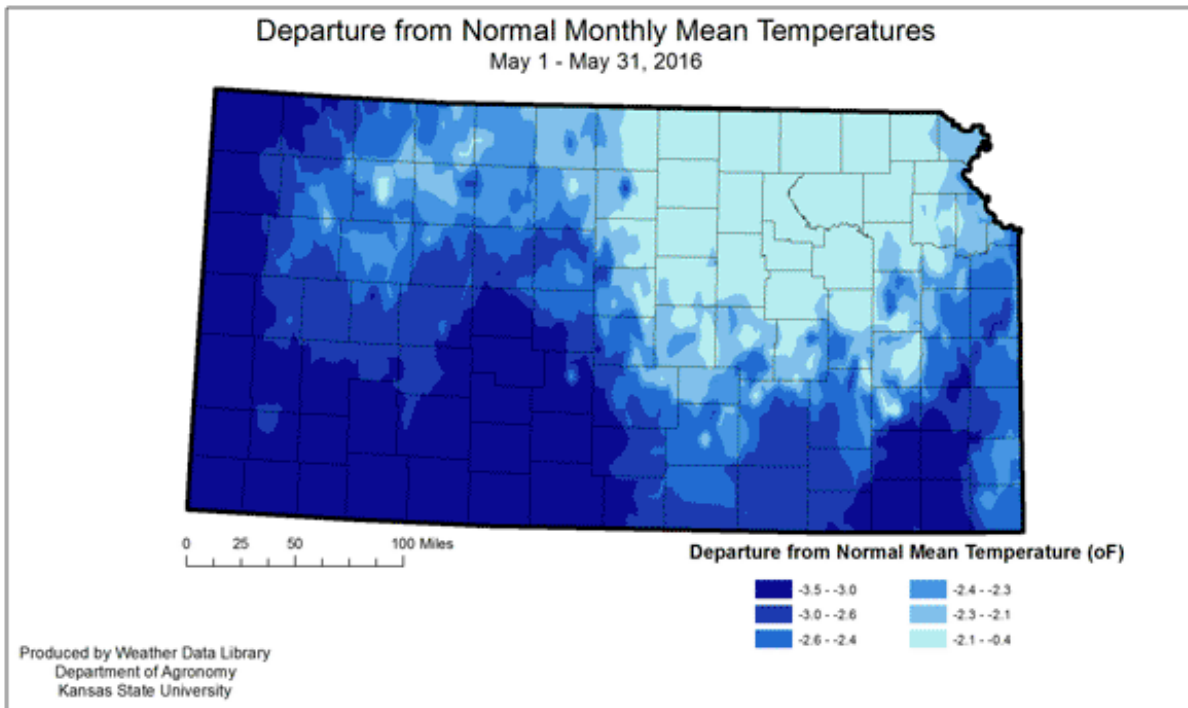
Lucas Haag, K-State Northwest Area Crops and Soils Specialist
Curtis Thompson, K-State Weed Management Specialist
Fred Vocasek, Servi-Tech Laboratory, Dodge City
Dale Younker, USDA-NRCS, Garden City
Alan Schlegel, Agronomist, Southwest Research-Extension Center, Tribune

A complimentary lunch will be served at noon. There will be an optional tour of irrigated weed management trials after lunch.

9. Kansas weather summary for May: Cool and mostly wet

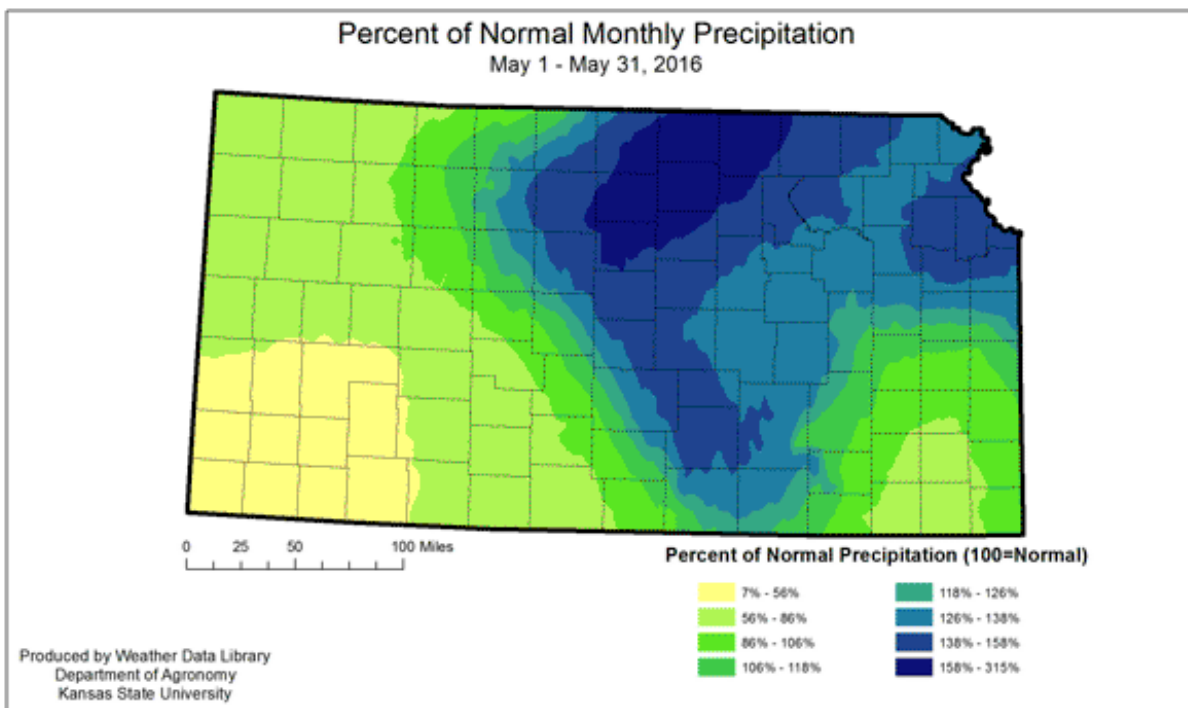
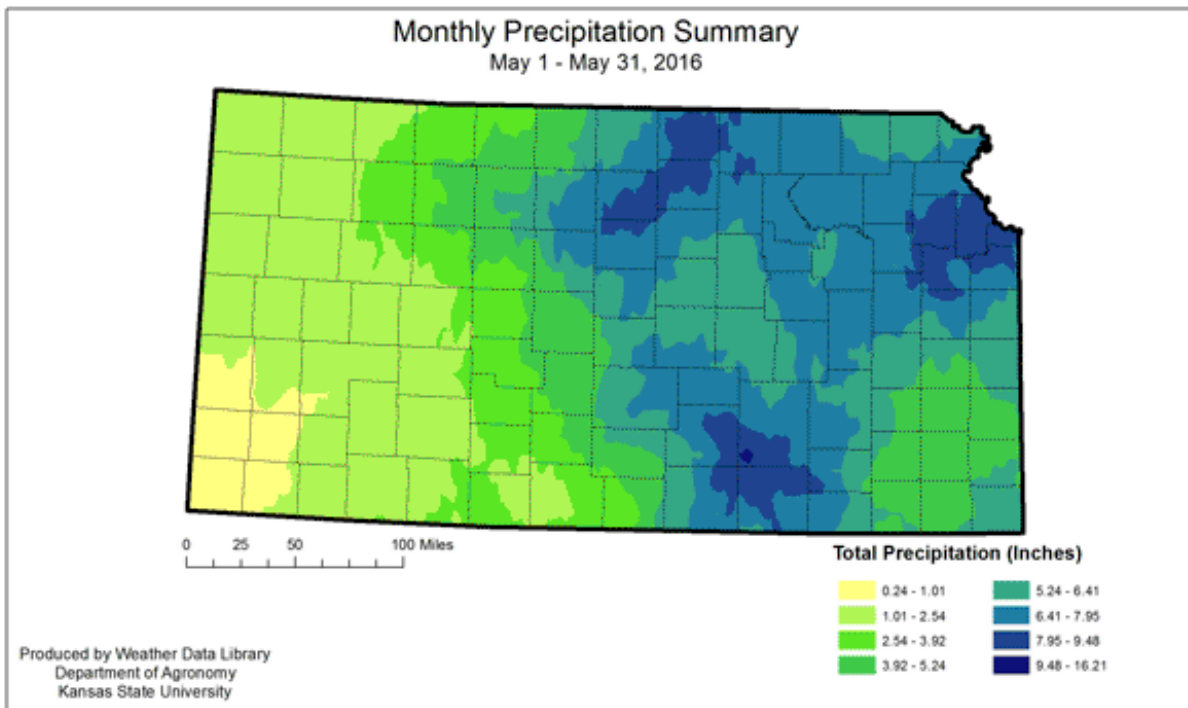
Spring ended on a cool note across the state. The mean temperature for the state was 61.3 degrees F, which was 2.5 degrees cooler than normal. While on the cool side of the normal distribution, it was only the 27th coolest since 1895. The Southeast Division had the largest departure with a mean temperature 62.6 degrees F, or -3.1 degrees cooler than average. The North Central Division was closest to normal, with a mean temperature of 61.7 degrees F or -1.8 degrees cooler than normal. There were no daily record high temperatures, and only two record warm low temperatures. On the cold side of the record, there were 77 record low maximum temperatures and 5 record low minimum temperatures during the month. The warmest high temperature was 94 degrees F recorded at Medicine Lodge (Barber County) on the 27th. The coldest temperature was 28 degrees F recorded at Sharon Springs (Wallace County) on the 2nd. The low temperatures so late in the season brought concerns of damage to vegetation that moved out of dormancy early. This was especially true for winter wheat.

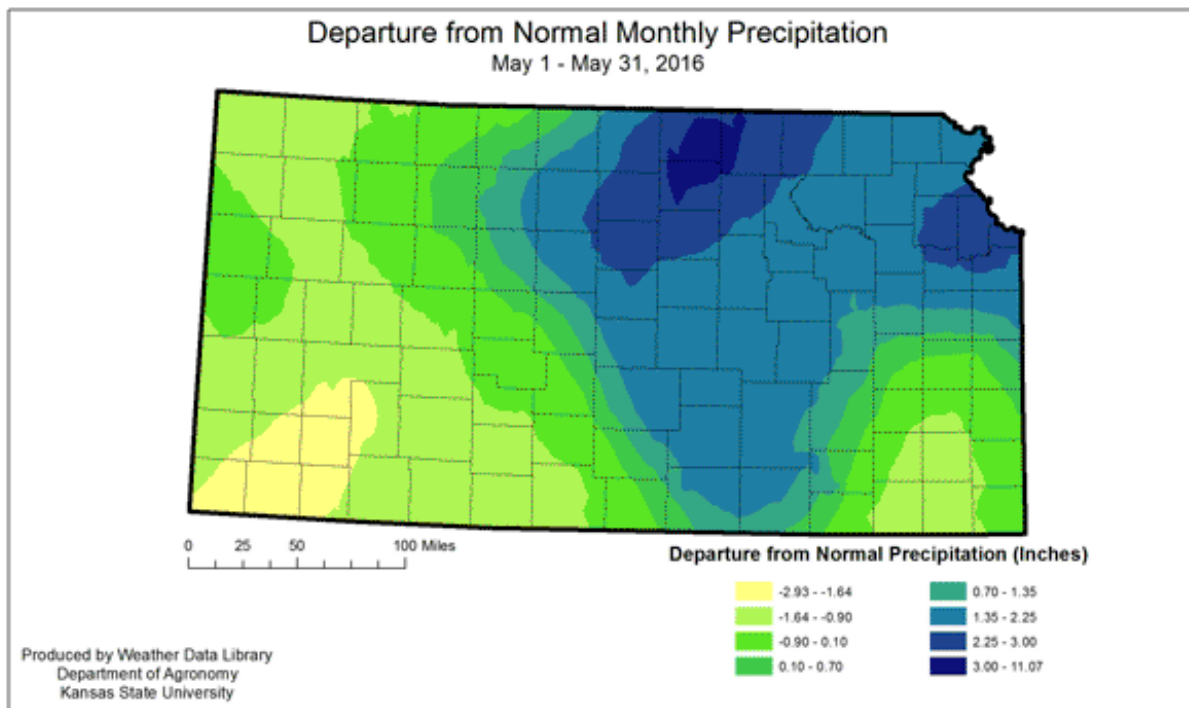




The wet conditions that were common in late April continued into May, and spread eastward. The month ended almost exactly at normal precipitation. The North Central and Northeastern divisions were the wettest: 151 percent of normal for the North Central Division and 133 percent of normal for the Northeast. The Southwest Division was the driest, averaging just 1.22 inches or 44 percent of normal. Despite that dryness, the year-to-date average for the division is still at 113 percent of normal. May ranks as the 33rd wettest May on record. The greatest monthly total was 16.21 inches at

Rock, Cowley County (NWS). The greatest total for CoCoRaHS stations was 11.98 inches at Hunter, Mitchell County. There were 92 new daily record precipitation totals. Twenty-one of those were record high amounts for May. None of these set monthly records.





Along with the increased rainfall pattern there was an increase in severe weather reports. There were 59 tornadoes reported, as well as 104 reports of damaging wind. The most common severe weather report was hail. There were 223 reports of hail during the month.

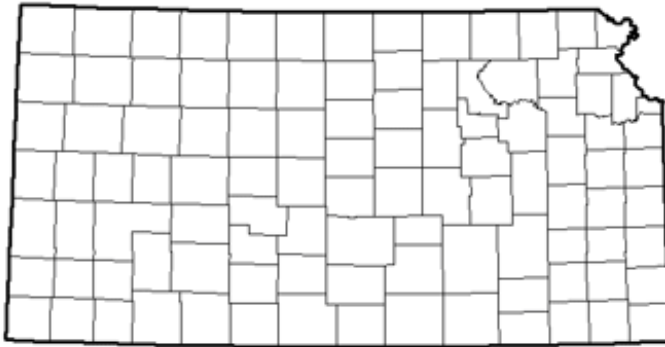
The wet month resulted in dramatic improvements in the drought status. The end of April saw 43 percent of the state as drought free. The last Drought Monitor issued in May saw the entire state labeled drought-free. The precipitation outlook for June is for wetter-than-average conditions. However, the short-term outlooks are for drier-than-average conditions for the first half of the month statewide. If the drier conditions persist, abnormally dry conditions are likely to reappear in the Drought Monitor, particularly in the western divisions.

U.S. Drought Monitor Kansas

May 31, 2016

(Released Thursday, Jun. 2, 2016)

Valid 8 a.m. EDT



Drought Conditions (Percent Area)

	None	D0	D1	D2	D3	D4
Current	100.00	0.00	0.00	0.00	0.00	0.00
Last Week 5/24/2016	100.00	0.00	0.00	0.00	0.00	0.00
3 Months Ago 3/5/2016	94.55	5.45	0.00	0.00	0.00	0.00
Start of Calendar Year 1/2/2015	97.84	2.16	0.00	0.00	0.00	0.00
Start of Water Year 6/29/2015	80.79	14.72	4.48	0.00	0.00	0.00
One Year Ago 6/2/2015	76.35	18.97	4.68	0.00	0.00	0.00

Author:

Mark Svoboda

National Drought Mitigation Center



<http://droughtmonitor.unl.edu/>

Intensity:

D0 Abnormally Dry

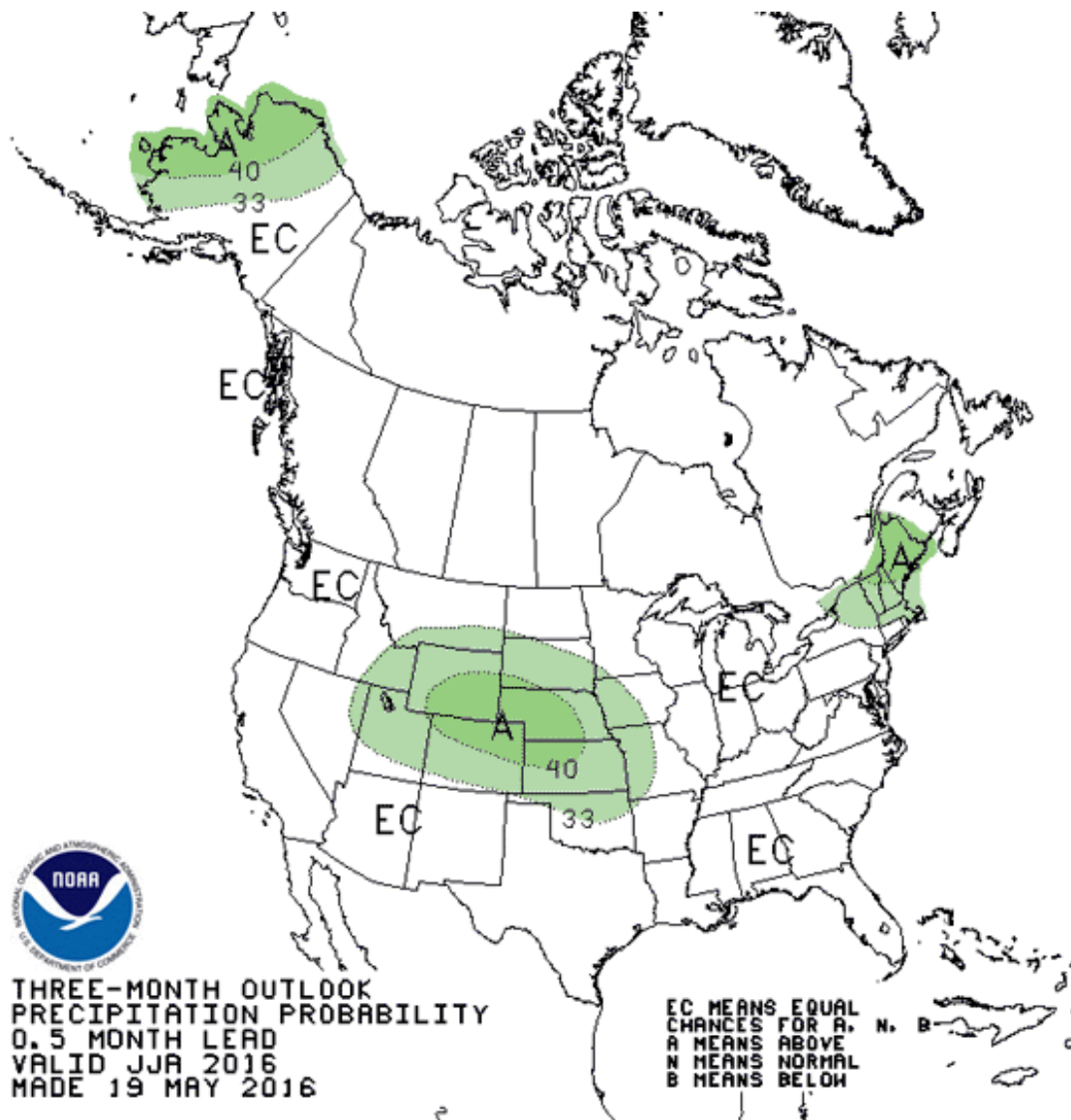
D3 Extreme Drought

D1 Moderate Drought

D4 Exceptional Drought

D2 Severe Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.



May 2016

Kansas Climate Division Summary

Precipitation (inches)			Temperature (°F)						
May 2016			2016 Jan through May				Monthly Extremes		
Division Total	Dep. ¹	% Normal	Total	Dep. ¹	% Normal	Ave	Dep. ¹	Max	Min

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Northwest	2.43	-1.05	69	9.31	1.37	117	58.2	-2.4	90	29
West Central	1.80	-1.25	59	7.99	0.46	105	59.0	-2.6	92	28
Southwest	1.28	-1.49	44	7.80	0.94	113	61.2	-2.9	93	29
North Central	6.32	2.22	151	12.70	2.50	123	61.7	-1.8	90	36
Central	5.68	1.38	131	12.76	1.73	117	62.2	-2.4	89	36
South Central	5.27	0.83	115	12.43	0.55	104	63.0	-2.7	92	32
Northeast	6.52	1.70	133	14.78	2.36	118	62.0	-2.0	88	35
East Central	6.19	0.99	117	13.82	0.00	99	62.1	-2.4	88	31
Southeast	5.88	0.05	102	14.13	-1.74	90	62.6	-3.1	89	35
STATE	4.52	0.31	100	11.64	0.81	108	61.3	-2.5	93	28

1. Departure from 1981-2010 normal value

Source: KSU Weather Data Library

Mary Knapp, Weather Data Library

mknapp@ksu.edu