Issue 921

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eUpdate

08/25/2022

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. Final irrigation of the growing season - Timing is everything

This year has been especially challenging for irrigators as we started the year with below normal levels of profile water in most places followed by below normal precipitation. As we look towards the end of the irrigation season, producers have an opportunity to improve their water productivity by properly timing their final irrigation application. This is an important decision as an early termination of irrigation can result in reductions in grain yield, primarily through reductions in the kernel weight yield component. Conversely, a late termination of irrigation results in unnecessary pumping, energy consumption, and increasing the risk of soil compaction at harvest due to increased soil water and the risk of water loss through drainage.

With the goal of matching available water to crop needs while avoiding excess, it is important to understand crop water use requirements late in the growing season. Anticipated water use from various growth stages until physiological maturity for corn, grain sorghum, and soybeans is shown in Table 1.

Table 1. Anticipated water use for corn, grain sorghum, and soybeans at various growth stages.

Stage of Growth	Approximate number of days to maturity	Water use to maturity (inches)
Corn		
Blister	45	10.5
Dough	34	7.5
Beginning dent	24	5
Full dent	13	2.5
Black layer	0	0
Grain Sorghum		
Mid bloom	34	9
Soft dough	23	5
Hard dough	12	2
Black layer	0	0
Soybeans		
Full pod	37	9
Beginning seed	29	6.5
Full seed	17	3.5
Full maturity	0	0

Adapted from K-State MF2174, Rogers and Sothers.

Research in western Kansas has shown the importance of keeping the management allowable depletion limited to 45% during the post-tassel period. In other words, maintaining available soil water contents above 55%. By knowing anticipated water use from a given growth stage and the remaining soil water in the profile, producers can add just enough irrigation water to meet that demand and maintain profile available soil water content above 55%.

By closely following the growth and development of the crop, one can know when physiological maturity, i.e. black layer in corn, has been reached and at that point water use for the production of grain yield has ceased and additional irrigation is certainly unnecessary.

Termination based on calendar dates

Traditionally many producers have used a fixed calendar date to determine their final irrigation. Long-term studies conducted by Freddie Lamm at the Northwest Research-Extension Center at Colby show the potential problems in this approach. Table 2 shows silking, maturity, and irrigation termination dates for a long-term study in corn. Over the course of this study, the irrigation termination date for maximum grain yield varied from August 12 to September 21. This is a significant departure from a general rule of thumb using Labor Day as a termination date. As shown, the use of a fixed date on the calendar without regard to crop progress, soil water status, or ET demand would have resulted in both forfeited yield and wasteful pumping across this timeframe.

Table 2. Silking, maturity, and irrigation termination dates for a long-term study in corn.

Year	Date of Anthesis	Date of Maturity	Irrigation Season Termination Date For		
			80% Max Yield	90% Max Yield	MaxYield
1993	20-Jul	30-Sep	5-Aug	5-Aug	15-Aug
1994	20-Jul	15-Sep	5-Aug	15-Aug	15-Aug
1995	20-Jul	29-Sep	5-Aug	13-Aug	18-Aug
1996	20-Jul	3-Oct	17-Jul	17-Jul	29-Aug
1997	23-Jul	1-Oct	23-Jul	23-Jul	27-Aug
1998	20-Jul	28-Sep	20-Jul	20-Jul	24-Aug
1999	23-Jul	6-Oct	24-Jul	13-Aug	20-Sep
2000	12-Jul	20-Sep	14-Sep	20-Sep	20-Sep
2001	16-Jul	29-Sep	30-Jul	22-Sep	22-Sep
2002	22-Jul	30-Sep	4-Aug	30-Aug	7-Sep
2003	22-Jul	23-Sep	3-Aug	3-Aug	18-Aug
2004	19-Jul	28-Sep	8-Aug	21-Aug	27-Aug
2005	20-Jul	28-Sep	2-Aug	9-Aug	29-Aug
2006	17-Jul	25-Sep	30-Jul	13-Aug	13-Aug
2007	18-Jul	19-Sep	14-Aug	21-Aug	28-Aug
2008	24-Jul	10-Oct	31-Jul	6-Aug	27-Aug
Average	**19-Jul**	**27-Sep**	**2-Aug**	**13-Aug**	**28-Aug**
Standard Dev.	**3 days**	**6 days**	**13 days**	**19 days**	**13 days**
Earliest	**12-Jul**	**14-Sep**	**17-Jul**	**17-Jul**	**12-Aug**
Latest	**24-Jul**	**10-Oct**	**14-Sep**	**21-Sep**	**21-Sep**

* *Estimated dates are based on the individual irrigation treatment dates from each of the different studies when the specified percentage of yield was exceeded.*

Consequences of excess late-season irrigation

In the silt-loam soil profiles common in western Kansas, water drainage out of the soil profile starts to occur when the profile water content rises above 60% available soil water. The rate of drainage loss increases rapidly with increasing water content. Late-season irrigation in excess of crop water use results in increased accumulation of water in the profile, which is subject to drainage losses. A survey of irrigated corn fields was conducted in 2010 and 2011 (Figure 1). Fields were surveyed after corn harvest across three east-west transects in western Kansas.

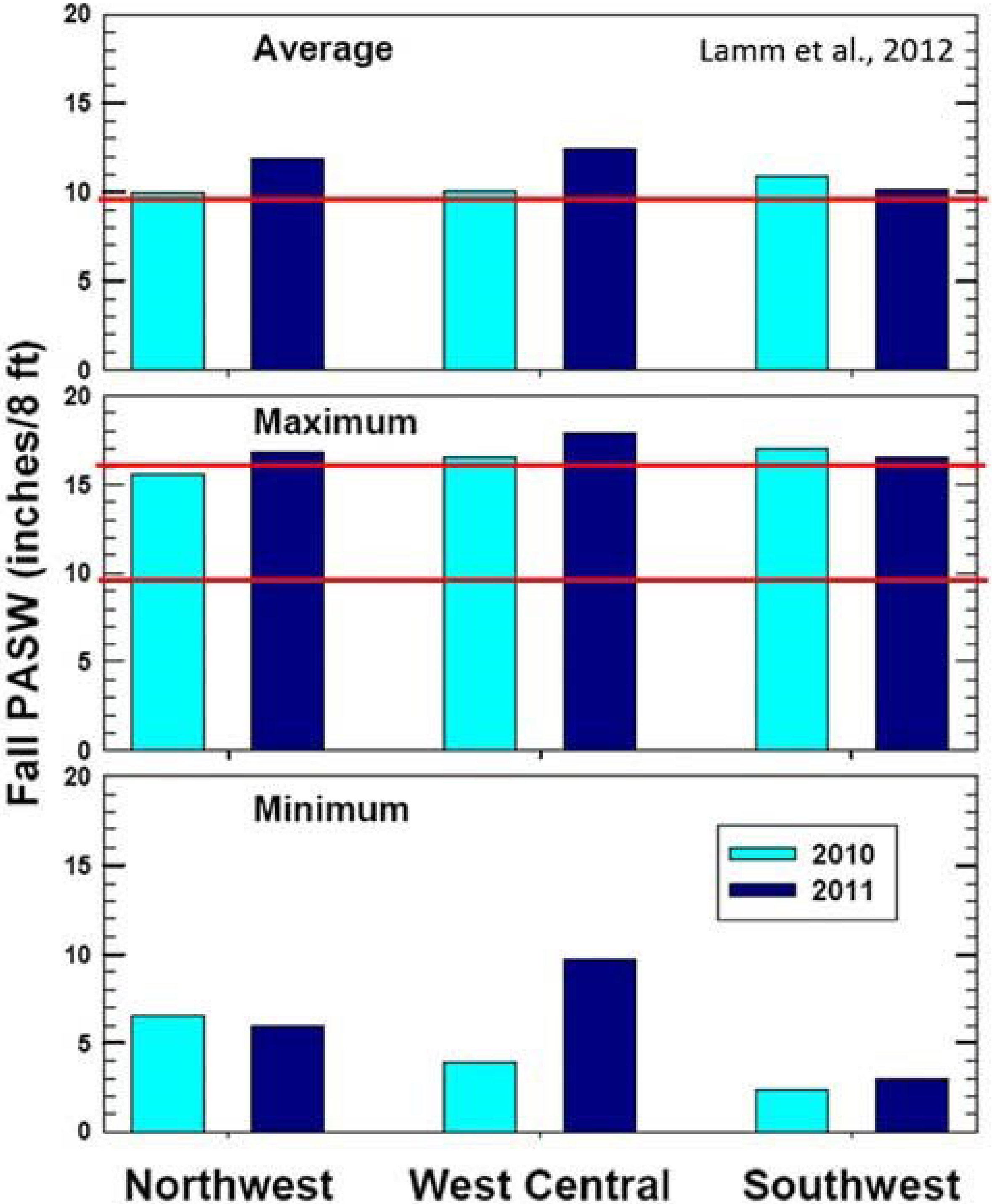

Figure 1. Results from 2-year survey of irrigated corn fields. Fields were surveyed after harvest across three east-west transects in western KS.

The line at 9.6 inches of plant-available soil water (PASW) denotes the approximate water content where drainage losses would start to occur. On average, most producer fields were near this level of soil water storage indicating a good management strategy as drainage losses had been minimized while yet maintaining adequate soil water to complete grain fill.

Producer fields near the minimum observed values likely did not have adequate soil water to ensure maximum grain yields. The most concerning scenario however, are the fields at the upper end of soil water values such as the maximum observation. The red line at 16 inches PASW represents field capacity, the point at which free drainage and significant water losses from the profile would occur. In the wettest producer fields, in all three regions, significant amounts of free drainage and water loss would have been occurring at the time of crop maturation and harvest.

Timing of the final irrigation:

1. Determine crop growth stage and anticipated remaining water use
2. Determine soil water status in the field by probe or calibrated soil sensor technology
3. Determine irrigation strategy necessary to meet remaining crop water use while maintaining soil water content at or above 55% (limit depletion to 45%).
4. Be ready to make adjustments based on changes in ET demand, precipitation, etc.

Additional information, including a step-by-step procedure, can be found in publication **MF2174**: "**Predicting the final irrigation for corn, grain sorghum, and soybeans**" - http://www.bookstore.ksre.ksu.edu/pubs/MF2174.pdf

Special Note: Much of the data in this article was collected by Freddie Lamm, Irrigation Engineer at the Northwest Research-Extension Center at Colby. Freddie passed away in May 2022, just months short of completing his 43rd year of irrigation research at the NWREC. A tribute to Freddie's career can be found at: https://newprairiepress.org/cgi/viewcontent.cgi?article=8336&context=kaesrr

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2. Planning your wheat fertility program: Start now by soil testing

Wheat planting is just a month or so away in parts of Kansas, so now is the time to get your soil sampling done to have good information on which to base your fertilizer inputs. This is particularly important with higher fertilizer prices contributing to very tight margins for wheat.

Which nutrients should be tested?

The most important tests and nutrients to focus on this year depends in part on where you are located, the choices you make when applying N, and your tillage system. The nutrients for which wheat is most likely to show responses statewide are nitrogen (N) and phosphorus (P). Wheat is the most P-responsive crop we grow in Kansas, and while P removal with wheat may be less than with corn or soybeans, the relative yield response is often the highest. Therefore, knowledge of P soil test levels and fertilizer needs will be valuable. In addition, low soil pH is becoming a problem, especially fields with a history of high rates of N application and relatively low cation exchange capacity.

In addition to the "Big 3" (pH, N, and P), potassium (K) deficiency in wheat can also be found in some areas of southeast and south central Kansas. Wheat is generally less prone to K deficiency than many of the rotation crops commonly grown, such as corn, soybeans or grain sorghum. Generally, the focus of a K fertilization program is with the rotation crops, and meeting the higher K needs of corn and soybeans minimizes the chance of a K deficiency in wheat.

The 0-6 inch soil sample

A standard 0-6 inch surface sample is normally used to test for pH and the non-mobile nutrients such as P and K. Phosphorus and K are buffered processes in our Kansas soils. This simply means that the soil contains significant quantities of these nutrients, and the soil tests we commonly use provide an index value of the amounts available to the plant, not a true quantitative measure of the amounts present. In the case of P, most Kansas soils require about 18 pounds of P_2O_5 to increase 1 ppm in soil test P; for K is around 8 pounds K_2O to increase 1 ppm K soil test.

The buffering value for both P and K varies based on soil cation exchange capacity (CEC) and the soil test levels. On high CEC soils, especially those soils with high clay content, the buffering capacity goes up, so the soil test levels will change more slowly. However, on low CEC soils, the buffering capacity can be much lower, and soil test levels can change rapidly. The same situation occurs with soil test levels. On soils with low soil test P or K levels, it will require more P or K to raise the soil test than at high soil test levels.

In addition to requesting the standard soil tests of pH, P, and K from the 0-6 inch surface sample, producers might also want to monitor soil organic matter levels and micronutrients such as zinc (Zn). Zinc is not a nutrient commonly found deficient in wheat production. However, it is important for corn and grain sorghum. Thus including it in your sample package would be helpful for planning for these rotation crops.

Soil organic matter (SOM) is an important source of nutrients such as N and sulfur (S). When calculating the fertilizer needs for both these nutrients, SOM is taken into consideration. For wheat production, 10 pounds of available N and 2.5 pounds of S is credited for every 1% SOM in the soil.

The 0-24 inch soil sample

In addition to pH, SOM, P, K, and Zn -- all of which are non-mobile in soils and accumulate in the surface – the mobile nutrients N, S, and chloride can provide significant yield responses when deficient in soils. Since all three of these nutrients are mobile in soils and tend to accumulate in the subsoil, we strongly recommend the use of a 24-inch profile soil sample prior to growing wheat, corn, or grain sorghum.

Nitrogen is a nutrient likely to provide yield response statewide. One common misconception is that the accumulation of N in the soil profile only occurs in the drier, western half of the state. However, with our dry winters, N can accumulate in the soil statewide. Rainfall tends to peak in Kansas in June and July, with a rapid decrease in monthly precipitation in the fall. Rainfall totals are generally lowest in December and January. Wheat takes up the majority of its N prior to flowering. In southeast Kansas that is in April, and in north central Kansas it is in early May most years.

In many years, especially following dry summers like this year, significant amounts of N can be present in soils at wheat planting. On the other hand, after good yields, the residual N levels may be lower than the commonly used “default” value, and N fertilizer rates would need to be adjusted accordingly. Don’t miss the companion article in this issue on the correlation of the amount of nitrate in the soil profile and wheat yield.

Sulfur deficiency is increasing across the state in wheat production also. There are two primary causes: the reduction in sulfur deposition from the atmosphere seen over the past 2-3 decades, and the reduction in S content in many P fertilizers. While not as soluble as nitrate, S is also a relatively mobile nutrient which accumulates in the subsoil. The S profile soil test is a good way to determine S needs.

Chloride (Cl) is the third essential mobile element to be considered for wheat production with profile soil testing. Chloride deficiency is normally found in the eastern half of the state on soils that do not have a history of potash (KCl) application. In general, this includes many areas in eastern Kansas, north of the Kansas River, and the central corridor of wheat production. Chloride deficiency is associated with grass crops, wheat, corn, and grain sorghum, and is correlated with the plants ability to resist plant disease. Again, the profile soil test for chloride is well calibrated in Kansas and should be considered.

Summary

In summary, wheat producers in Kansas should consider soil testing to help in making accurate fertilizer decisions. Accurate decisions are especially important during years with low grain prices and tight budgets. Furthermore, after variable conditions and yield levels across the state, fertilizer needs may require adjustments based on soil test. Wheat producers specifically, should use surface 0-6 inch samples to determine the need for lime on low pH soils, P, K, Zn, and soil organic matter. They also should be using 24-inch profile soil tests for N, S, and Cl. Now is the time to get those samples taken, to ensure there will be enough time to consider those test results when planning your fall fertilizer programs.

For more information on soil sampling and submitting samples to the **K-State Soil Testing Laboratory**, visit their website at http://www.agronomy.k-state.edu/services/soiltesting/.

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3. Soil fertility and wheat production: Profile nitrate levels and wheat yield

An article in this eUpdate issue gives a great summary on planning the best wheat fertility program through timely soil testing. This article addresses the correlation between the amount of nitrate in the soil profile and wheat yield.

Taking 24-inch soil profile-N samples in the fall has been a recommended practice for making an N recommendation for winter wheat for many years. However, due to the mobility of nitrate-N in the soil, soil test values observed in the fall may be different from values observed in the spring, particularly on soils prone to leaching. Because many producers wait until spring green-up to make their N application**, does soil sampling in the fall for nitrate-N really provide useful information for N management in wheat?** That is a legitimate question.

Analysis of yields taken from K-State research plots that received no N fertilizer shows a strong positive relationship with fall soil profile nitrate-N (Figure 1).

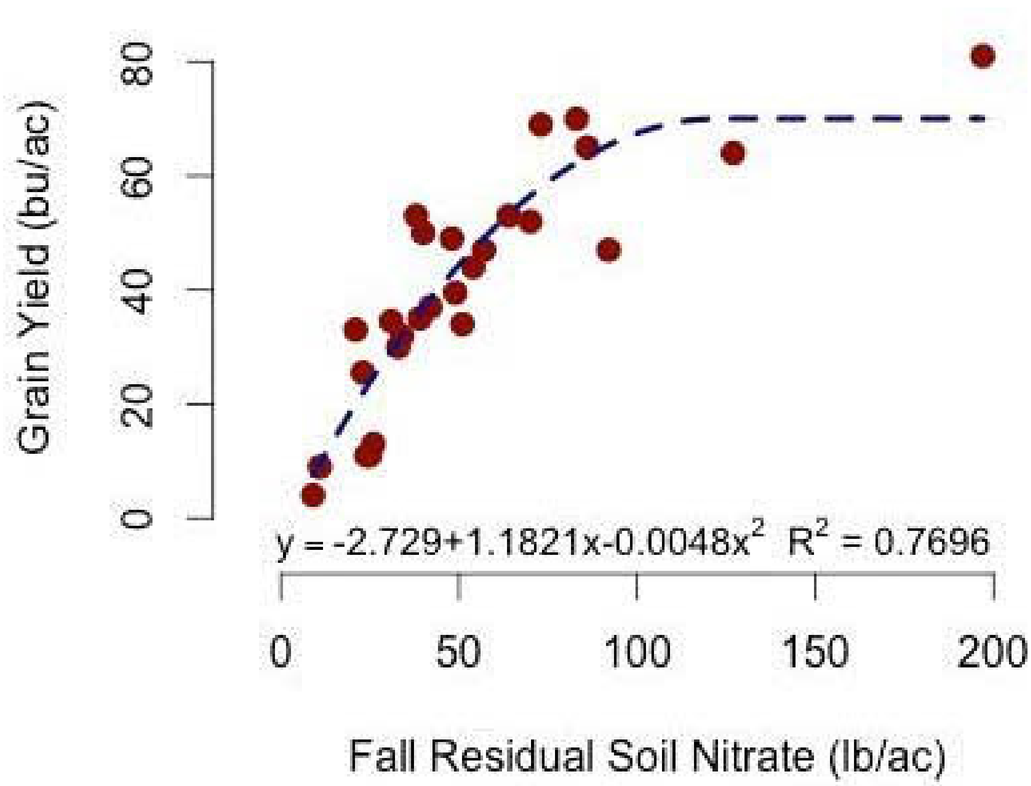

Figure 1. Relationship between fall soil profile nitrate-N level and wheat yield with no N fertilizer applied. Graph by Dorivar Ruiz Diaz, K-State Research and Extension.

We found that at low soil nitrate levels, wheat yields responded well to applied fertilizer. We also found that when fall soil profile nitrate-N levels are greater than 80 to 100 lb/acre, it is unlikely the site will respond to additional fertilizer N applied in the spring.

In short, a strong relationship was found between wheat yield and fall nitrate-N levels from 24-inch profile soil test analyses when no N fertilizer was applied. Although new practices have been developed to improve N management in winter wheat, soil sampling in the fall for nitrate-N remains an important practice to manage N efficiently and can result in considerable savings for producers.

When soil sampling for N is not done, the K-State fertilizer recommendation formula defaults to a standard value of 30 lb/acre available N. In this particular dataset, the average profile N level was 39 lb N/acre. However, the N level at individual sites ranged from 11 to 197 lbs N/acre. Most recommendation systems default to a standardized set of N recommendations based on yield goal and/or the cost of N. Without sampling for N or using some alternative method of measuring the soil's ability to supply N to a crop, such as crop sensing, the recommendations made for N will be inaccurate, resulting in a reduction in yield or profit per acre and increased environmental impact.

Failure to account for the N present in the soil wastes a valuable resource and can result in excess foliage, increased plant disease, inefficient use of soil water, and reduced yield. Soil sampling in fall for nitrate-N can have a significant impact on N recommendations for winter wheat in Kansas soils.

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4. Soybean yield potential estimation

With most Kansas soybean fields already in reproductive stages, it is time to start assessing yield potential from those fields.

Soybeans can easily compensate for the occurrence of stress (relative to corn), more so if the timing of the stress is before seed filling. One of the key factors on the crop's ability to compensate stress situations is the significant overlapping of vegetative and reproductive stages that indeterminate soybeans express, allowing them to keep producing new leaves even toward the reproductive period. On the other hand, the production of flowers could normally last between 4-6 weeks, which potentially allows to replace flowers and small pods abortion.

Since the final number of pods is not determined until reaching the beginning of seed filling, when estimating soybean yield potential, we must keep in mind that the estimate could change based on timing of this estimation and weather conditions. For example, wet periods toward the end of the reproductive period can extend the seed-set period, promoting greater pod production and retention, with heavier seed weight.

Estimating final yield before harvest can be a very tedious task, but a simplified method using yield components can be applied to start setting yield expectations.

From a physiological perspective, the main yield components to consider are:

- plants per acre,
- pods per area,
- seeds per pod, and
- seed size.

When can I start making soybean yield estimates?

There is not a precise time, but we can start making soybean yield estimates as soon as the end of the R4 stage, full pod (pods are ¾-inch long on one of the top four nodes), or at the onset of the R5 stage, beginning seed (seeds are 1/8-inch long on one of the top four nodes). Keep in mind that yield prediction is less precise at these early reproductive stages since the seed number per area, as well as the seed weight, are not yet completely defined. At this early stage of seed development, it is important to only consider the pods that are at least ¾-inch long to avoid over-optimistic estimations since smaller pods can still abort under stress conditions.

As far as we move into R6 stage (full seed), the seed number (main yield component) is significantly defined, yet the conditions during seed filling will determine the effective seed number as well as the size of the seed. The closest to maturity (R7 stage) that we move the estimation, the most accurate the expectation and overall yield prediction.

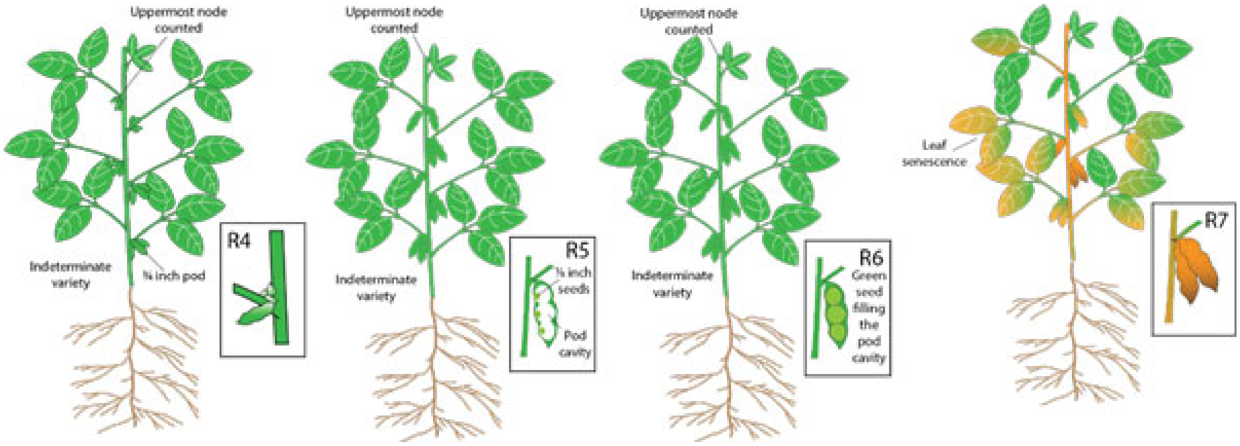

Figure 1. Soybean phenological stages to start yield prediction using the yield components method.

How many samples are needed to account for field variation?

Make yield estimations in different areas of the field, at least 6 to 12 different areas. It is important to properly recognize and identify the variation within the field, and then take enough samples from the different areas to fairly represent the entire field. Within each sample section, take consecutive plants within the row to have a good representation. The variability between plants in terms of number of pods and seed size needs to be considered when trying to get an estimation of soybean yields. In addition, variability between areas within the same field needs also to be properly accounted for (e.g. low vs. high areas in the field). In a nutshell, the more variability to represent, the more samples we would need for a good estimation.

The yield components equation

Soybean yield estimates following the conventional approach are based on the following components (**Eq. 1**):

Eq. 1

$$\left[\left(\frac{plants}{ac.}\right) x \left(\frac{pods}{plant}\right) x \left(\frac{seeds}{pod}\right)\right] \div \left[\left(\frac{seeds}{lbs.}\right) x \left(\frac{lbs.}{bu}\right)\right]$$

where,

1. **Plants/ac.** A simplified approach can be applied by using samples covering 1/10,000th of an acre with sections of 30 inches width by 21 inches length (**Figure 2, step 1.**). Thus, the average of plants on several sections multiplied by 10,000 will give us an estimation of the numbers of plants per acre. Following this simplified approach, if the soybean plants are arranged in 30-inch rows we just need to sample a single row; 2 rows if the row spacing is 15 inches; and in 4 rows if the row spacing is 7.5 inches.

2. **Pods/plant.** Once the samples have been obtained, we proceed to count and later average the number of pods per plant (**Figure 2, step 2.**).
3. **Seeds/pod.** Then, we proceed to count and later average the number of seeds per pod (**Figure 2, step 3.**). Soybean plants will have, on average, 2.5 seeds per pod (ranging from 1 to 4 seeds per pod), primarily regulated by the interaction between the environment and the genotypes. Under severe drought and heat stress, a pessimistic expectation would be an average of 1-1.5 seeds per pod.
4. **Seeds/acre.** A calculation of the total number of plants/ac (1)., pods/plant (2), and seeds/pod (3), obtaining the total number of seeds per unit area (**Figure 2, step 4.**).
5. **lbs/bu.** For this estimation, the "test weight" for soybean could be considered here as a constant number at 60 lbs./bu.
6. **Seeds/lbs.** The number of seeds per pound will vary depending the seed filling conditions, which will determine the seed size. Normally, this number could range somewhere between 2,500 (bigger seeds) to 3,500 (smaller seeds) seeds per pound, for optimal to unfavorable seed filling conditions. Combined with a constant test weight of 60 lbs./bu, this will lead to a range of expectation of seeds per bushel between 150,000 seeds per bushel to 210,000 seeds per bushel, respectively (**Figure 2, step 5**).

The final step to get the estimation consist in: (i) dividing seeds/acre by seeds/bu to obtain the yield estimation in bushels per acre (**Eq. 2**).

Eq. 2

$$\left(\frac{seeds}{ac.}\right) \div \left(\frac{seeds}{bu}\right) = {bu}/{ac.}$$

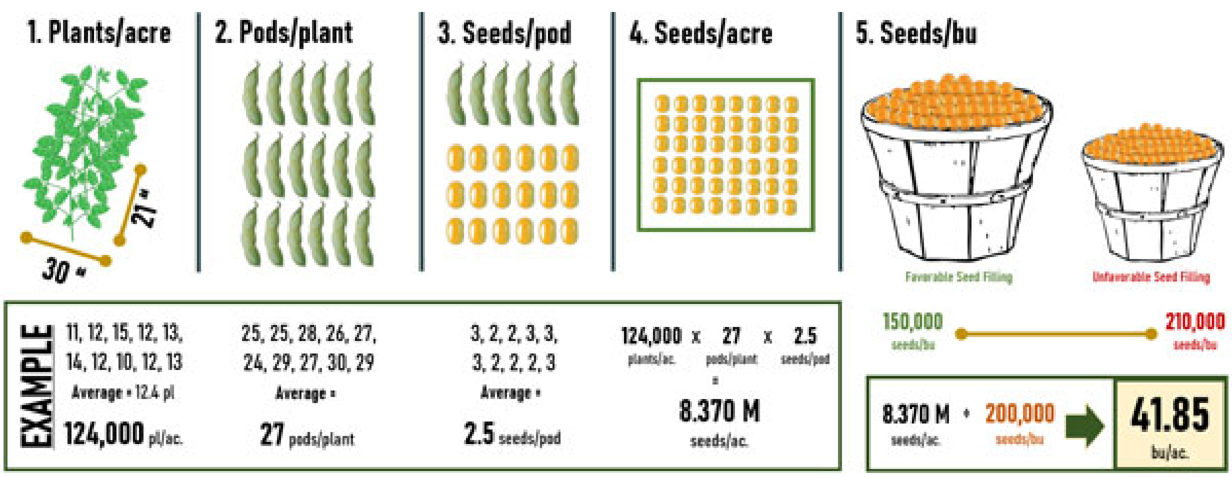

Figure 2. Example of yield estimation method using samples of 1/10,000th of an acre (21-inch x 30-inch sections) for a regular yield until seed filling, where the seed size is expected to be reduced compared to favorable seed filling conditions, increasing the #seeds/bu component.

Example for average conditions

In Figure 2, we have taken 10 samples of 30x21 inches sections, leading to an average number of 12.4 plants. Since these sections are 1/10,000th of an acre, our first component, the plant density is 124,000 plants/acre. Then, in those 12 plants, we have measured on average 27 pods per plant. If we assume a "normal" growing season condition, then we could expect to count around 2.5 seeds per pod. Combining these components, we obtained an expectation of 8.370 M seeds per acre. Finally, we had to assume (if the estimation is early) or represent (if close to maturity) the seed filling conditions. In this case, we have used regular to poor seed filling due to the lack of precipitation combined with heat, thus we divided the seeds per acre by an expectation of 200,000 seeds per bu (small seed size), giving us an estimate of 41.85 bu/a.

Adjusting for 2022 expectations

So far, the 2022 season have shown a good start during May and June, but challenging conditions from drought and heat experienced during July and August. Thus, even if the pod number is the same as in a normal season, for a "droughty" (from R2 to R6 stages) growing season such as the present one, the final seed number will be negatively impacted. Therefore, a yield calculation for unfavorable conditions while defining the number of seeds per pod component could be as follows:

$$(124{,}000\ \frac{plants}{ac.}\ x\ 27\ \frac{pods}{plant}\ x\ 1.5\ \frac{seeds}{pod}) \div\ 200{,}000\ \frac{seeds}{bu} = \mathbf{25.11}\ {}^{\boldsymbol{bu}}/_{\boldsymbol{ac.}}$$

This situation could be more severe if the stress conditions started earlier in the reproductive period, impacting the final number of pods, and if the stress conditions are not alleviated in the coming weeks, severely reducing the final seed weight.

The practice of estimating yields in soybeans will provide an opportunity for farmers and agronomists not only to obtain a more reliable prediction of yields but to scout fields for associated issues before harvest, such as insects, diseases, and other potential production problems.

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5. 2022 Kansas Performance Tests with Winter Wheat Varieties report

The 2022 Kansas Performance Tests with Winter Wheat Varieties report is now online. The Kansas Agricultural Experiment Station annually compares both new and currently grown wheat varieties across different regions in Kansas. These performance tests generate unbiased information designed to help Kansas growers chose the best wheat varieties for their cropping system.

In this report, you will find a recap of the 2021-22 wheat crop, with a detailed discussion of weather conditions from planting through grain filling. The combination of dry and cool conditions extended the dormant period of the wheat crop: The majority of the varieties evaluated by K-State Research and Extension did not reach the first hollow stem stage of development until March 26 in Hutchinson, which compares to as early as March 6 in years with a warm winter. A recap of insect pressure and diseases is also included. More importantly, the results of the 2022 wheat variety performance tests are also shown.

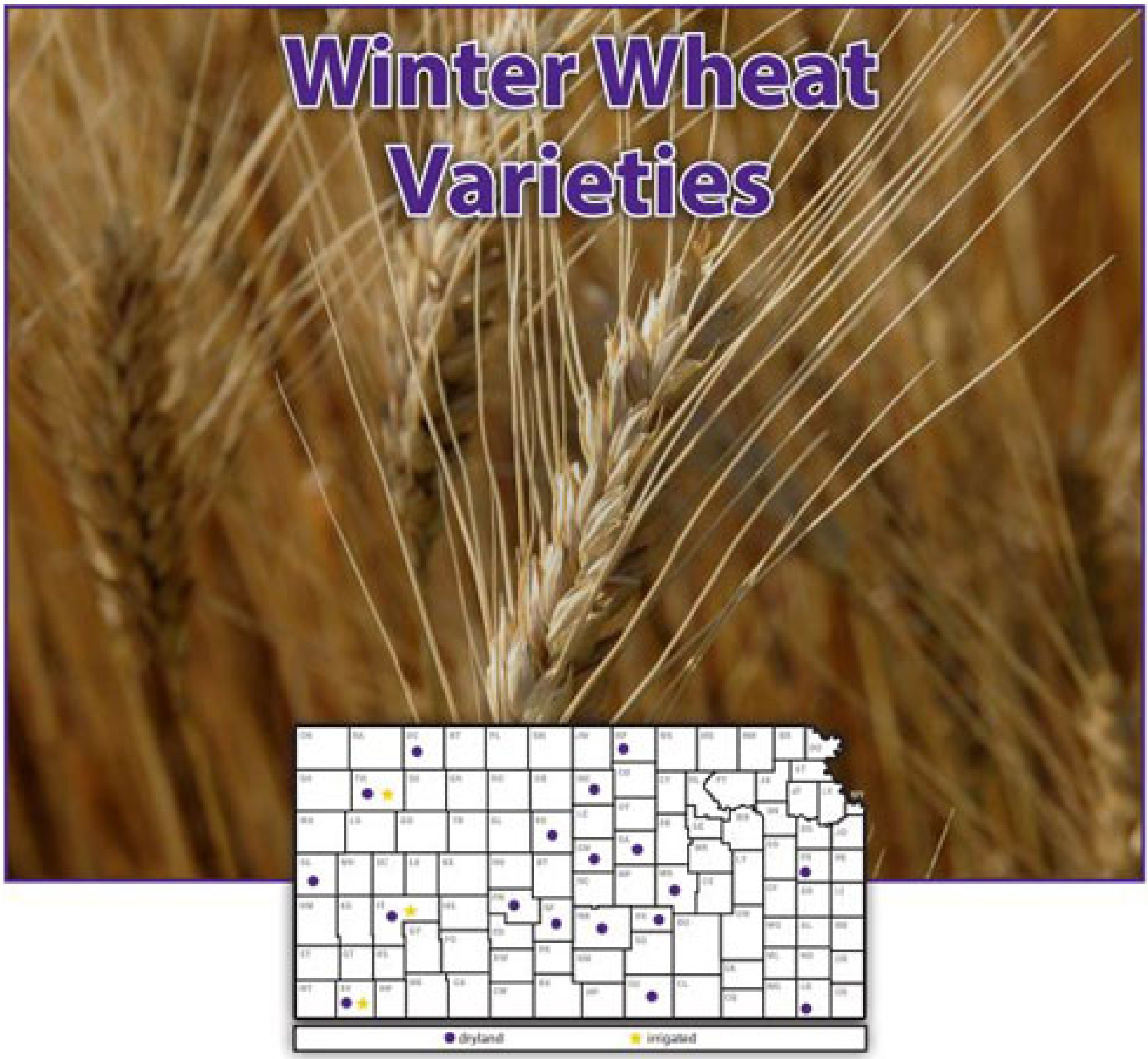
Producers and crop consultants can use this resource to help select wheat varieties for their operation by checking for varieties that show a consistently good performance in their region. Be sure to keep extenuating environmental conditions in mind when examining test results.

The online version of the 2022 variety performance report is available here: https://bookstore.ksre.ksu.edu/Item.aspx?catId=299&pubId=24842.

Performance test results from previous years are available at http://www.agronomy.k-state.edu/services/crop-performance-tests/winter-wheat/index.html

2022 Kansas Performance Tests with

Winter Wheat Varieties



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6. 2022 Fall Weather Outlook for Kansas

While the summer statistics aren't staggering, the impacts of above-normal temperatures and dry conditions have been substantial. As we move into fall, the focus turns towards harvesting and wheat planting. Copious moisture is needed to bring the state even close to normal. This story spotlights what is needed to erode moisture deficits and the fall forecast.

Precipitation Deficits

July's statistics were greatly skewed by a cooler/wet period late month. Additionally, timely moisture has kept 2022 off the list of driest years on record thus far. August is making a run to change that though. As of this writing (August 24), only an average of 0.71 inches of precipitation has fallen statewide. If the month ended today, August 2022 would be the third driest August on record, behind only 2000 and 1913. Thankfully, moisture is in the forecast at the end the month.

Thus far in 2022, the state has averaged 16.89 inches of moisture, 4.9 inches below the average value of 21.79 (Figure 1). This means that before the state could be considered normal for the year, 4.9 inches of precipitation would have to occur statewide. Keep in mind, eastern Kansas averages about twice the annual precipitation as in western portions of the state.

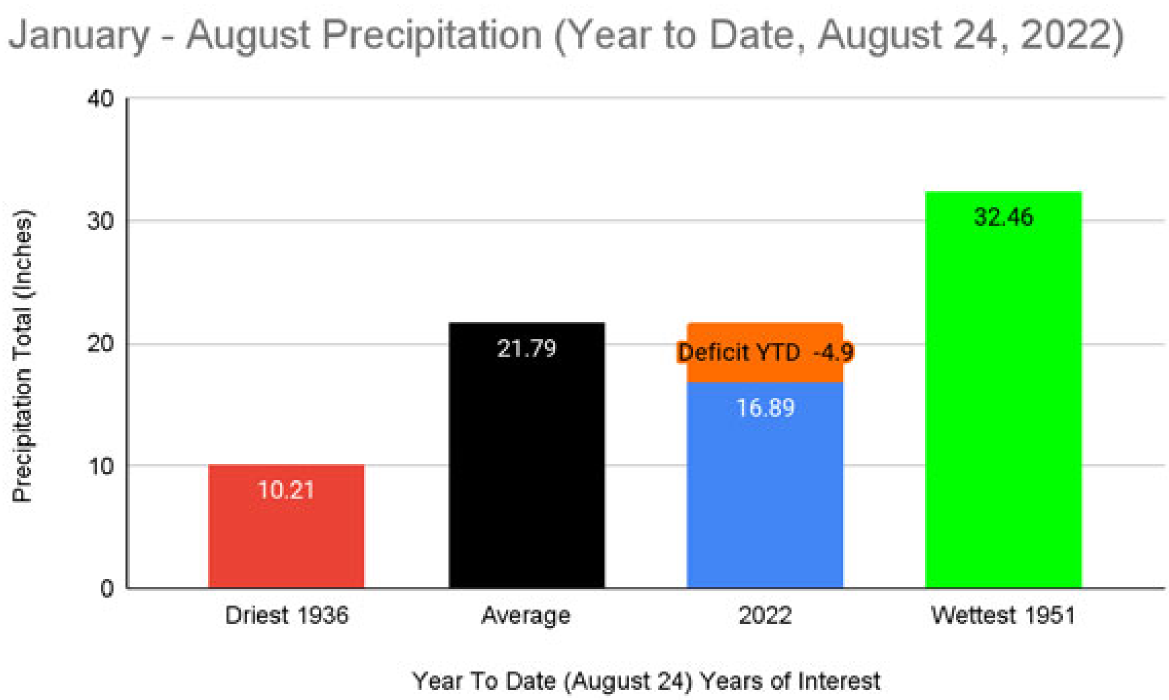

Figure 1. Year to date precipitation in 2022 compared to average, the driest (1936) and the wettest (1951). Departure from normal, -4.9 inches for 2022 is shown in orange as of August 24, 2022. Source: Weather Data Library

The bigger question then becomes how much can Kansas expect for the latter part of the year? The 30-year average moisture from September through December is 7.21 inches (Figure 2). Obviously, that isn't uniformly spread across Kansas; one would expect about double that in the east and half that in the west. Additionally, September averages 2.52 inches, with decreasing amounts each month through the end of the year. December averages just 1.07 inches statewide. While heavy rains can't be ruled out in the later months, it becomes more unlikely with time. Combined with the current deficit, Kansas would need 12.11 inches to break even for 2022. That is highly unlikely since there are only three September-to-December periods on record with more than 12 inches of rain. Note that despite the impressive dry conditions last November and December 2021 (Figure 2), moisture was near average due to the timing of the dryness and a substantial rain event in September and October. With the recent trends of heavy rain throughout the United States, let's avoid a deluge that matches those numbers; that wouldn't be beneficial. Slow and steady is our hope.

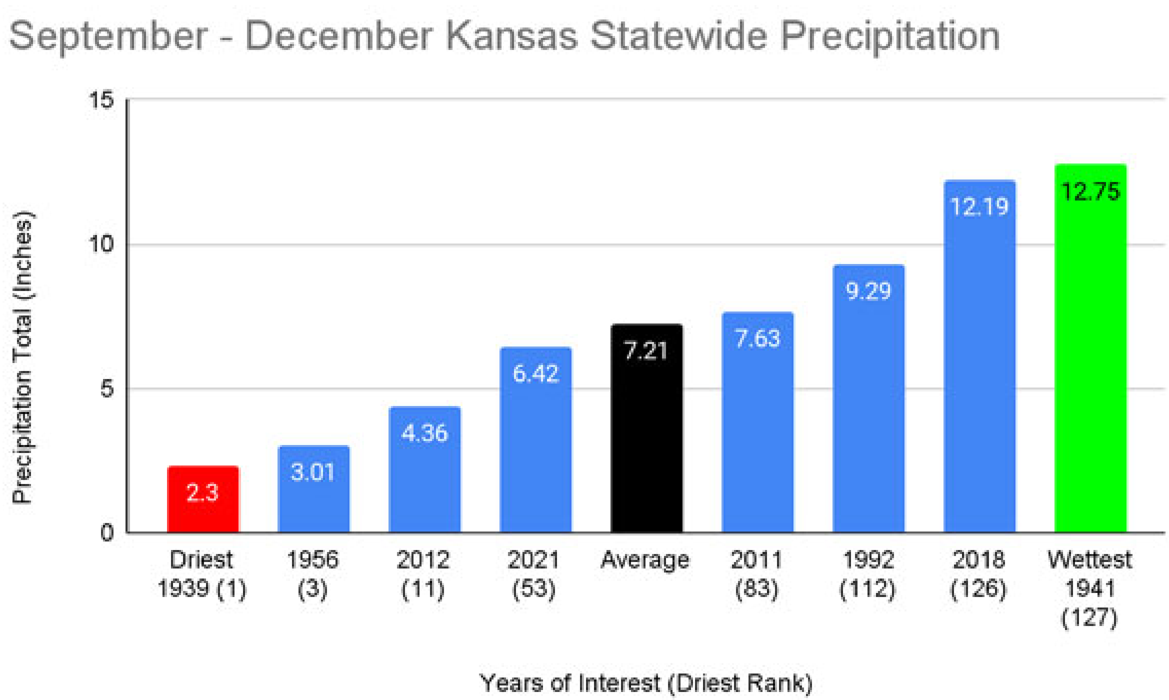

Figure 2. Statewide precipitation average through the remainder of the year (September through December) compared to some historic years of note. Source: Weather Data Library.

The Fall Outlook

Typically transition seasons are challenging to forecast for and 2022 is no exception. With substantial drought persisting across Kansas and neighboring states, combined with the numbers above, drought will likely continue into 2023 barring an impressive pattern change. It is important to note the recent increases in moisture in both the southern Plains and the desert Southwest. These are areas to watch for potential positive feedbacks of increased moisture. Unfortunately, south/southwesterly flow periods are relatively rare as we begin to get frequent cold frontal passages later in fall with predominant north/northwest flow climatologically favored (Figure 3). Therefore, average air masses impacting Kansas become colder and relatively drier, not optimizing this newly increased surface moisture to our south/southwest.

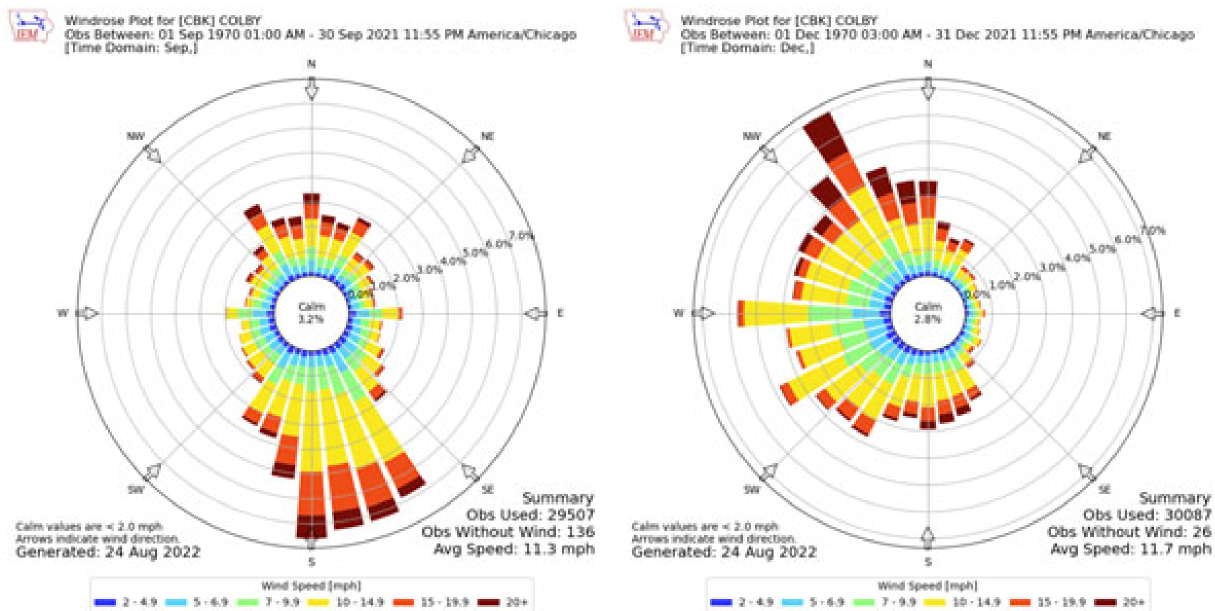

Figure 3. Wind roses (showing wind speed and dominant average direction) from September (left) and December (right) at Colby. Source: IEM Mesonet.

While other global and regional oscillations become more prominent during the winter months, the most dominant, the El Niño-Southern Oscillation (ENSO), will likely be the main headline for winter 2022/2023. Forecasts predict the current dominant La Niña to persist for the third consecutive fall (and likely winter). 2021 remains in the front of our minds with the significant heat/dryness to end the year. These extremes are favored for Kansas winters during La Niña and are of great concern. While we aren't forecasting extremes to that level, the current Climate Prediction Center (CPC) outlooks favor warmer/drier than normal conditions for the September through November timeframe (Figure 4).

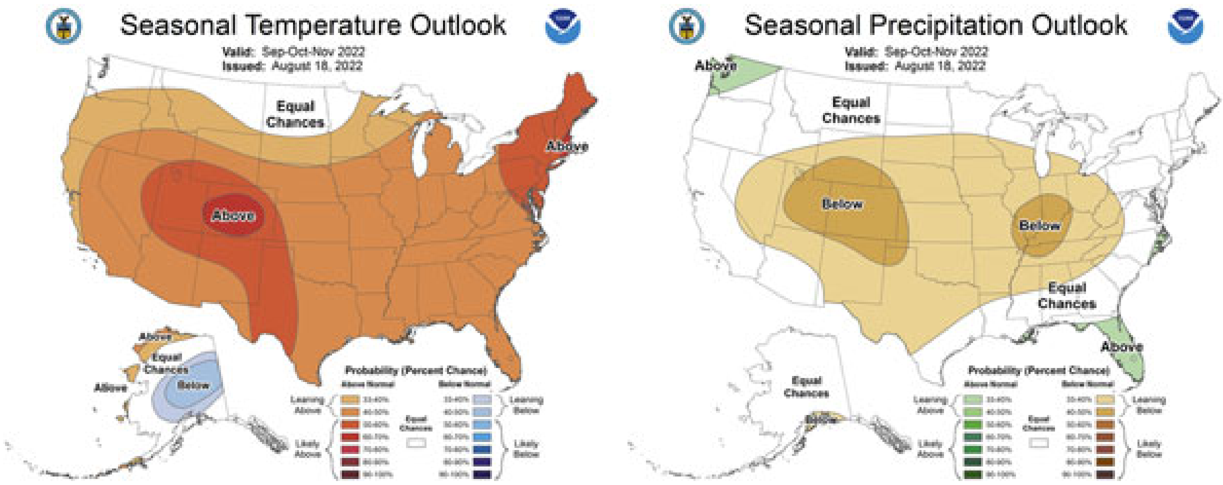

Figure 4. Climate Prediction Center outlooks for Fall 2022. Source: CPC

There are a few additional glimmers of hope that remain. With persistent high pressure across the western US, similar to what brought significant rains to Oklahoma and Texas, stagnant moisture will reside in the southern Plains. With occasional frontal passages, this will present an opportunity for moisture to move northward in advance of each front. Several rounds of thunderstorms are possible as they interact with these fronts, more so should the fronts stall. This will hopefully bring some needed moisture for southern portions of the state. This pattern has been resistant to break down for almost two weeks and looks to hold on through at least mid-September.

Lastly, while the tropics have been calm for the most part in the Northern Hemisphere, activity is beginning to increase. Our greatest focus resides in the western Pacific. A current typhoon named "Tokage" will turn northeast into the northern jet stream in the coming days (Figure 5). While this won't have immediate impacts for the US, it will work to keep the current pattern in place across much of the continent for another few weeks. That may be well timed for that southern Gulf moisture to be transported slightly further north into Kansas as mentioned previously. The remainder of the season is expected to be near normal for the West Pacific and hopefully an additional storm next month (typhoon potential exists through November) could act to break down the pattern to an even wetter result. Unfortunately, forecast models are not confident on this solution and keep Kansas warm and dry for the most part. We need to hold on to the hope that this drought can't (and won't) last forever! However, it will continue into 2023.

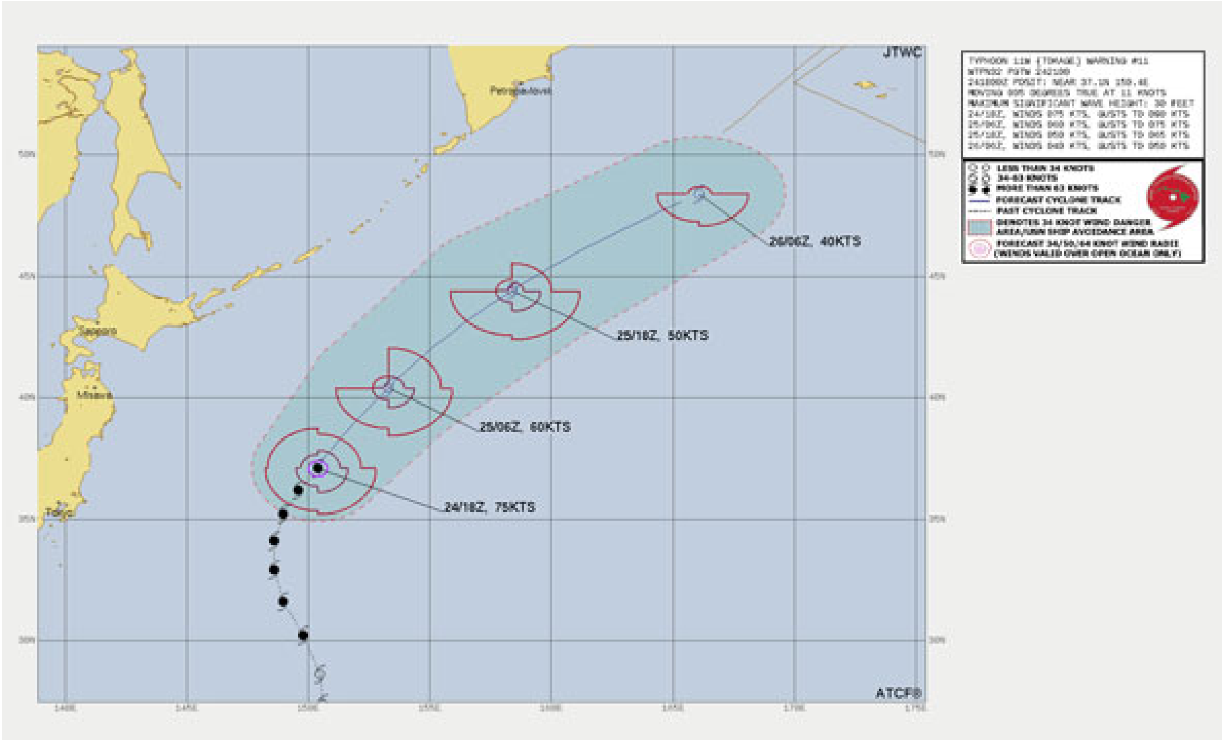

Figure 5. Typhoon Tokage forecast track in the western Pacific (Japan to the left in the image). Source: Joint Typhoon Warning Center.

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