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SOYSTAGE–A TOOL FOR PREDICTING SOYBEAN REPRODUCTIVE STAGES

Over the past few years, many of the in-season inputs applied to a soybean crop to maintain its health and optimum yield potential have increasingly been based on the crop's reproductive stage of development. Once a soybean crop is planted and emerged, the timing of the crop's developmental stages can be predicted based on years of documentation of the time of occurrence of those stages. Thus, a tool that can accurately predict phenology stages–especially reproductive stages–based on either planting or emergence date will be an invaluable resource for producers.

Such a tool has been developed for Midsouth soybean producers by scientists at the Univ. of Arkansas. This online tool, called SOYSTAGE, can be used to predict the dates of reproductive stages R1 [beginning flower–one open flower at any node on the main stem], R5 [beginning seed–seed that is 1/8 inch long in the pod at one of the four uppermost nodes on the main stem with a fully developed leaf], and R7 [beginning maturity or physiological maturity–one mature-colored pod anywhere on the main stem]. See A Visual Guide to Soybean Growth Stages from Univ. of Wisc. Ext. to see these stages. These three reproductive stages are arguably the most important to which management inputs are timed. R3 [beginning pod–pod 3/16 inch long at one of the four uppermost nodes on the main stem with a fully developed leaf], which is the stage at which a first fungicide application to soybeans is usually recommended, will occur roughly halfway between R1 and R5. R8 [harvest maturity] generally occurs 7 to 10 days after R7.

The gap between planting date and emergence [cotyledons above the soil surface] is greatly influenced by soil and weather conditions. Under optimum conditions, emergence may occur in as few as 4 to 5 days; however, under harsh soil and weather conditions which can occur following early plantings in the Midsouth, emergence may occur up to 14 days or more after planting. Click here for information from an MSPB-funded project that shows how early-season cool temperatures can affect time to soybean emergence. This information can be used to aid in predicting when emergence or day 0 for SOYSTAGE calculations will occur.

Details about the development of SOYSTAGE are presented in an article by Caio dos Santos, Montserrat Salmerón, and Larry C. Purcell titled "Soybean Phenology Prediction Tool for the US Midsouth" in the journal Agric. & Environ. Lett. 4:190036 [2019], and in a Univ. of Ark. publication titled "Soybean Development Stage Predictions" by Purcell, dos Santos, and Salmerón [2021]. Major points presented in these articles about the development and use of SOYSTAGE follow.

- Long-term [1981-2016] temperature data that were used in model development were obtained for 2776 locations in Arkansas, Texas, Louisiana, Mississippi, Missouri, Illinois, and Tennessee.
- SOYSTAGE begins simulations at the date of emergence rather than planting date because of the high variability between planting date and emergence date as described here.
- SOYSTAGE was developed using average daily temperature as an input rather than hourly temperatures since previous research found little difference between thermal units derived from the two.
- The model provides predictions for dates of R1, R5, and R7 based on historical weather data after the user selects an emergence date and soybean variety MG that was planted at a particular location. These three reproductive stages are defined according to the commonly used definitions provided by Fehr and Caviness and shown in the linked aforementioned growth stage publication from the Univ. of Wisconsin.
- The model predicts the above three reproductive stages using 35 years of weather data, 2776 locations, and MG's ranging from 3.2 to 6.7 in 0.5 MG increments, and for emergence dates ranging from 14 March to 27 June. The range in emergence dates accounts for latitudes that are <33°N to those that are >35°N.
- The dates of occurrence of the three reproductive stages for each location-emergence date combination were converted to days after

emergence [DAE], averaged over the 35 years, and presented using month-day format.
- The model predictions of R1, R5, and R7 dates agreed well [R^2 = 0.95, 0.92, and 0.86, respectively–See Fig. 2 in above-linked journal article] with observed dates across 27 site-years in the Midsouth.
- SOYSTAGE is comprised of 384 interactive maps. The data access system is composed of three selection boxes where the user can choose among 16 emergence dates, eight MG's, and three phenological stages. When the user hovers the mouse over the map, a popup box provides the desired information. To further refine the predictions for a specific location, the user can zoom in to the image.
- The model was built assuming no drought stress, which can affect phenological development of nonirrigated soybeans.
- SOYSTAGE can be accessed using any device with an internet connection. It works with commonly-used browsers.
- SOYSTAGE is currently restricted to the midsouthern U.S.
- SOYSTAGE was designed to require minimal input by the user. Just access SOYSTAGE, then click on "see phenology maps based on historical weather data" or "predict phenology for the current year", then fill in the boxes. The estimates based on user inputs will appear.

Producers are encouraged to do the following.
- Since SOYSTAGE uses emergence date as the starting point, become accustomed to recording emergence date for fields that will receive inputs based on reproductive stage. If an emergence date is not known, use the information here to estimate this date.
- Bookmark SOYSTAGE for easy access to it whenever the estimated date of a particular stage of soybeans in a particular field is needed.
- Access SOYSTAGE soon after emergence to acquire estimates of the dates of reproductive stages of soybeans in fields where inputs will be applied according to these stages. This will ensure that these dates will be anticipated so that inputs will be applied in a timely manner.
- Use SOYSTAGE to replace all previous tools for estimating dates of occurrence of soybean reproductive stages since it will be the most accurate for all locations within its Midsouth range.

The research used to develop SOYSTAGEwas financially supported by the United Soybean Board and the Midsouth Soybean Board [MSSB]. MSPB is a significant contributor to the MSSB and was instrumental in initiating the research that was used to validate the model predictions.

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