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Soybean Development Stage Predictions

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Introduction

Management decisions for soybean are often based on development stages. The ability to predict key development stages can aid in these decisions. For example, insecticide application thresholds differ among growth stages and irrigation initiation and cutoff decisions are determined in part by crop development. Likewise, the ability to predict maturity would be helpful in scheduling labor and harvesting equipment.

The most widely used system for describing soybean vegetative development begins with seed emergence (VE, Fehr and Caviness, 1977). Main-stem nodes with a fully developed leaf, beginning with the unifoliolate leaf, are designated as V1. Subsequent nodes with a fully developed leaf are designated as V2, V3, (etc.) until the first flower appears on the plant, which denotes the beginning reproductive development (R1). Other key reproductive stages include R2 (full bloom), beginning seedfill (R5), end of seedfill or physiological maturity (R7) and harvest maturity (R8).

The prediction of soybean development is complicated because it depends on a complex interaction between photoperiod (the number of daylight hours) and temperature. Daylight hours, of course, change throughout the year and among locations, depending upon latitude. Additionally, soybean maturity groups (MGs) differ in their sensitivity to photoperiod and because temperatures differ for specific dates from year to year, basing development upon calendar dates introduces error.

SoyStage – an online tool for predicting soybean development

Because of these interacting factors, predicting soybean development for a particular MG, planted on a given date at a particular location, is difficult. We have created an online tool that accounts for these interacting factors, using 35 years of historical weather data for 2776 locations throughout the Midsouth to accurately predict soybean development. We call this online tool SoyStage. SoyStage also uses the current year's weather data for prediction up until the present date and then completes projections using the historical weather data.

A three-year research project, funded jointly by the United Soybean Board and the Midsouth Soybean Board, determined the temperature and photoperiod responses for MGs 3 through 6 in one-half MG increments. The data was applied to locations ranging from College Station, Texas to Columbia, Missouri and for planting dates from March through June. SoyStage predicts R1, R5, and R7 growth stages based upon either historical weather data or weather data for the current year.

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"Phenology Maps" tab, predictions using historical weather data

Selecting the "Phenology Maps" tab on SoyStage pulls up a map of the United States with several drop-down menus (Figure 1). A highlighted portion of the map consists of the Midsouth region where the original research was conducted. From the drop-down menus, one can select the crop emergence date beginning March 14 and continuing until the end of June in weekly intervals, the relative MG from 3.2 to 6.7 in one-half MG increments and the development stage (R1, R5, or R7) that is of interest.

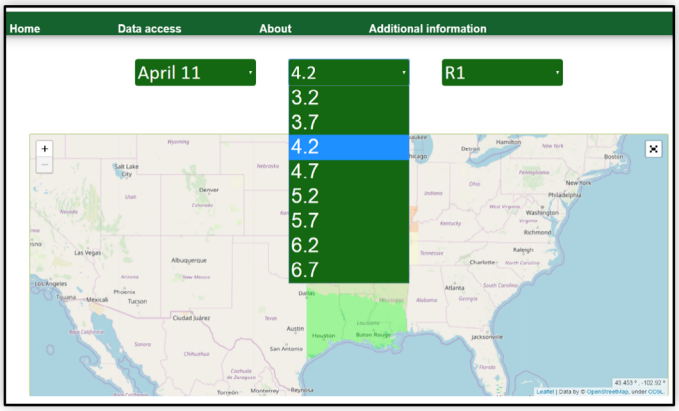

Figure 1. A screenshot of SoyStage showing drop-down menus for emergence date, maturity group, and growth stage.

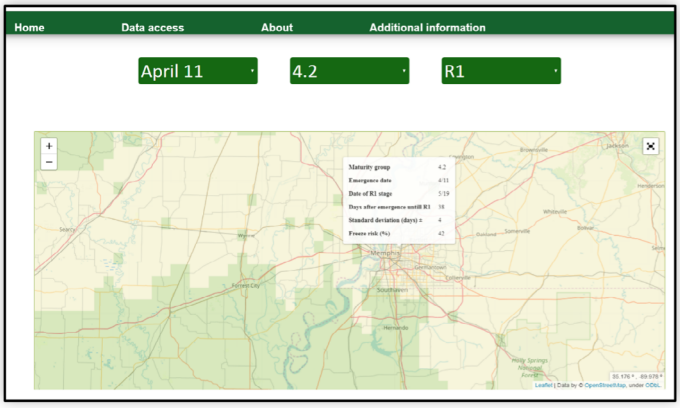

Figure 2. A screenshot of SoyStage predicting the R1 growth stage near Memphis, TN when a MG 4.2 cultivar emerges on April 11.

After making selections with the drop-down menus, the user can zoom into the area of the map that is of interest using the mouse wheel or the plus/minus options on the map. Figure 2 shows a screenshot of SoyStage that has selections for the R1 growth stage near Memphis with an emergence date of April 11, and for a MG 4.2 cultivar. When the cursor moves over the map, a pop-up window appears, indicating the date of the predicted growth stage, the number of days after emergence of the predicted growth stage, the standard deviation of the predicted growth stage (based upon the predicted values over 35 years of weather data for that location) and freeze risk. The freeze risk is expressed as a percentage of years that freezing temperatures occurred at that location after emergence over 35 years.

It is important to note that predictions are based upon emergence dates and not planting dates; this is because the time between planting and emergence may be as few as 4 days under optimum conditions to 14 days or more when the soil is dry or cold. The predicted dates of R1, R5, and R7 from SoyStage agree very closely with the observed dates from the original field experiments. The average differences between the predicted dates and observed dates were 0.15 days for R1, 1.10 days for R5, and 3.7 days for R7. Harvest maturity (R8) typically occurs around a week after the predicted date for R7.

"Current Year" prediction tab

The "Current Year" portion of SoyStage uses weather data for the current year beginning from the emergence date to the current date, and after the current date, predictions are based upon historical weather data.

Although the predictions for determining R1, R5, and R7 are the same as described for the "Phenology Maps" tab, the user interface and output are different (Figure 3). Users select their location by entering a five-digit postal code, which can be anywhere in the United States. As with the "Phenology Maps" tab, a drop down menu allows selection of MGs from 4.2 to 6.7 in one-half MG increments.

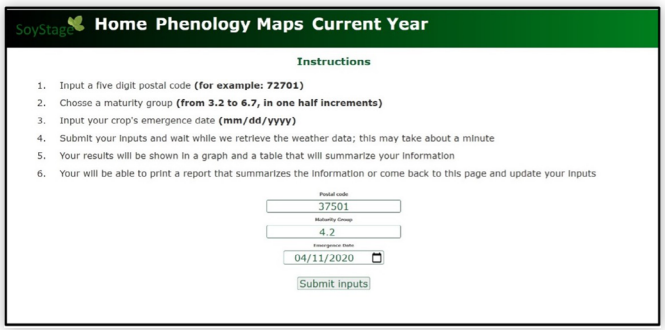

Figure 3. A screenshot of the "Current Year" tab of SoyStage showing the inputs for predicting R1, R5, and R7 for a MG 4.2 cultivar emerging on 4/11/2020 near Memphis, TN.

After submitting the inputs on the "Current Year" tab, SoyStage generates a graph that shows the photothermal accumulation using weather data for the current year as a solid blue line (Figure 4) and for the remaining portion of the season using historical weather data as an orange line. The intersection of the dashed horizontal lines for the respective growth stages (R1, R5, and R7) with the solid blue line indicates the date at which a particular growth stage will be reached. For example, in Figure 4, the dashed

green line (for R5) intersects the solid blue line on 07/07, indicating that beginning seed fill (R5) will begin on July 7. Dates for R1, R5, and R7 are also provided in a tabular form as shown in Figure 5.

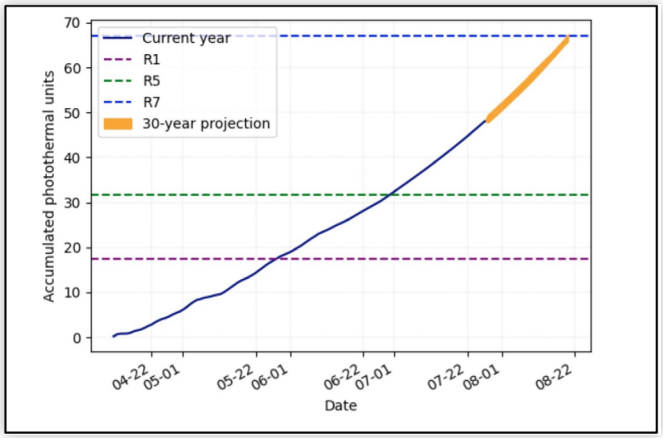

Figure 4. Screenshot of the "Current Year" tab of SoyStage. The date at which the dashed lines intersect the solid blue or orange line indicate predicted dates for R1, R5, or R7.

Data summary

Location	Memphis, Tennessee
Maturity group	4.2
Emergence date (month/day)	04/11
Current year vs 30-year average (photothermal units)	-4.6

Growth Stage	Projection for the current year	30-year average
R1 (month/day)	05/29	05/19
R5 (month/day)	07/07	06/28
R7 (month/day)	08/21	08/16

This report was produced by SoyStage (http://soystage.uark.edu) on 07/29/20 .

Update inputs Print

Figure 5. Tabular data showing the predicted dates for R1, R5, and R7 using data from the current year and data using the 30 year average.

Accessing and using SoyStage

SoyStage can be accessed at https://soystage.uark.edu/ from any internet-capable device and works with commonly-used browsers, including Safari, Chrome, and Firefox. After entering the site, there are tabs at the top of the page for "Home," "Phenology Maps" and "Current Year" as discussed previously. The "Home" tab also includes information on the development of SoyStage and a list of publications that document the data used to create the program.

Further reading and documentation

At the SoyStage website is a list of publications providing documentation important to the development of this tool. Below is a partial list of those references.

Dos Santos, C., M. Salmerón, and L.C. Purcell. 2019. Soybean phenology prediction tool for the Midsouth. Agric. Environ. Let. 4:190036. doi:10.2134/ael2019.09.0036

Fehr, W.R., and C.E. Caviness. 1977. Stages of soybean development. Special Rep. 80. Iowa Agricultural and Home Economics Experiment Station, Iowa State Univ., Ames.

Salmerón, M., and L.C. Purcell. 2016. Simplifying the prediction of phenology with the DSSAT-CROPGRO-Soybean model based on relative maturity group and determinacy. Agr. Syst. 148:178-187.

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