United Soybean Board Domestic Programs
Report Form

Project # and Title	#2234, Effect of Planting Date, Latitude, and Environmental Factors on Choice of Maturity Group in Mid-South Soybean Production
Reporting Period	Final report, October 1, 2011 through December 31, 2014
Project Status	Project status is documented on the following pages.

Effect of Planting Date, Latitude, and Environmental Factors on Choice of Maturity Group in Mid-South Soybean Production

PROJECT # 2234 - FINAL REPORT

United Soybean Board Domestic Programs

Mid-South Soybean Board

MID-SOUTH Soybean Board

USB UNITED SOYBEAN BOARD Making Your Checkoff Pay Off.

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UofA DIVISION OF AGRICULTURE RESEARCH & EXTENSION University of Arkansas System

Effect of Planting Date, Latitude, and Environmental Factors on Choice of Maturity Group in Mid-South Soybean Production

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Report Overview

Final Report for United Soybean Board Domestic Programs and Mid-South Soybean Board

Project #	2234
Title	Effect of Planting Date, Latitude, and Environmental Factors on Choice of Maturity Group in Mid-South Soybean Production
Project duration	October 1, 2011 through December 31, 2014
Organization	University of Arkansas

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Executive summary

Soybean producers make important production and economic decisions based upon information supplied by extension personnel, seed companies, local seed dealers, and others. It is crucial that this information and consequent recommendations take into account the wide planting window and latitudes in the US Midsouth and is applicable to the particular conditions of that producer. This project aims at increasing the understanding of latitude, planting date and soybean MG choices in soybean yield and seed quality for improving recommendations.

Experiments with 4 planting dates and 16 soybean cultivars of MG 3 to 6 were conducted at 8 locations in 2012 and at 10 locations in 2013 and 2014. The locations comprised a 10° range in latitude from Columbia, MO to College Station, TX. Data were collected for more than 1600 treatments (with four replicates) across all locations and the three growing seasons. Data included soybean yield, during season field notes (phenology, node number and stem height, lodging, green stem, and shattering), and seed quality data (standard germination, accelerated aging, protein and oil concentration, seed grade, and seed damage).

An analysis of yield stability for the 2012 to 2013 growing seasons indicated that for early- to mid-planting dates from late March to late May, soybean MG 4 and 5 cultivars were the best MG choices, with the highest yield and stability across locations. On the other hand, for late plantings ranging from mid-May to early July, soybean MG 4 cultivars were the best soybean MG choice, followed by MG 3 cultivars. Contrary to common soybean recommendations, soybean MG 5 and 6 at late plantings, yielded significantly less than earlier soybean MG choices in more than 80% of the environments.

An analysis of yield components, phenology, and environmental variables (temperature and intercepted radiation) improved the understanding of yield determination throughout the conditions of the region and indicate that late MG 5 and 6 cultivars did not perform as well as earlier cultivars, in particular for late plantings. The poor performance of MG 5 and 6 cultivars at late plantings was associated with an excessive length of vegetative phase, high temperatures during flowering that could increase flower abortion and reduce future seed size, and lower temperatures during seed filling that may decrease seed filling rate.

Light interception is a key factor determining yield and is affected by planting date, latitude, MG, and row spacing. Our data show that light can be limiting under late planting dates in the Midsouth and partially explain the decline in soybean yields. Decreasing row spacing can increase light interception in late plantings and increase soybean yields. To a lesser extent, using a later MG cultivar may increase yields for very late planting dates provided that the crop has time to mature prior to frost. Similarly, under very early planting dates, growing soybean MG 3 under a narrow row spacing or switching to a later soybean maturity is a potential strategy to increase light interception and soybean yield.

Soybean seed quality showed a large variability depending on the latitude, planting date and MG choices. Oil concentration in seed increased on average with early planting dates, southern latitudes, and early soybean MG. On the other hand, protein concentration in seed decreased with early planting dates. Standard germination and accelerated aging improved with late planting dates, northern latitudes and late soybean MG. Results show a decrease in germination with average minimum temperatures during seed filling above 19°C (66°F).

US seed grade was very low in general and indicates the potential use of the data gathered in this project to design strategies aimed at improving seed quality. The main cause of low seed grade observed was a high percentage of seed damage. Seed damage includes seeds damaged by weather, heat, mold, insects, and green seeds. Seed damage increased with early plantings and, to lesser extent, with early soybean MG and southern latitudes.

In summary, results from this project have generated soybean MG recommendations for irrigated soybean with early and late planting dates in the US Midsouth that question previously recommendations, and document some of the environmental variables involved in the yields obtained. Further analysis including data from the 3-year study and simulation studies are expected to generate more location- and planting date-specific recommendations. Moreover, the detailed results from seed quality across the wide range of environments in this project are the first of its kind, and will be valuable in understanding management options that can maximize seed quality and net economic returns.

Evaluation of Key performance indicators

1. *Publish manuscripts and extension materials and make presentations at meetings and through the internet documenting optimum MGs for yield and seed quality across the Midsouth.*

Results from the project have been presented in a total of 22 meetings with growers, soybean boards, and extension groups across the US Midsouth (see the bibliography at the end of the document). Presentations summarizing results, as well as a handout with a summary of the findings was prepared for the Tri-State Soybean Forum on January 9. Other extension and outreach material is listed in the bibliography.

Results from the project from 2012 and 2013 have been presented at 5 research meetings, and documented in 3 research papers (1 published, 1 submitted, 1 under co-authors review) that focus on: a) yield stability and MG recommendations for early vs. late planting dates across the environments in the Midsouth, b) study of light interception across row spacings, planting dates and soybean MG choices and simulation of different scenarios to give recommendations that can maximize light interception, and c) study of the factors determining yield and yield components for early vs. late planting dates and soybean MG choices, such as phenology, light interception, and temperature during different developmental stages. Future target publications including yield data from 2014, seed quality, and simulation of soybean phenology and yield are listed in the bibliography.

2. *Document stability of yield and seed quality for MGs 3 through 6 across multiple planting dates and locations.*

An analysis of soybean MG choices that maximize average soybean yield and yield stability for early vs. late planting dates in the Midsouth was completed with data from 2011 and 2012. The results were published in a research journal, presented at several meeting, and included in a project summary handout. Detailed results and recommendations based on this stability analysis are presented in detail in section 1.1 below.

Preliminary results of soybean oil and protein stability for soybean MG choices across environments in the Midsouth were presented at two research meetings with data from 2011. The large amount of seed samples in this project (n > 5000) and the detailed seed quality data gathered (oil, protein, seed germination, accelerated aging, seed grade, and seed damage) has delayed the completion of the analysis of seed quality to several months after soybean harvest. Seed quality results from 2014 are expected to be completed in April 2015 and further analysis documenting stability of soybean seed quality will be made available during 2015.

3. *Provide as supplementary material to published manuscripts, complete observations of crop development, weather data, management history, yield, and seed quality for all locations, planting dates, MGs, and varieties for the 3-year study.*

Once the seed quality analysis from 2014 have been completed during 2015, a complete dataset from the 3-year study will be made available.

The dataset will include: location, planting date, soybean MG and cultivar, soybean yield, phenology, main stem node number and height, seed size, seed number, oil and protein, standard germination and accelerated aging, percentage of seed damage, and seed grade. Moreover, daily weather data information and irrigation management will be provided.

4. *Make available on the MSSB website materials listed as 1 through 3 above.*

Materials summarizing finding from this project have been made available at the MSSB website: http://www.midsouthsoybeans.com/. These include a summary video and quarterly progress reports.

Further documentation of the project will be included during 2015. Moreover, a user-friendly decision tool including an economic analysis will be developed during 2015 in a continuing project and made available at the MSSB website.

5. *Publish manuscripts comparing predicted measurements of crop development based upon photoperiod and temperature responses of different MGs versus the observed measurements of crop development.*

The DSSAT-CROPGRO-Soybean crop simulation model has been used in this project for the simulation of soybean phenology and yield. Prediction of phenology with data from 2012 and 2013 have shown good model performance. The predictive capacity of the model has been documented in a research paper (publication 2) and used to study light interception under simulated scenarios of planting dates, soybean MG choices and different row spacings in Arkansas.

After compiling phenology and management data from 2014, the model will be evaluated for its performance predicting soybean phenology across a wide range of environments, soybean MG choices, and planting dates in the Midsouth (publication 6). Moreover, this publication will include a simulated study across different planting dates, MG and locations and with long term weather data. This simulation study will provide best soybean MG recommendations for optimizing environmental conditions during soybean development. These recommendations would be targeted to avoid periods of high temperature stress during flowering as well as maximizing light interception and duration of the soybean reproductive periods based upon historical weather data.

6. *Prepare manuscripts, extension, and web-based materials illustrating the probability of achieving various yield levels for different MGs across a wide range of planting dates at representative sites using long-term weather data and a calibrated and validated crop model.*

In order to optimize model calibration for prediction of soybean yield and due to the large amount of data in this project, DSSAT-CROPGRO-Soybean is currently being adapted for its use with the high performance computing facilities of the University of Arkansas. This will speed and improve the calibration process. Data from 2012 and 2013 will be used for improved phenology and yield calibration, and data from 2014 will be used for model evaluation. The datasets required for model evaluation from 2014 have just been received from each location and simulation files are currently being prepared.

A publication is targeted to evaluate the DSSAT-CROPGRO-Soybean model to predict soybean yield, seed size and seed number across the wide range of conditions in this project (publication 7). Long term weather data for a total of 20 locations in a 10 degree range of latitude in the Midsouth, a range of planting dates in weekly intervals, and soybean MG choices from 3 to 6 will be used. The results will be summarized to show the soybean MG with the highest probability of high yields (publication 8).

7. *Prepare a farmer-friendly summary of the project that can serve as a decision-making guide for MG selection for a particular location on any given day of year during the planting window.*

The project will generate a large amount of information that will be very useful growers. In order to make outcomes from this project easily available and specific for different locations and management combinations, a user-friendly decision tool will be developed that can help growers make informed decisions.

This decision tool is part of the continuing project in 2015 and will include as well an economic analysis. Users will be able to select the closest location from 20 different options in a 10 degree range of latitude, their week of planting, and compare outputs for two different soybean MG choices. The tool will provide information on soybean yield, expected phenology, irrigation requirements, expected soybean market price and economic return.

Summary of results and project outputs

1. Soybean MG x planting date recommendations – YIELD

1.1. Stability analysis of soybean yield

Results from 2012 and 2013 were used to evaluate yield stability of soybean MG choices for early vs. late planting systems across the environments in the Midsouth. In general, the 1st and 2nd planting at each location were considered an "early planting system", and the 3rd and 4th planting were considered a "late planting system".

- For early planting systems, MG 4 to late MG 5 cultivars had the highest average yields (Figure 1 A).
- For late planting systems, MG 4 cultivars had the highest average yields followed by MG 3 cultivars (Figure 1A).
- MG 4 cultivars succeeded being at the top of the yield ranking in 100% of the environments studied and in both early and late planting systems (Figure 1B).
- Yield of MG 5 cultivars were at the top of the ranking in 100% of the environments with an early planting but dropped to < 30% with a late planting.
- **These results are the first of their kind to show the advantage of MG 4 cultivars in late planting. Current recommendations for late planting recommend MG 5 or 6 cultivars when planting late or when double cropping after wheat.**

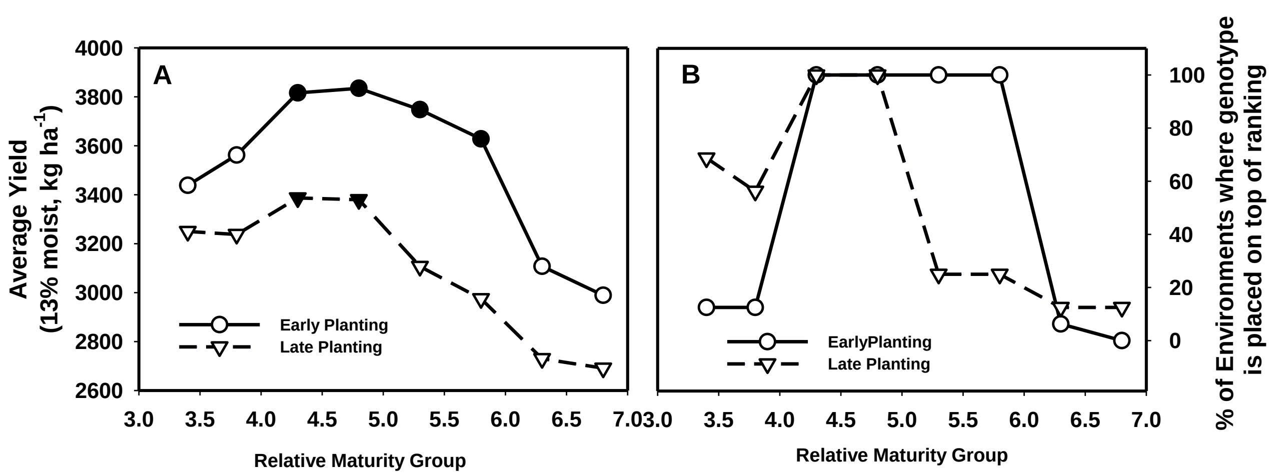

Figure 1: Estimates of the mean soybean maturity group effect by planting system (Early and Late) at environmental index (EI) = 0 (equivalent to average) (A) and % of environments were groups within a type of planting were on top of the ranking or not significantly lower than the highest yielding group (D). Closed symbols in Figure A indicate soybean maturity groups with significantly higher values within each planting type.

1.2. Light interception and row spacing

In addition to the data collected within this project, measurements to estimate light interception were taken during 2012 and 2013 at the Arkansas locations. Light interception was measured from weekly digital images of the crop canopy and related to cumulative thermal time for two different row spacings. Data collected have allowed the estimation of light interception as a function of thermal time for a narrow-row spacing (46-48 cm, or 18-19 inch) and for a twin-row spacing (19 cm twins on 97 cm beds, or 7.5 inch twins on 38 inch beds) based on the relationships obtained experimentally (Figure 2). These data indicate that 95% of the light would be intercepted by 657°C days for narrow rows and 890 °C days for twin rows (with T_{base}=10°C), corresponding to about 66 and 89 calendar days, respectively, with average temperatures of 20 °C (68°F).

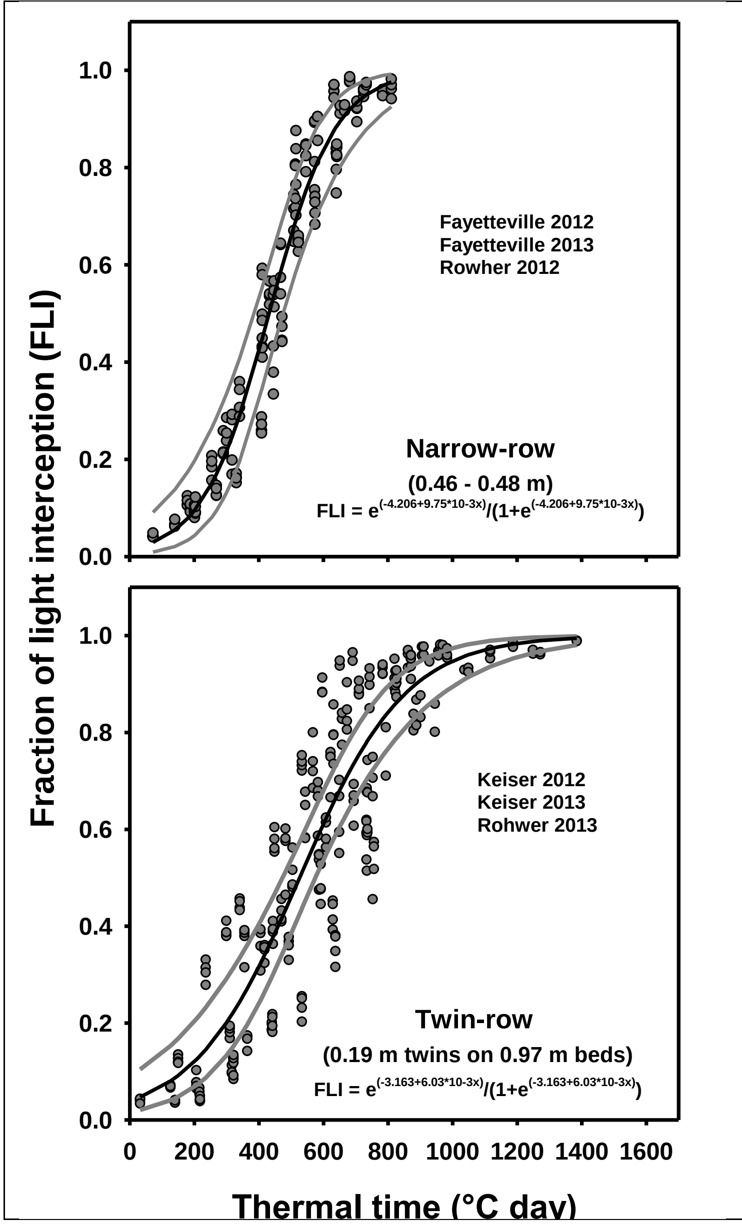

Figure 2: Fraction of light interception as a function of cumulative temperature for a narrow-row spacing (46-48 cm) and for a twin-row spacing (19 cm twins on 97 cm beds). Symbols represent observed data, solid black lines represent a logit fit with 95% confidence interval (grey solid lines).

The study also analyzed the relationship between relative soybean yield and the cumulative intercepted photosynthetically active radiation (CIPAR) (Figure 3). Finally, a simulation study combining phenology predictions with DSSAT-CROPGRO-Soybean and estimation of light interception was conducted. The simulation study included the two types of row spacing, MG 3 to 6, planting dates from March to July, and 30-yr of historical weather data from Rohwer and Fayetteville, AR (Figure 4).

- 650 MJ m^{-2} of CIPAR was sufficient to obtain 95% of maximum yields, and relative yield decreased when CIPAR was greater than 687 MJ m^{-2}.
- The simulation study identified MG and row spacing combinations that can intercept CIPAR close to the 650 MJ m^{-2} threshold to obtain maximum relative yields.
- With early to mid- planting dates, light is usually not limiting. However, when planting soybean MG 3 before May, switching to a narrower row spacing or using later MGs can increase light interception and yields.
- Light is more likely to limit soybean yield as planting date is delayed. When planting date is delayed to June and July, switching to a narrower row spacing and, to a lesser extent, using later soybean MGs, will likely increase yields provided that the crop can complete seed filling prior to frost.

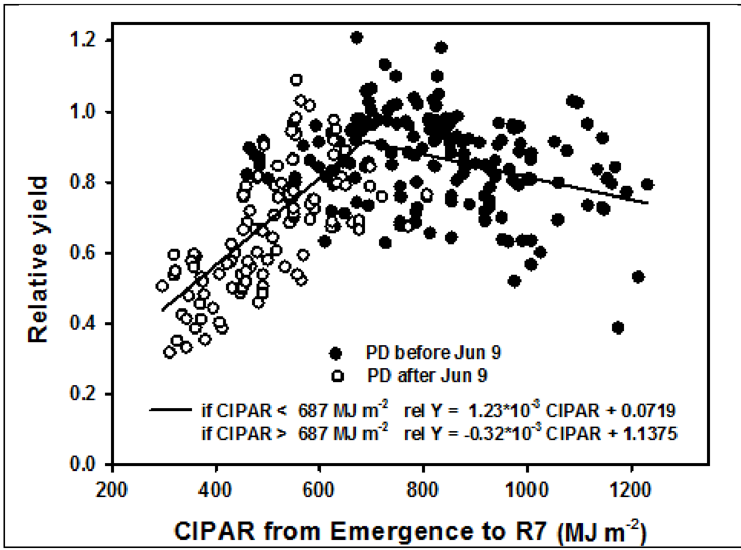

Figure 3: Relationship between soybean relative yield and CIPAR from emergence to physiological maturity (R7). Data from three years, three locations, 4 planting dates and soybean MG cultivars from 3 to 6.

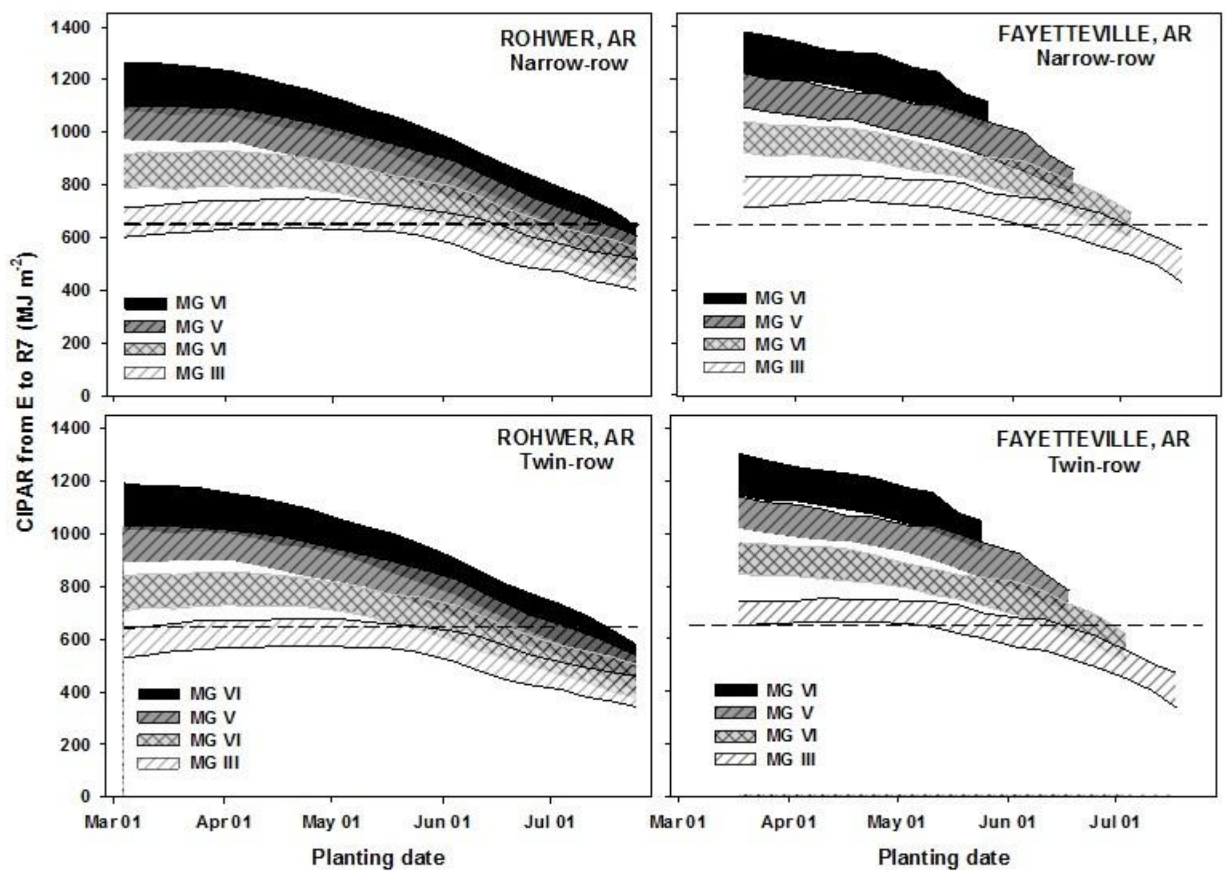

Figure 4: Average CIPAR by planting date, maturity group (MG) and for a narrow (0.46 – 0.48 m row spacing) and twin row spacing (0.19 m twin rows on 0.97 cm beds). Data range shown from the 10 to 90% percentile based on 30 years of historical weather data from Rohwer (left-side graphs) and Fayetteville (right-side graphs). The horizontal dashed line indicates the 650 MJ m^{-2} CIPAR threshold to obtain 95% of maximum relative yield.

1.3. Analysis of yield determinants.

In order to gain a better understanding of the factors determining soybean yield for the different MG and planting date combinations, an analysis was conducted with data from 2012 and 2013 that included: length of soybean developmental periods, seed number and seed size, and average temperature and CIPAR during different soybean developmental periods. Average temperatures during vegetative, flowering (R1 and R5) and seed filling (R5 to R7) were obtained from daily average temperature and recorded phenology data. CIPAR was obtained from daily PAR and the fraction of light interception. The fraction of light interception was estimated as a function of thermal time using the equations obtained experimentally for two different row spacings in Arkansas shown in Figure 2.

- Seed number (seeds m^{-2}) was on average greater at early planting dates compared to later plantings. Early MG 5 cultivars had the greater seed number, followed by soybean MG 4 and late MG 5 cultivars (Figure 5).
- Seed weight (g $seed^{-1}$) was greater for early plantings compared to later ones, and decreased as MG increased (Figure 5).

- The length of soybean developmental stages was greater with early plantings compared to late ones (Figure 6).
- Total CIPAR from emergence to R7 and during the seed set period (R1 to R6) was greater for early plantings compared to late plantings and increased with later soybean maturities (Figure 7).
- In MG 3 and 4, average temperature during flowering was almost 2°C lower in early plantings compared to the later ones. In MG 5 and 6 early planted, average temperature during flowering was 1°C greater than in MG 3 and 4. For late plantings, average temperature during flowering was similar across soybean MG cultivars (Figure 8).
- Average temperature during seedfill decreased with later soybean MG and with later soybean plantings (Figure 8).

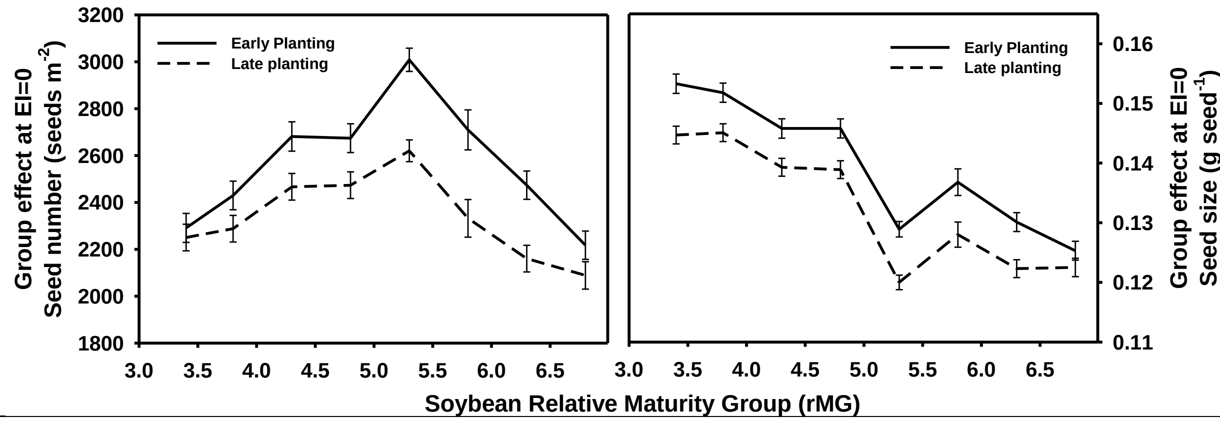

Figure 5: Average seed number (A) and seed size (B) by soybean maturity group and planting date (early vs. late).

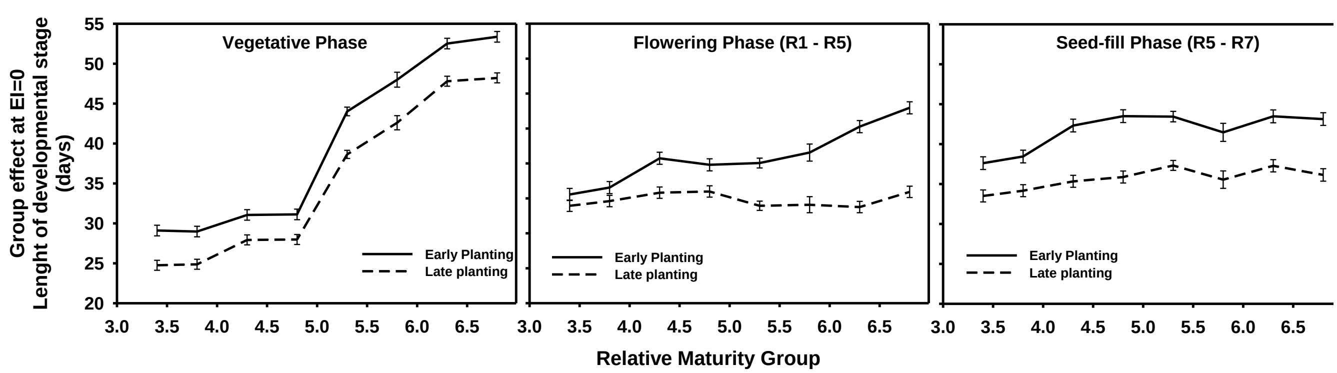

Figure 6: Average length of the soybean vegetative phase (emergence to R1) (A), length of the flowering phase (R1 to R5) (B), and length of the seed filling phase (R5 to R7) (C) by soybean maturity group and planting date (early vs. late).

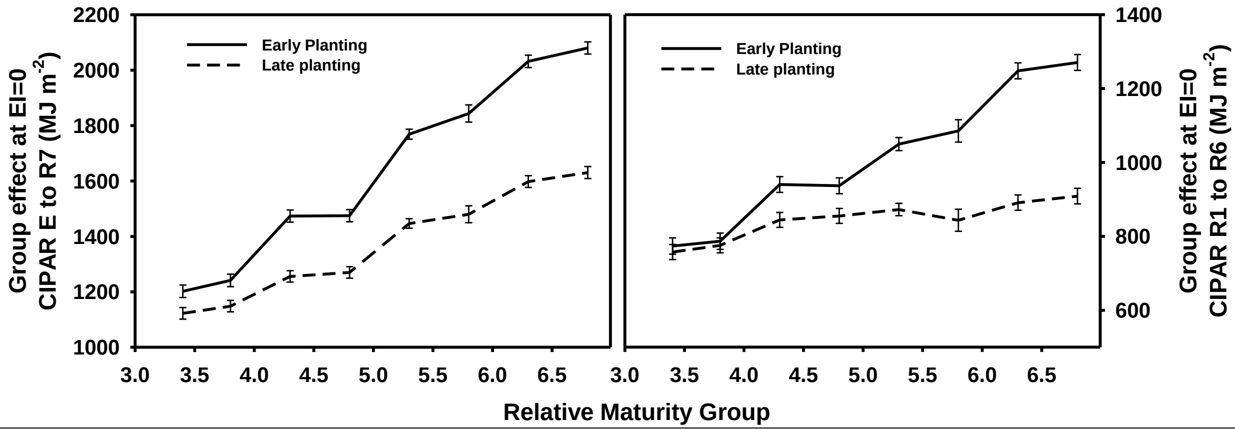

Figure 7: Average cumulative interpreted photosynthetically active radiation (CIPAR) during the soybean growing season (A) and during the seed set period (R1 to R6) (B) by soybean maturity group and planting date (early vs. late).

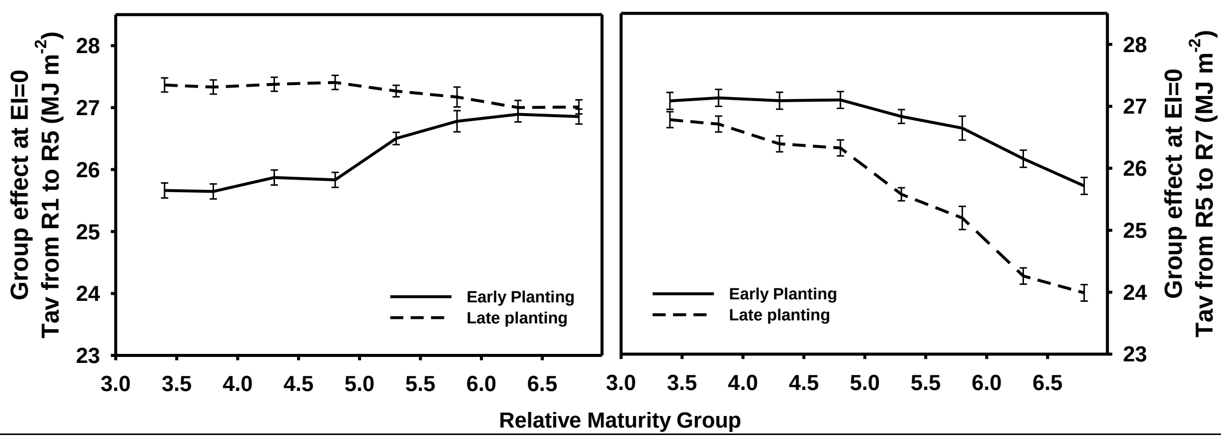

Figure 8: Average temperature during flowering (R1 to R5) (A) and average temperature during the seed filling phase (R5 to R7) (B) by soybean maturity group and planting date (early vs. late).

Soybean yield can be determined by the two main yield components, seed size and seed number. The analysis of environmental factors that affect yield component determination during the different developmental stages can help better understand the processes influencing yield in our environments:

- Seed number increases as the amount of radiation intercepted (CIPAR) increases during the time of flowering and seed set. Our data indicate that higher CIPAR in early plantings partially explains the higher seed number compared to late plantings.
- High temperatures during flowering can increase seed abortion and reduce final seed number. With early planting systems, the higher temperatures during flowering in MG5 and MG 6 cultivars compared to earlier MG can help explain the reduced seed number despite the higher amounts of CIPAR intercepted by these cultivars. When planting date is delayed, CIPAR decreases and average temperature during flowering increases, both contributing to a decrease in seed number and yield.

- Duration of seed filling (in days) was similar across MGs. However, a reduced rate of seed filling with low temperatures during the seed filling phase can explain the reduced seed size with late plantings and later maturities.
- Moreover, high temperatures during earlier stages of development (flowering phase) can reduce final seed size by affecting early cell division. The higher average temperature during flowering with late MG 5 and 6 cultivars in early plantings compared to earlier maturities could be further limiting seed size in these cultivars.

The results obtained have important implications for recommendations of soybean MG choices in the Midsouth. Our results document how the choice of MG had a great impact on CIPAR and on the average temperature during key developmental stages. The results indicate that high temperatures during seed set could be one of the reasons for the reduced yields with late planting dates and later soybean maturities, even when genotypes can intercept high amounts of CIPAR. These conclusions can be particularly relevant for the most southern locations in the Midsouth and can allow to design environment-specific management strategies that target optimum environmental conditions (of both temperature and CIPAR) during key developmental stages in soybean.

An extended length of reproductive periods is associated with increased yields in soybean. Our results indicate that soybean MG 5 and 6 cultivars increase the length of the growing cycle by mostly increasing the duration of the vegetative phase and, to much lesser extent, the reproductive one. This delay in the start of flowering positions the reproductive period in less favorable environmental conditions Therefore, our results manifest some of the limitations for the use of soybean MG 5 and 6 cultivars and bring some insight for possible ideotypes that could increase yield potential in the Midsouth.

2. Seed quality

2.1. Oil and protein

The analysis of oil and protein in seed from 2012 and 2013 are completed, and the analysis for the 2014 growing season are expected to be completed by April 2015. Preliminary analysis and conclusions from data of 2012 and 2013 are presented below:

- Seed oil concentration averaged across locations by soybean MG and planting date showed a similar trend during 2012 and 2013, with an increase in oil concentration with early planting dates and early soybean MG cultivars (Figure 9).
- Average oil concentration decreased with an increase in latitude (Figure 10).
- The analysis of temperature during seed filling period on the seed oil concentration only partially explained the variability in oil concentration and was location specific (data not sown). Further analysis looking at environmental factors related to oil concentration will be conducted combining data from the three growing season.

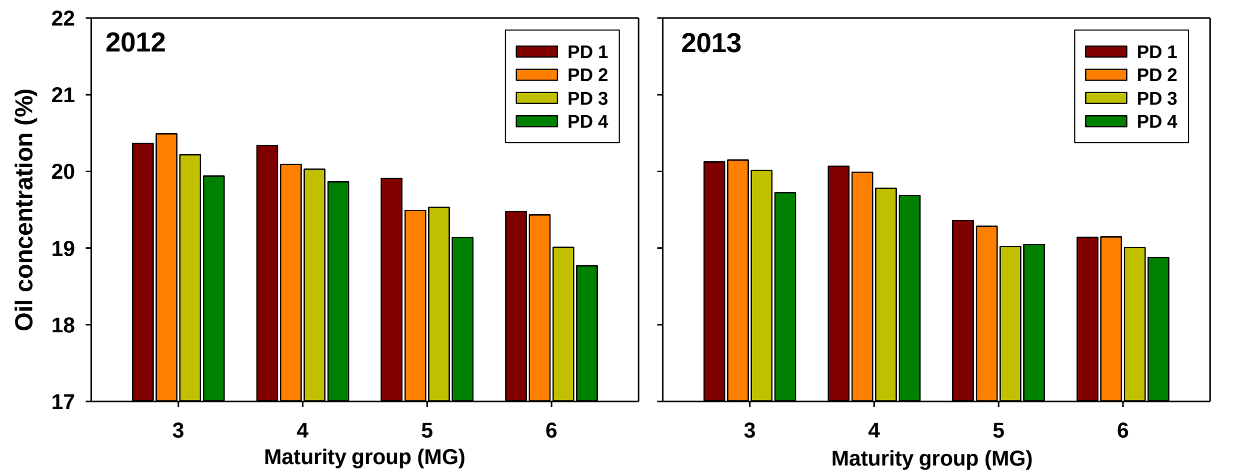

Figure 9: Average oil concentration in soybean seed by planting date (PD) and soybean maturity group (MG) in 2012 and 2013.

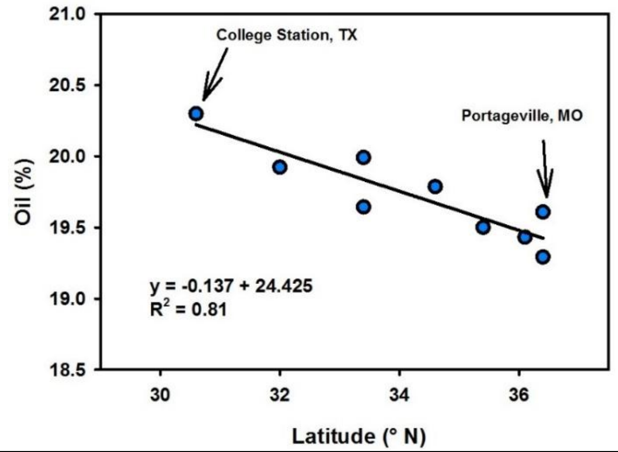

Figure 10: Relationship between average oil concentration in seed (%) and latitude of each experimental station.

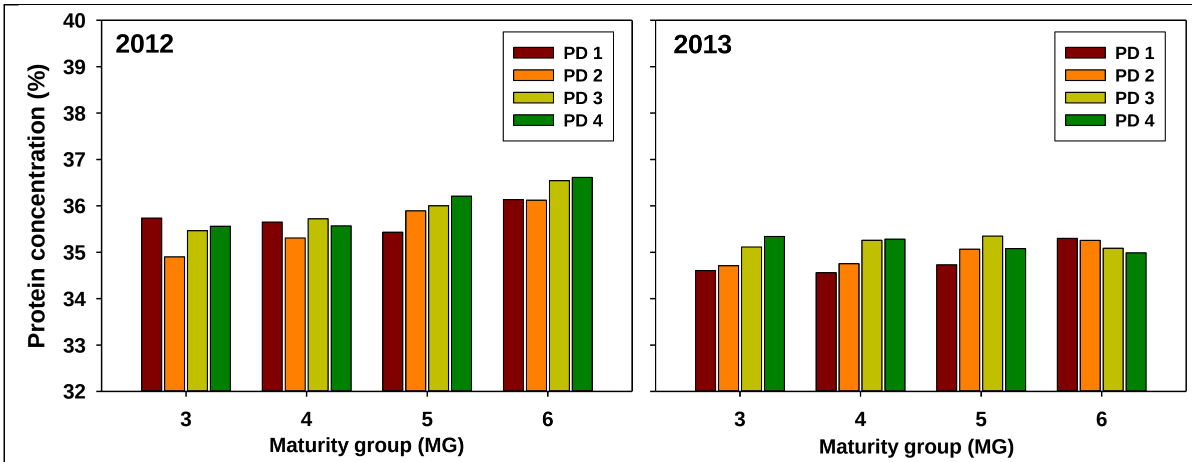

Figure 11: Average protein concentration in soybean seed by planting date (PD) and soybean maturity group (MG) in 2012 and 2013.

- Protein concentration did not show a clear trend with planting date and MG choices (Figure 11). There was no clear effect of latitude and temperature (data not shown).
- The analysis of variance for protein concentration in seed revealed that a large fraction of the variability (36%) was explained by genotype alone (MG and cultivars within MG). Environment (location and PD) explained 27% of the variation, and the interaction of environment with genotype explained 24%.

Results from the stability analysis of oil and protein concentration in seed revealed that average oil and protein concentration and their stability were highly dependent on the soybean MG choice (data not shown). Main conclusions from the stability analysis are presented below.

- The most stable cultivars for achieving a high protein concentration were the MG 6 cultivars.
- In the case of oil concentration, MG 3 cultivars were the least stable, with large differences across environments, but still showed significantly higher oil concentrations than the other MG choices studied.
- Further analysis including data from the 3-year study and taking into account the planting system effect (early vs. late) will allow a more complete understanding of environmental and management factors affecting oil and protein concentration.

2.2. Standard germination and accelerated aging

Data from analysis of standard germination and germination after accelerated aging has been completed for the 2012 and 2013 growing seasons. The complete dataset including data for the 2014 growing season will be available by April 2015. Some conclusions from the 2012 and 2013 are presented below:

- Standard germination shows a tendency to increase with later soybean maturities and delayed planting (Figure 12). The tendencies are consistent during 2012 and 2013. However, germination was greater in general during 2013.
- Germination after accelerated aging shows a similar response to planting date and MGs as standard germination (Figure 13), but was on average 19% lower than standard germination.
- Analysis of the effect of temperature during the seed filling phase on germination indicated that both standard germination and germination after accelerated aging decreased when minimum temperature increased above 19°C (66°F) (Figure 14).

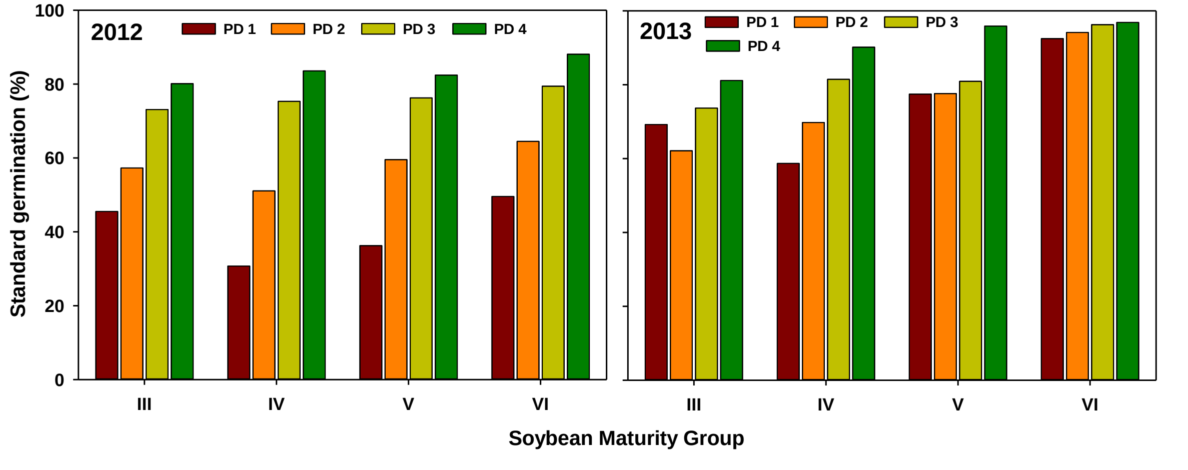

Figure 12: Average standard germination by planting and maturity group (MG). Preliminary results with data from 50% of the locations.

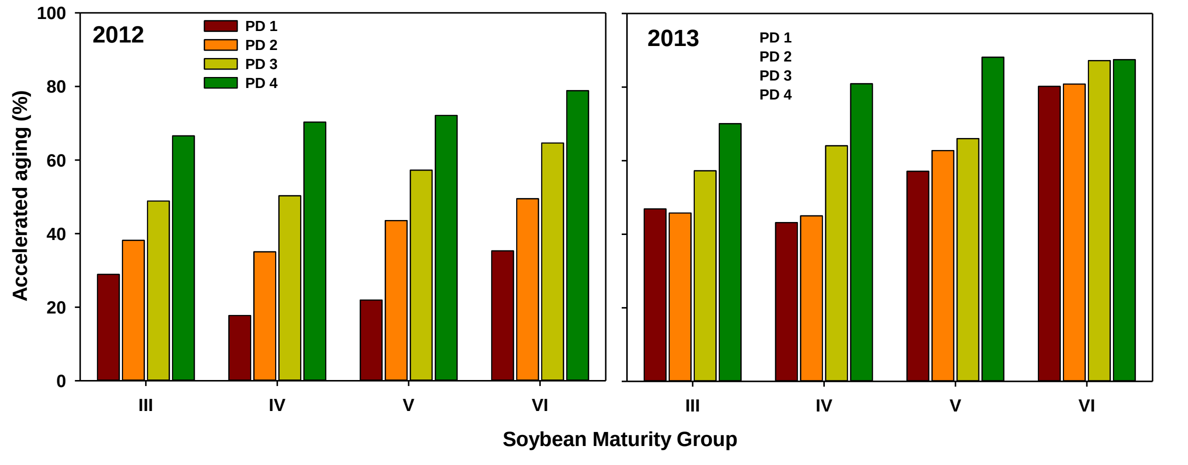

Figure 13: Average accelerated aging by planting and maturity group (MG). Preliminary results with data from 50% of the locations.

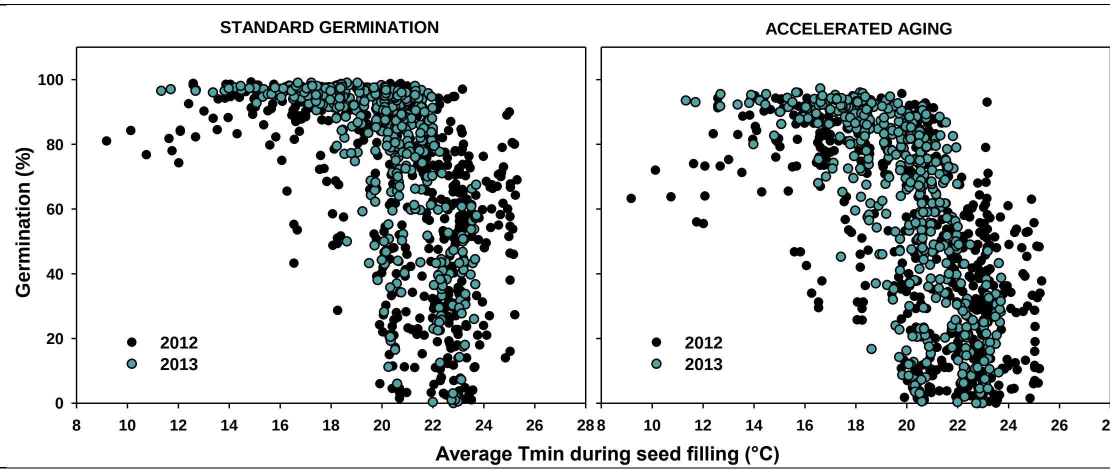

Figure 14: Relationship between standard germination of soybean seeds and average minimum temperature during seed filling. Results shown for 2012 and 2013 across locations, planting dates and cultivars.

2.3. Seed grade and seed damage

Seed grade was measured from seed subsamples harvested from each plot in our experiments (n > 6000 samples). The seed grade analysis follows the standard procedure that includes estimation of foreign material, test weight and seed size, and percentage of damaged seeds. Results have been completed for 2012 and 2013, and the dataset for 2014 is expected to be available in April 2015. Below is presented a summary of results and conclusions from 2012 and 2013:

- US seed grade was variable, depending on the year, location, PD, and soybean MG. In general, seed grade was low and did not meet the minimum requirements for grade #4 under some conditions (Figure 15).
- The main cause for the low grade in soybean seeds in our experiments was the high percentage of damaged seeds. Damaged seeds includes seeds damaged by weather, heat, mold, insects, and green seeds.
- In both 2012 and 2013 we observed that seed damage averaged across locations improved with later planting dates (Figure 6). Seed damage also tended to decrease at the most northern latitudes and with later soybean MG, although results were not always consistent.
- The analysis of results for the 3-year study, combined with location specific environmental variables is expected to improve the understanding of the mechanisms and factors involved in the high incidence of damaged seeds and consequent low seed grade.

In summary, results from our project have put in evidence how seed grade can be a crucial limiting factor for soybean grown in the Midsouth. Our results are the first of its kind documenting the variation in seed grade across a wide range of environments and possible management factors. A better understanding of the effect of planting date and MG on seed damage across a range of latitudes generated from this project can contribute to improve seed quality in Midsouth soybean production.

Considering the effect of seed grade on soybean market price can influence the best PD x MG recommendations for a given location that will lead to maximum economic returns for growers. Future efforts during 2015 in a continuing project will aim at studying these interactions in collaboration with economists.

U.S. Seed grade #

U.S. Seed grade #
1
2
3
4
>4

Columbia, MO

PD	III	IV	V	VI
1	4	4	4	4
2	4	4	4	4
3	4	4	4	4
4	4	4	3	>4

Verona, MS

PD	III	IV	V	VI
1	4	>4	4	>4
2	3	4	2	3
3	2	3	3	2
4	3	3	2	1

Portageville, MO

PD	III	IV	V	VI
1	>4	>4	>4	4
2	>4	>4	>4	4
3	>4	>4	4	4
4	>4	>4	4	3

Stoneville, MS

PD	III	IV	V	VI
1	4	>4	>4	>4
2	>4	>4	>4	>4
3	>4	>4	>4	>4
4	>4	>4	>4	4

Fayetteville, AR

PD	III	IV	V	VI
4	3	3	3	1

Rohwer, AR

PD	III	IV	V	VI
1	1	2	4	4
2	2	3	3	3
3	3	3	3	3
4	2	2	2	2

Milan, TN

PD	III	IV	V	VI
1	>4	>4	4	4
2	>4	>4	>4	4
3	4	4	4	3
4	3	3	3	2

St. Joseph, LA

PD	III	IV	V	VI
1	2	3	3	4
2	4	4	3	4
3	3	4	4	4
4	4	3	4	4

Keiser, AR

PD	III	IV	V	VI
1	>4	4	2	2
2	>4	3	3	2
3	4	3	3	3
4	4	3	3	3

College St., TX

PD	III	IV	V	VI
1	>4	>4	>4	>4
2	>4	>4	>4	>4
3	>4	>4	>4	1
4	>4	>4	>4	1

Figure 15: Soybean U.S. seed grade by location, planting date, and soybean maturity group in 2013. Legend in the left indicates U.S. seed grades from 1 (maximum grade) to 4, and > 4 for seed that did not reach the minimum quality requirements for U.S. grade 4 and is considered as “grade” seed.

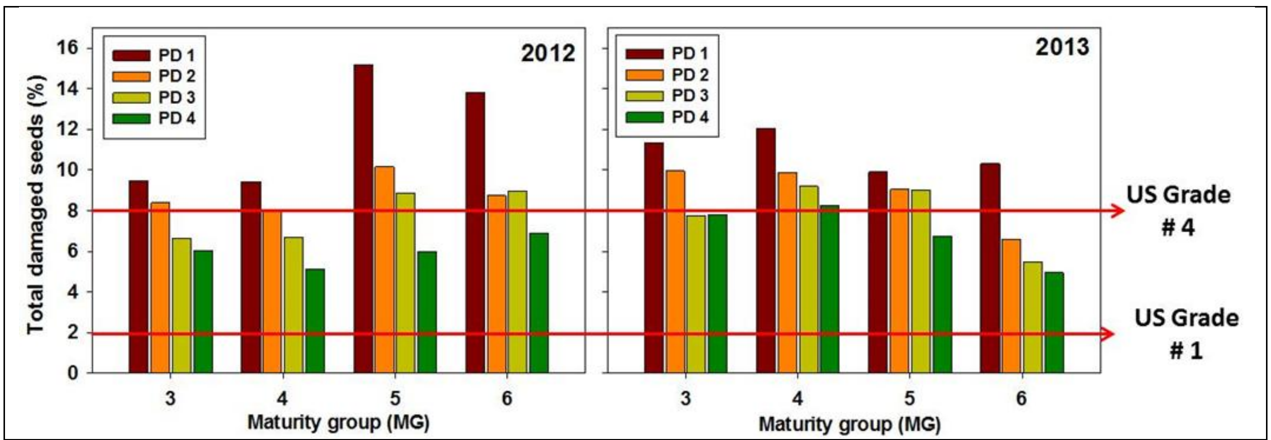

Figure 16: Percentage of damaged seeds in harvested soybean seed, averaged by planting date (PD) and soybean maturity group (MG) in 2012 and 2013. The horizontal lines indicate the thresholds for U.S. seed grade 1 and 4.

1. Crop model simulations

3.1. DSSAT - CROPGRO simulation of phenology

The DSSAT-CROPGRO-Soybean crop simulation software was used for the simulation of soybean phenology. The model uses daily weather data and takes into account the temperature and photoperiod sensitivity of a genotype to predict phenology.

The model requires the input of cultivar coefficients specific for each cultivar. Cultivar coefficients were obtained based on the relative soybean maturity group (rMG) of each soybean cultivar and the default cultivar coefficients in CROPGRO for soybean MG 3 to 6. A summary of results and future steps is presented below:

- The model showed a good model performance in the prediction of soybean phenology with data from 2012 and 2013 (Figure 17).
- The predictive ability of the model was used to study genotype x management scenarios that can maximize light interception in a publication recently submitted to a research journal.
- Cultivar coefficients are being further calibrated to improve prediction of developmental stages as a function of soybean rMG with data from 2012 and 2013. Afterwards the model will be evaluated with data from 2014 for its performance predicting soybean phenology across the wide range of environments, soybean MG choices, and planting dates in the Midsouth.

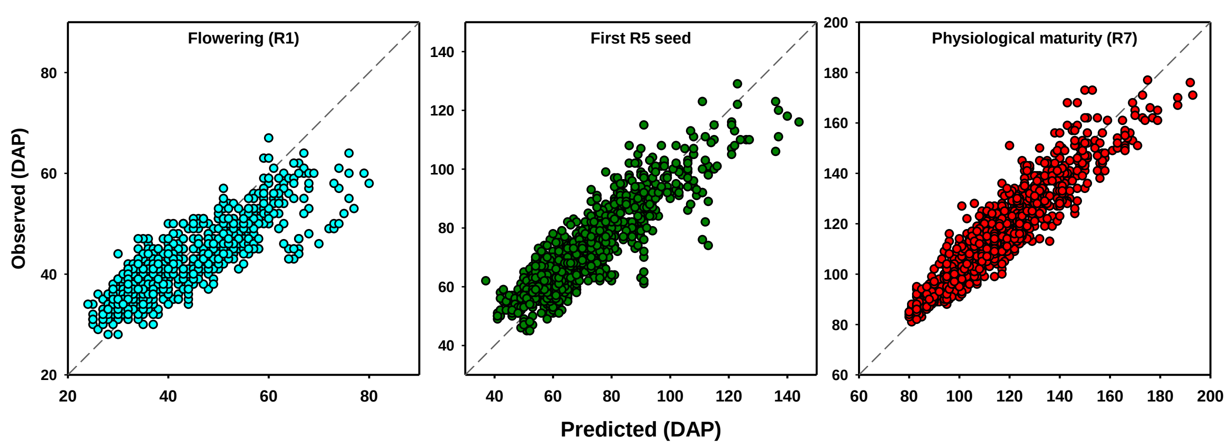

Figure 16: Simulated and observed day after planting (DAP) for beginning flowering (R1) (left), first R5 seed in the main stem (middle), and physiological maturity (R7) (right). The dashed line represents the 1:1 line. In a perfect fit, all data points would fall on the 1:1 line.

In summary, simulation results from our project indicate that the DSSAT – CROPGRO-Soybean model can be an accurate and flexible tool for prediction of phenology across a wide range of environments and managements scenarios in the Midsouth. This predictive tool for phenology has possible applications that can be useful for growers, such as prediction of field operations, expected soybean market price for a given harvest time, and study of genotype x management combinations that can optimize environmental conditions during key soybean developmental stages.

3.2. DSSAT – CROPGRO simulation of yield

The DSSAT – CROPGRO- Soybean crop simulation software is able to predict yield, together with water and nitrogen balances and limitations. The goal of this project is to evaluate the ability of the model to predict yield based on a simplified choice of soybean MG, since this can be most useful for growers. Data from 2012 and 2013 are being used for model calibration and data from 2014 will be used for model evaluation. Some of the preliminary results of yield simulation and steps followed for calibration and evaluation of the model are summarized below:

- Preliminary results with data from 2012 and 2013 and default cultivar coefficients based on soybean rMG indicate that yield predictions can benefit from improved calibration of cultivar coefficients related to yield.
- The accuracy of the model was dependent on the location and the PD x MG treatment. The model was able to predict yield trends at some locations and year combinations (Figure 17). For some location and years, the model accuracy was dependent on the soybean MG (Figure 18). For example, yields at College Station in 2012 were predicted well for MGs 3 and 4 but not for MG 5 and 6.
- Some of the factors that can influence model predictions are being studied to improve the model performance across all environments, such us: a) model inputs related to water balance specific to a location and year; b) treatments subject to biotic stresses that the model does not reproduce and that should not be included in model calibration; c) poor model predictions dependent on soybean MG choices that can be improved by modification of soybean cultivar coefficients.
- The tool in DSSAT for the calibration of cultivar coefficients requires a long computation time. To speed the calibration process, DSSAT is currently being adapted to be run with the high performance computing facilities of the University of Arkansas.

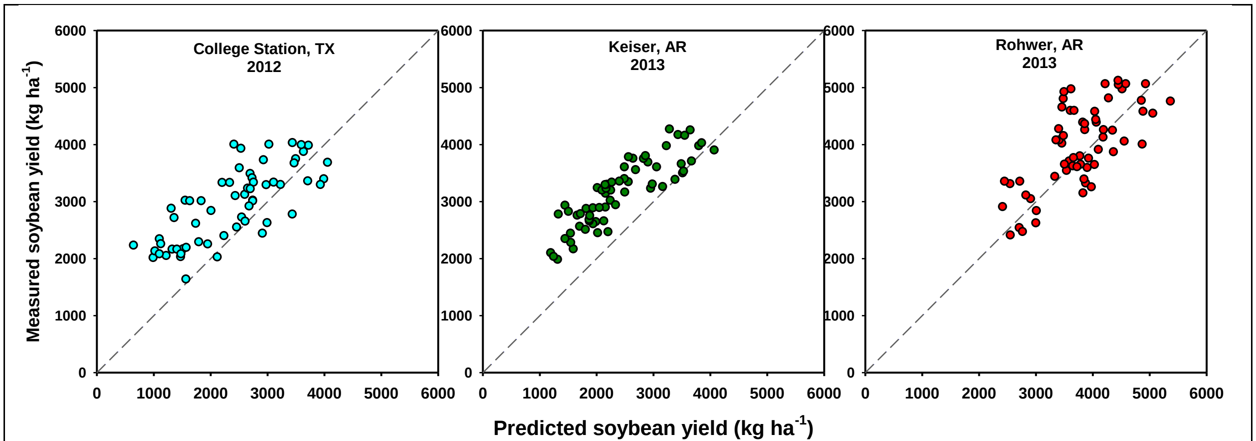

Figure 17: Soybean yield measured in the field and predicted with DSSAT-CROPGRO-Soybean for three location x year combinations and shown by MG. Data includes 4 planting dates and 16 soybean cultivars from MG 3 to 6. The dashed line represents the 1:1 line.

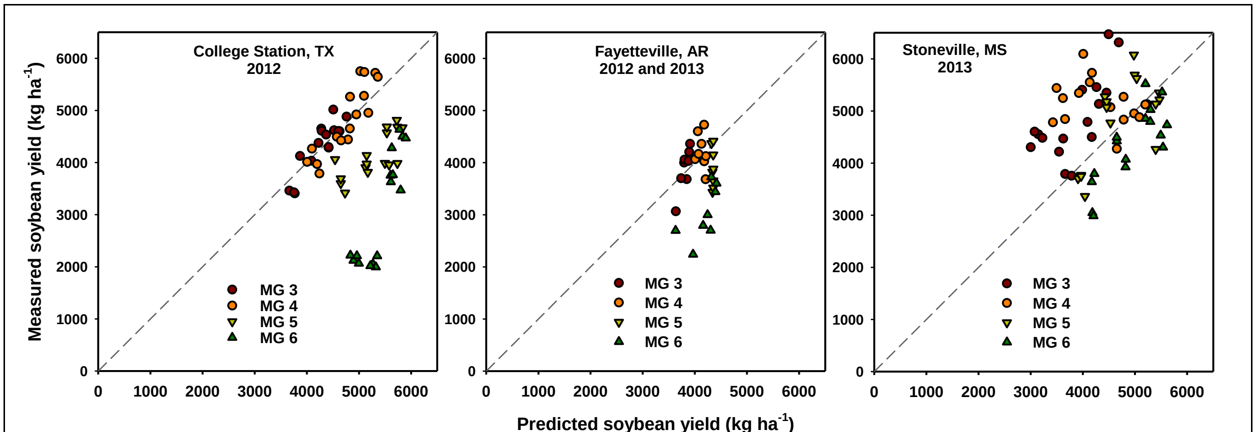

Figure 18: Soybean yield measured in the field and predicted with DSSAT-CROPGRO-Soybean for three location x year combinations and shown by MG. Data includes 4 planting dates and 16 soybean cultivars from MG 3 to 6. The dashed line represents the 1:1 line.

Future plans

✓ Data analysis and documentation of findings:
Given that data from 2014 are still being gathered, analysis of results, publication of research manuscripts and extension material will continue during 2015. The documentation of seed quality across our environments, together with calibration and evaluation of the DSSAT-CROPGRO-Soybean, will be some of our major outcomes from this project.

✓ Economic analysis:
Management decisions of planting date and MG selection will not only influence soybean yield but also management costs associated with irrigation, seed quality, and soybean market price at the time or harvest. Taking these factors into account may affect the best soybean MG recommendations for a given planting date and location. The continuing project in 2015 will include an economic analysis aimed at answering these questions.

✓ Development of a decision-tool:
To move the results of this project into the hands of producers so that they can make informed decisions, we are constructing a software program that provides outcomes on yield, crop development, irrigation needs, expected soybean price at the time of harvest, and economic return. Inputs from users include location, soil texture (silty loam or clay), anticipated planting day, and MG. Results will be obtained from a simulation study for 30 years of weather data and given as averages with confidence intervals and probabilities.

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