Assessing planting date effect on soybean yield and dry-down for different maturity groups and planting dates in Eastern Kansas

Tainá H. da Silva, Venicius E. Pretto, Gabriel da R. Hintz, Eric Adee, Ignacio A. Ciampitti

Summary

The United States (US) ranks as the second-largest global soybean producer. Especially in Kansas, soybean relevance relates to the double-cropped cropped soybean after winter wheat. While this cropping system allows efficient land use, late planting dates may reduce soybean yields. For this reason, understanding the impact of planting dates on yield is crucial for Kansans farming. Our goals were to: i) explore the interaction between planting date and soybean maturity group; and ii) characterize the soybean seed filling and dry-down processes in Kansas. An experiment was carried out in Topeka, under irrigation during the 2023 growing season. Five genotypes and two planting dates (early and late) were tested. Our results showed that delaying the planting date increase moisture lost per growth degrees days (GDD). Furthermore, late planting date requires less GDD than early planting date resulting in faster dry-down, affecting the dry down process. Furthermore, our study showed significant impact of MG for both planting date on seed yield. The highest yields were achieved by MGs 3.4, 3.8 and 4.2, regardless of the planting date, averaging 84, 81 and 90 bu ac^{-1} for early, and 80, 77 and 80 bu ac^{-1} for late planting dates. The shortest and the longest MGs (2.8 and 5.2) presented yield penalizations.

Introduction

The United States holds the position of the world's second-largest soybean producer. In the 2023 season, the total soybean acreage in the country reached 83.5 million acres, with Kansas State contributing to approximately 5% of the national area. (USDA, 2023). The planting window in Kansas spans three months, from early April to early July, with a noticeable reduction in maximum yields of 20 kg ha^{-1} day^{-1}, as planting dates progress later in the season (Ciampitti *et al*., 2022). Moreover, maturity groups III and IV are the most grown throughout central and eastern Kansas, and V and VI are more prevalent in the southeast region (Ciampitti *et al*., 2022).

The optimal soybean harvest moisture is ~13%. Seed moisture under the optimum can result in mechanical damage and a decline in the seed quality (Elmore and Roeth, 1999), and reduction in sealable volume, reducing profits. However, harvesting above the optimum moisture implies incurring additional costs related to drying. Considering these factors, it becomes evident that harvesting around the optimal moisture is essential for seed quality and boost profitability.

The aims of our study are: i) assess the soybean maturity group effect on yield for both early and late planting dates; and ii) explore whether delaying soybean planting date affects soybean dry-down velocity in Eastern Kansas.

Procedures

A field experiment was carried out in Topeka (39°04'38" N, 95°46'05" W) at the *Kansas River Valley Experiment Field* area, during the 2023 growing season. Five genotypes and two planting dates were tested (Table 1). The plot size was set at 45 feet long by 20 feet wide with 8 rows per plot and arranged under a randomized complete block design with five replications for each planting date. Irrigation was employed when the crop showed water stress symptoms.

Table 1. Description of treatments, planting date and genotypes (and maturity groups).

Factor	N (levels)	Treatments
Planting Date	2	May 8th (Early) June 10th (Late)
Genotypes	5	P28A65E (2.8) P34A98E (3.4) P38A28E (3.8) P42A84E (4.2) P52A14SE (5.2)

Weather

Weather data was collected from the Silver Lake station, which is the closest weather station (~ 6.4 miles from the experiment). Figure 1 illustrates the weather characterization for the growing season, including maximum and minimum temperature, precipitation, and irrigation. The minimum temperature recorded was 15.1°F and the highest maximum temperature was 105.6°F, highlighting the intense heat experienced throughout the whole season. The total precipitation for the growing season considering an average crop length among the maturity groups was 13.8 inches and 8.6 inches by irrigation. For the early planting date and 11.2 inches of precipitation and 8.5 by irrigation for the late planting date.

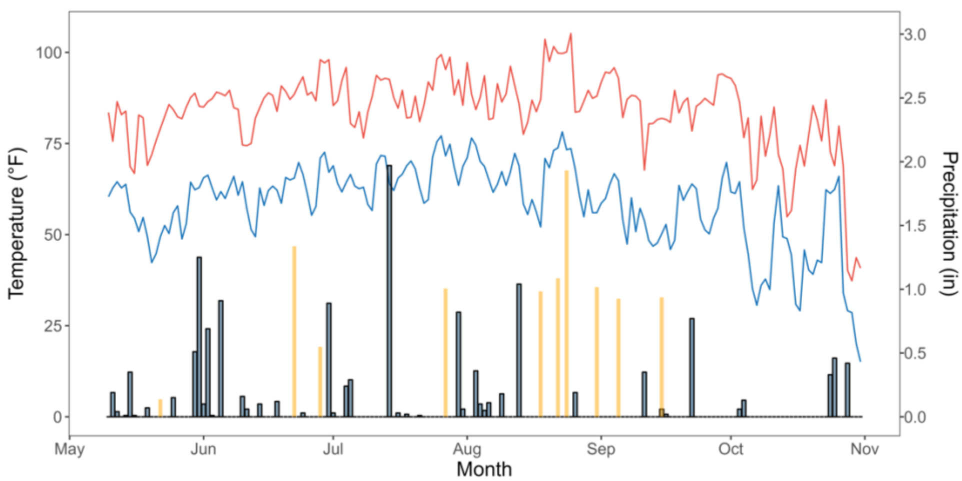

Figure 1. Daily maximum, minimum temperatures, and precipitation at the Silver Lake meteorological station, Topeka. Blue lines stand for minimum temperature, red lines stand for maximum temperature, yellow bars stand for irrigation, blue bars stand for precipitation.

Field sampling and laboratorial process

In order to access the seed moisture content, samplings started at early R5 phenological stage, according to Fehr and Caviness (1971). Pods were collected weekly until the optimum seed moisture to harvest (13 g/100g). The sampling size was one row x 21 in with the number of plants varying from 4 to 6. All the pods from the four uppermost and four lowermost nodes of the main stem were collected, and immediately allocated in a Ziploc bag to avoid moisture losses. In the lab, the pods were placed in a humidified chamber with hot water and only the seeds were kept. Individual samples were composed of all seeds collected from the pods. After, they were weighed to obtain the fresh weight and then dried under 165 °F until constant weight. After it was dried, the dry weight was measured. Seed moisture content was calculated as the difference between the seed fresh and dry weight divided by the fresh weight.

$$Moisture = \frac{(Fresh\,Weight - Dry\,Weight)}{Fresh\,Weight}$$

We calculated Growth Degrees Days (GDD) by the average of the high and low temperatures minus the base temperature to get the daily GDDs. In the sequence, the cumulative GDD was calculated throughout the growing season.

$$GDD = \frac{(Tmax + T\min)}{2} - Tbase$$

Statistical analysis

The yield data analysis was performed using analysis of variance (ANOVA) for each planting date. A generalized linear model was fitted considering the MGs as the predictor variable. A gamma distribution was specified to describe yield. If a significant effect was observed ($P < 0.05$), a Tukey test was performed to compare the means. The moisture data was assessed using a non-linear regression with GDD as the predictor variable, and bootstrap was performed to generate confidence intervals of the parameters of the model. A significant difference of the parameters for different planting dates was observed when 0 was not included in the difference between the parameters (CI 95%). All analysis was performed using *stats*, *car* and *emmeans* packages in R (R Core Team, 2024).

Results

Soybean seed moisture loss

Our results showed that delaying planting increases seed moisture loss rate for all MGs (Figure 2). The average grain moisture loss, in % per GDD, for the dry-down period for each cultivar starting from the shortest to the longest MG was: 0.15, 0.18, 0.18, 0.26, and 0.28 for the early planting date; and 0.24, 0.24, 0.23, 0.61, and 0.50 for the late planting date. Therefore, the faster dry-down for the MGs 4.2 and 5.2 in the late planting date was due to the frost occurrences at the end of the period as low minimum temperatures can be noticed in Figure 1.

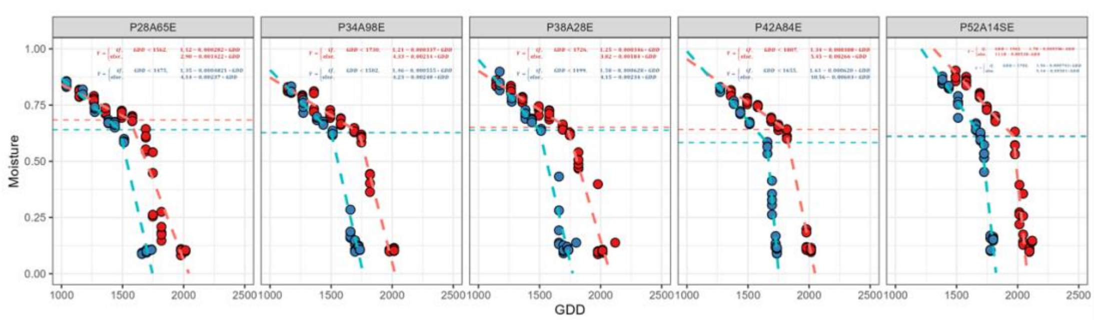

Figure 2. Relationship between moisture loss and accumulated GDD per MG and planting date. Red stands for the early planting date, and blue stands for the late planting date.

Seed yield

The MGs showed a significant impact on yield for both planting dates ($p<0.05$; Figure 3). The highest yields were achieved by the MGs 3.4, 3.8 and 4.2, regardless of the planting date, averaging 84, 81, and 90 bu ac^{-1} for early, and 80, 77, and 80 $bu.ac^{-1}$ for the late planting dates. The shortest and the longest MGs (2.8 and 5.2) presented yield penalizations, averaging 75 and 70 for early, and 61 and 60 $bu.ac^{-1}$ for late planting dates. These results support the most used soybean MGs currently used in Kansas.

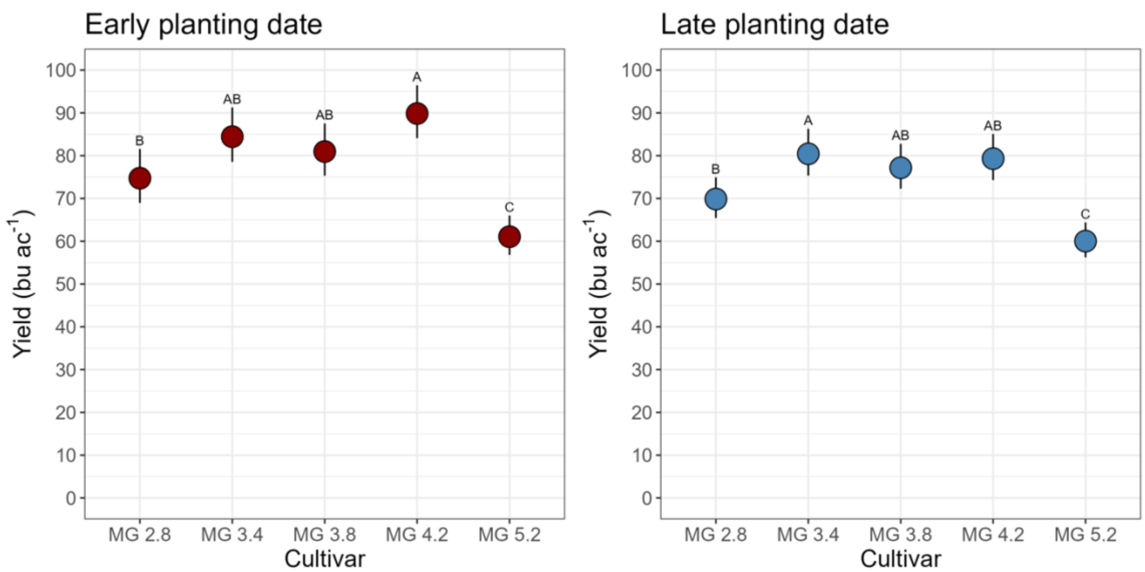

Figure 3. Relationship between yield and cultivars across different maturity groups (MGs) under two planting dates (early, May 8, and late, June 10).

References

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