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What Do We Know About the Impact of Late Planting on U.S. Average Soybean Yield?

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We looked at several issues related to late planting for corn in recent series of *farmdoc daily* articles (April 14, 2022; April 21, 2022; April 28, 2022; May 9, 2022; May 19, 2022). Similar concerns have been raised about delayed planting of soybeans due to cool, wet weather this spring. Based on recent weekly *Crop Progress* reports from the USDA, planting progress for the 2022 U.S. soybean crop has been proceeding at a slower normal pace. As of May 22nd, 50 percent of soybean acreage in 18 major producing states was planted, compared to a 5-year average for this week of 55 percent. Soybean planting has been particularly late in the upper midwestern states of Minnesota, North Dakota, and South Dakota. The purpose of this article is to examine what we know about the relationship between late planting and the U.S. average yield of soybeans.

Analysis

We begin the analysis by considering the beginning date for a significant late planting penalty for soybean yields. There is not complete agreement on the optimum planting window for maximizing soybean yields or the date when late planting begins to impose a substantial yield penalty. Both the optimum window and cutoff date for a significant late planting penalty certainly varies by geographic location. For market analysis purposes, however, it is useful to identify one date for the end of the optimum window that can be applied to the U.S. soybean crop. Acreage planted after that date would be considered to be planted late and yield potential would be expected to be reduced as the percentage of the acreage planted late increases.

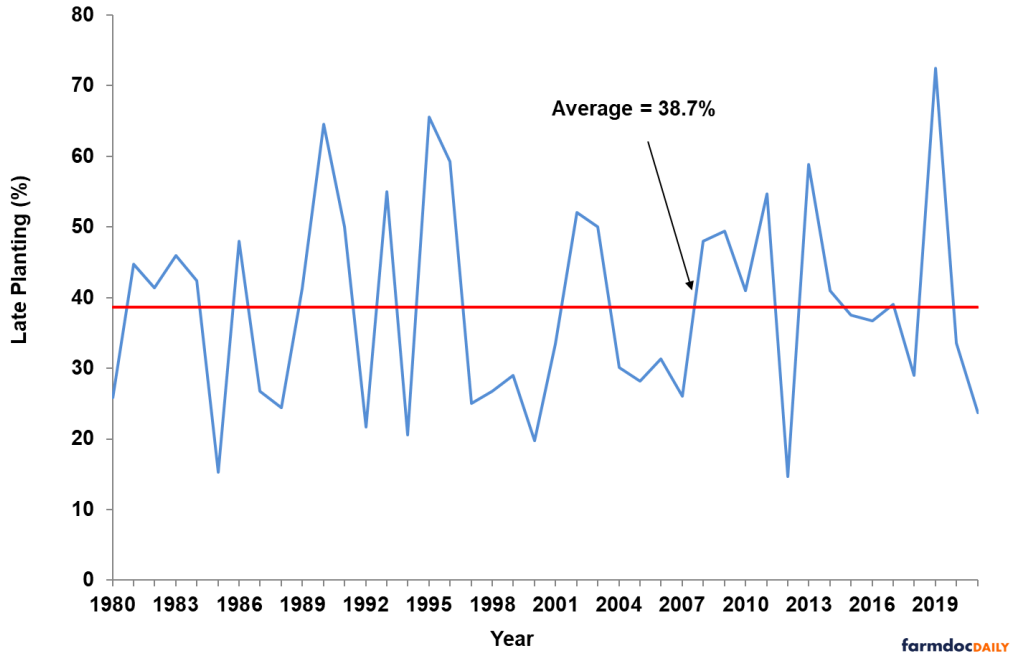
In order to set the late planting cutoff date in our earlier work (*farmdoc daily*, May 2, 2018; June 6, 2019; May 20, 2020), we reviewed information generated from agronomic research relating planting date to soybean yields at the farm-level. Results from soybean planting date research for different years and different locations vary throughout the U.S., but the evidence indicates planting on or before May 1 generally is associated with higher yield. De Bruin and Pederson (2008) provide widely-cited evidence in this regard for Iowa and also highlight earlier studies from the 1980s and 1990s that showed the benefits of earlier planting of soybeans in the upper Midwest of the U.S. Early planting benefits are not limited to

the Midwest. A veritable revolution has occurred in the Mid-South and Delta regions in the last 25 years regarding soybean planting dates (e.g., *farmdoc daily*, May 10, 2017).

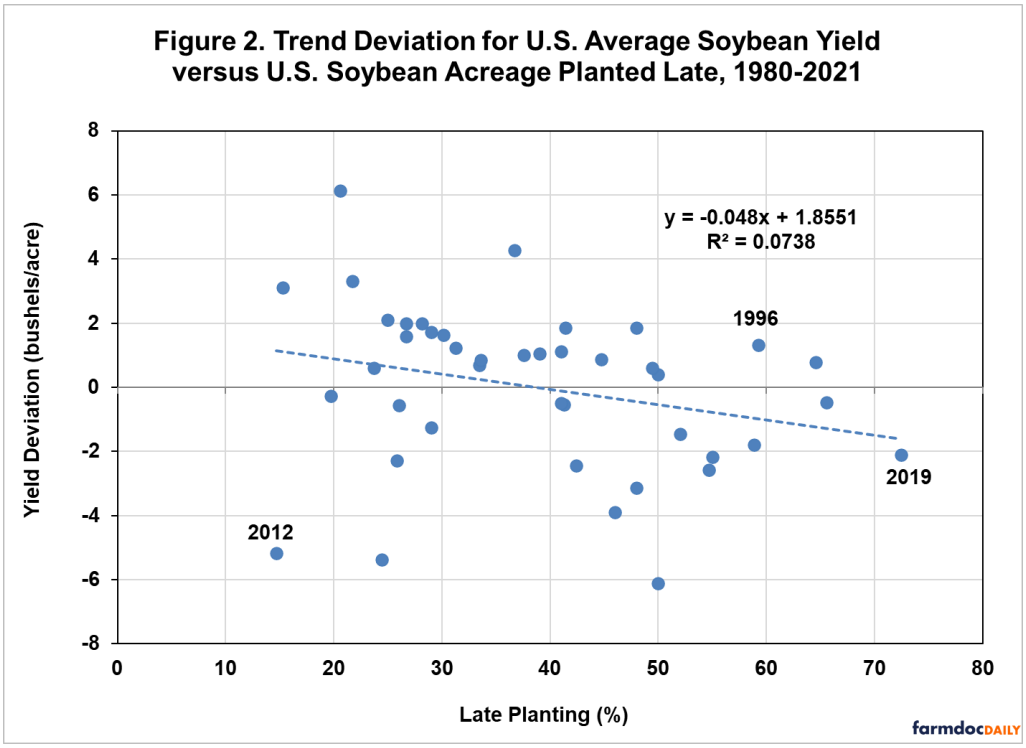
We follow our earlier work and specify the beginning date for substantial late planting penalties on soybean yield in the U.S. to be June 5th from 1980-1985, May 30th from 1986-1999 and May 25th from 2000 forward. One can certainly argue for an earlier cutoff date in later years, e.g., May 10th, in the heart of the Corn Belt based on planting date studies. However, we opt for the May 25th date in light of the large shift in soybean acreage in the far northern parts of the Corn Belt and the later date of the optimal planting windows in these areas. This also keeps the cutoff date for soybean late planting after the cutoff date for corn (May 20th), consistent with the behavior of U.S. farmers in planting the two crops.

Figure 1 shows the percentage of soybeans planted late in the U.S. over 1980-2021 based on the cutoff dates specified above. On average, late planting based on this measure was 39.2 percent, with the bulk of the observations between about 20 and 50 percent. There is no evidence of a trend up or down over time in the late planting percentage using our cutoff dates, which results in a stable measure of late planting. The average level of late planting for soybeans, 38.7 percent, is much higher than for corn, 17.6 percent, that we reported in the *farmdoc daily* article of April 28, 2022. At least half of this difference can be attributed to double-crop planting of soybeans. Late-planted soybean acreage in 2019 came in at the highest total since 1980 with 72 percent remaining to be planted as of May 25. While 2019 was the highest in the sample period, late planting was almost as high in two other years (1990 and 1995). Late planting has been below average in each of the last two years.

Figure 1. U.S. Soybean Acreage Planted Late, 1980-2021



The next step of the analysis is to estimate the impact of late planting on the U.S. average soybean yield. Figure 2 shows the relationship between the trend deviation for U.S. soybean yield and U.S. soybean acreage planted late over 1980 through 2021. The trend deviation is computed based on a quadratic trend for U.S. average soybean yields over this period. The figure shows that, as expected, there is an overall negative relationship between late planting and soybean yield deviations from trend. Specifically, for a 10 percent increase in late planting the U.S. average soybean yield decreases by 0.5 bushels per acre. It is also interesting to consider the implication of the intercept estimate of the regression model. It implies that when late planting is zero the increase in soybean yield above trend is 1.9 bushels. This is the maximum benefit of early planting on the U.S. average yield of soybeans according to this regression model. The maximum loss in yield from high levels of late planting should also be noted. For example, the model predicts that the 72 percent level of late planting in 2019 led to a 1.6 bushel decline below trend for the U.S. average soybean yield.

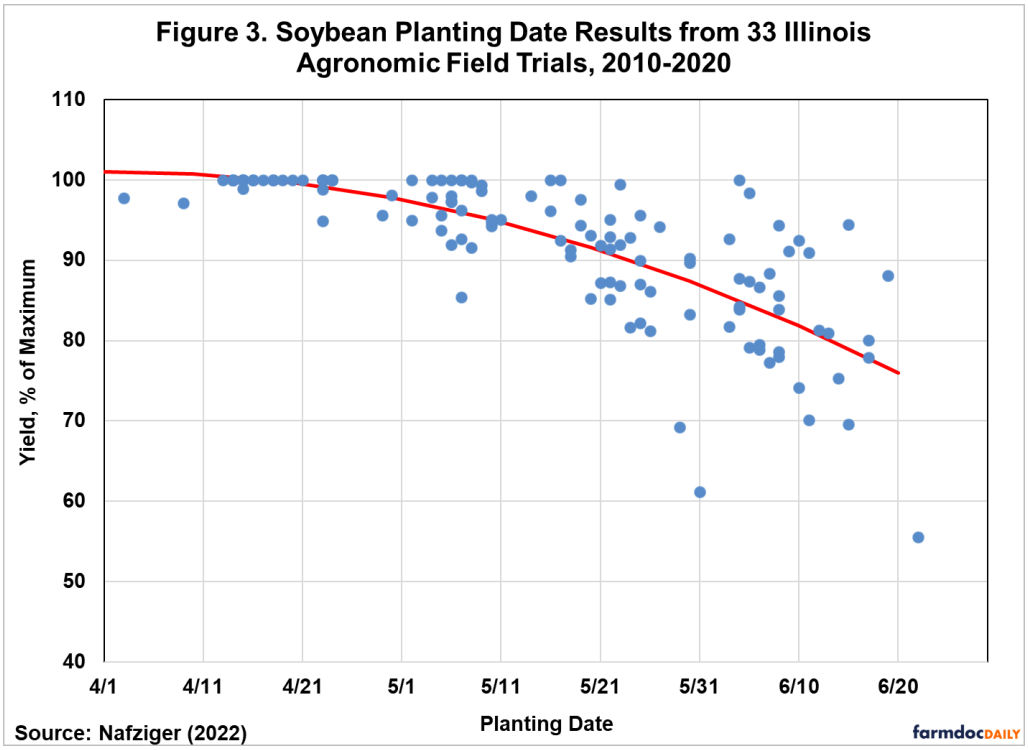


It is important to emphasize that the explanatory power of the regression model in Figure 2 is quite low, as the R2 is only 7.4 percent. Because of this low explanatory power, the regression model in Figure 2 should be treated with a good deal of caution. This does not mean that late planting should be ignored when projecting soybean yield, but rather, other factors, in particular summer weather, are typically more important in explaining deviations from trend yield. Two years provide good examples. Late planting was well above average in 1996 but the soybean yield was still above trend due to favorable summer weather conditions. Conversely, late planting in 2012 was at the low end of the sample range but the soybean yield was extremely low relative to trend due to the severe drought that summer.

Since several factors influence the magnitude of the U.S. average soybean yield in any given year, particularly summer weather conditions, it is important to jointly consider all of the relevant factors in order to quantify the impact of late planting. In technical terms, this means that the regression model in Figure 2 may suffer from "omitted variable bias." We addressed this problem by estimating a crop weather regression model in earlier work (*farmdoc daily*, May 20, 2020) that relates the U.S. average soybean yield to trend, the percentage of the crop planted late, and an array of weather variables. The regression model estimates indicate that the U.S. average soybean yield decreased by 0.7 bushels per acre for each 10 percent of the crop that is planted late, close to the estimate from the simple bivariate model presented in Figure 2.

The overall impression from Figure 2 is there is a surprisingly small impact from late planting on the U.S. average yield of soybeans. Perhaps the best way to illustrate this is to consider the average trend deviation when sorting the data into thirds based on the level of late planting. The one-third of years in the lowest range of late planting (average = 23.4 percent) were on average +0.4 bushels above trend; the one-third of years in the middle of the range of late planting (average = 37.3 percent) were on average +0.9 bushels above trend; and the one-third of the years in the highest range of late planting (average = 55.3 percent) were on average -1.3 bushels below trend. Whether one is in the lowest third of late planting or highest third, the difference in yield deviations, on average, is not much more than one bushel.

We next compare the late planting results found in Figure 2 with agronomic field trials for planting dates in Illinois (*farmdoc daily*, April 14, 2022). Figure 3 presents the results from 33 northern, central, and southern Illinois field trial locations over 2007-2020. Data from these experimental field trials reveal two key patterns. First, there is a relatively wide time window for planting soybeans in Illinois and expecting "normal" yields. This window runs from roughly early April though early May. Second, the yield penalty is non-linear and increases sharply for planting past mid-May, with reductions as large as 20 to 30 percent.



Comparison of Figures 2 and 3 reveals the same puzzling difference in results as we found in corn (*farmdoc daily*, April 28, 2022; May 9, 2022). Specifically, the estimated size of late planting impacts from regression studies is linear and fairly small when compared to the non-linear and large late planting impacts based on agronomic field trials. We previously hypothesized several possible reasons for the differences (*farmdoc daily,* May 9, 2022):

1. The planting trial results are reported as the percentage of maximum yield in a test location for a given year, which is not the same as deviation from trend yield. The maximum trial yield in any year can be far above or below trend yield for the state or the entire U.S., and the maximum varies across trial locations. This creates an inherent apples and oranges problem when comparing results from the two types of studies.

2. The planting trial results are site-specific within Illinois, while the data used in regression studies are state or national averages. State or national average observations may still be at too high of a level of aggregation to accurately reflect impacts at a local level.

3. The explanatory power of planting date in field trial studies is not as high as commonly perceived. This means there is a wide variation in the yield outcome in field trials for a particular planting date, especially the later the planting date. The lesson is that there is a wide potential range of yield outcomes on a given planting date even in field trials.

4. There may be a small sample problem with state or national aggregate data used in regression studies. As shown in Figure 2, there are only a handful of years with late planting greater than 60 percent. These are the years where we would expect late planting impacts to be large, mirroring the non-linear impacts found for very late planting dates in the field trial studies. It may be the case that summer weather was better than average simply by chance in this small handful of years. This was certainly the case in 2019, which was a record year for late planting. If we assume that field trial data is the best available, this means in the future we should expect to see a cluster of years with high levels of late planting and large negative deviations below trend yield. At that point, the aggregate data used in regression studies would show a similar non-linear relationship as is found in field trial studies.

Implications

In this article, we examine what we know about the impact of late planting on the U.S. average soybean yield. Late planting is defined for as the percentage of the U.S. soybean crop planted after June 5th from 1980-1985, May 30th from 1986-1999, and May 25th from 2000 forward. We then estimate a regression model between soybean acreage planted late and trend deviations for the U.S. average soybean yield over 1980 through 2021. The results indicate a 10 percent increase in late planting decreases the U.S. average soybean yield by about 0.5 bushels per acre. Overall, the impact of late planting is rather modest, causing the national soybean yield to deviate above or below trend by no more than one bushel in most years. Other factors, namely summer weather, dominate the impact of late planting in determining the national average soybean yield. Based on latest planting progress data from the USDA, it appears that U.S. soybean acreage planted late (after May 25th) this year will be somewhat higher than average. However, the increased level of late planting is not likely to be large enough to necessitate a downward adjustment in the U.S. average soybean yield forecast for 2022.

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