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Forming Expectations About 2008 U.S. Corn and Soybean Yields—Application of Crop Weather Models that Incorporate Planting Progress

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INTRODUCTION

In the current environment of strong domestic and export demand, relatively low world stocks, and historically high prices, the expected size of the 2008 U.S. corn and soybean crops takes on added significance. The market's expectation about the prospective size of the crops will have a major influence on prices for the next three months. Production will obviously be determined by the magnitude of planted acreage, the resulting acreage harvested, and by average yield. Typically, expectations about planted and harvested acreage are solidified with the USDA's June *Acreage* report. That is not he case this year, however, due to widespread flooding and replanting in Illinois, Indiana, Iowa, Minnesota, Missouri, and Wisconsin. A special USDA survey in those areas in July will provide a clearer picture of planted and harvested acreage in the USDA's August *Crop Production* report.

Corn and soybean yield prospects are always uncertain and that uncertainty is magnified this year due to much of the crop being planted later than usual, extensive flood damage, and extensive replanting in some areas. The purpose of this brief is to evaluate 2008 yield potential for corn and soybeans in Illinois, Indiana, and Iowa using previously developed crop weather models that estimate the impact of technology (trend) and state average monthly weather variables on state average yield (Tannura, Irwin, and Good 2008a,b). Models are first re-estimated to better capture the influence of May precipitation and late planting, and then used to project state average yields in the three states under varying weather scenarios. The projected yields in those states are next used to project U.S. average yields. Finally, based on USDA's projection of harvested acreage in the June *Acreage* report, projections of the size of the 2008 corn and soybean crops are made for the various weather scenarios.

PLANTING DATES AND YIELD

Among the many factors, other than weather, that can influence corn and soybean yields, planting date has been demonstrated as important (Egli 2008). There are, however, two aspects of planting date that may be important for yields. One is the trend toward earlier planting that is thought to contribute to the overall trend increase in yields. Figure 1 illustrates the trend toward earlier planting of corn and soybeans in Illinois. Compared to 1965, corn and soybean planting in Illinois in 2005 was started and completed about two weeks earlier.

The second aspect of the planting date influence on yields is the timeliness of planting in a given year. Agronomic research reveals that "late" planting in a given year generally results in lower yields than timely planting (Pecinovksy and Benson 2001; Nafziger 2008; Nielsen 2008). Figures 2 and 3 are representative of results from agronomic experiments investigating the effect of planting date on corn and soybean yields. In central Illinois, for example, average corn yields are not found to be substantially different for planting dates ranging from early April to early May. Yields, however, generally decline at an accelerating rate for planting dates after early May. In central Iowa, average soybean yields are not found to be substantially different for planting dates ranging from late April to early June. Yields generally decline sharply, however, for planting dates after mid-June.

Planting date results from agronomic experiments are widely used as a guide to planting decisions by farmers. This is sensible for individual farmers in a given year because the experiments carefully isolate planting date impacts by holding other production factors constant. However, experimental results do not necessarily provide good estimates of actual planting date impacts for large-areas, such as states or regions. The first reason is that planting in any given year is spread over several weeks, with some acres planted in a timely fashion and some planted late. The second reason is that spring and summer growing season weather varies substantially from year-to-year. Nielsen (2008) notes that yield loss estimates from agronomic experiments are relative to the maximum yield possible in a given year. The variation in maximum yield due to variation in growing season weather can easily swamp the impact of planting delays.

An alternative approach is to partition the effect of planting date on state average yields over time using a crop weather model. This is also challenging due to uncertainties about the specification of planting date variables, and consequently, few attempts have been made to estimate the impact of planting date on state average yields. Kucharick (2008) recently investigated the relationship between state average corn yields, planting dates, and monthly average weather variables over 1979 through 2005 for 12 Corn Belt states. Results were mixed, but generally showed that earlier planting explained a significant proportion of corn yield trends in the western and northern Corn Belt. Kucharick did not delineate the impact of earlier planting dates over time versus late planting in any given year. In addition, the study used a relatively short sample period, projected planting progress for dates before actual planting progress data were available in some years, and imposed a linear relationship between yield and precipitation variables.

STATE LEVEL PLANTING PROGRESS

The U.S. Department of Agriculture (USDA) provides a weekly assessment of cumulative state corn planting progress, expressed as the percentage of the crop planted, in the *Crop Progress* report. Planting progress data for 1979 through 2007 are available at the USDA's Quick Stats web site (www.nass.usda.gov/QuickStats). For years before 1979, planting progress information is available in the *Weekly Weather and Crop Reports* from individual states. Since 1979, weekly planting progress has been reported for all states as of the week ended on Sunday. Prior to that, the week-ending date was Monday for Illinois and Iowa. The week ending date for Indiana was Saturday for 1960-1966, Friday for 1967-1976, and Sunday for 1977-1978.

There are at least two dimensions needed to describe corn and soybean planting progress over time. The first is the trend towards earlier planting dates. To measure this trend, we compute the number of days before or after May 1st that state planting progress reaches 50%. The calendar date of 50% completion is estimated by linear interpolation for the week in which 50%

completion was reached. This is expected to be a more robust measure of trends in planting progress than the measure used by Kucharik (2008), since non-zero planting progress is nearly always reported for the week before and after 50% progress is reached. Kucharik computes the calendar date when 10% planting progress is reached. In some years, the first reported data on planting progress is larger than 10%, which implies that the 10% date is projected without knowledge of actual planting progress in the previous week.

Figures 4 and 5 show the number of days before or after May 1st that 50% corn and soybean planting progress, respectively, is reached in Illinois, Indiana, and Iowa over 1960 through 2007. Positive observations on the vertical axis indicate the number of days after May 1st that 50% planting progress is reached and negative observations indicated the number of days before May 1st. While there has been substantial annual variation in planting progress in each state, a clear trend towards earlier planting is evident. Since 1960 in Illinois, for example, the trend line indicates that the 50 percent completion date moved from about May 20th to about May 1st for corn and from about May 30th to May 20th for soybeans. Similar changes occurred in Indiana and Iowa. In general, the 50 percent progress date in these three states is now about 20 days earlier for corn and 10 days earlier for soybeans than in 1960.

Kucharik (2006, 2008) suggests that a key factor underlying the move to earlier corn planting is a desire to increase the likelihood that higher yielding full season hybrids will reach maturity before the first killing frost. Other factors contributing to earlier planting of corn include a shift toward tillage in the fall, conservation tillage, the development of hybrids with a higher tolerance to suboptimal growing conditions, seeds coated with temperature active polymers, increased resistance to disease and pests, and improved equipment (planter) functioning. Since soybeans in the Midwest are generally planted after the completion of corn planting, earlier planting of corn has resulted in earlier planting of soybeans.

As a side note, while planting has been occurring earlier in Illinois, Indiana, and Iowa, there is little evidence that the crop is being planted more rapidly in these states. The speed of planting is not central to the study at hand, but is more of a curiosity. There are a number of ways to depict the speed of planting progress during the season. One way is the percent of the crop planted during the peak planting week each year. This measure should reflect the combined impact of weather, management practices, and planting equipment capacity. Those percentages are reported in Figures 6 and 7 for corn and soybeans, respectively, in Illinois, Indiana, and Iowa. Contrary to conventional wisdom, there is no trend toward planting a larger percent of corn or soybeans in the peak week since 1960. These results are consistent with those of Kucharik (2006), who reported that the average number of days from 10% to 75% corn planting progress tended to *increase* slightly over 1979 to 2005 in 12 Corn Belt states. Taken together, the evidence suggests that weather is likely the major determinant of planting speed rather than equipment size. Finally, it is interesting to note that average peak progress in both corn and soybeans is somewhat higher for Iowa compared to Illinois and Indiana.

The second dimension of planting progress is the “lateness” of planting in a given year. Measuring the magnitude of late planting is complicated by three issues. The first is the changing yield penalty as planting dates become progressively later. Based on the response curves presented in Figures 2 and 3, separate variables representing the percentage of the crop planted in each 10-day interval could be specified. This would likely lead to over-parameterized models and imprecise parameter estimates. Estimation would be further complicated by the positive correlation between such variables. The second issue is that the definition of "lateness" has undoubtedly changed over the sample period. It is reasonable to assume that the trend towards earlier planting dates documented in Figures 4 and 5 goes hand-in-hand with changing experimental evidence on optimal planting dates. The third issue is that planting date impacts are already represented to some degree in the crop weather models via May precipitation variables. It is not surprising that the correlation between measures of the lateness of corn and soybean planting and May precipitation range from about 0.5 to 0.6 in Illinois, Indiana, and Iowa.

A two-pronged approach was adopted to represent late plantings in each year of the sample. The first part of the approach was to change the specification of May precipitation from a linear to a quadratic form in the crop weather model. Tannura, Irwin, and Good (2008a) report negative coefficients for May precipitation in all three states for corn and soybeans. This implies that the optimal amount of May precipitation is zero, a result that seems unrealistic upon reflection. A quadratic specification is more logical, as it allows the relationship between May precipitation and corn and soybean yields to exhibit declining yields if too little or too much precipitation is received. When excessive precipitation is observed in May this will presumably lead to planting delays and yield declines.

The second part of the approach was to include a variable in the crop weather models to represent corn and soybeans planted towards the end of the windows represented in Figures 2 and 3. The underlying logic is that May precipitation "picks up" the yield impact of planting dates for corn and soybeans through most of May, but an additional variable is needed to reflect the sharp drop in yield for corn and soybeans planted in the last third of the planting windows considered in agronomic experiments. An issue in specifying this variable is that the definition of "late" may need to be adjusted over the sample period. What was considered late based on agronomic experiments in 2007 may not have been late in 1960.

Two sources were consulted about changing agronomic recommendations for corn and soybeans planting dates since 1960. First, *Illinois Agronomy Handbooks* were available going back to 1968. The *Handbooks* always emphasized "early" planting of corn in Illinois, with the definition changing over time. The most notable change occurred in the early 1980s, when recommendations focused on *completing* corn planting by early May. Previously the focus was on *starting* to plant corn by mid-April. There was little change in recommendations for soybeans, with the main thrust that farmers should complete soybean plantings in the month of May. Second, Pecinovsky and Benson (2001) report results of soybean planting date studies in Iowa from 1976 through 2001. Planting date recommendations from 1976-1980 are about a week later than recommendations for 1992-2001, but the main finding is that sharp reductions in soybean yields are observed starting in early June.

The available history of agronomic planting date recommendations confirms a trend towards earlier planting of corn and soybeans in the Corn Belt. However, a definitive change in the recommendations is not obvious. Recommendations for corn did appear to emphasize earlier planting starting in the mid-1980s. Based on this information, the late planting variable for corn is defined as the percentage planted after May 30th over 1960-1985 and after May 20th over 1986-2007. For soybeans, late planting is defined as the percentage planted after June 10th for the entire 1960-2007 sample period. These variables are plotted in Figures 8 and 9 for corn and soybeans, respectively. There is almost no trend in any of the late planting variables, indicating that the specifications of "lateness" are stable over time. The charts also indicate that the percentage of corn and soybeans planted late is low in most years and a handful of years have very high values. Late plantings in corn and soybeans are highly correlated between Illinois and Indiana (about 0.80), but not between Iowa and Indiana (about 0.30), likely reflecting the variability in spring weather patterns moving from east to west across the Corn Belt.

PLANTING PROGRESS AND STATE AVERAGE YIELDS

The crop weather models developed by Tannura, Irwin, and Good (2008a,b) were re-estimated using state-average corn yields in Illinois, Indiana, and Iowa over 1960-2007. The original model specifications were based on the well-known work of Thompson (e.g., 1969 1970). A linear time trend variable was used as a proxy for technology. Weather variables included total pre-season precipitation (September-April) and May through August monthly precipitation and temperature. Pre-season precipitation and all temperature variables were included in linear form, while May through August precipitation was included in quadratic form. Two planting date variables were initially included in the model: 1) the date relative to May 1st when planting progress reached 50 percent, and 2) the percentage of the crop planted after May 30th over 1960-1985 and after May 20th over 1986-2007 for corn and the percentage of the crop planted after June 10th over 1960-2007 for soybeans.

Initial estimation results revealed that signs were inconsistent in both corn and soybeans for the variable reflecting the date relative to May 1st when planting progress reached 50 percent. In no case was the estimated coefficient statistically significant. This result implies that the impact of the trend towards earlier planting over time in corn and soybeans, while important, is fully captured in the linear technology trend variable. In contrast, Kucharik (2008) reports that it is possible to disentangle the impact of planting date from other factors that impact the overall trend in corn yields, with the trend in planting date explaining a significant proportion of corn yield trends in the western and northern Corn Belt. Our results are consistent with Egli's (2008) argument that it is impossible to accurately disentangle the plant modification, management, and environmental changes that contribute to yield trends.

Final models deleted the variable reflecting the date relative to May 1st when planting progress reached 50 percent. Estimation results for the final models are presented in Tables 1 and 2 for corn and soybeans, respectively. The results indicate that the models explained 95% of the variation in corn yields for the three states and between 89 and 91% of the variation for soybeans. In line with Tannura, Irwin, and Good's original results, the estimates in Table 1 revealed that corn yields in the three states were particularly affected by technology, the magnitude of precipitation during June and July, and the magnitude of temperatures during July and August. Similarly, Table 2 revealed that soybean yields in the three states were most affected by technology, the magnitude of precipitation during June through August, and the magnitude of temperature in August.

As discussed in the previous section, a two-pronged approach was adopted to represent impact of planting progress on corn and soybean yields. A quadratic specification for May precipitation is assumed to "pick up" the yield impact of planting dates for corn and soybeans through most of May and an additional "late" variable is used to reflect the sharp drop in yield for corn planted after May 20th (May 30th before 1986) and soybeans planted after June 10th. As illustrated in Panel A of Figure 10, the results confirm that excessive precipitation in May reduces corn yields in all three states, although yield penalties are not large until levels of precipitation become extreme. For example, corn yield in Illinois is estimated to drop 7 bushels per acre when May precipitation equals 7 inches, a total reached only four times over 1960-2007. The x's indicate that average May precipitation in each state is slightly greater than the optimum. Panel B of Figure 10 indicates that estimation results for soybeans are less consistent, which perhaps is not surprising given that soybean planting dates typically stretch across both May and June. The shape of the relationship for soybeans is as expected only for Indiana. May precipitation has virtually no impact in Illinois and the impact is always negative for Iowa.

The coefficient for the late planting variable has the anticipated sign (negative) in each state for both crops (see also Figures 11 and 12). For corn, however, the coefficient is small and statistically insignificant except for Iowa, where each one percent of the crop planted late results in a 0.32 bushel reduction in the state average yield. The estimated reduction in Illinois and Indiana is only 0.04 and 0.01 bushels, respectively. For soybeans, late planting has a statistically significant impact on state average yield in Illinois and Indiana. The magnitude of the coefficients are similar for all three states, with each one percent of the soybean crop planted late reducing the state average yield by 0.07 to 0.09 bushels.

The estimated impact of planting progress on state average yields of corn and soybeans is modest compared to the results of agronomic research and in comparison to general perception. The primary explanation of the modest impact is that crops are planted throughout the planting date window. Even in "late-planted" years, much of the crop is planted in a timely fashion and, as Nielsen (2008) points out, summer growing season weather dominates.

MODEL PROJECTIONS FOR 2008

The crop weather models estimated over 1960-2007 and presented in Tables 1 and 2 are used to project state average yields for 2008 in the three states under varying weather scenarios. The alternative weather scenarios and resulting state average yield forecasts for Illinois, Indiana, and Iowa are generated as follows:

(1) Unadjusted trend forecasts for 2008 are based on trend-only regressions estimated over 1960-2007.
(2) Average weather trend forecasts for 2008 are based on the crop weather regressions presented in Tables 1 and 2. Average values of the late planting and weather variables for 1960-2007 are used to forecast yields for 2008.
(3) Actual weather to date and average July-August weather forecasts for 2008 are based on the crop weather regressions presented in Tables 1 and 2. Actual values for late planting, preseason precipitation, May precipitation, and May temperature in 2008 are used. Preliminary June precipitation and June temperature in 2008 are used. Average values of July and August precipitation and temperature for 1960-2007 are used.
(4) Unfavorable July and August weather forecasts for 2008 are based on the crop weather regressions presented in Tables 1 and 2. Actual values for late planting, preseason precipitation, May precipitation, and May temperature in 2008 are used. Preliminary June precipitation and June temperature in 2008 are used. Values one standard deviation below average over 1960-2007 are used for July and August precipitation and values one standard deviation above average over 1960-2007 are used for July and August temperature.
(5) Favorable July and August weather forecasts for 2008 are based on the crop weather regressions presented in Tables 1 and 2. Actual values for late planting, preseason precipitation, May precipitation, and May temperature in 2008 are used. Preliminary June precipitation and June temperature in 2008 are used. Values one standard

deviation above average over 1960-2007 are used for July and August precipitation and values one standard deviation below average over 1960-2007 are used for July and August temperature.

Panel A in Table 3 presents the state average forecasts for corn and soybeans under the different weather scenarios. The unadjusted trend yield forecasts in column 1 can be thought of as the unconditional trend measured across all weather patterns observed during the sample period. The forecasts for 2008, then, are based on linear trends fit to actual state average yields from 1960 through 2007. This is probably the most widely used measure of trend yields, with varying sample periods used to estimate the trend.

The average weather trend yield forecasts in column 2 indicate the trend yields that would be projected if neither favorable nor unfavorable weather occurred. The trend is calculated by assuming average temperature and precipitation over 1960-2007 occurs for each month in 2008. It is significant that the trend yield projections based on average weather assumptions are higher than projections based on the unadjusted trend that reflects actual weather conditions during the sample period. That is, yields expected from average weather conditions are higher than expectations based on the unconditional trend. The explanation is found in the fact that unfavorable weather reduces yield much more than favorable weather increases yield. The unconditional trend is lower than the average weather trend because of occurrences of unfavorable weather during the sample period.

The yields forecasts in columns 3, 4, and 5, indicate the yield projections based on actual 2008 planting progress, actual weather through June, and alternative assumptions about weather for July and August as summarized above. With average weather for July and August, yield projections for both crops in all three states are higher than the unadjusted trend projections. Corn yield forecasts based on average summer weather are lower than the average weather trend forecasts, as is the Iowa soybean yield forecast. The forecasts of soybean yields in Illinois and Indiana assuming average summer weather, however, are higher than the average weather trend forecasts. Very unfavorable weather conditions in July and August result in very low yield projections for both crops in all three states, while the assumption of very favorable weather results in very high forecasts. All forecasts assume no unusual weather event outside of the variables included in the model, such as an early, widespread freeze in September.

There is, of course, great interest in the impact of planting progress on corn and soybean yields in 2008. A useful way of capturing this impact is to compute the combined affect of May precipitation and late planting in the crop weather models under two scenarios: 1) average levels of the two variables over 1960-2007, and 2) 2008 levels. The information needed to compute the combined impact for 2008 is presented in Table 4. Relative to average levels, corn yields in 2008 are estimated to drop 2.9, 3.5, and 6.3 bushels per acre in Illinois, Indiana, and Iowa, respectively, due to May precipitation and late plantings. Relative to average levels, soybean yields in 2008 are estimated to drop 1.1, 0.4, and 1.0 bushels per acre in Illinois, Indiana, and Iowa, respectively, due to May precipitation and late plantings. The magnitude of the yield declines due to slow planting progress in 2008 are relatively small due to the fact that May precipitation, while high, was not extremely high, and the magnitude of late planting, while above average, was considerably less than previous highs (see Figures 8 and 9). It is important to keep in mind that these estimates do not take into account the impact of replanting due to flooding in some areas of Illinois, Indiana, and especially, Iowa during June 2008.

U.S. yield and production forecasts for 2008 are developed in Panel B of Table 3. Alternative yield forecasts are developed and applied to the forecast of harvested acreage reported in the USDA's June *Acreage* report to generate a production forecast. The unadjusted trend yield forecasts for both corn and soybeans in column 1 are based on trend-only regressions of actual U.S. average corn and soybean yields estimated over 1960-2007, the same methodology as used for unadjusted state trend forecasts. Since crop weather forecasts are only available for Illinois, Indiana, and Iowa, a procedure for projecting U.S. yields under various weather scenarios based on these state level forecasts was developed. The first step was to calculate a simple average of the three state forecasts. The second step was to adjust the three-state average by the average ratio of the three-state average yield to national average yield over the last 10 years. Since Illinois, Indiana, and Iowa typically represent at least 40% of U.S. production this ratio is fairly stable and averaged 1.079 for corn and 1.158 for soybeans over 1998-2007 (dropping 2003 for soybeans). As an example of the adjustment procedure consider the scenario of the average weather trend for corn. The simple average of the three state yield forecasts is 171.8 bushels. Divided by 1.079, that average projects to a U.S. average yield of 159.2 bushels.

As an additional U.S. yield benchmark, forecasts based on July 1st crop condition ratings were are also generated. The crop conditions forecasts are based on regressions of the sum of good and excellent ratings reported by the USDA in the final *Crop Progress* report of the season over 1986-2007 on trend-adjusted yields. Those regression estimates for 2008 are as follows:

U. S corn yield = 112.75 + 0.6507 X percent rated good or excellent

U. S. soybean yield = 31.634 + 0.194 X percent rated good or excellent

The sum of good and excellent crop conditions as of June 29, 2008 was 61 percent for corn and 58 percent for soybeans suggesting yield potential of 152.4 bushels for corn and 42.9 bushels for soybeans.

The various models result in a wide range in the U.S. yield forecasts for both corn and soybeans. Corn yield forecasts range from 129.3 to 163.8 bushels and the soybean yield forecasts range from 37.8 to 45.3 bushels. As a result, production forecasts are also in a wide range, from 10.204 billion to 12.930 billion bushels for corn and 2.723 billion to 3.269 billion for soybeans. However, the forecasts based on the crop weather model that incorporates weather through June and assumes average weather in July and August and forecasts based on crop condition ratings at the end on June are remarkably close. That is as expected since the two models presumably incorporate the same weather and crop conditions to date. A U.S. corn crop near 12 billion bushels and a soybean crop near 3.1 billion now appear most likely.

Production expectations for both crops, however, remain very uncertain for at least three reasons. First, the magnitude of harvested acreage is not yet known. Second, remaining summer weather is not known. Third, the crop yield models have relatively large forecast errors. Figure 13 illustrates the range in state yield forecasts for the various weather scenarios that fall within one standard error of the mean forecast. The standard errors are based on the out-of-sample forecast errors generated by Tannura, Irwin, and Good (2008a). Those yield ranges are quite large due to the size of the standard errors, which are about 20 bushels per acre for corn and 4 bushels per acre for soybeans.

Finally, note that, with the exception of the unfavorable July and August weather forecasts, these yield and production expectations exceed those of the USDA's World Agricultural Outlook Board. The *World Agricultural Supply and Demand Estimates* (WASDE) report released on July 11, 2008 estimated 2008 U.S. corn yield potential at 148.4 bushels per acre and production at 11.715 billion bushels. Soybean yield potential was estimated at 41.6 bushels per acre and production at 3 billion bushels.

REFERENCES

Egli, D.B. "Comparison of Corn and Soybean Yields in the United States: Historical Trends and Future Prospects." *Agronomy Journal* 100(2008):S79-S88

Kucharik, G.J. "Contribution of Planting Date Trends to Increased Maize Yields in the Central United States." *Agronomy Journal* 100(2008):328-336.

Kucharik, G.J. "A Multidecadal Trend of Earlier Corn Planting in the Central USA." *Agronomy Journal* 100(2006):1544-1550.

Nafziger, E. "Thinking About Corn Planting Date and Population." *The Bulletin*, No. 2, Article 7, University of Illinois Extension, April 4, 2008). [http://www.ipm.uiuc.edu/bulletin/article.php?id=890]

Nielsen, R.L. "Corn Planting Date is Important, But…" Corny News Network Articles, Department of Agronomy, Purdue University, April 12, 2008. [http://www.kingcorn.org/news/articles.08/PltDate-0412.html]

Pecinovsky, K., and G.O. Benson. "Twenty-Six Years of Soybean Planting Date Studies." ISRFO1-13, Northeast Research and Demonstration Farms, Iowa State University, 2001. [http://www.ag.iastate.edu/farms/2001reports/ne/Twentysixyearsofsoybean.pdf]

Tannura, M.A., S.H. Irwin, and D.L. Good. "Weather, Technology, and Corn and Soybean Yields in the U.S. Corn Belt." Marketing and Outlook Research Report 2008-01, Department of Agricultural and Consumer Economics, February 2008a.

Tannura, M.A., S.H. Irwin, and D.L. Good. "Are Corn Trend Yields Increasing at a Faster Rate?" Marketing and Outlook Brief 2008-02, Department of Agricultural and Consumer Economics, February 2008b.

Thompson, L.M. "Weather and Technology in the Production of Corn in the U.S. Corn Belt." *Agronomy Journal* 61(1969):453-456.

Thompson, L.M. "Weather and Technology in the Production of Soybeans in the Central U.S." *Agronomy Journal* 62(1970):232-236.

Table 1. Regression Estimates of Crop Weather Models for Corn Yield in Illinois, Indiana, and Iowa, 1960 - 2007

	Coefficient Estimates		
Independent Variable or Statistic	**Illinois**	**Indiana**	**Iowa**
Constant	274.96 ***	249.34 ***	382.69 ***
	(3.33)	(3.02)	(4.47)
Annual Time Trend	1.97 ***	1.79 ***	2.06 ***
	(20.43)	(17.09)	(21.51)
Late Planting	-0.04	-0.01	-0.32 **
	-(0.28)	-(0.12)	-(2.11)
Preseason Precipitation	0.39	0.13	1.01 **
	(1.06)	(0.33)	(2.28)
May Precipitation	1.97	3.89	4.33
	(0.57)	(0.95)	(0.66)
May Precipitation²	-0.37	-0.64	-0.63
	-(1.00)	-(1.45)	-(0.92)
June Precipitation	16.28 ***	16.20 ***	8.16
	(3.50)	(3.97)	(1.60)
June Precipitation²	-1.75 ***	-1.78 ***	-0.79
	-(3.50)	-(3.81)	-(1.68)
July Precipitation	14.23 **	13.69 ***	17.66 ***
	(2.13)	(3.67)	(5.55)
July Precipitation²	-1.10	-1.07 ***	-1.75 ***
	-(1.44)	-(2.91)	-(5.47)
August Precipitation	3.81	13.41 **	4.54
	(0.65)	(2.08)	(1.56)
August Precipitation²	-0.39	-1.48 *	-0.30
	-(0.53)	-(1.87)	-(1.11)
May Temperature	0.34	0.16	-0.52
	(0.86)	(0.43)	-(1.09)
June Temperature	0.38	-0.11	-0.89
	(0.54)	-(0.16)	-(1.38)
July Temperature	-2.20 ***	-1.95 ***	-2.46 **
	-(2.90)	-(2.86)	-(3.46)
August Temperature	-2.41 ***	-1.95 ***	-1.80 **
	-(4.30)	-(3.47)	-(3.13)
R^2	0.95	0.95	0.95
Standard Error (bu./acre)	7.73	7.47	8.36
Regression F-statistic	40.93 ***	38.92 ***	40.60 ***

Note: The figures in parantheses are t-statistics. One, two, and three stars denote statistical significance at the 10%, 5%, and 1% levels, respectively. Monthly precipitation variables are stated in inches, monthly temperature variables are stated in degrees Farenheit, and late planting is measured as the % planted after May 30th from 1960-1985 and after May 20th from 1986-2007.

Table 2. Regression Estimates of Crop Weather Models for Soybean Yield in Illinois, Indiana, and Iowa, 1960 - 2007

	Coefficient Estimates					
Independent Variable or Statistic	**Illinois**		**Indiana**		**Iowa**	
Constant	45.62	*	19.17		25.90	
	(1.76)		(0.75)		(0.83)	
Annual Time Trend	0.40	***	0.41	***	0.48	***
	(12.36)		(10.06)		(12.73)	
Late Planting	-0.08	*	-0.09	***	-0.07	
	-(1.72)		-(2.77)		-(1.03)	
Preseason Precipitation	0.18		0.15		0.36	*
	(1.50)		(1.25)		(2.24)	
May Precipitation	-0.15		1.49		-1.51	
	-(0.14)		(1.18)		-(0.65)	
May Precipitaiton^2	0.03		-0.15		0.10	
	(0.22)		-(1.09)		(0.42)	
June Precipitation	1.34		4.48	**	2.73	
	(0.93)		(3.58)		(1.48)	
June Precipitaiton^2	-0.10		-0.43	*	-0.23	
	-(0.63)		-(3.00)		-(1.32)	
July Precipitation	3.04		3.78	**	3.38	***
	(1.47)		(3.26)		(2.95)	
July Precipitation^2	-0.24		-0.34	***	-0.34	***
	-(0.99)		-(3.01)		-(2.94)	
August Precipitation	2.60		2.99		3.74	***
	(1.43)		(1.50)		(3.58)	
August Precipitation^2	-0.21		-0.26		-0.28	***
	-(0.94)		-(1.05)		-(2.87)	
May Temperature	-0.04		-0.03		-0.05	
	-(0.33)		-(0.29)		-(0.30)	
June Temperature	0.21		0.05		0.35	
	(0.91)		(0.25)		(1.50)	
July Temperature	-0.08		-0.11		-0.39	
	-(0.36)		-(0.53)		-(1.50)	
August Temperature	-0.62	**	-0.25		-0.24	
	-(3.57)		-(1.44)		-(1.17)	
R^2	0.91		0.93		0.89	
Standard Error (bu./acre)	2.40		2.31		3.02	
Regression F-statistic	22.07	***	29.48	***	17.71	***

Note: The figures in parantheses are t-statistics. One, two, and three stars denote statistical significance at the 10%, 5%, and 1% levels, respectively. Monthly precipitation variables are stated in inches, monthly temperature variables are stated in degrees Farenheit, and late planting is measured as the % planted after June 10th.

Table 3. Alternative Forecasts of 2008 Yield and Production for U.S. Corn and Soybeans

Crop/State or Crop/ Production Component	(1) Unadjusted Trend Model	Crop Weather Model (2) Average Weather Trend	(3) Actual To Date and Average July-August Weather	(4) Unfavorable July-August Weather	(5) Favorable July-August Weather	(6) July 1st Crop Conditions Model
Panel A. State Yield Forecasts						
Corn						
Illinois (bu./acre)	159.8	173.2	169.4	147.0	185.9	NA
Indiana (bu./acre)	153.2	165.5	153.3	131.1	166.4	NA
Iowa (bu./acre)	163.7	176.6	165.4	140.4	178.0	NA
Soybeans						
Illinois (bu./acre)	46.5	47.4	48.3	42.6	52.2	NA
Indiana (bu./acre)	47.7	48.6	49.1	44.7	51.2	NA
Iowa (bu./acre)	49.0	51.8	50.9	43.8	54.0	NA
Panel B. U.S. Production Forecasts						
Corn						
Yield (bu./acre)	150.7	159.2	150.8	129.3	163.8	152.4
Harvested Acres (mil. acres)	78.9	78.9	78.9	78.9	78.9	78.9
Production (mil. bu.)	11,896	12,565	11,901	10,204	12,930	12,027
Soybeans						
Yield (bu./acre)	41.4	42.5	42.7	37.8	45.3	42.9
Harvested Acres (mil. acres)	72.1	72.1	72.1	72.1	72.1	72.1
Production (mil. bu.)	2,983	3,068	3,079	2,723	3,269	3,093

Notes: NA denotes 'not applicable.' Unadjusted trend forecasts for 2008 are based on trend-only regressions estimated over 1960-2007. The next four 2008 forecasts are based on the crop weather regressions presented in Tables 1 and 2. The last forecast is based on a crop conditions regression model. See the text for a detailed explanation of each forecast. Harvested acres are taken from the USDA's June 2008 *Acreage* report.

Table 4. Estimated Impact of Planting Progress on 2008 Corn and Soybean Yields in Illinois, Indiana, and Iowa

Crop/State	Average May Precipitation (inches)	Average Late Planting (%)	2008 May Precipitation (inches)	2008 Late Planting (%)	Combined 2008 Yield Impact (bu./ac)
Corn					
Illinois	4.3	13.7	5.8	21.6	-2.9
Indiana	4.4	21.3	5.7	28.6	-3.5
Iowa	4.3	9.2	5.9	18.6	-6.3
Soybeans					
Illinois	4.3	15.7	5.8	32.0	-1.1
Indiana	4.4	20.6	5.7	25.0	-0.4
Iowa	4.3	8.5	5.9	12.0	-1.0

Notes: Average May precipitation and average late planting are computed over 1960-2007. Late planting is the percentage of the crop planted after May 30 over 1960-1985 and after May 20 over 1986-2007 for corn and the percentage of the crop planted after June 10 over 1960-2007 for soybeans. 2008 yield impacts combien

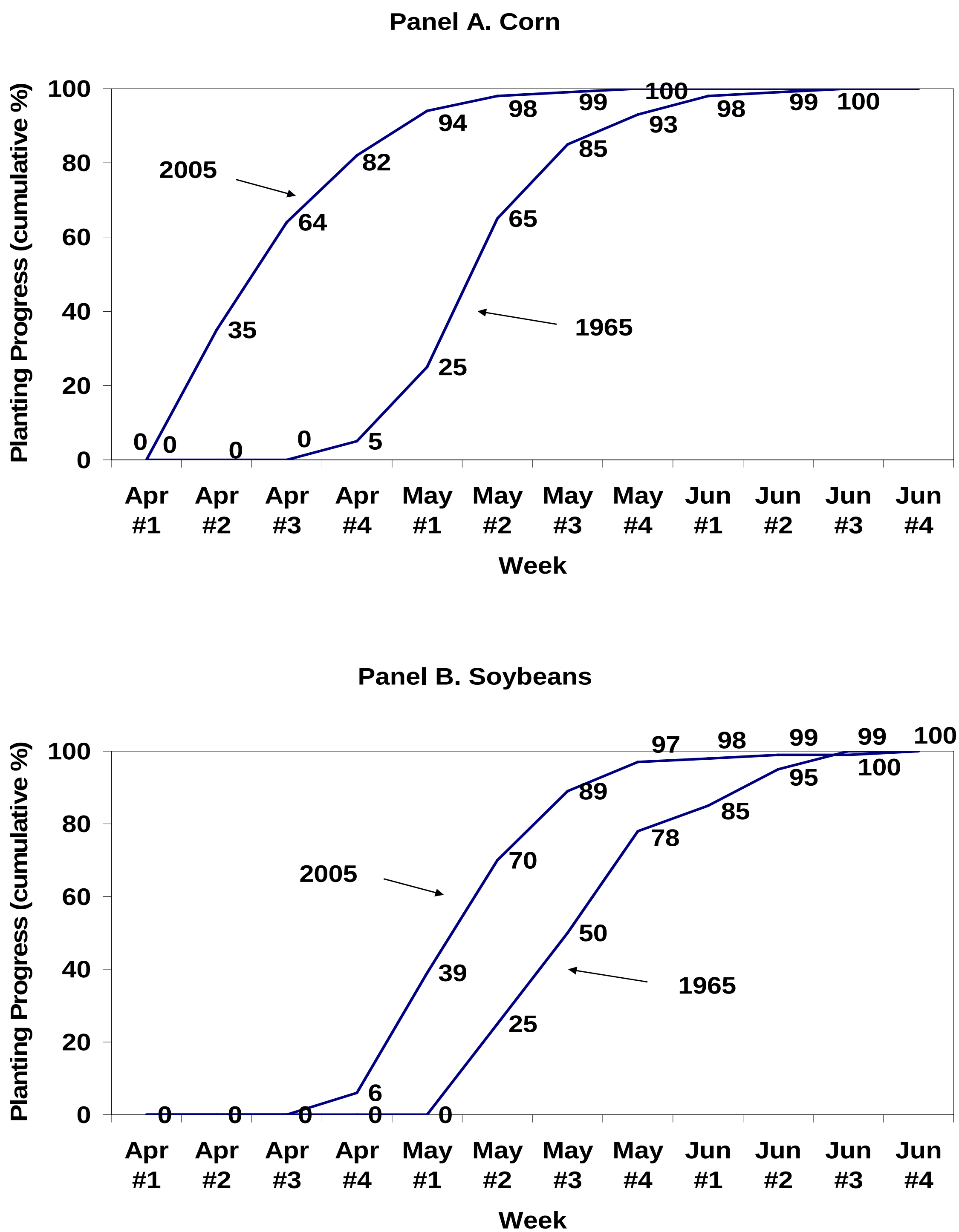

Figure 1. Comparison of Illinois Corn and Soybean Planting Progress in 1965 and 2005

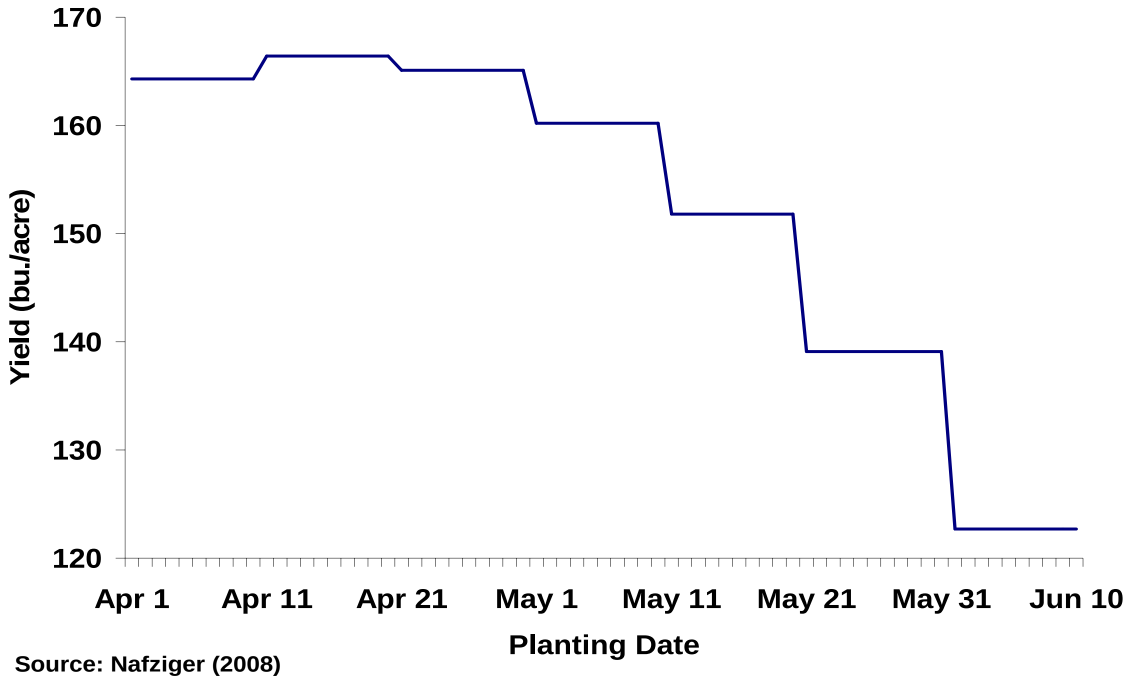

Figure 2. Response of Corn Yield in Central Illinois to Planting Date

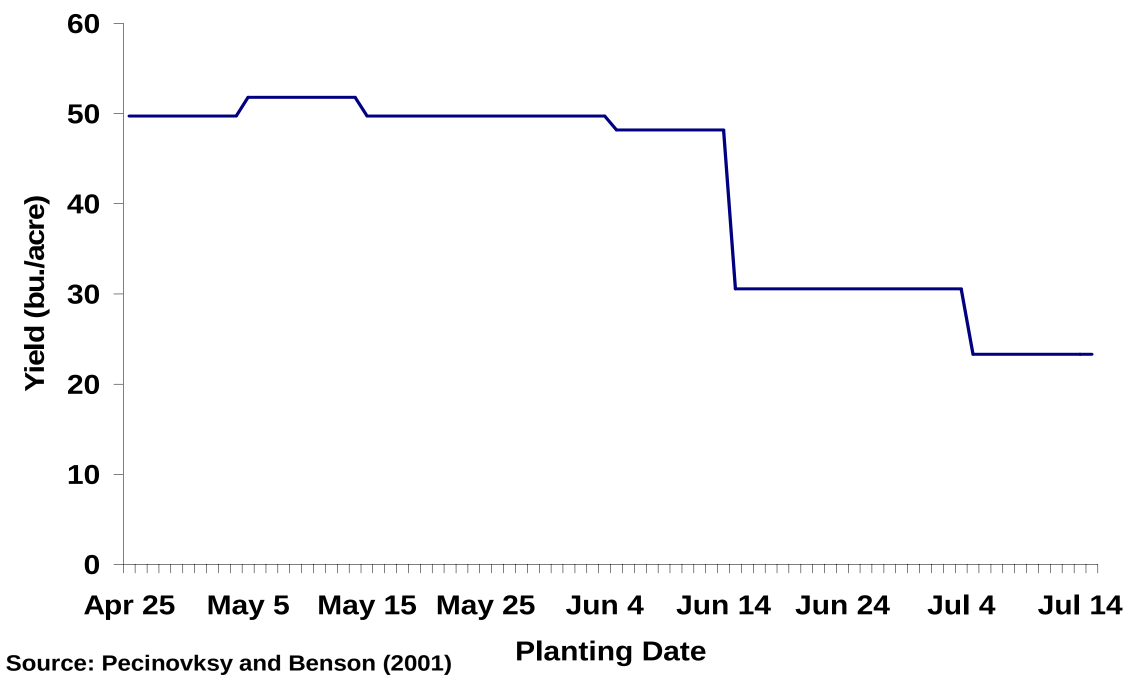

Figure 3. Response of Soybean Yield in Central Iowa to Planting Date

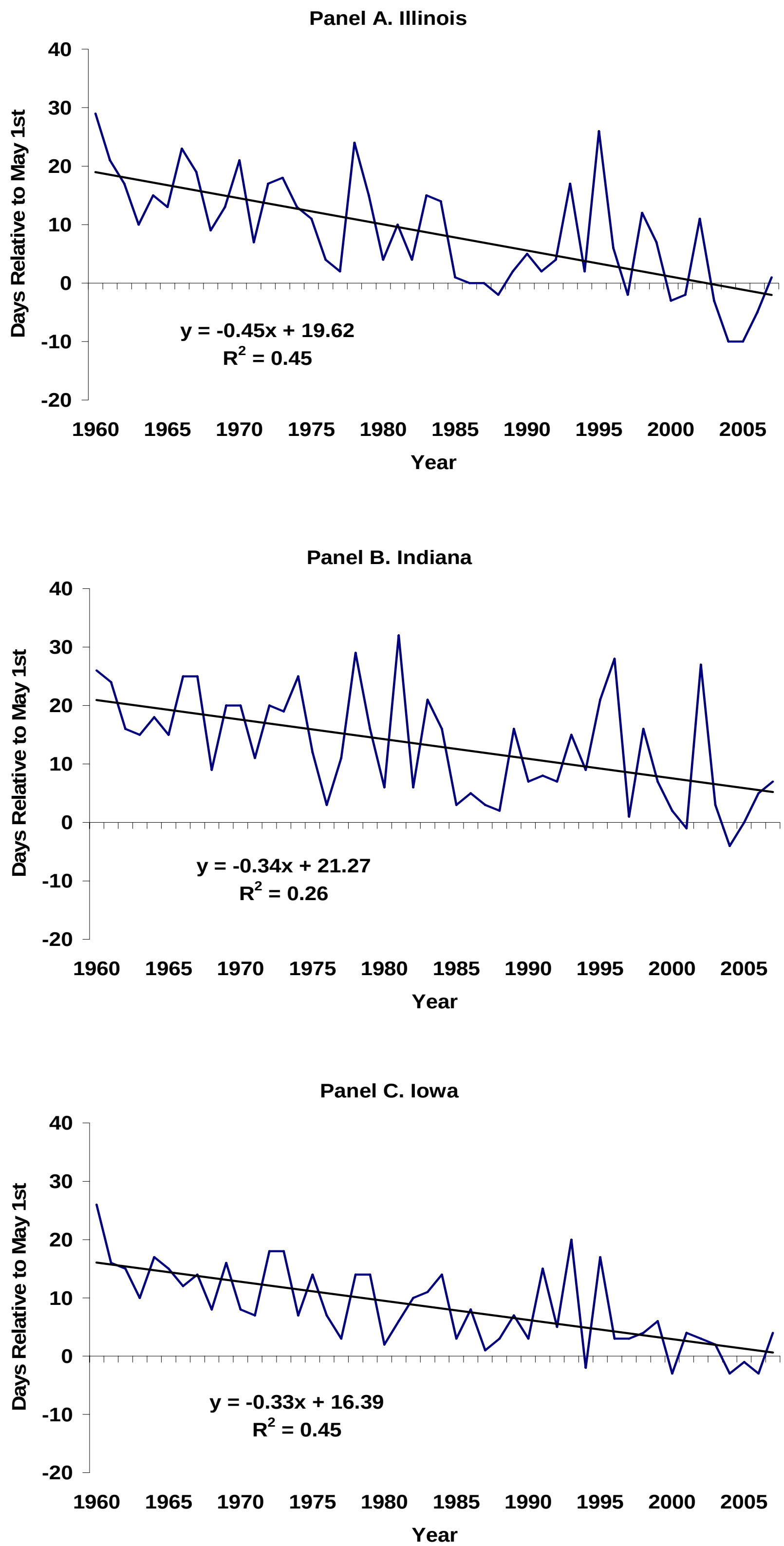

Figure 4. Number of Days Before (-) and After (+) May 1st that 50% Corn Planting Progress is Reached in Illinois, Indiana, and Iowa, 1960 - 2007

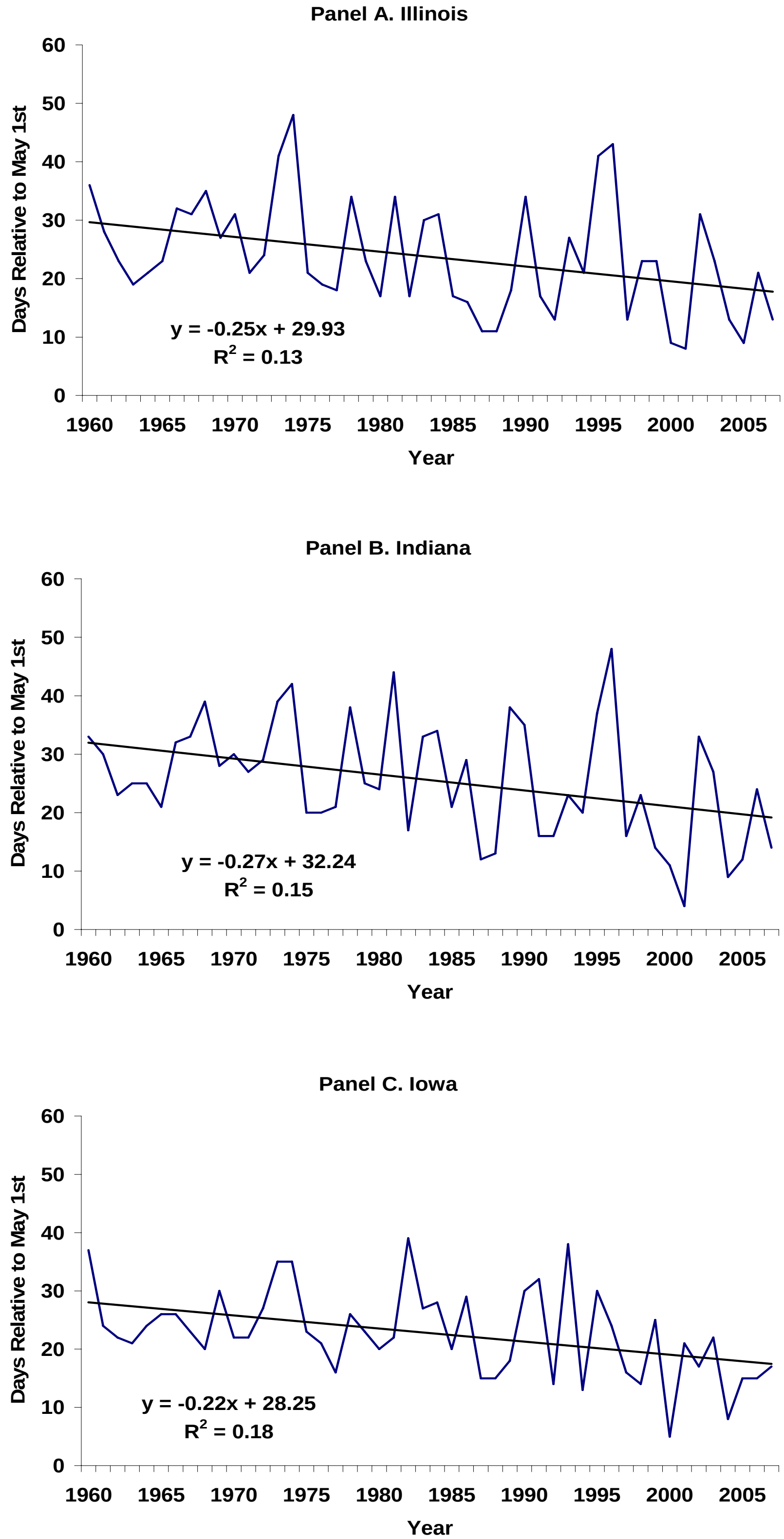

Figure 5. Number of Days Before (-) and After (+) May 1st that 50% Soybean Planting Progress is Reached in Illinois, Indiana, and Iowa, 1960 - 2007

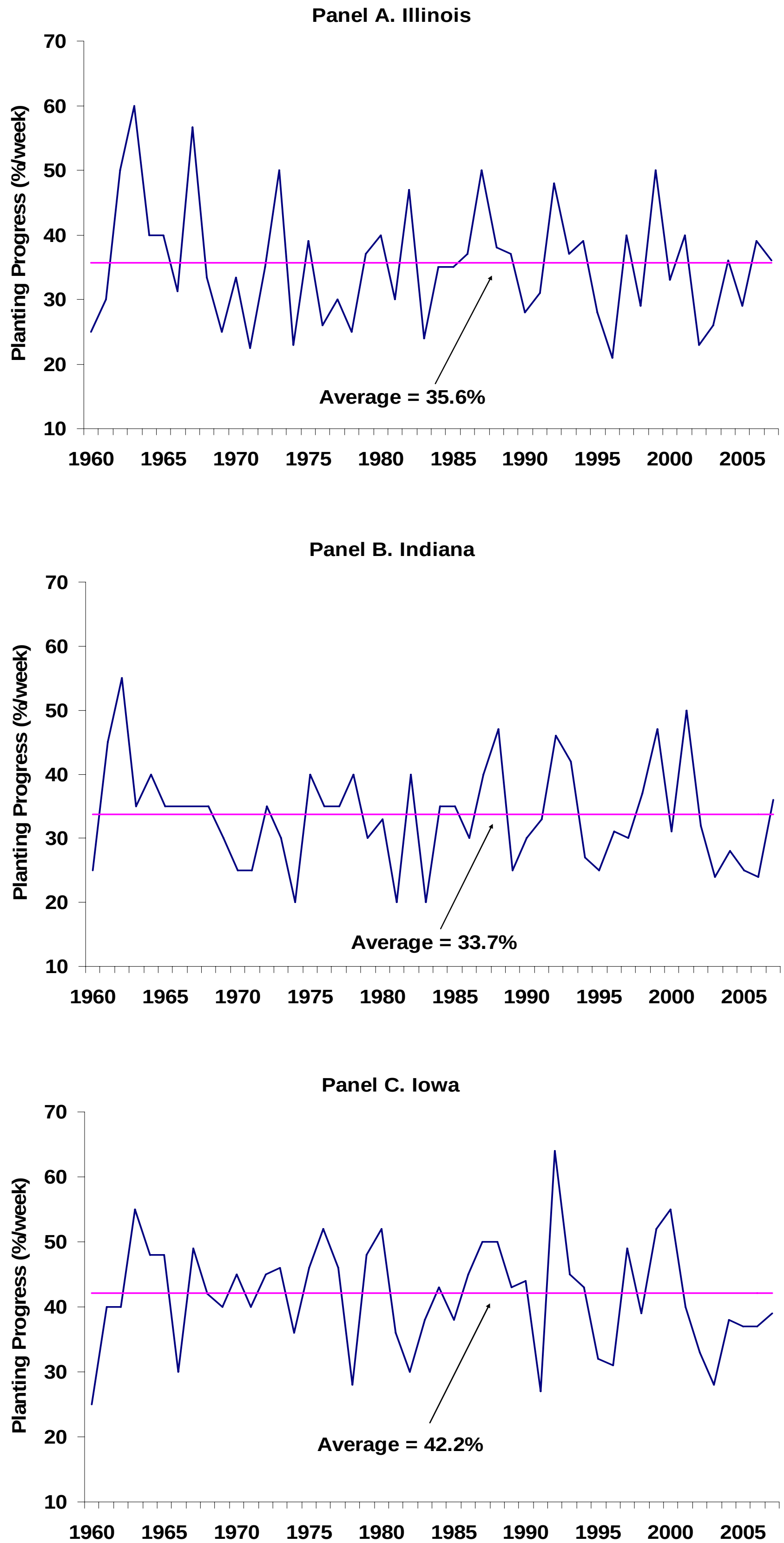

Figure 6. Maximum Corn Planting Progress in a Single Week for Illinois, Indiana, and Iowa, 1960 - 2007

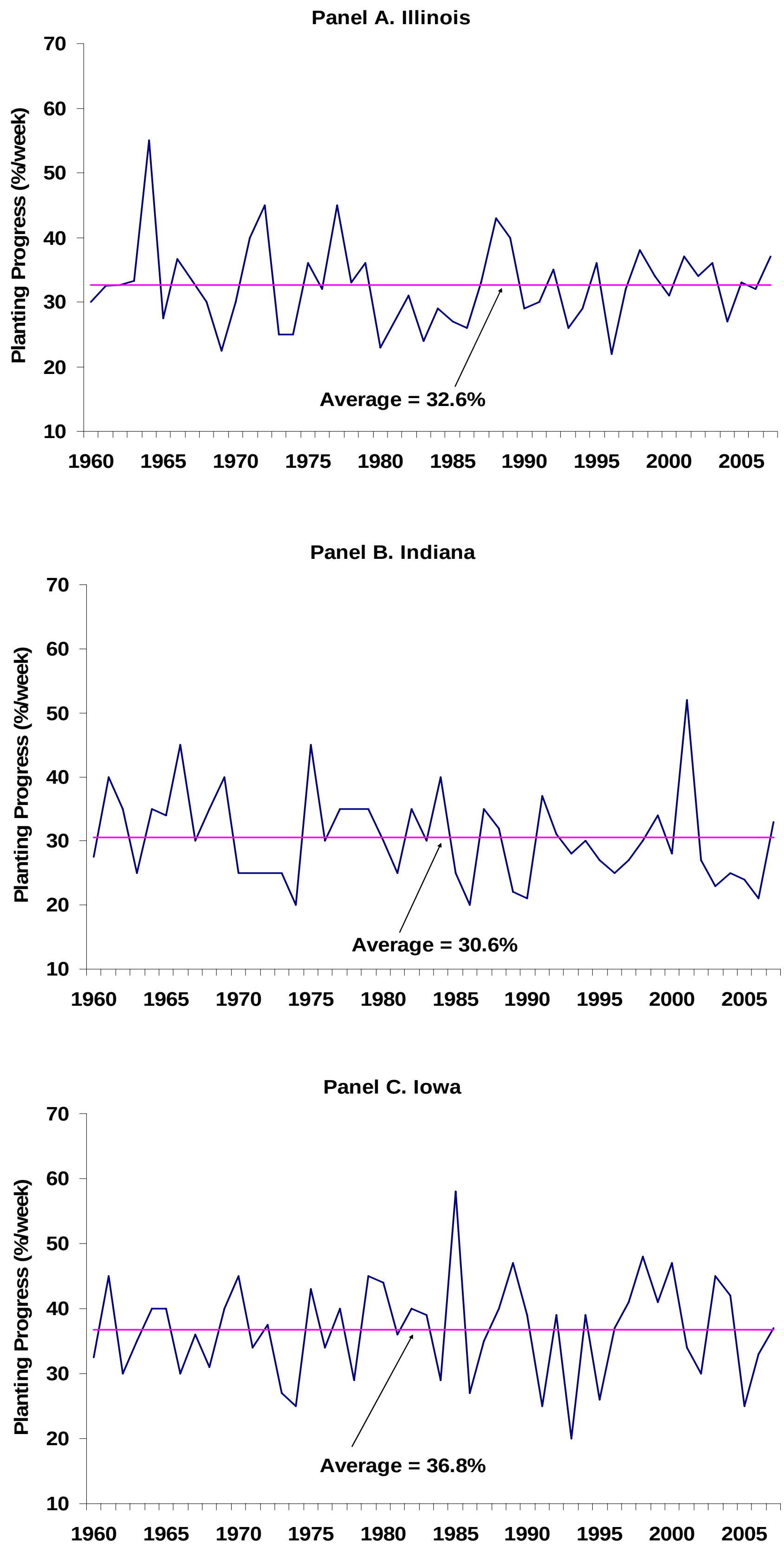

Figure 7. Maximum Soybean Planting Progress in a Single Week for Illinois, Indiana, and Iowa, 1960 - 2007

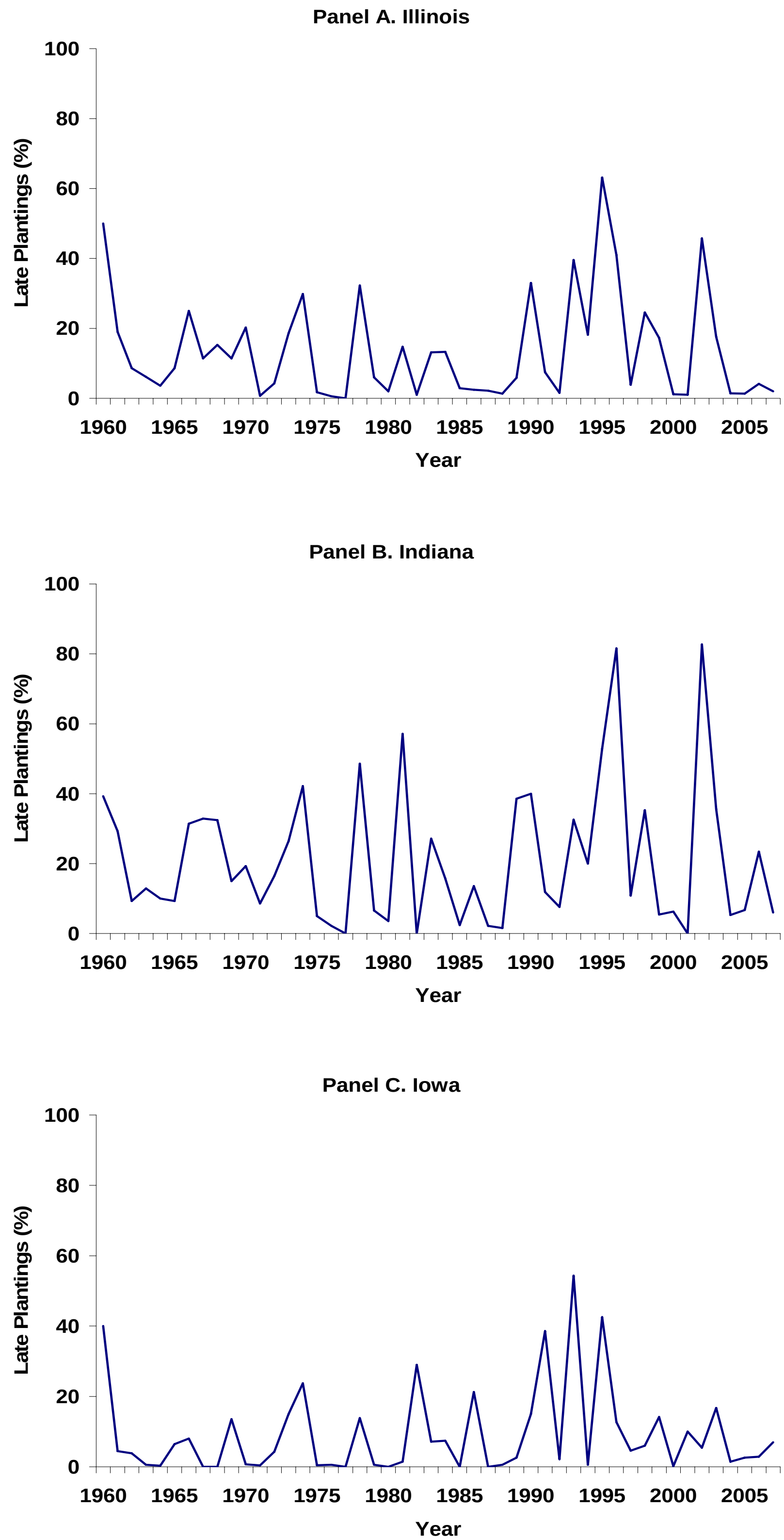

Figure 8. Percent Late Planted Corn (1960 - 1985: after May 30th; 1986 - 2007: after May 20th) in Illinois, Indiana, and Iowa, 1960 - 2007

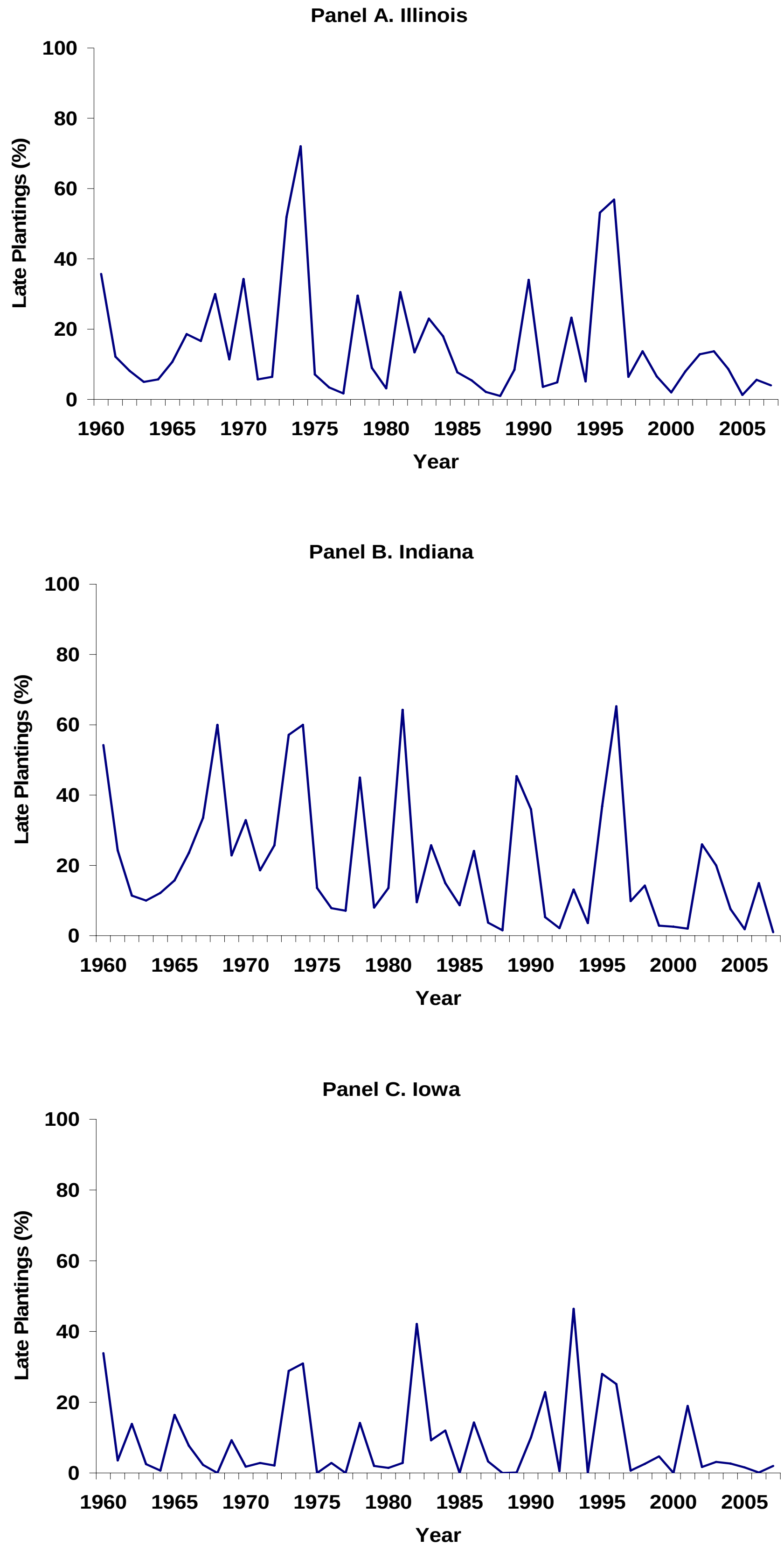

Figure 9. Percent Late Planted Soybeans (after June 10th) in Illinois, Indiana, and Iowa, 1960 - 2007

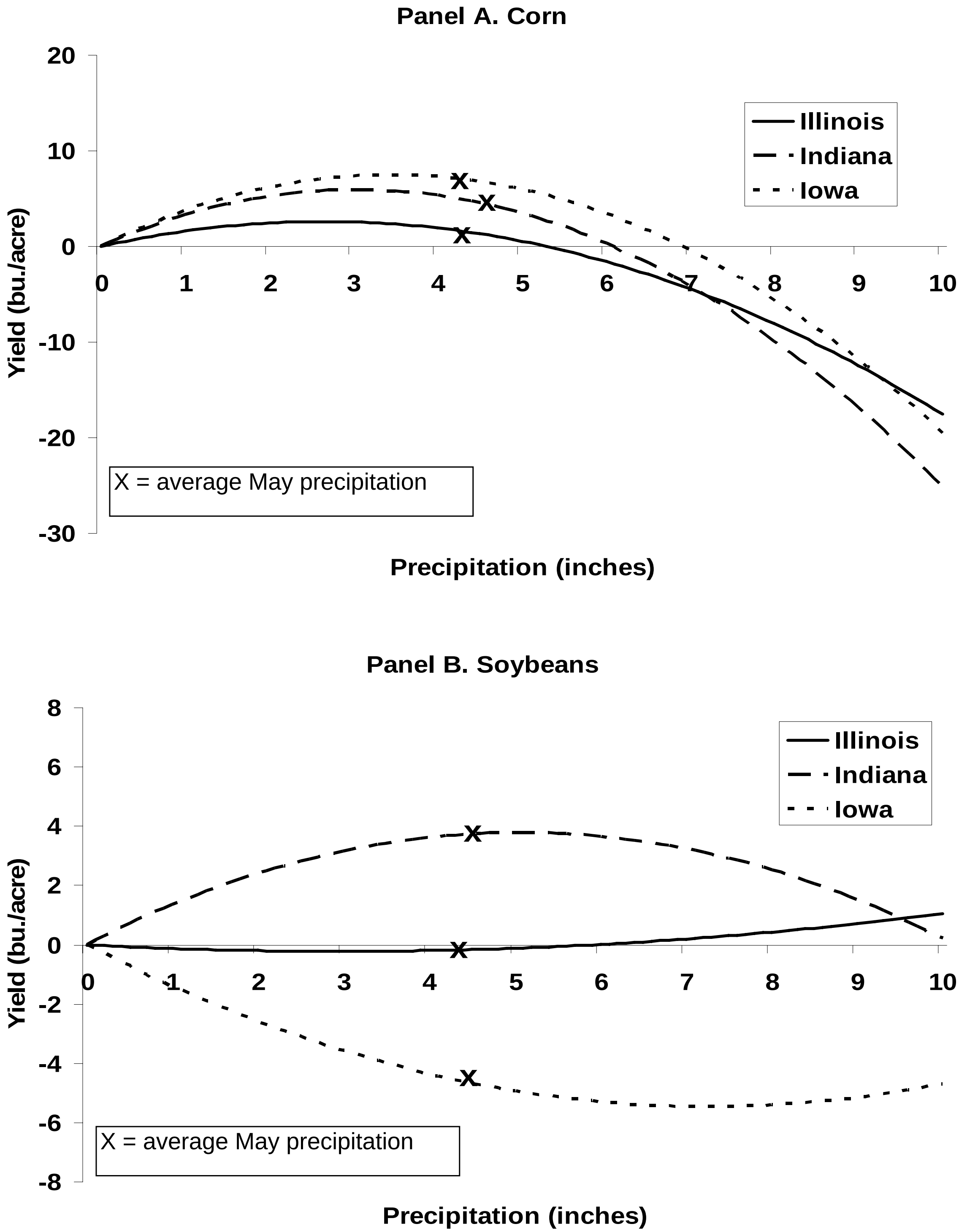

Figure 10. Estimated Impact of May Precipitation on Corn and Soybean Yields in Illinois, Indiana, and Iowa, 1960 - 2007

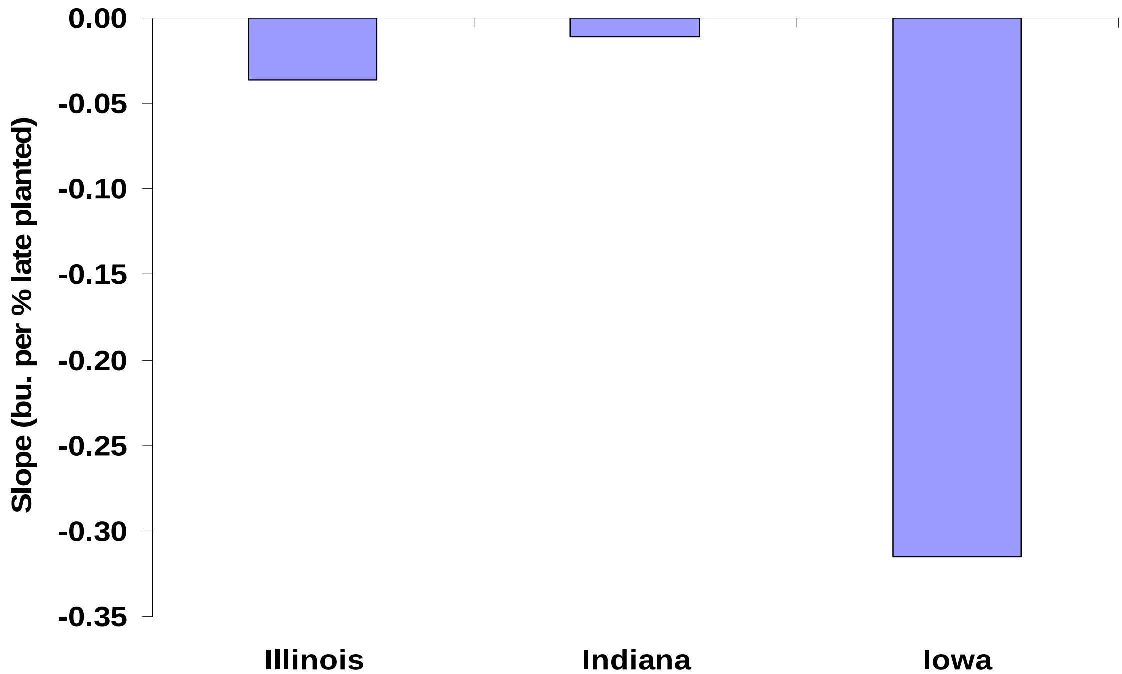

Figure 11. Estimated Impact of Late Planting (1960 - 1985: after May 30th; 1986 - 2007: after May 20th) on Corn Yields in Illinois, Indiana, and Iowa, 1960 - 2007

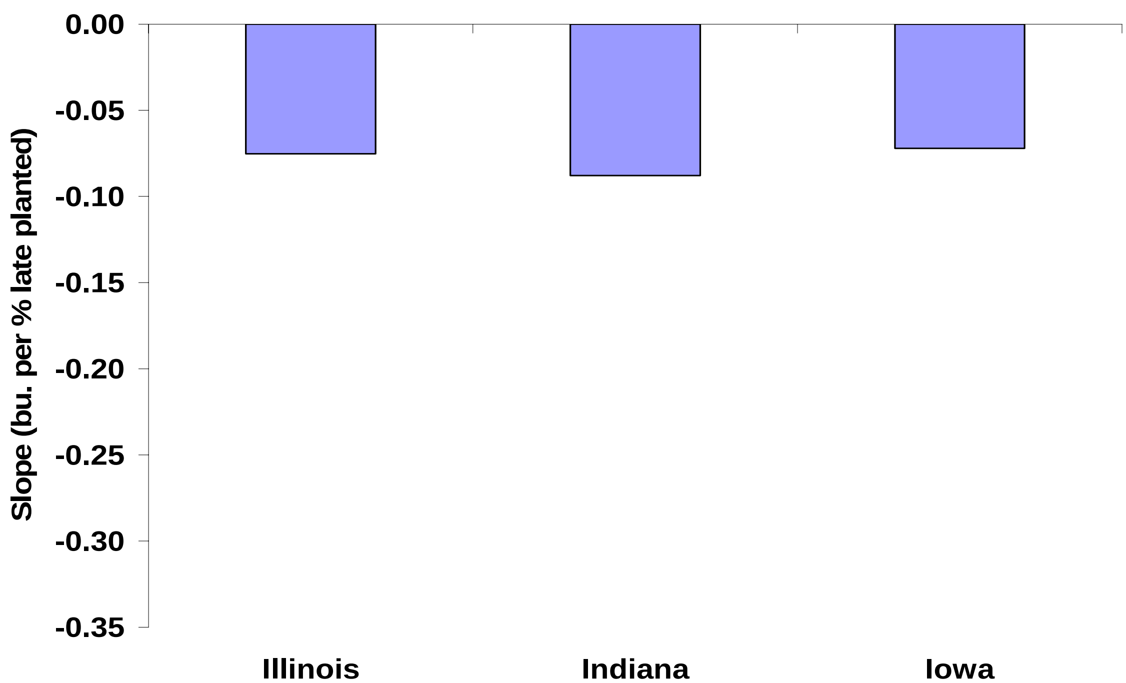

Figure 12. Estimated Impact of Late Planting (after June 10th) on Soybean Yields in Illinois, Indiana, and Iowa, 1960 - 2007

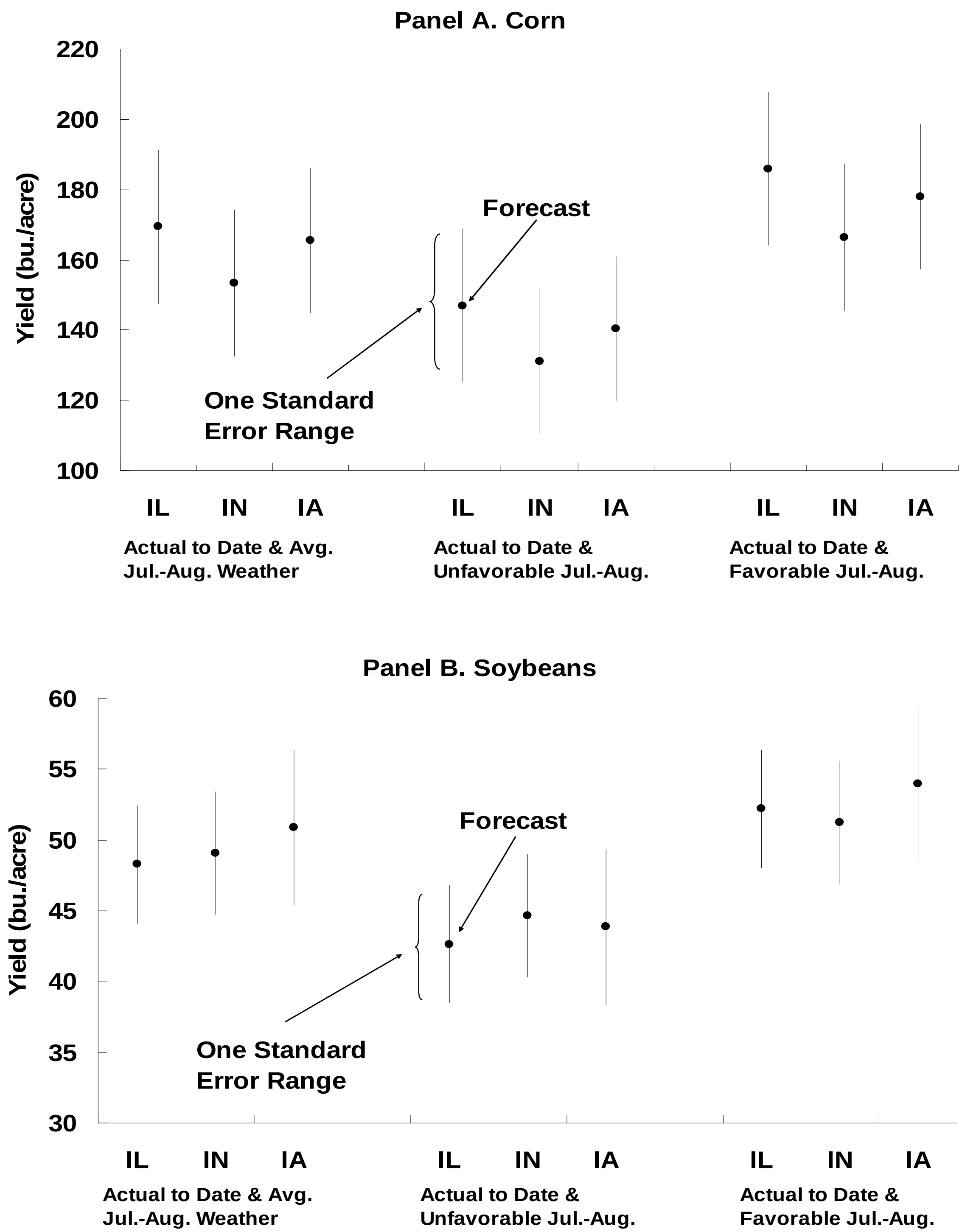

Figure 13. Error Ranges for 2008 Crop Weather Model Forecasts of Corn and Soybean Yields in Illinois, Iowa, and Indiana