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A Multidecadal Trend of Earlier Corn Planting in the Central USA

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ABSTRACT

The scientific literature suggests that a trend toward earlier corn (*Zea mays* L.) planting has taken place over the past several decades and is largely attributed to improving technology. To substantiate this idea, analysis of two datasets were performed: (i) U.S. Department of Agriculture (USDA) weekly crop progress data from 1979 to 2005 were analyzed to quantify trends in the date that 10, 25, 50, and 75% of corn planting had been completed across 12 Corn Belt states; (ii) National Centers for Environmental Prediction (NCEP) daily climate data were studied to understand whether springtime warming was a major contributor to any observed planting date trends. Statistical analysis suggested that the initiation of corn planting (10% planted) at the state level has become earlier ($P < 0.05$) by 0.3 to 0.8 d yr^{-1}, with a regional, weighted average of 0.48 d yr^{-1} earlier ($P < 0.0001$). The regional average planting date trends were −0.45, −0.39, and −0.37 d yr^{-1} for the 25, 50, and 75% planted thresholds, respectively, and all were significant ($P < 0.05$). Consequently, the initiation of corn planting is now averaging approximately 2 wk earlier relative to the early 1980s. Continued development of genotypes that are tolerant of suboptimal temperatures, planting equipment improvements, and adoption of time-saving management practices like conservation tillage are the more likely contributors to earlier planting rather than wide-ranging springtime warming. However, it is unrealistic to expect that this long-term trend will continue indefinitely because early planting will ultimately be limited by frozen soils.

The calendar date of corn seed sowing across the U.S. Corn Belt is highly deterministic to the end-of-season yields that are achieved, particularly in northern regions where growers are challenged by a later arrival of spring and a shorter average growing season (Darby and Lauer, 2002; Gupta, 1985; Lauer et al., 1999). Because early planting increases the time period whereby plants can absorb solar radiation, perform photosynthesis, and accumulate biomass, higher yields generally result where the growing season is longest and soil moisture is nonlimiting. Early planting allows for higher yield potential (e.g., later maturing) hybrids to be used with confidence as long as the hybrids are tolerant of low (nonfreezing) temperatures that can occur after sowing (Gupta, 1985). Early planting also increases the likelihood that plant physiological maturity will occur before killing frosts occur in the fall.

Previous research has noted that a variety of technological factors including the development of hybrids with a higher tolerance to suboptimal growing conditions (e.g., cold, wet soils), increased resistance to diseases and pests, and improved equipment (planter) functioning have led to a large-scale shift toward much earlier corn planting today than several decades ago (Bruns and Abbas, 2006; Lauer, 2001). For example, Bruns and Abbas (2006) cited that in the Mid-South USA, the 50% corn planted date has shifted earlier by about a month (from early May to early April) over the past 30 yr. Other studies by Duvick (1989) and Lauer (2001) also state that significant shifts in corn planting, to a much earlier date, have occurred across the Corn Belt region. However, there has not been a comprehensive data analysis that documents such trends over the past few decades.

Because agroecosystems comprise a significant portion of the total land area across the Corn Belt, a dramatic shift in the timing of crop planting similar to that noted in the Mid-South could significantly affect the seasonality of C and water exchange, and will influence the large-scale phenology and surface albedo of the region (Twine et al., 2004). Thus, documentation of land management trends and vegetative response are particularly important to C cycle science, vegetation-climate feedbacks, and the interpretation of drivers of change in remote sensing observations of the land surface, particularly during the last 30 or so years. Furthermore, any trend toward an earlier initiation and completion of planting could have contributed to a portion of the yield increases that have occurred since the 1950s, and therefore analysis of these data are relevant to studies of future yield increases and the underlying drivers of such change.

The objectives of this research were to: fully examine and document large-scale patterns and changes in corn planting dates across the central USA for the previous ~30 yr, and investigate whether any changes were induced by large-scale climate trends. In this study, we present and analyze state level U.S. Department of Agriculture (USDA) weekly crop planting progress data (defined as the percentage of corn acreage planting that has been completed at any point in time) from 1979 to 2005 for 12 states that currently occupy approximately 82% of the total U.S. corn harvested area. The National Centers for Environmental Prediction gridded reanalysis climate data of daily minimum and maximum temperature and precipitation rate were also analyzed to determine whether trends in springtime weather conditions over the 27-yr period were potential drivers of any observed trends in the USDA data.

MATERIALS AND METHODS

Weekly corn planting progress data (expressed as a percentage of planting that is completed) for 12 Corn Belt states (IL, IN, IA, KS, KY, MI, MO, MN, NE, OH, SD, and WI) were obtained for the 1979 to 2005 time period through the USDA

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Abbreviations: CTIC, Conservation Technology Information Center; DOY, day of year; NCEP, National Centers for Environmental Prediction.

National Agricultural Statistics Service (available online at www.nass.usda.gov). The crop progress data are based on a national survey of approximately 5000 field reporters who make frequent visual observations each week beginning in early April regarding planting progress, crop phenological development, and harvesting. Weekly data collected within each county are summarized and weighted by acreage to form crop reporting district and state level data.

In this study, all available weekly data, grouped by state, were input into the SAS-JMP statistical discovery software package (SAS Institute, 2002) and a neural net algorithm was used to fit a *S*-shaped numerical function through each growing season's weekly data for each year and each state independently (refer to Fig. 1 as an example). This statistical curve fitting was performed assuming a temporal resolution of 1 d so that a continuous daily record of planting progress could be constructed and therefore easily compared across all years because the survey reporting dates varied by year. The date of occurrence for planting progress at four thresholds of completion (10, 25, 50, and 75%) were subjected to linear regression analysis (using SAS-JMP) to detect any statistical trends (and level of significance or P value) for each individual state over the 27-yr study period. Regional (12 state) average dates of occurrence for each planting threshold were formed by weighting each state's calendar date (day of year) by the fractional planted corn acreage relative to the total acreage for all 12 states. These weighted regional average values for the 27-yr period were also subjected to linear regression analysis.

Daily mean, minimum, and maximum air temperatures (at a 2-m reference height) and daily precipitation rates were obtained for the 1979 to 2005 time period from the NCEP Reanalysis gridded climate data, available from the National Oceanic and Atmospheric Administration (NOAA) CIRES Climate Diagnostics Center in Boulder, Colorado (www.cdc.noaa.gov). These data are available at an original spatial resolution of 2.5° longitude, with latitudes centered at 37.142°, 39.047°, 40.952°, 42.856°, 44.761°, 46.666°, and 48.571° over the chosen study area. These data were subjected to linear regression analysis to determine whether trends in various temperature thresholds or monthly precipitation had occurred over the study period, which may have supported any observed trends in planting progress. The climate variables analyzed included the following: the last occurrence of freezing temperatures (using daily minimum thresholds of −2.2°C and 0.0°C); monthly average temperatures and total precipitation for March, April, and May; and the calendar date that

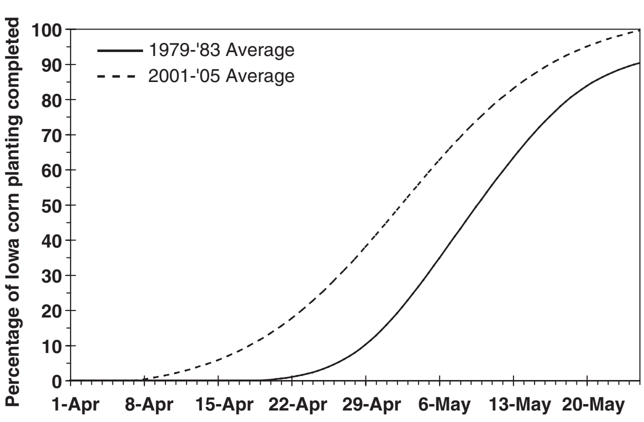

Fig. 1. Interpolated daily progression of corn planting progress in Iowa for two 5-yr time periods at the beginning and end of the data record: 1979 to 1983 compared with 2001 to 2005.

the 15-d running mean daily temperature reached 10°C and 12.78°C, respectively.

RESULTS AND DISCUSSION

Between 1979 and 2005, 11 of the 12 state records (i.e., all except Ohio) showed a significant ($P < 0.05$) trend toward earlier first planting, designated as the day of year (DOY) that 10% of total corn acreage was planted (Fig. 2A and Table 1), and hereafter referred to as the 10% planted date. The linear trends over the 27 yr ranged from a maximum of 21.7 d/27 yr (0.8 d yr^{-1}) earlier in Kentucky to a minimum of 8.4 d/27 yr (0.3 d yr^{-1}) earlier in Michigan. At the beginning of the record (averaged from 1979 to 1983), the average 10% planting date ranged from April 25 (±7.1 d) in Missouri to May 8 (±6.4 d) in South Dakota (Table 2). Toward the end of the record (from 2001–2005), the 10% planting date ranged from 4 April (±4.7 d) in Missouri to 28 April (±4.8 d) in South Dakota (Table 2). We note that in the beginning of the period, the majority of planting was initiated within a 2-wk timeframe across the Corn Belt (e.g., 25 Apr.–8 May), whereas by 2005, planting was being initiated sometime within a larger 4-wk period (Fig. 2A). This may be indicative of regional differences in adapting new management practices, farm machinery, technology, hybrids, or it could be a result of changing springtime weather conditions across the region.

The regional (area weighted) average 10% planting date advanced (earlier) by −0.48 d yr^{-1} ($r^2 = 0.48$, $P <$ 0.0001) across the entire 12-state region. Thus, the initiation of corn planting across the Corn Belt region is currently taking place ~13 d earlier now compared to the early 1980s (Table 3, Fig. 3). This result corroborates a previous study that suggested corn-planting dates across the entire Corn Belt became earlier by approximately 4 wk between 1930 and the 1980s (Duvick, 1989), and is in agreement with trends previously shown for Wisconsin corn planting from 1976 through 1999 (Lauer, 2001).

The magnitude (~−0.3 to −0.8 d yr^{-1}) of state level trends for 25, 50, and 75% planted date thresholds (Table 1, Fig. 2B) were similar to the computed linear trend for the 10% threshold, however, the number of states that showed statistically significant trends of earlier planting ($P < 0.05$) generally decreased as the value of the planted thresholds analyzed increased. For example, 10 of 12 states had significant ($P < 0.05$) trends for the 25% planted threshold, but only 8 and 4 states yielded significant results for the 50 and 75% thresholds, respectively (Table 1). However, very large changes were apparent even for the 75% planted date in some states, as farmer management changes in Kentucky, Kansas, Minnesota, and Nebraska have caused this threshold to be reached 12 to 18 d earlier during the course of the last 27 yr (Tables 1 and 2; Fig. 2B). In the early 1980s, 75% of corn planting was completed in a timeframe between 18 May and 28 May; currently, this is now occurring between 5 May and 21 May (Table 2, Fig. 2B).

The varied results (e.g., magnitude of the trends) produced as a function of the planted thresholds analyzed suggests that while farmers have worked toward an ear-

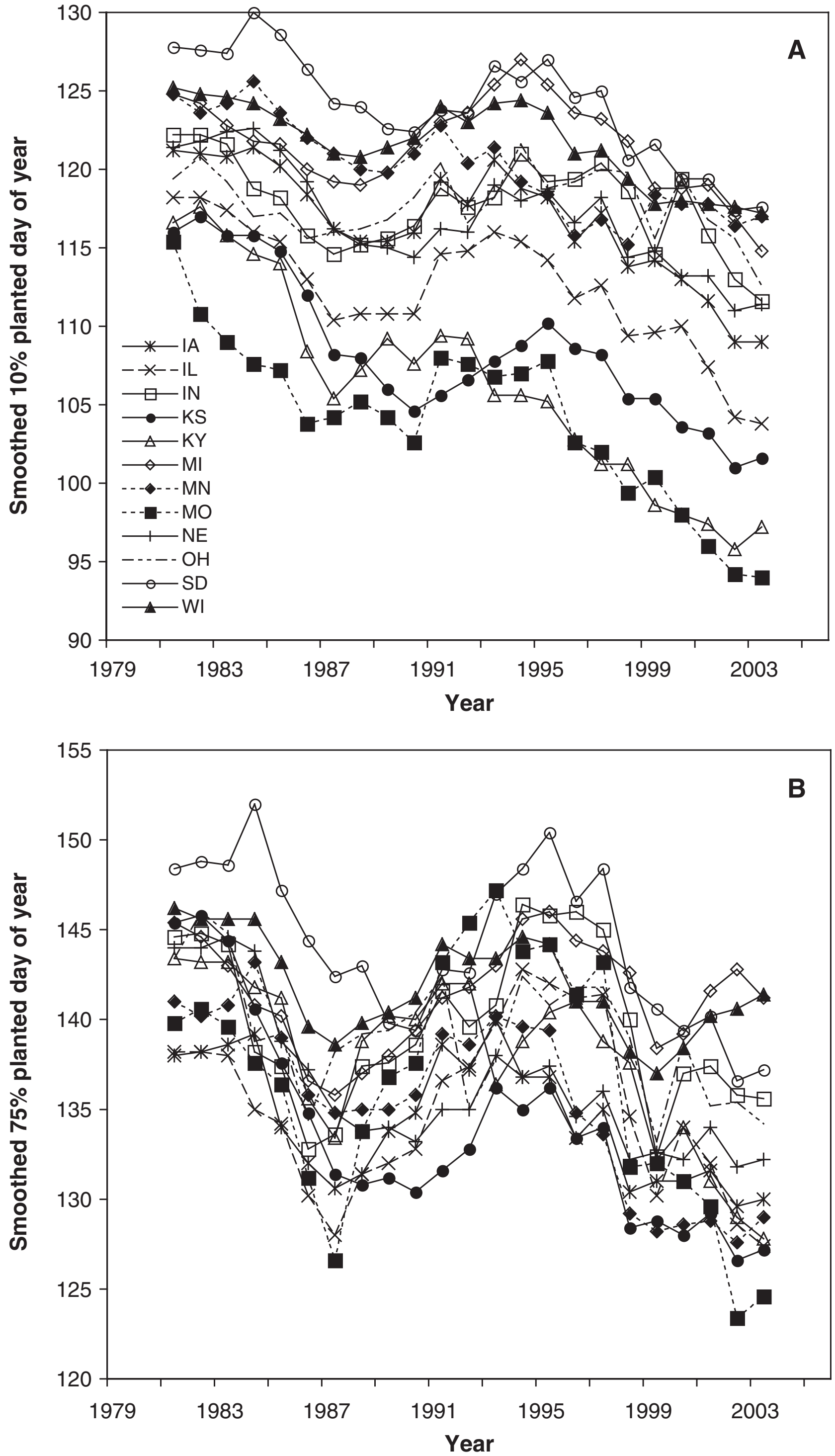

Fig. 2. State level interpolations of the day of year when (A) 10% and (B) 75% of corn planting was completed during the 1979 to 2005 time period. Each data point represents a 5-yr moving average of the actual annual quantities. Standard two character abbreviations for each state are used and apply to both A and B.

lier start to corn planting, they did not always complete their planting by an equal number of days. In fact, when trends for the total number of days elapsed between the 10% planted and 75% planted thresholds were analyzed over the 27 yr, the state data that produced statistically significant trends ($P < 0.1$; Iowa, Indiana, and Kentucky) suggested the duration of time needed to progress from 10 to 75% planting completed was taking 0.2 to 0.3 d yr^{-1} longer.

The number of days that elapsed between the 10 and 75% completion of planting stages varied from an average of 15.2 (±5.6) d in Minnesota to a maximum average of 31.6 (±12.2) d in Michigan. This range of planting duration is likely driven by a variable number of work-

Table 1. Linear trends and statistics of the 10, 25, 50, and 75% corn planting date thresholds for 1979 to 2005.

	10% Planted			25% Planted			50% Planted			75% Planted		
State	d yr^{-1}	d 26 yr^{-1}	*P* value	d yr^{-1}	d 26 yr^{-1}	*P* value	d yr^{-1}	d 26 yr^{-1}	*P* value	d yr^{-1}	d 26 yr^{-1}	*P* value
Kentucky	−0.833	−21.7	<0.001	−0.795	−20.7	<0.001	−0.687	−17.9	0.004	−0.582	−15.1	0.028
Missouri	−0.820	−21.3	0.001	−0.831	−21.6	<0.001	−0.614	−16.0	0.055	−0.486	−12.6	0.148
Kansas	−0.606	−15.8	<0.001	−0.593	−15.4	<0.001	−0.617	−16.0	<0.001	−0.702	−18.5	<0.001
Illinois	−0.556	−14.5	0.001	−0.464	−12.1	0.008	−0.364	−9.5	0.072	−0.301	−7.8	0.217
Iowa	−0.509	−13.2	0.001	−0.416	−10.8	0.005	−0.318	−8.3	0.036	−0.304	−7.9	0.108
South Dakota	−0.462	−12.0	0.002	−0.422	−11.0	0.007	−0.416	−10.8	0.019	−0.365	−9.5	0.085
Minnesota	−0.438	−11.4	0.003	−0.554	−14.4	<0.001	−0.491	−12.8	0.003	−0.576	−15.0	0.004
Nebraska	−0.412	−10.7	0.002	−0.429	−11.2	0.001	−0.463	−12.0	0.003	−0.460	−12.0	0.005
Indiana	−0.361	−9.4	0.058	−0.338	−8.8	0.111	−0.314	−8.2	0.183	−0.231	−6.0	0.411
Wisconsin	−0.348	−9.0	<0.001	−0.341	−8.9	0.001	−0.292	−7.6	0.012	−0.226	−5.9	0.104
Michigan	−0.321	−8.4	0.001	−0.269	−7.0	0.035	−0.192	−5.0	0.159	0.017	0.4	0.918
Ohio	−0.228	−5.9	0.232	−0.248	−6.4	0.270	−0.244	−6.3	0.348	−0.315	−8.2	0.299

able field days in each state during spring (influenced by weather), farm size and equipment, and the typical length of time in spring that farmers have to get full-season hybrids in the ground before yield losses are likely to occur due to delayed planting.

The regional, weighted average planting date trends were −0.45, −0.39, and −0.37 d yr^{-1} for the 25, 50, and 75% planted thresholds, respectively, and all were significant ($P < 0.05$, Table 3). Thus, the overall regional trend is for planting to be initiated and progressing toward completion faster today than several decades ago, but the most significant trends are on the initiation end of the planting progress continuum (Table 3, Fig. 3).

We investigated the idea that regional climate change, specifically warmer and drier springtime weather conditions, were a driving factor to earlier planting. Lauer (2001) questioned whether earlier corn planting dates in Wisconsin were a testament of real technological progress in farming, or were being driven by global warming. It would be easy to presume that a push toward earlier planting has been induced by climate change as evidence suggests the onset of spring is starting earlier across much of North America and is generally linked to warming in the Northern Hemisphere over the last half of the 20th century (Schwartz et al., 2006).

There does not appear to be strong evidence for widespread springtime warming from 1979 to 2005 to support the idea that climate change has been the most important factor driving the earlier planting trends encompassing the *majority* of the Corn Belt. An analysis of the NCEP daily mean temperature reanalysis suggests that linear trends of the date that 15-d running mean temperatures reached 10°C and 12.78°C (an assumption and surrogate used here for approximate optimal planting times, and the coolest temperatures that seed germination would occur) (Dwyer et al., 2000) were not statistically significant ($P < 0.1$) across the large majority of the study region (Fig. 4A, 4B).

However, portions of Kansas, southern Nebraska, northern Missouri, west-central Illinois, and southern Iowa did show a significant trend of the 10°C, 15-d running mean temperature threshold being reached earlier by 0.4 to 0.6 d yr^{-1}, which is on the same order of the magnitude of the planting trends. This suggests that earlier planting may have been supported by springtime warming trends in this smaller region (Fig. 4A). In contrast, across the northern half and eastern portions of the Corn Belt, virtually no trend or a trend toward cooler (but not statistically significant) springtime temperatures has occurred over the past several decades. Thus, the climate contributions to these trends appear, at best, to be mixed, and vary substantially in a spatial context. One important observation from this analysis is that the degree of warming was more significant and wide-ranging for the cooler temperature threshold analyzed (10°C) than the warmer (12.78°C). Linear trends in the date of the last occurrence of freezing temperatures (using daily minimum thresholds of −2.2°C and 0.0°C), an average spring temperature composite (March–May), and monthly temperature and precipitation for March, April, and May were also studied independently, but did not support the idea that significant warming or drier conditions over the region had supported the observed trends toward an earlier initiation and completion of corn planting. The

Table 2. Average date of occurrence for various planted threshold across the Corn Belt for 5-yr periods at the beginning and end of the statistical analysis. Numbers in parentheses denote one standard deviation (d).

	10% Planted		25% Planted		50% Planted		75% Planted	
State	1979–1983	2001–2005	1979–1983	2001–2005	1979–1983	2001–2005	1979–1983	2001–2005
Illinois	28 Apr. (4.1)	14 Apr. (3.6)	4 May (4.6)	21 Apr (6.1)	11 May (5.6)	29 Apr. (9.0)	18 May (7.1)	7 May (11.4)
Indiana	2 May (5.4)	22 Apr (12.3)	9 May (8.0)	29 Apr. (12.8)	17 May (10.4)	26 Apr. (12.6)	25 May (13.0)	16 May (13.2)
Iowa	1 May (4.3)	19 Apr. (3.5)	5 May (4.5)	26 Apr. (3.6)	10 May (5.0)	3 May (3.8)	18 May (9.3)	10 May (4.8)
Kansas	26 Apr. (5.4)	12 Apr. (1.7)	4 May (4.8)	20 Apr. (1.5)	14 May (3.3)	28 Apr. (1.5)	25 May (1.1)	7 May (1.8)
Kentucky	27 Apr. (9.7)	7 Apr. (3.6)	5 May (10.8)	15 Apr. (4.9)	13 May (11.5)	26 Apr. (8.5)	23 May (11.5)	9 May (12.1)
Michigan	5 May (3.5)	25 Apr. (5.0)	11 May (4.1)	2 May (6.0)	18 May (4.8)	11 May (7.0)	25 May (5.9)	21 May (7.2)
Minnesota	5 May (6.6)	27 Apr. (7.7)	9 May (6.2)	1 May (7.0)	14 May (6.3)	5 May (6.6)	21 May (7.5)	9 May (6.4)
Missouri	25 Apr. (7.1)	4 Apr. (4.7)	3 May (7.3)	12 Apr. (5.1)	11 May (7.7)	22 Apr. (4.8)	20 May (7.6)	5 May (6.5)
Nebraska	1 May (4.6)	21 Apr. (2.3)	9 May (5.5)	28 Apr. (2.9)	17 May (7.9)	5 May (3.7)	24 May (9.2)	12 May (4.2)
Ohio	29 Apr. (4.7)	23 Apr. (9.0)	7 May (7.0)	30 Apr. (10.8)	14 May (10.0)	7 May (12.1)	23 May (14.6)	14 May (12.5)
South Dakota	8 May (6.4)	28 Apr. (4.8)	14 May (5.9)	4 May (5.0)	21 May (6.5)	10 May (5.0)	28 May (7.7)	17 May (5.1)
Wisconsin	5 May (3.6)	27 Apr. (2.3)	12 May (3.5)	4 May (2.9)	19 May (4.4)	12 May (4.1)	26 May (6.1)	21 May (4.3)

Table 3. Linear trends calculated for the date when varied percentage of corn planting was completed for 1979 to 2005. These values are an aggregated average for the 12 Corn Belt states analyzed, weighted according to each state's planted corn area (ha) relative to the regional total.

Planting completed threshold	Linear trend	Total change	r^2	*P* value
	d yr^{-1}	d		
10%	−0.483	−13.0	0.48	<0.0001
25%	−0.448	−12.1	0.39	0.0005
50%	−0.394	−10.6	0.28	0.0049
75%	−0.370	−10.0	0.20	0.0210

running mean temperature indices studied, however, are likely better indicators of farmer response to springtime temperature because they can be monitored in real time and human decisions can be based off of temperature perturbations from expected conditions.

However, while these air temperature indices are useful for a general interpretation of whether climate may have influenced planting behavior, a much more difficult quantity to assess (and more relevant to driving trends in springtime planting) are how the number of "workable field days" has changed. Central U.S. farmers typically plant over a period of a few weeks to a month during stints where weather conditions are optimal to perform fieldwork, which may only amount to 2 to 4 d each week during April and May (Nafziger, 2002). The sequence of weather patterns and the level of soil "trafficability" will partially determine whether a farmer is able to initiate getting seed into the ground.

Following on this idea, once a grower initiates corn planting, weather and soil conditions among other factors such as completion of other field activities, equipment breakdowns, and operational efficiency, begin to all play an integrated role in how quickly all planting is completed. The choice of the first planting "wave" appears to be getting earlier by about 8 to 22 d (e.g., the 10% planted date) at the state level, meaning growers are choosing to head to the fields earlier to initiate planting. However, growers aren't always nearing completion of their planting (e.g., the 75% planted threshold) by a similar number of days earlier, and this may be indicative of the following: (i) the number of workable field days during each week changes after the start of planting due to weather pattern changes; (ii) growers aren't pushing as hard to finish all of their planting because they achieved an early start and perceive themselves to be slightly ahead of schedule; or (iii) differences in farm operations and average farm sizes lead to varied planting behavior (after initiation) across the Corn Belt. In reference to the last point above, highly sophisticated, large farm operations that are responsible for hundreds to more than a thousand acres might be more likely to invest in cutting-edge technology so that they have the best chance to complete all planting before yield potential declines. In contrast, small operators who farm less than 81 ha (200 acres) and are doing so as a part-time activity, often plant when it is most convenient and might not have the ability to respond quickly to brief planting windows when they occur.

If climate change doesn't point strongly to supporting earlier planting since 1979 over the entire region, what is the more likely reasoning for the unified, advancing planting dates? Other data suggests that farmers are becoming much more efficient at field operations, and a growing number are gradually adopting management practices that can facilitate earlier planting (Lithourgidis et al., 2005). Perhaps the most significant changes are a trend toward performing tillage immediately after fall harvests, and the adoption of reduced-tillage or no-tillage management practices over the past three decades. Data from the Conservation Technology Information Center (CTIC) showed that the percentage of U.S. cropland managed with conservation tillage practices increased from 26.1% in 1990 to 40.7% in 2004, while the fraction of land acreage that was subjected to conventional tillage practices declined from 48.7% in 1990 to 37.7% in 2004 (CTIC, 2004). The greatest change was through the adoption of no-till tillage, which gained 18.4 million ha (45.5 million

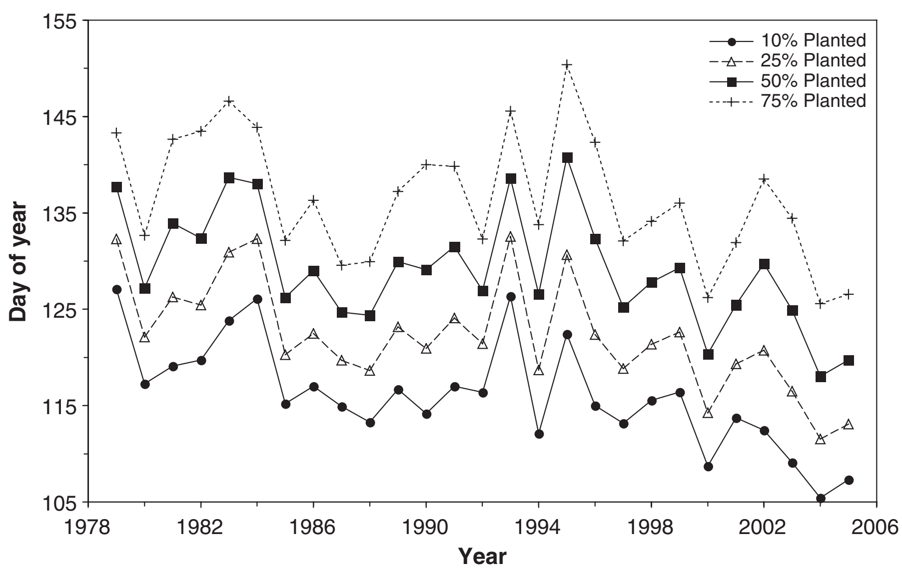

Fig. 3. Regional, 12-state weighted average (by planted area) 10, 25, 50, and 75% corn planted date, respectively.

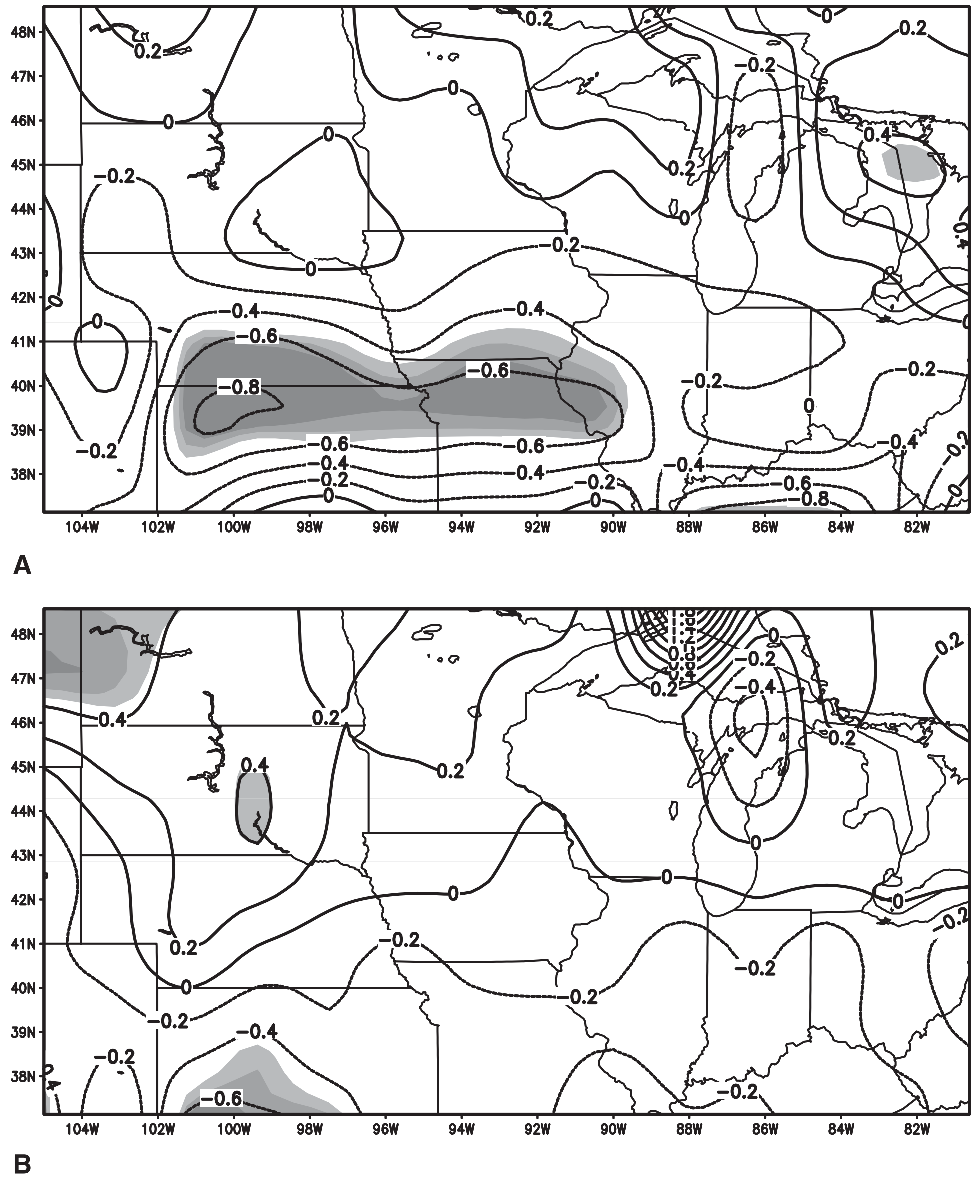

Fig. 4. Trend of change in day of year when the 15-d running mean daily air temperature reaches: (A) 10°C and (B) 12.78°C over the 1979 to 2005 time period (the contour intervals are d yr^{-1}). The light, medium, and dark gray shadings signify trends at the 90, 95, and 99% confidence intervals.

acres) from 1990 to 2004, mostly at the expense of conventional tillage, which decreased by 13.1 million ha (32.3 million acres).

Reduced tillage practices lead to a significant reduction in time and resources (i.e., labor and fuel) needed to prepare soils in spring before planting can take place (Arvidsson et al., 2000; Lithourgidis et al., 2005). The use of more advanced equipment that is more efficient in operation that can complete several tasks in one pass may also be a contributor to planting earlier in springtime (Popp et al., 2000). However, reduced tillage practices and the increasing adoption of leaving corn stubble on the soil surface reduces the rate at which soils will warm during the early spring compared to conventional management practices (Hayhoe et al., 1996).

To help offset some of these factors that can lead to a slower warming of soils during spring and to continue promotion of earlier planting, advances in technology and plant breeding have also enhanced the heartiness of plants and their ability to deal with less than ideal growing conditions that persist in early spring (Bruns and Abbas, 2006; Lauer, 2001; Lee et al., 2002). New hybrids are becoming better suited to fight off disease and pests that may attack the plant during the early growth stages and are gradually being developed to handle suboptimal temperatures (nonfreezing) that plants may encounter after early planting, particularly in northern Corn Belt locations (Dwyer et al., 2005; Lee et al., 2002). The continued advancement of fungicide and insecticide chemistries used in seed development and production also have added to early season plant heartiness so that seedlings can withstand disease, increasing the likelihood of survival (Lauer, 2005). Finally, the new development of seeds with a temperature-activated polymer coating may continue to allow for earlier planting (of a few weeks) in cooler and wetter soils (Gesch and Archer, 2005).

CONCLUSIONS

While there is convincing evidence for earlier planting across the Corn Belt during the past several decades, the statistical analysis presented here pointed out that the magnitude of these trends varied considerably for each state's composite data. The far eastern states of Ohio and Indiana had the weakest trends of the 12 states studied, and the data for Ohio produced no significant trends for any of the planted thresholds analyzed. It is unclear why this particular region has not changed in accordance with the remainder of the Corn Belt.

One potential causal affect of earlier planting may be a contribution to the increase in corn yields that have occurred since the 1950s. Regardless of the exact causes that have supported earlier corn planting, this trend could have supported a switch to hybrids suited for a longer growing season, which would encourage yield gains (Gupta, 1985; Lauer et al., 1999; Nielsen et al., 2002; Swanson and Wilhelm, 1996), or it would lengthen the time window that growers had to complete their field activities before significant delays would instigate switches to shorter season hybrids with lower yield potential. Earlier planting reduces the risk of fall frost damage to corn and decreases the likelihood that the crop will suffer injury from late insect and disease pest problems such as European Corn Borer (*Ostrinia nubilalis*) and gray leaf spot (*Cercospora zeae-maydis*; Ohio State University Extension, 2005). Furthermore, if the first crop planted were to be damaged, in many cases there would still be enough time to replant (Nafziger, 2002). However, it is difficult to separate the relative contributions of specific agronomic practices and other breeding changes to yield trends because of their interrelated nature, but it is likely that these planting date trends have contributed partially to the increasing yields over the past several decades (Cardwell, 1982). Finally, earlier planting contributes to lower grain moisture leading to reduced drying time and energy costs, which is now a major concern of growers due to rising fuel prices (Ohio State University Extension, 2005).

Farmers may eventually reach a point where it will become more difficult to increase operational efficiency and plant earlier, especially for those that are already adopting time saving strategies. However, continued development of new corn genotypes and the planting of polymer coated corn seed may continue to allow for earlier planting to take place in the future. However, it is unrealistic to expect that a trend toward earlier planting will continue indefinitely because planting will ultimately be limited by freezing temperatures, snow cover, and frozen soils in many locations.

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