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Previous Crop Impacts Winter Wheat Sowing Dates, Available Water at Sowing, and Grain Yield

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Summary

Cropping systems choices can directly affect the sowing date for winter wheat, which is among the most important variables that determine attainable yields in the U.S. Central Great Plains. Our objective was to investigate the effect of the previous crop on winter wheat grain yield through the modulation of sowing date and its impact on plant available water at sowing, and temperatures during the critical period for yield determination. A no-tillage rainfed field experiment was established in 2019 at Ashland Bottoms, KS. Winter wheat was sown either after summer fallow, full-season soybean, double-cropped soybean, or corn—thus, resulting in a range in sowing dates of 270–326 days of the year (September 27 to November 22). The optimum sowing date for the site based on grain yield was estimated at day of year 296 ± 5 (October 18 to 28). Winter wheat after summer fallow and after a full-season soybean crop resulted in the greatest yields, whether sown at the optimum date or slightly later than optimum. Winter wheat yield was positively related to plant available water at sowing. Later sowing dates were most likely to reduce plant available water at sowing, and could delay wheat's development resulting in higher temperatures occurring during the critical period for yield determination (i.e., the days surrounding anthesis). Later sowing also shortened grain filling duration due to an overall later cycle and elevated temperatures. Thus, adjusting winter wheat sowing dates is the first step that determines the crop's yield potential through improved plant available water at sowing, and reduced temperatures during the critical period for yield determination. When following a summer crop, winter wheat should be sown as soon as the previous crop is harvested to try to mitigate these negative effects of late sowing.

Introduction

Winter wheat yields in the U.S. Great Plains have been stagnant for decades (Patrignani et al., 2014) at levels well below their potential (Lollato et al., 2017). As there is a large gap between potential and actual yields, improved management practices could help increase wheat yield and production in this region (e.g., Jaenisch et al., 2019, 2022; de Oliveira Silva et al., 2021, 2022; Lollato et al., 2019a). Crop rotation combined with no-tillage systems can boost crop grain yield and improve yield stability while broadening crop yield adaptability to varying yielding conditions (Simão et al., 2022). However, crop rotation can impact the winter wheat sowing date, which is crucial in determining attainable yields in the U.S. Central Great Plains (Jaenisch et al., 2021;

Munaro et al., 2020). The optimum winter wheat sowing date is site-specific and impacts the crop's winter hardiness and water and temperature regimes.

The length of the fallow period preceding the wheat crop can impact the amount of water available at sowing (Lollato et al., 2016). Additionally, early sowing dates may result in excessive biomass production and increased soil water usage. While high fall biomass production is desired for dual-purpose winter wheat (i.e., grown for forage and grain; Lollato et al., 2019b), grain-only winter wheat yield may be compromised by lower soil water later in the spring if wheat is sown too early in the fall (Lollato et al., 2021). Conversely, a late sowing date can delay winter wheat's reproductive stages and reduce grain yield due to decreased grain numbers and shorter grain filling duration during high temperatures (Lollato et al., 2020). Our objective was to investigate the effect of the previous crop on sowing date for winter wheat and its impact on plant available water at sowing, and temperatures during the critical period for yield determination.

Procedures

Site Description and Agronomic Management

A rainfed field experiment was established in the fall of 2019 near Ashland Bottoms, KS, (10 miles south of Manhattan) in a Roxbury series soil (fine-silty, mixed, mesic Cumulic Haplustoll). Initial soil fertility levels based at 0- to 6-in. depth showed a soil pH = 6.0; and extractable phosphorus and potassium of 14.3 and 317 ppm, respectively, using the Mehlich-3 method. In this report, we combined data from the previous three growing seasons. Diammonium phosphate (DAP 18-46-0) starter fertilizer was applied to all plots at 50 lb/a. Winter wheat variety Zenda was sown at 7.5-in. row spacing by using a Great Plains 506 no-till drill on 2000 ft^2 plots (40 ft wide × 50 ft long). Seeding rate was adjusted according to sowing dates. When winter wheat was sowed early and late, seeding rate was adjusted to 120 lb/a; otherwise, seeding rate was 90 lb/a. Wheat was harvested on June 6 using a Massey Ferguson XP8 small-plot, self-propelled combine on the center of each plot (300 ft^2 area). Pests, weeds, and diseases were monitored regularly, so they were not limiting factors in this experiment.

Treatments and Analysis

Winter wheat was sown following four cropping systems, which resulted in a range of 270–326 day of the year (DOY; equivalent to September 27 to November 22) at sowing (Table 1). Relative grain yield was calculated as actual yield divided by annual maximum yield. Critical period was determined as beginning at 572°F before and lasting until 212°F after anthesis (Couëdel et al., 2021; Sadras et al., 2022). Mean temperature during this period was estimated using data from a nearby Kansas Mesonet station. Soil water was measured using a Diviner 2000 capacitance probe at 39.40-in. depth with 4-in. intervals. Plant available water at sowing (PAW) was estimated across all depths by subtracting the soil wilting point. The PAW was only evaluated for optimum and late sowing dates due to lack of sensors at early sowing dates plots.

Results

Winter wheat relative grain yield showed a quadratic relationship with day of the year at sowing (Figure 1) where yields increased as day of the year at sowing increased until reaching a peak, considered the optimum sowing date (OSD), after which date the winter wheat yields decreased. The OSD was defined as 296 ± 5 (October 18 to 28), and any sowing date earlier or later than that range can negatively affect winter wheat grain yield.

Winter wheat relative yield showed a positive linear relationship with PAW, meaning that as PAW at sowing increased, winter wheat grain yields also increased (Figure 2A). Overall, the optimum sowing date resulted in greater PAW than late sowing (Figure 2B). Temperature at the critical period had a linear negative relationship with grain yield (Figure 3), suggesting that winter wheat grain yield decreases as temperature at the critical period for yield determination increases.

The greatest relative winter wheat yield was observed following summer fallow and full-season soybean at both optimum and late sowing dates (Figure 4). Following summer fallow, winter wheat relative yield was lower for the early sowing date, likely due to greater soil water usage during fall. Similarly, winter wheat following double-cropped soybean had similar relative yield as early sowing after summer-fallow, likely due to lower soil water after double-cropped soybean. Winter wheat relative yield after corn was the lowest compared to all other treatments, likely due to the extremely late sowing date (DOY = 326) and lower soil water after corn, which had a high soil water usage during the season.

Preliminary Conclusions

Overall, the sowing date of winter wheat impacted grain yield through its effects on soil available water at planting, and temperature during the critical period for grain yield determination. Later sowing dates resulted in an increased likelihood of lower soil water at planting and higher temperatures during critical period for yield determination, which negatively impacted grain yield. Since no differences were observed between optimum and late sowing date for winter wheat following summer fallow and full-season soybean, plant available water at sowing may be more limiting than temperature in reproductive stages, as winter wheat sowed late after double-cropped soybean had a lower yield than winter wheat sowed late after full-season soybean. A double-cropped soybean system (i.e., soybean following winter wheat) is likely to use more water than full-season soybean since it is a continuous cropping system that has no winter fallow period. Therefore, regardless of the cropping system adopted, if winter wheat is following a summer crop it must be sown as soon as possible after the summer crop is harvested, and sowing dates later than mid-November should be avoided.

Acknowledgments

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Table 1. Summary of previous crop and the respective day of the year at sowing for winter wheat

Previous crop	Day of the year at sowing
Summer fallow	270, 278, 289, and 312
Full-season soybean	295 and 312
Double-cropped soybean	312
Corn	326

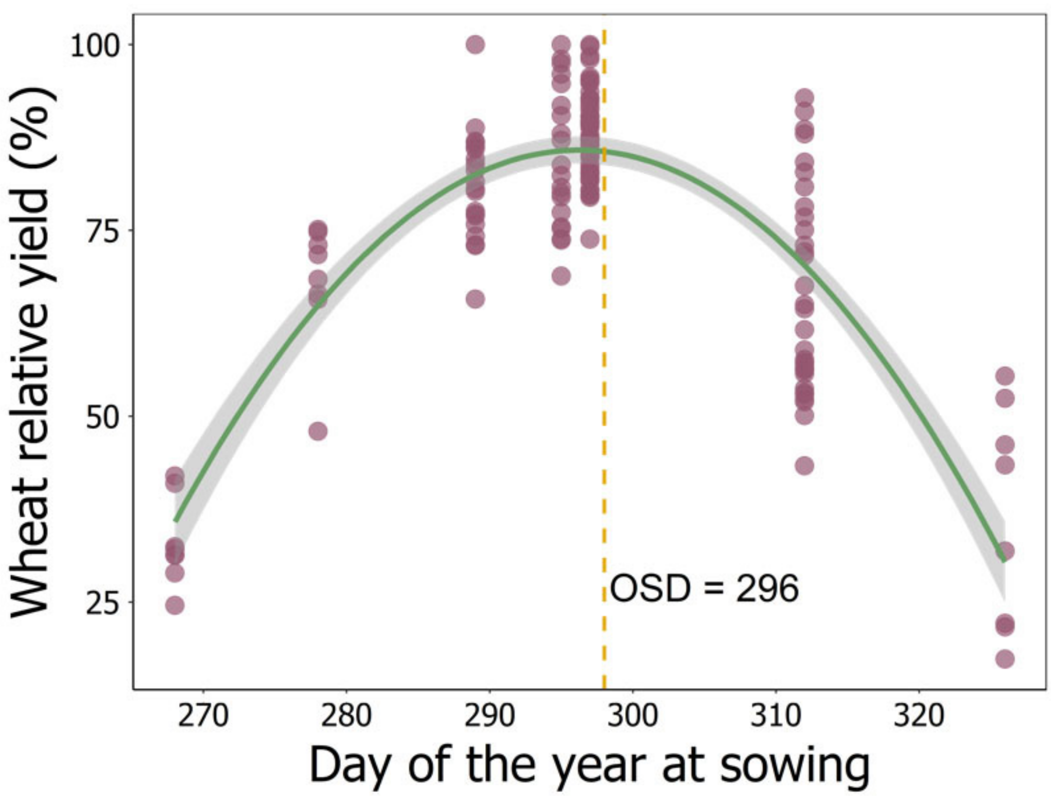

Figure 1. Quadratic relationship between winter yield relative yield and day of the year at sowing. The optimum sowing date (OSD) was estimated at 296 ± 5 (mid-October).

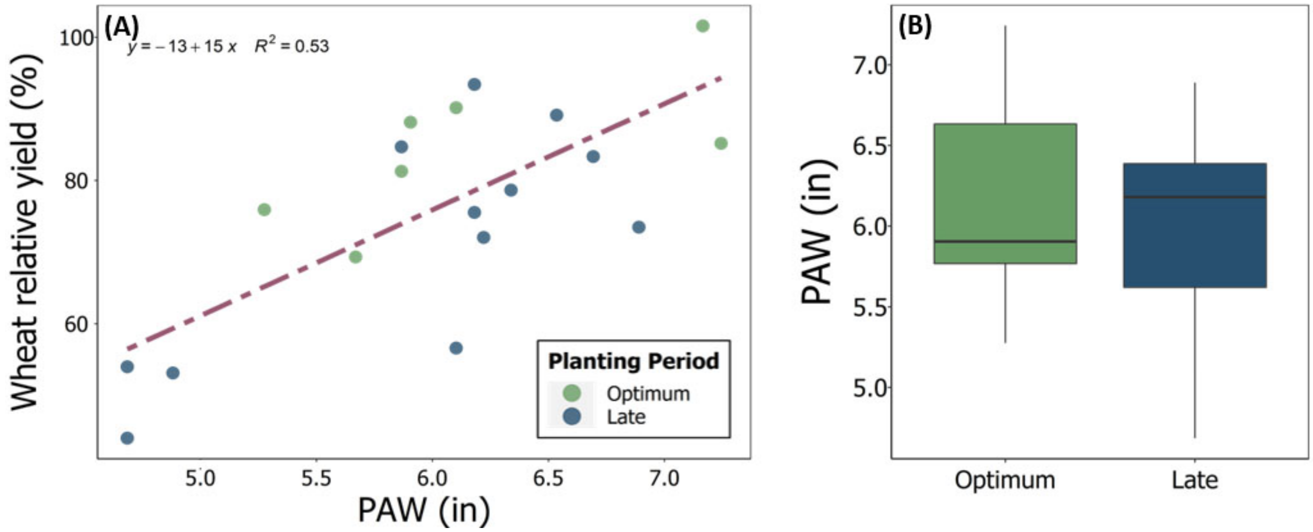

Figure 2. Linear positive relationship between winter wheat relative yields and plant available water at sowing (PAW) (A); and PAW at different sowing dates (B).

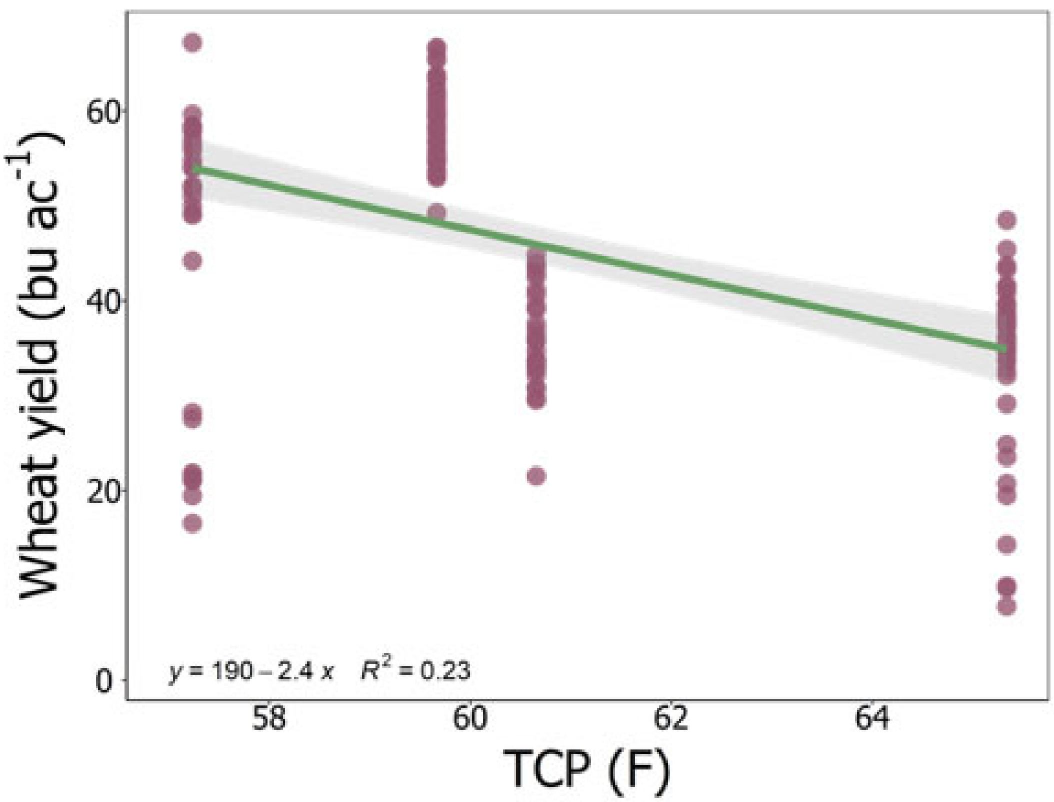

Figure 3. Winter wheat grain yield as affected by temperature during the critical period (TCP) for yield determination.

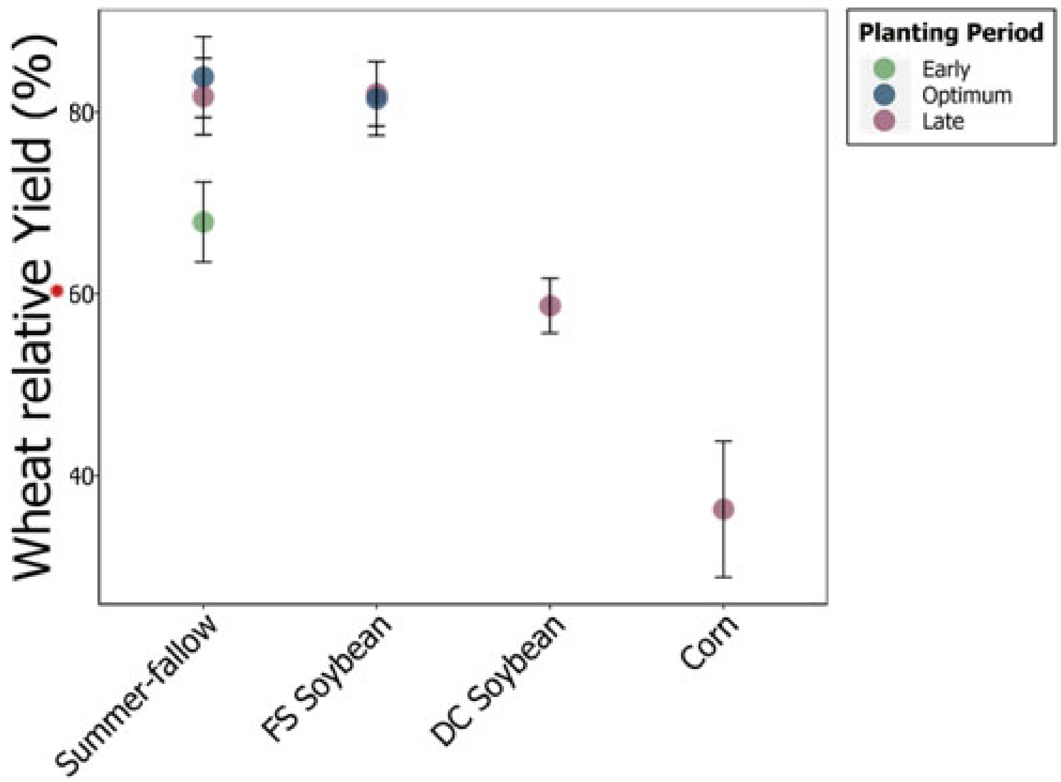

Figure 4. Winter wheat relative yield at three sowing periods (early, optimum, and late) following summer fallow, full-season soybean (FS Soybean), double-cropped soybean (DC Soybean), and corn.