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Performance of Corn Hybrids with Contrasting Maturity in Northeastern Kansas

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Summary
Corn (*Zea mays* L.) hybrid selection is one of the most important agricultural management decisions made by farmers. Both genetic yield potential and adaptation to the local environment vary widely across corn hybrids, and have a direct impact on yield and input costs. This study compared the performance of corn hybrids with contrasting comparative relative maturity (CRM, referring to their growth cycle), to evaluate their differences in crop phenology, grain yield and its components—grain number and grain weight. The field experiment was conducted during the 2022 growing season in Manhattan, KS (U.S.), testing five commercial corn hybrids with contrasting CRM under rainfed conditions. The overall length (days) of crop growth cycle across all corn hybrids ranged from 92 to 120 days, and the grain yield ranged from 102 to 146 bu/a. The variation in grain yield across hybrids was mainly explained by differences in grain number and grain weight.

Introduction
Corn's (*Zea mays* L.) planting date and hybrid maturity are the main management factors regulating the length of the growing season and, therefore, determining grain yield potential (Capristo et al., 2007). Thus, early planting dates and long maturing hybrids are commonly used to maximize corn yield potential in the U.S. Corn Belt (Baum et al., 2019). However, shorter maturing corn hybrids are recommended when moving toward higher latitudes, where radiation and temperature impose limitations, especially during the grain filling stage.

Kansas, located in the U.S. Central Great Plains region, ranks seventh in corn production by state (Kansas Department of Agriculture, 2017). However, to our knowledge there is no information on the yield performance of short maturing hybrids (< 90 comparative relative maturity; CRM). Use of such hybrids is an approach to intensify our less current, less diversified farming systems. This work aims to quantify changes in crop phenology and final yields (and its components) for corn hybrids with contrasting maturity in the state of Kansas, U.S.

Procedures
A field experiment was conducted at the Kansas State University Experimental Field located at Manhattan, KS, U.S. (39°13'04.5"N; 96°35'55.6"W) during the 2022 growing season on a silty clay loam soil. Initial soil analyses at pre-planting are

described in Table 1. Daily temperature data were retrieved from the Manhattan Kansas Mesonet weather station (Kansas Mesonet, 2023), located less than 1 mile from the experimental site.

The experimental design was a randomized complete block design (RCBD) with five replicates. The treatments consisted of five different hybrids from Corteva Agriscience (Johnston, IA, U.S.) of varying hybrid maturity: 75, 82, 91, 101, and 111 CRM. Plots were eight rows, 2.5 ft apart, and 32.8 ft long. The experiment was planted on May 10, and in order to maximize radiation capture, plant population increased as hybrid maturity decreased (Edwards et al., 2005; Assefa et al., 2016). Thus, target seeding rates were 56,000, 54,000, 48,000, 43,000, and 37,000 seeds/a for the 75, 82, 91, 101, and 111 CRM, respectively. Crops were maintained without nutrient limitations through the application of fertilizers during the crop cycle. Weeds were controlled by a combination of pre- and post-emergence herbicides. Plots were also hand weeded to control remaining weeds. The experiment was managed under rainfed conditions (without additional irrigation) and conventional tillage.

Date of silking and physiological maturity (black layer observed in grains of the midportions of the ear) were recorded when 50% of the plants in each plot reached these stages using the scale proposed by Ritchie et al. (1986). Thermal time, measured in growing degree-days (GDD, °F per day), from planting to silking and from silking to physiological maturity were calculated using the following equation:

$$GDD = \left[\frac{T_{max} + T_{min}}{2} \right] - T_b$$

where T_{max} is the daily maximum air temperature, T_{min} is the daily minimum air temperature, and T_b is the temperature below which the process of interest does not progress, in that study 50°F (Gilmore and Rogers, 1958).

After physiological maturity (R_6), 16.4 linear feet of the two central rows were evaluated to determine total biomass and grain yield. The yield was calculated based on harvested area and adjusted to 15.5% standard grain moisture. Furthermore, 1,000-grain weight was determined by counting and weighing 200 grains, and the number of grains ft^{-2} was calculated from grain yield and 1,000-grain weight.

To analyze the effect of hybrid maturity on grain yield, yield components, and harvest index, mixed effect models were fitted with the lme4 (Bates et al., 2015) package in RStudio (RStudio team, 2020) and then analyzed with ANOVA. Treatment was set as a fixed effect factor, while block was included as a random effect. Pairwise comparisons were conducted with a Tukey-Kramer method using a significance level of α = 0.05.

Results

The observed days from planting to maturity ranged from 92 (522 GDD) to 120 (807 GDD) for the 75 and 111 CRM, respectively (Figure 1A and 1B), with major differences for the reproductive period [flowering (R1) to maturity (R6)].

Longer hybrids (111 CRM) achieved higher yields (Figure 2). The observed values ranged from 102 to 146 bu/a for CRM 75 and 111, respectively, a 25% yield gap. Thus, for each day that the relative maturity is shortened, corn yield decreased by 1.5 bu/a.

Likewise for yield, both yield components had significant differences among corn hybrids ($P \leq 0.05$, Figure 3). Regarding grain number, there was an increasing trend from CRM 82 (246/ft^2) to CRM 101 (315 grains/ft^2), plateauing for 101 and 111 CRM (Figure 3A). Furthermore, the longest hybrid maturity (CRM 111) presented larger grain weight (303 mg per grain) compared to the medium (~ 251 mg per grain; CRM 101, 91, and 82) and short hybrids (~210 mg per grain; CRM 75) (Figure 3B).

Conclusion

This study showed that with regular planting dates, long-maturing corn hybrids achieved greater yields compared to shorter maturing hybrids. These variations in grain yield were explained by differences in grain number and grain weight. However, it should be noted that there is a research gap regarding the behavior of different maturity types across a wider range of planting dates, especially for late planting dates. Therefore, future studies should evaluate different planting dates to measure the impact of placing the crop growth stages at different times of the year.

Acknowledgments

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Table 1. Soil characterization (pH, organic matter [OM], Mehlich phosphorus, sand, silt, and clay content, $N\text{-}NO_3^-$ and $N\text{-}NH_4^+$) of corn experiments carried out in Manhattan, KS, in 2022

Depth	pH	OM	P	Sand	Silt	Clay	$N\text{-}NO_3$	$N\text{-}NH_4^+$
inches		%	ppm	%	%	%	ppm	ppm
0–8	6.9	2.3	19.33	13	59	28	---	---
0–24	---	---	---	---	---	---	8.04	6.1

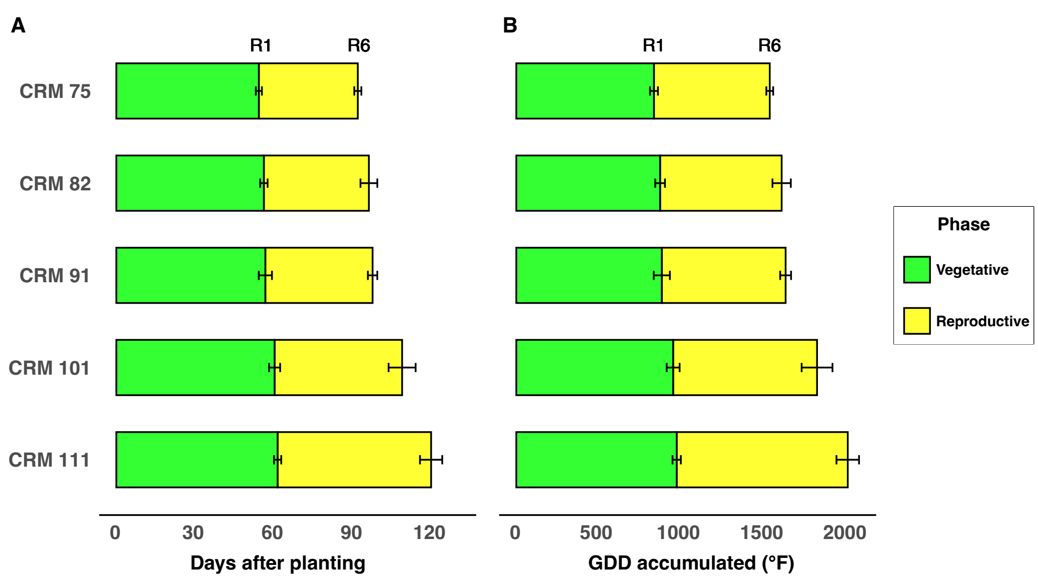

Figure 1. Comparison of the different corn hybrid maturities in accumulated days (A, days after planting) and growing degree days (B; GDD in °F) from planting to flowering (R_1) and from flowering to maturity (R_6).

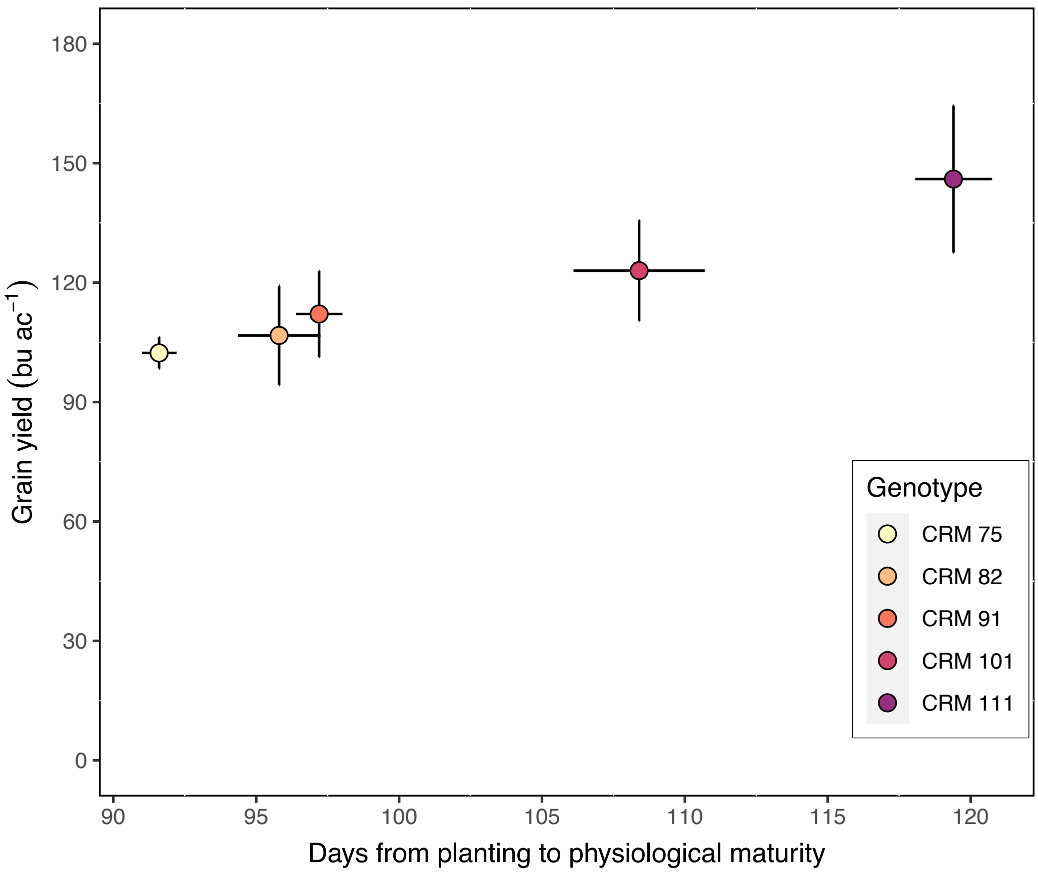

Figure 2. Relationship between grain yield (bu/a) and days to physiological maturity (after planting) for five hybrids at Manhattan, KS, in 2022. The error bar represents the standard error of the means.

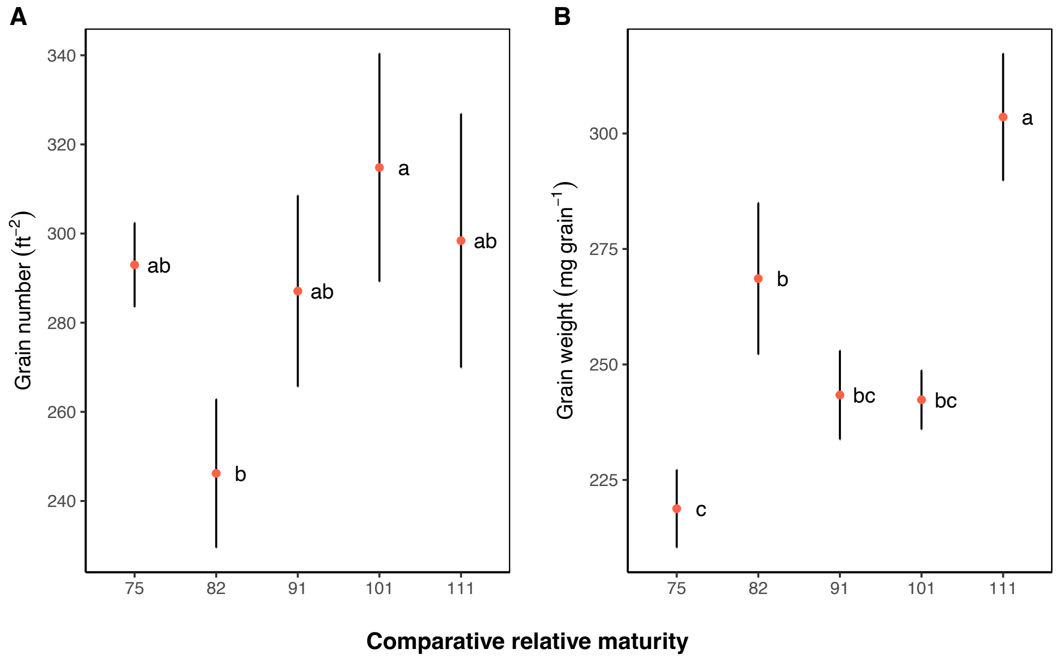

Figure 3. Grain number (A; grains/ft^2) and grain weight (B; mg per grain) for five different hybrid maturities during the 2022 growing season. The error bar represents the standard deviations of the means. Different lowercase letters indicate significant differences among hybrids according to Tukey test (*P* < 0.05).