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Wheat Development and Yield as Affected by Era of Variety Release and In-Furrow Fertilizer

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Wheat Development and Yield as Affected by Era of Variety Release and In-Furrow Fertilizer

Abstract

Limited information exists on the interaction between historical and modern wheat varieties and in-furrow fertilizer. Our objectives were to estimate grain yield and differences in dynamics of biomass accumulation of historical and modern winter wheat varieties as affected by different fertilization practices. Two field trials were established during the 2017–2018 growing season in Kansas. Eight winter wheat varieties released between 1920 and 2016—Kharkof (1920), Scout 66 (1966), Karl 92 (1988), Jagger (1994), Jagalene (2001), Fuller (2006), KanMark (2014) and Larry (2016)—were sown using one of two different fertilizer treatments: either the university recommendation (control with no in-furrow fertilizer due to high testing soil-P levels) or a treatment where 100 lb/a MESZ were applied in-furrow. Grain yield was greater in semi-dwarf varieties relative to tall varieties. In-furrow fertilizer showed greater grain yield in comparison with no fertilizer treatment. Whole plant biomass accumulation at maturity did not change over decades. In-furrow fertilizer presented larger biomass accumulation than no fertilizer treatment. Harvest index increased from tall to semi-dwarf varieties. More site-years of this study are needed to determine whether there is a need for re-evaluation of current fertility recommendations for semi-dwarf wheat varieties, considering that no interaction between variety and fertility was observed.

Keywords

wheat, year of release, historical trends, in-furrow fertilizer, semi-dwarf

Cover Page Footnote

The authors appreciate the Kansas Wheat Commission for providing funds necessary to perform this research. We also acknowledge the Kansas State University Wheat Production Team for the help collecting and processing the field data.

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R.E. Maeoka and R.P. Lollato

Summary

Limited information exists on the interaction between historical and modern wheat varieties and in-furrow fertilizer. Our objectives were to estimate grain yield and differences in dynamics of biomass accumulation of historical and modern winter wheat varieties as affected by different fertilization practices. Two field trials were established during the 2017–2018 growing season in Kansas. Eight winter wheat varieties released between 1920 and 2016—Kharkof (1920), Scout 66 (1966), Karl 92 (1988), Jagger (1994), Jagalene (2001), Fuller (2006), KanMark (2014) and Larry (2016)—were sown using one of two different fertilizer treatments: either the university recommendation (control with no in-furrow fertilizer due to high testing soil-P levels) or a treatment where 100 lb/a MESZ were applied in-furrow. Grain yield was greater in semi-dwarf varieties relative to tall varieties. In-furrow fertilizer showed greater grain yield in comparison with no fertilizer treatment. Whole plant biomass accumulation at maturity did not change over decades. In-furrow fertilizer presented larger biomass accumulation than no fertilizer treatment. Harvest index increased from tall to semi-dwarf varieties. More site-years of this study are needed to determine whether there is a need for re-evaluation of current fertility recommendations for semi-dwarf wheat varieties, considering that no interaction between variety and fertility was observed.

Introduction

Improvements in wheat yield over time were a combination between advances in wheat breeding (e.g. introduction of dwarfing genes) and better agronomic management practices (e.g. fertilizer input and pesticide usage). However, the increased grain yield potential of semi-dwarf wheat varieties may have had the hidden consequence of a shift in the nutrient requirements of the modern wheat plants. Therefore, current fertilizer recommendations need to be tested to determine whether an update is needed to match nutrient necessities of modern varieties and increase the return over investment. The objectives of this project were to evaluate whether historical and modern winter wheat varieties respond differently to in-furrow fertilizer in high P-level soils and to determine the partial contribution from genetic and agronomic management to wheat yield gain and biomass accumulation and partitioning.

Procedures

Experiments during the 2018 harvest year were established in Belleville and Hutchinson, KS. Both experimental sites were characterized to have more than 40 ppm extractable phosphorus (P), which is double the minimum required by a wheat crop (about 20 ppm). A complete factorial treatment structure was established in split-plot design with four replications, with main plots arranged as randomized complete block design and sub-plots completely randomized within main plots. Main plots were eight winter wheat varieties released between 1920 and 2016 that were divided by height: tall, Kharkof (1920), Scout 66 (1966); and semi-dwarf, Karl 92 (1988), Jagalene (2001), Fuller (2006), KanMark (2014) and Larry (2016). Sub-plots were two fertilization treatments 1) control with no in-furrow fertilizer, and 2) 100 lb/a applied in-furrow as 12-40-0-10-1 (N-P-K-S-Zn).

Wheat was sown October 12, 2017, at Belleville, and October 19, 2017, at Hutchinson, at a seeding rate of 60 lb/a (approximately 1.28 million seeds/a). All the locations were planted under conventional tillage methods following a previous wheat crop. Plots were 30-ft long × 4.38-ft wide, with seven 7.5-in. spaced rows. At both locations, high levels of inherent soil nitrogen (N) was available so no fall N fertilization was necessary. Topdress N (46-0-0) was applied early spring (Feekes 5–6) across the entire experiment with a yield goal of 90 bushels per acre. Two foliar fungicide applications were performed (Feekes 6–7, Feekes 10.5) to avoid foliar diseases and consequently yield losses. Similarly, commercial herbicide products were sprayed to ensure weeds were not a limiting factor. No significant insect pressure was observed, therefore insecticide applications were not warranted. Plots were harvested for grain using a self-propelled small-plot combine. Grain moisture was measured at harvest and grain yield was corrected for 13.5% moisture content. Aboveground biomass was collected at harvest maturity. Harvest index was calculated, dividing grain yield by whole plant biomass at harvest maturity. Analysis of variance considered varieties and fertilization practice as fixed effects, and location and replication nested within location as random effects.

Results

Growing Season Weather

Overall, the 2017–18 growing season was excessively dry for both locations, especially during fall, winter, and early spring. However, precipitation prior to sowing allowed good stand establishment, and favorable conditions in late spring contributed to grain yield. Seasonal mean temperatures were similar to the 30-year average.

Grain Yield

There were significant variety and fertility effects on wheat grain yield. Grain yield ranged from 58 bu/a for Kharkof to 94 bu/a for Jagalene (Figure 1A). On average, tall varieties yielded around 65 bu/a, while semi-dwarf varieties yielded around 88 bu/a (Figure 1A). Besides variety effect, in-furrow fertilizer significantly increased grain yield relative to no fertilizer treatment by approximately 6 bu/a (Figure 1B).

Overall, we observed a low yield gain during the period between 1920 and 1966; then, a substantial yield gain period between 1966 and early 1990s; and a decrease in the pace of progress afterwards. The genetic progress across the entire study-period was ~0.35 bu/a/yr.

Dynamics of Biomass Accumulation

There was a significant fertility effect on wheat aboveground biomass accumulation at maturity, but virtually no difference among varieties other than numerical. On average, tall varieties accumulated approximately 9658 lb/a and semi-dwarf varieties accumulated 9879 lb/a (Figure 2A). Karl 92 showed the lowest biomass accumulation across varieties (9013 lb/a), around 865 lb/a fewer than the average for semi-dwarf varieties (Figure 2A); however, this difference was not statistically significant. In-furrow fertilizer treatment significantly increased biomass accumulation at maturity relative to no fertilizer treatment by approximately 584 lb/a (Figure 2B). There was significant variety effect on harvest index. Harvest index is the quotient between grain yield and whole plant biomass at maturity, and it ranged from 0.39 for Kharkof to 0.56 for Jagalene (Figure 2C). Significant improvements in harvest index at the same biomass levels of semi-dwarf varieties improved the ability to allocate more biomass into the grain without increasing the whole plant biomass. In-furrow fertilizer treatment had the same harvest index relative to no fertilizer treatment.

Acknowledgments

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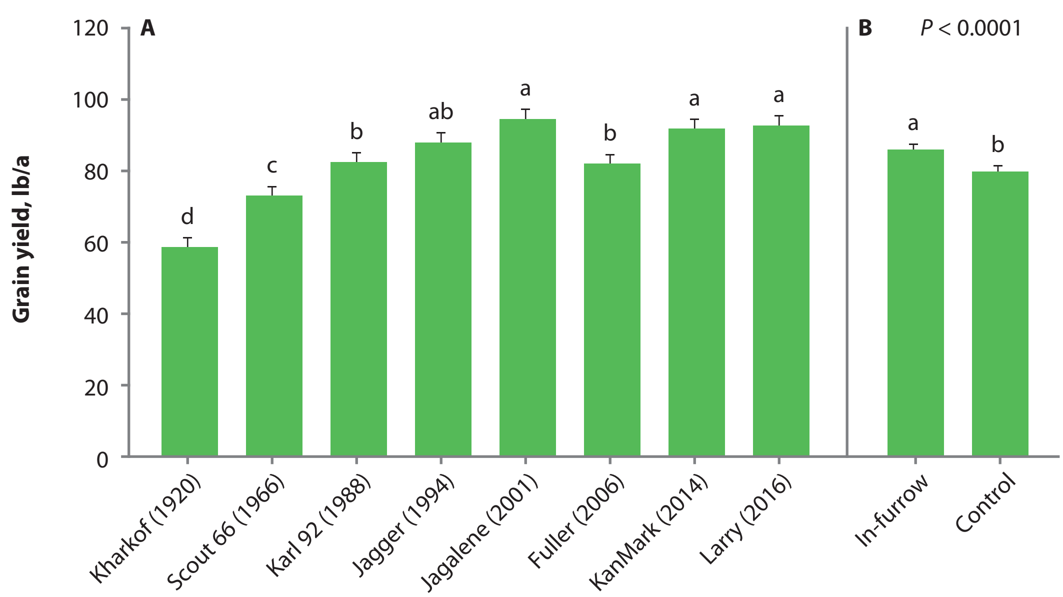

Figure 1. Grain yield of varieties released between 1920 and 2016 (A), grain yield comparison of in-furrow fertilizer treatment and control (bars show mean and standard error) (B) during the 2017–18 growing season in Kansas.

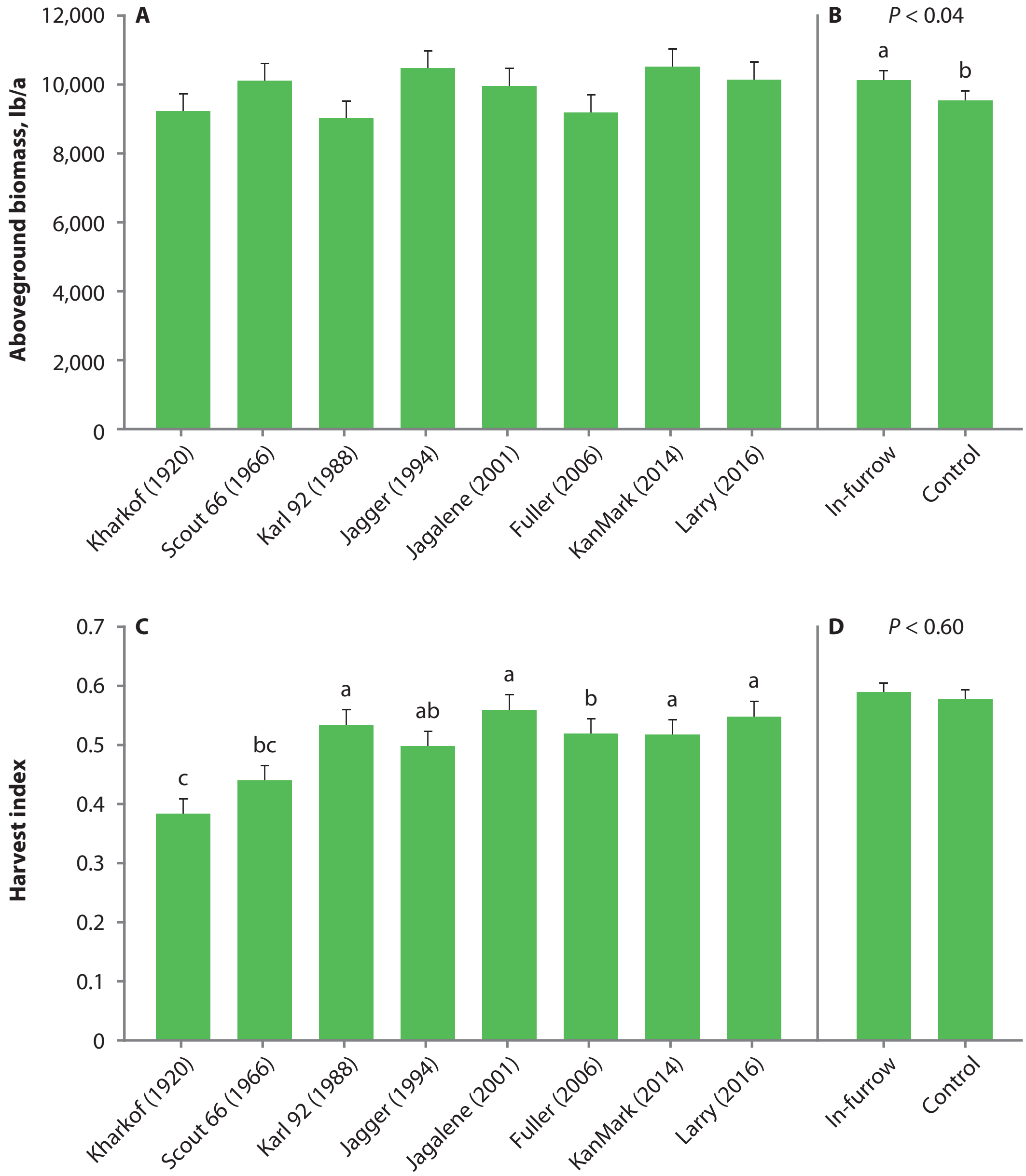

Figure 2. Dynamics of biomass accumulation as affected by year of variety release at maturity (A), biomass accumulation comparison of in-furrow fertilizer treatment and control (bars show mean and standard error) (B), harvest index as affect by year of variety release (C), harvest index comparison of in-furrow fertilizer treatment and control (bars show mean and standard error) (D) during the 2017–18 growing season in Kansas.