CORN RESPONSE TO P AND K PLACEMENT, TIMING AND RATES IN STRIP-TILLAGE SYSTEMS IN EASTERN SOUTH DAKOTA

A. Cauda and P. Kovács
South Dakota State University, Brookings, SD
Agustin.Cauda@jacks.sdstate.edu – (785)-317-6085

ABSTRACT

Strip-tillage is increasingly adopted as a conservation management practice because it combines many of the agronomic advantages of conventional tillage while similar benefits of no-till in between the berms. The objective of this study is to evaluate the effects of P and K fertilizer placement, application timing, and fertilization rates within strip-tillage systems on corn (*Zea mays* L.) performance in eastern South Dakota. Field experiments have been established near Brookings and South Shore, South Dakota, using a split-plot design with four replications. Main plot treatments consist of five combinations of tillage system and fertilizer timing/placement: strip-tillage with spring banded, fall banded, fall broadcast, and spring broadcast fertilizer applications and conventional tillage with fall broadcast application. Six P and K fertilizer rates were assigned to subplots. Measurements of V6 nutrient uptake, biomass accumulation, and grain yield will be collected and analyzed to assess the effectiveness of these management practices and their potential to improve nutrient use efficiency and corn productivity.

INTRODUCTION

Phosphorus (P) and potassium (K) are essential macronutrients for corn (*Zea mays* L.) production because they play critical roles in early-season growth, biomass accumulation, reproductive development, yield components, and final grain yield (Kaiser et al., 2005; Mengez et al., 2026). Adequate nutrient availability during vegetative growth is particularly important, as it influences ear development, kernel formation, and overall crop productivity. Consequently, effective P and K management is necessary to maintain high yield and economic profitability in corn production.

Nutrient availability and crop uptake are influenced not only by the amount of fertilizer applied but also by its placement and timing. Phosphorus, in particular, has limited mobility in the soil, making fertilizer placement an important factor affecting nutrient-use efficiency (Borges & Mallarino, 2001; Randall & Hoeft, 2013). Potassium management can also influence key yield components, including kernel number, kernel weight, and grain yield, especially in environments where crop response to K fertilization is expected (Drescher et al., 2021; Mengez et al., 2026). Therefore, optimizing fertilizer placement and application timing is essential for improving nutrient availability throughout the growing season and maximizing crop performance.

Among fertilizer placement strategies, banded applications have received considerable attention due to their potential to enhance nutrient availability. Banded fertilizers are concentrated in a localized zone near the developing root system,

increasing the likelihood of nutrient uptake during critical stages of plant growth. In contrast, broadcast applications distribute nutrients uniformly across the soil surface, which may reduce nutrient-use efficiency because nutrients are not concentrated in the immediate vicinity of crop roots. Previous research has demonstrated that banded P applications can improve nutrient accessibility and crop performance compared with broadcast applications by placing nutrients closer to actively growing roots (Borges & Mallarino, 2001; Fernández & White, 2012).

Conservation tillage practices, particularly strip tillage, have emerged as sustainable alternatives to conventional tillage systems. Strip tillage disturbs only a narrow portion of the soil where the crop row is established while leaving crop residue undisturbed between rows. This approach helps reduce soil erosion, conserve soil moisture, and maintain surface residue cover. In addition to these environmental benefits, strip tillage may improve nutrient management by allowing fertilizer to be placed directly within the crop row, thereby increasing nutrient accessibility to developing roots.

Because both tillage and fertilizer management influence nutrient availability and plant growth, evaluating their interaction is important for improving corn production. Understanding how tillage systems and P and K fertilizer placement strategies affect biomass accumulation, yield components, and grain yield can provide valuable information for developing efficient and sustainable nutrient management practices. Therefore, the objective of this study was to evaluate the effects of tillage systems and P and K fertilizer placement strategies on corn growth, biomass production, yield components, and grain yield.

MATERIALS AND METHODS

This study is part of a long-term corn-soybean [*Glycine max* (Merr.) L] rotation experiment started in 2024. The study was conducted during the growing season at two locations in South Dakota: near Brookings and South Shore. Both sites were managed under the same corn-soybean rotation system, with the same experimental areas maintained under the rotation throughout the study. Corn was planted using the Pioneer P95819V and P9193Q hybrids at Brookings and South Shore, respectively, at a seeding rate of 84,000 seeds acre^{-1}. At both locations, plots consisted of four rows spaced 30 inches apart, measuring 10 ft in width and 45 ft in length.

Five tillage and six fertilizer placement systems were evaluated: spring strip tillage with banded P and K fertilizer (SSTB), fall strip tillage with banded P and K fertilizer (FSTB), spring strip tillage with broadcast P and K fertilizer (SSTBR), fall strip tillage with broadcast P and K fertilizer (FSTBR), and conventional tillage with broadcast P and K fertilizer (CT). Strip-tillage treatments received fertilizer either in a subsurface band within the tilled row or as a surface broadcast application, whereas the conventional tillage treatment received broadcast fertilizer incorporation following tillage operations. The fertilizer source used for all treatments consisted of a phosphorus and potassium blend containing one-third Aspire® (0-0-58-0.5B) and two-thirds MicroEssentials® SZ (12-40-0-10S-1Zn). Fertilizer was applied at four rates: 0, 160, 200, and 275 lb acre^{-1}. In 2024, fertilizer treatments included Control, Control + Starter,

Medium, and High rates. In 2026, the experiment returned to the same portion of the field (and the same bands with strip-tillage) where the project was established in 2024, and the fertilizer program was expanded to include six rates: Control, Control + Starter, Medium-Low (medium rate was applied in 2024, and low rate was applied in 2026), Medium-Medium, High-Medium, and High-High. Fertilizer was applied at the designated rates according to each year's treatment structure.

In addition to the P and K fertility treatments, one starter fertilizer treatments were included. One treatment received starter fertilizer as 10-34-0 applied at a rate of 5 gal acre^{-1} at planting without any additional P and K application. The experiment was arranged as a factorial combination of tillage and fertilizer management practices to evaluate their effects on corn growth, biomass production, yield components, and grain yield. Plot assignment followed a split-plot design where the tillage system and fertilizer placement combination were in the whole plots, and the P and K rates were the sub-plots

RESULTS AND DISCUSSION

Early- season biomass accumulation (V6 stage)

To evaluate the effects of tillage and P and K fertilization on early-season corn growth, biomass was measured at the V6 growth stage. At Brookings, biomass accumulation was significantly affected by the tillage system/fertilizer placement combination ($p < 0.001$), whereas fertilizer rates ($p = 0.713$) and the tillage × fertilizer rate interaction ($p = 0.759$) were not significant (Figure 1). In contrast, at South Shore, fertilizer rate significantly affected biomass accumulation ($p < 0.001$), whereas tillage systems ($p = 0.555$) and the tillage × fertilizer rate interaction ($p = 0.752$) were not significant (Figure 2).

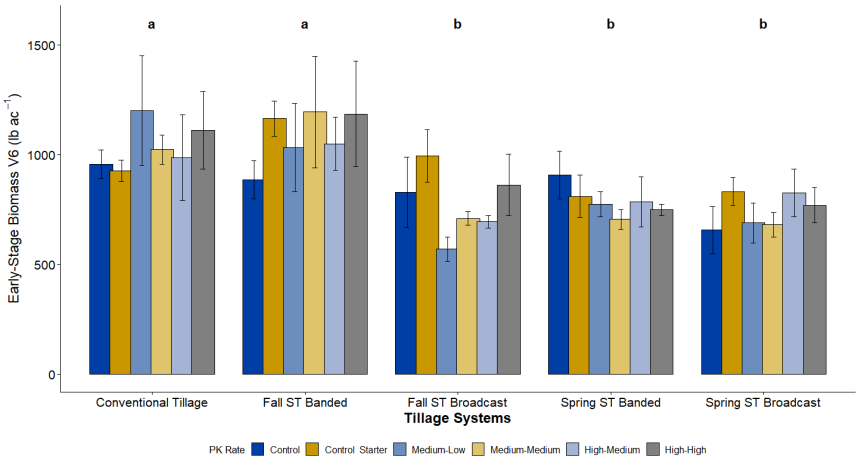


Figure 1. Early-season corn biomass accumulation at the V6 growth stage as affected by tillage system and phosphorus (P) and potassium (K) fertilizer rate at Brookings, SD. Bars represent treatment means, and error bars indicate ± standard error of the mean.

Fall ST banded and Conventional tillage produced the greatest biomass, whereas fall ST broadcast, spring ST banded, and spring ST broadcast reduced biomass accumulation by approximately 245 to 291 lb ac^{-1}.

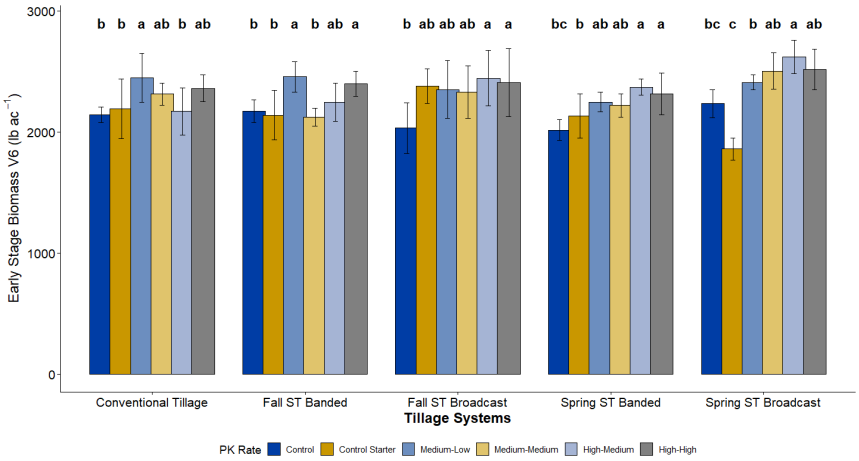


Figure 2. Early-season corn biomass accumulation at the V6 growth stage as affected by tillage system and phosphorus (P) and potassium (K) fertilizer rate at South Shore, SD. Bars represent treatment means, and error bars indicate ± standard error of the mean.

The high-high fertilizer rate treatment produced the greatest biomass accumulation, averaging 277 lb ac^{-1} more than the control. Medium-low and high-medium rates increased biomass accumulation by 261 and 245 lb ac^{-1}, respectively, while medium-medium increased biomass by 183 lb ac^{-1} compared with the control (Figure 2).

Grain yield

Grain yield responses exhibited different pattern between locations. At Brookings, grain yield was significantly affected by tillage system (p = 0.05) and P and K fertilizer rate (p = 0.09), whereas the tillage × fertilizer rate interaction (p = 0.970) was not significant (Figure 3). In contrast, South Shore did not present any significant difference between the main factors and their interaction. Conventional tillage generally produced the highest grain yields across fertilizer rates, indicating that tillage had a greater influence on grain yield than P and K fertilization. In contrast, grain yield at South Shore was not affected by fertilizer rate (p = 0.82), tillage system (p = 0.60), or their interaction (p = 0.9) (Figure 4). Although numerical differences among treatments were observed, grain yield responses were relatively small and inconsistent across fertilizer rates and tillage systems.

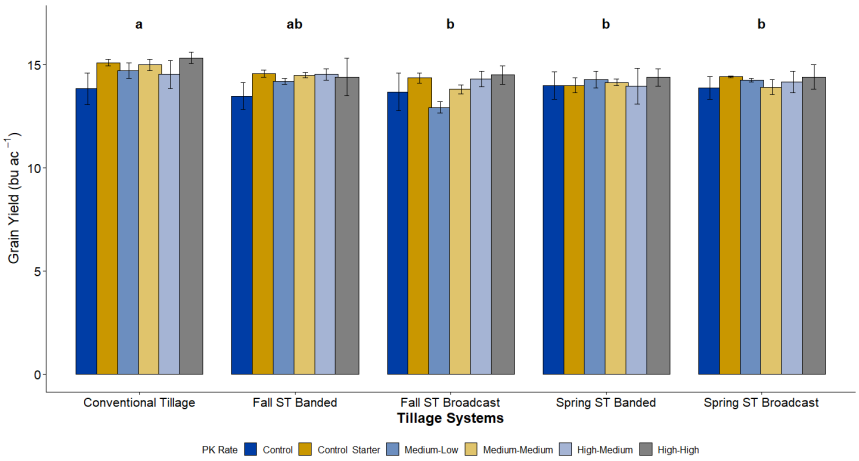


Figure 3. Corn grain yield as affected by tillage system and P and K fertilizer rates at Brookings, SD. Error bars represent ± standard error.

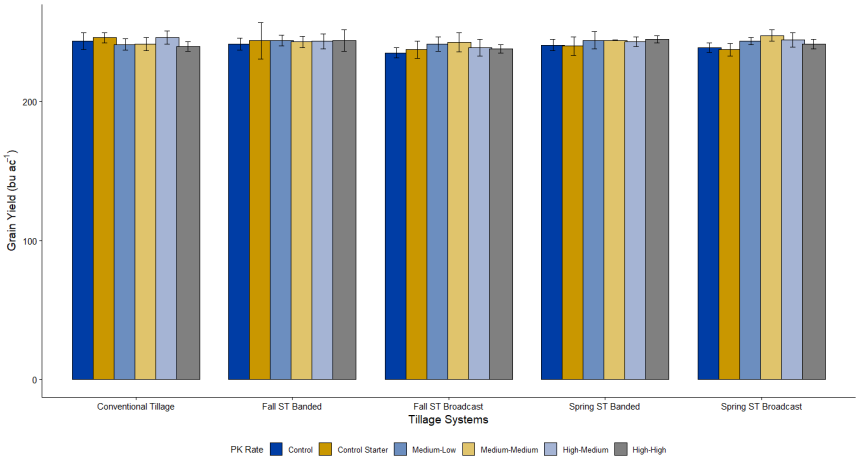


Figure 4. Corn grain yield as affected by tillage system and P and K fertilizer rates at South Shore, SD. Error bars represent ± standard error.

To conclude, tillage system and fertilizer placement had a greater impact on early-season corn growth than P and K fertilizer rate. Fall strip-tillage with banded fertilizer consistently promoted greater biomass accumulation than the others tillage systems, emphasizing the role of enhanced root-zone conditions and improved nutrient availability in supporting early-season corn growth at Brookings, SD. While biomass responses to increasing P and K rates were observed at South Shore, SD, these effects were not consistently reflected in grain yield. The limited yield response suggests that soil nutrient availability was generally sufficient to meet crop demand across environments. Although grain yield differences among tillage systems were relatively small, the implementation of strip-tillage may still provide important agronomic and environmental benefits compared with conventional tillage, including improved soil conservation and enhanced soil health. Overall, the results indicate that optimizing tillage and fertilizer placement practices may provide greater benefits for early corn

growth than increasing fertilizer rates alone, while continued evaluation of this long-term corn-soybean rotation study will help determine the long-term implications for nutrient use efficiency, soil health, and crop productivity.

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