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Occasional Tillage and Nitrogen Application Effects on Winter Wheat and Grain Sorghum Yield

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Abstract

Occasional tillage ahead of winter wheat planting could alleviate herbicide-resistant weeds, redistribute soil acidification, and improve seedbed at wheat planting. The objective of this study is to determine occasional tillage and nitrogen (N) fertilizer application effects on winter wheat, and grain sorghum yields and soil quality in a wheat-sorghum-fallow cropping system. Treatments were three tillage practices: 1) continuous no-tillage (NT); 2) continuous reduced-tillage (RT); and 3) single tillage operation every 3 years (June-July) ahead of winter wheat planting [occasional tillage (OT)]. The sub-plot treatments were assigned to four N fertilizer rates (0, 40, 80 and 120 lb/a of N). Preliminary results showed tillage had no effect on winter wheat grain yield. Applying N fertilizer increased wheat yield, ranging from 21 bu/a with no N fertilizer to 29 bu/a when N fertilizer was applied at 120 lb/a of N. Tillage and N fertilizer effects on grain sorghum yield varied over the 2 years of the study. Grain sorghum yields in 2017 decreased with RT but tillage had no effect on sorghum yields in 2018. Averaged across tillage and years, sorghum grain yield was 54 bu/a with no N fertilizer and 84 bu/a when N was applied at 120 lb/a of N. Both sorghum and winter wheat grain yields obtained with 80 lb/a of N were not different from those with 120 lb/a of N, suggesting 80 lb/a of N may be adequate for both crops.

Keywords

nitrogen, occasional tillage, winter wheat

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A.K. Obour, J.D. Holman, and A.J. Schlegel

Summary
Occasional tillage ahead of winter wheat planting could alleviate herbicide-resistant weeds, redistribute soil acidification, and improve seedbed at wheat planting. The objective of this study is to determine occasional tillage and nitrogen (N) fertilizer application effects on winter wheat, and grain sorghum yields and soil quality in a wheat-sorghum-fallow cropping system. Treatments were three tillage practices: 1) continuous no-tillage (NT); 2) continuous reduced-tillage (RT); and 3) single tillage operation every 3 years (June-July) ahead of winter wheat planting [occasional tillage (OT)]. The sub-plot treatments were assigned to four N fertilizer rates (0, 40, 80 and 120 lb/a of N). Preliminary results showed tillage had no effect on winter wheat grain yield. Applying N fertilizer increased wheat yield, ranging from 21 bu/a with no N fertilizer to 29 bu/a when N fertilizer was applied at 120 lb/a of N. Tillage and N fertilizer effects on grain sorghum yield varied over the 2 years of the study. Grain sorghum yields in 2017 decreased with RT but tillage had no effect on sorghum yields in 2018. Averaged across tillage and years, sorghum grain yield was 54 bu/a with no N fertilizer and 84 bu/a when N was applied at 120 lb/a of N. Both sorghum and winter wheat grain yields obtained with 80 lb/a of N were not different from those with 120 lb/a of N, suggesting 80 lb/a of N may be adequate for both crops.

Introduction
Adoption of NT practices during fallow by many producers in the central Great Plains (CGP) has increased the quantity of residues retained on the soil surface, and soil moisture storage. This has allowed for cropping intensification in dryland systems in the CGP from winter wheat-fallow to winter wheat-summer crop-fallow or a more intensified cropping system with no fallow depending on soil water availability. The benefits of NT include reduction in soil erosion, increased soil organic matter accumulation, improved soil structure, and increased soil water storage.

Despite these benefits, stratification of soil nutrients, organic matter, and pH tend to develop near the soil surface in long-term continuous NT systems. In addition, the lack of effective herbicides for perennial grass weeds—such as three-awn grass (*Aristida purpurea* Nutt.) and tumble windmill grass (*Chloris verticillata* Nutt.) —and the emergence of glyphosate-resistant weeds pose challenges in NT crop production. Also in drier years, the upper layer (0-2 inches) of soils in NT tends to be "hard" and presents a challenge to placing seed in subsoil moisture at the time of wheat planting. This may cause poor plant establishment and reduce winter wheat yields. Occasional tillage of NT soils may be necessary to alleviate herbicide-resistant weed issues, redistribute soil acidity, and improve seedbed at wheat planting. Research objectives are to determine the impacts of OT and N application on crop yields and soil water availability, and long-term effects of OT on soil health and herbicide-resistant weeds.

Procedures

Field experiments were initiated in spring 2017 at the Kansas State University Agricultural Research Center near Hays, KS, to address the previously mentioned objectives. Study design is a split-split-plot with three replications in a randomized complete block design. Main plots were three crop phases of a wheat-sorghum-fallow, sub-plot treatments were three tillage practices: 1) continuous NT; 2) continuous RT; and 3) single tillage operation every 3 years (June-July) ahead of winter wheat planting (OT). The sub-sub-plots were assigned to four N fertilizer application rates (0, 40, 80, and 120 lb/a of N). The reduced tillage treatments had two to three tillage operations during fallow ahead of wheat planting and one tillage operation prior to sorghum planting. All tillage operations were done with a sweep-plow to a depth of 4– to 6–inches. Each phase of the crop rotation, tillage, and N fertilizer treatment is implemented in each year of the study. Winter wheat and sorghum grain yields were determined by harvesting a 5 × 80 ft area from the center of each plot using a small plot combine. Statistical analysis with the PROC MIXED procedure in SAS version 9.4 (SAS Inst., Cary, NC) was used to examine winter wheat and grain sorghum yields as a function of tillage and N fertilizer application.

Results

Winter Wheat Grain Yield

Winter wheat grain yield in 2018 was not affected by tillage (Figure 1a). Averaged across N rates, wheat grain yield was 25 bu/a with NT or OT, and 23 bu/a with RT. Applying N fertilizer did increase wheat grain yield. Across tillage treatments, grain yield ranged from 21 bu/a with no N fertilizer to 29 bu/a when N fertilizer was applied at 120 lb/a of N. However, wheat grain yield was not different when N was applied at 80 lb/a of N or 120 lb/a of N (Figure 1b).

Tillage effects on sorghum grain yield varied over the 2 years. In 2017, sorghum grain yields with NT or OT were not different. However, RT operations reduced sorghum grain yield compared to the other tillage treatments (Figure 2). Tillage had no effect on grain sorghum yields in 2018, possibly due to abundant precipitation during the sorghum growing season in 2018. Similarly, sorghum response to N fertilizer application differed over the 2 years. Application of N fertilizer increased sorghum yields in 2017, but grain yields produced with 40 lb/a of N were similar to that achieved with greater N rates. In the 2018 growing season, applying N fertilizer resulted in a linear increase in sorghum grain yield. Averaged across tillage treatments, sorghum grain yield ranged from 52 bu/a with no N fertilizer application to 91 bu/a when 120 lb/a of N was applied (Figure 3). The differences in N response between 2017 and 2018 growing seasons were because of the differences in precipitation amount in the 2 years that affected amount of available soil water for sorghum production. Across the 2 years and tillage treatments, applying N fertilizer increased grain yield from 54 bu/a with the check treatment (no N applied) to 84 bu/a with 120 lb/a of N. However, grain yield with 80 lb/a of N (79 bu/a) was not different from that obtained with the highest N rate of 120 lb/a of N.

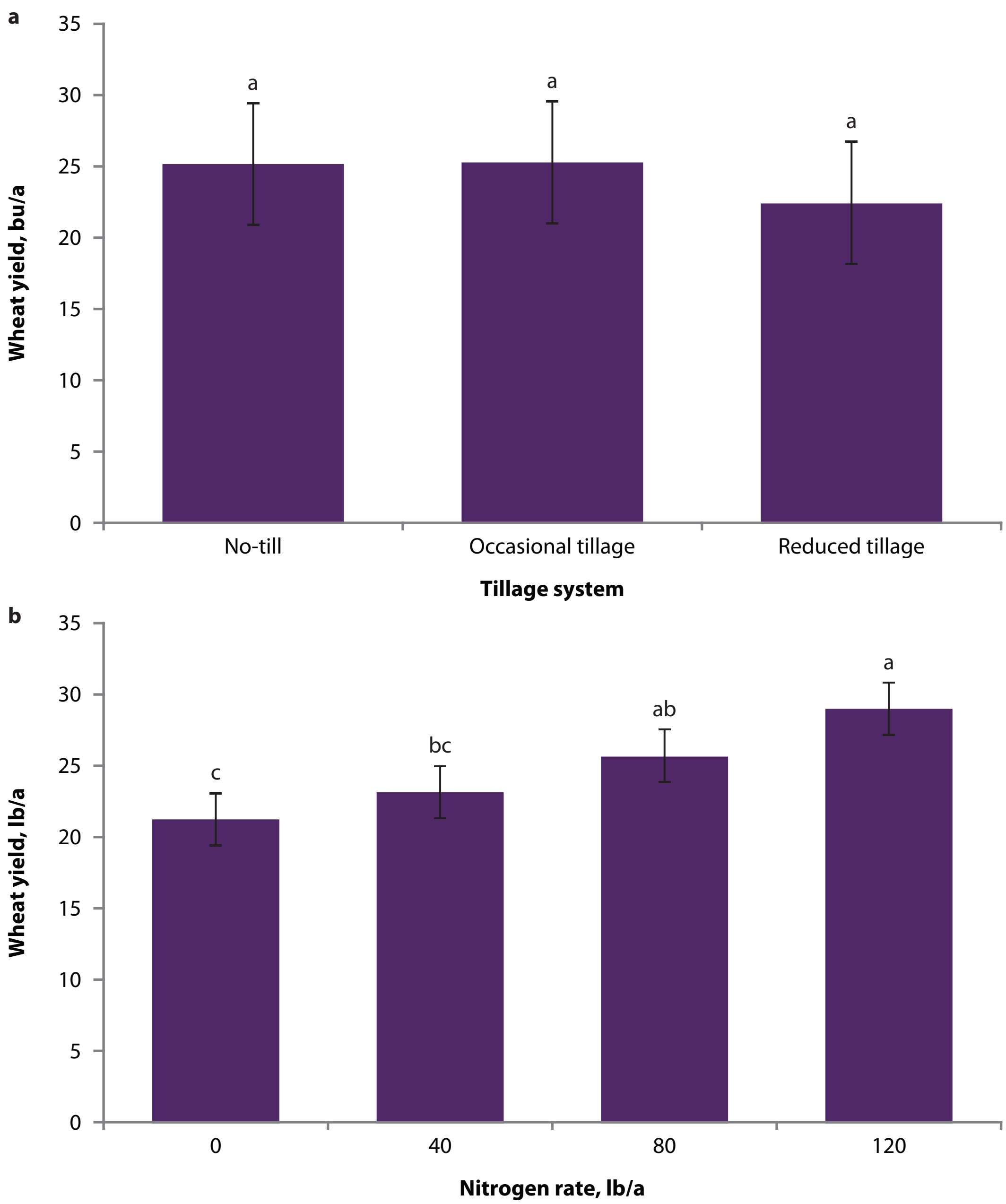

Figure 1. Winter wheat grain yield as affected by tillage (a) and N fertilizer application rate (b) in 2018 growing season at Hays, KS. Data for tillage effects are averaged across four N rates and three replications (n = 12), and data for N rate effects are averaged across three tillage treatments and three replications (n = 9). Means followed by same lower case letter(s) are not significantly different (*P* > 0.05).

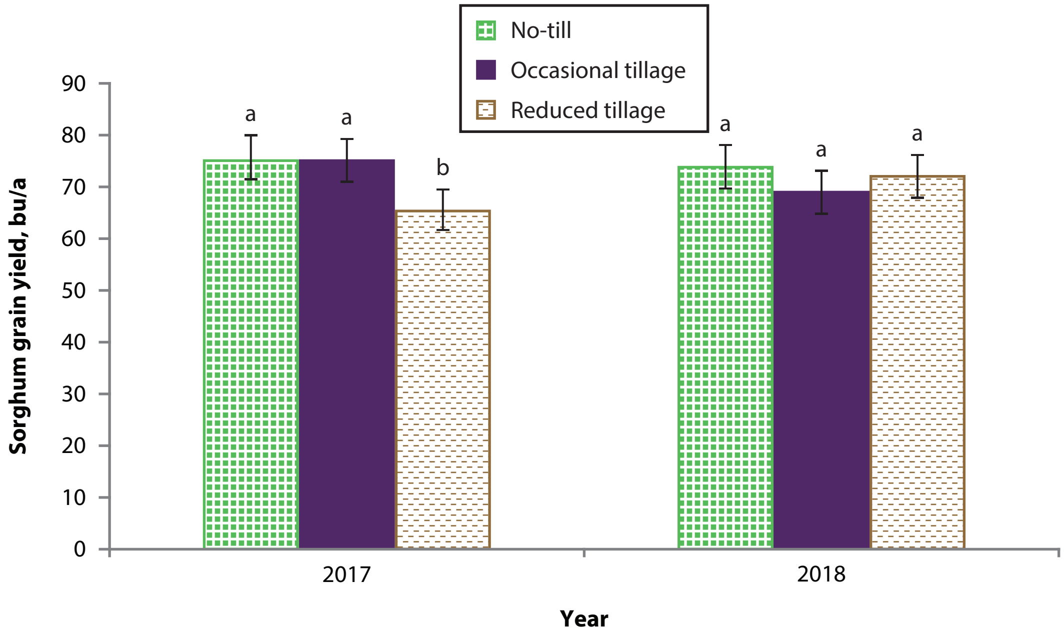

Figure 2. Grain sorghum grain yield as affected by tillage system in 2017 and 2018 growing seasons at Hays, KS. Data are averaged across four N treatments and three replications (n = 12). Means followed by same lower case letter(s) within a year are not significantly different ($P > 0.05$).

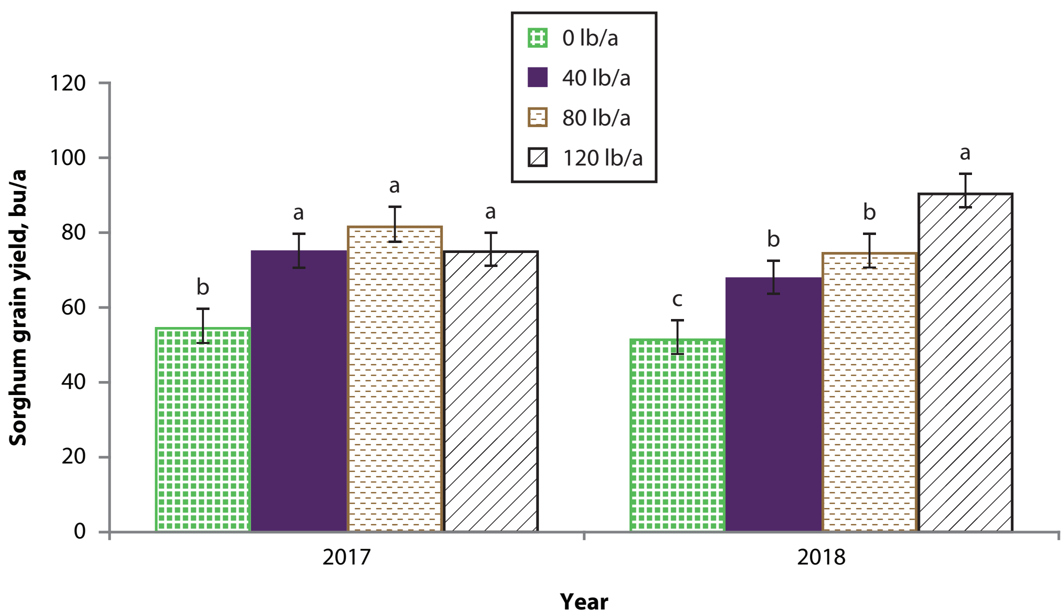

Figure 3. Grain sorghum grain yield as affected by nitrogen fertilizer application rates in 2017 and 2018 growing seasons at Hays, KS. Data are averaged across three tillage treatments and three replications (n = 9). Means followed by same lower case letter(s) within a year are not significantly different ($P > 0.05$).