FORAGE PRODUCTIVITY, WEED DENSITY, AND SOIL PROPERTIES AFFECTED BY GRAZING AND TILLAGE OF ANNUAL FORAGES

P.S. Mauler, J.D. Holman, L.M. Simon, A.K. Obour, S.K. Johnson, and K.L. Roozeboom
Kansas State University Southwest Research-Extension Center, Garden City, KS

ABSTRACT

No-tillage (NT) management of annual crop production systems has often been observed to increase precipitation capture and storage. However, long-term NT can lead to decreased water infiltration due to compaction especially when fields are annually grazed. Compaction as well as cooler soil temperatures can inhibit crop establishment and reduce production. Minimum tillage (MT) (one to two operations between crops) could be used to break up surface compaction, increase water infiltration, improve crop establish, and increase production. Additionally, the development of herbicide resistant weeds presents a challenge to long-term NT production systems. An on-farm study was established in 2016 near Jetmore, KS to investigate the effects of annual tillage with a sweep plow compared to NT in a grazed continuous winter triticale (×*Triticosecale*) production system. Stocking rates were adjusted to the amount of plant growth which was dependent on precipitation. Stocking rates averaged 2 acres per 600 to 650 lb in the fall and 1 acre per 850 to 900 lb in the spring with yearling heifers. Forage productivity, weed density, and soil properties were determined in the 2020 and 2021 production years before and after the implementation of summer tillage. Soil properties were compared to an adjacent perennial grass pasture in 2020. Results showed MT increased available triticale forage by 29% compared to NT when measured in March though treatments were similar when measured in June. Averaged across years, tilled plots had 380% less weed density compared to NT before tillage occurred and 1530% less weed density after tillage and herbicide application. Soil chemical and physical properties were unaffected by tillage compared to NT in the 0- to 2-inch and 2- to 6-inch soil depths. However, when compared to an adjacent perennial pasture in 2020, both MT and NT plots had greater soil bulk density (13%), lower soil organic carbon (40%), and lower mean weight diameter of water stable aggregates (69%). These preliminary results suggest MT of grazed annual forage systems reduced weed density and increased fall through early spring forage productivity without affecting soil properties.

INTRODUCTION

Growing annual forages in semi-arid dryland cropping systems in the central Great Plains and increase cropping intensity, benefit livestock production, rest native rangeland, and increase profit (Holman et al., 2020; 2021). No-tillage (NT) management of annual crop production systems has often been observed to increase precipitation capture and enhance soil health (Blanco-Canqui and Ruis, 2018) However, long-term NT can lead to decreased water infiltration due to compaction especially when fields are annually grazed. Compaction as well as cooler soil temperatures can inhibit crop establishment and reduce production. Minimum tillage (MT) (one to two operations between crops) could be used to break up surface compaction, increase water infiltration, improve crop establish, and increase production (Holman et al., 2021). Additionally, the development of herbicide resistant weeds presents a challenge to long-term NT production systems. Across the semi-arid Great Plains, herbicide resistant kochia (*Bassia scoparia*) and Palmer amaranth (*Amaranthus palmeri*) are major challenges to effective NT management (Kumar et al., 2018; 2020). This experiment compared MT and NT management of grazed continuous triticale (×*Triticosecale*) to determine effects on forage production, weed density, and soil properties.

MATERIALS AND METHODS

An annual forage grazing and tillage experiment was initiated in 2016 at an on-farm field near Jetmore, KS. The study was a randomized complete block design with four replications. Two tillage treatments, NT and MT, were implemented in a grazed continuous winter triticale cropping system. Plots were 50 ft wide and 1300 ft long. In this experiment, tillage was implemented twice during the fallow period between winter triticale crops using a Minimizer sweep plow (Premier Tillage, Quinter, KS) between July 1 and August 1. The sweep plow is a minimum disturbance implement commonly used in the region for weed control. Both MT and NT treatments received the same herbicide applications which usually consisted of a mixture of glyphosate, dicamba, and 2-4,D.

Every year, winter triticale was planted between August 15 and September 15 and was grazed through the winter and spring. Stocking rates were adjusted to the amount of plant growth which was dependent on precipitation. Stocking rate averaged 2 acres per 600 to 650 lb in the fall and 1 acre per 850 to 900 lb in the spring with yearling heifers. Livestock were removed to an adjacent native grass pasture either before or soon after heavy rain events (>0.5”) for a few days to allow the soil surface to dry and minimize surface compaction. Otherwise, livestock were left on the field to graze. Grazing ended between May 15 and June 15 either after triticale reached heading stage in wet years or after the crop had been grazed out, in dry years.

In 2021, triticale forage was measured in March and June to estimate early spring and early summer forage availability using two 2.5 ft^2 quadrats. Samples were oven-dried at 122°F until a constant weight was reached to determine dry matter. In 2020 and 2021, weed density was measured before tillage in the month of June and after tillage and herbicide application in July. Weed density was estimated using a 2.5ft^2 quadrat in June and a 100 ft^2 quadrat in August. A larger quadrat was used in August due to low weed density following tillage and herbicide application.

In 2020 and 2021, soil properties were measured before and after summer tillage. In 2020 only, an adjacent perennial grass pasture dominated by buffalograss (*Bouteloua dactyloides*), sideoats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), and little bluestem (*Schizachyrium scoparium*) was also sampled for comparison with the annual triticale. Soil bulk density, organic carbon, and water stable aggregates were measured in two increments of 0- to 2-inches and 2- to 6-inches soil depth at these two time periods. Two intact soil cores of 6 inches in depth and 2 inches in diameter were randomly taken from each plot to determine soil bulk density. Samples were dried at 221°F for a minimum of 48 hours and bulk density was computed as mass of oven-dried soil divided by volume of the core. Ten additional 6-inch cores were collected randomly from each plot to determine soil organic carbon. Soil samples were mixed in the field, allowed to air-dry, and ground to pass through a steel sieve with 0.08-inch openings. Subsamples were ground to pass through a 0.01-inch screen and soil organic carbon was concentrations were determined by dry combustion after pretreatment with 10% (v/v) hydrochloric acid to remove carbonates. Penetration resistance was measured in June 2021 at 5 points within each plot using a hand cone penetrometer (Eijkelkamp Co., Giesbeek, The Netherlands) and readings were divided by the area of the cone (1 cm^2). Values of penetration resistance were adjusted to a field capacity gravimetric water content of 0.35 (g/g) (Busscher and Bauer, 2003). Additional soil samples were collected from the 0- to 2-inch soil depth with a flat shovel for the determination of water stable aggregates. Two sub-samples from each replicate were used to estimate mean weight diameter by the wet-sieving method. Statistical analyses were completed using PROC GLIMMIX of SAS ver. 9.4 (SAS Institute, 2012, Cary, NC) with year and treatment considered fixed and replication considered random. Differences were considered significant at $P \leq 0.05$.

RESULTS AND DISCUSSION

Available triticale forage was 29% greater in the MT plots compared to NT when measured in March 2021 (Fig. 1). However, no difference in available forage was present by June. In 2020, MT plots had 130% less weed density compared to NT before tillage occurred and 1840% less weed density after tillage. In 2021, MT plots had 450% less weed density compared to NT before tillage occurred and 1340% lower weed density after tillage (Fig 2.). In June 2020, soil bulk density showed no difference between MT and NT plots in the 0- to 2-, 2- to 4-, or 4- to 6-inch soil depths. However, averaged across soil depths, MT (1.29 g cm^{-3}) and NT (1.32 g cm^{-3}) plots were about 13% greater than the perennial pasture (1.15 g cm^{-3}). Also in June 2020, soil organic carbon showed no difference between MT (1.72%) and NT (1.75%) plots in the 0- to 2-

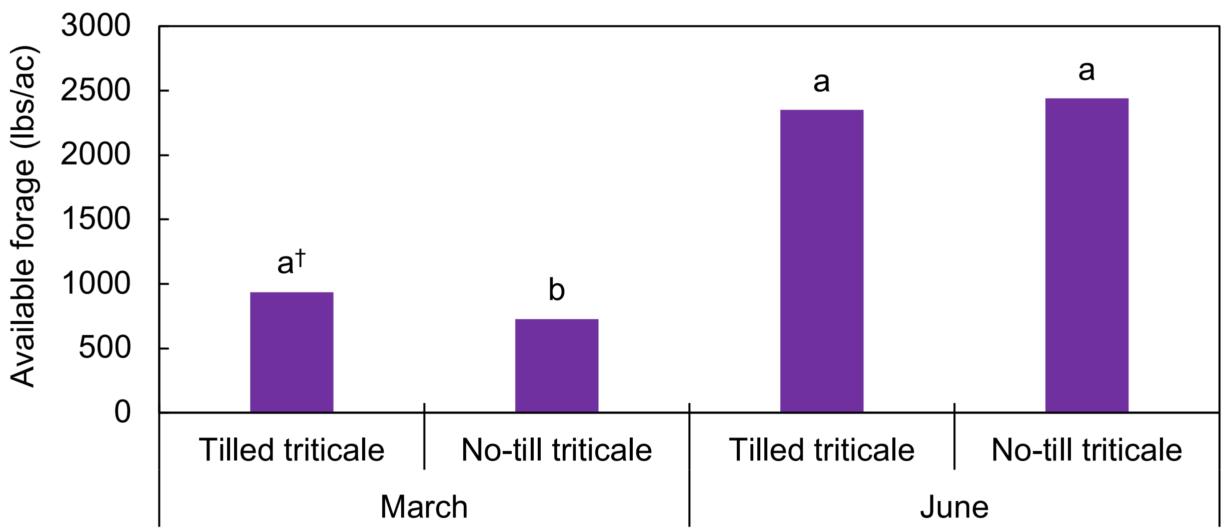

Figure 1. Tillage effects on triticale forage production in 2021 near Jetmore, KS.
†Means with the same letter are not significantly different (P <0.05) among years.

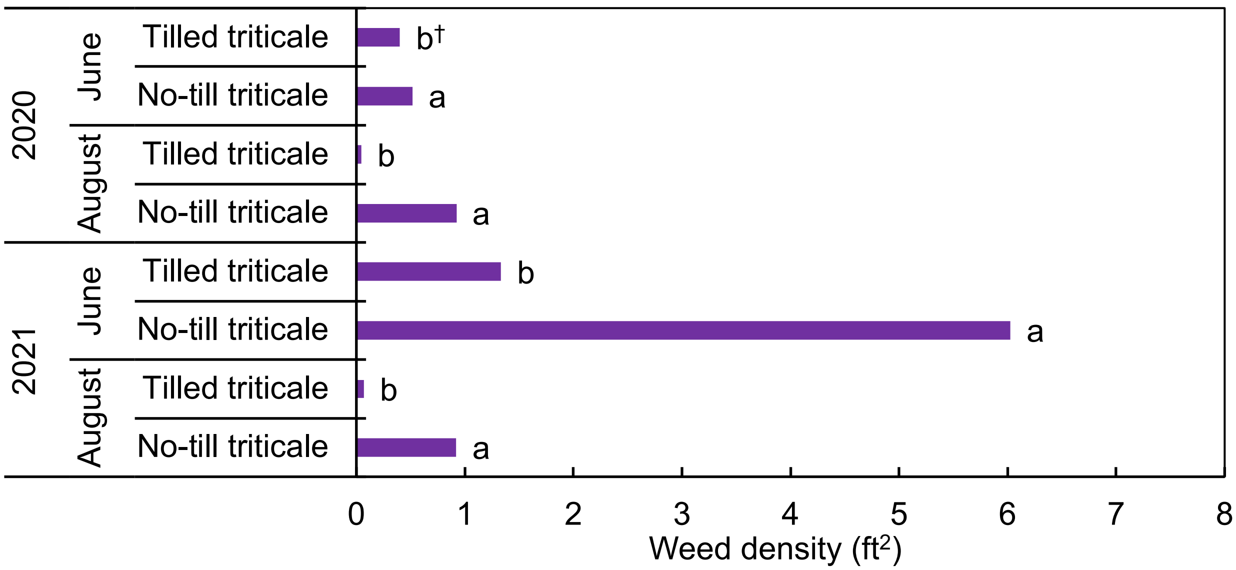

Figure 2. Tillage effects on weed density in a grazed winter triticale system in 2020 and 2021 near Jetmore, KS.

†Means with the same letter are not significantly different (*P* <0.05) among years.

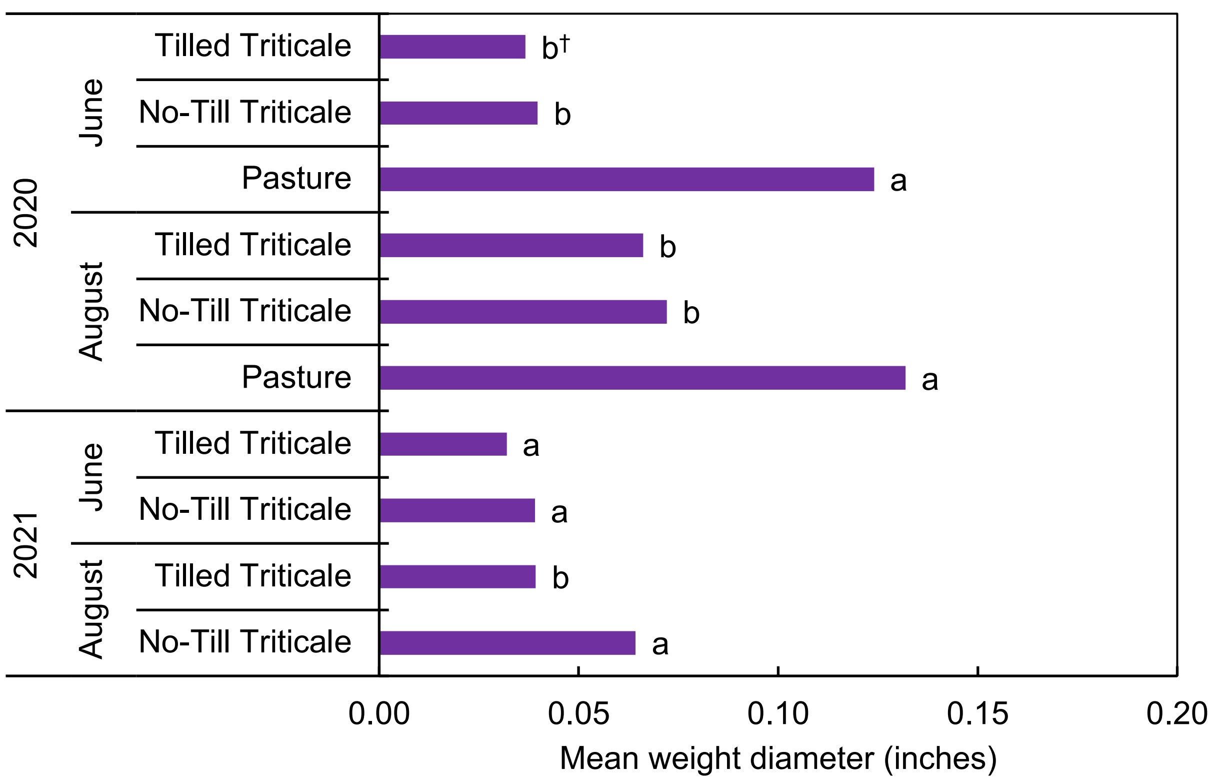

Figure 3. Tillage effects on mean weight diameter of water stable aggregates in the 0- to 2-inch soil depth in a grazed winter triticale system in 2020 and 2021 near Jetmore, KS.

†Means with the same letter are not significantly different (*P* <0.05) among years.

inch soil depth. However, both tilled and NT plots were about 57% less than the perennial pasture (2.72%). In June 2021, penetration resistance in the 0- to 6-inch soil depth was not different between MT (246 pounds/inch^2) and NT (263 pounds/inch^2).

In June 2020, there was no difference in mean weight diameter of water stable aggregates between the MT and NT plots though both were about 69% less than the perennial pasture (Fig. 3). Similar trends were observed in August 2020 with MT and NT being similar though significantly less than the perennial pasture. In June 2021, mean weight diameter was not different between the MT and NT plots. However, in August 2021, the MT plot was 39% less than NT plot possibly due to a greater tillage intensity compared to 2020 (one tillage operations versus two operations).

In conclusion, MT increased early available forage and substantially reduced weed density compared to NT. Bulk density, soil organic carbon, soil penetration resistance, and mean weight diameter of water stable aggregates were not different with tillage compared to NT, though both were less than the adjacent perennial pasture. Smaller mean weight diameter with tillage in August 2021 is notable. Another sample collection in 2022 will enhance our understanding of tillage effects in this system. Overall, results suggest that shallow tillage can be used to increase yields and reduce weeds with minimal effects on soil properties in grazed annual forage systems.

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