Response of Proso Millet to a No-Till Production System

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ABSTRACT

Proso millet (*Panicum miliaceum* L.) is well-adapted for the Central Great Plains and is commonly grown with a conventional mechanical tillage production system in a winter wheat (*Triticum aestivum* L.)—millet-fallow rotation. Research was conducted on a Weld silt loam (fine, montmorillonitic mesic Aridic Paleustoll) near Akron, CO to determine proso millet response to a no-till production system. Eliminating tillage increased proso millet grain yields and water use efficiency (WUE) over 20% compared to conventionally tilled proso millet production. Nitrogen fertilizer at 22 or 44 kg N ha^{-1} increased grain yields and water use efficiency of no-till proso millet regardless of whether precipitation received during the cropping season was 1% below (1985) or 33% below (1986) the long-term average for this location.

INTRODUCTION

The development of more efficient cultural practices for storing soil water during fallow periods has increased the potential for producers to grow two crops in three years in the Central Great Plains, rather than only one crop in two years. One successful two-crop-in-three-year scheme is winter wheat—proso millet-fallow (Anderson et al. 1986, Shanahan et al. 1988). The success of this rotation is increased when weed control is maintained during the fall after wheat harvest. Fall weed growth can consume 5 to 15 cm ha^{-1} of soil water (Greb 1979), and proso millet grain yield was increased 23% when fall weeds were controlled by sweep plowing (Anderson et al. 1986).

In the eastern part of the Central Great Plains, an ecofallow production system has been developed for a winter wheat—sorghum (*Sorghum bicolor* Moench.)-fallow rotation (Hinze and Smika 1983). Ecofallow relies on the use of herbicides for weed control, using minimal mechanical tillage. By eliminating tillage in the production system, wheat residue is maintained on the soil surface to suppress soil water evaporation from the soil surface (Greb 1983, Phillips 1984). This reduction of soil water loss by evaporation should supply more soil water for crop use, thus increasing the crop's water-use-efficiency (WUE). Another means to improve a crop's WUE is to apply N fertilizer to soils low in fertility (Greb 1983). Since water is the most limiting factor for plant growth in this semi-arid region (Greb 1983, Hinze and Smika 1983, Shanahan et al. 1988), any cultural manipulations which increase WUE should improve the probability of successful crop production during drought years. The objective of this study was to determine if eliminating tillage and applying N fertilizer would increase the efficiency by which proso millet converts a limited water supply into grain.

MATERIALS AND METHODS

The experiment was conducted on a Weld silt loam (fine, montmorillonitic, mesic Aridic Paleustoll) at Akron, CO. The soil contained 12 g kg^{-1} of organic matter and the pH was 7.0. The experimental design was a two-way factorial in a split plot arrangement, with the two factors being tillage system as whole plots and N fertilizer rates as subplots. Tillage systems compared were: (i) a conventional system of sweep plowing twice in the fall for weed control after wheat harvest, followed by spring disking to prepare a seedbed and (ii) a no-till system with herbicides providing weed control. In the no-till system, paraquat (1,1'- dimethyl-4,4'bipyridinium ion) at 0.28 kg ai ha^{-1} was applied twice in the fall after wheat harvest, and atrazine (6-chloro-N-ethyl- N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine) at 0.56 kg ai ha^{-1} was applied in April, approximately 60 days before planting proso millet. Herbicides were applied in 280 L ha^{-1} of spray solution with a 4 m boom sprayer. Three N levels were evaluated: 0, 22, and 44 kg N ha^{-1} as ammonium nitrate applied 30 days before planting. Fertilizer was applied by hand and incorporated by the spring disking in the conventional system, or remained on the soil surface with the no-till system. Plot size for each individual cell of a particular tillage by fertilizer treatment was 4 m by 4 m. All treatments were replicated four times.

'Cope' proso millet was planted 1 to 2 cm deep with a deep- furrow hoe drill at 11.2 kg ha^{-1} in 0.3-m rows on 7 June 1985 and 18 June 1986. Soil water content was determined gravimetrically for all treatments on three dates: (i) after wheat harvest, (ii) at proso millet planting, and (iii) after proso millet harvest. The sampling depth was 1.3 m, with two random samples collected per plot. Plant samples were harvested from 3 rows 1.2-m long in all plots to determine grain and straw yields and harvest index. WUE was calculated by dividing grain yield by crop water use (soil water use + crop season precipitation).

RESULTS AND DISCUSSION

No-Till vs Conventional Till Comparison

Eliminating tillage increased proso millet grain yields and WUE in both years (Table 1). The growing season (June 1 to Sept. 30) precipitation levels for the two cropping periods ranged from 67 (1986) to 99% (1985) of the 78-year average (212 mm), yet no- till proso millet yielded over 20% more than conventional-till proso millet in both years. This positive effect of eliminating tillage on grain yields was more pronounced during the dry year (1986), as grain yields were 34% higher with the no-till system. The harvest index was not affected by tillage system. Soil water storage by planting time was increased by eliminating tillage in 1985, but not in 1986.

Table 1. Effect of tillage system on soil water storage at planting time and agronomic response of proso millet grain production. Treatment means are an average of all N levels within each tillage system.

Tillage System	Soil-Water Storage (mm (1.3 m)$^{-1}$)	Grain Yield (kg ha^{-1})	Harvest Index[1]	Water-Use Efficiency ((kg ha^{-1}) mm^{-1})
		1985		
Conventional	150	2290	0.43	7.6
No-till	160	2730	0.42	8.9
F-test	*	**	NS	**
CV (%)	2.1	15.4	2.7	14.7
		1986		
Conventional	84	1200	0.44	7.9
No-till	86	1610	0.47	9.4
F-test	NS	**	NS	**
CV (%)	2.7	7.0	6.1	11.4

*, ** *Significant at 0.05 and 0.01 probability levels, respectively.*
NS—Not significant at the 0.05 probability level.
[1] *Harvest index = grain yield divided by above ground biomass.*

Nitrogen Fertilizer Effect on Proso Millet Production

Tillage system and precipitation level influenced proso millet response to N fertilizer. Grain yields were increased by N with both tillage systems in 1985 when precipitation was 99% of the 78- year average (Fig. 1). However, when precipitation was only 67% of the 78-year average in 1986, the addition of N increased grain yield only with the no-till system. Wheat residue on the soil surface reduces soil water evaporation (Greb 1983), which would provide more soil water for plant use in the no-till system and alleviate the water stress effect that occurred with conventionally tilled proso millet in 1986.

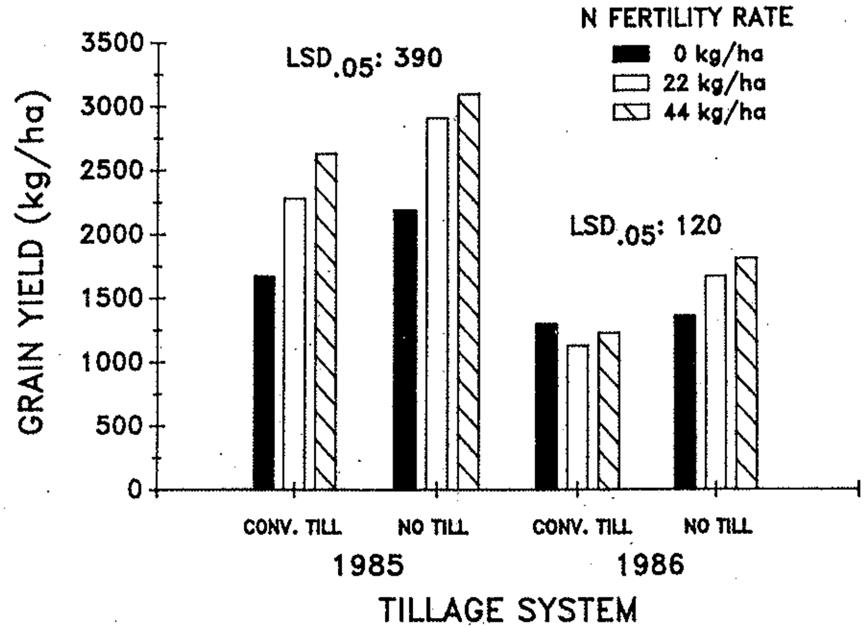

Figure 1. Effect on N fertilizer within each tillage system on grain yield of proso millet in 1985 and 1986.

Nitrogen fertilizer increased WUE of no-till proso millet in both years, but only in 1985 with the conventionally tilled proso millet (Fig. 2). During the dry year (1986), proso millet WUE in the conventional tillage system was not affected by N fertilizer, exhibiting the same response as shown with grain yields.

SUMMARY

Proso millet grain yields and WUE in the Central Great Plains were increased by more than 20% by eliminating tillage in the production system. Nitrogen fertilization at 22 or 44 kg N ha^{-1} increased grain yields and WUE of proso millet grown without tillage, thus, demonstrating the benefit of additional N in no-till production systems for proso millet in this area. The implementation of these two cultural practices, eliminating tillage and adding N, increased the effectiveness of proso millet converting the limited water supply into grain, and may decrease the probability of crop failure due to drought in this region.

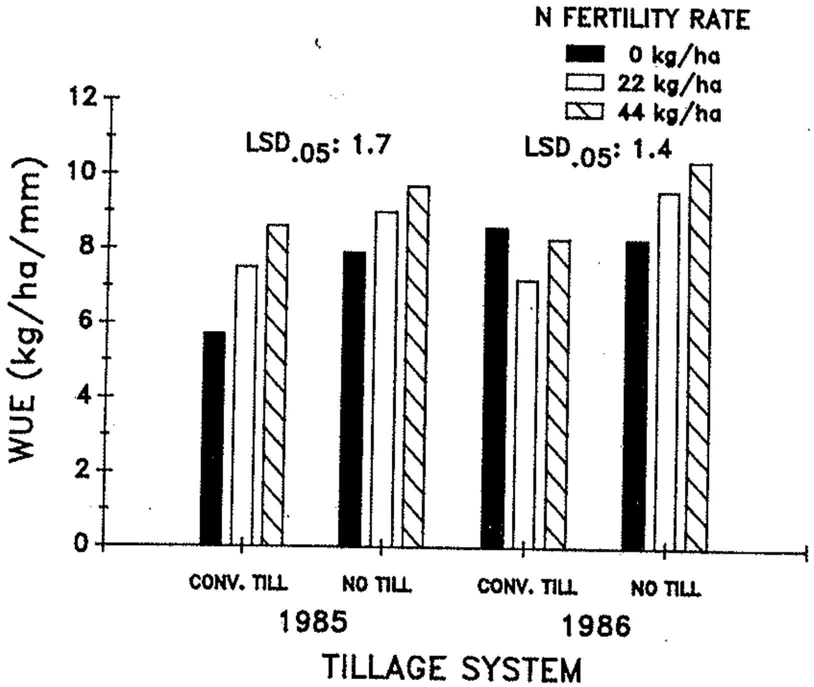

Figure 2. Effect of N fertilizer within each tillage system on water-use-efficiency (WUE) of proso millet grain production in 1985 and 1986.

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