No-Till Proso Millet Production

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ABSTRACT

Proso millet (Panicum miliaceum L.) is well-adapted for the Central Great Plains and is commonly grown with a mechanical tillage production system in a winter wheat (Triticum aestivum L.)-millet-fallow rotation. The use of tillage results in extensive wind and water erosion, however. Research was conducted on a mesic Aridic Paleustoll soil near Akron, CO, to determine proso millet response to a no-till production system. Eliminating tillage increased proso millet grain yields from 2290 to 2730 kg/ha in 1985 and from 1200 to 1610 kg/ha in 1986, compared to tilled proso millet production. Water use efficiency (WUE) also increased in the no-till system. Nitrogen fertilizer at 22 or 44 kg N/ha increased grain yield, N concentration of grain, and WUE of no-till proso millet regardless of whether growing-season precipitation was near normal or 33% below the long-term site average of 212 mm. Atrazine [6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine] applied either in the previous fall or 60 d before planting provided effective in-crop weed control for the no-till production system. Atrazine applied in the spring required two paraquat (1,1'-dimethyl-4,4'-bipyrindinium ion) applications at 0.28 kg ai/ha to control weeds the previous fall. Nitrogen fertilizer did not affect the bioactivity or soil persistence of atrazine.

A winter wheat-proso millet-fallow rotation is successful in the drier parts of the central Great Plains, provided fall weed control after wheat harvest is achieved. Fall weed growth can consume 80 to 250 mm of soil water (7). Proso millet grain yield increased 23% when fall weeds were controlled by sweep plowing (2). Tillage is not required for controlling weeds when residual herbicides are used (3). By eliminating tillage, wheat stubble remains upright and increases snow trapping, which results in more soil water storage (6,7). Soil water relations change under no-till systems, with higher water content in the 0- to 15-cm depth and less evaporation from the soil surface (17), conditions which are more favorable for crop growth in the drought-prone central Great Plains. However, no-till production systems in the cornbelt have occasionally had deleterious effects on corn (Zea mays L.) establishment and grain yields. These effects were attributed to: (i) lower soil temperatures during emergence which delayed early season plant growth, and (ii) ineffective weed control (17).

The elimination of tillage from crop production systems also affects soil processes that influence N status of soil (11). The rate of nitrate mineralization is usually depressed when crop residues are maintained on the surface during fallow (8). In the central Great Plains, tillage in the fall increased soil nitrate levels the following spring by 43% compared to tillage in the spring only (2). Previous research has indicated that proso millet does not consistently respond positively to the addition of N fertilizer (2), but if tillage does not occur in the fall, a possible shortage of soil N may occur in a no-till production system and reduce the efficiency of water conversion into grain.

Nitrogen fertility also influences weed-crop interactions. The use of N fertilizer on small grains has influenced weed density and competition (5,16,18). Common lambquarters (Chenopodium album L.) density was increased in barley (Hordeum vulgare L.) with N fertilizer, and caused a grain yield reduction (5). However, the application of more than 40 kg N/ha significantly depressed weed populations in wheat (16).

Triazine herbicides are used for weed control in proso millet (1). However, herbicide by N fertilizer interactions have been reported. As the level of ammonium nitrate fertilizer increased, weed control with simazine [6-chloro-N,N-diethyl-1,3,5-triazine2,4-diamine] decreased (12,13). The explanation for this loss of weed control was that ammonium nitrate enhanced simazine degradation. Atrazine is the prevalent triazine herbicide used with proso millet and its degradation has been either reduced or enhanced by N fertilizer, depending on soil type (9).

The objectives of this study were to determine if: (i) eliminating tillage will increase the efficiency by which proso millet converts a limited water supply into grain; and (ii) weed control in a no-till system will be affected by N fertilizer.

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 of organic matter and the pH was 7.0. Growing-season precipitation (June 1–September 30) was 99% of the normal in 1985 and 67% normal in 1986; the 78-yr average is 212 mm. The experimental design was a split plot factorial, with tillage system being the main plots and N fertilizer rate assigned to the subplots. Two tillage systems were compared: (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. Paraquat at 0.28 kg ai/ha was applied twice in the fall after wheat harvest, and atrazine at 0.56 kg ai/ha was applied in April, approximately 60 d before planting. The herbicides were applied in 280 L/ha of spray solution with a 4-m boom sprayer. Three N levels (0, 22, and 44 kg N/ha as ammonium nitrate) were applied 30 d before planting. The fertilizer was applied by hand, and was incorporated only in the conventional system by the spring disking. Plot size for each individual cell of a particular tillage by fertilizer treatment was 4 m by 4 m. Both main and subplot treatments were replicated four times.

‘Cope’ proso millet was planted 1 to 2 cm deep with a deep-furrow hoe drill at 11 kg/ha 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 in September from three rows 1.2 m long in all plots to determine grain and straw yields and harvest index.

three spring-applied atrazine treatments was achieved by April dates. Weed control in the preceding year for the applications, 0.28, and 0.56, and 0.84 kg ai/ha applied on planting.

Soil water use at planting time and agronomic response of proso millet grain production. Treatment means are an average of all N levels within each tillage system. Table 1. Effect of tillage system on soil water storage at planting time and agronomic response of proso millet grain production. Grain yield divided by aboveground biomass.

The WUE was calculated by dividing grain yield by crop season precipitation. Nitrogen concentration in the grain was determined (10).

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A second study examining N fertilizer-atrazine interaction was established adjacent to the above water use (soil water use from planting until harvest). The herbicides were applied in 280 L/ha of spray solution with a boom sprayer. Plot size was 4 m by 4 m. All treatments were replicated four times.

Soil samples to a depth of 25 mm were randomly collected from each plot 60, 90, and 120 d after application of atrazine. The herbicides were applied in 280 L/ha of spray solution with a boom sprayer. Plot size was 4 m by 4 m. All treatments were replicated four times.

Aboveground fresh weight was measured 21 d after emergence to determine growth inhibition by atrazine. The number of seed-bearing weed plants were recorded in individual cells of a particular fertilizer by herbicide combination was not significant at the 0.05 probability level.

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. A second study examining N fertilizer-atrazine interaction was established adjacent to the above water use (soil water use from planting until harvest). The herbicides were applied in 280 L/ha of spray solution with a boom sprayer. Plot size was 4 m by 4 m. All treatments were replicated four times.

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Table 2. \( CV \) LSD (0.05): atrazine

- Atrazine has been shown to increase N concentration of proso millet shoots (14), thus, higher protein in the grain is desirable.

- Data expressed as number of days plant growth in the no-till system.

- Mean of 1985 and 1986. The treatment means represent the average for both tillage systems within that N treatment.

Table 3. The number of seed-bearing weed plants in September of each year as affected by N fertilizer within a no-till system.

- Nitrogen fertilizer did not affect weed numbers when growing-season precipitation was about average.

- When growing-season precipitation was only 67% of average, N increased grain yield only in the no-till system.

- In 1986, when growing-season precipitation was similar to its effect on grain yield. In the no-till system, WUE was increased by N in both years, but with the no-till system will respond positively to N fertilizer, even if N fertilizer may be needed to ensure an adequate N supply for plant growth in the no-till system.

- Previous research in the central Great Plains has shown that fall tillage increases the level of soil nitrates required before growth inhibition of kochia (13), prevalent weed infesting the site in that particular year; by Atrazine level at 0.28 kg a.i./ha applied immediately prior to planting main-crop proso millet weed free. In this study, however, doubling the atrazine rate reduced the number of kochia plants establishing in the higher atrazine rate treatment, with fewer than two redroot pigweed plants developed per plot in the 0.28 kg a.i./ha atrazine treatment, with fewer than two redroot pigweed plants developed per plot in the 0.28 kg a.i./ha atrazine treatment.

- Ammonium nitrate did not influence weed control of atrazine in the no-till system as shown by the regression curves of grain in some crops (4, 15). In this study, however, atrazine applied at 0.28 kg a.i. maintenance of proso millet weed free. In this study, however, atrazine at 1.12 kg a.i. at least 0.56 kg ai/ha. In this study, however, atrazine at 1.12 kg a.i. at least 0.56 kg ai/ha.

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- Atrazine increased the persistence of atrazine in this soil type (Table 3). During the dry year (1986), proso millet WUE (Fig. 2) was 16% less than the wet year (1985) (Fig. 1). If the producer of proso millet feeds his grain, he would accrue a double benefit of both N fertilizer effect on WUE of proso millet (Fig. 3), and the bioassay procedure. Ammonium nitrate did not influence weed control.
Fig. 4. Effect of 44 kg/ha of N fertilizer on no-till proso millet yield loss due to kochia competition in 1985.

Proso millet grain yields and WUE in a winter wheat-proso millet-fallow rotation in the central Great Plains were increased more than 20% by eliminating tillage in the production system. Nitrogen fertilizer at either 22 or 44 kg N/ha increased grain yields and WUE of no-till proso millet. Nitrogen fertilizer did not deleteriously affect the duration of bioactivity of atrazine or its in-crop weed control. The addition of N fertilizer altered the competitive interaction between proso millet and kochia in 1985, increasing proso millet tolerance to kochia. The implementation of these two cultural practices, eliminating tillage and adding N, increased the effectiveness of proso millet for producing grain with a limited supply of water, and will decrease the probability of crop failure due to drought in this region.