Planting Date Effect on No-Till Proso Millet

R. L. Anderson

Research Question

Winter wheat-fallow is the most common rotation in the Central Great Plains. Because of improved weed control during noncrop periods, producers are now cropping more intensively with less fallow. Proso millet is well adapted to this region and commonly grown after winter wheat. Producers traditionally sweep plow their fields after wheat harvest for weed control, then disk in the spring to prepare a seedbed. To meet current government program requirements, however, producers must minimize tillage to maintain crop residues on the soil surface. Therefore, many producers are planting proso millet into no-till wheat stubble. The objective of this research was to examine planting date effect on proso millet grown in a no-till production system.

Literature Summary

Optimum planting date for proso millet has been reported for tilled production systems. Highest grain yield occurred when proso millet was planted on 15 May, with yield decreasing at either earlier or later plantings. This response was similar for several varieties. It is well documented that residue on the soil surface slows crop development because it reduces soil temperature in spring. High residue levels delay seedling development of corn, winter wheat, and spring wheat, and in some years, reduce yield. Because plant development is usually delayed by high residue level, one would expect that the optimum planting date for proso millet growth in a no-till system would differ from a tilled system.

Study Description

Proso millet was planted on six dates in 1988, 1989, and 1990 at Akron, CO.

Soil type: Weld silt loam

Planting dates: 18 May, 25 May, 1 June, 8 June, 15 June, and 22 June

Variety: 'Cope' proso millet

Planting rate: 10 lb/acre

Drill type: Hoe drill with 12 in. row spacing

N application: 30 lb N/acre of ammonium nitrate, broadcast

Growing season precipitation (June, July, and August): 5.7 in. in 1988, 9.5 in. in 1989, and 10.1 in. in 1990.

Location long-term average: 7.2 in.

Agronomic measurements: grain yield, water use efficiency, and crop water use

Applied Question

What is the optimal planting date for proso millet grown in a no-till production system?

Highest grain yield occurred when proso millet was planted on 8 June, with yields decreasing at earlier and later plantings (Fig. 1). Yield

Full scientific article from which this summary was written begins on page 454 of this issue.

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decreased by 20% when planted on 18 May and 22% when planted on 22 June compared with the 8 June planting. The optimum proso millet planting date in a no-till system is approximately 3 wk later than for a tilled system. Producers will achieve within 5% of maximum grain yield by planting between 2 June and 12 June. Crop water use efficiency response to planting date was similar to grain yield. When planted on 8 June, proso millet produced 260 lb grain/acre, with water use efficiency declining with earlier and later plantings, decreasing by 18% when planted on 22 June and 20% when planted 18 May. Crop water use ranged between 13 and 14 in. for all planting dates.

![Fig. 1. Proso millet grain yield at six planting dates. Data are averaged over all years of study.](image-url)

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Producers in the Central Great Plains are changing their cropping systems to include summer annual crops after winter wheat (Triticum aestivum L.). Proso millet (Panicum miliaceum L. — hereafter referred to as proso) is well adapted to this region, especially when planted after winter wheat. This study examined the response of proso to planting date in a no-till system. 'Cope' proso was planted at six weekly intervals, starting on 18 May. Proso yielded highest when planted on 8 June and will yield greater than 95% of its potential if planted between 2 June and 12 June. Water use efficiency (WUE) reflected grain yield trends, with WUE highest when proso was planted in early June. Total crop water use (soil water + growing season precipitation) ranged between 13 and 14 in. for all planting dates. Proso initiated stem elongation and anthesis after approximately 600 and 1100 growing degree days, respectively, regardless of planting date. Based on this study, producers should plant proso during early June to maximize yield potential in no-till systems.

WINTER WHEAT-FALLOW is the most common rotation in the Central Great Plains. Producers follow their land to store precipitation in the soil for future crop use, thus stabilizing winter wheat production. Replacing tillage operations during fallow with herbicides, however, has improved precipitation storage (Nielsen and Anderson, 1993; Smika, 1990) such that producers are now cropping more intensively. Crops such as proso, corn (Zea mays L.), and sunflower (Helianthus annuus L.) are being grown after winter wheat (Anderson, 1990b; Lyon and Anderson, 1993; Peterson et al., 1993a), and have increased total grain production. For example, a wheat-corn-fallow rotation produced 70% more grain than winter wheat-fallow over a 6-yr period, and 20 to 30% more profit (Peterson et al., 1993b). Producers also are changing rotations because winter annual grass weed infestations (Wicks and Smika, 1990), such as volunteer rye (Secale cereale L.), jointed goat-grass (Aegilops cylindrica Host.), and downy brome (Bromus tectorum L.) proliferate in a winter wheat-fallow rotation (Anderson, 1994). Because no herbicides are available to control these weeds in winter wheat, producers insert summer-annual crops in rotations to deplete the weed seed bank in the soil before winter wheat is planted again (Wicks and Smika, 1990).

Up until the 1970s, proso was grown in Colorado, Kansas, Nebraska, Wyoming, and South Dakota as a replacement crop when winter wheat was killed by either severe winters or hail. As market availability increased in the 1970s, producers began growing proso after winter wheat in a 2-crop-in-3-yr rotation (Shanahan et al., 1988). Historically, producers planted proso in late June and early July to avoid weeds (Hinze, 1977). With development of residual and foliarly applied herbicides for in-crop weed control (Anderson and Greb, 1987; Grabouski, 1971; Lyon and Baltensperger, 1993), producers can plant proso earlier, and consequently increase grain yield. For example, in southwestern Nebraska, proso yield increased 10 and 40% when planted on 15 May compared with early June and early July, respectively (Nelson, 1990). This response was similar for several varieties.

Abbreviations: EPIC, Erosion Productivity Impact Calculator; WUE, water use efficiency.
To meet government wheat harvest, then disk in the spring to prepare a seedbed sweep plow their fields for weed control after winter must minimize tillage to maintain crop residues on the field. Producers now test the effect of planting date on no-till proso grain yield, biomass production, and water use. Therefore, this study was conducted at Akron, CO, on a Weld silty clay loam (fine, montmorillonitic, mesic Aridic Paleustoll) in a tilled system. Producers responded positively to reduced- and no-till production systems: grain yield increases by 10 to 25% over the conventional sweep plow system (Anderson et al., 1980; Tanaka, 1989), and in some years, reduced tillage systems were weed-free in all years of the study. At the time of this study, atrazine was labeled for use in proso, but this label has since been withdrawn.

**MATERIALS AND METHODS**

**Study Procedures**

**Site Description**

The study was conducted at Akron, CO, on a Weld silt loam (fine, montmorillonitic, mesic Aridic Paleustoll) with 1.2% organic matter and a pH of 6.9 (0 to 3 in. depth). The 85-yr average yearly precipitation is 16.3 in., with 1.2 in. during August to 2.7 in. during July (Fig. 1). Average air temperature is 67, 73, and 71°F for June, July, and August, respectively.

**Growing Season Precipitation**

Precipitation during the growing season varied among years, ranging from 2390 to 3780 lb/acre. There were 111 and 168, respectively. This scale assigns a number for each developmental stage, with the entire life cycle determined by dividing grain yield by crop water use (soil water content).

**RESULTS AND DISCUSSION**

**Grain Yield Response to Planting Date**

Growing season precipitation by month during 1988, 1989, and 1990. Intended planting dates were 18 May, 0.5 lb a.i./acre was applied after winter wheat harvest. Plots were randomized complete block design with four replications. Ammonium nitrate at 30 lb N/acre was broadcast in all treatments before planting. Producers applied in-crop weed control. Plots were hand-harvested from 60 sq ft to determine grain yield and biomass production. Plant samples at harvest were hand-harvested from 60 plants randomly selected per plot. Water use efficiency was calculated by dividing grain yield by crop water use (soil available water). Sampling for fallow weed control, with atrazine at 0.5 lb/acre was applied after winter wheat harvest. Chlorpyrifos (trade name: Lannate) and a maximum of 86°F. Plant available soil water in 0 to 4 ft depth was 4.8, 5.6, and 8.8 in. for 1988, 1989, and 1990 received 30 and 39% more precipitation than normal (Fig. 1). Plant available soil water in 0 to 4 ft depth at planting averaged 8.8, 5.6, and 4.8 in. for 1988, 1989, and 1990. Ammonium nitrate at 30 lb N/acre was broadcast in all treatments before planting and after harvest. Sampling differences among treatments determined at the 0.05 level of probability.

Harvest index was calculated by dividing grain yield by biomass production. Plant height at maturity was recorded at the end of the growing season. Atrazine was labeled for use in proso, but this label has since been withdrawn. Development of 10 plants randomly selected per plot was determined by dividing grain yield by crop water use (soil available water). Sampling differences among treatments determined at the 0.05 level of probability.

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Proso yields were highest when planted on 8 June (Fig. 2). Yield decreased at earlier and later plantings, 20% when planted on 22 May, 25% over the conventional sweep plow system (Anderson et al., 1986; Hinze, 1977). Crop residue on the soil surface, however,slows crop development because it reduces soil warming in the spring. For example, high residue levels delayed early season development of corn (Phillips, 1984) and wheat (Greb 2019). Proso responded positively to reduced- and no-till production systems: grain yield increases by 10 to 25% over the conventional sweep plow system (Anderson et al., 1980; Tanaka, 1989), and in some years, reduced tillage systems were weed-free in all years of the study. At the time of this study, atrazine was labeled for use in proso, but this label has since been withdrawn. However, because residue on the soil surface delays plant development, proso may respond differently to planting date in no-till production systems.
maximum when planted between 2 June and 12 June (Fig. 3), but Nelson (1990) reported that highest yield in a tilled system occurred 3 wk earlier (15 May), with yield decreasing by 10 to 15% when planted on 1 June.

Response of Other Plant Characteristics to Planting Date

Planting date affected proso biomass, plant height, and WUE similarly to grain yield. Proso produced the greatest biomass and tallest plants when planted between 1 June and 15 June (Table 1). When planted on 8 June, proso produced 260 lb grain/acre per inch, with WUE decreasing by 18% when planted on 22 June and 20% when planted on 18 May (Table 1).

Harvest index did not change after 1 June. Total water use by proso ranged from 12.8 in. when planted on 18 May to 14.2 in. when planted on 8 June. Crop water use in this study was similar to previous studies, where total water use by proso averaged 13 to 14 in. (Anderson, 1990a; Anderson and Greb, 1987; Anderson et al., 1986; and Shanahan et al., 1988).

Proso developed more slowly at earlier plantings. When planted on 15 May, proso initiated stem elongation 45 d later, but when planted on 22 June, proso began stem elongation after 32 d (Table 1). Similar trends occurred with anthesis (Table 1), as well as with heading and inflorescence emergence (data not shown). This difference in development among planting dates was related to temperature, as proso required approximately 600 and 1100 GDD to initiate stem elongation and anthesis, respectively, regardless of planting date (Fig. 4).

Management Implications

Producers in the Central Great Plains are changing their cropping systems to minimize the duration of fallow (Halvorson et al., 1994; Peterson et al., 1993a). More intensive cropping, however, may increase crop sensitivity to erratic precipitation in this drought-prone region. To minimize drought impacts on crop success, producers can use two crop management strategies: (i) maximize WUE for each crop grown, and (ii) match cropping system to probability of water availability (Loomis, 1983).

For proso, WUE varied from 260 lb grain/acre per inch when planted on 8 June to 208 lb grain/acre per inch when planted on 18 May, a difference of 20% in efficiency. With limited water, producers can lower risk of crop failure by planting near 8 June. Matching a cropping system to water availability requires knowledge of crop water use, soil water level at planting, and precipitation probabilities (Loomis, 1983).

Compared over several years and tillage systems, proso water use ranges from 13 to 14 in., thus, using this knowledge in conjunction with other factors can improve crop yield and profitability.
Table 1. Proso millet response to planting date as expressed by various agronomic characteristics.

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>Harvest Plant water use (Ib/acre)</th>
<th>Biomass (Ib/acre)</th>
<th>Height (in.)</th>
<th>Anthesis (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 May</td>
<td>208</td>
<td>6370</td>
<td>39.2</td>
<td>64</td>
</tr>
<tr>
<td>25 May</td>
<td>214</td>
<td>6850</td>
<td>40.5</td>
<td>61</td>
</tr>
<tr>
<td>1 June</td>
<td>245</td>
<td>7230</td>
<td>42.5</td>
<td>59</td>
</tr>
<tr>
<td>8 June</td>
<td>260</td>
<td>7910</td>
<td>42.3</td>
<td>57</td>
</tr>
<tr>
<td>15 June</td>
<td>236</td>
<td>7310</td>
<td>41.9</td>
<td>51</td>
</tr>
<tr>
<td>22 June</td>
<td>212</td>
<td>5960</td>
<td>39.0</td>
<td>45</td>
</tr>
</tbody>
</table>

With anticipated water availability enables producers to assess risk in their crop decisions. An alternative cropping strategy to winter wheat-proso-fallow could be planting winter wheat after proso harvest, without a fallow period. In this study, available soil water (4-ft depth) remaining at proso harvest ranged from 2.3 to 3.2 in., even though late crop season precipitation varied dramatically among years (Fig. 1). Winter wheat grain yields of 45 to 50 bushels require 14 to 16 in. of total water in northeastern Colorado (Greb, 1979; Nielsen and Halvorson, 1991). Average crop season precipitation for winter wheat at this location is 11.7 in., thus, if a producer matched this cropping strategy to 80% of expected precipitation, an assessment of low to moderate risk (Loomis, 1983), grain yield-water use equations for this area predict a winter wheat yield of 37 to 43 bu/acre (Nielsen and Halvorson, 1991).

Rotation research has demonstrated the potential of a winter wheat-proso cropping strategy (Halvorson et al., 1994). Wheat yield in this rotation averaged 70% of wheat after fallow, while combined proso and wheat yields in this rotation yielded 64% more grain on an annualized basis than wheat-fallow.

Crop growth models, such as the Erosion Productivity Impact Calculator (EPIC) model, simulates crop development based on weather variables (Williams et al., 1989). Integrating the development equation for proso (Fig. 4) into EPIC will enable this model to predict proso development for a location by inputing the location’s heat unit accumulation.

Seedling emergence models for individual weeds are being developed (Harvey and Forcella, 1993). Integrating crop development, planting date response, and emergence pattern for a selected weed may enable crop growth models to guide management decisions to favor proso over that weed. Altering crop planting date to avoid peak emergence periods of weeds is a component of low-input crop production systems (Forcella et al., 1993), and offers promise for proso. For example, planting proso on 3 June or 22 June reduced kochia (Kochia scoparia) population by 60 and 90%, respectively, compared with a 15 May planting (Anderson, 1988).