Production Agriculture

Proso Millet Yield and Residue Mass following Direct Harvest with a Stripper-Header

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ABSTRACT

Proso millet (*Panicum miliaceum* L.) (PM) is an important crop for dryland rotations in the central Great Plains. The crop is traditionally swathed before combining to promote uniform drying of the panicle and to minimize seed shattering losses. Direct harvesting of PM with a stripper-header would eliminate the swathing operation resulting in cost savings, and increased standing crop residues to enhance erosion protection, snow catch, and precipitation storage efficiency. This study was conducted to determine yield differences between conventionally swathed and stripper-header harvested PM and to compare PM residue mass and orientation following the two harvest techniques. The study was conducted over four growing seasons at Akron, CO. Proso millet was harvested either by swathing and then picking up the swath with a combine, or by direct harvesting with a stripper-header attached to the combine. Seed yields and moisture contents at harvest were not significantly different between treatments. About 20% more seed was found on the ground with the stripper-header harvest than with the conventionally swathed harvest, but the increased shattering resulted in only about 1% loss of the average final yield. Using a stripper-header resulted in both the standing residue mass and the silhouette area index following harvest to be four times greater than in conventionally swathed PM. A stripper-header can be used to successfully direct harvest PM thereby reducing harvest costs and increasing surface crop residues following harvest.

PROSO MILLET is well suited to the limited precipitation patterns and high summer temperatures of the central Great Plains (Anderson et al., 1986; Briggs and Shantz, 1913), and can either tolerate drought and intense heat or avoid those conditions by growing quickly to maturity (Baltensperger, 1996). Proso millet is used for human consumption in some Asian and African countries (Baltensperger, 1996), but most of the PM grown in the central Great Plains is used for birdseed. In this region PM is grown in rotation with winter wheat (*Triticum aestivum* L.) as an alternative to other summer crops such as corn (*Zea mays* L.), sunflower (*Helianthus annuus* L.), or grain sorghum (*Sorghum bicolor* L.) (Anderson et al., 1999; Nielsen et al., 1999; Shanahan et al., 1988).

Proso millet in the central Great Plains is generally planted the first week of June, although a very broad planting window is available due to PM's short growing season (Baltensperger, 1996). It grows throughout the summer months and is usually swathed in early to mid-September. Proso millet is swathed because the seeds do not mature or dry uniformly. Depending on the year, grain elevators will only accept PM seed at or below the 120 to 140 g kg^{-1} moisture range. Swathing PM promotes rapid drying and also limits the standing grain exposure to wind, rain, and hail and the potential yield loss attributable to seed shatter (Baltensperger et al., 1995a).

Wheat in this region has recently been harvested with a stripper-header (McMaster et al., 2000; Tado et al., 1998; Wilkins et al., 1996). A stripper-header, compared with a conventional cutter-bar header that cuts off the plant and seed head, is a large, rapidly-spinning drum with finger-like attachments that exclusively "strip" the grain from the head of the plant, leaving the stalk of the plant standing in the field. Advantages of this harvest technique include greater precipitation storage efficiency from taller residue that enhances snow catch and suppresses evaporation (Black and Siddoway, 1977; Nielsen, 1995; McMaster et al., 2000; Nielsen et al., 2005); reduced machinery wear from running less biomass through the combine; and shortened harvest period due to faster combine ground speeds. Additionally, the greater silhouette area index (SAI = stem height × diameter × population) resulting from taller standing stems following harvest reduces wind speed near the soil surface and thereby reduces wind erosion potential (Siddoway et al., 1965; Bilbro and Fryrear, 1994). These benefits would also apply to PM which sometimes leaves very little standing residue when conventionally harvested by swathing, especially following a dry growing season (Nielsen, unpublished data, 2005). Wind erosion problems and poor seedbed conditions for the following crop could be ameliorated by the additional standing millet residue left following a stripper-header harvest (Hagen and Armbrust, 1994; Hagen, 1996; McMaster et al., 2000).

Because of rising fuel costs, producers are concerned with the added expense of the swathing operation. Benefits of stripper-

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Abbreviations: PM, proso millet; SAI, silhouette area index.

Table 2. Precipitation and wind conditions in the time interval between swathing and stripper-header harvest of proso millet at Akron, CO (2003–2006).

Weather parameter	2003	2004	2005	2006
Precipitation, mm	1	22	trace	36
No. of days with precipitation	2	7	1	6
No. of days with daily average wind speed greater than 5 m s^{-1}	0	2	0	10
No. of days with maximum wind gust >13 m s^{-1}	3	4	2	9

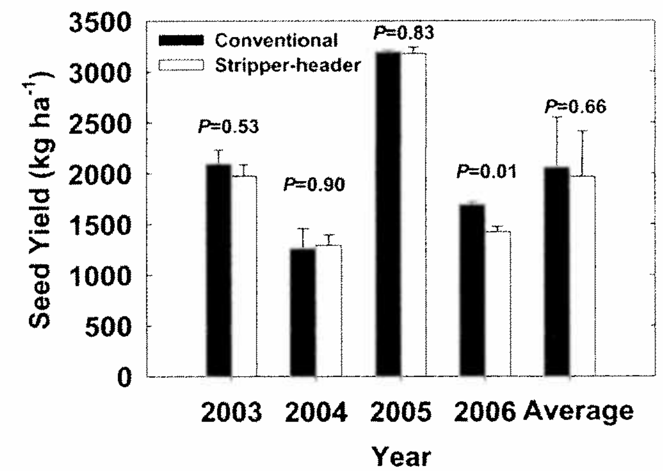

Fig. 1. Proso millet seed yields from conventionally swathed and stripper-header harvested treatments at Akron, CO, 2003–2006. Error bars represent the standard error of the mean (SEM). *P* values are probability that the null hypothesis (no difference between harvest methods) is true.

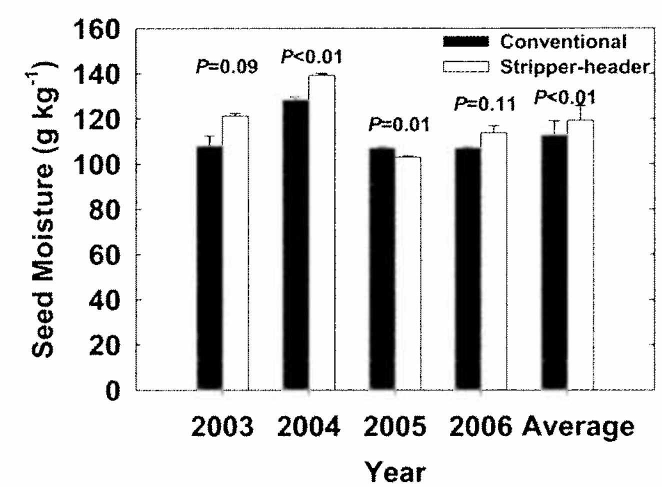

Fig. 2. Proso millet seed moisture content at harvest from conventionally swathed and stripper-header harvested treatments at Akron, CO, 2003–2006. Error bars represent the standard error of the mean (SEM). *P* values are probability that the null hypothesis (no difference between harvest methods) is true.

harvest and allowing the PM grain to dry standing in the field so that the stripper-header could be used for direct harvest did not result in detrimental yield losses when averaged across the 4 yr of the study. While there was no difference in harvest technique averaged over years, there was a yield difference due to harvest technique in 2006, with a 16% (268 kg ha^{-1}) lower yield obtained with the stripper-header harvest. Environmental conditions in 2006 were not conducive to harvesting PM with a stripper-header without a yield loss (Table 2). A total of 42 d passed between swathing the conventional treatments and harvesting the stripper-header treatments with 35 d between pickup and direct stripper-header harvest. During this time, six separate rainfall events resulted in 36 mm of precipitation. In addition to the rainfall, the standing PM experienced 10 d with daily average wind speed greater than 5 m s^{-1} and 9 d with a maximum recorded wind gusts greater than 13 m s^{-1}.

A major concern with harvesting PM with a stripper-header is that the seeds will not mature and dry sufficiently without the swathing operation. Moisture content of the PM seed varied from 103 to 139 g kg^{-1} (Fig. 2), with the greatest moisture content in 2004 and the driest in 2005. Stripper-header-harvested PM had higher seed moisture content in 2004, and lower seed moisture content in 2005. Although not statistically significant, seed moisture was higher for the stripper-header treatments in 2003 and 2006. However, the difference in seed moisture content due to harvest technique is of little practical consequence as the generally greater seed moisture content from the stripper-header harvest would not prohibit on-farm storage or acceptance of seed by commercial grain elevators. All PM seed moisture contents, regardless of harvest technique, were within the range that grain elevators would accept in all 4 yr of this study. Additionally, there were no differences in PM test weight or seed color due to harvest technique that would influence the marketability of the crop (data not shown).

Another concern with stripper-header harvesting of PM is that the increased standing time required for direct harvest of PM would result in greater seed shatter from wind, rain, birds, snow, and the action of the rotating stripper-header drum. This did not appear to be a major problem throughout the 4 yr of this study as yields from the two harvest techniques were different only in 2006 and were the same when averaged over the 4 yr of the study (Fig. 1). The yield advantage for conventionally harvested millet in 2006 was 268 kg ha^{-1}. These results may not be representative of harvest technique effects on all cultivars of PM as the shatter-resistant cultivars used in this study were specifically selected to maximize the success of direct harvest with a stripper-header.

As anticipated, more seeds were on the ground following stripper-header harvest than following combining of the picked-up swath (20% averaged over the 4 yr) (Fig. 3), although the increase was significant in only 2 of the 4 yr. The increased yield loss due to shatter from the stripper-header harvest averaged about 20 kg ha^{-1} over the 4 yr, a relatively small amount that did not significantly affect yield. With these data we were not able to specifically attribute this slight increase in seeds on the ground to the increased period of time that the PM was standing in the field before harvest or to the actual process of the stripper-header harvesting. In 2005 there were 31% more seeds on the ground following stripper-header harvest than following combining of the picked-up swath. In this year the increase in seeds on the ground was most likely primarily attributable to the stripper-header as there were only 6 d between swath pickup and stripper-header harvest with essentially no precipitation and not very windy conditions in that interval (Table 2).

Because of the importance of crop residues to successful dryland crop production in the central Great Plains (Nielsen et al., 2005), residue mass remaining in the field following the