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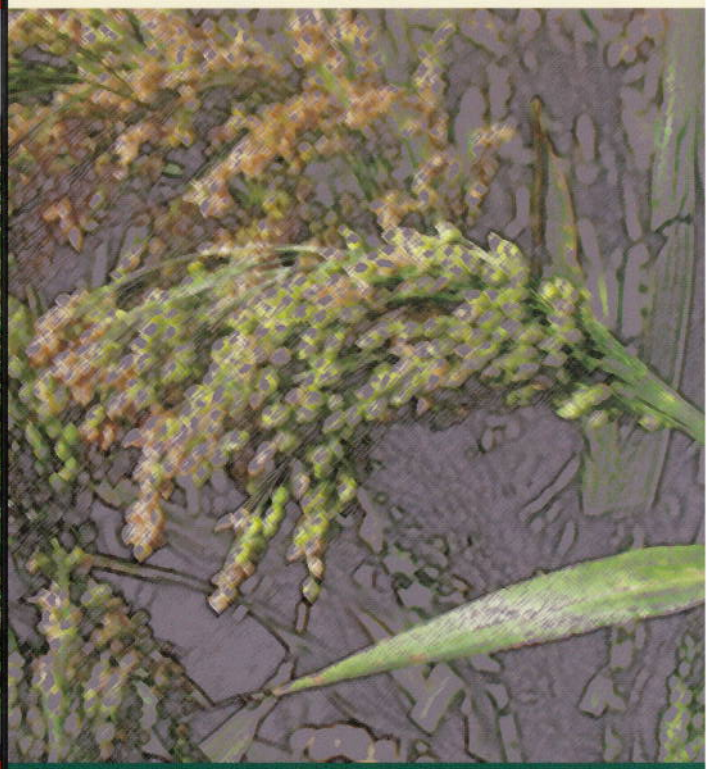

PROSO MILLET
in the Great Plains

IANR

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PROSO — A DESCRIPTION

Proso millet, *Panicum miliaceum* (L.), is a warm-season grass capable of producing seed 60 to 90 days after planting. It has been called millet, hog millet, and yellow hog. It has been grown in many countries including China, the former Soviet Union, Afghanistan, Romania, Turkey, and India.

Historically, proso acreage in the Great Plains has been highly variable, depending on the winter wheat crop survival, government programs, and market price. United States acreage has averaged from 200,000 to 600,000 acres annually, with 2001 production exceeding 485,000 tons. Nebraska, South Dakota, and Colorado were the largest producers of proso from 1982 through 2006 (*Tables I* and *II*). Most of the additional production occurs in adjacent states.

Proso can be used in several ways. Proso millet grain is used as bird and livestock feed in the United States and for livestock feed and human consumption in other countries. The feed value of proso millet for cattle and swine is generally considered to equal that of grain sorghum or corn (when less than 50 percent of the corn in the ration is replaced) (*Table III*). For swine and poultry, proso should be supplemented with lysine (like most other cereal grains). Some processing is necessary when feeding proso grain to livestock, mostly to crack the hard seed coat to allow for better digestion.

Table I. Harvested acres of proso millet from 1982 through 2006.

Year	Colorado	Nebraska	South Dakota	Other	United States
1982	32,944	18,892	102,778	45,320	199,934
1987	90,529	70,866	75,465	54,985	291,845
1992	65,501	43,383	91,071	39,806	239,761
1999	240,000	150,000	150,000	0	540,000
2000	150,000	135,000	85,000	0	370,000
2001	230,000	180,000	175,000	0	585,000
2002	115,000	100,000	60,000	0	275,000
2003	285,000	170,000	165,000	0	620,000
2004	330,000	135,000	130,000	0	595,000
2005	275,000	125,000	115,000	0	515,000
2006	255,000	110,000	110,000	0	475,000

Source: USDA-NASS (1982-1992 from Census of Agriculture); (1999-2006 from Ag Statistics).

Table II. Proso millet production (cwt) from 1982 through 2006.

Year	Colorado	Nebraska	South Dakota	Other States	United States
1982	728,326	573,852	2,660,036	1,065,134	5,027,348
1987	2,262,863	2,184,227	2,037,316	1,698,162	8,182,568
1992	1,938,702	1,309,976	2,408,249	962,303	6,619,230
1999	4,080,000	2,475,000	2,400,000	0	8,955,000
2000	1,425,000	1,215,000	1,020,000	0	3,660,000
2001	4,025,000	2,790,000	2,887,500	0	9,702,500
2002	604,000	600,000	630,000	0	1,834,000
2003	2,707,500	1,615,000	1,402,500	0	5,725,000
2004	3,960,000	1,687,500	1,885,000	0	7,532,500
2005	2,750,000	2,187,500	1,897,500	0	6,835,000
2006	2,677,500	1,210,000	1,210,000	0	5,097,500

Source: USDA-NASS (1982-1992 from Census of Agriculture); (1999-2006 from Ag Statistics).

PROSO'S PLACE IN A CROP ROTATION

As a warm-season grass crop, proso millet is typically planted in late May or early June and harvested in late August or early September. It works well in rotation with winter annual crops such as winter wheat or warm-season broadleaf crops such as sunflower. Inserting proso into a winter wheat/fallow rotation is an excellent way to extend and diversify the rotation in order to help control winter annual grass weeds in winter wheat and to reduce disease and insect pressure. Adding a summer crop such as proso millet also spreads the workload and reduces both production and marketing risk.

Proso has a shallow root system. Its rooting depth is generally limited to the upper three feet of soil. It is one of the most efficient crops at removing water from the topsoil and converting it to dry matter (see *Water Use and Yield*). Proso is often thought to rely on summer rains and use very little stored subsoil water; Nebraska research suggests however, that soil water levels at planting may be used to predict proso grain yields with a high degree of success. The research indicates that proso grain yields respond more consistently to soil water at planting than do other longer duration crops such as corn, grain sorghum, or sunflower.

Because proso has a shallow root system, it's often planted following sunflower, which has a deep, extensive root system that often depletes soil water to a depth of six or more feet. This deep depletion of soil water makes it difficult to follow sunflower with another deep-rooted crop unless summer fallow is used to help restore soil water to depth. A winter wheat/sunflower/proso/fallow rotation has been a successful rotation for some growers in the western Great Plains.

Proso also has worked well after corn or sorghum, and tolerates any atrazine remaining in the soil after the corn or sorghum crop. The warmer soil temperatures in corn or sorghum stubble fields allow proso to be planted earlier. Proso emergence in no-till is better after a row crop than after a small grain crop. The disadvantage of planting proso after corn or sorghum is that annual warm-season grass weeds may be promoted by growing two warm-season grass crops back-to-back in the rotation. This may be less of a problem with corn than sorghum because of the many effective herbicides available for use in corn.

Growers wishing to avoid summer fallow frequently use proso as a transition crop from a full-season summer crop back to winter wheat. Proso's shallow root system and short duration preserve deeper soil water that wheat can use in the spring if it can be successfully established in the proso stubble field, often quite dry in the top three feet following harvest. Winter wheat that is no-till planted into proso stubble is less prone to damage from blowing soil than wheat planted into summer fallow, and may benefit from increased snow capture.

Table III. Feed value of corn, proso millet, grain sorghum, and wheat in beef cattle.

		Energy*		
Feed	**Crude protein**	**NE_M**	**NE_G**	**TDN**
	%	------- Mcal/cwt -------		%
Corn, dry rolled	10.0	102	70	90
Proso millet	12.9	93	64	84
Sorghum, dry rolled	10.0	93	64	84
Wheat, hard, dry rolled	12.5	99	68	88

*NE_M = net energy for maintenance, NE_G = net energy for gain, and TDN = total digestible nutrients.

No-till proso production is gaining in popularity. Use of no-till protects the soil from wind and water erosion, increases soil water storage efficiency, and reduces the need for replanting as a result of soil crusting or seed burial following a heavy rain when compared to planting proso in a tilled seedbed.

If proso is used as a summer fallow replacement prior to winter wheat planting, consider planting proso early, for example in May, and selecting a shorter season variety such as *Earlybird* or *Horizon* (see *Choosing a Variety*). This will allow more time for rainfall between harvest and wheat seeding. Some work by the USDA-ARS at Akron, Colo., suggests that wheat may be adversely affected by allelochemicals in proso residues. This response is not consistent or fully understood at this time, but may be dependent on the proso variety grown.

Proso also can be planted as late as early July as a catch crop to replace winter wheat or other crops that have been lost due to freezing, wind erosion, drought, or hail.

SELECTING A FIELD

Proso can be successfully grown on many soil types, and it is probably better adapted than most crops to "poor" land, i.e. soils with lower water-holding capacity and fertility. However, proso will exhibit symptoms of iron chlorosis on soils with pH above 7.8.

Linly Stum
Southeast Colorado

Linly Stum has been growing proso millet for nearly 40 years in southeast Colorado near Towner. His farm is in eastern Kiowa County, close to the Colorado-Kansas border. Originally he grew proso millet in a winter wheat/proso millet/summer fallow rotation but has now gone to a winter wheat/proso millet continuous cropping, no-till, operation. He has benefited from 20 years of research at Colorado State University's Plainsman Research Center at Walsh.

Why Proso Millet and Not Another Rotation Crop?

- It requires the least amount of water of the cereal crops grown in eastern Colorado.
- A proso millet/winter wheat rotation allows a return to winter wheat without summer fallow if there's enough rain in late July and early August.
- It is a 60-day crop with a wide planting window.
- It has low input costs. Seed is $1.50-$2.00 per acre. Fertilizer rates are relatively low, and Stum reports no disease or insect pest problems.

Soil Preparation, Fertilization, and Weed Control

- Applies 30 oz glyphosate in late spring or early summer before planting. (Don't skimp on glyphosate.)
- Applies about 40 lb nitrogen per acre as liquid nitrogen.
- Applies phosphorus about once every four years.

Seeding Practices

- Variety: *Huntsman.*
- Plants proso millet around mid-June; needs moisture to plant so dates vary.
- Plants ½-1 inch deep.
- Seeds at a rate of 8-10 lb per acre, never more than 12-15 lb per acre.

Harvest

- Swathes proso millet in mid-August if planted by mid June. Swathing offers a longer harvest window because shattering is minimal.

Other Comments

- There is currently no crop insurance for proso millet in southeast Colorado.
- Stum says there is a crying need for a proso millet breeder in the Colorado/Nebraska/Kansas proso millet region due to the great potential for proso millet improvement, including the potential for ethanol production.

Linly Stum is willing to talk about proso millet with other farmers.

Business phone: (800) 289-1415
Home phone: (719) 727-4333
E-mail address: thunderbird@fairpoint.net
Interview by Jerry Johnson, January 15, 2008

Proso is frequently planted in areas where a severe hail storm has destroyed the wheat crop. These hail storms usually occur after May 15, and an attempt is made to plant as soon as the soil is dry enough.

Three problems prevail under these circumstances:

1) Wheat has removed much of the soil water;
2) Decaying wheat residue interferes with proso growth; and
3) Residual herbicide from the wheat crop may persist and injure proso.

Generally, in a wheat/fallow rotation it's better economically to plant proso into fallow intended for winter wheat planting in the fall and hold the hailed-wheat land for winter wheat planting in the fall. In a study conducted in the Nebraska Panhandle, proso yields were more than doubled by using available fallow ground for seeding compared with planting into hailed-out wheat land *(Figure 1)*. An increase of more than 1,000 lb/acre increases gross returns more than $50/acre with a price of $5.00/cwt.

The advantages of planting proso in the fallow ground are:

- the likelihood of having more soil water at planting, and
- the increased ability to control volunteer wheat on the land with the destroyed wheat crop.

Volunteer wheat control diminishes the risk of developing a serious wheat streak mosaic problem in the succeeding wheat crop. While planting proso in the fallow ground may be a good option, there is a danger that the hailed-wheat land won't have enough soil moisture for successful fall planting of winter wheat.

PREPARING THE FIELD

Proso is usually planted in the spring into wheat stubble harvested the previous July. A firm, moist seedbed is necessary to establish a good stand of proso that will compete with weeds. There are as many ways to get a firm moist seedbed as there are farmers growing proso. Some general guidelines follow.

No-till methods are popular and, if managed properly, can produce an

excellent seedbed for proso. Use glyphosate (sold under many brand names) to control weeds after harvesting the previous crop and before seeding proso. You can use a no-till drill to plant proso into wheat stubble, but conventional drills also may be modified to handle these conditions.

No-till allows the greatest soil water accumulation after harvest of the previous crop and protects the soil from wind and water erosion. Research in western Nebraska showed that yields with no-till are similar to yields with moldboard plowing or stubble mulching; additionally, crusting problems and the need to replant are greatly reduced with no-till. No-till also may improve carbon balance through the extended sequestering of carbon in the straw residue.

If you use a moldboard plow to bury wheat residue, use it early in the spring to allow time for further tillage operations and rainfall to firm the soil. Plowing is the most expensive method of preparing a proso seedbed and increases soil erosion risk from water and wind. Stubble-mulch methods use implements such as sweep plows, rod weeders, mulch treaders, and field cultivators to reduce surface residue enough for conventional drills to seed proso, but leave enough residue on the soil surface to reduce soil erosion.

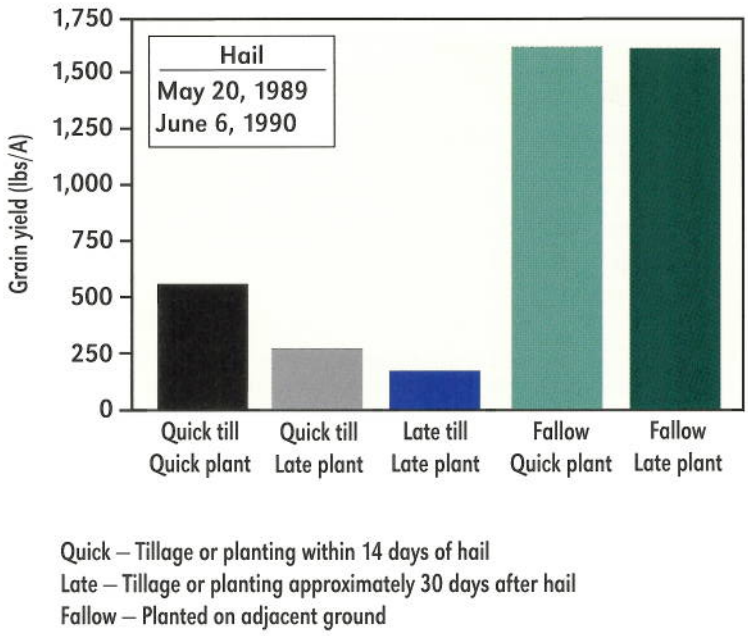

Figure 1. Proso millet grain yield following five different recrop strategies after the loss of winter wheat to hail.

FERTILIZATION

Use soil testing as the foundation of nutrient management in proso millet production. A soil sample from the surface (0- to 8-inch depth) should be analyzed for organic matter, pH, phosphorus, potassium and nitrate (N) and subsoil samples (to a 36- or 48-inch depth) also should be taken for nitrogen. Refer to the University of Nebraska-Lincoln NebGuide G1740, *Guidelines for Soil Sampling,* for more information. Soil test for nitrate-nitrogen before planting each proso millet crop. Other soil tests are recommended every three to four years.

Table IV. Nitrogen recommendations for proso millet with a 3-foot soil sampling depth.

		Previous crop	
Soil test nitrate-N		Fallow	Wheat
lbs NO_3-N/acre	ppm NO_3-N	lbs N/acre to apply	lbs N/acre to apply
0-20	0-1.9	55	75
21-35	1.9-3.2	35	55
36-50	3.2-4.6	20	35
51-65	4.6-6.0	10	20
66-80	6.0-7.4	0	10
>80	>7.4	0	0

Nitrogen (N) Recommendations. Most proso millet requires additional nitrogen. Proso planted following another crop, such as wheat, has a higher nitrogen requirement than after summer fallow. Suggested fertilizer nitrogen rates for proso are shown in *Table IV.*

All nitrogen fertilizer sources are generally effective. Incorporate urea-based fertilizers to avoid nitrogen volatilization (gaseous loss as ammonia), especially on calcareous soils. When nitrogen fertilizers are placed with the seed at planting, apply no more than 20 lb of nitrogen per acre to avoid stand damage. Under extremely dry conditions, or when using a row spacing of 12 inches or wider, reduce the maximum amount of nitrogen placed in the seed furrow to 10 lb per acre. Higher rates of nitrogen can be safely applied when placed at least two inches away from the seed. Never place ammonium thiosulfate (12-0-0-26) in the seed furrow.

Table V. Phosphorus recommendations for proso millet.

Soil test value		
Bray P-1 ppm	Olsen - P ppm	Banded* lbs P_2O_5/acre to apply
< 10	< 6.7	30
10-15	6.7-10	20
15-20	10-13.3	10
> 20	> 13.3	0

*Double this value for broadcast application.

Table VI. Potassium recommendations for proso millet.

Soil test value ppm K	Broadcast lbs K_2O/acre to apply
0-39	120
40-74	80
75-124	40
≥125	0

Phosphorus (P) Recommendations. Most proso millet grown in the western Great Plains is on high pH or calcareous soils. On these soils the Olsen-P soil test is recommended. For neutral to acid soils, the Bray P-1 or Mehlich 3 soil test is recommended.

How you apply phosphorus affects plant response. Using banded-phosphorus fertilizer with the seed has been more effective than broadcasting phosphorus. Phosphorus recommendations in *Table V* are for banded phosphorus, and should be doubled for broadcast application.

Potassium (K) Recommendations. Most Great Plains soils contain sufficient potassium for maximum proso millet production. *Table VI* shows potassium needed for low-testing soils.

Other Nutrients. Proso millet rarely shows increases from sulfur or other micronutrients, and zinc deficiency can be determined by soil testing. When the DPTA-Zn test is less than 0.5 ppm, zinc application is recommended. One-half to one pound of zinc with 10-34-0 (seed-applied in furrow) should be sufficient to prevent zinc deficiency.

CHOOSING A VARIETY

Proso breeding efforts in Nebraska have provided a wider choice of proso varieties, but these choices may be limited by a desire for specific traits such as seed color. Nearly all proso grown in the major production areas is white-seeded. A yearly update of common varieties can be found in the UNL Extension Circular, EC101, *Spring Seed Guide.* This information is also available online from *http://varietytest.unl.edu.*

Six white-seeded varieties, all in the variety tests for 2007, are discussed below and listed in the order of their performance based on six years at multiple locations. The acreage of each variety is not well-documented since more than half of the acres were planted to non-certified seed. However, based on a survey of states growing proso millet, these six varieties cover most of the acres of proso grown.

Huntsman is a late-maturing variety that is also the tallest of the current varieties. It has an excellent yield record and good seed size. Released in 1994 by the Nebraska Agricultural Experiment Station, it has a six-year multi-location yield average of over 2,000 pounds per acre.

Earlybird is an early-maturing short-stature variety with a good yield record and large seed size. It was released in 1994 by the Nebraska Agricultural Experiment Station.

Horizon is a short-stature variety released in 2003, and similar in maturity to *Earlybird.* It was a joint release from Nebraska, Wyoming, South Dakota, and Colorado. Because of its shortened grain fill period, it is ready to harvest two to three days earlier than *Earlybird* or *Sunrise,* even though it flowers at about the same time. Its six-year yield average is 200 pounds per acre less than *Huntsman.*

Sunrise was released in 1995 for its large seed size, high yield potential, lodging tolerance, and mid-season maturity. It has a maturity midway between *Huntsman* and *Earlybird.*

Sunup was released by the Nebraska Agricultural Experiment Station in 1989. Although it was high-yielding at the time of its release, it has now been surpassed by many of the newer varieties. It also has small seed compared to the other white-seeded varieties. The varieties listed above should be considered as replacements for *Sunup*.

Dawn was the start of the modern varieties and is the parent of most of the varieties listed here. It has good seed size, a compact panicle type, is short in stature and early in maturity. It's ready for harvest as much as one week earlier than many of the other varieties listed here. Its six-year yield average is a little more than half that of the top-yielding variety, *Huntsman*. It was released in 1975 by the Nebraska Agricultural Experiment Station.

Red-seeded proso has some demand, but probably is best grown away from the usual production areas and identified with a contract or specific market. If red seed is desired, the choice is *Cerise*, an early maturing variety from Nebraska. It has smaller seed size and is less acceptable as a feed due to its higher tannin content. Bird seed manufacturers use small amounts of red proso to improve eye appeal of the final product.

Recent proso breeding efforts are to develop waxy starch, which has many applications in food and industrial use. For proso, it means that the cooked product is sticky and easily eaten with chopsticks. Whereas most proso is now used in birdseed production, or for animal feed, the market could expand for proso as human food, primarily for export to Asian markets. The first waxy proso is named *Plateau* and is still in the process of being released. Its yield is similar to *Earlybird* and *Horizon*, but it has smaller seed size.

Currently, there are few producers of certified proso seed in the region. The best guides to finding them are the *Nebraska Seed Book*, published by the Nebraska Crop Improvement Association, (also available on-line at: *http://www.unl.edu/ncia/seedbook.html*), the *Colorado Certified Seed Directory*, published by the Colorado Seed Growers Association, the *Wyoming Certified Seed Growers Seed Directory*, published by the Wyoming Seed Growers Association, and the *South Dakota Certified Seed Grower Directory*. These resources are available from local agricultural extension educators.

Theron Anderson
Southeast Wyoming

Theron Anderson has been raising dryland and irrigated proso millet near Albin, Wyo., for more than 25 years. His typical dryland rotation is winter wheat/corn/proso millet/fallow. Once in a while, if the millet price is right and he has good spring soil moisture, he will plant proso after proso. He thinks proso millet works well after corn, especially if atrazine is used on the corn. On one farm he plants winter wheat, sunflowers, and proso, followed by a fallow period. His main irrigated rotation is winter wheat/dry beans/winter wheat, but if he grows sunflowers, he will often follow them with proso millet.

Why Proso Millet and Not Another Rotation Crop?

- Proso millet is one of the only crops that generate a positive income; it is more profitable than summer fallow.
- Seeding costs are low.

Soil Preparation, Fertilization, and Weed Control

- Have fields as weed-free as possible.
- Following corn or sunflower, he discs at least two times and then uses a rod-weeder before planting.
- On irrigated land, soil preparation is dependent on the preceding crop.
- Applies about 20 lb nitrogen per acre and 10 lb phosphorus per acre with the drill; his experience is that too much fertilizer will stress the crop in dry years.
- Uses proso millet in his rotation to deal with persistent weed problems like Canada thistle; it allows time for the weeds to get big enough in the spring to get a good kill before planting.

Seeding Practices

- Variety: feels that *Horizon* does best on his farm, but also likes *Sunrise* and *Huntsman*.
- Anderson likes to plant foundation or registered seed for increase through the Certified Seed Program.
- Uses his hoe drill in clean wheat stubble; he feels he gets better seed placement.
- Uses his air seeder if millet planting follows corn or sunflowers.
- Plants at a depth of ½-1½ inches, depending on soil moisture.
- If hard rain results in crusted soil before plant emergence, Anderson says "Might as well replant."
- Typically plants between June 1 and July 4.
- Seeds at a rate of 10-15 lb per acre on dryland no-till; on irrigated acres he seeds at 15-20 lb per acre.

Harvest

- Swathes to allow plants to dry down in the windrow; has tried to direct combine and use a stripper-header, but either the crop is too short to harvest or there is too much moisture in the seed for safe storage.

Theron Anderson is willing to talk about proso millet with other farmers.

Home phone: (307) 245-3476
Interview by Jack Cecil, February 4, 2008

Henry Roghair
Central South Dakota

Henry Roghair has been growing proso millet for about 17 years on his farm near Okaton, S.D. He started growing the crop in the early '90s, mainly to introduce diversity into his crop rotation. Before then, the main rotation on the farm was winter wheat/fallow. His basic rotation is now proso millet/winter wheat/oats/pea or lentil or sunflower, but this rotation can change depending on available moisture and weeds. If conditions are very dry he would not plant sunflower, a crop that requires a lot of soil moisture. In high weed pressure situations, he would not plant lentil.

Why Proso Millet and Not Another Rotation Crop?

- Proso millet can be planted late, which allows Roghair to better spread his workload.
- Proso is not a high water use crop and has a short growing season.

Soil Preparation, Fertilization, and Weed Control

- During the first two years, Roghair raised proso using conventional tillage methods, but then he switched to no-till practices.
- In order to keep his fields weed-free, Roghair makes one or two burndown applications with glyphosate in the fall before proso millet, depending on the previous crop.
- He usually makes two burndown applications in the spring before planting proso millet. In the first application, in May, he applies a mixture of glyphosate and 2,4-D. The rate of application varies depending on weed pressure. The second application of glyphosate is done just before planting.
- For fertilizer, he applies 45 lb of actual nitrogen per acre in the form of urea placed between the crop rows with the drill.
- He has not faced any major weed problems in the proso crop.

Seeding Practices

- Variety: *Sunrise* — the bird industry likes it because it has a large kernel. He will likely change to *Horizon* in the future because it has yielded slightly better than *Sunrise* in area test plots.
- Roghair uses a John Deere 1895 no-till drill, which he also uses for seeding winter wheat.
- Usually plants proso millet June 1 and mid-June. He has planted as early as mid-to late May and as late as July 4. The planting date varies from year-to-year depending on the moisture situation.
- Seeds at a rate of 20 lb per acre.
- His seeding depth is about ¾ inch. Roghair has planted at a depth of about one inch in drier years to get to moisture. He has not had a crusting problem since moving to no-till practices.

Harvest

- He swathes proso millet around the end of August to the first week of September.
- His proso millet yields have averaged about 35 bu/acre.

Other Comments:

- He would like to see more variety trials in South Dakota.

Henry Roghair is willing to talk about proso millet with other farmers.

Home phone: (605) 669-2819
Interview by Thandiwe Nleya, January 30, 2008

PLANTING THE CROP

Planting efforts should place the proper amount of seed into a moist, warm, and firm seedbed at the proper time so proso seedlings can emerge quickly and have the greatest competitive advantage over weeds. Usually, it's hard to meet all these goals and the producer must choose the least damaging compromise.

Proso millet has a wide planting window ranging from May 10 to June 30 and can be a backup if winter or early spring crops fail due to drought, hail or freeze damage. However, the best time to plant proso can vary greatly with seedbed conditions. For example, optimum planting dates for proso differ between tilled and no-till seedbeds. If the seedbed has been tilled and little residue remains on the soil surface, proso yield will be highest when planted in mid-May. If planted in a no-till seedbed, optimum yield occurs by planting approximately two weeks later. These different responses to planting dates relate to soil temperature. Optimum soil temperature for proso seed germination ranges from 55°F to 65°F. Soil temperature rises sooner in tilled systems than in no-till systems due to lack of crop residue.

For either seedbed type, yield decreases if proso is planted earlier or later than the optimum time. For example, in a no-till seedbed, proso will yield within 5 percent of its potential if planted between June 2 and June 12, but its yield will decrease 20 percent if planted in mid-May or late June *(Figure 2)*.

In western Nebraska, proso can produce a seed crop when planted as early as May 10 or as late as July 5. If good weed control is practiced, the earlier date will produce better yields. Earlier planting also takes better advantage of spring rains.

Later planting gives proso a better potential for competing with weeds without the use of herbicides. Factors such as condition of seedbed, timing of rains and, in the case of a catch crop, timing of hail or frost, can influence the best date for planting proso.

A wide variety of seeding rates can be used without significantly influencing yield. Generally, use higher rates to avoid the necessity of reseeding after a heavy rainstorm. Recommended rates can be as

low as 8 lb per acre, but rates of 15 to 20 lb per acre are more common. A rate of 12 lb per acre would be adequate with a good drill that minimizes the chance of crusting. Proso will thin itself if planted too thick. A thin stand will tiller profusely and compensate if the stand is uniform.

The equipment used to plant proso is usually dictated by the equipment available for other crops. The most common drill is one used for winter wheat, usually a deep furrow or hoe-opener type. This isn't the best choice since it's difficult to maintain a shallow depth with it. When a hoe drill is used, the seeding rate is set high (20 lb/acre) and the depth is quite shallow. Packer wheels can be very beneficial if planting into a loose seedbed, but that combination is most susceptible to crusting from a heavy rainstorm.

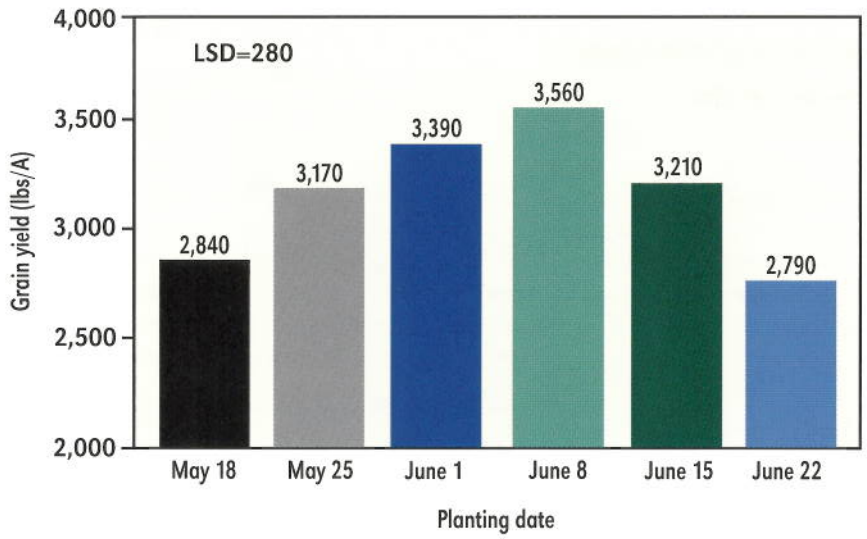

Figure 2. Proso grain yield in a no-till seedbed as affected by planting date. Data collected over three years in northeastern Colorado.

The most desirable drill for planting proso, where stubble is not a problem, is a double-disk drill, which places the seed into a shallow slot and firms the soil around it. It leaves very little furrow to wash in and crust in the event of a heavy rainstorm. The final drill type is one designed for no-till wheat. No-till proso works very well. Soil crusting is minimized in no-till systems. Regardless of the type of equipment used, the seed must be firmly packed and covered with 1/2 to 3/4 inch of soil. Nebraska studies showed that drill choice did not greatly affect yield if a good job of seeding was accomplished. Studies showed that drills with narrow row spacing (6- to 10-inch) gave a yield advantage over wider row spacing (12- to 15-inch).

EMERGENCE PROBLEMS

The two weeks after planting is a critical period for growing proso. During this period, a light rain can be helpful; a heavy rain can be destructive. Heavy rains can bury the seed too deep to emerge or create a soil surface crust too dense for seedlings to penetrate, resulting in poor plant stands. This is when the effects of a superior drill become most apparent. A seedbed firmly packed around the seed, as the result of using the right drill, encourages germination even when conditions appear quite dry. Using the right drill also prevents a heavy rain from burying the seed too deep and allows an implement such as a rotary hoe to break the crust around the seed, if necessary. Seed burial and soil crusting after a heavy rain are minimized in a no-till seedbed.

Check the stand periodically during the two weeks after planting. The density of stand within the row is important. If there are fewer than 10 plants in a foot of row, weed competition could become a problem. Consideration should be given to replanting, especially if it's still early in the season. Uniformity is important. Large skips or gaps in the field reduce yield and encourage weeds. A marginal stand can best be preserved with a strong weed control program.

During the periodic checking of stand, you may observe a problem of poor secondary root development. The proso plants appear attached to the soil by only a thread of root. This condition is related to a loose seedbed and occurs most often in moldboard-plowed and heavily disked fields. This usually occurs more than two weeks after planting.

The only cure is a rain shower that allows the secondary roots to begin growing into the soil surface. Replanting would not likely help since the condition is caused by a loose, dry soil surface. Avoid applying 2,4-D or dicamba (*Clarity*®) to plants with poor secondary root development. These herbicides may cause lodging and delay brace root development.

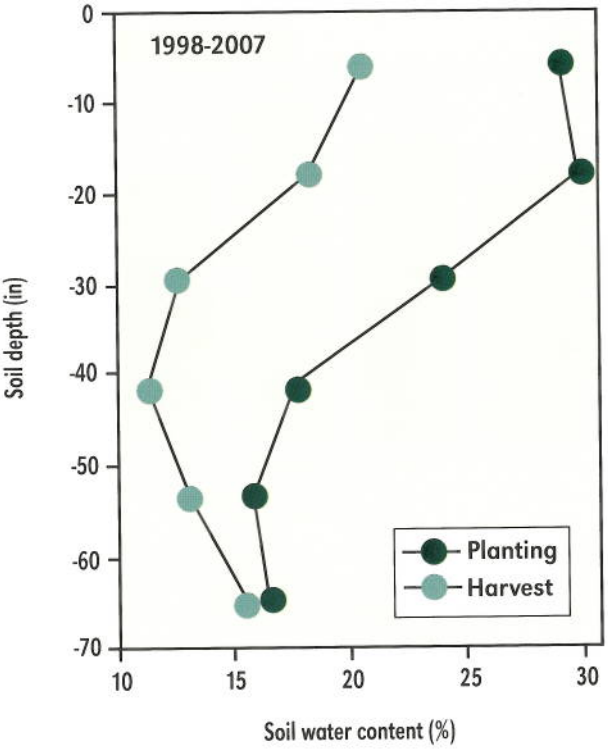

Figure 3. Volumetric soil water profiles at proso millet planting and harvest.

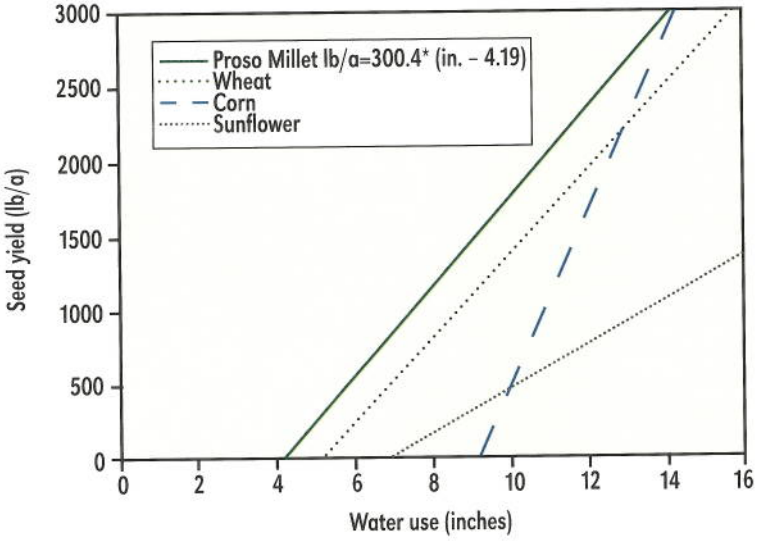

Figure 4. The response of seed yield to water use for proso millet, winter wheat, corn, and sunflower.

WATER USE AND YIELD

Proso millet can be considered a more shallow-rooted crop than winter wheat, corn, or sunflower. See *Figure 3* for a graph showing the 10-year average soil water content at planting and harvest from the soil surface to 65 inches below the surface for proso millet grown on a silt loam soil at Akron, Colo. Significant amounts of stored soil water can be extracted from the top three feet of soil. Approximately 90 percent of the total seasonal water use comes from precipitation in the growing season and stored water from the top three feet of the soil profile.

Proso millet is highly productive under low-water availability conditions and its seed yield increases with water use at a rate of about 300 lb/acre per inch of water use after about four inches. This is lower than corn (about 580 lb/acre per inch), but higher than winter wheat (about 280 lb/acre per inch) and sunflower (about 150 lb/acre per inch). Water use required before seed formation begins is about 4 inches for proso millet, which is lower than for wheat (5 inches), sunflower (7 inches), and corn (9 inches).

The actual yield obtained for a given water use can vary widely from year to year. For example, the production function shown in *Figure 4* predicts a yield of 1,145 lb/acre at a water use of 8 inches, but at Akron, yields obtained with 8 inches of water ranged from 350 to 2,000 lb/acre.

This wide range in yields at identical water use is generally due to precipitation timing. Very dry conditions following planting can result in low plant populations and lower than expected yields, while timely precipitation during flowering and grain fill can result in higher than expected yields.

Recorded water use for the proso millet grown at Akron, Colo. has ranged from about 4 to 14 inches, resulting in yields of 0 to nearly 3,000 lb/acre. Variability in water use directly results from variability in growing season rainfall (ranging from about 1 to 9 inches at Akron) and available soil water at planting, ranging from 4 to 11 inches for a proso millet/fallow/wheat (PM/F/W) rotation or from 3 to 8 inches for the more intense, continuously cropped, proso millet/wheat/corn (PM/W/C) rotation. Available soil water at planting at Akron averaged 1.35 inches more for a millet following wheat rotation than a millet following corn rotation, due primarily to a three-month longer non-crop period in which precipitation was stored. The average (1998-2007) proso millet water use and yield are 9.62 inches and 1,868 lb/acre for the PM/F/W rotation and 8.58 inches and 1,370 lb/acre for the PM/W/C rotation at Akron.

GROWTH RATE

Proso development can be related to temperature by using growing degree days (GDD). Growing degree days are calculated from air temperature for each day and accumulated from the time proso is planted. The GDD formula is:

GDD = (maximum temperature + minimum temperature) / 2 - 50.

(If the minimum or maximum temperature is below 50°F or above 86°F, use 50 or 86 in the equation.)

For proso, we use a base temperature of 50°F and a maximum of 86°F for the optimum growing conditions, as proso growth is minimal below or above these temperatures. Relating GDD accumulation to plant development shows that the varieties *Sunrise and Sunup* develop similarly, with heading beginning about 925 GDD after planting, flowering about 1125 GDD, and maturity about 1585 GDD.

Huntsman proso takes about 100 GDD more to reach maturity than *Sunrise* or *Sunup*. This development-temperature relationship has been consistent for proso when planted over a range of planting dates. Some varieties — especially the older, taller varieties — may respond more to day length because they are more photoperiod-sensitive. Primary adaptation of waxy proso to the region has been through incorporation of heat unit driven maturity into photoperiod-sensitive germplasm.

COMBATING WEEDS

Weeds can be a serious problem in proso millet. There are three basic weed control strategies: 1) non-chemical, 2) herbicide use in-crop, and 3) pre-plant burndown herbicide followed by in-crop use of herbicide (no-till).

Strategy One

Strategy One requires some special management decisions. The two necessary ingredients for successful proso production without herbicides are:

1) to have the field weed-free by tillage just prior to planting; and
2) to plant later in the season (typically after June 10) into a warm, moist seedbed to encourage rapid growth.

The later planting date also allows major weed flushes such as kochia and Russian thistle to occur prior to seeding, when tillage can be used for control. Planting late may reduce yields but will require less cash outlay for herbicides. A seeding rate of 15 to 20 lb per acre will provide more effective competition with weeds. Narrow row spacing, for example 7.5 inches instead of 12 inches, provides

Ken Disney
Southern Nebraska Panhandle

Ken Disney operates a 100 percent dryland organic farm near Lodgepole. The Disney Farm has been organic since 1991. Prior to that, it was primarily a wheat/fallow operation with barley, oats, and safflower occasionally grown. Wheat and proso millet are now the primary cash crops. A legume, usually peas, is seeded as a green manure crop following harvest of the spring crop. Disney has also grown amaranth, sunflowers, and several other crops.

Why Proso Millet and Not Another Rotation Crop?

- Proso millet is a very marketable crop.
- It has a short growing season.
- It is relatively inexpensive to grow.
- Proso millet can help get rid of annual weeds. The stubble stays weed-free up to five weeks longer than wheat stubble.

Soil Preparation, Fertilization, and Weed Control

- Usually uses three operations after wheat harvest. He uses a Noble blade in two of these operations.
- Ground can't be too loose, and there needs to be good moisture near the soil surface.
- Disney uses peas to fix nitrogen, usually in the 30-40 lb per acre range, which along with residual nitrogen is enough for production of winter wheat, his primary cash crop. Proso millet has to perform on residual nitrogen.
- Wild buckwheat is hard to clean out of proso millet seed. Can't have a heavy infestation in an organic production field.
- Proso millet competes well with redroot pigweed as long as moisture is available. You don't want it to be a problem, but a few plants don't seem to hurt.

Seeding Practices

- Variety: *Sunup* and *Sunrise*. Disney would prefer taller varieties for more plant residue. He likes varieties 36 inches tall or taller at maturity.
- Plants proso from May 25 through June; a five-week window. He tries to have his proso seeded by June 10. Some of the best proso millet yields on replanted proso have been seeded around June 20.
- Seeds at a rate of 18 lb per acre.
- Disney uses a double disk drill, if available. He feels proso millet comes up better and the double disk drill makes smaller ridges. Even 0.2 inch of hard rain will wash soil into furrows. This can result in reduced seedling emergence as a result of soil crusting.
- Doesn't use a rotary hoe if seedling emergence is poor; prefers to replant it.
- Seedbed not too loose or too deep. Seed into moisture at 3/4 - 1 inch planting depth.

Harvest

- Disney doesn't get in a big hurry to swath proso millet. He waits until three-fourths of the head turns brown before swathing. He feels you can lose test weight if you swath too early.
- Three to four days after swathing, proso is usually ready to harvest.

Ken Disney is willing to talk to other farmers about proso millet.

Phone: (308) 483-5673
Interview by Karen DeBoer, February 10, 2008

David Hagstrom
Southern Nebraska Panhandle

David Hagstrom operates a dryland farm near Kimball. His crop rotation is winter wheat/proso millet/summer fallow. This gives him two planting times, two harvest times, and spreads out the work so he doesn't need to hire custom work.

Why Proso Millet and Not Another Rotation Crop?

- Wheat equipment will work for proso; doesn't need other equipment.
- Proso helps control downy brome and jointed goatgrass. Oats and barley are not as effective as proso for control of these grassy weeds.

Soil Preparation, Fertilization, and Weed Control

- After wheat harvest, blade stubble one time as soon as weeds are tall enough. Let some volunteer start first. As soon as soil temperature is 50°F, blade a second time and apply anhydrous ammonia. Blade again in November. If needed, he will use glyphosate to control early spring weeds.
- Usually applies 40 lb of nitrogen per acre. He has seen good response to nitrogen fertilizer. Plants can grow twice as tall. He has not seen a response to phosphorus fertilizer.
- Hagstrom tills immediately ahead of the drill with a Krause Landstar with a coil packer behind the implement. He stresses the need to have a firm seedbed.
- He has not had much trouble with weeds in his proso.

Seeding Practices

- Variety: Uses *Sunrise* because it has a fairly large seed, doesn't lodge and yields well.
- Uses an air seeder drill with 9-inch row spacing. If he has soil moisture in the spring, he will use 3-inch spreader tips on the shanks. He believes this provides better weed control because canopy closure occurs earlier.
- Tries to be half-done seeding by Mother's Day and done by May 21.

Harvest

- Typically uses a stripper-header, but has swathed in some situations, such as when he had too many acres of proso to dry it all in the bin. Will harvest with a stripper-header from 28 percent moisture down to 15 percent or 16 percent moisture (will badly shatter below this). A stripper-header allows proso harvest at higher moisture for cleaner seed.
- Dries wet grain in his bins to 12 percent moisture.
- Hagstrom will store proso in a bin if the price at harvest is $4 or less per cwt. It is a true supply-and-demand market.

David Hagstrom is willing to talk to other farmers about proso millet.

Phone: (308) 235-2701
Interview by Karen DeBoer, February 12, 2008

more rapid shading of the interrow area and increased crop competition with weeds.

Strategy Two

For **Strategy Two**, proso should also be planted into a weed-free seedbed, but can be planted earlier in the season (typically between May 25 and June 5) since many annual broadleaf weeds can be controlled in the crop with postemergence herbicides.

Most broadleaf weeds in proso millet can be economically controlled with 2,4-D; not all 2,4-D products are labeled for use in proso. Check the label before using any 2,4-D product in proso millet. Apply 2,4-D amine (4L) at a rate of 1 pint/acre to proso in the 3- to 5-leaf stage. Crop injury may occur if 2,4-D is applied to plants outside the 3- to 5-leaf growth stage or to plants stressed by heat and drought. Injury will frequently result in poor root development and injured plants often will fall over and lay on the ground. Do not apply 2,4-D herbicide during hot, dry periods.

Adding Clarity to 2,4-D amine will increase control of weeds such as kochia, especially triazine-resistant kochia, and wild buckwheat. Clarity also may provide a week or two of residual weed control for some later-emerging weeds. Add Clarity at a rate of 4 oz/acre to 0.75 pint/acre 2,4-D amine (4L) per acre. Like 2,4-D, Clarity may cause injury to proso millet if applied outside the 3- to 5-leaf growth stage or in periods of high temperatures or drought. Risk of crop injury is slightly greater with Clarity than with 2,4-D alone. Clarity should not be used when susceptible crops are within a half-mile of the application site.

Peak® provides some residual control of later-emerging broadleaf weeds, but somewhat limits cropping flexibility. For example, sunflowers and garbanzo beans cannot be planted for 22 months following a Peak application. Apply Peak at a rate of 0.38 to 0.5 oz/acre with three-fourths of a pint of 2,4-D amine (4L) per acre. Add a non-ionic surfactant at a rate of 1 quart/100 gallons of spray solution.

Aim® herbicide can significantly improve the control of buffalobur, a common weed found throughout western Nebraska and designated as a noxious weed in some states.

To control it, add Aim as a tank mix partner to 2,4-D or 2,4-D + Clarity. In a field study conducted near Sidney, Nebr., control of buffalobur was just 20 percent with 2,4-D amine and 30 percent with 2,4-D amine + Clarity. By adding half an ounce of Aim to these two treatments, buffalobur control increased to 93 percent and 85 percent, respectively. Peak + 2,4-D amine provided 80 percent control of buffalobur in this same study.

Because of buffalobur's designation as a noxious weed in several western states, including Washington, Idaho and Utah, it cannot be imported to those states and bird seed packagers will not purchase proso millet seed if it contains buffalobur seed.

Buffalobur, with its yellow flowers and spiny stems and leaves, is a common weed found throughout western Nebraska. It is considered a noxious weed in several western states, so bird seed packagers will not purchase proso millet seed if it contains buffalobur seed. (Patrick J. Alexander @ USDA-NRCS PLANTS Database)

Adding Aim to other labeled herbicides also improved control of broadleaf weeds such as kochia and Russian thistle when weeds were drought-stressed, but did not improve control when these weeds were not drought-stressed.

Aim herbicide should be added at a rate of one-half ounce per acre. Add a nonionic surfactant at a rate of 1 quart/100 gallons of spray solution. Plant coverage is essential for good control because Aim is not a translocated herbicide. Aim should be tank-mixed with other herbicides labeled for use in proso millet to broaden the range of weeds controlled.

Strategy Three

Strategy Three requires using a nonselective herbicide such as glyphosate prior to seeding to control emerged weeds. The number of applications required will vary with the year. Proso is no-till drilled into winter wheat stubble and postemergence herbicides are used in the crop as previously described.

Control of buffalobur and other problem weeds can be enhanced through crop rotation and good weed control strategies in the other phases of the crop rotation. When proso follows winter wheat, use post-harvest weed control to reduce weed seed production of warm-season weeds such as kochia, pigweed species, and Russian thistle. These can be problematic in the following proso crop. Controlling weeds after wheat harvest also reduces soil water loss, which benefits the following proso crop.

INSECT PESTS

Insects don't usually seriously affect proso millet. Most insect or mite damage occurs when large numbers move into the proso early, when the plants are small or have limited foliage. This occurs with thrips and spider mites (Bank's grass mite) when they move off maturing wheat in June and onto proso seedlings. This problem can be severe under very dry conditions, when thrips or mite populations have increased through the spring and early summer on wheat and then move onto the slower-growing proso.

Damage by both thrips and mites shows up as yellow speckling on the leaves, and plants may show signs of water stress. A good rain will reduce mite and thrip problems and allow the millet to grow out of the damage. Prolonged damage to young seedlings, coupled with severe water stress, can result in stand reductions, stunted plants, or both. No control options can effectively reduce these problems.

Grasshoppers can become a serious problem in proso millet grown adjacent to wheat or non-crop areas. The heaviest damage occurs when the grasshoppers move from maturing or recently harvested wheat into the green proso fields. Significant defoliation can occur if grasshopper populations are large. Target grasshopper control early before grasshoppers become adults or treat non-crop areas surrounding proso fields, because more effective insecticide options are available than for the proso crop.

Three species of stem-boring insects can damage proso millet. If proso is grown adjacent to corn, European corn borers can become established. These infestations are most likely to occur in irrigated areas. The larvae bore into the stems and can cause heads to die back. Also, two species of stem maggots have been found damaging proso in the region. The wheat stem maggot and a related species will feed within the stem near the upper node and cause the head to die prematurely, preventing seed fill. Significant infestations are rare, but the isolated damage (fired heads) is very apparent in the field. Insecticide control is not warranted as effective treatment timing would be difficult.

Proso is not a host for the Russian wheat aphid or wheat curl mite; however, proso is susceptible to wheat streak mosaic virus and can become infected by wheat curl mites moving into proso just before wheat harvest. The mites will not survive, but the resulting virus infection may cause some yellowing or mosaic symptoms. The impact of this infection in proso seems to be negligible.

Figure 5. Symptoms of bacterial spot include round to oblong water-soaked spots that expand to form oval to elongate, tan necrotic lesions with thin dark margins.

DISEASE PROBLEMS

One of the few proso problems observed in western Nebraska has been poor germination and emergence. The cause is suspected to be several soilborne fungal pathogens such as *Helminothosporium* and *Fusarium* spp. infecting emerging seedlings. Another documented problem is head smut, caused by *Sphacelotheca destruens.* Head smut is widespread on proso and can significantly reduce grain yields if favorable conditions for the pathogen exist. Serious losses have been realized where producers used home-grown seed from a previously infected crop. Fortunately, treating seeds with various fungicides was successful in reducing smut infection by more than 90 percent, compared to untreated seeds.

During 2003, bacterial spot was detected and the causal agent was identified as the fluorescent bacterium *Pseudomonas syringae.* Symptoms included round to oblong water-soaked spots that expanded to form oval to elongate, tan necrotic lesions with thin, dark margins *(Figure 5)*. The disease was found in more than 15 fields in four counties (Box Butte, Scotts Bluff, Morrill, and Cheyenne) in the Nebraska Panhandle. Its presence was noted during the cool, wet periods of mid-May, but became a non-factor once temperatures warmed and new leaves emerged in June. This disease has appeared again sporadically during cool, wet periods in late spring, but has not become a yield-limiting problem.

Numerous diseases in millet have been reported worldwide, including those caused by bacterial, fungal, viral, and nematode pathogens. Most of these reports concerned pearl millet, but it's assumed that proso would be equally susceptible to many of the same diseases. Several of these pathogens are readily found in western Nebraska

agricultural production, including wheat streak mosaic virus, *Rhizoctonia solani* and other seedling pathogens, and many diverse nematodes such as stubby-root, root-knot, and lesion. Therefore, ample potential exists for proso millet in western Nebraska to be affected by a number of diseases, yet it does not consistently suffer from disease.

HARVESTING PROSO

Since proso shatters easily when ripe, there is some risk in allowing the grain to completely mature and dry while standing. A small wind can cause considerable shattering. Therefore, swathing should be done when the top of the main head has mature seed. Since proso seed develops from the seed coat to the center, mature seed can be identified by starchiness in the center. Threshing can then be delayed until the grain is below 13 percent moisture. Attaining a 13 percent moisture level during September can be a challenge some years since humidity is high, dew is frequent, and temperatures are lower.

Proper setting of the combine is important for proso harvest. See your combine's owner's manual for guidance. Marketing proso is difficult when the millet hulls have been removed and only the yellow-colored inner berry is left. A good rule of thumb is to have equal numbers of loose outer glumes as removed hulls.

Dawn was the first variety of proso that showed some promise of harvest by direct combining. More recently the varieties *Sunup* and *Huntsman* were released with larger seeds, greater uniformity in maturity, less seed shatter, greater height, and less susceptibility to lodging. These characteristics increase the potential for successful direct harvest using a combine equipped with a stripper-header. A four-year study conducted at Akron, Colo. compared conventionally swathed and combined proso with direct-harvested proso using a stripper-header. In that experiment the stripper drum speed was 500 rpm, the cowling setting was up, and ground speed was 5 mph. The time between swathing and swath pickup averaged six days, and time to stripper-header harvest averaged another 17 days past the date of swath pickup.

Jared, Ryan and Richard Kurtzer
Northeast Colorado

The Kurtzers have been growing proso millet successfully for at least 20 years on their farm near Haxtun, Colo. Proso millet is a planned dryland crop within a three-year rotation of winter wheat/corn/proso millet in a no-till cropping system. The Kurtzers started growing millet after fallow and got 40 to 50 bu/acre yields. They started no-till cropping in 1998 and were able to get 60 to 70 bu/acre yields following Roundup-Ready dryland corn in continuous cropping — without a summer fallow period. Jared indicated that, in an average annual precipitation area of 15 inches, they have just enough moisture to consistently produce good crops in this continuous dryland cropping system. He says that proso millet in the rotation makes everything else work. The millet fits strongly into the rotation.

Why Proso Millet and Not Another Rotation Crop?

- Millet makes continuous cropping work and fits well into this crop rotation.
- Millet follows corn really well and is harvested just in time to plant wheat.
- Millet stubble protects fall-seeded wheat and captures winter snow.
- Millet responds well to no-till cropping.

Soil Preparation, Fertilization, and Weed Control

- The Kurtzers use a no-till continuous cropping system with chemical weed control.
- In March, 40 lb liquid nitrogen per acre is streamed on to standing corn stalks (not shredded) to trap snow. Streaming nitrogen reduces the chance of it being tied up in the corn residue.
- At planting, another 20 lb nitrogen per acre is applied with 20 lb P_20_5 per acre in the drill hopper box in the same seed tube.
- A burn-down herbicide is used just before planting and 2,4-D is used to control in-crop annual broadleaf weeds.
- Practice good field sanitation for all crops and between crops.
- Puncturevine is a problem in proso millet but it can be managed.

Seeding Practices

- Variety: *Sunup*.
- June 10 is the target seeding date. Timely planting is critical.
- Proso is planted with a no-till John Deere 1890 air-seeder into corn stalks.
- Seeding rate is 25 lb per acre.

Harvest

- Swath when the top half of head is brown.
- If proso is planted about June 10 it can be harvested September 1 and they can get back to winter wheat.
- They cut proso high when swathing and leave 1-foot-tall stubble for planting wheat.
- Combine at 12 percent moisture or less. Proso has been combined at 13.5 percent moisture, but then it must be dried by forced air in the bin. It is difficult to force air through millet.

Other Comments

- Crop insurance is available for proso in their area.
- Success of proso millet was conversion to no-till.

Jared Kurtzer is willing to speak to other growers about proso millet.

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E-mail address: Cumminspower@hotmail.com
Interview by Gus Foster. Edited by Jerry Johnson, February 16, 2008

Midcap Farms
Northeast Colorado

Midcap Farms have been producing proso millet successfully for the last 50 years near Wiggins, Colo. Initially, the Midcaps planted millet as an opportunity crop when wheat stands were lost or thin or when they got above-average spring moisture permitting a millet crop. They tried a winter wheat/proso millet continuous cropping rotation on some of their ground, but continuous cropping with 13 inches of average annual precipitation is risky and managing summer grasses, especially sandbur, can be problematic. They are wheat seed producers and proso millet is in a planned crop rotation of winter wheat/proso millet/fallow that allows them to control summer grasses, have good quality seed wheat, and consistent yields.

Why Proso Millet and Not Another Rotation Crop?

- Millet fits the cropping sequence.
- Millet in rotation provides two crops in three years.
- Millet produces under their limited rainfall conditions.
- Millet fits nicely into a no-till cropping system.

Soil Preparation, Fertilization, and Weed Control

- No-till seeding into wheat stubble.
- Place 30 lb nitrogen at planting using mid-row banders as part of the planter unit.
- Practice good field sanitation between crops and control weeds after wheat harvest prior to a killing frost. It may require two late summer/fall herbicide applications.

Seeding Practices

- Variety: *Huntsman.*
- Timely planting is important. Midcaps seed from the third week of May to the second week of June depending on when they can control the initial flush of weeds before planting with a burn-down application.
- Their seeding rate is 10 lb per acre.
- Seeding depth is 1 inch but they have had millet emerge from a 2-inch depth.

Harvest

- Historically they direct cut standing millet without swathing. This was very successful but timing of harvest is critical because millet needs to be harvested at 13 percent moisture and then forced-air dried in the bin. Shattering was not a problem if they started cutting at 13 percent moisture and finished harvest in about four days and millet got down to about 11 percent moisture.
- Now they swath their millet so they can manage time better in the fall when they plant wheat and manage their wheat seed business.

Other Comments

- They were comfortable direct cutting millet, but it requires close attention and you have to be there when the crop is ready.
- Important to success is controlling weeds after wheat harvest (you can't let grassy weeds escape and go to seed) and practicing whole crop rotation field sanitation.

Fred Midcap is willing to talk to other farmers about proso millet.

Phone: (970) 483-5265
Interview by Gus Foster. Edited by Jerry Johnson, February 15, 2008

This study found no differences in seed yield or seed moisture content at harvest between the two harvest methods despite the delay. Direct harvest with a stripper-header eliminates the cost and labor of swathing and leaves more standing residue following harvest. This will increase precipitation storage efficiency and provide more stored soil water for the subsequent crop.

However, producers should be aware that some years may show a yield loss associated with shatter and lodging if proso harvest is delayed in order to allow the grain to dry sufficiently for direct harvest with a stripper-header. Having the capability to dry grain can move harvest with a stripper-header to approximately the same time as swather pickup. Bin driers must have good airflow and clean grain is imperative. Floor screens and vent screens in bin driers must be small enough to keep from filling with proso. Flow driers have been used successfully by some growers.

PROSO AS A FORAGE CROP

Proso produces enough plant material to be considered a forage crop. It would have to be harvested soon after heading, however, to optimize forage quality. Proso has not been used extensively for forage because it has a lower leaf-to-stem ratio than superior plants such as foxtail millet [*Setaria italica* (L.) P. Beauv.]. Therefore, when forage is desired, farmers generally plant foxtail millet. However, if the need for forage occurs after planting, proso makes an acceptable hay crop. The proso variety *Horizon* produces more forage than *Dawn* or *Rise.*

Most proso grown for grain is swathed prior to full maturity and then combined, resulting in straw of relatively high feed value compared to other grain crops that have lost most of their leaves prior to harvest. Proso straw has been used successfully as part of the feed for wintering dry, pregnant beef cattle.

PRODUCTION COSTS

Proso millet is a low cost-of-production alternative for dryland producers in the Great Plains. Typically, the proso crop is no-till seeded into wheat stubble. The stubble is sprayed once or twice in the fall and again in the spring just prior to planting. An example budget for proso millet is given in *Table VII* on a per-acre basis. Variable costs of production are estimated at $72.80 per acre, while fixed costs are estimated at $64.44 per acre. The total cost per acre, including management and overhead charges, is $137.24 per acre. These cost-of-production estimates should be used as a guide only. Calculate your own costs and price portions for all of your production to meet management objectives.

The cost-of-production estimate can be used to determine the break-even prices necessary for different levels of expected production. *Table VIII* shows the expected net returns for several price and yield levels for proso millet.

MARKETING PROSO

The bulk of proso sold in cash trade is marketed through elevators in counties where it is grown most extensively. This grain is cleaned further, processed, and used for bird seed. Both domestic and wild bird seed is packaged by adding other grains for color and nutrition. Some proso goes through a dehulling process and supplies both human and animal needs. Some is exported and some used for specialty purposes. India and several African nations are large proso producers and consumers, mainly using proso for human consumption. The largest export markets for U.S. proso have been Angola, Senegal, Japan, and western Europe. As noted earlier, marketing proso is easier if it's been cleaned of all buffalobur.

The proso millet market is characterized by significant changes in the supply and demand relationship on a year-by-year basis. These swings in

Table VII. Projected cost of production for no-till dryland proso millet in western Nebraska, 2007.

Variable Costs	Cost per acre					
	Labor	Fuel & lube	Repairs	Materials & custom	Total	Your estimate
Spray - fall	0.49	0.38	0.64	6.20	7.71	_____
	Roundup Ultra rt 24 oz/acre @ $0.18/oz					
	2,4-D ester 4# 1 pt/acre @ $1.88/pt					
Spray - preplant	0.49	0.38	0.64	22.36	23.87	_____
	Roundup Ultra rt 24 oz/acre @ $0.18/oz					
	2,4-D ester 4# 0.5 pt/acre @ $1.88/pt					
	28-0-0 30 lb N/acre @ $0.57/lb N					
No-till drill	1.59	2.70	2.22	10.20	16.71	_____
	Proso millet seed 12 lb/acre @ $0.85/lb					
Spray for weeds	0.49	0.38	0.64	1.50	3.01	_____
	2,4-D amine 1.00 pt/acre @ $1.50/pt					
Combine	1.94	4.70	2.64	0.00	9.28	_____
Truck	Custom			5.20	5.20	_____
	Custom trucking 20 cwt/acre @ $0.26/cwt					
Operating interest @ 8.5% for 8 months					3.73	_____
General overhead					3.29	_____
Total variable costs					**$72.80**	_____
Fixed costs						
Machinery						
Depreciation					16.93	_____
Interest					13.49	_____
Land rent					25.00	_____
Management					9.02	_____
Total fixed costs					**$64.44**	_____
Total of all costs					**$137.24**	_____

Table VIII. Estimated net returns ($ per acre) for proso millet in the Great Plains under a range of prices and yields.

Price	Proso Millet Yield (lb/acre)					
($/cwt)	1250	1500	1750	2000	2250	2500
$3.00	(97.79)	(90.94)	(84.09)	(77.24)	(70.39)	(63.54)
$4.00	(85.29)	(75.94)	(66.59)	(57.24)	(47.89)	(38.54)
$5.00	(72.79)	(60.94)	(49.09)	(37.24)	(25.39)	(13.54)
$6.00	(60.29)	(45.94)	(31.59)	(17.24)	(2.89)	11.46
$7.00	(47.79)	(30.94)	(14.09)	2.76	19.61	36.46
$8.00	(35.29)	(15.94)	3.41	22.76	42.11	61.46
$9.00	(22.79)	(0.94)	20.91	42.76	64.61	86.46
$10.00	(10.29)	14.06	38.41	62.76	87.11	111.46
$11.00	2.21	29.06	55.91	82.76	109.61	136.46
$12.00	14.71	44.06	73.41	102.76	132.11	161.46

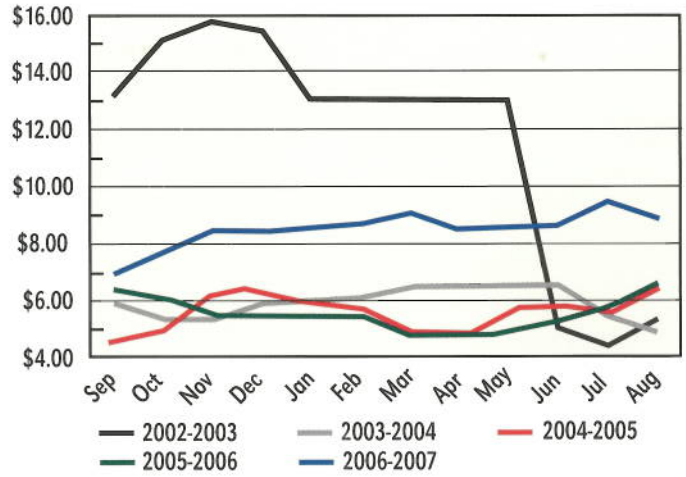

Figure 6. Average western Nebraska monthly proso millet prices for 2002-2003 through 2006-2007 crop production years.

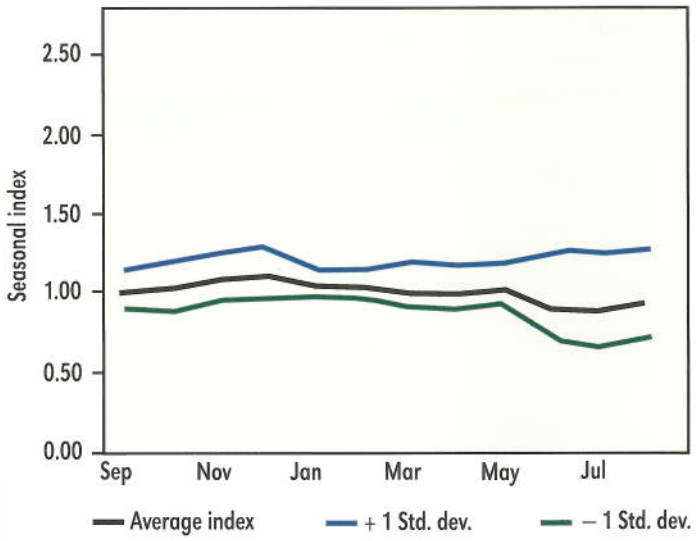

Figure 7. Five-year average monthly price index for proso millet from 2002 through 2007.

production and demand can create extreme volatility in the market as *Figure 6* shows. Marketing proso can be a challenge, and pricing is difficult to predict prior to harvest. In years of high prices, production will increase, creating an oversupply and, likely, much lower prices the next year.

The best approach to pricing proso millet is to calculate production costs and seek price protection in the form of cash contracts with an elevator or direct cash sales at planned price targets. Without the benefits of established futures contract institutions (such as the Chicago Board of Trade for grains) and with relatively thin local markets, price risk is high. Due to price volatility, storage is often used to take advantage of seasonal price patterns *(Figure 7)*. Storage requires disciplined management, set price targets, and selling of grain as opportunities arise.

Typically, proso millet prices will move upward in the fall as harvest is completed and bird seed companies attempt to fill retail sale commitments in the winter months. Prices tend to be steady through winter and weak at planting time.

Proso millet can be a profitable dryland crop in the region, if producers can achieve yields near 20 cwt per acre and have the marketing discipline to price at profitable market levels. When used in a wheat rotation, proso millet allows the producer to return to winter wheat in the rotation by getting the crop off early in the fall, and gives him or her a crop that can be planted directly into wheat stubble, thus reducing the need for tillage in the system. Proso millet is relatively cheap to produce and there is an extensive market system in western Nebraska, eastern Colorado, and South Dakota to help producers move the crop into market channels.

To prevent grain loss due to shattering, proso is often swathed and placed in a windrow when the top half of the head is ripe. Several days later, a combine with a pick-up attachment is used to harvest the grain.

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Producing and Marketing

PROSO MILLET

in the Great Plains

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