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Producing and Marketing Proso Millet in the High Plains

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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 of the world including China, the former Soviet Union, Afghanistan, Romania, Turkey, and India.

Historically, proso production in the High Plains has been quite variable, depending on the survival of the winter wheat crop, government programs, and market price. United States acreage has averaged 200,000 annually, with 1986 production exceeding one-million, one-hundred weight (cwt). South Dakota and North Dakota were the largest producers of proso from 1970 through 1985. Acreage is still large in these states, but production has become more evenly distributed across Nebraska, Colorado, South Dakota and North Dakota (*Table I*). Most of the additional production occurs in adjacent states.

Table I. 1987 and 1992 dryland production of proso millet in the region (From the U.S. Census of Agriculture, 1992).

	1992	*1987*	*1992*	*1987*
	-----cwt-----		% of U.S. Production	
Colorado	969,000	1,131,000	29.2	27.3
Nebraska	655,000	1,092,000	19.7	26.4
South Dakota	1,204,000	1,019,000	36.4	24.6
North Dakota	399,000	719,000	12.0	17.4
Kansas	49,000	75,000	1.5	1.8
Wyoming	7,000	15,000	0.2	0.3
Total Regional Production	3,283,000	4,051,000	99.2	97.8

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 of the world. The feed value of proso millet for cattle and swine is generally considered to equal that of grain sorghum or milo and corn (when less than 50 percent of the corn in the ration is replaced) (*Table II*).

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

Feed:	*Crude protein (%)*	*Energy*		
		NEM (Mcal)	*NEG* (Mcal)	*TDN* (%)
Corn, dry rolled	10.0	102.0	70.0	90.0
Proso millet	12.9	93.0	64.0	84.0
Sorghum, dry rolled	10.0	93.0	64.0	84.0
Wheat, hard, dry rolled	12.5	99.0	68.0	88.0

For swine and poultry, it should be supplemented with lysine (like most other cereal grains). When feeding proso grain to livestock some processing is necessary, mostly to crack the hard seed coat to allow for better digestion. The economics of raising proso for livestock feed depend on yield levels and production costs relative to other feed grains.

Proso produces enough plant material to be considered a forage crop. It would have to be harvested soon after the seed begins to fill to avoid loss of seed during harvest. Proso has not been used extensively for forage because the pubescence on the stems and leaves causes some irritation to livestock. Also, proso has a lower leaf-to-stem ratio than plants such as foxtail millet, which generally causes it to be of lower quality. Proso usually gives lower forage yield than foxtail millet and, therefore, when forage is desired farmers generally prefer foxtail millet.

Proso's Place in a Crop Rotation

In a crop rotation, proso can be used to gain an extra cash crop every three years in a wheat-fallow rotation. It also can be grown as a cash crop when wheat acres are reduced by government programs to less than one-half the total acres of the farm. Proso can be planted late as a catch crop to replace winter wheat that has been lost due to freezing, wind erosion, drought, or hail. As a rotation crop, proso has the advantage of enhancing weed control, especially with winter annual grasses in winter wheat.

As a dryland crop grown without fallow, proso is a very efficient user of soil water and can produce a grain crop on 13 to 14 inches of annual moisture.

Studies at Akron, Colo., indicated that proso begins producing grain after only 6 inches of total water use, while winter wheat requires 9 to 10 inches of water before initiation of grain production.

Proso has a shallow rooting system. Its rooting depth is generally limited to the upper 2 to 6 inches. It is one of the most efficient crops at removing moisture from the topsoil and converting it to dry matter. Proso requires approximately 270 pounds of water to produce 1 pound of dry matter; wheat requires approximately 530 pounds of water to produce 1 pound of dry matter. Proso is often thought to rely on summer rains and use very little stored subsoil moisture, however, Nebraska research suggests 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, milo, or sunflower.

Proso fits in rotations with row crops and small grains. Deep-rooted crops remove the subsoil moisture, while proso uses topsoil moisture and summer precipitation. Proso can replace summer fallow in a winter wheat-fallow rotation. Continuous cropping provides more surface cover and makes it easier to meet the requirements of conservation compliance.

Studies comparing winter wheat-fallow and winter wheat-proso millet were conducted for five years in west central South Dakota. Winter wheat planted no-till into proso stubble had an average yield 71 percent of winter wheat planted on fallow in the same study. The continuous cropping system required more fertilizer. After five years of continuous cropping, the proso crop developed a green foxtail weed problem. However, there is an economic advantage to replacing summer fallow with proso on a portion of the acres when proso prices exceed $4.00/cwt.

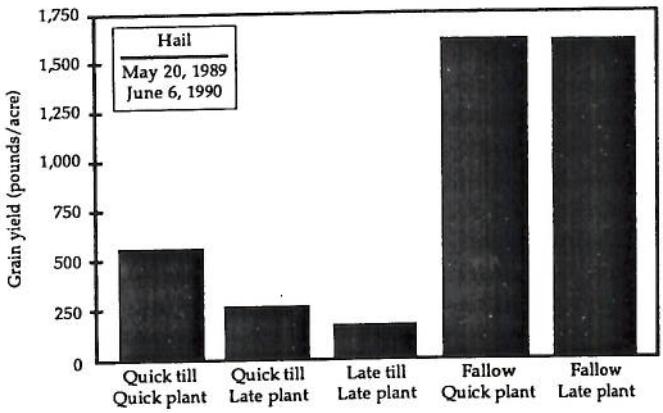
Proso has also worked well after a row crop like corn or sorghum. Proso tolerates atrazine that may remain in the soil after the corn or sorghum crop. The warmer soil temperatures in corn or sorghum stubble fields allow proso to be planted earlier. Proso emergence when planted no-till is better after a row crop than a small grain crop.

Selecting a Field

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

Proso is frequently planted in areas where a severe hail storm has destroyed the wheat crop. These hail storms usually occur after May 15. An attempt is made to plant as soon as the soil is dry enough. Three problems prevail under these circumstances. First, wheat has taken a considerable amount of moisture from the soil profile; second, decaying wheat residue interferes with proso growth; and third, residual herbicide from the wheat crop may persist and injure proso. Generally, in a wheat-fallow rotation it is more desirable to plant proso into fallow intended for wheat planting in the fall and to utilize the hailed wheat land for fall winter wheat planting.

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)*. The increase of more than 1,000 pounds/acre would increase gross returns more than $50/acre using a price of $5.00/cwt. The advantage of using the fallow ground is the soil moisture at planting. The danger with this strategy is that hailed wheat land may not store sufficient moisture to provide successful seeding of winter wheat in the fall.



Quick — Tillage or planting within 14 days of hail.
Late — Tillage or planting approximately 30 days after hail.
Fallow — Planted on adjacent ground

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

Preparing the Field

Proso is usually planted in the spring into wheat stubble that was 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.

If a moldboard plow is used to bury the wheat residue, it must be done early in the spring to allow time for further tillage operations and rainfall to firm the soil. Using the moldboard plow is the most expensive method of preparing a proso seedbed. Plowing also increases the risk of soil erosion from water and wind, but it is the easiest method of limiting weed competition.

Another method of eliminating wheat residue is burning. The burned residue is disked lightly then proso is seeded. Although results are good and the cost considerably less than with plowing, the long-term effects of burning coupled with local burning laws make this an undesirable method of seedbed preparation.

A third method is the stubble-mulch method, which uses implements such as sweep plows, tandem disks, rod weeders, mulch treaders, and field cultivators. The purpose is to reduce surface residue enough to allow conventional planting tools to seed proso, but to leave enough residue on the surface to reduce soil erosion. The stubble-mulch system is a popular method with farmers in this region.

The final method of seedbed preparation is the use of no-till. This was a more viable system prior to 1991, before proso was removed from the atrazine label. Atrazine provided a cheap residual herbicide to control weeds from wheat harvest until proso was well established. Several glyphosate (Roundup®) treatments are now required to control weed growth during this period. A no-till drill can be used to plant proso into wheat stubble, but conventional drills may be modified to handle these conditions. No-till allows the greatest moisture accumulation after wheat harvest and protects the soil from wind and water erosion. Six years of research in western Nebraska show that yields with no-till are similar to yields with moldboard plowing, burning, or stubble mulching; additionally, crusting problems and the need to replant are greatly reduced with no-till.

Fertilization

Although the fertility requirements of proso are not high, it is generally recommended that 40 pounds per acre of nitrogen be applied when proso follows wheat. If a full year of fallow precedes proso, fertilizer is not recommended. This recommendation can be fine-tuned by sampling soil to determine residual nitrogen levels. In-row fertilizer reduces weed competition and gives the best response per unit of fertilizer applied, especially when phosphorus is required. For more information on fertility management of proso, refer to NebGuide G89-924, *Fertilizing Proso and Pearl Millet.*

Choosing a Variety

A wider choice of proso varieties is available today because of the proso breeding efforts in Nebraska. 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. Red-seeded proso has some demand, but probably is best grown away from the usual production areas and with a contract or specific market identified. A yearly update of common varieties can be found in the Nebraska Cooperative Extension Publication, EC 107, *Nebraska Proso and Sunflower Variety Tests.*

Three varieties were released in 1994 and 1995. *Sunrise* is a joint release of the University of Nebraska and USDA. It is a large, white-seeded variety with excellent yield potential. It is intermediate in maturity, has excellent lodging tolerance, and is expected to replace *Sunup* in most growing areas. *Huntsman* is also a joint release of the University of Nebraska and USDA. It is a large, white-seeded variety with excellent yield potential. It is late in maturity, has excellent lodging tolerance, and is expected to replace *Cope* in most growing areas. It is shorter than *Cope.*

Earlybird was released by the University of Nebraska. It is a large, white-seeded variety with excellent yield potential. It is early in maturity, has excellent lodging tolerance, and is expected to replace *Dawn* and *Rise* in most growing areas.

Sunup is a 1989 release from Nebraska. It is a white-seeded variety with excellent yield potential. It's taller than *Rise* but not as tall as *Panhandle.* It is a tight, panicle-type variety similar to *Dawn* and *Rise. Sunup* is as lodging resistant as *Dawn* and *Rise* and is larger seeded than *Rise.* It is less susceptible to seed shattering than the common proso varieties. *Sunup* has replaced *Rise* as the most commonly grown variety in Nebraska. The newer releases are all larger-seeded and have a similar panicle type.

Several other distinct types of proso are available. *Panhandle* from Nebraska, *Minco* from Minnesota, and *Abarr* from Colorado are all similar to the original common white. Although these varieties differ slightly in height, yielding ability, and maturity, they have white seed and are readily marketed through normal channels in the proso growing areas. They all have fairly open panicles and suffer from lodging and seed shattering.

A second type with acceptable white seed is *Minsum,* which was developed in Minnesota as an early maturing variety with a very loose panicle type. Colorado developed a tall, late maturing variety, *Cope,* which has acceptable white seed. Due to its maturity, *Cope* is likely best adapted to Colorado conditions.

Nebraska released *Dawn,* a very short, very early variety with a tight panicle. It has a superior white grain, but is inferior agronomically because of its height. *Dawn* should not be planted in no-till wheat stubble. A similar variety, *Rise,* is taller, better yielding, and has smaller white seed. Both varieties have been lower yielding than *Sunup.*

If red seed is desired, the two choices are *Cerise,* an early maturing variety from Nebraska, or *Red Leonard,* a tall, late maturing variety from Colorado. *Red Leonard* has superior yield if planted early. Both have smaller seed size and are less acceptable as a

feed due to a higher tannin content. Bird seed manufacturers use small amounts of red proso to improve eye appeal of the final product.

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, the *Colorado Certified Seed Directory*, published by the Colorado Seed Growers' Association, and the *South Dakota Certified Seed Grower Directory*. They are available from local agricultural extension educators. Similar publications are available in other states.

Planting the Crop

The goal of the planting operation is to place the proper amount of seed into a moist, firm seedbed at the proper time so the proso can produce seed and have the greatest competitive advantage over weeds. Usually not all these goals can be met and the least damaging compromises must be made.

The best planting date for proso can vary greatly with circumstances. For example, the optimum planting date for proso differs between a tilled and a no-till seedbed. If the seedbed has been tilled and little residue remains on the soil surface, proso will yield highest when planted in May. If planted into a no-till seedbed, optimum yield occurs by planting approximately two weeks later. This different response to planting date is related to crop residue's retarding of soil warming in the spring.

For both seedbed types, 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 decreases 20 percent if it is 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

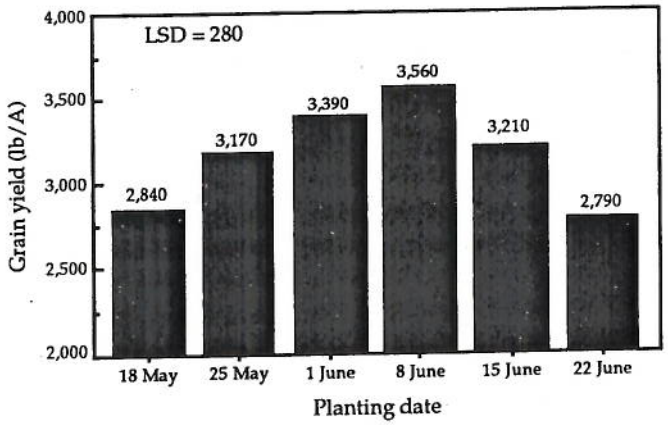


Figure 2. Proso grain yield in a no-till seedbed as affected by planting date. Data collected over three yers in northeastern Colorado.

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, higher rates are used to avoid the necessity of reseeding after a heavy rainstorm. Recommended rates can be as low as 8 pounds per acre, but rates of 20 pounds per acre are more common. A rate of 12 pounds per acre would be very 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 is not the most desirable type since it is difficult to maintain a shallow depth with it. When a hoe drill is used, the rate is set high (20 lb/acre) and the depth is quite shallow. The packer wheels can be very beneficial if planting into a loose seedbed, but that combination is most susceptible to crusting from a heavy rainstorm.

The most desirable drill for planting proso where stubble is not a problem is a double-disk drill. It can place the seed into a shallow slot and firm 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. Regardless of the type of equipment used, it is necessary to have the seed firmly packed and covered with 1/2- to 3/4-inch of soil. Nebraska studies showed that choice of drills did not greatly affect yield if a good job of seeding was accomplished. They found that drills with narrow row spacings gave a yield advantage over wider row spacings.

Emergence Problems

One of the most critical periods when growing proso is the two weeks after planting. During this period, a light rain can be helpful while a heavy rain can be destructive. The effects of a superior drill become most apparent at this time. A seedbed that is firmly packed around the seed encourages germination even when conditions appear quite dry. It also prevents burying the seed too deep with a heavy rain 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 and consideration should be given to replanting, especially if it is 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, a problem of poor secondary root development is sometimes observed. This usually occurs later than two weeks after planting. 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. The only cure for this condition is a rain shower which 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 (Banvel®) to plants with poor secondary root development. These herbicides may cause lodging and delay brace root development.

Growth Rate

Proso development can be related to temperature by using growing degree days (GDD). This temperature unit is 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.

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 *Cope* proso begins tillering 430 GDD after planting and initiates heading and flowering after approximately 750 and 1,100 GDD have accumulated. This development-temperature relationship has been consistent for proso when planted over a range of planting dates. However, some varieties may respond more to day length than *Cope*, as they are more photoperiod-sensitive.

Combating Weeds

Weeds can be a serious problem in proso. 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 requires some special management decisions. The two necessary ingredients for successful proso production without herbicides are to have the field weed-free by tillage just prior to planting and to plant late in the season (typically after June 10) into a warm, moist seedbed to encourage rapid growth. The later planting date may reduce yields but will require less cash outlay for herbicides. A seeding rate of 15 to 20 pounds per acre will provide more effective competition with weeds.

Strategy two 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 such broadleaf weeds as redroot pigweed and lambsquarters can be killed later. If these weeds are not present when proso reaches the five-leaf stage, spraying will not be necessary. Currently, only 2,4-D amine (Formula 40®) and Banvel are labeled for use in proso. Banvel has a 24c (Special Local Need) registration in Colorado, Nebraska, South Dakota, and Wyoming. Most small broadleaf weeds can be controlled with 1/2 pound per acre 2,4-D amine (16 ounces of 4EC) applied when proso plants have two to five leaves present. If more difficult-to-control weeds such as kochia, knotweed, or wild buckwheat are present, the best herbicide treatment for postemergence weed control is a combination of 1/8 pound per acre Banvel (4 ounces of 4EC) and 3/8 pound per acre 2,4-D amine (12 ounces of 4EC). The risk of crop injury does increase slightly with the use of Banvel. Banvel should not be used when susceptible crops are within 1/2 mile of the application site.

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

Atrazine is no longer labeled for use with proso. Using atrazine with proso places the producer and crop in jeopardy with the law. It is also illegal to plant proso in fields that were treated with atrazine after June 10 of the previous year. The loss of atrazine labeling in proso has increased management demands and the cost of proso production.

Prosulfuron (Peak®) is a sulfonylurea herbicide that is being considered for use in proso millet. If federal labeling is obtained, *Peak* plus 2,4-D amine will provide excellent early postemergence control of broadleaf weeds with the added benefit of supplying some residual control of later emerging broadleaf weeds.

Insect and Disease Problems

Proso millet is seldom seriously affected by insects. The most common insect problem in proso millet occurs when thrips or spider mites (Bank's grass mite) move off maturing wheat in June and damage proso seedlings. This problem can be severe under very dry conditions when the thrips or mite

populations increase in wheat and the proso is growing at a slower rate. A good rain will solve both the insect problem and allow the millet to out grow the damage. Prolonged damage to young seedlings coupled with severe moisture stress can result in stand reductions. Grasshoppers can also become a serious problem in proso millet. The heaviest damage from grasshoppers occurs if the grasshoppers move from maturing or recently harvested wheat into the green proso fields.

Some stem-boring insects can damage proso millet. If proso is adjacent to corn, populations of European corn borer can become established in the proso millet. Also, the wheat stem maggot can sometimes be found within the proso millet stem. These insects bore into the stem 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. Proso is not a host for the wheat curl mite or Russian wheat aphid, so it is one of the few crops that is safe to have growing when planting wheat. Chinch bugs can be a serious pest of proso but do not pose a problem in current production areas.

One of the few diseases found on proso is head smut, *Sphacelotheca destruens*. Nebraska researchers have found that seed treatment is a good way to prevent head smut.

Harvesting Proso

Since proso shatters easily when ripe, it is quite risky to allow the grain to completely mature and dry while standing. *Dawn* was the first variety of proso that showed some promise of being harvested by direct combine, although there is a great risk in allowing it to reach safe storage moisture while standing. A small wind will cause considerable shattering. Therefore, it is recommended that swathing 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 when it is starchy in the center. Threshing can then be delayed until the grain is below 13 percent moisture. Attaining a 13 percent moisture level can be a challenge during some years since humidity is high, dew frequent, and temperatures lower during September.

Proper setting of the combine is important for proso harvest. Cylinder speed should be about 20 percent slower than for wheat harvest or about 850 rpm. The biggest problem in marketing proso is when the hulls have been removed and only the yellow-colored inner berry is left. A good rule of thumb is to leave as many of the loose outer glumes on as there are hulls removed.

Marketing Proso

The bulk of proso sold in the cash trade is marketed through elevators in the 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, such as mushroom production. Proso is the only millet of quantity involved in world trade.

Proso prices have historically been higher than corn or sorghum *(Figure 3)*, but this varies dramatically from season to season. When the premium human food and bird seed markets are saturated, the price quickly drops to feed grain values. Proso prices have ranged from $2.50 to $22 per cwt over a 5-year period. In a period of increased acreage, more grain is produced than the markets can absorb. This excess also includes grain produced outside the traditional marketing area.

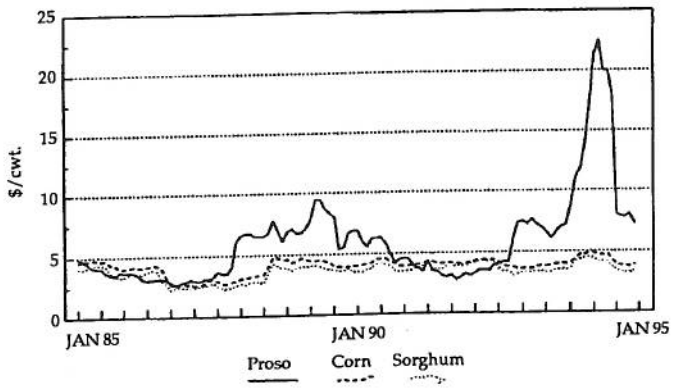


Figure 3. Panhandle proso and Nebraska corn and sorghum prices.

Using monthly price indexes, prices tend to peak in December and again in April *(Figure 4)*. The average price index for a month shows the average relationship of prices in that month to the average for all months in the year. For example, a monthly price index of 1.00, or 100 percent, means that the average price for the month was equal to the average for the year. A 0.90 index indicates the monthly average price was 90 percent of the yearly average price; an index of 1.1 means the monthly average price was 110 percent of the yearly average price. Using price indexes can be useful in estimating future monthly prices, but should not be used alone, i.e. without regard to price trends.

$$\frac{\text{Index of future month} \times \text{Price current month}}{\text{Index of current month}} = \text{Estimated price in future month}$$

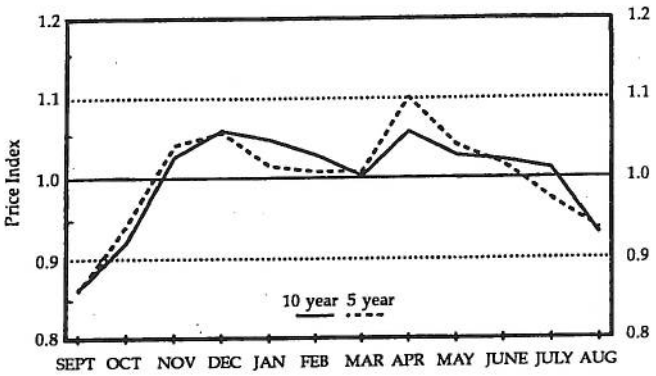


Figure 4. Seasonal proso price indexes in western Nebraska elevators.

The best approach to pricing proso millet is to calculate production costs and seek price protection, i.e. 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. This, coupled with extreme price volatility, makes marketing a challenge. Due to price volatility, storage is often used to take advantage of seasonal price patterns. Storage requires management to be disciplined and that price targets be set.

The 1994 University of Nebraska cost-of-production calculations for proso millet are briefly listed below on a per-acre basis. Using 20 cwt as an average yield results in production costs of $7.39 per cwt. These cost-of-production estimates should be used as a guide only. Producers should calculate their own costs and price portions or all of their production to meet management objectives.

		Per Acre
Assumed Yield		20 cwt
Assumed Land Cost		$350
Assumed Machinery Investment		$220.32
	Per Acre	**Price Targets per CWT**
Operating Costs	$ 43.38	
Machinery Interest	$ 15.20	
RE Taxes	$ 14.40	
	$ 72.98	$ 3.65
Machinery Depreciation	$ 26.98	
Land Interest	$ 40.60	
	$ 67.58	140.56/20= $ 7.03
Overhead	$ 2.17	
Unpaid Management	$ 5.00	147.73/20= $ 7.39
Profits	$ 7.39	
	$ 14.56	
Total	$155.12	$ 7.76

Other Proso Millet Literature

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How to Produce Proso Millet (A Farmer's Guide). 1990. Gary W. Wietgrefe.

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