Pearl Millet for Grain

Cooperative Extension Service
The University of Georgia
College of Agricultural and Environmental Sciences

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Cover - TifGrain 102 pearl millet in the grain filling stage.

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Introduction

Pearl millet (*Pennisetum glaucum* [L.] R. Br.) has a long history of use as a summer grazing and hay crop in the southeastern United States. The recent development of new, adaptable and productive grain pearl millet hybrids in the Southeast gives crop producers a suitable alternative feed grain for dryland production.

Pearl millet is one of the most drought resistant grains in commercial production. It is able to grow in areas that experience frequent periods of dry weather during either the vegetative or reproductive phases.

Pearl millet appears to be more tolerant of sandy and acidic soils than other summer grain crops. It is deep-rooted and can use residual nitrogen, phosphorus and potassium and, therefore, may not need the levels of fertility required by other summer grains. These characteristics enhance pearl millet's desirability in lower input, dryland production systems.

On-farm demonstrations and research have shown that pearl millet can reliably produce yields of 70 or more bushels of grain per acre with careful management. Severe drought reduces the yields of pearl millet; however, the plant is capable of withstanding periods of drought that would cause greater yield reductions or crop failure in other summer grain crops. It is well suited for double cropping behind small grains and vegetables.

The grain can be used in poultry, cattle and swine rations without adversely affecting feed efficiency or weight gain. Total metabolizable energy of pearl millet is similar to corn. Crude protein levels in pearl millet range from 12 to 14 percent.

Growth Habits and Requirements

Pearl millet is a summer annual crop well-suited for double cropping and rotations.

It germinates well at soil temperatures of 75 to 90 ^{o}F. Emergence occurs in two to four days under favorable conditions. Seedling development occurs during the first two to four weeks, and rapid stalk development occurs soon after. Tillering may be extensive in sparse stands, particularly if good soil moisture is available. Flowering usually begins at 40 to 50 days after emergence, and the plant reaches physiological maturity by 75 to 85 days after emergence.

Growth and maturation are usually hastened with late plantings.

Pearl millet can be grown on a wide variety of soils ranging from clay loams to deep sands. Yields and grain quality, however, are best on deep, well-drained productive soils. Soil management and tillage that encourages deep rooting generally enhance yields and seed quality. Do not grow millet on soils prone to "water logging" in wet seasons. Doing so will cause shallow rooting, low seed protein and poor yields.

Irrigation can improve stand establishment if soil is dry during and after seeding. Little is known about pearl millet response to irrigation during growth. It appears that pearl millet responds less to irrigation than other grain crops. Greatest water use occurs during the bloom and soft dough stages. A very deep root system and less defined "critical water use period" makes pearl millet tolerant of short duration drought.

Recommended Cultural Practices

Varieties: A new hybrid, TifGrain 102 has been cooperatively developed and released by the USDA-ARS and the University of Georgia at Tifton. Seed harvested from a hybrid will not produce a uniform or productive crop the following year. Therefore, new seed will have to be purchased annually to obtain high yields associated with hybrid vigor. Other hybrids suitable for grain production in the southeastern U.S. continue to be developed. Hybrids developed for use in other regions have not been evaluated in the southeast, so their performance is not known.

Several forage pearl millet hybrids are available for purchase. Most, however, will not develop grain. Be sure to plant only those hybrids developed for grain production if your intention is to produce a grain crop.

Planting Date: Do not begin early plantings until soil temperatures at the 2-inch depth are at least 70 ^{o}F. Planting in cooler soils will result in problems with reduced emergence and greater competition from weeds.

For economical grain production, pearl millet can be planted in the Piedmont area from May 1 to July 15. In the Coastal Plain, planting can be extended to August 10 under ideal conditions. We have observed better performance at the earlier planting dates, which often avoid the lengthy summer droughts that can occur in Georgia. Plantings for wildlife can be established until the end of August in the Coastal Plain areas.

Seed Bed Preparation: Optimum stand establishment is obtained when a weed-free, firm seedbed is prepared. Prepare the soil and seedbed similar to that for other summer crops. Deep till or in-row subsoil sandy textured soils to disrupt any hard pans. No-till or conservation-tillage plantings can be successful and are desirable on highly erodible land or clayey soils. This will reduce soil erosion and enhance stand establishment due to better seed depth control in firmer soils. Control emerged weeds prior to planting. If no-tilling in the spring, deep tillage ahead of the winter cover crop in the fall is preferred. However, reconstitution of the hardpan in sandy

soils can occur, particularly if good rainfall occurs during the winter.

Seeding Rates: Use precision planters or grain drills capable of planting 2 to 5 pounds of seed/acre (Table 1). Pearl millet tillers profusely and can make up for large skips within the rows without suffering severe yield losses. A plant every 3 to 4 inches can give excellent yield results with good management practices. While it is difficult to obtain low seeding rates, seeding rates of 4 to 5 lbs/ acre don't appear to be detrimental to yield. Populations of 150,000 to 200,000 plants per acre are more than sufficient for good grain yields. Any planter and plates that place seed 1 to 2 inches apart, such as air or vacuum planters, should provide good results.

Table 1. Recommended seeding rates for different row spacings.

Row width (inches)	Seed/foot of row	Seed/acre (lbs)
30	9 to 10	2.6
24	8 to 9	3.0
18	6 to 7	3.0
14	5 to 6	3.1

Row Spacings: Row spacing can vary from 14 to 30 inches. We have found more consistent yield, grain protein content and reduced damage from chinch bug at a 21 inch row spacing.

Row spacings of 30 inches or less have been used in research and commercial production and are suitable for cultivation and production (Table 2). Depending on the year, good yields have been obtained in rows 14-21 inches wide. Narrow rows enhance weed control due to shading accomplished by canopy closure (Figure 1).

Figure 1. A closed canopy from proper row spacing provides weed control and results in higher yield.

Seeding Depth: Pearl millet should be seeded ½ inch to ¾ inch deep. It is a small seed (40,000 to 70,000 per pound) and it does not have the energy to emerge when planted deeper. Firm soil on top of seed.

Fertility: Fertilizer requirements for pearl millet are similar to those for grain sorghum. Apply 80 to 100 pounds of nitrogen per acre in soils with a clay pan (Table 2). In deep soils, pearl millet can respond to applications of 100 to 140 pounds of nitrogen per acre. Apply 1/3 fertilizer at planting, and the remaining 2/3 about 3 to 4 weeks after planting. Apply potassium, phosphorus and magnesium according to soil tests as recommended for grain

Table 2. Yield (bu/acre) of TifGrain 102 pearl millet in response to row spacing, nitrogen application, and planting date at Tifton, GA.

		2001			2002
Row spacing	April 12	May 31	June 28		8 planting dates
(inches)					
14	83	81	63		63
21	87	75	65		62
36	69	73	52		54
lsd(0.05)	12	10	13		4
Nitrogen	April 12	May 31	June 28		8 planting dates
(lbs/acre)					
75	84	73	58		60
125	73	82	57		60
lsd (0.05)	8	7	9		3

Figure 2. Poor control of weeds, particularly crabgrass (top) and Texas panicum (bottom) will result in severe yield loss and increased chinch bug infestations.

sorghum. It may be necessary to add 10 to 15 pounds of sulfur per acre to avoid deficiencies, particularly in Coastal Plain soils. Because pearl millet can grow well at a lower soil pH than other grain crops, base liming requirements on the needs of the succeeding crops (5.8-6.5).

Pest Control

Grain pearl millet is not difficult to grow, but you will be more successful if you are aware of some problems that can occur and pay attention to a few basic details.

Weeds: Good weed control is necessary for a successful crop, and it is particularly important to control early emerging weeds. It may be beneficial to plan your rotations so that pearl millet follows a crop in which grass-controlling herbicides were used. Grass weeds such as crabgrass and Texas panicum are the most difficult to control (Figure 2).

Good results have been obtained by planting in stale seed bed, or into rye stubble. When planting into stale seed beds, prepare the soil two to three

weeks ahead of planting. Allow weeds to emerge and broadcast a burn-down herbicide such as paraquat or glyphosate. Plant pearl millet by no-tilling into the stale seed bed or rye stubble without further disturbing the soil.

The herbicide 2,4-D should be applied to emerged broadleaf weeds at 3 to 4 weeks after emergence or when the crop is 8 to 12 inches tall. The broadcast rate for 2,4-D is 1 pint per acre of a 4-pound formulation or 0.5 pounds per acre active ingredient. Apply to emerged broadleaf weeds when crop is 8 to 12 inches tall. The herbicide 2,4-D and cultivation are the best options for controlling most weeds in pearl millet. While other chemicals such as atrazine provide excellent control without injury, they are not labeled for use on the crop, and thus applications would be illegal. Pearl millet has shown sensitivity to many of the herbicides used on other grass crops. If early season weed control is sufficient, good stands and proper row spacing make pearl millet highly competitive with late emerging weeds.

Figure 3. Chinch bug nymphs and adults. Chinch bug is the predominant insect pest of pearl millet and must be controlled to prevent crop failures.

Insects: *Chinch bug* is the main insect pest of grain millet, and control is vital to a successful crop. They are a particular problem in hot, dry weather, and in fields with a heavy infestation of either crabgrass or Texas panicum.

Chinch bugs can damage pearl millet anytime from the seedling stage to the soft dough stage. Damaged plants can have a drought-stressed appearance, and generalized death of lower leaves. Early infestations can cause severe stand loss. Heavy infestations can also wither and kill plants from before flowering through grain filling. Identifying a problem early will prevent losses.

Chinch bugs have different stages (nymphs and adults) that differ in color, size, and appearance (Figure 3). They can be difficult to spot. Look for chinch bugs at the lower stems, between the stem and leaves. If disturbed by slapping the base of the plants, chinch bugs are often dislodged and can often be seen on the ground around the base of the plants.

Figure 4. Green stink bugs and other similar insects affect pearl millet during grain fill.

Inspect fields every 5 to 7 days until heading. Because of the damage chinch bugs cause, preventative applications of "Mustang" insecticide should be made 14 to 21 days after seedling emergence to control early infestations in dry weather. Sprays must penetrate the canopy to effectively control chinch bug, and canopy closure by 30 days after planting limits the effectiveness of later applications. Application after heading is ineffective. Consult your county agent or the Georgia Pest Control Handbook for current recommendations for insecticides and application rates.

Stink bugs and other insects may require control on developing grain heads. These insects are most active when pearl millet is planted from July 1 to August 1. Stink bug (Figure 4) feeding causes small and shriveled seed. Corn earworms, webworms, and fall armyworms can also destroy and damage seed. Economic yield loss may occur when 15% or more of the grain heads are infested. These insects are best controlled by a single insecticide application at 50% pollen shed. Consult your county extension agent for currently labeled insecticides and rates.

Nematodes: Pearl millet hybrids differ in their resistance to nematodes. Because TifGrain 102 has good resistance to both the peanut and southern root-knot nematodes, and to the sting nematode, it can be used in rotations without causing nematode problems in subsequent crops such as peanut and cotton.

Diseases: *Rust* can be a major problem of pearl millet (Figure 5). Planting before the end of June should minimize yield and grain quality losses to rust. TifGrain 102 has shown good resistance to rust, but consult your seedsmen for current hybrid characteristics.

Figure 5. Rust is a late-season disease. Early planting will allow the crop to mature before disease develops.

Figure 6. Pyricularia leaf spot and other leaf spots will cause only minimal damage.

Figure 7. Pre-harvest grain molds will be more severe when weather is wet or humid.

Pyricularia leaf spot (Figure 6) and other leaf diseases are frequently observed with warm temperatures and wet foliage. Grain yield losses are minimal with the level of resistance exhibited by TifGrain 102.

Grain molds will develop when grain fill and maturation occurs in wet or humid conditions (Figure 7). Grain should be harvested as early as possible after maturity since some grain molds will increase if harvest is delayed. Grain molds may reduce the quality of the grain, but it does not appear that aflatoxins or fumonisins will be a problem in pearl millet production.

Bird Damage: Birds readily consume pearl millet seed off of the plants in the field. Losses can be severe in small fields or when harvest is delayed for an extended period after maturity. Some losses can be avoided by planting in May so fields can be harvested before migratory birds pass through in September and October. **Crop Monitoring and Timely Harvest Are Essential to Minimize Bird Damage.**

Harvesting and Handling

Grain can be harvested as early as 40 days after flowering. Harvesting can begin when seed moisture content drops below 15% but artificial drying to 10-12% moisture after harvest is needed to prevent storage molds. A desiccant can be used to dry the stems and leaves prior to harvest to improve harvesting efficiency.

Pearl millet grain does not separate easily from the seed head so careful adjustments in the combine are necessary to get efficient harvest. Poorly adjusted combines will result in significant losses of grain. Proper combining will take some experimentation.

Figure 8. Pearl millet has small seeds, so proper drying before storage will help to maintain the high quality of the grain.

The height of the cutting bar should be set just below the height of the heads. Take as little leaf and stem as possible.

Good results have been obtained by the following settings in a dry crop: Cylinder speed should be set at 700 rpm. Set concave at 5/16 inch. Set chaffer at 1/2 inch and sieve at 3/16 inch. Set cleaning fan speed to 700 rpm to remove as much debris as possible.

Changes in seed moisture occur through the day and will affect the effectiveness of the combining operation. Keep checking the sample throughout the day to determine if adjustments in settings are needed.

Properly dried grain will store well, but mold will develop on grain that has not been dried. Drying after harvest may be difficult because of the small seed size (Figure 8). You can get good results by lining peanut wagons with fine-mesh screens and blowing warm air through the grain (stacked no deeper than 3 feet)

Drying grain requires air temperatures of 110 to 120 ^{o}F at 40 cfm. Grain at 3 ft depth has approximately 2 ½ to 3 inches static pressure. It is important to determine if drying facilities have the capacity to dry grain in a timely manner due to small grain size and pore spacing. Grain can be held at 12% moisture in north Georgia, but requires 11% moisture for storage in southern Georgia.

Marketing and Economics

Pearl millet is a relatively new grain crop in Georgia, therefore no readily-available markets have been established. Although the grain is well-suited for both human and animal consumption, producers should secure a market prior to planting.

Currently, markets are being tested to incorporate the grain in poultry rations. As a feed grain, pearl millet is most desirable for poultry production. Pearl millet is an excellent source of amino acids and protein for poultry. It can be fed whole or ground to poultry, but requires milling prior to being fed to cattle or swine.

Pearl millet is an excellent crop for wildlife plantings and attracts quail, doves, and songbirds.

In other countries, pearl millet is milled both dry and wet and consumed as a food grain. Because the grain is gluten-free, marketing opportunities may exist in health-food outlets in the U.S.

Since a market has not been fully established for millet, prices received for the product can vary according to the value to the user.

An example of a production budget has been prepared for your convenience (Table 3). Compare the costs provided in the budget with those on your farm to help determine the price needed to grow pearl millet profitably.

Check with your local county agent to see if any additional information is available on markets as they develop in Georgia.

Table 3. Total cost budget analysis for grain pearl millet production.

Variable Costs			Unit	Units per Acre estimated	Total Units actual used	Unit Price ($/unit)	Your Cost
	Seed		lb	4	4	$3.00	$12.00
	Lime		ton	0.25	0.25	$24.00	$6.00
	Fertilizer						
		Nitrogen	lb	100	100	$0.24	$24.00
		Phosphate	lb	20	20	$0.20	$4.00
		Potash	lb	20	20	$0.13	$2.60
	Herbicide		acre	1	1	$7.50	$7.50
	Insecticide		acre	1	1	$15.00	$15.00
	Machinery - Preharvest						
		Fuel	gal	5	5	$0.85	$4.25
		Repairs & maintenance	acre	1	1	$11.00	$11.00
	Machinery - Harvest						
		Fuel	gal	3	3	$0.85	$2.55
		Repairs & maintenance	acre	1	1	$12.00	$12.00
	Land rent		acre	1	1	$15.00	$15.00
	Labor		hrs	3	3	$7.50	$22.50
	Other		$			0	$0.00
	Interest on capital		%/6 mos		$138.40	9.00%	$6.23
	Drying percentage required=	8%	bu	69.6	69.6	$0.20	$13.91
Total Variable Costs							$158.54
Fixed Costs							
	Preharvest machinery		acre	1	1	$15.20	$15.20
	Harvest machinery		acre	1	1	$25.90	$25.90
	Overhead		$	1	$199.64	5.00%	$9.98
	Management		$	1	$199.64	5.00%	$9.98
	Land		$	1	1	0	$0.00
Total Fixed Costs							$61.06
Total Costs							$219.60
Expected Yield			lb/acre =	4000		bu/acre =	69.6
Variable cost per lb =				$0.04		bushel =	$2.28
Fixed cost per lb =				$0.02		bushel =	$0.88
Total costs			lb =	$0.05		bushel =	$3.16

The cost budget analysis assumes double-cropped land. Production estimates are based on 57.5 lbs/bu. Your actual costs are likely to differ from the presented values.

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