4 - Fertilization and Liming

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In Arkansas, grain sorghum is traditionally grown in the less productive soils and often under dryland conditions, resulting in yields below the potential of the crop. Plants develop an aggressive root system that increases the ability of this crop to mine the soil for nutrients and water. Grain sorghum performs better than most crops under limiting conditions, but considerably higher yields are obtained if grown under optimum water and nutrient conditions.

Soil pH

Nutrient Availability

Grain sorghum grows best at soil pH values between 6 and 7.5, since this is the pH range at which most nutrients are more easily accessible to plant roots. Aluminum and/or manganese toxicity may become a problem in more acid soils (pH below 5.5), while phosphorus and/or magnesium may be deficient at this same pH.

Certain micronutrients may become limited in many alkaline soils (pH above 7.5), but deficiencies are seldom seen in grain sorghum fields in Arkansas. With the exception of molybdenum, the micronutrients become less available for plant uptake as the soil becomes more alkaline (pH above 7.5). However, most grain sorghum varieties grown in the state are fairly tolerant of alkaline soils on which they are grown. Iron and/or zinc deficiency, a common problem in highly alkaline soils of Texas and other western states, is seldom a problem in grain sorghum fields in Arkansas.

They are called micronutrients because they are used in small amounts compared to the macronutrients (see insert). For instance, while a good sorghum crop may use 150 pounds of nitrogen per acre, it may use only 0.5 pound per acre of zinc, copper and manganese. However, micronutrient deficient conditions may reduce expected yields considerably if not corrected.

Macronutrients
Nitrogen
Phosphorus
Potassium

Secondary Nutrients
Calcium
Magnesium
Sulfur

Micronutrients

Iron	Copper
Zinc	Molybdenum
Manganese	Cobalt
Boron	Chlorine

The secondary elements – calcium, magnesium, and sulfur – are generally considered adequate in soils unless plant and soil tests indicate otherwise. The University of Arkansas soil testing lab routinely tests for calcium, magnesium and "available" sulfur. Soil test calcium and magnesium levels are usually adequate, as long as lime needs are met.

Most sulfur in soils is in unavailable forms, associated with organic matter and clay. Sulfur, in the sulfate form, becomes available in small amounts at various times throughout the year. Sulfate-sulfur may be either taken up by growing plants or leached downward by water movement. For this reason, sulfates usually accumulate in subsoils that contain more clay than the topsoils. Therefore, soil tests for S are difficult to interpret unless the subsoil is also tested. Leaf analysis is useful in evaluating the S status of a plant during the growing season. Plants may have low levels of S early in the growing season, but as the plant roots extend into the S-rich subsoil, or as S is released from organic matter, S levels in plants increase.

Lime Recommendations

Lime applications should be based on soil tests. The University of Arkansas recommends lime when the soil pH is below 5.7, except where rice is in the rotation (Table 4-1). Recommended rates range from 1 to 3 tons per acre. If rice is not in the rotation, lime rates are based on soil pH and calcium content (Table 4-2). The more acid and the heavier the soil, the higher the rate of lime recommended. Continued cultivation, and the use of chemical fertilizers, especially those containing ammonium and sulfur, tends to decrease soil pH over time. Irrigation with water high in calcium carbonate will increase soil pH.

Table 4-1. Lime Recommendations for Grain Sorghum When Rice Is in the Rotation.

Soil pH	Lime (tons/acre)
Above 5.5	0
5.3 – 5.5	1
5.0 – 5.2	1.5
Below 5.0	2.5

Dolomitic lime (red lime) is the preferred source where soil test magnesium levels are below 75 pounds per acre. This usually occurs on the well- to excessively-drained acid soils away from the major rivers. If lime is needed, it is better to apply it during the fall to allow it enough time to react with the soil. Liming materials may have different Relative Neutralizing Values (RNV). The RNV of a material is based on its fineness and Calcium Carbonate Equivalent (CEC), with finer materials reacting quicker than coarse materials. An Ag lime with a CCE of 110 is “stronger” than an Ag lime with a CCE of 90, consequently less volume would be needed to increase the pH of a given soil.

Pelletized lime is sold in Arkansas at a considerably higher price than bulk agricultural lime. This material is produced from the finest lime particles, which are then bonded together with lignosulfonates (among several products) during the pelletizing process. The amount of pelletized lime to use should be between 60 to 75 percent of the amount of regular agricultural lime, depending on the source of the material. For instance, if the recommendation calls for 1 ton (2,000 pounds) of lime, only 1,200 to 1,500 pounds of pelletized lime would be required to raise the pH to the desired level.

On sandy or silt loam soils, where rice is in rotation and well water is used for irrigation, lime is recommended only after intensive soil and water testing. Separate soil samples should be collected near the water inlet, near the water outlet and also from the middle of the field. Water quality should also be determined. Apply lime based on Table 4-1 for the water outlet area regardless of the water’s calcium or bicarbonate content. If the water tests below 3 milliequivalents of calcium per liter, then the inlet area should also be limed according to Table 4-1.

These recommendations are designed to avoid zinc deficiency of the succeeding rice crop. Lime should be applied as far in advance of the grain sorghum as possible but not just before rice. About six months is needed for the applied lime to become completely effective.

Collecting soil samples in grids, for lime recommendations, may result in significant savings for producers. In some fields, the variability of soil pH is so high that savings in the range of 30 to 50 percent of the recommended lime have been achieved.

Table 4-2. Lime Recommendations for Grain Sorghum When Rice Is Not in the Rotation.

Soil pH	Soil Test Calcium (Lb/A by Mehlich 3 Extraction)			
	Below 1000	1000 - 3000	3000 - 4500	Above 4500
	------------ Tons/A ------------			
Above 5.7	0	0	0	0
5.2 – 5.7	1	1.5	2	2.5
5.0 – 5.2	1.5	2	2.5	3
Below 5.0	2	2.5	3	3

Fertilizer Recommendations

Nitrogen Rates and Sources

Nitrogen is probably the most limiting nutrient in grain sorghum production in Arkansas, with nearly 50 percent of the nitrogen removed with the grain, in contrast to 67 percent and 17 percent for phosphate and potash, respectively (Table 4-3). Total recommended N rates range from 60 pounds per acre for nonirrigated grain sorghum double-cropped after small grain to 150 pounds per acre for irrigated grain sorghum where yields are expected to exceed 6,000 pounds per acre. The normal recommendation for irrigated grain sorghum is 120 pounds per acre, compared to 100 pounds for nonirrigated (Table 4-4). A rough rule of thumb is that, based on the yield level, 2 pounds of actual nitrogen (N) are required for each 100 pounds of grain produced.

Figure 4-1 shows the typical nitrogen uptake pattern for a grain sorghum plant. It appears that the plant does not use much N during the first 20 days, but by the time the plant is 60 days old, it has used close to 60 percent of the total N. Consequently, a third to one-half of the total N is usually applied preplant. The remainder should be sidedressed by the sixth-leaf stage. An exception to this is where the entire recommended N is applied preplant as anhydrous ammonia, or for nonirrigated grain sorghum following small grain.

The remaining N not applied preplant should be sidedressed by the sixth-leaf stage. Some producers choose a three-way split, with a portion of the N (normally 100 pounds urea) being applied at the boot stage, making sure the fertilizer is applied after the dew has evaporated to avoid significant leaf burning. Fertilizer burn is more likely if liquid N is used when air temperature exceeds 80 degrees. Ground application equipment can be used for topdressing until the plants get so tall that stalk breakage is a problem. Small amounts of N may also be applied by overhead sprinkler irrigation systems.

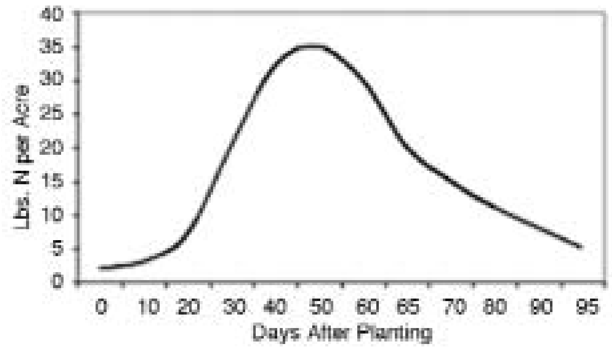

Figure 4-1. Typical nitrogen uptake pattern of a grain sorghum plant.

Animal manures, particularly poultry litter, may be used as supplements to commercial fertilizer. Rates should be based on soil test results and the nutrient content of the manure, keeping in mind that not all of the nitrogen in the manure becomes plant available the first year, and that applying manure based on N requirements may supply P in excess of plant needs. Where higher rates of animal manures are used, plant analysis should be used to monitor N needs for possible adjustments during the growing season.

Table 4-3. Nutrients Removed in a 100 bu/A Grain Sorghum Crop.

	N Lb/A	% of Total	P_2O_5 Lb/A	% of Total	K_2O Lb/A	% of Total
Grain	84	47	42	67	22	17
Stover	95	53	20	33	107	83

Table 4-4. Recommended N Rates for Grain Sorghum Based on Yield and Irrigation System.

	Irrigated		Nonirrigated	
	---------------------- Yield (lbs/A) ------------------			
	< 6000	> 6000	< 5000	> 5000
Single crop	120	150	100	130
Double crop after small grain	100	130	60	90

Common N sources include urea, ammonium sulfate, ammonium nitrate, liquid N and, to a minimum extent, anhydrous ammonia. Ammonium sulfate also supplies sulfur. All sources of N are effective if applied properly (Table 4-5).

Preplant Fertilizer

Starter applications can be of benefit, especially with grain sorghum seeds being small and lacking all the nutritional reserves of other crops such as corn. Liquid as well as dry N and P sources are available. Starter fertilizers can be applied by band application of either solid or liquid sources. An example of a solid material is 18-46-0, while a common liquid source is 10-34-0. One hundred pounds of these materials banded near the seed serves as a "pop-up" source of P. Another approach is to broadcast the recommended preplant N-P-K fertilizer and then "hip up" the row. This places a large portion of the preplant fertilizer near the row. All or part of the recommended fertilizer may be applied preplant. But large amounts of fertilizer, especially those high in K, should not be concentrated near the row or salt damage to seedlings may occur. This is particularly true for grain sorghum planted after June 1 or where it cannot be irrigated.

Phosphate and potash rates are based on soil test levels and may be applied either in the spring or in the fall (Table 4-6). If grain sorghum will be planted after wheat, the P and K needed for both crops may be applied to the wheat. In that case, no additional P or K is needed for direct application to the grain sorghum.

Table 4-5. Nitrogen Sources for Grain Sorghum.

Situation	Preferred Sources[1]
Preplant	Urea, DAP, AS
Sidedress	Urea[2], DAP, AS, 32% UAN

[1]DAP = diammonium phosphate, AN = ammonium nitrate, AS = ammonium sulfate, UAN = urea ammonium nitrate solution.

[2]Urea post applied onto dry soil.

Table 4-6. Recommended P and K for grain sorghum.

Soil test P	Lbs P_2O_5/A	Soil test K	Lbs K_2O/A
Above 100	0	Above 275	0
60 – 100	30 - 40	186 – 275	40 – 60
Below 60	60	125 – 185	60 – 90
		Below 125	90 - 120

Plant Analysis

Plant analysis is a more direct indicator of plant nutrition than are soil tests. However, care must be taken in interpreting plant analysis values because of environmental and cultural factors that may interfere. If a deficiency is suspected, collect whole plant samples if the grain sorghum is less than 12 inches high, making sure they are free of soil since that will contaminate the samples. If the plant is more than 12 inches high but prior to heading, collect several fully developed leaves below the whorl. If the plant is at heading, sample the second leaf from the top of the plant. Table 4-7 shows reference sufficiency ranges for grain sorghum grown in the southern United States. This table may be used as a guide for all plant food elements in leaf or whole grain sorghum plants. Keep in mind that collecting the appropriate plant part is critical for the identification of nutritional disorders. Certain elemental ratios are also important. Ratios larger or smaller than those in Table 4-8 indicate possible plant nutrient imbalances or errors in testing or reporting.

Table 4-8. Desired Elemental Ratios in Plant Tissue.

N/K = 0.8 to 1.6
N/P = 8 to 12
N/S = 10 to 20
K/Mg = 8 to 16
Fe/Mn = 2 to 6

Table 4-7. Reference Tissue Sufficiency Ranges for Grain Sorghum According to Growth Stage.

Growth Stage	Nutrient							
	N	P	K	Mg	S	Fe	Zn	Cu
	------------- % ------------					---------- ppm ----------		
Seedling	3.9	0.2-0.5	2.0	0.2-0.6	0.24	75-400	12-150	4-20
Vegetative	3.0-4.0	0.2-0.4	2.0	0.2-0.5		75-200	12-100	2-15
Flowering	2.5-4.0	0.2-0.35	1.4	0.2-0.5		65-100	12-100	2-7