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Nutrient Management Suggestions for Grain Sorghum

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Nutrient management for grain sorghum integrates fertilizer use with other factors that affect soil nutrient availability, including application of manure or other organic materials, and consideration of previous crops and of soil test values. Fertilizer nutrient needs for grain sorghum may be based on expected yield, soil nutrient levels, previous crop, and fertilizer-nitrogen costs relative to grain value.

Grain sorghum production in Nebraska typically requires nitrogen application. For sorghum following sorghum, corn, wheat, or another cereal crop in rotation, test for residual nitrate-nitrogen in the soil to a depth of 0-24 or 0-36 inches. This test is not needed for sorghum following soybean or alfalfa as high soil nitrate levels following these crops are uncommon. Separate equations are used to determine the economically optimal nitrogen rate for sorghum following a cereal crop and for sorghum following soybean in rotation. To determine phosphorus, potassium, and micronutrient needs, collect soil samples from the 0- to 8-inch depth every four to five years. Phosphorus is the second most likely nutrient to be deficient in the soil for profit maximization of grain sorghum production. Generally, the soils of Nebraska provide sufficient potassium, sulfur, zinc, and iron, but the crop may benefit from applying one or more of these nutrients on some soils. Profitable response of grain sorghum to applied calcium, magnesium, boron, chlorine, copper, manganese, and molybdenum is highly unlikely in Nebraska.

Nitrogen Requirement for Grain Sorghum Following Sorghum, Corn, or Another Cereal Crop

Estimates of nitrogen needed for grain sorghum following a cereal crop are based on expected yield, the amount of residual nitrate-nitrogen (NO_3-N), soil organic matter, and grain price relative to the price of fertilizer nitrogen. The University of Nebraska–Lincoln recommendation for the economically optimal N rate (EONR) for grain sorghum is estimated using the equation:

EONR (lb/acre) = [70 + (1.1 x EY) – (20 x OM) – (14 x NO_3-N ppm) – other credits] x (P_GP_N x 0.11)

where EY = expected yield (bu/ac) estimated as 1.05 x average sorghum grain yield over the past five years or more,

OM = percent soil organic matter to a maximum of 3 percent,

NO_3-N ppm = average nitrate-nitrogen concentration for the 2-3 foot depth in parts per million, and

P_GP_N = the price of grain ($/bu) divided by the price of fertilizer N ($/lb).

Other credits include nitrogen from manure or other applied organic material, and from irrigation water.

Nitrogen Requirement for Grain Sorghum Following Alfalfa or Soybean

Grain sorghum following alfalfa is not likely to benefit from applied nitrogen unless the alfalfa stand was poor. If the alfalfa stand was less than 30 percent of full stand or less than 1.5 plants per square foot, use the equation for estimating nitrogen need for sorghum following a cereal crop and then subtract 90 lb of nitrogen as the nitrogen credit due to the alfalfa crop.

Table I. Economically optimum nitrogen rate (EONR) for grain sorghum following soybean in rotation.

Expected yield (EY, bu/ac)	*Grain price to nitrogen price ratio (P_G/P_N), ($/bu grain) / ($/lb N)*				
	4	**6**	**8**	**10**	**12**
70	0	10	20	35	50
90	5	20	30	45	60
110	15	30	40	55	70
130	25	40	50	65	80
150	35	50	60	75	90
170	45	60	70	85	100
190	55	70	80	95	110

Grain price to nitrogen price ratio (P_GP_N), ($/bu grain) / ($/lb N).
EONR = -68 +0.49 EY + 6.9 P_GP_N.

Estimates of nitrogen needed for grain sorghum following soybean are based primarily on expected yield and sorghum grain price relative to the price of fertilizer nitrogen *(Table I)*. The University of Nebraska–Lincoln recommendation for the economically optimal nitrogen rate (EONR) for grain sorghum following soybean in rotation is estimated using the equation:

EONR (lb/acre) = -68 + 0.49 EY + 6.9 $P_G P_N$

where EY = expected yield (bu/ac) estimated as 1.05 x average yield, and

$P_G P_N$ = the price of grain ($/bu) divided by the price of fertilizer N ($/lb).

Therefore, if EY = 130, PG = $6.00/bu, and PN = $0.50/lb, then $P_G P_N$ = 6.00/0.50 = 12 and EONR = -68 +0.49*130 + 6.9*12 = 80 lb N/ac.

and EONR = -68 + 0.49 x 130 + 6.9 x 12 = 78 lb N/acre.

- If soil organic matter is less than 1.8 percent, increase the nitrogen rate by 20 lb/ac.
- If the weighted average nitrate-nitrogen concentration (ppm) in the root zone at 0-2 or 0-3 feet is greater than 6 ppm, decrease the nitrogen rate by 8 lb/ac for each increase of 1 ppm in nitrate-N.
- Credit manure nitrogen as appropriate.

Nitrogen Adjustment for Soil Nitrate-Nitrogen

Grain sorghum will use soil nitrate-nitrogen remaining in the rooting zone from the previous year. This soil nitrate-nitrogen can be estimated from soil samples taken to a minimum depth of 2 feet, but a 0-3 foot sample will allow a more accurate estimate. When soil test results for nitrate-nitrogen are not available, a value of 3 ppm can be used to calculate the EONR for grain sorghum following a cereal crop. Residual soil nitrate may be considerable if the previous crop was a cereal crop that had a lower than expected yield, but is typically low following soybean or alfalfa. The average nitrate-nitrogen concentration in the root zone (or the depth-weighted concentration) is determined from nitrate-nitrogen concentration in samples collected at several depths as illustrated in *Table II*.

Table II. An example calculation of average soil nitrate-nitrogen concentration, weighted by sample depth.

Soil Layer (inches)	*Thickness (inches)*	*Nitrate-Nitrogen (ppm)*	*Calculations*
0-8	8	15	8 x 15 = 120
8-24	16	10	16 x 10 = 160
24-36	12	3	12 x 3 = 36
Total Nitrate-Nitrogen 0-36 inches (ppm)			316
Average ppm per inch			316/36 = 8.8

Nitrogen Adjustment for Soil Organic Matter

Nitrogen is released from organic matter in the soil by mineralization. When a soil test for organic matter is not available, 1 percent organic matter is assumed for sandy soils and soils in the Panhandle, and 2 percent is assumed for other soils. The value is capped at 3 percent organic matter due to insufficient data from soils of higher organic matter.

Nitrogen Adjustment for Manure and Other Organic Wastes

When manure, compost, or municipal biosolids are applied before grain sorghum is planted, recommended rates of nitrogen should be reduced according to the type of organic material, the amount applied, and the method of application. Follow guidelines on estimating nutrients available from manure; see UNL resources on the Web at *http://manure.unl.edu/*.

Time and Method of Nitrogen Application

Nitrogen fertilizer may be applied at different times, including fall, spring preplant, planting time, side-dress, or in irrigation water. Fall applications are generally less efficient than growing season applications because of the increased risk of nitrogen loss from leaching or denitrification. Application of some nitrogen during the season as with side-dress application may be more efficient than single large doses, especially on sandy soils. Fall application of nitrogen is not recommended on sandy soils, where most of the nitrogen should be applied after sorghum is 1 foot tall with up to a third of the planned nitrogen applied at or before planting to prevent early season nitrogen deficiency.

Phosphorus Fertilization

Several soil extractants are used by commercial soil testing laboratories to determine available P. Most research has been conducted on calibrating Bray-1 P with corn response. The authors suggest the following equations to convert results using other extractants to a "Bray-1 P equivalent" to be used in making a P recommendation.

For Mehlich 2: Bray-1 = 0.9 * Mehlich II

For Mehlich 3: Bray-1 = 0.85 * Mehlich III

For Olsen P: Bray-1 = 1.5 * Olsen

Many, but not most, Nebraska soils need phosphorus to increase grain sorghum yields. Soil phosphorus availability is typically 2.5 times as much in the surface 2 inches of soil compared with the 0- to 8-inch depth.

Yield increases are expected from phosphorus applications when the soil test shows phosphorus for the 0-8 inch soil depth is below 15 ppm by the Bray-1 P and Mehlich-3 phosphorus soil tests, or 10 ppm by the Olsen phosphorus soil test (also known as the sodium bicarbonate phosphorus test; see *Table III*). When phosphorus soil tests are below 10 ppm by Bray-1 P or Mehlich-3 P, the probability of a yield increase to applied phosphorus fertilizer is greater than when phosphorus soil tests are between 10 and 15 ppm. UNL recommendations for phosphorus are based on the sufficiency concept and are typically adequate for grain sorghum yields up to 200 bushels per acre.

Soil phosphorus should be sampled every four to five years. Recommendations are calibrated for the 0-8 inch depth. Sampling at a shallower depth is likely to result in over-estimation of soil phosphorus levels, while the opposite is true for a deeper sampling depth. This is especially true for no-till and reduced tillage situations where soil phosphorus availability is typically greatest in the surface 2 inches of soil.

Table III. Phosphorus fertilizer suggestions.

Phosphorus Soil Test, ppm P		*Amount to Apply Annually (P_2O_5), lb/ac*	
Bray-1 P	*Olsen P*[2]	*Broadcast*	*Band*
0-5	0-3	80	40
6-15	4-10	40	20
>15	>10	0	0

[1]Bray-1 P for acid and neutral soils, Mehlich -2 and -3 can be used for all soils; see conversion to Bray-1 P in above text.
[2]Olsen P for calcareous soils.

Phosphorus Application Methods

Phosphorus fertilizers can be broadcast applied prior to planting or by placing the fertilizer in bands in the root zone. Band application of phosphorus fertilizer is usually more efficient than broadcast application, especially when soil test phosphorus is low. The fertilizer can be applied in preplant bands, but band application with the seed or 1.5 inches below and to the side of the seed at planting may be most efficient. Preplant banding with anhydrous ammonia (dual-placement) is also an effective application method but probably will not increase phosphorus use efficiency for most soils compared with band application of phosphorus fertilizer alone.

Potassium Fertilization

Most Nebraska soils are capable of supplying enough potassium for excellent grain sorghum yields. Soil sample tests for the 0- to 8-inch depth are useful in determining potassium fertilizer need *(Table IV)*. UNL recommendations for potassium are based on the sufficiency concept.

Table IV. Potassium fertilizer suggestions.

Potassium Soil Test, ppm K	*Relative Level (K_2O), lb/ac*	*Amount to Apply Annually*	
		Broadcast	Row[1]
0 to 40	Very Low (VL)	120	20
41 to 75	Low (L)	80	10
75 to 125	Medium (M)	40	10
>125	High (H)	0	0

[1]Banded beside seed row but not with the seed.

Sulfur Fertilization

Nebraska soils generally supply adequate sulfur for excellent grain sorghum production, but sandy soils that are low in organic matter may need added sulfur *(Table V)*. Sulfur must be in the sulfate form to be used by plants; thus, elemental sulfur must be oxidized to the sulfate form to be used. Band application is the most effective method of applying sulfur. When sulfur is applied in a band at planting, use sulfate sulfur since the oxidation process is not rapid enough for elemental sulfur to effectively supply early plant growth. Ammonium thiosulfate (12-0-0-26S) also is effective, but must not be placed with the seed because of the potential for seed germination damage. Ammonium thiosulfate is an excellent source when injected into irrigation water for sprinkler application and can provide sulfur in-season if a deficiency develops.

Table V. Sulfur fertilizer suggestions (sandy soils only).

Sulfur Soil Test, ppm SO_4-S	*Amount to Apply Annually, lb/ac*		
	Soil Organic Matter <1%		*Soil Organic Matter > 1%*
	Irrigation water with less than 6 ppm SO_4-S		
	Broadcast	Row[1]	Row[1]
<6	20	10	5
6-8	10	5	0
>8	0	0	0
	Irrigation water with 6 or greater ppm SO_4-S		
<6	10	5	0
6-8	10	5	0
>8	0	0	0

Sulfur Test - $Ca(H_2PO_4)_2$ Extraction
[1]Applied in a band next to row but not with seed.

Zinc Fertilization

Zinc deficiency is less common in grain sorghum than in corn and may occur where subsoil is exposed on soils leveled for irrigation, if calcareous soils are low in organic matter, or on sandy soils. Periodic soil testing of such soils to an 8-inch depth is suggested to assess soil zinc availability. Zinc deficiency also may occur in cases of heavy silt deposits with flooding as mycorrhyza — fungi that aid plants in phosphorus and zinc uptake — may be at low levels. Soil zinc can be raised easily to adequate levels by broadcasting zinc fertilizer. The broadcast rates in *Table VI* are designed to meet zinc requirements for three to four years. Zinc applied in a band beside the row is also effective, provided about 10 pounds of nitrogen is placed in the same band. Inorganic forms of zinc, such as zinc oxides, zinc sulfate or ammoniated zinc solutions, are more cost-effective than zinc chelates.

Table VI. Zinc fertilizer recommendations.

Zinc Soil Test Level		*Amount to Apply (Zn), lb/ac*[1]			
DTPA Extraction	*Relative Level*	*Calcareous Soils*[2]		*Noncalcareous Soils*	
ppm Zn		Broadcast	Band	Broadcast	Band
0 to 0.4	Low (L)	10	2	5	2
0.41 to 0.8	Medium (M)	5	1	3	1
> 0.8	High (H)	0	0	0	0

[1]Rates are for inorganic forms of zinc such as zinc sulfate.
[2]Calcareous soils defined as soils with moderate to excess lime.

Iron Fertilization

Symptoms of iron chlorosis, observed as yellow striping on leaves, may occur on highly calcareous or saline-sodic soils with pH levels above 7.8. Economic response of sorghum to iron application is rare in Nebraska, but the most effective treatment for correcting high pH chlorosis in grain sorghum is to apply 40-80 pounds of ferrous sulfate heptahydrate ($FeSO_4 \bullet 7H_2O$) per acre in the seed row. This treatment costs $10-$30 per acre, depending on product cost, and requires dry fertilizer application equipment on the planter. An alternative is to apply a stable iron chelate (FeEDDHA) with the seed as a liquid at the rate of 2 to 4 pounds of FeEDDHA per acre (see NebGuide G361). Foliar sprays using ferrous sulfate or FeEDDHA are not always effective in producing significant yield responses. Treatment needs to begin as soon as chlorosis first becomes visible and repeated every 7 to 10 days until newly emerged leaves remain green. Spray must be directed over the row to be effective. A standard application is 20 gallons per acre of a 1 percent iron sulfate solution.

Starter Fertilizer and Row Cleaning for No-till

Application of starter fertilizer containing nitrogen and phosphorus, and maybe sulfur, often results in increased early growth, which can be important to weed suppression and earlier flowering under no-till conditions. However, trial results indicate little or no effect on grain yield and grain moisture content in eastern Nebraska.

Row cleaning, or removing crop residue from the planting row, in no-till situations also may be practiced to enhance early growth and nutrient uptake. As with starter fertilizer, this practice was found to increase early growth but did not affect grain yield in research conducted in southeast Nebraska.

Lime Suggestions

Agricultural soils tend to acidify with time, primarily due to nitrogen application. Where grain sorghum is grown continuously or with other cereal crops, lime application is advised when the soil pH is 5.5 or less for the 0-8 inch depth as well as the 8-16 inch depth. In central and western Nebraska the surface soil may be acid but the subsoil may be calcareous; lime application at pH of 5.5 is not likely to be profitable in these situations. Where grain sorghum is produced in rotation with soybean, liming is advised when the soil pH is 5.8 or less. Surface application of lime without incorporation for no-till fields is effective but will require more time to correct the acidity of the deeper soil.

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