NebGuide

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Research-Based Information That You Can Use

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Fertilizer Recommendations for Soybean

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This guide provides recommendations for fertilizer use and lime application to optimize the profitability of soybean production in Nebraska.

Soybean production in Nebraska has expanded to 5.6 million ac/yr. During the past 30 years, the mean yield increase has been 0.49 bu/ac/yr for irrigated and 0.38 bu/ac/yr for rainfed production. The 2018 mean yield is 66 bu/ac for irrigated and 51 bu/ac for rainfed soybean. In general, the fertilizer requirements for soybean are less than for corn, sorghum, and wheat. Soybean yield increases in Nebraska are observed mostly with fertilizer phosphorus. In eastern and central Nebraska, lime application is required to optimize yield potential on some soils. Along the Platte River, in western Nebraska, and for calcareous soil in northeastern Nebraska, lime-induced iron deficiency chlorosis is often a concern. Soil tests occasionally indicate a need for potassium or zinc fertilizers.

Lime

Maintaining soil pH between 5.5 and 7.0 will enhance the availability of nutrients and microbial breakdown of crop residues. Symbiotic nitrogen fixation in soybean root nodules with *Bradyrhizobium japonicum* bacteria is maximized with soil pH of 5.5 to 7.0, although the bacteria will function at pH levels as low as 5.0.

The quantity of lime material needed to raise the soil pH to 6.5 in the surface 6 to 7 inches of soil is determined with a buffer pH soil test that is routinely performed when soil pH is 6.2 or less. Lime application is likely to be profitable on soils where soil pH is 5.8 or less at the 0- to 8-inch depth, and where the subsoil pH is 6.0 or less to a depth of 2 feet or more. See the NebGuides *Lime Use for Soil Acidity Management*, G1504, and *Management Strategies to Reduce the Rate of Soil Acidification*, G1503.

Lime is relatively insoluble and soil pH will gradually increase during the first six to 18 months after application but often with further increases in soil pH over several years. The cost of lime application is likely to require three or more harvests for full payback with more benefit from soybean than from corn in the rotation. Following payback, profitable returns are expected to continue over several years. Therefore, the profitability of lime application is influenced by how long the land will be farmed. Applying less lime more frequently may be more profitable if control of the land is uncertain and for no-till fields. Site-specific or variable rate lime application may be a profitable option, with application only to those areas where the surface pH is less than 5.8 or varying the lime rate according to lime need.

Nitrogen and Inoculation

Symbiotic fixation of atmospheric nitrogen by *Bradyrhizobium japonicum* bacteria present in soybean root nodules supplies on average about 55 percent and up to 74 percent of the nitrogen (N) needed by the crop.

Soybean grown on land where well-nodulated soybean has been grown in recent years is not likely to benefit from treating seed with the bacteria inoculum, but soil-applied or seed-applied inoculation provides good insurance for optimization of symbiotic nitrogen fixation. If soybean has not been produced previously in the field or if adequate presence of *Bradyrhizobium japonicum* bacteria is doubtful, seed inoculation is recommended.

Soybean effectively uses soil residual nitrate and nitrogen mineralized from soil organic matter. Soybean obtains 25 to 75 percent of plant nitrogen from the soil, with the balance supplied from symbiotic fixation. Before active nodules form on roots, all nitrogen supply is from the soil. Nodules appear on roots beginning three to four weeks after emergence when a fully developed trifoliolate leaf is present on the third or fourth node. Under some soil conditions (low pH, low organic matter, low residual nitrogen, large amounts of crop residue), the supply of nitrogen from soil and nodules may not be adequate. In these cases, soybean yield may be increased by applying nitrogen fertilizer. The need for nitrogen fertilizer cannot be predicted by soil tests. Soybean yield may be increased with fertilizer nitrogen application if one or more of the following conditions are present:

- The soybean crop does not have a uniform dark green color throughout the field (but is not chlorotic—light green to yellow interveinal tissue with dark green veins due to wet, saline, or calcareous soil conditions).
- Soils pH is less than 5.5.
- Soils have less than 1.5 percent organic matter or are eroded or compacted.
- Soybean has not been grown in the field for some time (although seed inoculation with *Bradyrhizobium japonicum* bacteria is the preferred practice for short- and long-term benefits), or the field has not had adequate nitrogen applied on grain crops.
- Active nodules (dark pink center) are absent from roots or few in number.

If nitrogen deficiency is suspected based on the above conditions, apply 50 to 100 pounds of nitrogen per acre. Ideally, nitrogen application should be tested first on a small part of the field to see if this corrects the problem before fertilizing the entire field. Excessive nitrogen availability at early growth stages can result in lodging-induced yield reduction. Fertilizer can be effectively applied as late as early pod fill, provided rainfall or irrigation occurs soon after application.

Routine nitrogen application to soybean is not recommended. The rate of soybean uptake of nitrogen is greatest between the onset of flowering to pod fill. In eastern and central Nebraska, the mean yield increase due to 27 lb/ac nitrogen applied at early seed formation was 1.05 bu/ac for 44 trials with yield of greater than 60 bu/ac; there was no additional yield increase with 54 lb/ac of nitrogen applied (Wortmann et al., 2012; Irrigated soybean has a small response to nitrogen applied during early reproductive growth. http://www.plantmanagementnetwork.org/sub/cm/research/2012/nitrogen/ doi:10.1094/CM-2012–0126–01-RS). In an analysis of research findings from 16 states, fertilizer N application for soybean was most effective with irrigation and with about 40 lb/ac applied to the soil preplant and again during a reproduction growth stage. This resulted in a mean yield increase of about 2.5 bu/ac, which was insufficient to make the practice profitable (Mourtzinis et al., 2017 Soybean response to nitrogen application across the US. https://coolbean.info/library/documents/Nstudy.pdf). Therefore, profitable response to routine nitrogen application for soybean is unlikely, especially if rainfed. However, application of 20–40 lb/ac of nitrogen by fertigation at the R3 growth stage could be considered for high yield situations. Interested producers are encouraged to investigate this practice on their most productive irrigated fields by leaving replicated check areas with no N application to evaluate the benefit of fertilizer nitrogen applied to soybean by fertigation.

Phosphorus

Soybean can produce maximum grain yield with relatively low soil test phosphorus levels compared with other major agronomic crops in Nebraska. Phosphorus application is not likely to increase grain yield at soil phosphorus concentrations above 12 ppm P with the Bray-1 test. Based on the experience and judgment of University of Nebraska soil scientists, *Figure 1* illustrates the approximate percent of potential yield attainable, and the probability of a yield increase with phosphorus fertilization at various soil test phosphorus levels.

Subsoil phosphorus levels are not considered in recommendations for phosphorus fertilization of soybean. However, in many areas of Nebraska subsoil phosphorus levels may be somewhat higher than those found in much of the Midwest and account for the lack of response to phosphorus fertilization on some soils. Phosphorus fertilizer recommendations are based on soil test phosphorus (*Table 1*). The Bray-1 test is the most used soil test for phosphorus

Table 1. Phosphorus fertilizer recommendations for soybean in Nebraska based on soil test phosphorus.

Phosphorus Soil Test			*P_2O_5 to Apply*
Bray-1	*Mehlich-3*	*Olsen*	
0–5	0–6	0–3	65
6–8	7–10	4–5	40
9–12	11–14	6–8	20
> 12	> 14	> 8	0

availability. The Olsen P test is used on soils with pH of 7.3 or greater. Some analytical labs in Nebraska may use the Mehlich-3 test.

These recommended phosphorus rates should be followed annually until testing the soil again after no more than four years, unless a heavy phosphorus application, such as with manure, is made. Adjust the phosphorus rates according to the results of the latest test. In Nebraska, soybean is commonly rotated with corn, which has a higher critical level for soil test phosphorus. The probability of a profitable yield increase to phosphorus fertilization of soybean at Bray-1 P soil test levels above 12 ppm is low *(Figure 1;Table 1)*. However, consider that with a field average Bray-1 P level of 12 ppm, areas within the field will test above and below 12 ppm. Site-specific or variable rate phosphorus application based on management-zone or grid soil sampling may be a more profitable approach. See *Guidelines for Soil Sampling,* G1740).

Phosphorus fertilizer can be applied by different methods although results of research conducted in Iowa, Kansas, and Minnesota indicate that both broadcast and band application of phosphorus are effective without much effect of tillage practice. The first year recovery efficiency for phosphorus is often greater with band than with broadcast application for low soil test phosphorus conditions.

Generally, use of a starter fertilizer with soybean is not likely to increase yields as indicated by results of research in Minnesota, even for no-till production, but fertilizer may be applied at planting in response to low nutrient availability (See *Using Starter Fertilizers for Corn, Grain Sorghum and Soybean,* G361). Nebraska producers commonly plant soybean later than corn when soil temperatures are higher and root growth is faster, accounting for the generally low benefit of starter fertilizer. However, band application of phosphorus fertilizer at planting can be a good practice if soil test results indicate a need for phosphorus. Fertilizer should not be placed in the soybean seed furrow due to the risk of seedling injury and loss of stand during germination. If fertilizer is applied at planting, it should be banded at least 1 inch away from the seed.

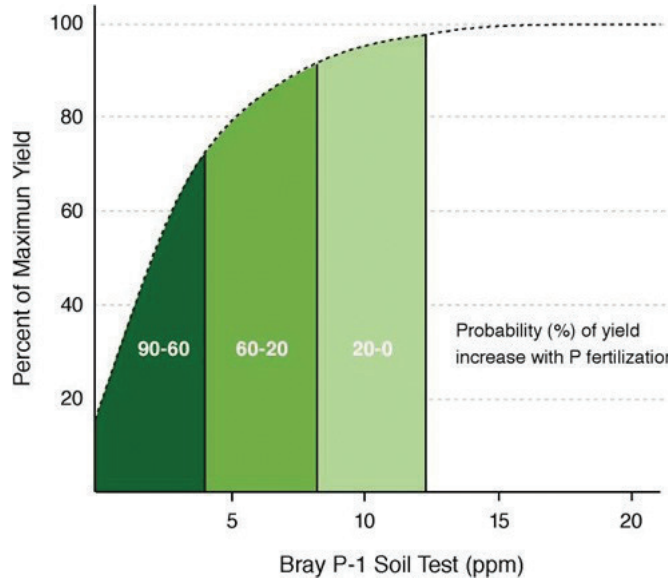

Figure 1. The conceptual probability of yield increase with phosphorus fertilization according to soil phosphorus concentration.

Potassium

Nebraska soils infrequently need potassium (K) fertilizer for soybean production even though soybean takes up much potassium *(Table 4)*. Potassium levels are generally high in both surface soil and subsoil in Nebraska with the exception of some sandy soils. Potassium fertilizer recommendations are based on soil test potassium levels *(Table 2)*. Broadcasting potassium prior to planting is efficient. If potassium is applied in a band at planting time, special care should be taken to locate the band at least 1 inch away from the seed to avoid seedling injury.

Sulfur

Soybean need for sulfur (S) fertilizer is unlikely at this time with the exceptions of some sandy soils. Soybean is tolerant of low soil test sulfur levels and is not likely to respond to sulfur fertilization in Nebraska. In 56 trials conducted in Nebraska, there was on average no change in soybean yield due to 4 lb/ac sulfur applied during early grain formation. As with nitrogen, the vast majority of soil sulfur is in organic matter and is mineralized from soil organic matter throughout the growing season. While the probability of yield response to applied sulfur is low, this probability may increase and fertilizer sulfur is inexpensive.

Iron

Iron (Fe) deficiency or chlorosis is a common problem with calcareous soil in Nebraska, as well as some seasonally

Table 2. Potassium fertilizer recommendations for soybean in Nebraska based on soil test levels

Potassium Soil Test*	K_2O to Apply
ppm	lb/ac
0–40	60
41–74	40
75–124	20
> 124	0

*Exchangeable K by ammonium acetate extraction; Mehlich III extracts more K and the above 75–124 range is equal to about 103–157 ppm by Mehlich III.

poorly drained soils of the Platte, Elkhorn, and Republican River valleys *(Figure 2)*. Iron chlorosis is not normally a problem of low soil iron levels, but rather an inability of the plant to use iron effectively. Iron chlorosis is difficult to manage economically as it occurs inconsistently and is worse under conditions of poor soil aeration, often associated with saturated soil.

Correcting iron chlorosis may require a combination of management practices.

- **Low soil nitrate.** Management of the previous crop to avoid high levels of nitrate-nitrogen in the surface soil during early soybean growth is important. With increased soil nitrate—whether remaining from the previous crop or due to fertilizer N application—the resulting increase in soybean uptake of nitrate can decrease iron availability to the plant.

- **Variety selection.** Consult with your seed dealer for current soybean varieties tolerant to iron chlorosis. Some cases of iron chlorosis are too severe for even the most tolerant varieties. If corn or grain sorghum has shown serious iron chlorosis in a given field or area of a field, it is unlikely that tolerant soybean varieties will produce well. Often the yield potential of tolerant compared with non-tolerant varieties is less when grown in areas with no problem of iron chlorosis.

- **Seeding density.** Iron chlorosis is more severe when soybean plant density is low. Planting 12 viable seeds per linear foot of row adds to acidification in the root zone for increased iron availability while diluting effects of nitrate and bicarbonate in the root zone and in the plant. High plant densities can also reduce soil water and improve aeration in the root zone.

- **Application of chelated iron fertilizers with the seed.** For those soils where variety selection and seeding density do not overcome iron chlorosis, application of iron chelate (Fe-EDDHA) fertilizer in the seed furrow has proved to be the most effective iron fertilizer treatment. The fertilizer rate can be 1 to 4 lb/ac of product, depending on the anticipated degree of chlorosis. Fe-EDDHA is a dry powder that mixes easily with water. The producer should dissolve the powder in 20 to 25 gallons/ac.

Figure 2. Iron chlorosis in soybean, western Nebraska.

- **Foliar treatment.** Soybean yield response to foliar application of iron fertilizer is inconsistent. Foliar application needs to be early in the season when there is little leaf area to intercept the application, and foliar iron uptake is reduced for leaf area damaged due to chlorosis. High air temperature and wind also reduce the effectiveness of foliar application. For these reasons, seed treatment is generally more effective than foliar application. To fully correct chlorosis symptoms by foliar treatment, two to three applications may be necessary using a 1 percent solution of ferrous sulfate ($FeSO_4$). Two pounds of ferrous sulfate or four pounds of ferrous sulfate heptahydrate ($FeSO_4 \bullet 7H_2O$) in 25 gallons of water makes a one percent solution. A greater than 1 percent solution of ferrous sulfate can cause leaf burn. Begin foliar applications with the first appearance of iron chlorosis symptoms and treat at seven to 10 day intervals until the new growth shows normal color. The more severe the chlorosis, the harder it is to correct. Iron chelates can be used for foliar application. Adding a commercial wetting agent or a cup of mild household detergent to 100 gallons of solution can improve plant coverage. Adding five pounds of urea fertilizer per 100 gallons of spray solution also may improve the effectiveness of foliar iron application.

- **Site-specific management.** Due to the expense of soil and foliar applied iron treatments with no benefit in field areas with no iron chlorosis, producers may prefer

Table 3. Zinc fertilizer recommendations for soybean in Nebraska based on soil test levels.

Zinc Soil Test*	Zinc to Apply	
	Calcareous Soil	Non-Calcareous Soil
ppm	lb/ac	
0–0.4	1 row or 10 broadcast	1 row or 5 broadcast
0.4–0.8	0	0
> 0.8	0	0

* DTPA zinc: zinc extraction is greater with Mehlich III so that 0.4 ppm by DTPA is equivalent to about 1.4 ppm by Mehlich III.

Table 4. Soybean nutrient uptake with 65 bu/ac grain yield and 3.2 t/ac stover yield.

	Removed in seed	Remaining in stover	Total uptake
Nutrient	lb/ac		
N	244	165	410
P_2O_5	57	39	96
K_2O	86	99	185
S	6.5	19.5	26.0
Zn	0.07	0.39	0.46

Adapted from Franzen, D. and J. Gerwing. 1997. Effectiveness of using low rates of plant nutrients. North Central Regional Research Publication 341.

site-specific application of iron fertilizer and even site-specific planting of tolerant varieties at a high seeding density. An aerial photograph of a field with chlorotic symptoms can indicate where iron chlorosis is likely to occur. Producers can use management zone maps created from aerial photos of past crops to control fertilizer application with either an automated, global positioning system (GPS) or manually, using a cab-mounted on/off switch.

Zinc

Zinc (Zn) deficiency in soybean is rare but can occur. Zinc fertilization may be beneficial where soil zinc levels are low, particularly in field areas that were leveled for irrigation or eroded, and are low in organic matter *(Table 3)*. If a previous corn crop did not show zinc deficiency, it is not likely that soybean will exhibit deficiency symptoms (See *Use and Management of Micronutrient Fertilizers in Nebraska,* G1830).

Other Micronutrients

Boron, chlorine, copper, manganese, and molybdenum deficiencies have not been observed in soybean grown in Nebraska. Therefore, yield increases are not expected from applying these micronutrients.

Manure Application for Soybean

Manure application before planting soybean may increase yield, often by about 3 bu/ac in the first year after application. However, manure rates should be calculated so that total available manure nitrogen during the soybean growing season does not surpass half the soybean nitrogen removal rate. This will make it less likely that elevated postharvest soil nitrate levels will result in much leaching of nitrate below the root zone. Research in other states indicates an increase in white mold when manure is applied for narrow-row soybeans.

Nutrient Removal

Table 4 illustrates nutrient removal for a 65 bu/ac soybean crop in Nebraska. The nitrogen required for a soybean crop at this yield level will be supplied from the soil (as residual nitrogen and nitrogen derived from mineralized organic matter) and from symbiotic fixation from the atmosphere, with little if any need for supplemental nitrogen fertilization.

Resources

Additional information and new research results may be found at the UNL Soil Fertility Home Page: *http://soilfertility.unl.edu/*

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