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Fertilizer Recommendations for Soybean

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This guide provides recommendations on how to manage soil fertility with fertilizer and lime application to optimize the profitability of soybean production.

Soybean production in Nebraska has expanded significantly over the past twenty years and is second only to corn in area planted, at almost five million acres. In general, the fertilizer requirements for soybean are typically less than for other crops such as corn, sorghum and wheat. Yield increases of soybean in Nebraska are observed mostly with nitrogen and phosphorus application. Generally, soils that have been fertilized for corn should have adequate fertility for soybean production. In eastern and central Nebraska, lime application may be required to optimize yield potential on some soils. In central and western Nebraska, lime-induced iron chlorosis may often be a concern. In rare instances, soil tests may indicate the need for potassium or zinc fertilizers.

Lime

Maintaining soil pH between 5.5 and 7.0 will enhance the availability of nutrients such as nitrogen and phosphorus, as well as microbial breakdown of crop residues. Symbiotic nitrogen fixation in soybean root nodules by *Bradyrhizobium japonicum* bacteria is optimal between pHs of 5.5 and 7.0, although the bacteria will function at pH levels as low as 5.0. A lime requirement test (buffer pH) is routinely performed during soil test procedures on soils with a pH of 6.2 or less. Lime application is likely to be profitable on soils where the 0- to 8-inch surface pH is 5.8 or less, and where the subsoil pH is 6.0 or less to a depth of two feet or more. For soils with surface pH values greater than 5.5 or subsoils with pH 6 or greater, lime application is less likely to be profitable.

Along with the soil pH test, a lime requirement test (buffer pH) is routinely performed on soils with a pH of 6.2 or less. Based on this test, the quantity of lime material necessary to raise the soil pH to 6.5 in the surface 6 to 7 inches is determined.

The profitability of lime application for soybean production is influenced by how long the land can be farmed. Lime application will rarely provide a payback in one year, and four to seven years may be required for full payback. Since lime is relatively insoluble, soil pH will gradually increase during the first 6-18 months after application. Applying less lime more frequently may be more profitable if land tenure is uncertain and for no-till situations. Site-specific lime application also may be a profitable option for

soybean, applying lime only to those areas where the surface pH is less than 5.8.

Nitrogen

Bacteria present in soybean root nodules will fix nitrogen from the atmosphere, normally supplying most or all nitrogen (N) needed by the plant. Soybean grown on land where well nodulated soybean has been grown in recent years will probably not require inoculation; however, if soybean has not been raised previously or if there is any question about the presence of *Rhizobium* bacteria, inoculation is recommended.

The soybean plant will effectively utilize soil residual nitrate and nitrogen mineralized from soil organic matter. Soybean will obtain 25 to 75 percent of plant nitrogen from the soil, with the balance supplied from symbiotic fixation. In some situations, nitrogen supplied by fixation may not fully meet crop needs. Before active nodules form on roots, all nitrogen will be supplied to the plant from soil. Under some soil conditions (low pH, low organic matter, low residual nitrogen, large amounts of residue), the supply of nitrogen from soil and nodules may not be adequate. In these cases, soybean yield can be increased by applying nitrogen fertilizer. The need for nitrogen fertilizer cannot be predicted by soil tests. Nitrogen may be needed 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 are acid with a pH of less than 5.5.
- Soils are light colored, low in organic matter, eroded or compacted.
- Soybean has not been grown in the field for some time, 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.
- The soybean crop was not inoculated and deficiency symptoms are present.

If nitrogen deficiency is suspected based on the above conditions, apply 80 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 and yield reduction. Fertilizer can be applied as late as early pod fill and still be effective, provided rainfall or irrigation occurs soon after application.

Soybean demand for nitrogen and water is greatest during pod fill, particularly after the R-3 growth stage. Recent research in Kansas has shown that in fields with an already high yield potential (greater than 60 bushels per acre), an application of 20 to 40 pounds of nitrogen per acre at the R-3 stage can increase yield by 5 to 10 percent. Research and demonstration efforts in Nebraska have found this increase to be inconsistent and difficult to predict. Of ten trials conducted between 1997 and 2001, two showed a significant yield increase to supplemental nitrogen (one at average yield levels of 64 bu/acre, the other at average yield levels of 48 bu/acre). All but one of the non-responsive sites had average yield levels of less than 60 bu/acre. Interested producers are encouraged to investigate this practice on their most productive irrigated fields by using replicated treatment strips to evaluate the benefit of supplemental nitrogen on their farms. Response to nitrogen application at R-3 to R-4 growth stages will be enhanced by irrigation. Thus, response to late season nitrogen application under dryland conditions is less likely.

Phosphorus

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

Subsoil phosphorus levels usually are not an issue when making recommendations for phosphorus fertilization. In many areas of Nebraska subsoil phosphorus levels may be somewhat higher than those found in much of the Midwest, explaining the lack of response to phosphorus fertilization on some soils. *Table 1* provides phosphorus fertilizer recommendations based on Bray-1 and Olsen phosphorus tests. The Olsen P test is used on soils with pH of 7.3 or greater. The Mehlich-3 phosphorus test may be used by some analytical labs in Nebraska. Results from the Mehlich-3 test are interpreted equivalent to Bray-1 phosphorus.

These recommended rates should be followed annually for four years, after which the soil should be tested again and rates adjusted accordingly. Soybean will most often be grown in rotation with corn in Nebraska, which will have a higher critical level for soil test phosphorus. Consequently,

Table 1. Phosphorus fertilizer recommendations for soybean in Nebraska based on Bray-1 or Olsen phosphorus tests.

Phosphorus Soil Test		P_2O_5 to Apply (pounds per acre)
Bray-1 or Mehlich-3	Olsen	
(ppm)		
0 - 4	0 - 3	65
6 - 8	4 - 5	40
9 - 12	6 - 8	20
> 12	> 8	0

The following equation provides an alternative to using table values:
 P_2O_5 (lb/acre) = (15 - Bray-1 P (ppm)) x 6, if Bray-1 P (ppm) < 15

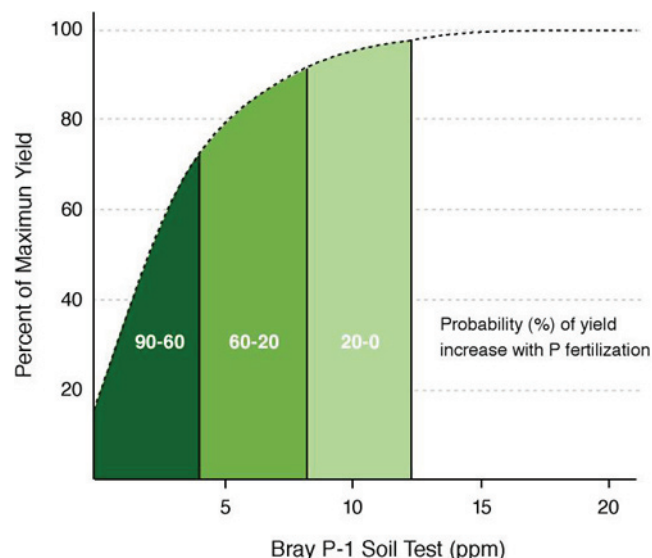


Figure 1. Conceptual probability of yield increase with phosphorus fertilization according to soil phosphorus concentration.

producers using a corn/soybean rotation will most likely want to maintain soil phosphorus at a higher level than if growing soybean alone; however, the probability of an economic yield increase to phosphorus fertilization of soybean at Bray-1 P soil test levels above 12 ppm is low. With an average Bray-1 P level of 12 ppm in a field, there likely will be areas within the field that test above and below 12 ppm. Site-specific phosphorus application to lower-testing regions may be a more profitable approach, although identifying lower phosphorus regions within fields is problematic.

Phosphorus fertilizer can be broadcast applied and incorporated into the soil prior to planting. With low soil phosphorus levels, band application of fertilizer is more efficient than broadcasting. The producer should space fertilizer bands 10 to 15 inches apart and 3 to 6 inches deep. Generally, no great advantage exists for using a starter fertilizer with soybean. Recent research in Minnesota confirms that no consistent benefit exists for starter fertilizer with soybean, even for no-till production. Nebraska producers plant soybean later than corn, when soil temperatures are higher and thus nutrient availability is greater. If a starter fertilizer is used, it should be banded at least one inch away from the seed. Fertilizer should not be placed with the soybean seed due to the risk of seedling injury and loss of stand during germination.

Potassium

Nebraska soils seldom need potassium (K) fertilizer for soybean production. Potassium levels are generally high in both surface soil and subsoil. Even though soybean uses relatively large quantities of potassium, using potassium fertilizers for soybean usually is not profitable. *Table 2* provides potassium fertilizer recommendations for soils based on soil potassium levels. Broadcasting and incorporating potassium prior to planting is the most efficient application method. If potassium is applied in a band at planting time, special care should be taken to locate the band at least one inch away from the seed to avoid seedling injury.

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

Potassium Soil Test*	K ₂ O to Apply
(ppm)	(pounds per acre)
0 - 40	60
41 - 74	40
75 - 124	20
> 124	0

*Exchangeable K

Sulfur

Soybean need for sulfur (S) fertilizer is very unlikely. Soybean is tolerant of low sulfur test levels in the soil and is not likely to respond to sulfur fertilization in Nebraska. As with nitrogen, the vast majority of sulfur present in soil is contained within soil organic matter and will mineralize from soil organic matter throughout the growing season.

Iron

Iron (Fe) deficiency or chlorosis is a common problem on high pH soils in Nebraska, as well as on some seasonally poorly drained soils in the Platte, Elkhorn and Republican River valleys (Figure 2). Lime-induced chlorosis is not normally a problem of low soil iron levels, but an inability of the plant to use iron efficiently. The problem 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 often requires a combination of management practices, including selecting appropriate varieties, properly adjusting seeding density, applying iron materials with the seed, and using foliar iron sprays.

- **Variety Selection.** Consult with your seed dealer for current soybean varieties tolerant to chlorotic conditions. Some soil conditions are too severe for even the most tolerant varieties. If corn or grain sorghum has shown serious chlorosis in a given field or area of a field, it is unlikely that the most tolerant soybean varieties will produce well.
- **Seeding Density.** Seed density has an influence on how well a soybean variety tolerates an alkaline soil—even with tolerant varieties. Chlorosis is more severe when plant density is low. Higher plant densities can remove water and improve aeration in the root zone. Producers should plant at a density of 12 viable seeds per foot, regardless of row spacing. This seeding density is excessive for most varieties grown under less chlorotic conditions.
- **Application of Iron Fertilizers With the Seed.** For those soils where variety selection and seeding density do not overcome chlorotic conditions, the producer may apply an iron chelate (Fe-EDDHA) fertilizer with the seed. Applying Fe-EDDHA directly with the seed at planting is the most effective and consistent fertilizer treatment. The fertilizer rate depends on the anticipated degree of chlorosis, but the most common rates are between one and four pounds of product per acre. Fe-EDDHA is a dry powder that mixes easily with water. The producer should dissolve the powder in 20 to 25



Figure 2. Iron chlorosis in soybean, western Nebraska.

gallons of water per acre and apply it directly with the seed, without adding any other fertilizer.

- **Foliar Treatment.** Soybean yield response to foliar application of iron fertilizers is inconsistent. One problem with foliar application is that material must be applied to the leaves, and early in the season there is little leaf area, and what exists may be damaged due to chlorosis. Frequently, chlorosis may be too severe for foliar iron application to be effective. 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 one percent solution of ferrous sulfate (FeSO₄). Two pounds of ferrous sulfate or four pounds of ferrous sulfate heptahydrate (FeSO₄•7H₂O) in 25 gallons of water makes a one percent solution. Using greater than a one percent solution can lead to leaf burning.

Iron chelates also 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 foliar spray performance.

The more severe the chlorosis, the harder it is to correct. With foliar applications, begin treatments as soon as symptoms are detected and treat at 7- to 10-day intervals until new growth shows normal color.

- **Site Specific Management.** Due to the expense of iron treatments, applied either with the seed or foliarly, and the lack of benefit in non-chlorotic field areas, producers may wish to apply these fertilizers site-specifically. An aerial photograph of a field with chlorotic symptoms can be a good indicator of where chlorosis is likely in the future. Producers can use management zone maps created from aerial photos to control fertilizer application with either an automated, global position 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 Zn levels are low, particularly in field areas which have been leveled for irrigation or which have been eroded and are low in organic matter. If a previous corn crop did not show zinc deficiency, it is not likely that soybean will exhibit deficiency symptoms. *Table III* provides recommended zinc fertilizer rates for soybean in Nebraska.

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

Zinc Soil Test*	Zinc to Apply	
	Calcareous Soil	Non-Calcareous Soil
(ppm)	(pounds per acre)	
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

Other Micronutrients

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

Manure Application for Soybean

Manure application before planting soybean may increase yield potential. On-farm trials conducted in eastern Nebraska often have found a yield increase of about 3 bu/acre 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 the nitrogen removal for the predicted soybean yield. This calculation should include soil residual nitrate and predicted irrigation water nitrate. Because soybean nodules may not completely cease functioning in manured soil, the best management practice for manure application is to apply less than half the soybean nitrogen removal rate. This will make it less likely

that end-of-season soil nitrate levels are elevated, and that nitrate will leach below the root zone. In addition, research in other states has found a possible increase in white mold when manure is applied to narrow-row soybeans.

Nutrient Removal

Table IV illustrates nutrient removal for a typical soybean crop in Nebraska (yield of 50 bu/acre). Most or all of 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.

Table IV. Soybean nutrient uptake with 50 bu/acre seed yield, 5000 lb/acre stover yield.

Nutrient	Removed in Seed	Remaining in Stover	Total Uptake
	(pounds per acre)		
N	188	127	315
P ₂ O ₅	44	30	74
K ₂ O	66	76	142
S	5	15	20
Zn	0.05	0.3	0.35

Source: Franzen, D. and J. Gerwing. 1997. Effectiveness of Using Low Rates of Plant Nutrients. North Central Regional Research Publication 341.

Web Resources

Additional information and new research results may be found at the following Web sites:

UNL Soil Fertility Home Page:
<http://soilfertility.unl.edu/>

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