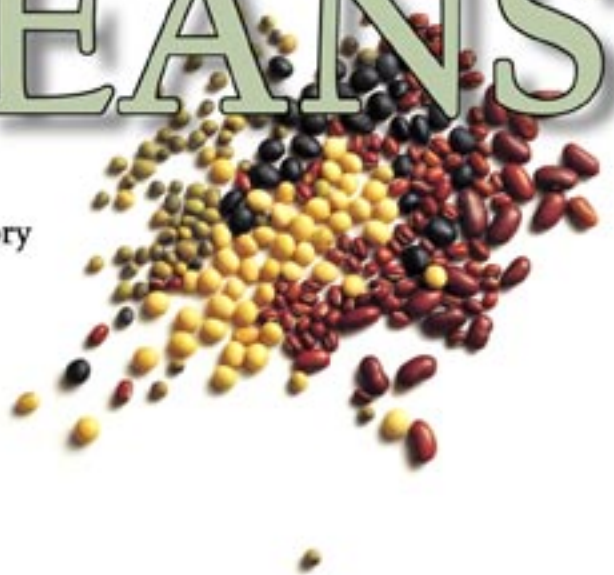




Nutrient Management Guidelines for DRY BEANS

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Nutrient Management Guidelines for Dry Beans

Sound nutrient management is just one of several important components of a profitable dry bean production system. A good soil fertility program enhances the benefits of other cultural practices, but it cannot compensate for poor management of other inputs and variables. A balanced soil fertility program is vital for success. Excessive applications of a nutrient can reduce production because that nutrient can accumulate at levels toxic to the plant, induce deficiencies of other nutrients, or increase susceptibility to problems such as lodging or disease. Including soil testing and research-based fertilizer guidelines in the planning process can help achieve an efficient fertilizer program that will maintain profitable yields, improve crop quality, and promote early maturity.

The following fertilizer guidelines are based on Wyoming research as well as guidelines and research from neighboring states. They assume representative soil sampling and the use of good crop management practices. Keep in mind that soil test results are only one factor influencing crop response to fertilizers and should be considered together with information about the previous crop, soil texture, and irrigation practices when making decisions about fertilizer applications. Fertilizer recommendations may also need to be adjusted based on economic factors, past experience, and common sense.

Soil testing is a valuable tool when used properly, but a soil sample that does not accurately represent the field from which it was taken is of little value and may lead to errors when determining fertilizer application rates. Before planting occurs, a representative soil sample should be collected from the tillage zone (usually a 6 or 8 inch depth) for determination of pH, organic matter, available nitrogen, phosphorus, potassium, and micro-

nutrients. Nitrogen recommendations are more reliable when based on available nitrogen (nitrate-N) to a depth of 12 inches. A typical sampling approach is to extract a 12-inch soil core from 15 to 20 random locations within a 20- to 40-acre field. Divide each core into two 6-inch sections, placing all top sections into one container and all bottom sections into another. This allows the laboratory to analyze each depth increment separately. If tillage operations thoroughly mix soil to a depth of one foot, it is not necessary to separate the surface and subsurface layers. Once a quality sample has been collected, it should be air dried and then sent immediately to a reputable regional laboratory that has experience analyzing soil with properties similar to those found in Wyoming.

Nitrogen (N)

As a member of the legume family, beans are capable of utilizing N from the air through symbiotic fixation of atmospheric nitrogen gas (N_2). Nodules that form on bean roots contain *Rhizobium* bacteria that convert N_2 into plant-available forms. These bacteria can be purchased as an inoculum that is applied at planting to the seed or in the seed furrow. Research in Wyoming and surrounding states has repeatedly shown that in most fields with a recent history of bean production, inoculating the seed provides no measurable benefit. If beans have not been grown in a particular field within the past two or three years or if previous bean crops were not well nodulated, bacterial populations may be low, and inoculation is recommended. When using inoculants, pay close attention to instructions for storage and application. Effectiveness is reduced if the inoculant is not mixed uniformly with seed or is applied in a discontinuous band in the seed row. Moreover, inoculants contain

Table 1. Nitrogen fertilizer guidelines for irrigated dry beans based on residual soil nitrate-N ($\text{NO}_3\text{-N}$) for a 12-inch sampling depth. Yield goal: 30 cwt/acre.

Soil test N ppm $\text{NO}_3\text{-N}^a$	Fertilizer N ^b pounds/acre
0	90
5	68
10	45
15	23
20	0

^a1 ppm (part per million) equals 1 mg/kg

^bTo adjust N application rate for a different yield goal, add or subtract 3.3 pounds for each cwt that the desired yield goal differs from 30 cwt (3,000 pounds/acre). Fertilizer N application rate should not exceed 120 pounds N/acre.

living bacteria that may be killed by improper handling, resulting in failure of the inoculation.

Although beans are a legume, a typical crop requires N from the soil in addition to what is supplied through N_2 fixation. It is estimated that less than half of the roughly 150 pounds of N per acre required by a 2,500-pound per acre bean crop is obtained through fixation. The remaining 50 percent must come from residual N in the soil, N released from organic matter, N in irrigation water, or fertilizer. Supplemental N will promote vigorous growth during the first 20 to 30 days following emergence when nodules are not yet active, and cool soil temperatures limit mineralization of organic N. Research in Wyoming and neighboring states has shown that maximum bean yields will usually be produced with 30 to 80 pounds of N fertilizer per acre depending on residual soil N, but yield responses have been observed with up to 120 pounds of N per acre. Economically optimum N rates are usually slightly lower than agronomically optimum application rates (i.e. the lowest amount of fertilizer that produces the maximum yield).

University of Wyoming N guidelines for beans are shown in Table 1. These guidelines are based on responses observed in the Big Horn Basin. Responses will

vary depending on your specific circumstances. If beans follow a grain or non-legume, increase the recommended N fertilizer by 15 pounds of N per ton of straw or residue up to 50 pounds additional N per acre. Typically, barley and oats produce from 30 to 50 pounds of straw per bushel of grain, varying with soil fertility, varietal straw length characteristics, etc. Wheat usually produces from 50 to 70 pounds of straw per bushel.

Use caution when applying N fertilizer to beans. Excessive N can inhibit nodule formation, delay maturity, promote excessive growth, and increase insect and disease problems. If white mold is present, N fertilizer can significantly increase the degree of damage by increasing canopy density. Manure or high-N crop residues (such as alfalfa) can release significant amounts of available N for two years following application. Fertilizer N use following application of these organic N sources should be considered cautiously. A shorter season variety or an early planting date may be advisable when N availability is known to be excessively high. If other fields are available, it may be best to select a field with a lower residual N level to reduce the risk of delayed maturity.

While most of the fertilizer N applied to beans is broadcast and incorporated prior to planting, other timing and placement options may be beneficial under certain circumstances. For example, with relatively high application rates of 80 pounds of N per acre or more on sandy soils, a split application may help reduce leaching losses and seedling injury due to fertilizer salt effects. Placement of fertilizer materials in direct contact with the seed is not recommended. Place fertilizer at least 1 inch from a seed row in medium- to fine-textured soil and at least 2 inches away in sandy soils. In recent Wyoming research, 20 pounds of N per acre placed 2 inches from the seed moderately enhanced emergence in fine-textured soil and slightly reduced emergence in sandy-textured soil (Figure 1). Application rates of 40 pounds of N per acre or greater had no negative effect on seedling emergence in the fine-textured soil, but did reduce the stand substantially in the sandy soil. As a rule of thumb, the sum of N and K_2O in a starter band should not exceed 20 pounds per acre for the typical placement of 2 inches to the side and 2 inches below the seed.

Phosphorus (P)

Beans will usually respond favorably to P fertilizer when soil-test P is low. If broadcasting, incorporate P into the soil before planting. Banding P near the seed row at planting is usually more efficient than broadcasting. Banding can also improve P availability in cool, wet, or compacted soil conditions. Phosphorus fertilizers have a lower salt index than N and potassium (K) materials, but contact between P fertilizers and bean seed should still be avoided.

Response to P is less likely if P or manure has been applied to other crops in the rotation. Probability of P response increases with N application. Avoid excess P because it can induce zinc and/or iron deficiencies. University of Wyoming guidelines for broadcast P applications are shown in Table 2. Fixation reactions reduce the efficiency of P fertilizers and the effect is greater in fine-textured and high-lime soils than in low-lime and coarse-textured soils. To compensate for P fixation, recommended P application rates are adjusted for soil texture as shown in Table 2. Recommended application rates for banded P applications are one half of the broadcast rates because banding slows P fixation by reducing contact between P fertilizers and soil particles.

Figure 1. Seedling emergence as affected by N fertilizer banded 2 inches to the side and 2 inches below dry bean seed at planting time.

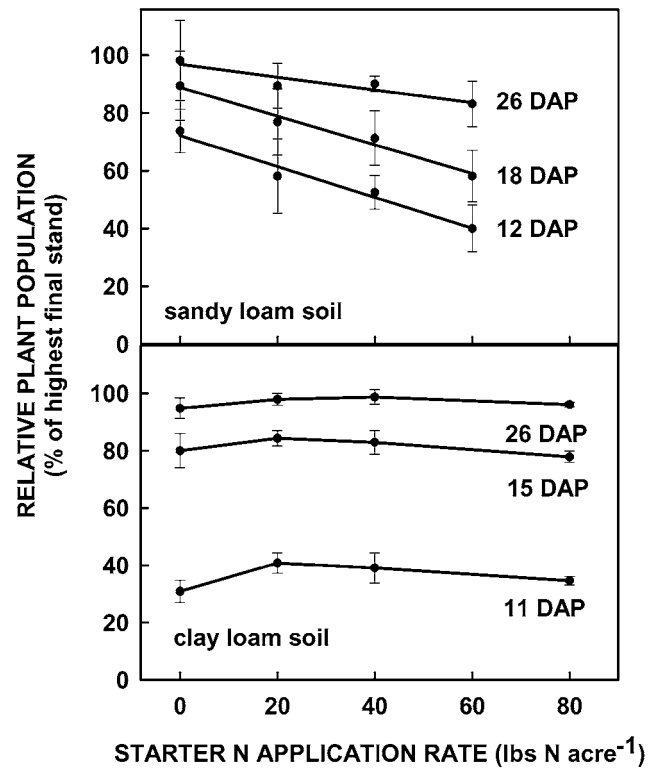


Table 2. Phosphorus fertilizer application guidelines for irrigated dry beans based on soil test P levels (6-inch sampling depth). Recommendations are for broadcast applications; for banded applications, reduce tabular values by 50 percent.

Soil P ^a	Soil Texture		
	Coarse	Medium	Fine or High Lime ^b
ppm	pounds P ₂ O ₅ /acre		
0-6	45	65	90
6-14	0	30	55
14-22	0	0	20
>22	0	0	0

^aP test is by NaHCO₃ extraction (Olsen method).

^bHigh-lime soils are those with a lime equivalent greater than 2 percent.

Table 3. Potassium fertilizer guidelines for irrigated dry beans based on a spring K soil test (6-inch sampling depth).

Soil K ^a	Fertilizer K
ppm	pounds K ₂ O/acre
<60	50
60-120	25
>120	0

^aK test is by AB-DTPA.

Potassium (K)

Potassium fertilizer guidelines are listed in Table 3. Many Wyoming soils are high in K, and beans have a relatively low K requirement. Bean yield responses to K have not been observed in Wyoming research, but if a response is to occur it would be expected primarily with sandy soils. However, crop removal can deplete soil K reserves with time, even on some medium- and fine-textured soils, so it is always a good idea to monitor the K status of the soil with regular soil testing.

When comparing soil test K levels from one year to the next, be sure to know what time of year each sample was collected. Even when no K fertilizer is added, soil test values will vary throughout the year, with the highest levels in the winter and early spring and the lowest levels in the fall. This is partially due to crop uptake,

release of K from minerals, leaching, and differences in soil moisture conditions. Because of this seasonal variation, it may be misleading to compare results from a sample collected in the spring with results from a sample collected in the fall. For best results, always collect samples at the same time of the year.

Zinc (Zn)

Dry beans are sensitive to Zn deficiency. Early deficiency symptoms include mild interveinal yellowing and leaf deformation appearing first on new leaves (Figure 2). As the symptoms progress, necrotic (dead) spots develop, and margins appear lighter in color than the interior of the leaf. Soil conditions such as high pH, low organic matter, coarse texture, high available P, compaction, restricted root zones, and leveled or eroded soils favor development of Zn deficiencies, which can reduce yields and delay crop maturity. Even a mild Zn deficiency can cause maturity delays of several days to a week or more. University of Wyoming Zn guidelines are shown in Table 4. In some situations, a Zn application may be beneficial even in high-testing soils. These situations include high available N or P (either from soil or fertilizer), later-maturing varieties, high soil pH, and cool, wet soils. Research conducted in Wyoming has shown that Zn application can reduce delays in maturity caused by unfavorable soil conditions. Banding Zn near the row at planting is usually more effective than broadcasting and allows use of lower Zn rates.

Figure 2. Visual indications of zinc deficiency in dry bean leaves.



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Table 4. Zinc fertilizer guidelines based on soil test Zn (6-inch sampling depth).

Soil Zn ^a ppm	Fertilizer Zn ^b pounds Zn/acre
<1.0 (<1.5)	10
1.0-1.5 (1.5-2.2)	5
>1.5 (>2.2)	0

^aZn test is by AB-DTPA. Numbers in parentheses are ranges to use for beans following sugar beets.

^bGuidelines for broadcast Zn; rate may be reduced by 50 percent for banded Zn.

Zinc can be supplied by applying soluble Zn salts such as zinc sulfate before or at planting, or if unexpected deficiencies occur during the season, it can be supplied with foliar sprays. Chelates such as zinc ethylenediamine tetra-acetic acid (EDTA) are also available and are effective. They are more expensive per unit of Zn than salt-based fertilizers, but since they are less susceptible to being tied up by soil constituents, the recommended application rate is typically one third of that for zinc sulfate. Foliar applications of a 0.5 to 1.5 percent zinc sulfate solution applied with 20 to 30 gallons of water per acre should correct a moderate mid-season deficiency, but multiple applications may be necessary. For more severe deficiencies, foliar applications may temporarily alleviate visual deficiency symptoms without producing the desired yield response.

Iron (Fe)

Beans are also susceptible to Fe deficiency chlorosis, which is commonly associated with high soil pH, high free calcium carbonate (lime) in the soil, and low soil organic matter. Cool, wet conditions also promote Fe deficiency chlorosis, but symptoms that develop under these circumstances will often disappear as soils warm. Similar to Zn, Fe deficiency is characterized by interveinal yellowing of the new leaves. However, there are some distinct differences in visual symptoms that will help distinguish Fe from Zn deficiency. With Fe deficiency the yellowing is intense (almost white) yet the veins remain distinctively green (Figure 3). As severity increases, small necrotic spots will develop, advancing to larger areas of dead tissue. Persistent chlorosis can reduce yields severely. Iron chlorosis is best treated with foliar applications of iron sulfate or chelates. Soil applications are not usually effective. A 1-percent iron sulfate solution (ferrous form of iron) applied at 20 to 30 gallons per acre will usually correct the chlorosis, but multiple applications in one-week intervals may be necessary. Chelates are very effective and cause less leaf burn, but are more expensive and still must be applied multiple times. The best preventative measure is to plant chlorosis-resistant varieties. Consult with seed company representatives for recommendations regarding varieties appropriate for the area where beans are being grown.

Figure 3. Visual indications of Fe deficiency in dry bean leaves.



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Table 5. Guidelines for collecting dry bean tissue samples and interpreting laboratory results based on accepted critical nutrient ranges (CNR) for N, P, K, and Zn. Any nutrient level that falls below its corresponding CNR is considered deficient. This table is based on information in *Critical Nutrient Ranges in Northwest Crops* (WREP-43).

Nutrient	Growth Stage	Plant Part	CNR	Excess
N	1st trifoliolate leaf (fully expanded)	whole top	3.0-4.0%	—
P	1st trifoliolate leaf (fully expanded)	whole top	0.20-0.30%	—
N	June	recently expanded trifoliolate leaf	4.0-5.0%	—
P	June-July	recently expanded trifoliolate leaf	0.25-0.35%	—
K	early July	whole top	2.6-3.2%	—
Zn	mid season	recently expanded trifoliolate leaf	20-25 ppm	—
Zn	bud stage	whole top	—	>300 ppm

Other Nutrients

Other nutrient deficiencies have not been documented in Wyoming; however, there has been a growing interest in use of sulfur fertilizers for many crops including dry beans. A sulfur response is unlikely on fine-textured soils, but application of 20 to 30 pounds $\text{SO}_4\text{-S}$ per acre is suggested for sandy, low-organic-matter ($\leq 1.0\%$) soils irrigated with low S (≤ 5 ppm) water. If you suspect problems other than those discussed above, contact a UW Cooperative Extension Service office for more information.

Foliar Feeding

Most plants including beans readily absorb nutrients through their leaves. As a result, foliar feeding is an effective way to quickly increase the nutrient content of plant tissue. This approach has proven to be an effective way to correct severe Fe and Zn deficiency symptoms; however, yield increases are not always realized since yield potential has often already been reduced before the appearance of visible deficiency symptoms.

Nutrients have also been applied as a foliar feed during early flowering to eliminate the possibility that undetected nutrient deficiencies may reduce pod set. There has been no research in Wyoming to either support or discredit this practice, and it is not currently recommended by the University of Wyoming. Available research shows that yield responses to foliar feeding are limited to situations where tissue nutrient levels are confirmed to be deficient. Plant nutrient status can be determined by collecting tissue samples from 15 to 20 random locations throughout a field or area of interest and having them analyzed by a reputable laboratory. The information in Table 5 is provided as a guide for collecting samples and interpreting laboratory results. Finally, remember that foliar feeding is not a substitute for maintaining adequate nutrient levels in the soil, but it can be used successfully to supplement a sound fertilizer program.