AGRI-FACTS
Practical Information for Alberta's Agriculture Industry

Revised February 2013 Agdex 142/532-1

# Irrigated Dry Bean Nutrient Requirements for Southern Alberta

Irrigation farmers in southern Alberta have found that dry beans can fit well into their overall crop rotation and farm management program. Dry beans yield very well under irrigation, providing excellent economic returns when grown in the Brown soil zone of southern Alberta. This region has suitable soil and climatic conditions, including the necessary growing degree days and frost-free growing season for successful bean production.

The benefits of including beans in a crop rotation include reduced nitrogen fertilizer requirements compared to cereal and oilseed crops, greater residual soil nitrogen levels for subsequent crops and more diverse crop rotations. These factors help break weed, disease and insect cycles.

This factsheet summarizes fertilizer and nutrient management results to help producers maximize the profitability of beans on their farms and be competitive on the world markets.

*Irrigated dry beans can fit well into an overall crop rotation.*

## Importance of soil sampling and testing

Soil sampling and testing can give an excellent inventory of plant-available nutrients and other soil chemical factors important for crop production. This inventory is a basis for recommending additional nutrients for crop production on an individual field basis.

Soil nutrient levels vary from year to year and may vary within fields, even on fields that seem to be uniform. Producers need to follow certain recommended steps for soil sampling and testing to develop a sound, ongoing soil fertility management program. Poor soil sampling technique is a major problem, which can cause variation in fertilizer recommendations.

Soil testing is only as good as the quality of the soil samples. Soil sampling should be done on an individual field basis. Samples from different fields should not be mixed.

Begin by evaluating each field to determine representative areas. Major areas within fields that have distinctly different soil properties, such as texture, should be sampled and fertilized as separate units due to the variation in soil nutrient availability.

Samples for soil testing should be taken at 0 to 6, 6 to 12 and 12 to 24 inch (0 - 15, 15 - 30 and 30 - 60 cm) depths from at least 20 locations within each field and then bulked into composite samples.

## Inoculant and nitrogen fixation

Rhizobia bacteria infect bean roots and form nodules. The bacteria use energy from the plant and in return, provide nitrogen to the plant. As a result, much of the nitrogen (N) required by beans can be provided from the soil and bacterial fixation, which can greatly reduce, and at times eliminate, the need to add nitrogen fertilizer. Inoculation with the proper strain of *Rhizobium phaseoli* bacteria is essential to ensure fixation.

There are three main types of inoculants:

**Powdered** – fine peat containing the rhizobium, applied directly to the seed.

**Liquid** – contains the rhizobium in a buffered liquid, applied directly to the seed and is held in place using a sticker.

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**Granular –** small, peat-based granules contain the rhizobium, applied in the seed row.

The powdered and liquid forms have been the most commonly used, but granular inoculants are gaining popularity because of their convenience and effectiveness.

It takes three to five weeks after seeding for the bacteria to infect plant roots and form nodules. The effectiveness of the inoculation process can be assessed by simply digging up plants and observing the number, size, colour and distribution of the nodules.

Nodules on roots close to the original location of the seed that are reddish or pink inside indicate the bacteria are functioning and fixing nitrogen. Nodules are likely not fixing nitrogen when they appear white, grey or greenish when cut in half. Nodules widely distributed through the root system would indicate that soil bacteria have also infected the roots. These bacteria may or may not function effectively in fixing N to meet plant requirements.

Soil tests are important in deciding whether or not fertilizer should be applied. Beans are only able to fix 30 to 40 per cent of their total N requirements. Therefore, the remaining N needed must be supplied by the soil from organic matter breakdown (this process is nitrogen mineralization) or from fertilizer.

When growing beans in soils testing less than 80 to 100 lb N/ac, there are times when additional N fertilizer may benefit vegetative growth and help achieve optimum yield. In a cool, wet spring, when nodules are slow to develop, plants may not be able to obtain sufficient N from the soil, resulting in a nitrogen deficiency and delayed crop growth. Therefore, in soils found to be deficient in soil N, a modest application of N fertilizer may be a good investment.

Remember that excess N fertilizer may reduce the amount of N fixed by a legume crop and could delay crop maturity. Mid-season N applications are normally not recommended and until today, have not clearly shown a yield benefit. An exception would be under conditions of failed inoculation and obvious N deficiency.

# Nitrogen and inoculant recommendations

Alberta Agriculture research has shown that response to inoculant is not consistent in increasing crop yield. Generally, the yield benefit of inoculation will range from 2 to 12 per cent.

The benefit of inoculation tends to be reduced when fields with a history of inoculant use from past bean production develop a build-up of rhizobia bacteria in the soil. Therefore, the field history of bean production can have a strong effect on the yield benefit of using an inoculant.

Generally, when beans are inoculated, there is improved root nodulation, but this activity may not result in a yield benefit at the end of the growing season. The practice of adding the rhizobium inoculant with the seed at the time of seeding is recommended as a potentially important management practice.

Traditionally, beans have not been considered a good nitrogen-fixing pulse crop. Field research has shown that optimum yield is generally achieved when the soil N in the 0 to 12 inch (0 - 30 cm) depth plus fertilizer N totalled between 80 to 100 lb N/ac when grown as a row crop (Table 1).

Recently, there has been an increase in growing beans as a solid-seeded crop. When beans are solid seeded, the yield potential is generally slightly higher. For solid-seeded beans, it is recommended that soil N in the 0 to 12 inch (0 - 30 cm) depth plus fertilizer N should total between 100 to 120 lb N/ac (Table 1). It should be noted, the N fertilizer recommendations for solid-seeded beans are preliminary, and field research is ongoing to develop these recommendations further.

The use of an inoculant along with modest nitrogen fertilizer application has proven to be the best approach to optimize bean yields under irrigation in southern Alberta.

**Table 1. Nitrogen fertilizer recommendations for row cropped and solid-seeded irrigated dry beans in southern Alberta**

| Soil test N level (lb/ac - 0 to 12 inches) | Recommended N fertilizer rate | |
|---|---|---|
| | Row cropped | Solid seeded |
| | (lb/ac) | |
| 0 - 10 | 90 | 110 |
| 10 - 20 | 80 | 100 |
| 20 - 30 | 70 | 90 |
| 30 - 40 | 60 | 80 |
| 40 - 50 | 50 | 70 |
| 50 - 60 | 40 | 60 |
| 60 - 70 | 30 | 50 |
| 70 - 80 | 20 | 40 |
| 80 - 90 | 10 | 30 |
| 90-100 | 10 | 20 |
| 100-110 | 0 | 10 |
| 110-120 | 0 | 10 |
| >120 | 0 | 0 |

The information in Table 1 forms the basis for making fertilizer recommendations for southern Alberta bean growers. Generally, most irrigated fields have soil N levels greater than 40 lb N/ac, and therefore, most bean growers would not have to apply more than about 50 to 80 lb N/ac depending on whether beans are grown as a row crop or a solid-seeded crop.

# Phosphorus fertilizer recommendations

Table 2 provides recommendations for phosphate fertilizer based on soil test analysis using the modified Kelowna method. The recommendations in Table 2 are based on banded phosphate fertilizer. Broadcast-incorporated rates should be increased by 1.5 to 2 times to be equally effective on low P soils.

**Table 2. Banded phosphate fertilizer recommendations for beans at various soil test levels based on the modified Kelowna P soil test method**

| Soil test P level (lb/ac - 0 to 6 inches) | Recommended $P_2O_5$ (lb/ac) |
|---|---|
| 0 - 10 | 60 |
| 10 - 20 | 50 |
| 20 - 30 | 40 |
| 30 - 40 | 35 |
| 40 - 50 | 30 |
| 50 - 60 | 25 |
| 60 - 70 | 20 |
| 70 - 80 | 15 |
| >80 | 0 |

# Potassium requirements

Beans tend to have a higher requirement for potassium (K) than cereal crops and often require almost as much potassium as nitrogen. However, only 20 to 25 per cent of the K taken up by a bean plant is contained in the seed at harvest. The remaining K is in the leaves and stems, which are normally returned to the soil.

A soil test attempts to measure the plant-available and exchangeable soil K. The K in soil available to plants is dissolved in soil water, and the exchangeable K is loosely held on the exchange sites on the surface of clay particles. The exchangeable K, which is positively charged (K+), is loosely held on the negatively charged exchange sites on the surface of clay minerals and is referred to as exchangeable K. As the available K dissolved in the soil water is taken up by plant roots, exchangeable K is released into the soil solution to maintain equilibrium between the two forms.

Many southern Alberta soils are medium to high in available and exchangeable potassium, often ranging from 400 to 1,000 lb of K/ac in the 0 to 6 inch (0 - 15 cm) depth of soil. Generally, when soils test greater than 300 lb K/ac, potassium fertilizer is not required. Table 3 provides general recommendations for potassium fertilizer requirements when soils are less than 300 lb K/ac.

If potassium is required, potassium chloride fertilizer (0-0-60) should be applied to correct the deficiency.

**Table 3. General potassium fertilizer recommendations for irrigated dry beans**

| Soil test K level (lb/ac - 0 to 6 inches) | Recommended $K_2O$ (lb/ac) |
|---|---|
| 0 - 50 | 140 |
| 50 - 100 | 120 |
| 100 - 150 | 100 |
| 150 - 200 | 80 |
| 200 - 250 | 60 |
| 250 - 300 | 40 |
| 300-350 | 20 |
| >350 | 0 |

Generally, K deficiencies are most likely to occur on intensively cropped sandy soils. When potassium fertilizer is required, banding K is the most efficient method of application. Therefore, if potassium is required, it may be best to either band it before seeding or side band it at the time of seeding. Broadcast-incorporated K should be increased by 1.5 times to be as effective as banded K application on deficient soils.

# Sulphur recommendations

Sulphur (S) deficiencies are normally not a problem on irrigated soils in southern Alberta. Irrigation water generally contains enough sulphate-sulphur ($SO_4$-S) to meet crop requirements.

Soil sampling and testing can help determine if sulphate-sulphur may be deficient in a field. Soil samples should be taken from the 0 to 6, 6 to 12 and 12 to 24 inch (0 - 15, 15 - 30 and 30 - 60 cm) depths to determine the amounts of S at each depth.

There are times when sulphate-sulphur deficient areas are found on sandy soils or in a small percentage of a field in the surface soil. Sulphate-sulphur deficiencies may occur after heavy precipitation events that could leach the

sulphate from the surface soil into the subsoil. This action can result in the surface soil being deficient in sulphate, yet there may be adequate sulphate in the subsoil.

For example, if such a situation occurs after seeding and plant roots have not penetrated to the 12 to 18 inch (30 to 45 cm) subsoil depth, then sulphate deficiency could potentially occur. This finding makes it rather difficult to determine if sulphur fertilizer is necessary. If sulphur deficient areas are suspected within a field, sample and test different soil areas separately to confirm if a potential deficiency exists.

If soil S levels are less than 20 lb/ac in the top 12 inches (30 cm), Table 4 can be used as a guide to assist in interpreting a soil test as well as to decide if sulphur fertilizer is required and what rates to use. If sulphur is required, apply a sulphate-containing fertilizer such as ammonium sulphate (21-0-0-24) to correct the deficiency.

**Table 4. General sulphate-sulphur fertilizer recommendations for irrigated dry beans**

| Soil test S level (lb/ac - 0 to 12 inches) | Sulphate-sulphur recommendations (lb/ac) |
|---|---|
| 0 - 5 | 25 |
| 5 - 10 | 20 |
| 10 - 15 | 15 |
| 15 - 20 | 10 |
| >20 | 0 |

Elemental S fertilizer products are available, but often the elemental S will not convert to a plant-available form rapidly enough to meet crop requirements in the first year it is applied. Therefore, a fall broadcast application of elemental S, followed by spring incorporation, is best used in a longer term program to build soil S levels.

# Micronutrient fertilizer requirements

Beans require all the essential micronutrients. Some micronutrient research work has been conducted with beans; however, only zinc (Zn) has been identified as being occasionally deficient on coarse textured soils when cropped to beans.

From the research data, Zn fertilizer recommendations have been developed (Table 5). Note that Zn recommendations are based on a very limited amount of field data where bean responses occurred. Recommendations are based on a combination of soil texture and soil analysis of a 0 to 6 inch (0 - 15 cm) soil sample depth using the DTPA extractable zinc method.

**Table 5. Zinc fertilizer recommendations for irrigated dry beans based on soil texture and DTPA extractable zinc**

| Soil texture | Zinc soil test level in ppm (0 - 6 inches) | Zinc recommended |
|---|---|---|
| Medium to fine (loam-clay loam) | >1.5 | No zinc recommended* |
| | 1.0 - 1.5 | 3 lb Zn/ac soil applied or one foliar application |
| | <1.0 | 5 lb Zn/ac soil applied or 1 - 2 foliar applications |
| Coarse (sandy loam to loamy sand) | >2.0 | No zinc recommended* |
| | 1.0 - 2.0 | 3 lb Zn/ac soil applied or one foliar application |
| | <1.0 | 5 lb Zn/ac soil applied or 1 - 2 foliar applications |

* Foliar zinc application may be necessary at soil test levels above the critical level when soil conditions are very cool and wet, reducing Zn availability to the plant.

**On medium to fine textured soil types**, zinc is not recommended above a critical level of 1.5 ppm.

- between 1.0 and 1.5 ppm, 3 lb of soil applied Zn/ac is recommended
- below 1.0 ppm, 5 lb of soil applied Zn/ac is recommended

**On sandy soils (sandy loam to loamy sand)**, zinc is not recommended above a critical level of 2.0 ppm.

- between 1.0 and 2.0 ppm, 3 lb of soil applied Zn/ac is recommended
- below 1.0 ppm, 5 lb of soil applied Zn is recommended

Banding the zinc before or at the time of seeding is the preferred method of application. However, soil-applied zinc sulphate could be substituted for one or two foliar applications. Zinc deficiency can be induced by cool, wet soil conditions in spring, which may reduce soil zinc availability to the crop.

Beans grown in soils that have soil test Zn levels above the critical level may still show visual symptoms of Zn deficiency during wet, cool conditions in June. Beans will often grow out of the deficiency as the weather warms up. However, if cool weather conditions are prolonged, a foliar application could result in a yield benefit.

Previous work with boron (B) and beans in southern Alberta did not result in improved crop growth or yield. However, several locations resulted in a 5 to 15 per cent bean yield reduction to a 3 lb B/ac banded application. Even small applications of B can be potentially toxic to a sensitive crop like beans.

Growers should consult with either a soil or crop specialist before using micronutrient fertilizer with beans.

# Summary

Producers can benefit from using inoculant with beans. However, to reach the full yield potential, additional nitrogen fertilizer is recommended on fields that have less than 80 to 90 lb N/ac in the 0 to 12 inch (0 - 30 cm) depth of soil. A nitrogen fertilizer recommendation chart (Table 1) has been developed for soil testing labs, fertilizer dealers and producers to fine tune nitrogen fertilizer recommendations.

The response to phosphorus fertilizer is generally small, usually due to moderate to higher soil test P levels in irrigated soils. However, phosphorus is very important in bean production, and a maintenance application may be beneficial, even at higher soil test levels. A phosphorus fertilizer recommendation chart (Table 2) was developed from the research data.

Bean research trials in southern Alberta have shown no response to potassium fertilizer. Therefore, an estimated recommendation chart was developed (Table 3), based on theoretical assumptions. Generally, as long as soil test K levels (using the modified Kelowna method) are above 300 lb K/ac, response to K fertilizer is unlikely, based on southern Alberta trials.

Although zinc-deficient soils are not common in southern Alberta, bean response to Zn fertilizer was observed and was clearly prevalent on coarse textured soils. From these trials, a Zn fertilizer recommendation chart (Table 5) was developed, but further research work is needed in the future to refine these recommendations.

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02/13/200