Fertilizing Small Grain

Cooperative Extension South Dakota State University

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The 5.4 million acres of small grain planted annually in South Dakota account for about 37% of the value of all feed grains, cash crops, and hay produced in the state. Proper fertilization of wheat, oats, barley, and rye could add $32 million to net farm income.

Putting your fertilizer dollars on small grain is a "good bet" in South Dakota. Research results from 140 experiments over the past 10-year period show that small grain, fertilized on the basis of soil tests, returned more than $2.40 for each dollar invested in fertilizer. That's a 240% return on investment. In some cases the most profitable response was obtained by applying rates of fertilizer in excess of those recommended from soil tests. This can take place in some years because soil test recommendations are based on average growing conditions and are designed to produce near maximum profits over a period of years.

There may be several reasons why small grain crops respond so consistently to proper fertilization, including the fact that much of the growth takes place in the cool parts of the growing season when available levels of soil nutrients are not maximum. Thus additions of nitrogen (N), phosphorus (P₂O₅), and potassium (K₂O) frequently produce visual fertilizer responses, particularly when available soil reserves are low. Whether or not these initial responses result in increased yields depends on factors such as rainfall, insects, disease, temperature, weed control, and variety.

Many South Dakota soils are no longer able to provide sufficient levels of the essential nutrients required for high profitable yields. The soils have been depleted of nutrients by continuous cropping and soil erosion to such an extent that in many cases low soil fertility limits small grain yields even more than lack of available soil moisture.

**SMALL GRAIN PLANT NUTRIENTS**

Nitrogen and phosphorus are the two nutrients most needed for small grain production in South Dakota. Under certain conditions, the use of potassium may also be justified. If the soil cannot supply sufficient nitrogen, phosphorus, and potassium, supplemental nutrients must be added as fertilizer. At present, addition of other elements is unnecessary for top yields of small grain. Apparently our soils are supplying these nutrients in sufficient quantities in most cases.

**Nitrogen**

South Dakota soils contain between 2,000 and 5,000 pounds of nitrogen per acre in the plow layer. However, most of this nitrogen is "tied up" in the organic matter (decaying crop residue) and is not readily available to plants. About 1 to 1½% of soil nitrogen becomes available to small grain crops each year. The actual percentage depends on soil temperature and moisture.

Estimating the amount of nitrogen provided by soil should be the first step taken in deciding how much nitrogen fertilizer to use. Soil tests, such as that for soil organic matter or nitrates, are useful for estimating soil nitrogen levels. Other factors such as soil moisture, manure applied, and legumes grown will also affect response to nitrogen fertilizer. For this reason they must also be evaluated in planning a fertilizer program for small grain.

**Note:** Nitrogen-deficient small grain fields are easily recognized. The plants are pale yellowish-green and stunted. Severely starved plants can be identified by the yellow leaf tips.

**Phosphorus**

South Dakota soils contain between 1,000 and 2,000 pounds of phosphorus per acre in the plow layer. Both the organic and mineral portions of our soils contain some phosphorus. However, like nitrogen, it is not all readily available for crops to use. Availability of soil phosphorus depends on such factors as soil temperature, moisture, and pH (a measure of acidity or alkalinity). A soil test is the best guide to determine the amount of phosphorus to add for top small grain production.

**Note:** Phosphorus-deficient small grain plants display much less vigor such as slower growth and less tillering. Mild shortages may not cause a color difference. Severe shortages usually cause the leaf tips to turn brown and eventually die. A phosphorus deficiency can be confused with nitrogen deficiency, although a general yellowing of field is normally associated with a lack of nitrogen rather than phosphorus.

**FERTILIZER APPLICATION**

Using a drill attachment, broadcasting prior to seeding, and top-dressing are three common methods of fertilizing small grain. The choice may be dic-
tated by equipment available and kind of fertilizer needed. Excellent equipment is available for applying both liquid and dry fertilizer materials.

**Drill Attachment**

Attachments which place seed and fertilizer together in the same row have increased small grain yields more than any other method of fertilizer application. In some experiments where phosphorus fertilizer increased small grain yields, a grain drill attachment more than doubled the yield increases over those obtained when phosphorus was broadcast and incorporated ahead of seeding. The average yield increase from fertilizer applied with the drill attachment (table 1) was 5.2 bushels per acre, whereas broadcasting increased yields by only 2.5 bushels per acre.

**Table 1. Effect of Broadcast and Drill Applied Phosphate Fertilizer on Small Grain Yield (Average of 16 experiments)**

<table>
<thead>
<tr>
<th>Method of Placement</th>
<th>Check Yield Bu./A</th>
<th>Fertilized Yield Bu.</th>
<th>Yield Increase Bu.</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drill Attachment</td>
<td>25.5</td>
<td>30.7</td>
<td>5.2</td>
<td>20.4</td>
</tr>
<tr>
<td>Broadcast</td>
<td>25.5</td>
<td>28.0</td>
<td>2.5</td>
<td>9.8</td>
</tr>
</tbody>
</table>

*Barley and oats adjusted to 60-pound bushels.
†Experiments that responded to P treatment, rates were similar within any one experiment.

Phosphorus and potassium fertilizers applied with a drill attachment apparently are used more effectively by small grain crops than those broadcast. Nitrogen fertilizers may be applied with a drill attachment, however, other methods such as preplant or broadcast and plow down may be equally effective. The following caution points out a condition where separate broadcast applications of nitrogen fertilizer should be made.

**Caution:** Drilling more than 40 pounds total of actual nitrogen and potassium per acre combined with seed in 6-inch rows (20 pounds in 12-inch rows) can cause germination damage.

**Broadcast Before Seeding**

Broadcasting fertilizer is one of the most economical methods of application; however, it’s not the most profitable. It is acceptable for applying nitrogen. It is also suitable for applying phosphorus and potassium. However, higher rates are recommended to produce yield increases equal to those obtained when phosphorus and potassium are drilled with the seed (tables 2 and 3).

Phosphorus and potassium move only short distances from where applied. Therefore, they should be placed in a soil area that is suitable for root development. Plowing is the best way to work broadcast fertilizer into the soil. Disking is a very poor second choice because of the shallow placement. This usually means that phosphorus and potassium are not readily available when the top few inches of soil dry out. Soil incorporation of fertilizer shortly after application will also help prevent the gaseous loss of nitrogen and the loss of fertilizer material through water erosion.

**Table 2. Phosphorus Recommendations for Small Grain Based on Soil Test**

<table>
<thead>
<tr>
<th>Soil Test Value Lbs. P/A</th>
<th>Phosphorus Recommendations Lbs. P.O. (P)/A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>45 (20) - 60 (26)</td>
</tr>
<tr>
<td>6-15</td>
<td>30 (13) - 45 (20)</td>
</tr>
<tr>
<td>16-25</td>
<td>20 (9) - 30 (13)</td>
</tr>
<tr>
<td>26-40</td>
<td>15 (9) - 0</td>
</tr>
<tr>
<td>41+</td>
<td>0 - 0</td>
</tr>
</tbody>
</table>

General Broadcast Phosphorus Recommendation: 30 to 40 pounds phosphorus (P₂O₅)—or 20 to 30 pounds drill attachment.

**Table 3. Potassium Recommendations for Small Grain Based on Soil Test**

<table>
<thead>
<tr>
<th>Soil Test Values Lbs. K/A</th>
<th>Potassium Recommendations Lbs. K₂O (K)/A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-180</td>
<td>30 (25) - 45 (37)</td>
</tr>
<tr>
<td>81-150</td>
<td>20 (17) - 30 (25)</td>
</tr>
<tr>
<td>151+</td>
<td>0 - 0</td>
</tr>
</tbody>
</table>

General Broadcast Recommendation: 0 pounds potassium (K₂O).

**Top-Dressing**

Application of fertilizer on a growing crop is called top-dressing. It is satisfactory for applying nitrogen fertilizer, correcting a nitrogen deficient condition, or where preplant applications were not possible. When it is necessary, satisfactory results can be expected up to 30 days after planting, provided sufficient rainfall occurs to carry the nitrogen into the soil. Top-dressing is not a satisfactory way of applying phosphorus and potassium on small grains.

**Fertilizer Recommendations**

Fertilizer recommendations are based on soil tests that are related to fertilizer response in the field. A soil test is of little value if it is not based on research from field trials.

The nitrogen-supplying ability of the soil is evaluated with an organic matter test because the ability of a soil to furnish nitrogen for crop growth depends on the release of nitrogen from organic matter. Manure, legumes, and summer fallow also affect the amount of nitrogen available for plant growth and these factors need to be considered when making recommendations. (See sections 15, 17, and 18 of Agronomy Pamphlet No. 31, “Explanation of Soil Tests” for a detailed discussion of summer fallow, manure, and legumes.)
The phosphorus-supplying ability of a soil is evaluated by measuring the amount of soil phosphorus extracted with a dilute hydrochloric acid-ammonium fluoride solution and relating these values to response of phosphorus fertilizer in the field. There is excellent correlation between the phosphorus soil test and field response to applications of phosphorus fertilizer on small grain.

Recommended rates of phosphorus and potassium fertilizer according to soil tests are shown in tables 2 and 3. The nitrogen recommendations are based on yield potentials shown in table 4. Figure 1 identifies the areas of the state to which these yield potentials pertain.

Table 4. Nitrogen Recommendations for Small Grain Based on Soil Test

<table>
<thead>
<tr>
<th>Soil Test Area of South Dakota</th>
<th>Nitrogen Recommendations (Lbs. N/ A.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Matter %</td>
<td>A</td>
</tr>
<tr>
<td>0-2.0</td>
<td>60</td>
</tr>
<tr>
<td>2.1-2.5</td>
<td>55</td>
</tr>
<tr>
<td>2.6-3.0</td>
<td>50</td>
</tr>
<tr>
<td>3.1-3.5</td>
<td>45</td>
</tr>
<tr>
<td>3.6-4.0</td>
<td>40</td>
</tr>
<tr>
<td>4.1+</td>
<td>35</td>
</tr>
</tbody>
</table>

Yield Potential (bu. / A.)*

- Barley: 60 60 45 45 35
- Oats: 80 80 55 55 40
- Wheat: 35 35 25 30 25

*See figure 1.

General Broadcast Recommendations: 30 to 50 pounds of nitrogen and 30 to 40 pounds of phosphorus (P₂O₅).

Spring Seeded Small Grain

Summer Fallow. Summer fallowing stores moisture by eliminating plant growth during one season. Nutrients are also stored during this period. Consequently, there is generally less need for fertilizer on summer fallow. No nitrogen is recommended for fallowed small grain when the soil organic matter content is above 2% (table 4). At present, phosphorus and potassium recommendations (tables 2 and 3) are not altered for fallow because the “build-up” of available phosphorus and potassium during the fallow period should be detected in the soil test.

Continuous Cropping. Spring seeded small grain planted on nonfallow land usually requires more nitrogen than that planted on fallowed land. Therefore, some nitrogen is needed at all levels of organic matter (table 4). The phosphorus recommendations (table 2) are the same for both fallow and continuous cropping.

Winter Wheat

Most winter wheat is seeded on summer fallowed land which stores moisture and tends to accumulate nutrients in the soil. Phosphorus “build up” should show up in a soil test. Consequently, it is not necessary to adjust the phosphorus recommendation for fallow and nonfallow conditions (table 2).

On the other hand, nitrogen “build up” will not be detected by a nitrogen soil test which measures soil organic matter. Thus, the nitrogen recommendations are adjusted for fallow and nonfallow conditions (table 4).

Malting Barley

Fertilizing malting barley is a special situation because the brewing industry requires that the protein content of the grain not exceed 13.5%. This suggests that nitrogen fertilization of malting barley might be undesirable. However, research indicates that recommended rates of nitrogen fertilizer can be used on malting barley without greatly increasing the protein content if proper amounts of phosphorus and potassium are applied and the barley seeded early. Recommended rates of application are shown in tables 2, 3, and 4.
SOIL TEST

A soil test provides information needed to evaluate the fertility status of a soil and to help plan and maintain a good soil management program. Evaluation of specific crop requirements, past cropping history, and physical soil characteristics are used along with the soil test information to determine the amount and combination of nutrients needed for a certain crop or cropping sequence.

Your County Extension office has information on testing procedures, cartons for mailing, plus the information forms needed in submitting the sample. A detailed special publication, “Explanation of Soil Test Recommendation,” is returned with your soil test results and recommendations.