Fertilizer Application with Small Grain Seed at Planting

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Applying fertilizer with the seed at planting is one successful soil management practice that has long been recognized as a means to improve crop yields. Grain drills with fertilizer attachments eventually enabled the farmer to apply a small amount of fertilizer with the seed and plant in one operation.

A common practice in the Northern Great Plains dryland small grain production area is to apply 50 pounds per acre of 18-46-0 ($N+P_20_5+K_20$) fertilizer with the seed at planting. This practice provides 9 pounds per acre nitrogen (**N**) and 23 pounds per acre of P_2O_5 as phosphorus (10 pounds **P** per acre) as a starter fertilizer which improves early root and plant growth on low to medium testing soils. The starter fertilizer also has the potential to enhance plant development early in the spring, when soil temperatures are normally low and soil nutrient availability to a young root system is lower.

Higher yields with advances in soil management, improved varieties, a decline in soil organic matter, and a reduction in the use of summerfallow have increased the need for fertilizer, particularly **N**. Many, if not most, fields require more fertilizer than can be applied with the seed. Application of higher rates of fertilizer with the seed at planting often causes severe germination damage, low seedling emergence and poor stands with subsequent yield loss. The general recommendation for small grains, to limit seedling damage, was not to apply more than 20 to 30 pounds per acre of **N** plus K_2O with the seed at planting. Additional fertilizer (**NPK**) required for maximum yields was then applied in another operation, either broadcast or banded.

Although the broadcast and band application of fertilizers have been successful soil fertilizer management practices, there has been a resurgence of interest in applying higher rates of fertilizer with the seed, especially **N**. This interest has been driven by a desire to [1] reduce the number of field operations, [2] emphasize conservation tillage to improve soil water management, [3] reduce erosion by maintaining adequate residue on the soil surface, and [4] use high residue seeding equipment, like hoe drills and especially airseeders, that utilize a higher portion of the seedbed than the traditional double disk drill.

The question is continually being asked, how much **N** can be safely applied with small grain seed at planting time? The general recommendation of 20 to 30 pounds per acre of **N** + K_2O would probably hold true. However, many factors influence the actual rate to apply, and these factors may vary with specific conditions or locations. Some site specific factors that need to be considered when determining the rate of N to apply with the seed include **row spacing, seed furrow opener type, seedbed utilized** (width of seed spread), **soil texture, soil pH, soil water, precipitation, fertilizer placement, fertilizer form, fertilizer material and crop**.

Row Spacing

Row spacing is generally controlled by the type of seeding equipment. Some normal row spacings found on various seeding equipment include 6, 7, 7.5, 10, 12, 14, 16, 20, 22, and 30 inches. Row spacing is usually set by the equipment manufacturer specific for the particular crops to be planted. Wider row spacings are often achieved with narrow row spacing equipment by plugging some of the seeding units that meter the seed to the openers. The rate per acre of **N** that can safely be applied with the seed will decrease as the row spacing increases, because at a given rate per acre, the fertilizer is more concentrated and thus more fertilizer is in direct contact with the seed. Some seeding equipment may be designed with a variety of seed openers.

Seed Opener

The seed opener refers to the method used to place the seed into the soil. The main categories of seed openers include single-disc, double-disc, offset double-disc, disc-shoe, hoe and sweep or wide shovel which progressively disturb more soil at the time of seeding. The more soil disturbance the higher the rate of fertilizer that can be safely applied with the seed because more soil mixing occurs and less fertilizer remains in direct contact with the seed. The seed opener used on a particular piece of seeding equipment may dictate the row spacing allowed, since close spaced rows on the front gang of openers may be covered by the rear gang with more soil disturbance. Thus the seedbed utilized (**SU**) becomes one factor controlling the amount of fertilizer that can be safely applied with the seed at planting.

Seedbed Utilized

The amount or percent of seedbed that is utilized is determined by the row spacing, the particular type of opener which controls the soil disturbance, and the actual width or spread of the seed within the area of soil disturbance.
SU can be calculated by the following formula:

$$\text{Seed spread (in.)} = \frac{\text{\% seedbed utilized (SU)}}{\text{Row spacing (in.)}} \times 100$$

The typical double disk opener disturbs about 1 inch of soil and the seed is placed or spread in the same 1 inch. The **SU** for a double disk opener with 6-inch row spacing would be approximately 17 percent. Hoe openers, depending on size, width and depth of seeding, will disturb 2 to 5 inches of soil and normally spread the seed 2 to 3 inches. A hoe opener with 10-inch row spacing that spreads the seed 3 inches would have an **SU** value of 30 percent. The wide shovel or sweep opener, normally associated with air seeder units, will disturb soil as wide as the sweep, and the seed spread will depend on the type of spreader attached to the rear of the sweep on the tillage shank. A chisel plow with 12-inch spaced shanks and 12-inch sweeps that spreads the seed over a 6-inch band would have an **SU** value of 50 percent.

The rate of fertilizer that can be applied with the seed will vary based on the calculated **SU** value. The higher the value of **SU**, the higher the rate of fertilizer that can be applied with the seed at planting. The maximum rate of **N** fertilizer that can be applied with the seed at planting based on selected row spacings and **SU** can be found in **Table 1** for the double disk, hoe and wide shovel airseeder with various widths (inches) of seedbed utilized.

Soil Texture

Soil texture refers to the percentage of sand, silt, or clay in the soil. Coarse texture soils, loamy sand or sandy loam, contain a high proportion of sand. Fine texture soils, clay loam or clay, contain a high proportion of clay. Medium texture soils, loam and silt loam, contain a higher proportion of silt.

Soil texture influences the amount of fertilizer that can be applied with the seed at planting in two ways. Texture determines (1) the amount of water retained by the soil and (2) the cation exchange capacity (**CEC**) or the ability of the soil to adsorb the damaging ammonia ions (**NH_3**) released by nitrogen fertilizers.

Coarse texture soils have low water retention and low **CEC**, so seed germination damage will be greater on these soils, for the same fertilizer rate, than fine texture soils that have high water retention and high **CEC**. **Table 2**
gives a range of the amount of nitrogen fertilizer that can be successfully applied with the seed at planting based on soil texture and the **SU** for the double disk, hoe and air seeder type openers.

Soil Water

Soil water influences the amount of damage caused by fertilizer applied with the seed in two ways. First, the free ammonia released by N fertilizer materials has a high affinity for water. The water molecules in the soil essentially combine with the **NH_3**, reducing the damaging effect on the seed. Dry soils, as a result of texture or climatic conditions, contain little water and the excess **NH_3** (not adsorbed by the soil exchange sites) moves easily through the cell walls into the seed, actually seeking out the water in the seed embryo to cause damage.

Second, fertilizer placed in direct contact with the seed can also have a salt effect (burning). In dry soils, water in the seed embryo can actually move outward to dehydrate the seed or the soil water can be absorbed by the fertilizer material, then adequate water is not available for the seed to germinate. Rates of fertilizer placed with the seed at planting must be reduced under dry soil conditions.

Another important factor in relation to soil water is whether precipitation is received soon after planting. Since this cannot be predicted, the recommended amount of **N** applied with the seed should be on the conservative side, especially with urea as the fertilizer source. Circular SF-712, Fertilizing Wheat and Rye, recommends 15 lbs **N** per acre when using urea and 6 to 7-inch row spacing and to not use urea with wider spacing when using a double disk opener.

Fertilizer Placement

The distance the fertilizer is placed from the seed can have a tremendous effect on the rate of fertilizer placed with the seed at planting. Fertilizer placed in a narrow band in direct contact with the seed will have the greatest potential for damage. Damage decreases as the distance from the seed is increased.

This is partially related to **SU**, since greater soil-seed-fertilizer mixing action occurs as the seed and fertilizer is spread out. This can be observed by the diagrams in **Figure 1** which show a comparison between narrow placement and three types of different seed and fertilizer distribution patterns.

The area of fertilizer release will have an effect on placement and mixing of fertilizer in the soil. If the fertilizer is in the same flow pattern as the seed, little mixing occurs unless a spread pattern is employed. However, if the fertilizer is released separate from the seed, to the side, below or behind the seed, greater soil mixing will occur, reducing the potential for fertilizer damage. Type of fertilizer material (granular, liquid, or gas) can also affect the desired distance fertilizer is placed from the seed.

Fertilizer Material

Nitrogen fertilizer is manufactured as dry granular materials (ammonium nitrate or urea being the most common forms), liquid materials (aqua ammonia or nitrogen solutions) and gas (anhydrous ammonia). Granular materials remain and react close to the area where placed. If the granular material is adequately mixed with the soil, the germination damage is minimized. Liquid and especially gaseous materials will move farther in the soil from the point of placement.

N movement in the soil is controlled by texture, which determines the voids or pore space where water or air can move. Liquid and gaseous materials can be placed away from the seed and still move to the seed to cause damage. The extent of the damage is controlled by the reaction of the fertilizer with the soil and water, which are controlled by texture. Greater movement and germination damage is caused on coarse textured soils. Germination damage is also controlled by the fertilizer form.

Fertilizer Form

Fertilizers can damage the seed in two ways. The first, and most serious, way that fertilizers damage the seed is by specific toxicity. For most **N** fertilizers, ammonia (NH_3) toxicity is the largest factor that causes seed damage. The second way is by salt damage. All commercial fertilizers dissolve in water and make the soil solution saltier near the point of application. Fertilizers like potassium chloride (potash) and ammonium nitrate can injure the seed by the salt effect. Most phosphate fertilizers have a minimal salt effect.

Fertilizer form controls the amount of nitrogen that is released into the soil as NH_3. The NH_3 causes severe injury when in close proximity to the seed. The greatest potential for germination damage occurs with anhydrous ammonia because it is released into the soil as NH_3.

Urea fertilizer has the next highest potential to lower seed germination. Although urea is not an ammonium fertilizer when applied in the granular form, it quickly hydrolyzes to ammonium carbonate in the presence of the urease enzyme commonly found in soil. The ammonium carbonate is unstable and quickly decomposes to release NH_3.

Ammonium nitrate has the least potential for damaging seed because this granular material contains both ammonium (50 percent) and nitrate (50 percent). The nitrate nitrogen form, in comparison to the ammonia, has less effect on seed germination.

Liquid nitrogen materials are nonpressure solutions that contain mixtures of water, ammonium nitrate, urea and ammonia. Liquids contain no free **NH_3** and generally have lower potential for germination damage, but this depends on the proportion of each fertilizer form in the solution and their respective reaction in the soil.

At high application rates of fertilizer with the seed, the salt injury or "burn" can contribute to germination damage. Fertilizers increase the salt content in the soil solution, which influences the osmotic pressure, which in effect causes water movement from a lower to a higher salt concentration. Water moves out of the seed to the fertilizer pellet, actually drying out the seed and causing "burn" which lowers germination.

A salt index per unit of plant nutrients is given to various fertilizer sources. Nitrogen and potassium fertilizers have a higher salt index than phosphorus fertilizers. Higher analysis fertilizers generally have a lower salt index because less material is applied for the same amount of nutrients. Anhydrous ammonia, ammonium nitrate and urea have a salt index of 0.6, 3.0 and 1.6, respectively.

As higher rates of fertilizer are applied with the seed at planting, the salt effect, in addition to the **NH_3** effect, becomes a more important factor in determining the amount of germination damage.

Crop

The amount of germination damage caused by application of fertilizer with the seed at planting depends somewhat on the crop species. Some crop seeds are more sensitive to **NH_3** and salt injury as a result of their size, seed coat type, and water content.

Limited information is available on how specific crop seeds react to fertilizer applications with the seed. In general, small grain crops (wheat, barley and oats) are able to tolerate higher rates of N fertilizer with the seed than corn or soybeans, which are more sensitive. Small seeded crops (canola, mustard, flax, and millet) and coated seeds (sunflower) are probably inter-mediate in the amount of germination damage expected from high rates of fertilizer close to the seed. Sugarbeet seed is very susceptible to fertilizer injury. Additional research is needed to make recommendations for these specific crops and caution should be exercised with crops other than small grains.

Summary

The amount of germination damage associated with applications of fertilizer with the seed at planting will vary with seasonal or yearly climatic conditions and among or between locations. Growers should consider all factors that influence germination damage when determining the amount of **N** fertilizer to apply with the seed at planting. **Tables 1** and **2** are provided as general guidelines for the amount of N fertilizer to apply with the seed at planting based on only soil texture and seedbed utilization factors. Rates may need to be adjusted upward or downward based on the grower's specific conditions at planting related to soil water, fertilizer material and crop seeded.

Selected References

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Table 1.Maximum nitrogen fertilizer rates with small grain seed at planting based on planter spacing, planter type and seedbed utilization.

Planter Spacing

Planter Seed ------**6 Inch**------ -----**7.5 Inch**----- -----**10 Inch**----- -----**12 Inch**-----

Type Spread SU lb N / Ac SU lb N / Ac SU lb N / Ac SU lb N / Ac

(inches)

Double

disc 1 17% 20-30 13% 19-28 10% 17-23 8% 15-20

Hoe 2 33% 32-44 27% 27-38 20% 23-31 17% 20-27

3 50% 44-58 40% 37-48 30% 30-40 25% 26-34

Air 4 66% 56-72 53% 46-58 40% 37-48 33% 32-42

seeder 5 83% 68-86 68% 56-68 50% 44-57 44% 38-49

6 100% 80-100 80% 66-79 60% 51-55 50% 44-56

7 94% 76-90 70% 58-74 58% 50-64

8 80% 66-83 67% 56-71

9 90% 73-92 75% 62-78

10 100% 80-100 83% 68-86

11 92% 74-93

12 100% 80-100

SU=Seedbeed utilized

Table 2.Maximum nitrogen fertilizer rates with small grain seed at planting based on soil texture and seeded utilization.

Percent of Seedbed Utilized

10-20 30-50 60-100

Particle Size Double Disc Hoe Air Seeder

Soil Texture Sand Silt Clay 1 inch 2-3 Inch 4-12 Inch

------------ **Percent** ------------ ------------------------- **lb N per acre** -------------------------

Loamy sand 80 10 10 5 10-20 25-40

Sandy loam 60 35 15 10 15-25 30-45

Sandy clay loam 55 15 30 15 20-30 35-50

Loam 40 40 20 20 25-35 40-55

Silt loam 20 65 15 25 30-40 45-60

Silty clay loam 10 55 35 30 35-45 50-70

Clay loam 30 30 40 35 40-50 55-80

Clay 20 20 60 40 45-55 60-100

Figure 1.Four distribution patterns of fertilizer placed with the seed at planting.

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