Chapter 7: Fertilizing Sunflower

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Sunflower can grow in a wide range of soil conditions. However, it grows best on well-drained medium-fine textured soils (e.g., loam, clay loam soil) with near neutral soil pH (6.5 – 7.5). Keeping soil pH near neutral will also provide better nutrient availability from the soil compared to more acidic (pH<6.0) conditions. Sunflowers remove more nutrients from the soil as yield increases. In producing 100 lbs/ac of sunflower seeds, the plant needs to take up approximately 5 lbs of N, 2.5 lbs of P_2O_5, and 3.5 lbs of K_2O (IPNI, 2012).

Starter Fertilizer

Sunflower seeds are very sensitive to fertilizer salts. When planted in 30-inch rows, do not apply fertilizer in contact with the seed. Limit seed placed N + K to 5 lbs/ac when planted in 15-inch rows, and 10 lbs/ac when using 7-inch rows. Urea-based fertilizers, UAN, DAP (18-46-0) or thiosulphate should not be placed in contact with the seed.

Nitrogen

Soil testing is the most reliable method for determining fertilizer needs. Nitrogen (N) is generally the most limiting nutrient for sunflower production. A typical approach to determining N needs in crops is to use a yield response formula and subtract credits of soil test nitrate-N amounts and credits from a previous legume crop. The following equation is currently used to determine N fertilizer rate for sunflower: Yield goal (lbs/ac) × 0.05 – soil test nitrate-N (lbs N/ac) – legume credit + 30 lbs N/ac if using no-till.

Determining a “realistic” yield goal for sunflowers is important to achieve the most accurate N fertilizer rate. To determine a realistic yield goal, follow these four steps. First, gather yield data from the past five to 10 years. Second, delete obvious high and low yields. Third, average the remaining yields. Fourth, if soil moisture conditions are near field capacity (the amount of water the soil can hold without water moving down the soil profile), then increase the average yield by 6 to 10%. If the soil moisture conditions are poor (dry), then reduce the average yield by 6 to 10%. The percentage yield increase or decrease can vary by field, zone, or grid and gives you control of what you expect to see in the coming year. In most years, it is good to increase the value by 5 to 10% because it allows for the increasing yield trend we normally see from year to year. Overall, we want to make sure the yield goal is the yield you can most likely achieve (Table 7.1).

Table 7.1. Example of determining sunflower yield goal in moist and dry conditions.

Year	Yield (lbs/ac)
1	1,760
2	1,830
3	1,840
4	1,670
5	~~1,530~~ too low
6	1,680
7	1,740
8	~~2,060~~ too high
9	1,988
10	1,770
Average	1,790

Yield goal with moist conditions
(+6%) = 1,790 + (1,790 × 0.06) = 1,897
Yield goal with dry conditions
(-6%) = 1,790 – (1,790 × 0.06) = 1,683

In using the current yield goal-based equation and yields from the 2018 and 2019 sunflower hybrid yield trials in South Dakota (987 to 2,957 lbs/ac), soil test nitrate-N + N fertilizer-N recommendations would range from 50 to 150 lbs N/ac with a mean of 95 lbs N/ac. These values would decrease depending on soil test nitrate-N level (if soil test nitrate-N is unknown, use 40 lbs N/ac) and legume credits and increase if using no-till.

Recent South Dakota fertilizer-N response studies found an economically optimal fertilizer-N rate of approximately 80 lbs N/ac was very common regardless of sunflower yield. It is important to note that sunflowers are sensitive to over application of N. Recent studies in North Dakota and South Dakota found very little yield increase (and often a decrease) with fertilizer-N application rates significantly over 100 lbs N/ac. The small increase in yield with greater N rates shown in figure 1 was not statistically significant. Typically, as more N was available to the crop, plant biomass increased, resulting in larger leaves and taller stalks. However, total seed yield did not increase. Studies from North Dakota indicated that reduced sunflower yield with higher fertilizer-N rates was likely due to increased lodging severity and disease susceptibility. Additionally, recent studies from South Dakota showed that the oil content of sunflower seeds decreased with increasing fertilizer-N rates.

Most growers are concerned about lodging of sunflowers and the reduction of oil content of oil-seed sunflowers, which has been shown to be highly correlated to fertilizer-N rate. Therefore, the soil test nitrate-N + fertilizer-N level (Total required N) is capped at 150 lbs N/ac even though there may be small yield increases above this level in some years. Therefore, the new sunflower fertilizer-N recommendation is as follows:

1. Yield Goal × 0.05 = Total required N (soil test nitrate-N + fertilizer N). If this value is above 150 lbs N/ac, then it should be reduced to 150.
2. Total required N – soil test nitrate-N (lbs N/ac) – legume credit (lbs N/ac) + 30 lbs N/ac if using no-till.
    a. For legume credits see table 7.2.
    b. Recent research in South Dakota showed that in long-term no-till fields the additional 30 lbs N/ac is no longer needed. However, research is still on going to determine what length of time or level of soil quality is required before this additional N requirement can be dropped.

Example:

- Yield goal: 1,900 lbs/ac.
- Soil test results: 15 lbs nitrate-N available in the top two ft.
- Previous crop: Soybean. Therefore a 40 lb/ac N credit will be used.
- Tillage: Recent conversion to no-till. Therefore 30 lbs N/ac will be added to the N recommendation.

Yield goal is multiplied by 0.05 to determine total required N. If this value is above 150, it is reduced to 150. Next, from the total required N value, soil test nitrate-N (15 lbs/ac) and legume credit (40 lbs/ac) are subtracted and 30 lbs N/ac is added because we recently converted to no-till. The resulting N recommendation is 70 lbs N/ac.

1. **1,900 lbs/ac yield goal × 0.05 = 95 lbs of total N required**
2. **95 lbs of total required N – 15 lbs N/ac soil test credit – 40 lbs N/ac legume credit + 30 lbs N/ac no-till debit = 70 lbs N/ac recommendation.**

Properly crediting soil nitrate-N can be difficult when producing sunflowers because active roots go down 4 to 6 feet and soil N is typically assessed from a 0 to 24 inches soil sample (Table 7.2). These deep-rooted sunflowers can also utilize N from deeper parts of the soil profile than other crops. Thus, sunflowers

will often yield greater than the yield goal for a given N application rate. If possible, sunflower fields should be soil sampled to a 4-feet deep depth to assess the amount of N below 2-feet that can be accessed by the deep-rooting sunflower plants. This is especially helpful in new sunflower fields and when other deep-rooted crops, such as safflower have not been planted previously.

Table 7.2. Legume nitrogen (N) credits.

Previous Crop	Plants/ sq. ft.	Nitrogen Credit (lbs/ac)
Soybean, edible beans, peas, lentils, and other annual legumes	N/A	40
Alfalfa and legume green manure crops (sweet clover, red clover, etc.)[1] [2]	> 5	150
	3–5	100
	1–2	50
	< 1	0

[1] When no-tilling into alfalfa and legume green manure crops, use half credit.
[2] For 2nd year following alfalfa and legume green manure crops, use half credit.

Fertilizer-N Application Timing and N inhibitors

Split-N application, in theory, should be beneficial compared to a single at-planting fertilizer-N application as only a portion of the fertilizer-N provided to the sunflower would be susceptible to early season N losses. However, a study in South Dakota showed little yield difference between a single near-planting N application and when half of the total fertilizer N was applied at planting and the other half at V4 or R1 growth stage.

Urease inhibitors slow the conversion of urea to inorganic N, which protects it from environmental losses (volatilization, leaching, denitrification). Recent research found a trend towards greater seed yield and fertilizer-N uptake when using a urease inhibitor compared to a split-application or single application without an inhibitor. These results indicate when urea is used as the N source, a urease inhibitor could be an effective tool to produce sunflower in environmentally sensitive areas and reduce the need to apply fertilizer-N near planting and during the growing season.

Minimal differences have been found among N fertilizer materials when N products are properly applied. Therefore, N source decisions can be made based on availability, cost, and equipment.

Phosphorus

Phosphorus (P) removal by sunflower is generally very low and its extensive root system scavenges residual P effectively. Hence, response to P fertilization by sunflower in U.S. studies has been minimal even when following fallow. Phosphorus fertilizer application should be based on soil testing and only applied when soil test levels fall in the low to very low categories (Table 7.3). Additionally, recent studies have shown that it is likely more economically effective to focus on applying P fertilizer to the crop after sunflower. Therefore, the sunflower P fertilizer recommendation is zero.

Potassium

Potassium (K) fertilizer application should be based on soil testing and only applied when soil test levels are medium to very low. This level of soil test K normally only occurs in sandy soils. Potassium rate trials for sunflower have not been conducted in South Dakota to determine the level at which no yield increase is likely to occur. In other areas of the U.S., a soil test level of 160 parts per million is considered sufficient to maximize sunflower yield. This correlates well with data from our corn K rate studies that also has a sufficiency level of

Table 7.3. Soil test calibration levels used to determine the probability of response to fertilizer applications.

Nutrient	Soil Test	Very low	Low	Medium	High	Very high
Probability of response		80%	60-80%	40-60%	20-40%	< 20%
ppm extractable (0-6 inches)						
Phosphorus	Olsen-P	0-3	4-7	8-11	12-15	16+
Phosphorus	Bray P-1	0-5	6-10	11-15	16-20	21+
Potassium	NH_4 Acetate	0-40	41-80	81-120	121-160	161+
lbs/ac (0-2 feet)						
Sulfur	500 ppm P	0-9	10-19	20-29	30-39	40+

160 parts per million K. Few instances of K deficiency occur in South Dakota as the areas of the state where sunflower is most frequently planted have inherently high levels of K that are normally above 160 parts per million. However, when soil test levels fall below 160 parts per million a minimum of 60 lbs K/ac is recommended to optimize sunflower yield.

On most soils, banding of K near the seed is most efficient as K moves very little in soil, but it can also be broadcast and incorporated before planting. Refer to the starter fertilizer section to make sure N and K rates in starter fertilizers are not high enough to reduce seed germination. There are minimal differences in K availability among K fertilizers therefore any K fertilizer can be used without negatively affecting sunflower production.

Sulfur

Sulfur (S) fertilizer application is based on soil texture, tillage, and soil test level of the top 2 feet. Coarse textured soils are the most susceptible to S deficiency. Use table 7.4 as a guide to determine fertilizer S rate to apply to your field.

These S rates should be broadcast applied or a reduced rate of 10 to 15 lbs actual S/ac can be applied in the row or with the drill. Sulfur is a mobile nutrient and thus should be applied in the spring. Fall applications are not recommended as S can be leached below the rooting zone from winter and spring rainfall events. Sulfate forms of sulfur (ammonium sulfate 24% S, gypsum 18% S, and potassium sulfate 17% S) are the best sources for immediate effectiveness. Sulfur as a thiosulphate is also a good option but should NOT be applied with the seed as noted in the starter fertilizer section. Elemental S is not recommended as it requires 1 to 3 months in warm soil before it is completely available.

Other Nutrients

Other secondary and micronutrient deficiencies in sunflower are rare and have not been reported in sunflowers grown in South Dakota. The lack of deficiencies of these other nutrients may be due to the extensive root system of sunflowers. Deficiency symptoms of secondary and micronutrients are often only seen in sensitive crops such as corn, sorghum, edible beans, flax, and potatoes. Iron deficiency at the seedling stage of sunflowers results in interveinal chlorosis of the youngest leaves and plants are stunted. Zinc deficiency will result in stunted plants with distorted upper leaves and plants normally wilt as deficiency increases. However, deficiencies or responses to added micronutrients and secondary nutrients besides S are not likely in South Dakota. Therefore, application of these nutrients is not recommended.

Table 7.4. Sulfur recommendations for sunflower.

Soil Texture	Tillage	Sulfur Soil Test Categories (lbs/ac, 0-2 ft.)				
		Very low (0-9)	Low (10-19)	Medium (20-29)	High (30-39)	Very high (40-49)
		Sulfur Recommendations (lbs S/ac)				
Coarse	Conventional	25	25	15	15	0
	Strip-till or no-till	25	25	25	15	0
Medium/Fine	Conventional	25	15	0	0	0
	Strip-till or no-till	25	25	15	15	0

Selected References

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Notes

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