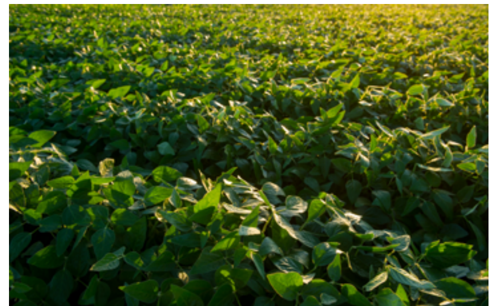
SDSU Extension

iGrow Soybean

BEST MANAGEMENT PRACTICES



Chapter 17:
Assessing Your Fertilizer Program

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In 2012, South Dakota soybean producers spent $48.12/acre on fertilizers (Chapter 56). This expenditure represents a 106% increase over what was spent on fertilizers in 2011. To optimize profitability, the effectiveness of these costs needs to be assessed. There are a number of steps that can be followed in this assessment, leading to an ultimate development of an improved fertilizer program (Table 17.1). The purpose of this chapter is to discuss scouting, conducting nutrient budgets to assess nutrient mining, using chlorophyll meters and tissue sampling to assess nutrient deficiencies, and using well fertilized reference strips to determine economic benefits from improved fertilizer practices.

Table 17.1. Steps for improving a fertilizer program.

Step 1.	Scout your field and look for problems.
Step 2.	Track changes in the soil nutrient level over the last several years. How do your soil nutrient levels compare to the optimum soil nutrient levels. (Chapters 25 and 26)
Step 3.	Conduct a nutrient budget over the last several years. In this calculation, both removal and additions need to be determined. Have you been mining that nutrient? Mining a nutrient is not necessary bad if the soil test levels are very high.
Step 4.	Consider collecting plant samples from problem areas. Have these samples analyzed for the nutrients in question. Compare your nutrient concentration with nutrient concentrations provided in Tables 17.3 and 17.4. If the sample nutrient concentration is below the critical level, this does not necessary mean that your yields have been decreased by that nutrient. Compare the soil nutrient levels with the plant nutrient levels.
Step 5.	If you believe that your fertilizer program was not effective, review your program. Specific questions that need to be considered include: Was your application approach effective? Did you apply enough fertilizer? Did you apply the "best" fertilizer? For example, if you discover that iron deficiency chlorosis (IDC) reduced your yields, adding iron as a broadcast fertilizer most likely will not solve the problem. (Chapter 26)
Step 6.	Consider conducting on-farm testing prior to implementing an improved plan. On-farm testing provide data needed to calculate the economic return of the change. (Clay et al., 2011)

Step 1: Scouting a field.

Improving a fertility program starts with routine soil sampling and scouting of the field for nutrient problems. Details associated with soil sampling are available in Chapter 18 and details associated with field scouting are available in Chapter 29. When scouting a field for insects and diseases, take the opportunity to note potential nutrient deficiencies (Table 17.2).

A chlorophyll meter can also be used to quantify differences between healthy and unhealthy plants (http://www.ca.uky.edu/agc/pubs/agr/agr181/agr181.pdf). Based on differences in chlorophyll meter readings in healthy and un-healthy plants, corrective management can be identified. For example, a soybean plant that was not inoculated with N fixing bacteria (Chapter 23) or seeded into a high pH poorly drained area (iron deficiency chlorosis; Chapter 26) might have a meter reading of 72 while a healthy plant might have a value of 80. Based on these differences, you may decide to apply a Fe seed treatment.

Table 17.2. Soybean nutrient symptoms and possible solutions. Images of deficiency symptoms in soybeans are available at http://cropwatch.unl.edu/web/soils/soybean-nutrients

Nutrient	Symptom	Plant Part	Solution
Nitrogen	General yellowing	Older parts first	Treat seed with *Bradyrhizobium*
Phosphorus	Dark green or reddish purple leaves	Older parts first	Apply P fertilizer, check soil P level
Potatssium	Wilting, interveinal chlorosis, and scorching of leaf margins starting at the edge	Older parts first	Apply K fertilizer, check soil K levels
Sulfur	General yellowing	Younger leaves first	Apply S fertilizer and check soil S level
Iron	Yellowing of veins of the leaves generally found in high pH soils. Whole leaf may turn white.	Younger leaves first	Use Fe efficient cultivars and treat seed with Fe (Chapter 26)
Zinc	Pale green plants; interveinal mottling (or interveinal chlorosis in drybean) of older leaves leading to bronze necrosis; green veins	Younger leaves first	Apply Zn fertilizer

In South Dakota, a common nutrient to limit yield is P. Soybeans growing in deficient soils may be stunted, have small leaflets, dark green or purple colored leaves, delayed maturity, and reduced yields (Fig. 17.1). Deficiency symptoms frequently are observed in older leaves first. If the soil is cold and wet, P deficiency may be particularly noticeable. If P deficiencies are observed, tissue samples should be collected and analyzed. Solutions to P deficiencies in high pH soils include broadcast applying relatively high P rates or banding P fertilizer below the seed. These soils often have low Olsen P soil test values.

Figure 17.1. Phosphorus deficiency symptoms in soybeans. (Photo courtesy of Shamie Zingore, IPNI Africa).

Step 2: Track soil nutrient levels.

Information from a soil sampling program can provide critical information about available P. This approach is most useful when assessing soil fertility changes over a relatively long period of time. A decreasing soil P level with time suggests that P additions are less than P removal. For example, if the soil test P concentration decreases from 18 to 13 ppm over a 10-year period, this suggests that P is being mined. If nutrient mining (removal is greater than additions) has occurred, some nutrients may become limiting. When tracking spatial and temporal changes in soil P, it is important to understand that different extractants remove different amounts of nutrient and that changes in the soil sampling strategies can impact soil test results (Chapter 18).

Step 3: Determine nutrient budgets: mining or replacing.

Nutrient removal data, when combined with soil test information, can be used to assess soil nutrient mining and if additional fertilizer is required. In nutrient budgets, the nutrients removed by all crops must be considered in the calculations. Removal rates for selected crops are provided in Table 17.3. Nutrient removal rates for other crops are available in Clay et al. (2011).

Table 17.3. Estimates of nutrient removal of N, P, K, Mg, and S by major South Dakota crops.
(Source: Clay et al., 2011)

Crop	Plant Part	Unit	N	P_2O_5	K_2O	Mg	S
Corn	Grain	lbs/bu	0.9	0.38	0.27	0.09	0.08
	Stover	lbs/ton	16	5.8	40	5	3
Soybean	Grain	lbs/bu	3.8	0.84	1.3	0.21	0.18
	Stover	lbs/ton	40	8.8	37	8.1	6.2
Wheat	Grain	lbs/bu	1.5	0.6	0.34	0.15	0.1
	Straw	lbs/ton	14	3.3	24	2	2.8

Removal rates are determined by summing the amount of nutrients removed over several years, while additions are determined by summing the nutrient additions, including manure (Problems 17.1, 17.2). Sample calculations are available in Clay et al. (2011). If excessive mining has occurred (outputs>inputs) and soil test values have decreased, consider changing the fertility program.

Problem 17.1. Estimating crop P removal in a corn and soybean rotation. (Clay et al., 2011)

P removed by 52 bu soybeans/acre and 150 bu corn/acre

$$\text{Lbs } P_2O_5\text{/acre by soybean} = \frac{52 \text{ bu}}{\text{acre}} \times \frac{0.84 \text{ lbs } P_2O_5}{\text{bu}} = \frac{43.7 \text{ lbs } P_2O_5}{\text{acre}}$$

$$\text{Lbs } P_2O_5\text{/acre by corn} = \frac{150 \text{ bu}}{\text{acre}} \times \frac{0.38 \text{ lbs } P_2O_5}{\text{bu}} = \frac{57 \text{ lbs } P_2O_5}{\text{acre}}$$

Total removal in a corn and soybean rotation is 101 lbs P_2O_5/acre.

Problem 17.2. Determine the amount of N and P removed in the grian of a 210 bu/acre corn crop and 52 bu/acre soybean crop.

N removed by corn and soybean

$$\text{Corn N} = \frac{210 \text{ bu}}{\text{acre}} \times \frac{0.9 \text{ lbs N}}{1 \text{bu}} = \frac{189 \text{ lbs N}}{\text{acre}}$$

$$\text{Soybean N} = \frac{52 \text{ bu}}{\text{acre}} \times \frac{3.8 \text{ lbs}}{\text{bu}} = \frac{198 \text{ lbs N}}{\text{acre}}$$

$$\text{Total N} = 189 + 198 = 387 \text{ lbs N/acre}$$

P removed by corn and soybean

$$\text{Corn P} = \frac{210 \text{ bu}}{\text{acre}} \times \frac{0.38 \text{ lbs } P_2O_5}{1 \text{bu}} = \frac{80 \text{ lbs } P_2O_5}{\text{acre}}$$

$$\text{Soybean P} = \frac{52 \text{ bu}}{\text{acre}} \times \frac{0.84 \text{ lbs } P_2O_5}{\text{bu}} = \frac{43.7 \text{ lbs } P_2O_5}{\text{acre}}$$

$$\text{Total } P_2O_5 = 80 + 44 = 122 \text{ lbs } P_2O_5\text{/acre}$$

The N and P budget are determined by subtracting removal rates from additions. The N budgets have little meaning because soybeans have the capability to convert atmospheric N_2 to plant N (N fixation). For P, if the budget is negative (removal > additions), check the soil test and plant nutrient values. If the soil test values have decreased and the plant P level is below the critical P level, consider changing your P management program.

Step 4: Plant tissue analysis.

An in-season assessment can be conducted through tissue samples. This approach can be used to compare the nutrient concentration in your plant material to relatively broad benchmarks that define expected values. This approach was originally designed to identify nutrient deficiencies. It is important to note that many of these benchmarks were defined over 30 years ago. Today visual deficiencies are rarely observed, and therefore it is difficult to include visual symptoms into an in-season assessment tool.

We believe that tissue sampling complements rather than replaces other assessment techniques. It is important to note that assessments based on concentrations are sometimes misleading because stunted plants may have high concentrations. These samples can be sent to most soil testing laboratories. A list of addresses of these laboratories is available in Chapter 18.

Soybean tissue sampling

Different sampling protocols are used for different plants and crop growth stages. For soybeans, 30 to 50 of the most recently mature trifoliates should be collected from early (R1) to mid-bloom (R3) (Rehm, 2006; Chapter 3). When collecting this number of leaves, care must be followed to insure that the leaves do not mold. At the seedling growth stage, collect the entire plant. These samples should be sent to a plant testing laboratory for analysis. If the analysis is below the expected range, that nutrient may limit growth.

Corn tissue sampling

For corn, different plant parts should be collected for different growth stages. For seedlings, 15 to 20 whole plants should be collected. For plants 12 inches tall (30 cm) to tasseling, the first 15 to 20 fully developed leaves from the top of the plant should be collected. From tasseling to silking, 12 to 20 ear leaves should be collected (Bundy, 2004; Rehm, 2006; Clay et al., 2011). The ear leaf is the leaf directly below the ear. Again, care should be followed to make sure the plants do not mold. The plant samples should be sent off to an appropriate laboratory. The expected ranges for selected nutrients are provided in Table 17.5.

Table 17.4. Expected nutrient ranges for soybean trifoliates collected between R1 and R3. (Modified from Rehm, 2006 and http://www1.extension.umn.edu/agriculture/nutrient-management/docs/AG-FS-3176-1.pdf). Images of the plants at R3 are available in Chapter 3.

Plant Nutrient	Unit	Expected Range
Nitrogen	%	4.01-5.50
Phosphorus	%	0.26-0.50
Potassium	%	1.71-2.50
Sulfur	%	0.21-0.40
Calcium	%	0.36-2.00
Magnesium	%	0.26-1.00
Iron	ppm	51-350
Zinc	ppm	20-50
Boron	ppm	21-55
Copper	ppm	10-30
Manganese	ppm	21-100

Table 17.5. Expected ranges of selected nutrients for corn collected at three growth stages. Images of corn growth stages are available at http://weedsoft.unl.edu/documents/growthstagesmodule/corn/corn.htm, and Clay et al., 2011.

Nutrient	Unit	Seedling	Vegetative	50% Silk
Nitrogen	%	4.0-5.0	3.5-4.5	2.70-3.50
Phosphorus	%	0.4-0.6	0.35-0.50	0.20-0.40
Potassium	%	3.0-5.0	2.0-3.5	1.70-2.50
Calcium	%	0.51-1.6	0.20-0.80	0.40-1.00
Magnesium	%	0.3-0.6	0.20-0.60	0.20-0.40
Sulfur	%	0.18-0.40	0.18-0.40	0.10-0.30
Iron	ppm	40-500	25-250	50-250
Zinc	ppm	25-60	20-60	20-70
Boron	ppm	6-25	6-25	4-15
Manganese	ppm	40-160	20-150	20-250
Copper	ppm	6-20	6-20	3-15

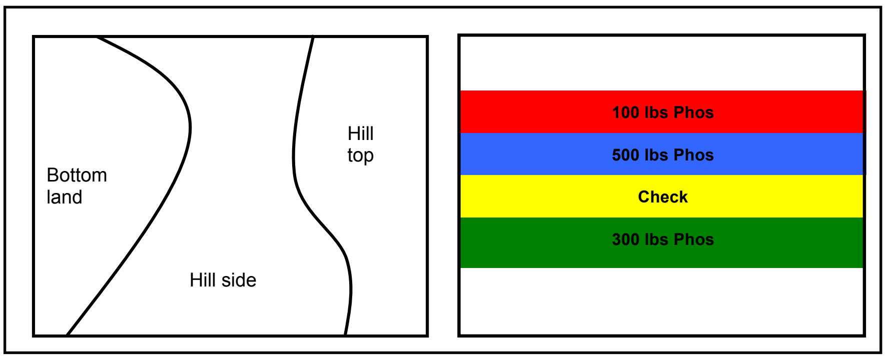
Step 5: Assessing your fertilizer program.

Compile your survey, production records, nutrient budgets, and tissue sampling. Is there a relationship between tissue samples, nutrient budgets, and soil nutrient concentrations? Based on this field-by-field assessment, determine if additional work is needed.

Step 6: Consider conducting an on-farm study.

On-farm studies that include well-fertilized reference control strips are a good strategy to field test specific practices, products, and rates (Fig. 17.2). Three basic approaches have been used in on-farm studies (Chapter 54). In the first method, the treatments are placed with a row up and down a landscape elevation gradient. This approach is used to test the treatment at the different landscape positions. In the second approach, treatments are placed perpendicular to the crop rows. In the third approach, treatments are applied at specific locations within your field. The yields from the treatments are then compared with your fertilizer program. Specific details of these techniques are provided in Chapter 54.

Figure 17.2. The placement of different treatments across a landscape.



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