SDSU Extension

iGrow Corn

BEST MANAGEMENT PRACTICES

Chapter 1:
Developing a Strategy to Achieve 300 Bushel Corn per Acre or Incrementally Increasing Current Yields

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Clues on how to maximize corn yields can be gleaned from corn contest winners. Most winning corn growers agree that achieving higher yields requires: 1) paying attention to management details, 2) building soil organic matter, 3) using innovative technologies combined with appropriate variety selection that can minimize pest stress, 4) timely planting, fertilizing, and scouting for pests, and 5) conducting on-farm testing. This chapter provides an eight-step plan to optimize corn yield (Table 1.1).

Table 1.1 An eight-step plan to optimize corn yield and profit for South Dakota producers includes:

1. Be a lifelong learner and conduct your own on-farm product testing.
2. Identify site-specific yield limiting factors (Chapters 16, 17, 19, and 21).
3. Use archived field records to: a) identify successful, as well as unsuccessful management strategies, b) design crop rotations that build soil health, and c) select hybrids and plant populations (Chapters 13 and 24).
4. Actively manage crop residues (Chapter 13).
5. Proactively manage field water. This may involve installing tile drainage in poorly drained soils. However, prior to installing tile drainage, check the soils for suitability with NRCS personnel to determine legal requirements (Chapters 30, 31, and 32).
6. Improve the soil nutrient program.
   a. Conduct N and P assessments (Chapter 29).
   b. Optimize fertilizer rates, timing, and sources (Chapters 25, 26, 27, and 29).
7. Proactively manage weeds, insects, and diseases (Chapters 39 through 52).
   a. Select hybrids that optimize yield and minimize pest stress (Chapter 10).
   b. Monitor weather conditions, scout fields regularly, track and map pest infestations.
   c. Use pre-emergence and post-emergence herbicides, apply insecticides and fungicides when needed, and rotate pesticide chemistries to avoid pest resistance.
8. Prepare and calibrate field equipment.
   a. Calibrate and prepare your planter for seeding.
   b. Clean, repair, and calibrate fertilizer and pesticide applicators (Chapter 41).
   c. Prepare the combine for harvest (Chapters 37 and 47).

1. Be a Lifelong Learner

Over the past 160 years, researchers and growers have learned that corn responds to multiple stresses simultaneously (Bloom et al., 1985; Rubio et al., 2003; Kim et al., 2008; Kharel et al., 2011), and for this reason, the strategy to increase corn yields involves examining many factors simultaneously. Companies are constantly introducing new products, all touted to help relieve plant stress, and enhance yield. However, not all products can be tested through unbiased research. Growers need to take responsibility to gain information about the appropriate use of these technologies. On-farm research will help provide information for deciding whether a product or technology is a good fit for your operation. Some of the products that are tested may fail, but this information is also valuable, and in the long run, will help in deciding what, if any, changes should be made.

2. Identify Site-specific Yield-limiting Factors

Most land parcels are not uniform, exhibiting variability in soil types and topography. This variability often means that cropping problems are not uniform and that a one-size-fits-all solution may not work. Therefore, fields should be scouted to determine WHAT and WHERE the problems are occurring.

Scouting can be a complex process, but the ultimate goal is to identify yield-limiting factors by area and rectify the problem(s) in a timely manner. Scouting intensity should be increased during high-risk periods (e.g., when climatic conditions are optimal for disease outbreak, or weed emergence). However, scouting is labor intensive and its efficiency may be improved through the use of a drone, aerial, or satellite imagery (Fig. 1.1), if combined with ground-truth information.

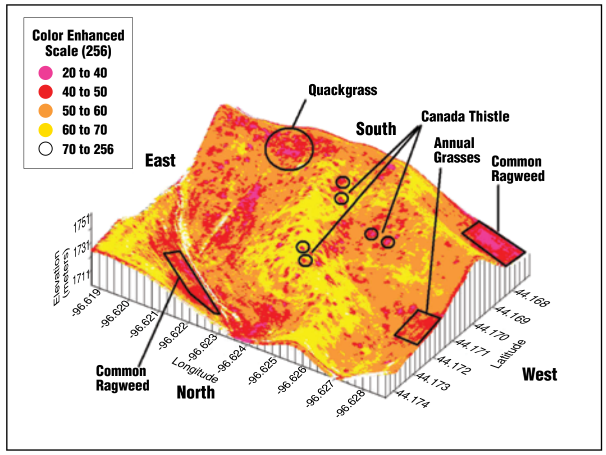

Figure 1.1 Aerial images from a South Dakota production field. Within the field different problems were confirmed by ground scouting. (Courtesy of D.E. Clay)

It is important to understand that solutions to problems may require multiple years of intervention. A specific example, crop lodging, is outlined below. Following scouting, the local agronomists determined that 40% of the field's higher elevation areas was lodged. Solving this problem will take multiple years. At harvest, the farmer should consider harvesting the field against the direction of lodging. In following years, lodged areas should be scouted to determine the amount of volunteer corn. These volunteer plants may harbor diseases and insects or be a highly competitive weed for the planted crop. To solve the problem, the core problem must be identified. Lodging can result from many causes, including extremes in soil moisture, poor root development, high-wind events, poor plant nutrition (K deficiency), excessive population, disease incidence (such as stalk rot), and/or insect damage (corn rootworm and/or corn borer), alone or in combination. Possible solutions may include:

1. Decreasing the corn seeding rate.
2. Seeding corn hybrids with quick dry-down time, shorter maturity rating, and improved stalk rot and insects resistance.
3. Increasing the amount of K added to the field. K deficiency symptoms often include yellowing and necrosis of lower leaves and can contribute to weak stalks and increased incidence of stalk rot. The deficiency may be exacerbated by crop residue harvesting, adverse climatic conditions, and organic or sandy soils (Sawyer, 2004).

3. Use Archived Field Records

Archived field records can be used to assess the effectiveness of the soil fertility program and pest strategies. For example, if the soil test P values have increased from 20 to 30 ppm over the past 10 years, consider reducing the P application rate. Archived field records will also provide critical information needed to select an appropriate hybrid and plant population and areas where specific pests have, in the past, been problematic.

Selecting a Corn Hybrid

Selecting the most appropriate hybrid is complicated by the release of new products with different traits or trait combinations. This means that varieties seeded last year may not be available or the best choice for next year. Corn hybrids are often classified as "racehorses," "workhorses," and "defensive." Racehorse hybrids produce relatively high yields under good and excellent conditions but low yields under poor conditions. Workhorse hybrids produce good yields under high- and low-yielding conditions. However, the maximum yield for these hybrids in the best conditions is often below the yield potential of the racehorse hybrid. Defensive hybrids produce relatively high yields under poor conditions but lower yields than racehorse or workhorse hybrids under good conditions. Variable-hybrid seeders provide the opportunity to replace workhorse hybrids that are typically uniformly sown across a field with defensive hybrids sown into low-yielding areas and racehorse hybrids sown into high-yielding areas (Chapter 10).

Determining the Plant Population Rate

Corn grows taller and produces a larger ear and thicker stalk when grown at low populations and has the opposite response at high population. This observation suggests that lodging can be partially solved by decreasing the seed rate. However, the population must be matched with water availability because if water is limiting, especially during the early reproductive stages, portions of the ear or whole ears may be barren. Too high of a population can result in poor root development that will increase the chance of lodging. Examples for calculating site-specific corn seeding rates are provided in Chapter 8.

Corn's growth in high populations also provides an opportunity to increase yields by reducing 30-inch row spacing to narrower rows, such as 20-inch spacing. The 30-inch row spacing was developed to: 1) allow for traffic of field equipment during in-season management of nutrients and pests, 2) reduce disease problems, and 3) match rows to harvest equipment. The advantages of narrow row systems include rapid closure of the canopy, reduced weed pressure, improved light interception, reduced evaporation, and less in-row crowding. The primary disadvantages of narrow rows are increased risk of compaction, reduced opportunity for field cultivation, and difficulty in making in-crop applications of fertilizers and pesticides.

4. Manage Plant Residues

Managing residue is critical for optimizing seed germination. Over the past 30 years, residue-management problems have increased because corn yield, and consequently, corn residue have doubled. When returned to the soil, corn residue has helped South Dakota farmers increase soil organic matter (Soil OM) content of most fields. Soil OM in cornfields of eastern South Dakota increased an average of 24% from 1985 to 2010 (Clay et al., 2012). However, the higher amounts of crop residues have complicated seedbed preparation, slowed soil warming, and contributed to a corn "yield drag" (i.e., lower corn yields than expected) (Gentry et al., 2013). Techniques to reduce residue problems include:

1. Chopping the corn residue with a stalk chopper or chopping combine header. Combine corn headers often are integrated with stalk choppers that have enhanced capacity to chop residue. Chopping residue helps improve stand uniformity and yields (Gentry, 2013).
2. Adopting tillage techniques that minimize contact between the seed and the surface residue, (for example strip-tillage in the planting zone).
3. Harvesting and baling residue after grain harvest. This technique has been widely adopted in the recent past. However, problems with soil erosion, soil organic matter reduction, and nutrient deficiencies should be considered when deciding whether to harvest residue or how much to harvest. Baling residue may also have the benefit of helping the soil warm up.

5. Proactively Manage Water

Over the past 40 years, corn yield increases in eastern South Dakota have been linked to improvements in water-use efficiency (WUE). For example, corn WUE was 6 bushels per acre-inch of rain in the 1950s, whereas in 2012 the water-use efficiency was over 9 bushels of grain per acre-inch of water. New hybrids are being developed that are expected to further improve WUE (Chang et al., 2014).

The location and magnitude of water problems are predictable in each field. Upper landscape positions (summit and shoulder areas) are often limited by too little water, whereas lower landscape positions (foot and toe slopes) are frequently limited by too much water. In addition, rainfall generally decreases from the east to west in South Dakota. If yields are limited by too little water, reducing the tillage intensity, installing irrigation, and/or planting drought-tolerant hybrids may increase yields (Chang et al., 2014). Irrigation is costly and in many areas high-quality water suitable for irrigation is not available. Additional information on irrigation is available in Chapter 33. If water is available, proper permits from the South Dakota Department of Water and Natural Resources must be obtained. In addition, an economic assessment should be conducted prior to installing a system. A general rule of thumb is that to pay for the irrigation costs, the irrigation water must produce a 50 to 70 bu/acre annual increase in corn grain yield.

Glaciation on the eastern side of the state has produced rolling topographies, and many fields contain troughs between the hill slopes. Drainage and grass waterways have been used to reduce ponding and erosion in these areas. Additional information on drainage is available in Chapter 30. In areas where too much water limits crop growth (a high water table), the installation of drain tile can increase yields from near zero to match a field's highest yielding areas. Fundamental differences between drainage in South Dakota and surrounding states include:

1. Most South Dakota fields do not have a designated drainage ditch, therefore discharging drainage water can be legally challenging.
2. South Dakota has many sodium-affected soils where tile drainage can contribute to the conversion of productive soil to nonproductive soil.

Historically, tillage was conducted to prepare a seedbed and help manage excess water. Tillage reduces plant available water 2 to 3 inches annually. To save water, tillage should be minimized and the amount of crop residue on the soil surface increased.

6. Improve the Soil Nutrient Program

Each nutrient has unique chemical reactions that impact its availability. Some negatively charged nutrients (NO_3^{-1} and SO_4^{-2}) can be rapidly lost with deep percolating water, whereas positively charged nutrients are retained near the surface (Table 1.2).

Soil testing has been used to assess the relative amount of nutrients available to the plant. In a general sense, soil test results provide an indication of the probability of a response to added fertilizer. If the soil test value is low, then the likelihood of a positive yield response is high (Fig. 1.3). When considering soil test P levels, it is important to remember that soil nutrient levels are highly variable across a field and that even if the average soil test value for a composite sample is very high, there may be large portions of the field that would be considered deficient. For example, if 10 soil cores are composited across a field and 2 cores (representing 20% of the field) have a soil test P level less than 10 ppm, the average could still be 20 ppm P or greater if the other 8 cores have medium, high, or very high values. These low soil test areas would benefit from P application, whereas the high and very high testing areas would not. Many farmers use precision grid sampling to help define this variability and areas where nutrient application would or

Table 1.2 Summary of nutrient reactions within the soil and plant. Images and a more complete discussion of nutrient deficiency symptoms are available at http://cropwatch.unl.edu (search for "key to nutrient deficiencies"). A capital expense means that the nutrient is stable in the soil and remains for years. It does not easily leach or volatilize.

Nutrient	Dominant species in soil	Leaching potential	Loss with erosion	Gaseous losses	Transport to root	Reactions within plant	Deficiency symptom	Consider as capital expense
N	NO_3^-	high	moderate	low	mass flow	mobile	yellowing	no
N	NH_4^+	low	high	high	diffusion	mobile	yellowing	no
P	$H_2PO_4^-$	low	high	none	diffusion	mobile	dark green/purple	yes
K	K^+	low	high	none	diffusion	mobile	dark green with necrosis of leaf margins	yes
Mg	Mg^{+2}	low	high	none	diffusion	mobile	green-yellow with dark yellow interveinal chlorosis	yes
S	SO_4^{-2}	moderate	low	low	mass flow	moderate	uniform pale yellow	no

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would not be profitable. Scouting, tissue sampling with laboratory analysis, or remote sensing, through aerial, satellite or drone technologies, may be used to better assess the effectiveness of the nutrient program (Chapter 22).

The effectiveness of the transport process is dependent on the mobility of the nutrient. For mobile nutrients, deficiency symptoms are first observed in older vegetation, whereas for immobile nutrients, the deficiency symptoms are first observed in younger vegetation. The mobile nutrients are N, P, K+, and Mg, whereas B and Ca are considered immobile. Nutrients that are moderate mobility include Cu, Fe, Mn, Mo, S, and Zn. During a plant's reproductive growth stages, the nutrients contained in the grain increase from zero at tasseling to accounting for over 50% of the N and P contained in the plant at black layer (physiological maturity) (Chapter 5; Benter et al., 2013).

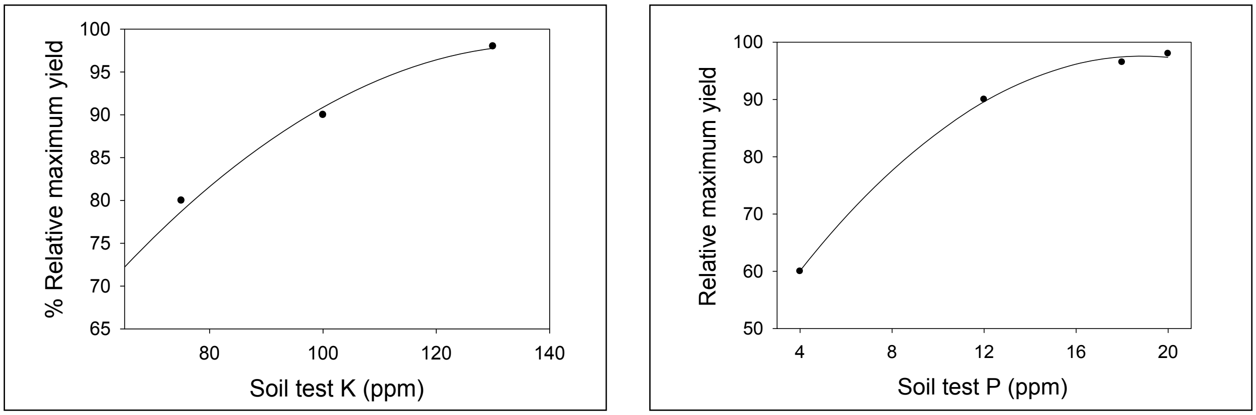

Figure 1.2 Relative corn response to increasing soil K and P levels (Bray test).

Theoretically, long-term nutrient sustainability requires that nutrient removal be balanced with nutrient supply or resupply (Table 1.2). A 300 bu/acre corn crop contains approximately 404 lbs N (corn 0.9 ×300 + 8.4 ton stover ×16 = 404), which is supplied by the soil and supplemental fertilizer applications. When nitrogen fertilizer is applied, there is a potential that a portion can be lost through volatilization or leaching. Using products that slow urea hydrolysis or nitrification can reduce N losses under some conditions.

Table 1.3 Nutrients removed in corn, soybeans, and wheat. *(Modified from Clay et al., 2011)*

Crop	unit	N	P_2O_5	K_2O	Mg	S
		lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Corn grain	bu	0.90	0.38	0.27	0.08	0.08
Corn stover	ton	16	5.8	40	5	3
Corn silage	ton	9.7	3.1	7.3	2	1.1
Soybean grain	bu	3.8	0.84	1.3	0.21	0.18
Soybean stover	ton	40	8.8	37	8.1	6.2
Wheat grain	bu	1.5	0.6	0.34	0.15	0.1
Wheat straw	ton	14	3.3	24	2	2.8

To grow 300 bu/acre corn, most agronomists believe that soil phosphorous and potassium levels should be in the very high soil test category. In South Dakota, very high soil test levels of P and K are > 16 ppm and > 161 ppm, respectively. Sampling date and soil drying can impact soil test P and K values based on laboratory analysis. Generally, nutrient concentrations are lower in the fall following harvest than in the spring following a period of recharge. In addition, drying and grinding a soil sample can increase the amount of extractable K. When considering raising the soil test results, on average (varies with soil) approximately, 20 lbs of P_2O_5/acre are needed to increase the soil test P value by 1 ppm, whereas 12 lbs of

K_2O/acre are needed to increase the soil test K value by 1 ppm.

In most fields, P leaching through the soil to groundwater is not a problem. However, if the soil P levels are extremely high or the soil has a sandy texture, leaching can occur. Environmental impacts can generally be eliminated by band injecting the P fertilizer into the soil or incorporating surface applied P into the soil. However, in South Dakota, it is not recommended to apply P, either as fertilizer or manure, if the Olsen soil test value is > 100 ppm.

During grain harvest (and if stover is removed), secondary (Mg, Ca, and S) and micronutrients (B, Zn, Mn, Fe, Cu, Mo, and Cl) are also removed from the field. Mass balance dictates that for long-term sustainability, these nutrients must be returned. Even though South Dakota research has not consistently documented the need for these nutrients, many farmers routinely supply micronutrients. Recent research suggests that drought stress can result in the down expression of many genes associated with nutrient uptake (Hansen et al., 2013). These findings suggest that if nutrient levels are low, plants may respond to micronutrient fertilizers in water-stressed areas (summit and shoulder areas) due to greater availability. Summit/shoulder areas also may have experienced high soil erosion rates, which would reduce the topsoil depth, water-holding capacity, and nutrient-supplying ability of the soil. The plant population and nutrient applications need to be well-managed to optimize yield.

7. Use Proactive Management for Weeds, Insects, and Diseases

Scouting and mapping pest infestations provides valuable information for improved management. Preventative measures, such as cleaning equipment, should not be skipped in the interest of time as new infestations often can be traced to poor sanitation. To prevent the development of pests that are resistant to chemical control mechanisms, rotate the control approaches (Chapter 43).

Weeds present during the critical weed-free period of corn growth (V1 to V6 or longer depending on weather conditions) can irreversibly reduce corn yields. These yield reductions are not necessarily caused by plant competition for water, nutrients, and light but rather by a reduction in the plant's photosynthetic capacity (Moriles et al., 2012). To minimize these losses, pre-emergence compounds should be applied to minimize early weed development and supplemental post-emergence herbicides should be applied if further control is needed. Since early planting is often recommended to maximize yield, fungicide and insecticide seed treatments are also recommended. Combining appropriate genomic traits and good agronomic practices with pesticide solutions for weeds, insects, and disease control is also encouraged.

8. Prepare and Calibrate Field Equipment

Many agronomists believe that the most important machine on the farm is the planter and that it must be in perfect condition to obtain top yields. Assessing seed population and spacing between adjacent seeds within a row can help determine planter efficiency. The desired and measured population should be similar, and in a general sense, decreasing seed spacing variability improves yield. Over the past several years, planter improvements in seed singulation, seed delivery, depth of placement, and opener technology have improved planter efficiency. It is recommended that planters be tested and calibrated annually by a knowledgeable planter mechanic.

Fertilizer and pesticide applicators also need to be calibrated. Maladjusted sprayers can apply either too little or too much in different portions of the field. If the rates are too low, the chemical treatment may not work, whereas if the rates are too high, yields may be reduced. Combines that are not properly adjusted can result in grain that is left on the field. A rule of thumb is that 2 kernels of corn/ft^2 or 5 soybean seeds/ft^2 on the ground behind a combine amounts to a 1 bu/acre harvest loss. Techniques to minimize grain losses include: 1) driving at an appropriate speed, 2) measuring yield losses and making appropriate adjustments, 3) using a reel speed (soybeans) that is 10% to 25% faster than the combine speed, and 4) harvesting the crop at an appropriate moisture content (Chapters 36 and 37).

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