NebGuide

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Setting a Realistic Corn Yield Goal[1]

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This NebGuide discusses how to set a realistic corn yield goal by acknowledging climatic yield limitations of corn in Nebraska and the yield history in a field.

Corn growers need to set a realistic corn yield goal in order to make sound decisions on corn hybrid, seeding rate, fertilizer application, and irrigation need. The goal should be the most profitable yield that can be expected for the particular set of soil, climate, and management practices. Yield goals should gradually increase over time, but cannot exceed the theoretical yield potential.

Previous recommendations were to use past yields to set yield goals, gradually boosting them over time because actual yields reflect field-specific conditions such as weather, soil, hybrid choice, crop management, and moisture supply. However, a more quantitative understanding of yield potential and yield gaps can lead to setting more realistic production targets and evaluating the risks associated with them.

Yield Potential and Yield Constraints

The yield potential is the maximum production of a crop cultivar that can be achieved in a given environment. Solar radiation during the growing season, temperature and crop characteristics determine the yield potential (*Figure 1*, green bars). These factors can only be managed under field conditions through hybrid choice, planting date, and plant density. Yield potential fluctuates somewhat from year to year (typically 10-15 percent) because of climate variations. To achieve the yield potential, the crop must receive optimum levels of water and nutrients and be completely protected against weeds, pests, diseases, and other factors that may reduce growth.

Growth-limiting factors such as water and nutrients determine the attainable yield. Yield potential is reduced by insufficient water supply, either from inadequate rainfall in dryland cropping systems or from failure to supply sufficient irrigation water. For much of Nebraska, available moisture is the most important growth-limiting factor. Hence, in addition to variety, solar radiation, temperature, and plant population, the degree of water deficit determines the attainable yield and magnitude of yield gap 1, as shown in *Figure 1*. The water deficit is determined by factors such as water holding capacity of the soil, rainfall, irrigation, and evapotranspiration, which vary from site to site and year to year. Management can be used to control the availability of both water and nutrients.

Other factors may further reduce yield (*Figure 1*, yellow bars), including diseases, insects, weeds, waterlogging, lodging, or poor soil quality. Their sum determines the size of yield gap 2 shown in *Figure 1*. Poor soil quality may include soil acidity or alkalinity, toxicities, or unfavorable soil physical properties resulting in compaction or poor drainage. Most of these soil quality problems cause yield reductions through negative effects on root growth.

Attainable yields differ between irrigated and dryland environments (*Figure 1*, blue bars). This must be considered when setting yield goals. In well-managed irrigated corn, the attainable yield is close to the yield potential and relatively stable from year to year because irrigation is provided during key growth stages to make up for water deficits. Consequently, for an irrigated crop, yield gap 1 in *Figure 1* is small and varies less from year to year. Management can be focused on providing sufficient nutrients to fully exploit the attainable yield while minimizing yield-reducing factors that determine yield gap 2. In dryland corn[2], the attainable yield is typically less than that for irrigated corn, but fluctuates widely, depending on the initial soil moisture status, soil water holding capacity, planting date, plant density, and rainfall during the growing season. Therefore, setting a realistic yield goal is more difficult in dryland agriculture than under irrigated conditions because both yield gaps 1 and 2 can vary greatly from site to site or year to year.

What is the Yield Potential of Corn in Nebraska?

Maximum yields obtained in corn yield contests are reasonable estimates of yield potential because corn is grown in these plots at high density with nearly unlimited water and nutrient supply, and full weed and pest control. During the past 20 years, annual yield records of the irrigated corn contest winners in Nebraska have averaged 295 bu/acre, with a standard deviation of $\pm$40 bu/acre among years (14 percent), which indicates the effect of growing season weather on the yield potential. During the same period, annual yield records of the dryland corn contest winners in Nebraska averaged 215 bu/acre. Although these numbers illustrate the upper yield limits that could be achieved, it is neither possible nor economical to grow corn at such yield levels everywhere in Nebraska.

To set a realistic yield goal, estimates of the attainable yield must be obtained for a specific location and individual management and combined with information about the yield history of the field. Potential yield and attainable yield vary

[1]This NebGuide replaces G481 by D.G. Hanway and D.H. Sander.
[2]The term “dryland corn” is used throughout this NebGuide to refer to corn grown under rainfed conditions, which includes environments with favorable and less favorable rainfall distribution.

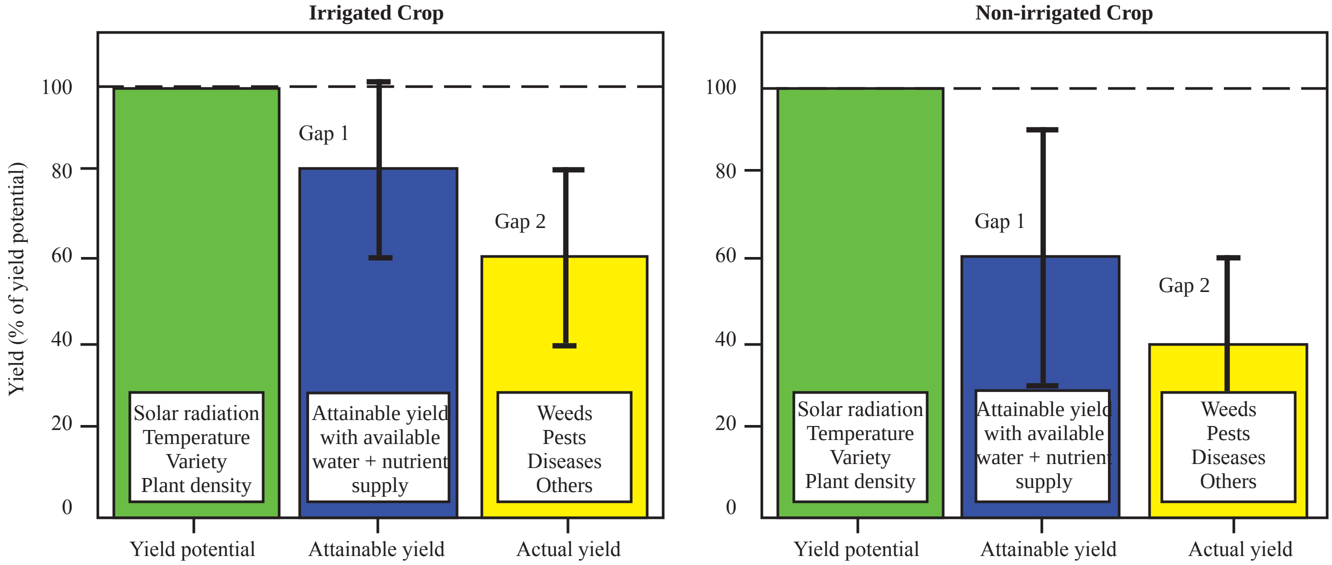


Figure 1. Conceptual illustration of yield potential, attainable water-limited yield, and actual farm yield as constrained by a number of production factors and their variability in irrigated and non-irrigated crops. For a specific location, the thin bars in each column indicate typical ranges of yield variation that may occur from year to year.

across the state, roughly following a northwest to southeast pattern, similar to that for growing degree days and rainfall (*Figure 2* and *Table I*). Growing degree days and precipitation are greatest in eastern, southeastern, and south-central Nebraska (*Figure 2*). With commonly grown hybrids and planting dates, a full supply of water by either rain or irrigation, no nutrient limitations, and final plant stands of 30,000 plants/acre, the attainable yield of irrigated corn in these areas averages about 245 to 255 bu/acre (*Table I*). Attainable irrigated yield is somewhat lower in northeast and southwest Nebraska (235-240 bu/acre) and lowest in north-central and northwest Nebraska (typically <220 bu/acre), mainly because of cooler temperatures and a shorter growing season. Attainable yields of dryland corn generally are much lower than those of irrigated corn and fluctuate more from year to year.

Table I provides general guidance for setting upper limits of yield goals. At any given location, weather differences from year to year can cause attainable yield to vary by up to 40 bu/acre for irrigated corn and 40 to 80 bu/acre for dryland corn (*Table I*), not counting years with extreme weather conditions. Under irrigated conditions, yield potential also increases with increased plant density. A yield potential of 300 bu/acre or more is feasible at certain locations in certain years, but it requires ideal climatic conditions and intensive crop management.

Using the Hybrid-Maize Model

Daily weather data and crop statistics on average actual planting and maturity dates of corn during the past 20 years were used in the Hybrid-Maize Model to estimate the yield potential and the attainable water-limited yield of corn for each year at 35 locations in Nebraska (*Table I*). The Hybrid-Maize Model simulates the growth and yield potential of fully irrigated and fertilized corn as a function of seasonal temperature and solar radiation for a particular planting date, hybrid maturity group, and final plant density. In addition, rainfall and soil type (texture) are taken into account for simulating the attainable, water-limited yield of dryland corn.

Means for each region in *Table I* are averages of the median yield potential simulated for all locations within a region. The common range shows the typical variation that occurred in 50 percent of all years.

Setting a Realistic Yield Goal

The yield goal should reflect what can be grown if normal weather prevails and good management is achieved. When setting yield goals, a producer should consider past yields in that field and perhaps, management areas within the field.

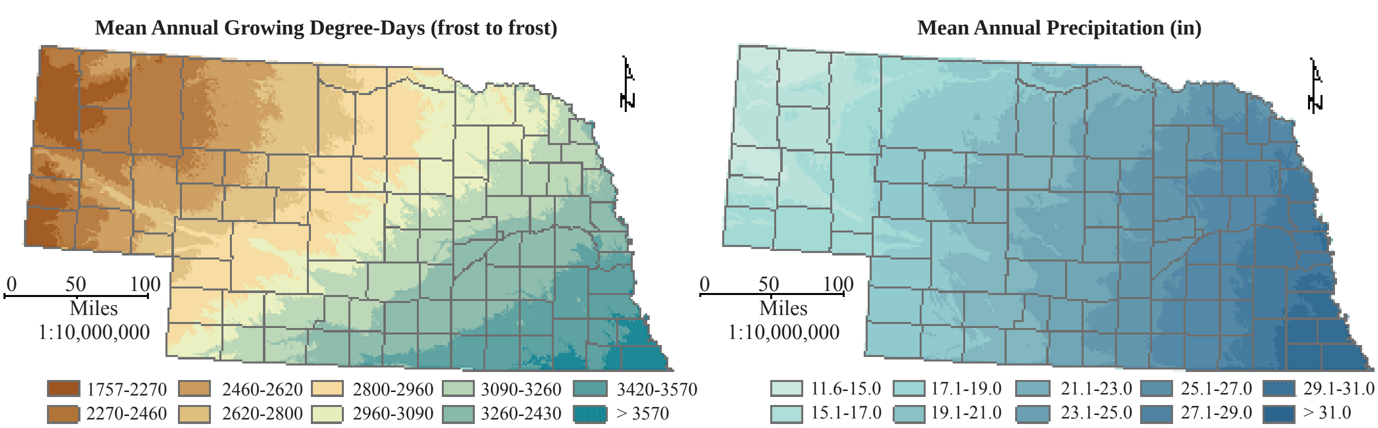


Figure 2. Spatial variation in growing degree days and annual precipitation across Nebraska. Growing degree days reflect spatial variation in solar radiation and temperature, which are key determinants of yield potential.

Table I. Attainable corn yields in different regions of Nebraska.

Region[1]	Planting date[2]	GDD (F)[2]	Irrigated corn (bu/acre) grown at 30,000 plants/acre		Dryland corn (bu/acre) grown at 25,000 plants/acre	
			Mean[3]	Common range	Mean	Common range
Southeast-East	May 5	2650	245	230-270	195	155-215
Central	May 6	2600	250	235-270	170	135-215
South-Central	May 3	2650	255	240-275	190	145-215
Southwest	May 8	2550	235	220-260	115	80-155
Northeast	May 9	2550	240	220-260	170	135-200
North-Central	May 10	2400	220	200-245	120	90-140
Northwest	May 7	2250	205	195-225	85	65-105

[1]Weather stations used for each region: **Southeast-East:** Lincoln-Havelock, Beatrice, Mead, Tarnov, Rising City; **Northeast:** Elgin, West Point, Concord; **Central:** Central City, Grand Island, Ord, Lexington, Kearney, Shelton, Smithfield, Gibbon; **South-Central:** Clay Center, Minden, Holdredge; **North-Central:** O'Neill, Ainsworth, Halsey, Gudmundsen, Arthur; **Southwest:** Cedar Point, McCook, Dickens, Curtis, North Platte, Champion, Grant; **Northwest:** Gordon, Bridgeport, Alliance, Sidney, Scottsbluff.

A yield goal should not exceed the attainable climatic yield potential of corn (*Table I*). If your soil has limited potential, recognize it and try to alleviate problems such as nutrient deficiencies or compaction. Striving for rarely achieved yields wastes money and may contaminate the ground and surface water.

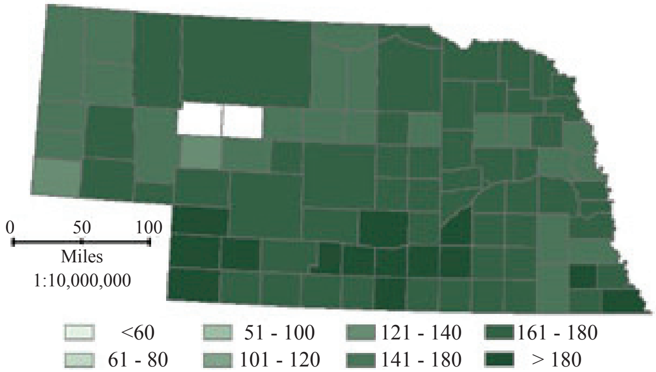
Improved corn hybrids, herbicides, and other technologies have led to increased corn yields. On average, irrigated and dryland corn yields in Nebraska increase at an annual rate of 1.6 bu/acre. Thus, following the guidelines described below, reaching yield goals this year and then boosting them realistically for next year can help an operation stay competitive and increase profits from corn production. Progressive growers with realistic current yield goals and good management should boost goals by about 1.5 to 2 bu/acre per year. Larger increases in yield goals are only justified if significant improvements are expected from soil and crop management changes (e.g., irrigation, soil improvement due to manure application, improved soil drainage, correction of nutrient deficiencies, increased plant density).

Irrigated corn: The yield goal should be 105-110 percent of the average of the past five corn seasons harvested and 80-90 percent of the attainable yield shown in *Table I*. Use only years with relatively normal weather conditions and no unusual events that may have caused extremely low or high yields for calculating the five-year yield average. Compare your yield goal with good corn yields that have been achieved in your area, including those obtained in variety trials. (Results from University of Nebraska variety trials are available on the Web at http://varietytest.unl.edu.) Irrigated corn yields mainly reflect climatic variation in growing season length and the amount of solar radiation that can be intercepted and converted to biomass. They are highest in central, southcentral, and southwest Nebraska (*Figure 3*). Be reasonably optimistic in setting yield goals. Do not continue to set yield goals at 220 bu/acre if you are consistently producing only 160 or 180 bu/acre. Weather conditions (*Table I*), soil conditions and management practices simply may not have the potential to produce 220 bu/acre corn. When past yield history and the estimated attainable yield are far apart, further analysis to determine limiting factors may be needed.

Dryland corn in eastern Nebraska: The yield goal should be within 105-110 percent of the five- to ten-year yield average and not more than 80-90 percent of the attainable water-limited yield shown in *Table I*. Dryland corn yields mainly reflect the patterns of precipitation in the state, with the highest yields generally in eastern Nebraska (*Figure 3*). When setting a yield goal, the dryland grower also should consider the moisture status at planting time. For example, if only the surface 3 feet of soil is moist and the rainfall probability during the growing season is predicted to be below normal, the yield goal should be reduced from that set with a fully moist root zone. In this case, both seeding and fertilizer rates should be reduced accordingly. Be ready to change the yield goal right up to planting and through sidedressing. Delay applying some nitrogen to maintain flexibility in matching nitrogen rates to revised yield goals.

Dryland corn in western Nebraska: Average annual precipitation is low in west-central and western Nebraska (*Figure 2*) and rainfall is highly variable among years, resulting in high risk of crop failure. Due to the large variability in actual grain yields from year to year, setting a yield goal is unrealistic. Growers should carefully measure soil water at planting and, based on factors such as crop residue conditions at planting and attitude toward risk, make adjustments in plant density. For dryland areas in the Panhandle, a base density of 12,000 plants per acre is recommended. This can be adjusted by ± 4,000 plants per acre.

Maximum Irrigated Corn Yield (bu/ac)



Maximum Rainfed Corn Yield (bu/ac)

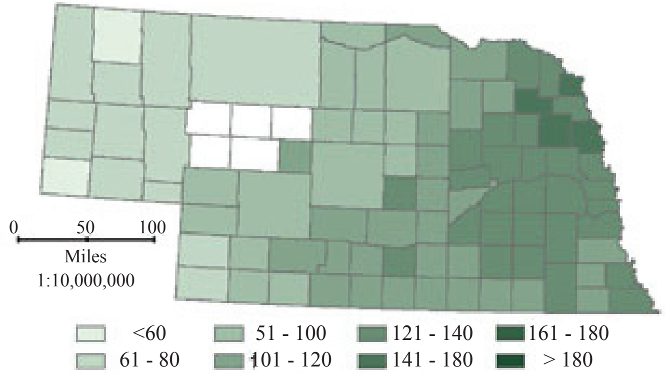


Figure 3. Maximum yields of irrigated *(left)* and dryland *(right)* corn (bu/acre) in Nebraska, by county.

Example of Setting a Realistic Yield Goal

Let's consider a fictitious farm in Clay County, Nebraska. The estimated attainable yield for the typical climate at this location is 255 bu/acre *(Table I)* for irrigated corn grown with final stands of 30,000 plants/acre. Therefore, the yield goal should be within a range of about 204 to 230 bu/acre (255 x 0.8 to 255 x 0.9). Actual yields were: 1996 – 194 bu/acre; 1998 – 186 bu/acre; 1999 – 232 bu/acre; 2000 – 155 bu/acre; 2001 – 190 bu/acre; 2002 – 206 bu/acre; and 2003 – 212 bu/acre. In 1999, the growing season was exceptionally long, resulting in much higher than normal yield. Yield in 2000 was exceptionally low due to extreme heat and insufficient irrigation. The five-year average yield is calculated without these two extreme years: (194 + 186 + 212 + 190 + 206)/5 = 198 bu/acre. Based on the past yield, the new yield goal is 198 x 1.05 or 198 x 1.1 = 208 to 215 bu/acre, which is within the calculated attainable yield range.

Management Decisions Based on Yield Goals

Key management practices that involve a yield goal include 1) choosing the most suitable corn hybrid, 2) planting at the right time and plant density, 3) providing adequate amounts of nutrients, and 4) recognizing within-field yield differences.

Choose corn hybrids that are best adapted to your production conditions and plant at the right time to fully exploit the site yield potential. Use information from seed dealers and independent and university field trials to select corn hybrids that have performed well in your environment. Consider planting areas with consistently high yields at higher densities.

Fertilizer recommendations should consider yield goal, especially for nitrogen because of the close relationship between yield and nitrogen uptake. The relationship of nitrogen need to yield is embedded in the UN-L nitrogen algorithm for corn, in which the required nitrogen amount (lbs N/acre) is estimated based on the expected yield (or yield goal) and then adjusted for various nitrogen credits (N rate = [35 + 1.2 yield goal] – credits). Depending on the soil organic matter content, the nitrogen recommendation is increased by 15 to 20 pounds of nitrogen per acre for each 20-bushel increase in yield goal (*Table II*). Be aware, however, that the UNL nitrogen algorithm may not apply to dryland corn environments in western Nebraska because setting a yield goal is unrealistic in areas with highly variable rainfall.

Setting the yield goal too high may result in excessive nitrogen applications and reduced net return from the crop. If you fertilized for a yield goal the last year or two that exceeded your actual harvested yield, considerable nitrogen may remain in the soil. Take soil samples at least 3 feet deep, have them analyzed for nitrate to determine nitrogen available in the root zone, and credit this amount when determining nitrogen fertilizer needs. Refer to NebGuide G174, *Fertilizer Suggestions for Corn*.

Table II. Effect of yield goal on nitrogen recommendations for corn when soil residual nitrate in the root zone tests low and soil organic matter (OM) varies.

Corn yield goal (bu/acre)	*UNL nitrogen recommendation (lbs/acre)*		
	1% OM	*2% OM*	*3% OM*
60	75	65	60
80	95	85	75
100	115	105	90
120	140	120	105
140	160	140	120
160	180	160	135
180	200	175	150
200	225	195	165
220	245	215	185

Source: Fertilizer Suggestions for Corn, NebGuide G174 (Revised November 2003), assuming: 3 ppm soil nitrate-N in the root zone, corn grown after corn, and no irrigation or manure N credits.

Some agronomists also may recommend adding other nutrients such as phosphorus, potassium, sulfur, or micronutrients based on a yield goal. In this case, it is important to know the total crop uptake requirements of corn and the net nutrient removal from the field with the grain. Note, however, that present UNL recommendations do not endorse this approach.

Producers should consider varying yield goals within a field if a history of yield maps is available. A single-year yield map cannot reliably distinguish random yield variation from more stable low- or high-yielding patterns that repeat each year. However, if yield maps have been collected for at least five years in irrigated fields (5-10 years may be needed for dryland corn), the mean yield can be mapped and divided into several classes to establish zones with different yield goals.

Summary

Using realistic yield goals can help in the management of hybrid selection, plant density, seeding rate, and fertilizer amounts. This can result in increased profit and decreased pollution to the environment. Critical reviews of yield goals on a regular basis can help keep management strategies current.

Additional Information

UNL Soil Fertility Web site — *http://soilfertility.unl.edu*

Shapiro, Charles A., Richard B. Ferguson, Gary W. Hergert, Achim R. Dobermann, and Charles S. Wortmann, Fertilizer Suggestions for Corn. UNL NebGuide G174.

Klein, Robert N. and Drew J. Lyon, Recommended Seeding Rates and Hybrid Selection for Rainfed (Dryland) Corn in Nebraska. UNL NebGuide G1528.

UNL Extension publications are available online at *http://extension.unl.edu/publications*.

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