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Dryland Water Management Guide For Corn on the Great Plains

A joint publication from University of Nebraska – Lincoln (UNL) Extension and Monsanto

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Dryland Water Management Guide
For Corn on the Great Plains

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Introduction

Managing water efficiently to optimize crop yield potential is a constant challenge for farmers in the Central Great Plains. This challenge is specifically evident on dryland fields where evapotranspiration typically exceeds annual rainfall. Understanding how crop rotation, residue management, product selection, plant population, row spacing, soil fertility, stored soil moisture and weed control all impact crop production and ultimately profitability is extremely important to the viability of production agriculture in this area. Adequate available soil moisture is one of the most important factors limiting dryland crop production in the Central Great Plains. This guide will provide a summary of research to help farmers manage limited available soil moisture and reduce moisture loss from the soil by increasing infiltration of rainfall, increasing snow trap and reducing evapotranspiration. Dryland water management is a systems approach which requires attention to all the aforementioned factors that impact corn production.

Drought events are a recurring challenge for dryland corn farmers on the High Plains. Making preventative drought mitigation decisions is critical to obtaining optimal corn yield potential. The availability of improved corn genetics, biotechnology traits and improved agronomic practices can help farmers manage drought and other risks. Understanding the contribution of these technology and agronomic factors can help farmers develop a system to mitigate stress and increase corn yield potential and profitability.

A demonstration trial was conducted in 2012 at the Monsanto Water Utilization Learning Center at Gothenburg, Nebraska (average annual precipitation 23.6 inches) to show how drought and agronomic management decisions may affect corn yield potential (Figure 1). Six treatments were as follows:

- Low Input – conventional tillage, shallow planting depth, poor weed control, corn product with poor stress tolerance and no insect control;
- Agronomics – no-till, proper planting depth, poor weed control, corn product with poor stress tolerance and no insect control;
- Weed Control – no-till, proper planting depth, good weed control corn product with poor

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stress tolerance and no insect control;

- Genetics – no-till, proper planting depth, good weed control, drought tolerant corn product and no-insect control;
- Insect Traits – no-till, proper planting depth, good weed control, drought tolerant corn product and YieldGard VT Triple® insect protection;
- Drought Tolerant Biotech Trait – no-till, proper planting depth, good weed control, and Genuity® DroughtGard® Hybrids corn product with VT Double PRO® insect protection.
- This demonstration trial shows the relative importance of making correct management decisions to minimize the impact of drought. Moisture conservation from using a no-till system and controlling weeds is essential. Additionally, proper planting depth, insect control, corn product genetics, and biotech traits all have the potential to improve the vitality of the corn plant and thus improve the chances corn will have increased yield potential when all of these factors are used together in a systems approach.

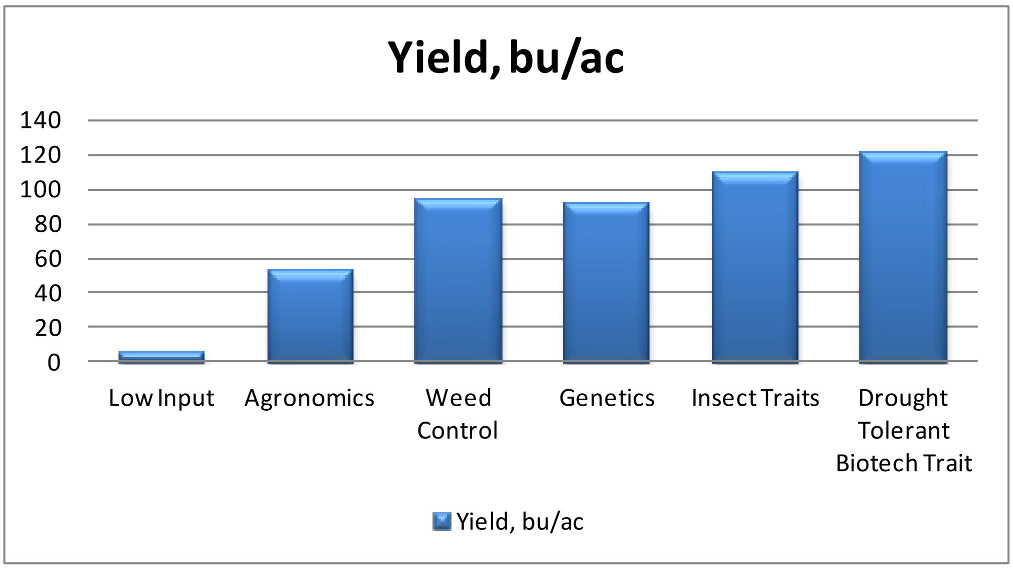


Figure 1: Yield from strip plots at Monsanto Water Utilization Learning Center at Gothenburg, Nebraska, 2012.

Harvest Time Decisions

Moisture Conservation with Residue

The amount of crop residue present at planting and maintained during the growing season affects soil moisture. In general, increasing quantities of crop residue may reduce soil evaporation by reducing soil temperatures and wind speed near the soil surface. Residue cover also may increase water infiltration compared to bare soil surfaces by preventing surface sealing and decrease water use by weeds through suppressed growth from cover and shade of the residue compared to a bare soil surface. Maximizing dryland corn yield potential in Nebraska usually requires 4,000-7,000 pounds of crop residue per acre with increasing benefits from the higher crop residue levels (UNL NebGuide G551). A bushel of winter wheat can typically produce 100 pounds of residue per bushel while corn typically produces 50 pounds of residue per bushel of grain yield. For more information consult UNL Extension NebGuide G2068.

Most no-till planters have a row spacing of 30 or 36 inches, so planters equipped with rolling coulters have few problems with planting in heavy residue. Potential planter clogging problems come mainly from the straw and chaff that passes through the combine and is left loose in a windrow or in piles. It is important to spread the straw as evenly as possible with the combine. Avoid piling the straw, for example, when the combine unloads grain. These piles and windrows are difficult to plant through and cause uneven emergence and seedling growth. The fines or chaff must be spread. If the combine is not equipped with a chaff spreader it is a good idea to install one. Good spreading of the fines also aids in volunteer wheat control. The amount of wheat straw can be reduced by selecting semi-dwarf winter wheat varieties and reducing the amount of nitrogen used.

Maintaining a good cover of crop residue is key to growing dryland crops:

- Cut the wheat high to maximize stubble height, leaving 15 to 18 inches of standing stubble. Select varieties of wheat that produce taller stalks, but excessive stalk height can lead to lodging. Missing one average head, which has 22 kernels in every square foot, can reduce harvested yield by about one bushel per acre, but the yield potential of the following crop may be increased significantly through the benefits of taller stubble. Usually the lower heads do not have 22 kernels so it will take more than one of them to lower the yield potential by one bushel per acre. (Kansas State University Wheat Production Handbook C529).
- Use a stripper header, when harvesting wheat to increase stubble height. Stripper platforms help maintain crop residue (Figure 2). They are beneficial when used with short-statured wheat varieties with good straw strength. The standing residue of tall wheat varieties with poor straw strength may lodge making planting difficult.
- Taller stubble traps more snow and takes much longer to disintegrate in the field than straw that has gone through the combine. A Kansas State University study found a 2 bushel increase in corn yield the following year for every inch of height increase in wheat stubble from 7 1/2 to 15 inches (Haag, Schlagel 2006.)
- Spread the straw and chaff uniformly.
- Spray wheat stubble shortly after harvest to control weeds to help prevent moisture loss.
- Do not harvest ecofallow corn for silage if you intend to plant corn in the same field the following year because the residue is critical to m oisture savings. Also, don't cut the corn for silage if you plan to seed no-till winter wheat or will fallow the field the next year in preparation to seed winter wheat in the fall.

Figure 2: Wheat harvested with a stripper header.

Avoid harvesting during wet soil conditions. This practice can lead to soil compaction that increases soil bulk density and decreases water infiltration and holding capacity. Compaction may also impede root growth, limiting the depth that water can be extracted from the soil.

One way to potentially gain economic return during the pre-winter wheat fallow period is to allow livestock to glean corn ears, loose leaves and corn shucks following harvest. Ecofallow corn should be pastured only when the fields are dry enough to prevent soil compaction and the burying of weed or corn seeds. Fields are dry enough when soil squeezed in the hand fails to hold its shape. Livestock grazing should be limited to a short period of time because cattle traffic can quickly destroy winter wheat residues.

Early Pre-Plant Decisions

When determining which crop to plant and the length of the maturity of the crop, several factors will increase the probability of having success. Soil type and ability of the soil to store soil water are critical components. Silt loam soils have the ability to store 2.0 to 2.5 inches of water per foot of soil, Table 1. Using a soil profile of 4 feet, the silt loam soil has the ability to store 8-10 inches of water. Conversely, fine sandy soils have the ability to store 1 inch of water per foot of soil. Thus, a 4 foot profile in sandy soils may only store 4 inches of water.

Table 1: Available Water Holding Capacities

Soil Textural Classification	Available water in 1 foot of soil at 100% of available water	Available water in top 4 feet at 100% of available water
	---- in/ft-----	---- in/4 ft ----
Fine Sands	1.0	4.0
Loamy Sand	1.1	4.4
Sandy Loam	1.4	5.6
Silty Clay or Clay	1.6	6.4
Fine Sandy Loam, Silty Clay Loam, or Clay Loam	1.8	7.2
Sandy Clay Loam	2.0	8.0
Loam, Very Fine Sandy Loam,or Silty Loam Topsoil with Silty Clay Loam or Silty Clay subsoil	2.0	8.0
Loam, Very Fine Sandy Loam, or Silt Loam Topsoil with Medium textured subsoil	2.5	10.0

Melvin, Steven R., and C. Dean Yonts. UNL Extension Circular EC709 – Irrigation Scheduling: Checkbook Method. 2009.

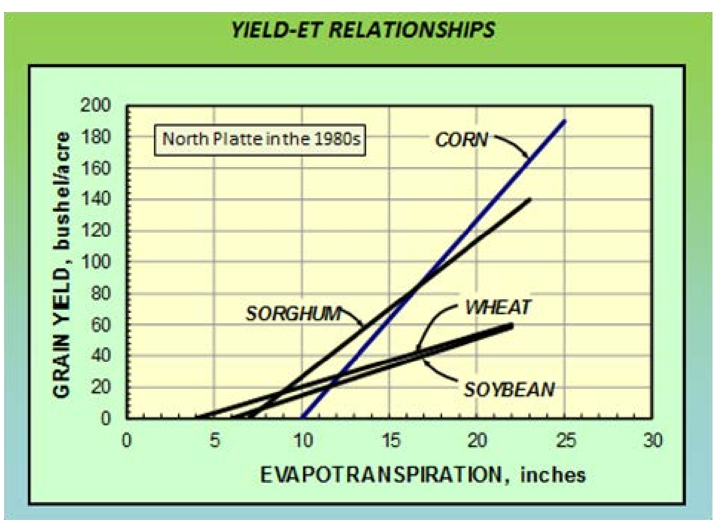
Knowing what soil type you have in your field and an accurate estimate of stored soil water goes a long way in your pre-plant decision making process. Another factor that plays into this process is the expected precipitation during the growing season. If stored soil water is limited and expectations are low for in-season precipitation, when selecting corn products with a shorter growing season and a lower water requirement to reach maturity. The more stored soil water available, the longer you can stretch the maturity range in product selection. However, use this recommendation cautiously and avoid going to the long maturity products unless you are ready to assume the risk of a crop being severely damaged by early frost or drought. Long growing season products and high plant population can increase the risk of crop failure.

Stored soil water can also help determine what crop to grow. If you question if you have enough soil water for corn to reach maturity, consider planting a crop with a lower water requirement, such as grain sorghum, wheat or sunflowers. Growing wheat in conjunction with corn in the rotation, can provide an additional three months of water accumulation during the fallow period since wheat is harvested about three months before the other crops. See the effect of corn yields with wheat or a fallow period in the rotation data in Table 2.

Table 2: Rotational Effect on Dryland Yields (in bushels/acre) at Brule, Nebraska (Greg Kruger Plot Data Summary. Personal Communication, Greg Kruger, UNL, 2012)

Rotation	2011	
	Wheat	Corn
w-w-w: wheat, wheat, wheat	57	-
c-f-w: corn, fallow, wheat	-	103 a
c-f-c: corn, fallow, corn	-	66 bc
c-c-c: corn, corn, corn	-	53 c
c-w-c-w: corn, wheat, corn, wheat	-	124 a

Figure 3 below shows the amount of evapotranspiration (ET) needed to get the first bushel/or pounds of grain for each individual crop. If beginning soil water is limited and in-season expected precipitation is minimal, you should consider growing a crop, such as wheat or sunflower, that requires less ET to get the first unit of yield. However, if there is a moderate amount of stored soil water and an expectation of ample in-season precipitation, corn can provide the most yield potential (and return) for each increment of ET.



Schneekloth, J.P. et al. 1991. Crop Rotations with Full and Limited Irrigation and Dryland Management.
Figure 3: Water Needed For Crop Production

Planting Time Decisions

Soil Fertility and Fertilizers

Proper soil fertility and fertilizer applications based on soil tests are essential for profitable winter wheat yield potential. Good winter wheat yield potential leads to good residue production which helps maximize corn yield potential the following year. Fertilizer should be applied according to soil tests and yield potential. Phosphorus makes winter wheat more competitive. Successful applications include using anhydrous ammonia, urea ammonium nitrate solutions, or dry fertilizers. If no-till, apply the phosphorus as starter and the nitrogen as liquid in fall or spring (UNL Extension Circular 143). Anhydrous ammonia can be applied in June, with or without phosphorus, with a sweep blade. Dual injection of anhydrous ammonia and phosphorus in 12-inch bands has worked well. July and August application of anhydrous ammonia should be done with a rodweeder. If sufficient rainfall does not occur after application with a sweep plow, the seedbed will not be firm. Avoid fertilizing when the soil is too wet because heavy loads compact the soil. Wheel tracks can be a problem, particularly when driving on wet soil.

Starter Fertilizer Application

Fertilizer attachments must be mounted in such a manner so as not to collect straw. Some fertilizer openers place liquid fertilizer below the seed. Worn openers may allow fertilizer to come within 1 inch of the seed and damage the seedling. Often the starter attachment is placed 4 inches from the row to avoid soil build-up on the planter's depth gauge wheels. A limited amount of starter fertilizer can be placed directly with the seed. However when fertilizer is placed with the seed, the potential risk of salt damage increases substantially.

Table 3. The amount of 10-34-0 that can be safely applied per acre for corn and grain sorghum in 30-inch rows as influenced by distance from the seed and soil texture.** Determine safe application rates for other fertilizers by dividing the value relative to 10-34-0 (see Table II, UNL NebGuide G361) into the amounts listed below.

Placement	Sandy Soils	Non-sandy Soils
	10-34-0 (gal/acre)*	
With the seed (pop-up)	5	5
1/4 to 1/2 inch from the seed	10	10
1 inch from the seed	20	40
2 inches or more from the seed	20+	40+

*The safe application rate for soybeans is one-half of these values.
**For narrower row-widths, the application rate may be increased. For 22-inch rows, multiply by 1.36 and for 15-inch rows multiply by 2. (UNL NebGuide G361).

Skip-Row Corn

Skip-row corn is a technique where one or two rows of corn are placed next to one or two blank rows. The idea behind skip-row planting is to keep developing corn plants from using all of the available water too early in the growing season. Because water in the soil between widely spaced rows cannot be reached by the plants until later in the season, water is available to plants in July and August. Corn is very sensitive to drought in the silking to blister growth stage of development (See Figure 4 after two seasons of skip-row corn in a plant 2 skip 2 system).

According to UNL research, if the corn yield potential is below 75 bu/a, farmers should use a skip row pattern. However, if the yield potential is between 75 to 100 bu/a, farmers can choose between skip-row and standard planting pattern. If the yield potential is over 100 bu/a, a standard planting pattern is preferred. This recommendation however does not hold true in Kansas where limited benefit has been observed in research evaluating skip-row to a standard planting pattern.

To maximize dryland corn yield potential in Nebraska with no-till skip-row planting, keep the following points in mind:

- No-till offers several potential advantages with appropriate levels of crop residue:
    - Much greater potential moisture savings: After base needs are met (10 inches of soil water) corn yield potential can increase 6 to 12.5 bushels per acre with every one-inch increase in soil water available to the crop.
    - Much faster potential soil infiltration of water compared to bare soils.
    - Higher yield potential.

For more information on skip row corn consult UNL Extension Circular EC196-12.

Figure 4: Skip-row corn in a plant 2 skip 2 system.

Seed Depth

Depth control is critical since planting too deep into cooler soils slows emergence, and planting too shallow may cause problems with covering the seed properly and rooting. Good depth control on a planter starts with independent flexible row units, which are essential. Shallow-planted corn (1.5 inches or less) may have trouble developing secondary roots important in anchoring the plant so it doesn't lodge. There must be sufficient weight on the planter units to ensure uniform penetration to the desired seeding depth of 2 inches. It is best to error on seeding deeper than too shallow. Seed firming devices to firm the seed in the bottom of the seed furrow help with germination and even crop emergence. When planting into wet soils, seed-furrow openers can cause problems by "slicking" the sides of the seed-vee. Upon drying, the nodal roots cannot penetrate the sides of the groove, resulting in what is known as rootless corn syndrome. Severe lodging may occur that resembles rootworm damage.

Over-packing the soil above the seed can be a problem when soil moisture extends to the surface. The soil must be pressed firmly enough to seal the seedbed but not hard enough to crust the soil upon drying. A seed press wheel can help set the seed firmly in contact with moist soil. Seed firming devices can help place the seed in the bottom of the seed furrow. Some soils become cloddy or have a tendency to crust if they are pressed firmly when wet. Usually these problems can be reduced by waiting for more favorable planting conditions and by leaving residue over the row.

Seeding Rates

Relative maturity, stress tolerance, prolificacy, and stalk lodging are some of the factors that should be considered when selecting corn products. Optimum seeding rates are affected by the corn product selected and environmental conditions. Full-season corn products have the greatest yield potential. A mid-season corn product at one location may be a full-season corn product at another location since season length varies greatly across the Central Great Plains. The length of the growing season is affected not only by the number of days from the last frost in the spring until the first frost in the fall, but also by latitude and altitude. In addition, the field micro-climate associated with residue cover, may greatly influence plant response to climatic conditions.

The biggest potential risk to producing high yielding corn is selecting corn products that are too long or too short in maturity. A short-season corn product has a lower yield potential than a long-season corn product; however, moisture limitations, frost, or both may limit performance of the long-season corn product in some years.

With a greater amount of soil water at planting, it is usually preferable to increase the planting rate rather than switch from a mid-season to a full-season corn product. If full-season corn products are used, reduce the plant population. Generally, for every four-day reduction in corn product maturity, 1 inch less water is required. However, this large amount is only true in well-watered conditions. For example, studies conducted with adequate soil moisture have shown that with a 2,400 or less Growing-Degree-Day (GDD) corn product, optimum harvest population was above 30,000 plants while with a GDD corn product of 2,700 or more, the optimum harvest population was 26,000 plants (UNL Extension NebGuide G2068). Check your seed guide for corn product GDD ratings.

Seeding rates for corn in Nebraska under dryland conditions have ranged from approximately 8,000 to 30,000 plants per acre. Water requirements of corn may decrease if the population is less than 18,000 plants per acre. Corn yield potential may increase from 6 to 12 bushels per acre for each additional inch of soil water beyond the 8 to 11 inches needed for initial grain development. Many agronomists feel that maximum production is reached with a 0.5 pound ear weight with row spacings of 20-36 inches (UNL Extension NebGuide G2068). The skip-row system (plant 2 skip 1, plant 1 skip 1, and plant 2 skip 2) probably increases ear weight to 0.6 pounds. Under dryland conditions, an ear weight of 0.6 pounds or even 0.7 pounds in a skip-row system may be a more desirable goal in areas with a longer growing season. But in areas such as the Nebraska Panhandle, a 0.4 pound or 0.5 pound ear in a skip-row system may be optimum on a year-to-year basis. This would provide some insurance if a drought occurred.

Planter Equipment

Manufacturers have developed planter attachments to handle crop residues, including wheat stubble. The most effective have been the spider wheel residue movers. These attachments move the stubble before the disk seed-furrow openers. Crop seed must be placed in firm moist soil, not into hair-pinned crop residue. Stubble handling attachments may move the stubble a few inches from the row. With good crop residue, including the fines, it is usually not necessary to move the crop residue out of the seed row (Figure 5). This can conserve soil water and help manage weeds. Compare this with Figure 6 where much of the crop residue was destroyed.

Figure 5: No-Till planting into residue left in place.

Figure 6: Planting with too much residue destroyed.

A bare soil area around the seed furrow may promote faster soil warming and seed germination, but the bare area may promote weed growth and crop residue may blow back over the row. This uneven residue spread will cause uneven emergence. Planters should be set to avoid moving pre-plant herbicides or soil away from the seed furrow. An alternative is to apply herbicides in a band over the row at planting, or broadcast after planting.

Usually double-disk, seed furrow openers open a seed-vee at a uniform depth. A disk-type furrower opener should not be set to move soil, which could cover the straw between rows, or be deep enough to cut a furrow that water runs down the row. Removing soil containing herbicides allows weeds to develop in the row. For more information consult UNL Extension NebGuide G551.

Insect management should be an essential part of any cropping system. In dryland situations, it is imperative that insects that attack the stalk or root system be controlled. Use of crop rotation, insecticides and biotechnology traits to manage insects, helps ensure a strong and aggressive root system, which can make full use of stored soil moisture.

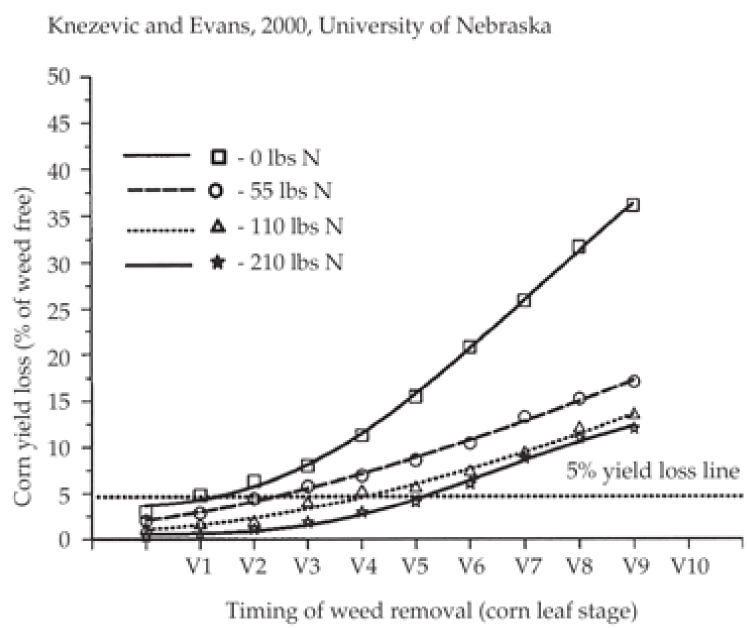
In-Season Decisions

One method to increase the storage of soil moisture is to allow the soil to be fallow for a period of time. Planting corn, sorghum or soybeans into untilled, weed-free winter wheat stubble that is 10 months old is an accepted practice in the Central Great Plains. In Nebraska, this system is known as ecofallow. Ecofarming and ecofallow are systems of no-till or reduced tillage. Ecofarming is defined as a system of controlling weeds and managing crop residues throughout a crop rotation with minimum use of tillage so as to reduce soil erosion and production costs while increasing weed control, water infiltration, moisture conservation and crop yield potential. The ecofallow period in a 3-year rotation of winter wheat-row crop-fallow is the period between harvest of wheat or another small grain and the planting of corn, sorghum or soybeans. Energy requirements are much lower for ecofallow than conventional fallow (UNL Extension NebGuide G551). Weed control depends on good cultural practices and herbicides. Good herbicide application and performance is essential for any conservation cropping system. Most of the failures of no-till planting are associated with poor weed control and poor crop residue distribution. Make sure to plan ahead to take care of weed problems early, as the goal should be complete weed control throughout the crop rotation. Don't plant into a weed problem unless you have a solution for controlling the weeds.

Spray as soon after wheat harvest as possible with appropriate herbicides, considering the row crops to be planted the following spring. Also, apply atrazine in September if corn and/or grain sorghum will be planted the next spring. Apply glyphosate for fields going into soybeans and to control emerged volunteer wheat. Select the herbicides for the row crops to be planted the following spring - herbicides that can be used preplant or preemergence. Apply appropriate postemergence herbicides if weeds are present. More effective herbicides are available for corn and soybeans than for sorghum. For local recommendations please visit the Roundup Ready PLUS® website at http://www.roundupreadyPLUS.com or see Guide for Weed Management in Nebraska. UNL Extension Circular EC130 or the Chemical Weed Control Guide, Kansas State University, SRP 1099, for the latest recommendations.

In undisturbed fields treated with herbicides prior to row crop planting, weeds often emerge in the areas disturbed by the planter units and the marker. It is best to use a guidance/guidance steering system instead of a physical disk marker.

Weeds should be controlled on a timely basis while maintaining as much residue as possible. Weeds use large amounts of soil water when they are not adequately controlled during the fallow period, and which results in spotty stands of wheat (or corn) because of dry soil areas that do not allow germination. Weeds are easiest to control when they are small (less than 4 inches). Delaying control of weeds until later in the growing season can cost farmers bushels of corn. For example when control was delayed until the corn reached the V6 stage, yield loss ranged from 8% to 20% depending on the environment. Waiting for more weeds to emerge can be costly because larger weeds are not easily controlled.



Stevan Knezevic. The Critical Period of Weed Control in Corn. UNL Cropwatch. Figure 7: Corn yield loss and beginning of the critical period of weed control as influenced by the timing of weed removal and nitrogen rate.

Weeds allowed to go to seed are likely to increase weed pressure in the subsequent crops, reducing yields and increasing production costs.

Care should be taken to reduce the potential of herbicide resistance development in weed species. Controlling weeds when they are small, using herbicides with residual activity and alternating herbicide chemistry and mode of action can reduce the likelihood of resistance developing.

For more information on making in-season management decisions, consult UNL Extension NebGuide G551.

Conclusion

Since available soil moisture is the limiting factor in many dryland cropping regions, farmers should adopt residue management practices that increase rainfall infiltration and reduce soil surface water evaporation. Additional factors such as crop rotation, corn product selection, plant population, row spacing, soil fertility, weed control and insect management are important practices in the systems approach of dryland water management. Making preventative drought mitigation decisions is critical to obtaining optimal corn yield potential. The availability of improved corn genetics, biotechnology traits and improved agronomic practices can help growers manage drought and other risks. Understanding the contribution of these technology and agronomic factors can help growers develop a system to mitigate stress and increase corn yield potential and profitability.

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