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Drought-stressed Corn

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Identification of Drought Stress and Its Effect on Corn Growth and Yield

A serious lack of water can affect plant health at any time during its development. Water moves from the soil through the plant and is lost to the atmosphere as water vapor. As water moves into and through the plant, it transports nutrients from the soil, through the roots and into the plant cells where they are involved in plant processes. Finally, water cools the plant through transpiration.

Inadequate moisture during any period of growth can result in death of plant tissues and reduced grain yield. Plants weakened by stress are more susceptible to disease and insects. Severe moisture stress is indicated by leaf wilting and is alleviated only when the plants receive additional water. This publication will discuss how to identify drought stress in corn, its effect on potential yield, and how to maximize economic return from drought-damaged corn.

The *National Corn Handbook* indicates that four consecutive days of visible wilting during the vegetative growth stage can reduce potential corn yield by five to ten percent. Potential number of rows of kernels is determined from the 10-leaf to the 12-leaf stage. Potential number of kernels per row is determined from the 12-leaf to the 17-leaf stage. If ear size is reduced due to stress during these vegetative growth periods, it cannot be corrected by relieving moisture stress later in the season.

Four consecutive days of wilting during silking and pollination can reduce yield as much as 40 to 50 percent. Drought accelerates pollen shed but retards the emergence of silks. Silks normally grow about 1 to 1.5 inches per day. If a silk is not fertilized by pollen when it first emerges, it will continue to grow, provided there is adequate moisture available for cell growth. Silks emerge from the butt end of the ear first, then progressively up the cob with the last silks to emerge from the tip end.

Moisture stress during pollination can result in a lack of synchronization between silking and pollen shed. Silking may be delayed in moisture-stressed plants and pollen grains do not remain viable long under drought conditions, especially when temperatures are in the mid 90s. A common result is a lack of viable pollen late in the pollination period when the silks from the tip are emerging, resulting in barren ear tips. Corn under moisture stress during early grain fill often will abort the last kernels to be fertilized by pollen. This also results in barren ear tips and is known as "tipping back".

Within one to three days after silks are pollinated and fertilization is successful, the silk will detach from the developing kernel. You can estimate the degree of successful fertilization by carefully removing the husk leaves from an ear shoot, shaking the cob, and observing how many silks shake loose. Another method to determine whether drought-stressed corn plants have been pollinated and fertilized is to look for small white blisters on the ear seven to ten days after pollen shed. To identify the blisters, take ears from several areas in the field and break them in half. Using a knife, dig out several kernels on each ear. If you find kernels that resemble blisters on the ears, assume kernel fertilization occurred. If you are unsure whether fertilization has occurred, check again in five to seven days. If the kernels were fertilized, the blisters will have rapidly increased in size.

Harvest Options

Many harvest options are available to corn producers. These generally fall into two categories: harvesting grain or harvesting forage.

Harvesting Grain

If the corn successfully pollinated and will produce grain, harvesting grain may be the best alternative for drought-damaged corn. The combine may need several adjustments to accommodate the smaller ear size and lighter test weight grain. (See the *National Corn Handbook* for recommendations on combine adjustments.)

Test weight is one of the factors that determines market grade. Drought stress during grain fill can cause light test weight grain, resulting in lower grain grade and a considerable price dock at the elevator. On the other hand, light test weight

corn usually makes good animal feed, having 90 to 100 percent of the feed value of normal corn. Light test weight grain can be a bargain for the feeder provided the corn does not contain mycotoxins. Mycotoxins in grain are discussed in the NU NebGuide, *Grain Molds and Mycotoxins in Corn* (G00-1408).

To estimate potential yield in standing corn, measure a distance equal to 1/1000 acre (*see box*) in one row and count the number of plants that will produce an ear. Repeat this in several areas of the field. Take an ear at random from each of these areas and count the number of rows of kernels and the number of kernels per row on each ear. Average the number of rows per ear and the number of kernels per row. Multiply the average number of rows by the average number of kernels per row to get the kernels per ear. The kernels per ear multiplied by the ears per acre results in the kernels per acre. There are about 90,000 kernels per bushel in normal corn. Drought-stressed corn may have 110,000 kernels per bushel. Dividing the kernels per acre by 110,000 results in the estimated yield of the drought-stressed corn.

Tip

To calculate the length of row equal to 1/1000 acre divide 43.56 sq ft. by the row spacing in feet.

Length of row equal to 1/1000 acre = 43.56 sq ft / (row spacing in inches / 12 in/foot).

For example: with a 30-inch row spacing, 1/1000 ac = 43.56/ (30 /12) = 17.42 ft or 17 ft 5 in of row.

For example: A dryland field of corn under moisture stress during pollination and kernel fill has 12,000 plants per acre with ears that pollinated but have "tipped back" to an average of only 24 kernels per row. There are an average of 14.3 rows of kernels per ear. The estimated grain yield (assuming enough moisture is received for photosynthesis to occur and transport of starch into the grain) would be 37 bushels per acre (12,000 x 24 x 14.3 / 110,000 = 37 bu/ac).

Harvesting Forage

Before grazing or mechanically harvesting the crop as forage, check the labels of all chemicals applied to that field. Be sure all pesticides (herbicides and insecticides) applied to the crop are cleared for forage and the minimum harvest interval has been met. Check with the USDA Farm Service Agency (FSA) office to maintain compliance with USDA farm program provisions and check with the crop insurance company before harvesting corn as forage. Finally, be aware of the potential for high nitrates in the forage and consider the following precautions that may need to be taken before feeding it to livestock.

When drought conditions prevent normal plant growth, the corn stalk may contain abnormally high levels of nitrate. When grazing these plants, an animal's rumen will convert nitrate in the forage to other nitrogen compounds. The first step in the process is conversion of nitrate to nitrite. Some of the nitrite is absorbed across the rumen wall into the bloodstream where it combines with hemoglobin in the blood to produce methemoglobin. Methemoglobin cannot carry oxygen.

Symptoms of nitrate (nitrite) poisoning include: difficult and rapid breathing, muscle tremors, low tolerance to exercise, incoordination, diarrhea, frequent urination, collapse and death. When nitrate poisoning is suspected, remove the contaminated feed, provide a high energy feed such as corn, and call a veterinarian immediately. The veterinarian can administer a methylene blue solution intravenously to counteract the effect of the nitrate. Because livestock can die from the resulting oxygen shortage, handle cattle as little and as quietly as possible to minimize their oxygen needs until a veterinarian can provide aid.

Under most feeding situations, nitrate-nitrogen (NO_3-N) levels over 0.226 percent (2260 parts per million or ppm) in feed are considered potentially toxic. Some laboratories report the concentration of nitrate (NO_3) instead of nitrate-nitrogen (NO_3-N). The potentially toxic level for nitrate is 1.0 percent (10,000 ppm). Nitrate testing of feed is especially important if high rates of nitrogen fertilizer or manure were applied, or if the soil has a high organic matter content.

Feedstuffs testing high in nitrates can be used as part of a ration if they are diluted with lower nitrate feeds. For example, you may mix corn silage with grass hay. Before deciding the percentage of each feedstuff to include in the ration, know the nitrate levels of all feedstuffs used, then blend the feedstuffs so the total ration does not exceed the potentially toxic threshold level. (For more information on blending feedstuffs, refer to the NU Lancaster County Cooperative Extension Fact Sheet, *Using a Pierson Square to create a blended product with desired properties*.)

The adverse effects of using livestock feeds with high nitrate concentrations are greater if the ration is not properly balanced. When using feeds that are high or suspected to be high in nitrate, make sure the ration is balanced nutritionally for vitamins (A and E), macro minerals and trace minerals.

Direct Grazing of Corn

Drought-stressed corn can be direct grazed by beef animals with some extra care and management. To minimize waste from trampling, use an electric fence to limit access to only that portion of the field that cattle will use in two to three days. The fence should then be moved to open up a new strip.

As mentioned above, nitrate is a concern in drought-stressed corn and cattle should never be turned hungry into a corn field. Always have cattle full of low nitrate forage before turning them in to graze for the first time. Cattle will tolerate higher levels of nitrate in their diet if they are allowed to acclimate to increasing levels over time. It is wise to supplement cattle with a high quality hay source or remove the cattle to pasture where they can graze forage low in nitrates for part of the day at first, then slowly reduce the amount of supplemental forage fed until they are receiving only the corn forage.

Nitrates are not evenly distributed in the corn plant. Nitrate levels are fairly low in the leaves and higher in the stalk, with the lower stalk being the highest in nitrate. Animals will eat the leaves first, then the upper stalk and finally the coarser lower stalk. When grazing standing corn, animals should not be forced to eat the lower stalk since it contains higher levels of nitrates. Provide plenty of clean water, salt and mineral to cattle grazing drought-damaged corn.

Greenchop

Chopping the forage and feeding it to the animals rather

than letting them directly graze the field is one way to minimize waste and improve use of available forage. Feeding greenchop requires great care, however. Always test nitrate levels in the greenchop before feeding it to animals. If nitrate is higher than the potentially toxic level (2260 ppm NO_3-N), use greenchop for only a portion of the total ration, with the balance of the ration comprised of lower nitrate forage sources. If drought-stressed corn is greenchopped and fed without ensiling, it should be fed immediately after it is chopped. Never allow greenchopped forage to heat in the truck or in the bunk because nitrate will quickly convert to nitrite. Nitrite is ten times as toxic as nitrate when fed to animals.

Have plenty of bunk space available (36 inches of bunk space per cow is recommended) so "boss" cows don't overeat and timid cows receive their share, then chop only the amount that will be eaten within two hours. It is better to feed small amounts two or three times daily than a large amount once per day.

Silage

Ensiling drought-stressed corn is preferred to chopping or grazing because ensiling reduces nitrate levels in the feed. During the ensiling process, one-third to one-half of the nitrate in the forage is converted to gaseous nitrous oxide compounds which leave the silage pile. *Caution!* These nitrogen oxide gases (known collectively as silo gas) are highly toxic to humans and livestock. Do not enter an enclosed space such as an upright silo for the first four weeks after filling without first running a blower for 15-20 minutes.

The tendency is to cut drought-stressed corn for silage too soon, resulting in silage with excess moisture, poor fermentation and reduced feed value. Stalks of plants with many or most leaves turning brown will contain considerable moisture. Always test moisture content of a sample before chopping silage. If the moisture content is above 70 percent, either wait to harvest, windrow the corn and let it field wilt before chopping for silage, or mix silage with dry ingredients like cracked corn or ground hay to bring the moisture content down to 65 to 70 percent for proper ensiling. It takes about 35 pounds of corn or hay to reduce the moisture content of one ton of wet silage by one percentage unit. If drought-stressed corn has pollinated, it is best to delay harvest as long as some green leaf and stalk tissue remains and the black layer has not formed on kernels. Rainfall and subsequent relief of moisture stress can increase grain dry matter and silage quality.

Estimating Yield of Drought-damaged Silage

With drought-stressed corn, you can expect to harvest about one ton of silage per acre for each six bushels of corn grain per acre that could have been harvested. For example, if you expect a grain yield of 50 bushels per acre, you can expect 8.3 tons per acre of 30 percent dry matter silage. If little or no grain is expected, a rough pre-harvest estimate of yield can be made by assuming one ton of 30 percent dry matter silage can be obtained for each one foot of height of plant material harvested, excluding the tassel.

Pricing Drought-stressed Silage

The feed value of silage made from drought-stressed corn is usually between 90 percent and 100 percent of silage made from well-eared corn, based on equal dry weights of the two feeds. Generally, crude fiber and protein is somewhat higher and TDN (total digestible nutrients) lower for silage made from drought-stressed corn rather than normal corn. This is because ears from drought-stressed corn may contain 50 percent or more cob by weight compared to 20 percent cob on normal ears. Drought-stressed silage should be tested for moisture percentage, nitrate content and feed value before feeding. The pricing methods discussed in the following section assume the silage is in the silo after undergoing the ensiling process.

Two methods can be used to determine a fair market value for silage; each make comparisons with other feed sources. The first compares the price of silage in the silo to the price of corn. A rule of thumb when pricing normal silage is a ton of 70 percent moisture (30 percent dry matter) silage should be worth 10 times the price of a bushel of corn. Drought-stressed silage may have somewhat lower feed value as compared to normal silage so this price estimate should be corrected based on relative feed value. If drought-stressed silage has 90 percent of the feed value of normal silage, it should be priced at 90 percent of the value calculated above.

The second pricing method for silage uses the price for corn and soybean meal. *Table I*, from the *National Corn Handbook*, lists prices for drought-stressed corn silage based on both energy (TDN) and crude protein (CP) content for a range of corn grain and soybean meal prices.

To use the table, find the price per bushel of shelled corn across the top and the price per hundredweight of soybean meal down the left side. The cell at the intersection of these two prices gives the value of drought-stressed corn with 30 percent dry matter, 65 percent TDN and 10 percent crude protein. For example: If corn is $2.20 per bushel and soybean meal is $9.50 per hundredweight ($190 / ton) the estimated price of drought-damaged silage in the silo is $21.77 per ton.

No matter which method is used to calculate price, the actual exchange price for drought-stressed corn silage will vary by area, depending on the relative supply and demand.

Dry Forage (Stover)

If the corn will not make sufficient grain to harvest with a combine and there is no local market for silage, a final marketing alternative is to windrow the corn, let it field dry and put it up as stover. The advantage of this method over making silage is that there is far less tonnage to haul.

The disadvantage is that the large stems, even when put through crimping rolls in a windrower, can take two to three weeks under ideal drying conditions to dry enough to make the average moisture content safe to bale.

Unlike with ensiling, nitrate level does not decline as forage dries. Take extra caution when feeding dry forage. If the initial nitrate test comes back high, cut the plants higher, 8-12 inches above the ground, to reduce the nitrate content of the forage. Always test the nitrate content in the dry forage before feeding to animals.

Corn stover can be hard to bale. It requires more horsepower than other forages when put through a square baler due to the effort required to shear the coarse stems. It also may be more difficult to form an even bale in a round baler and the bales tend to lose integrity (slough off). Some of this integrity

Table I. Value of drought-stressed corn silage, based on corn grain and soybean meal prices.*

Price of soybean meal	*Price of corn grain ($/bu)*						
	1.80	*2.00*	*2.20*	*2.40*	*2.60*	*2.80*	*3.00*
($/cwt)	*Value of corn silage ($/ton)*						
6.00	16.97	18.54	20.11	21.68	23.24	24.81	26.38
6.50	17.21	18.77	20.34	21.91	23.48	25.05	26.62
7.00	17.44	19.01	20.58	22.15	23.72	25.29	26.86
7.50	17.68	19.25	20.82	22.39	23.96	25.53	27.09
8.00	17.92	19.49	21.06	22.62	24.19	25.76	27.33
8.50	18.16	19.72	21.29	22.86	24.43	26.00	27.57
9.00	18.39	19.96	21.53	23.10	24.67	26.24	27.81
9.50	18.63	20.20	21.77	23.34	24.91	26.47	28.04
10.00	18.87	20.44	22.01	23.57	25.14	26.71	28.28
10.50	19.10	20.68	22.24	23.81	25.38	26.95	28.52
11.00	19.34	20.91	22.48	24.05	25.62	27.19	28.76
11.50	19.58	21.15	22.72	24.29	25.86	27.42	28.99
12.00	19.82	21.38	22.96	24.52	26.09	27.66	29.23
12.50	20.06	21.62	23.19	24.76	26.33	27.90	29.47
13.00	20.29	21.86	23.43	25.00	26.57	28.14	29.71

problem can be overcome by wrapping the bales with mesh or using more wraps of twine.

Finally, unless the corn stover is ground to reduce particle size, animals will sort, eating the leaves and small stems but leaving the coarse stems. Plan on more waste when feeding dry forage as compared to feeding greenchop or silage.

Pricing Dry Forage

Dry corn forage can be compared to drought damaged silage as an alternate feed source. If the two products have the same nutrient content on a dry matter basis, dry forage could be priced similarly on a dry matter basis.

A ton of 70 percent moisture (30 percent dry matter) silage contains 2000 x 0.30 = 600 pounds of dry matter. A ton of 20 percent moisture (80 percent dry matter) forage contains 2000 x 0.80 = 1600 pounds of dry matter. Therefore a ton of dry forage would contain 2.66 times as much dry matter per ton compared to silage. If drought-damaged silage is selling for $22/ton, dry forage *with the same nutrient content* might sell for about $22 x 2.66 or $58.50 per ton. Factors such as waste, handling, transportation, etc. may affect the relative value of silage versus dry forage for individual farms.

References

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Using a Pierson Square — to create a blended product with desired properties. Lancaster County Cooperative Extension Factsheet 02-299, available on the Web at *http://lancaster.unl.edu/factsheets/FieldCrops/299.htm*

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