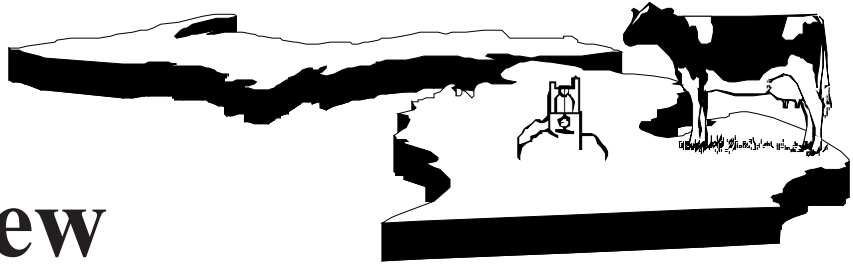


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Harvesting Drought Stressed Corn for Silage

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Corn should be harvested for silage when the whole plant dry matter is between 30 and 40%. The recommended harvest moisture ranges are the same for drought stressed corn as for corn grown under ideal soil moisture conditions (Table 1).

During drought conditions some of the corn plants may appear quite dry because the leaves are brown and dry but the presence of dry leaves is not an accurate indicator of whole plant dry matter content. The stalk, cob and grain contain the majority of the whole plant moisture. Attempting to predict

when to harvest corn for silage based on just looking at parts of the plant may result in the corn being harvested at less than ideal dry matter concentration. The reason whole plant dry matter at harvest is so important, is that the ideal dry matter for the silage fermenting bacteria and the prevention of silage juice seepage is between 30-40%.

Harvesting at dry matters lower than 30% (too wet) can result in an undesirable silage fermentation process that may result in unpalatable silage that can reduce dry matter intake of cows. Also, corn silage harvested at wetter than 30% dry matter, will usually result in seepage run-out from silage storages.

Harvesting at whole plant dry matter above 40% (too dry) can result in a poor fermentation because the material was too dry and there was not sufficient moisture for the fermenting bacteria and for adequate packing. The silage may not contain

Table 1. Recommended harvest dry matter for different types of storage structures.

Storage Structure	% Dry Matter Ranges
Bunker	30 - 35
Upright - non-sealed	32 - 40
Sealed Upright	32 - 40
Silage Bags	32 - 40

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Table 2. Nitrate (NO₃) levels in drought-stressed corn plants.

Plant Part	NO ₃ (parts per million)
Leaves	284
Ears	75
Upper 1/3 stalk	678
Middle 1/3 stalk	3,557
Lower 1/3 stalk	24,471
Whole plant	4,333

sufficient acid levels and may start heating during feed-out from the silo or bunker. In addition, silage drier than 40% will likely have decreased digestibility of fiber and starch.

Whole plant dry matter should be monitored starting a few weeks before traditional corn silage harvesting dates. The dry matter content of corn plants can decrease rapidly once the plant starts to dry down. When dry matters start to approach 30% monitoring every day or two of plants from different fields will help assure that no fields will be harvested outside of the desirable dry matters. Drought stressed corn can dry down very rapidly if the plants are not actively growing especially on days when the temperature is very hot and there are strong dry winds.

How to Determine Whole Plant Dry Matter

The only way to accurately determine when the whole corn plant is at 30% dry matter is to use a moisture tester. A Koster moisture tester or microwave oven can be used to obtain an accurate dry matter.

Hand cut 15-20 whole corn plants at the normal chopping height (about 4-6") from throughout a field but not from headrows because the plants might be drier there. Chop the entire stalks into silage particle sizes. Monitor those fields and locations every 2 to 3 days by again obtaining 15-20 stalks for

dry matter testing. This method will track the changes in dry matter and the rate at which the plants are drying down. This will aid in predicting when to start harvesting.

Kernel Milk Line or Kernel Dry Matter as a Method to Determine Whole Plant Dry Matter

Kernel milk line has been found to not be an accurate indicator of whole plant dry matter. Research at Michigan State University and elsewhere found that the whole plant dry matter varied as much as 15% when kernel milk line was used to predict whole plant dry matter. Thus kernel milk line is not an acceptable method to use to predict whole plant dry matter.

Kernel dry matter has also been found to not be an accurate indicator of whole plant dry matter. This is the case for drought stress and non-drought stressed corn kernels.

Thus the only accurate and acceptable way to monitor whole plant dry matter for deciding when to harvest corn for silage is to use a Koster moisture tester or the microwave oven method.

Nitrate Toxicity Potential

High nitrates concentrations in corn plants and corn silage can potentially be toxic to cattle.

Nitrates are normally taken up by plants from the soil

Table 3. Nitrate concentration in a feed ingredient and feeding recommendations.

NO ₃		NO ₃ -N		Feeding Recommendations
ppm ¹	percent ²	ppm	Percent	
<4,400	<0.44	<1,000	<0.1	Safe to feed, non-toxic level
4,400-8,800	0.44-0.88	1,000-2,000	0.1-0.2	Limit the feed to less than 50% of ration dry matter
8,800-17,600	0.88-1.76	2,000-4,000	0.2-0.4	Limit the feed to less than 25% of ration dry matter, do not feed to pregnant cattle
>17,600	>1.76	>4,000	>0.4	Do not feed

¹ % = > ppm (multiply % by 10,000)

² ppm = > % (divide ppm by 10,000)

Table 4. Multiplication conversion factors for various nitrogen compounds to nitrate (NO₃).

Nitrogen Substance	Chemical Formula	Multiplication Factor
Nitrate	NO ₃	1.00
Nitrite	NO ₂	1.35
Nitrate-nitrogen	NO ₃ -N	4.43
Nitrite-nitrogen	NO ₂ -N	4.43
Sodium nitrate	NaNO ₃	0.73
Potassium nitrate	KNO ₃	0.61

and utilized for the synthesis of plant protein. During drought conditions plant growth is impaired and nitrates can accumulate in the plant (Table 2). If sufficient rainfall occurs allowing for resumption of normal plant growth (this re-growth process takes a few days to start) the accumulated nitrates will be incorporated into plant protein.

During the silage fermentation process the fermenting bacteria utilize plant nitrates for their growth process. Therefore, nitrate concentrations of drought stressed corn plants will be lower after the plants have undergone the fermentations process. The exact reduction of nitrate concentrations cannot be predicted. If the potential of nitrate toxicity is a concern, testing for nitrate in the silage should be done after the forage material has gone through the entire fermentation process, about 4 weeks. Green chopping or grazing of drought-stressed corn is not recommended because of the potential for nitrate toxicity.

Ensiling of potentially high-nitrate containing forages can also result in production of various nitrogen oxide gases. These gases are highly toxic to humans and livestock. The danger of silo gas can exist from ensiling time to 4 weeks later. During this period, do not enter a silo without first running the blower for 15 to 30 minutes. Using a self-contained breathing apparatus is highly recommended. Any person exposed to silo gas should seek immediate medical attention to combat delayed poisoning symptoms.

The concentrations of nitrates in a feed ingredient and the recommended feeding rates of that ingredient are in Table 3.

Laboratory Testing for Nitrates

Corn plants and corn silage can be tested for nitrates by many commercial feed-testing laboratories. This testing is also available at the MSU Soil and Plant Nutrient Laboratory.

MSU Soil and Plant Nutrient Laboratory
A-81 Plant & Soil Sciences Building
Michigan State University
East Lansing, MI 48824-1325
(517) 355-0218
<http://www.css.msu.edu/SoilTesting.cfm>

Cost is \$12.00 per sample for chopped plant material or silage.

Care must be taken in sampling to ensure a representative sample. Grab samples should be taken from chopped forage from various locations in the field, which represents all levels of plant stress. Mix these samples in a bucket and place approximately one pint of material in a sealed plastic bag. Time between sampling and arrival at the laboratory must be as short as possible. Refrigeration of samples is beneficial, especially when the lag extends beyond one day. Green or wet samples allowed to stand at room temperatures or higher may lose nitrate via plant enzyme and bacterial activity.

All laboratories do not express plant nitrate concentrations in a similar manner. Table 4 contains multiplication factors to convert various nitrogen compounds to nitrate (NO₃).

Results of Michigan State University's Testing for Nitrates During the Drought of 1988

During the 1988 drought which was widespread in Michigan, whole corn plant samples were obtained from the areas affected by the drought on various dates and were tested for nitrates at the MSU Plant Diagnostic Clinic. The results are shown in the following table 5.

The data in Table 5, indicate the following:

(1) 1998 Drought in Michigan – The drought in 1988 started in mid-June. When the first sampling period (7/21-8/1/88) was conducted the corn plants were already subjected to at least a month of drought conditions. The data in table 5 represents only what occurred in 1988. This data does not indicate what the nitrate concentrations might be on a given date for other years.

(2) Fresh Corn plants – The data in table 5, is expressed as average and ranges for the 4 sampling date periods. Note the wide range in nitrate concentrations for each of the sampling periods. This indicates that concentrations were very variable due to the variability of drought conditions at the field locations where the plant samples were obtained.

The data in Table 5, does indicate the nitrate concentrations in the samples obtained in 1988 from across the state decreased as growing season progressed. However, data on rainfall or growing conditions occurring during the testing

Table 5. 1988 Michigan State University's Testing for Nitrates During the Drought of 1988.

Material	Sample Dates	Number of Samples	Average Concentration NO3 (ppm)	Range NO3 (ppm)
Fresh Corn Plants	7/21/88 - 8/1/88	21	8,800	20.0 - 17,100
	8/2/88 - 8/5/88	28	6,600	400 - 16,000
	8/5/88 - 8/12/88	14	3,700	300 - 11,600
	9/1/88 - 9/28/88	40	3,500	20 - 25,000
Corn Silage		17	880	20 - 3,500
Fresh Sudan Grass		5	11,300	600 - 35,000
Sudan Grass Silage		2	3,800	1,750 - 6,000

D. Roberts, Michigan State University, Plant Diagnostic Clinic, 1998

period from the areas where the samples were obtained is not known. Thus, nitrate concentrations for years other than 1988 will probably be different. Testing of whole corn plants for nitrate concentrations is the only way to know the nitrate concentrations for a particular field of corn.

(3) Corn Silage - Average nitrate concentrations was 880 ppm, which is much lower than for the fresh corn plant material. It is not known if plants from the field where the "Fresh Corn Plant" samples were obtained were part of the sample tested as "Corn Silage". So, the exact percent of nitrate that was reduced by silage fermentation cannot be predicted from this data.

(4) Corn Silage - All corn silage samples in 1988 had nitrate levels that were within the safe guidelines (table 3) for feeding to cattle. Hopefully similar results as what occurred in 1988 will occur in other years. That is, high nitrate levels occurring during the mid-late growing season will be lower as harvest date approaches and also lower in the silage after fermentation has occurred. For farmers the recommendation is to test the silage for nitrates before feeding if there is a concern.

Chopping Height Recommendations as Related to Nitrate Toxicity

Some publications suggest that drought-stressed corn be chopped 12-16" above normal chopping height (4-6") as a method to reduce nitrate concentrations. The lower 1/3 of the stalk may contain the highest nitrates concentrations (table 2). Although, the lower 1/3 of the stalk may contain the highest nitrate levels the silage fermentation process will reduce the nitrate levels. The whole plant nitrate levels are more important than just the concentration in a part of the plant. The chopping at 12-16" above normal chopping height will reduce whole field yields by about 5-10% for normal non-drought stressed corn, this yield reduction will probably be greater for drought stressed corn. This yield reduction needs to be considered. Michigan State University does not recommend chopping corn

at 12-16" above normal heights.

Use of Inoculants and Additives

Microbial Inoculants – Chopped corn is fermented by the bacteria that are on the plants while the corn was growing in the field. The bacteria utilize plant sugars as a substrate for growth. Normally, corn plants have a sufficient population of silage fermenting bacteria to support a good silage fermentation process. The purpose of a microbial inoculant is to provide additional bacteria that will result in an increase the rate of fermentation and production of acids that keep the silage stable during storage.

Drought stressed corn plants may not be well eared and have poor kernel development. Under normal growing conditions corn plant sugars are converted to starch, which is stored in the kernels. Earless or poorly eared corn plants will have sufficient sugars to support good bacterial growth because less of the sugars will have been converted to kernel starch. High temperature and humidity that often accompany droughts in Michigan will encourage silage fermenting bacteria populations to increase in the field. Under these conditions inoculants may not be cost effective.

However, silage fermenting bacteria populations may be lower when the humidity is low and temperatures are high, especially if there are hot dry winds. Also, bacterial populations may be low when temperatures before chopping are low, below 600, such as in the late fall. Under, these conditions use of an inoculant specific for corn silage may be cost effective.

NPN Additives – Anhydrous ammonia or urea is often added at harvest to increase the crude protein content of corn silage. Because drought-stressed corn plants may contain high concentrations of nitrates, which are an NPN source, the adding of anhydrous ammonia or urea to drought stress corn at harvest is not recommended. However, if after the silage has fermented and if the nitrate level of the silage is below 4,400 ppm, urea could be added to a ration as a degradable protein source at feeding time.

Nutrient Composition of Corn Silage from Drought Stressed Corn

Research at Michigan State University found that corn silage grown during the 1988 drought had increased NDF (fiber) digestibility as compared to corn silage grown during 1989 a non-drought stress, normal growing year (Table 6).

Drought stressed corn silage with no kernels or reduced kernel content will require the feeding of more grain supplementation. Once the diets using drought stressed corn silage are adjusted for differences in corn silage NDF content, the milk production should not be reduced and could possibly increase because of the higher NDF fiber digestibility.

Nutrient Composition

There are no direct laboratory analyses for NEL. The NEL values reported from feed analysis laboratories are calculated indirectly using equations, most often based on the ADF content of the feed. Some laboratories may use equations that include NDF, lignin, crude protein NDIN, ADIN, fat and ash to estimate NEL. Regardless of what equation is used, all NEL values are only estimates. The only way to accurately evaluate the energy value of a feed is to evaluate actual cow

response to a diet. If dry matter intake, milk production, milk composition or body condition change when cows are switched to a new ration than the ration should be evaluated and formulation adjustments made. With drought-stressed corn silage if NEL value used to formulate a ration is too high or low the cows will indicate this with changes in dry matter intake, milk production, milk composition or body condition. This evaluation may take a period of time and cause a degree of producer and nutritionist frustration.

Challenges that Occur with Drought-Stressed Corn

Corn silage that is grown under drought conditions can present challenges. Reduced tonnage per acre, which will require more acres to be chopped. Since hay yields may also be reduced, farmers may need to plan on feeding more corn silage to their cattle. This will require chopping more acres of corn than normal and probably have impact on the number of acres of corn that were planned to be harvested for grain. Farmers will need to determine which corn fields will be harvested as grain and which will be chopped for silage. Monitor the whole plant dry matter content so that fields will be harvested at the correct dry matter.

Table 6. Effect of environment on fiber component and NDF digestibility of corn forage.

	1988 (drought year)	1989 (normal year)
Growing degree days (5/1 - 9/1)	2,387	2072
Precipitation (inches 5/1 - 9/1)	8.4	16.3
Dry Matter Yields (Tons DM/Acre)	4.01 ¹	9.49 ¹
NDF (% of DM)	40.8	42.2
ADF (sequential, % of DM)	19.4	21.8
Lignin (% of DM)	2.44 ¹	2.96 ¹
Lignin (% of NDF)	6.02 ¹	7.01 ¹
NDF Digestibility (%)	50.3 ¹	42.0 ¹

¹Differences were significant.