Contents

Drought 2007

Since the beginning of the growing season, April 1, we have been facing precipitation deficits in many areas. These figures range between 3 to 5 plus inches and may be misleading since the majority of the drier than normal conditions have taken place since early June when crop water needs are relatively greater. Ag meteorologist Jeff Andresen notes that we should be seeing a range from 11.5 to 13.0 inches of rain by this time in the growing season as that is the norm. Unfortunately, we just haven't reached those numbers and areas that have the greatest deficits such as the southwestern and eastern Lower Michigan and the western Upper Pennisula have received up to 25 percent less precipitation than normal.

The Field Crops Area of Expertise team decided to take action and post information pertinent to the drought conditions. The following articles detail drought facts and vital news to assist growers through this hot, arid growing season.

Development of drought conditions in Michigan

Jeff Andresen
Agricultural Meteorology
Geography

Scattered showers and thunderstorms brought some much needed rainfall to a few locations across Michigan during late July, but the rainfall was localized and drought conditions persist in many areas of the state. For the growing season thus far (beginning April 1), precipitation deficits have grown in many areas to the 3-5 plus inch range, although these figures are somewhat misleading since the majority of the drier than normal conditions have taken place since early June when crop water needs are relatively greater. Normal precipitation for this time frame is on the order of 11.5-13.0 inches. Precipitation totals across the state as estimated by National Weather Service radar are given in Figure 1 and illustrate the areas of greatest deficits including areas of southwestern and eastern Lower Michigan as well as the western Upper Peninsula where totals remained less than 25 percent of normal. In some areas of the state, July 2007 will go into the books as one of the five driest on record. Meteorologically, the dryness has been associated with a persistent upper air ridging feature anchored across western North America that has reduced the amount of low-level moisture flow (the "raw material" of precipitation) into the Great Lakes Region. As of the beginning of August, drought conditions were reported across sections of the Upper Midwest in Minnesota, Wisconsin and Michigan southward through the Ohio Valley into the southeastern United States. These patterns are illustrated in the most recent version of the Palmer Drought Severity Index (Figure 2), which depicts areas of long term precipitation surpluses and deficits. Note that some of the drought conditions in Michigan have now slipped into “Severe” and “Extreme”categories.

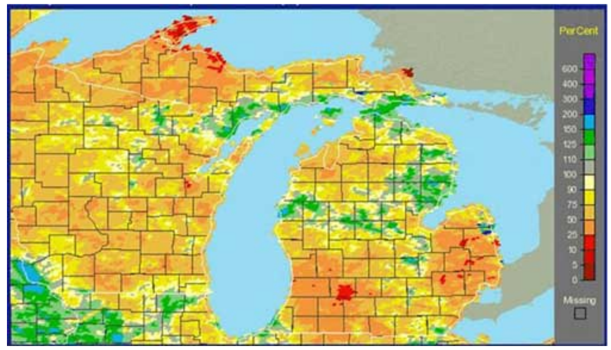


Figure 1. Percent of normal precipitation between June 2 and July 31, 2007. Precipitation values are based on National Weather Service Stage III precipitation estimates (courtesy of the National Oceanic and Atmospheric Administration).

As an example of the gradual depletion of soil moisture, volumetric soil moisture at a 10-inch depth under grass taken from the MAWN automated weather station at East Lansing is plotted versus time and with daily precipitation totals in Figure 3. The soil at the site is capac loam. Soil moisture can be seen to decrease from a value of approximately 0.25 inches^3/inches^3 following the rainfall of early June to about 0.10 inches^3/inches^3, then peak once again in late June following a 1.3 inches rainfall event before falling to its end of July level of approximately 0.08 inches^3/inches^3, which is near the soil=s wilting point.

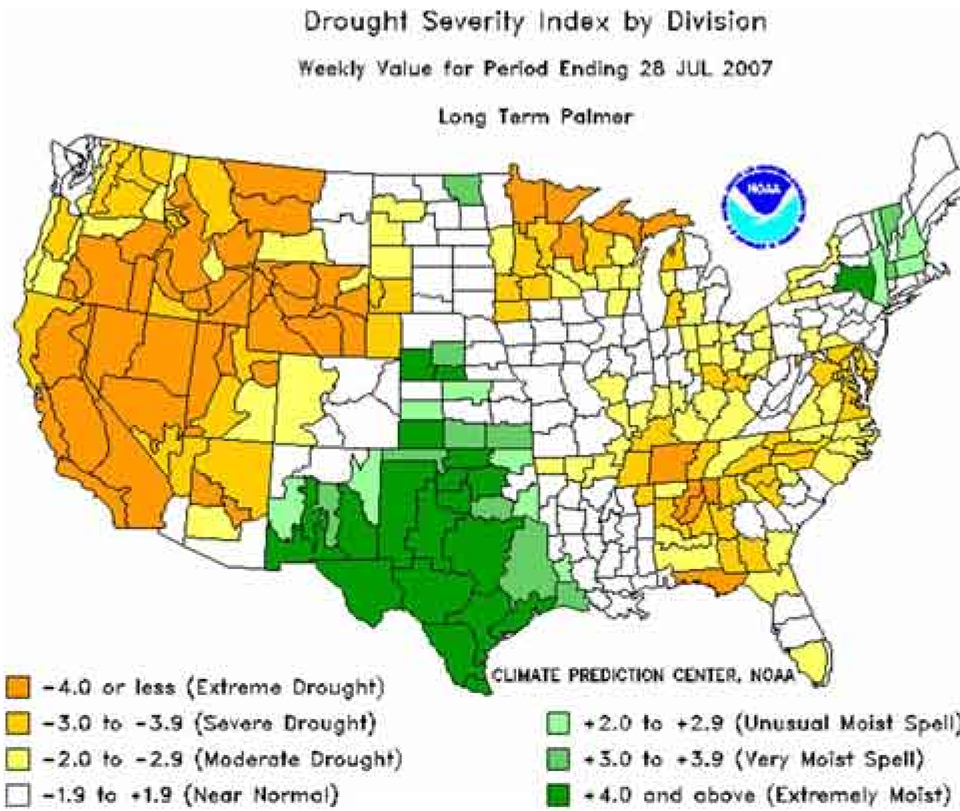
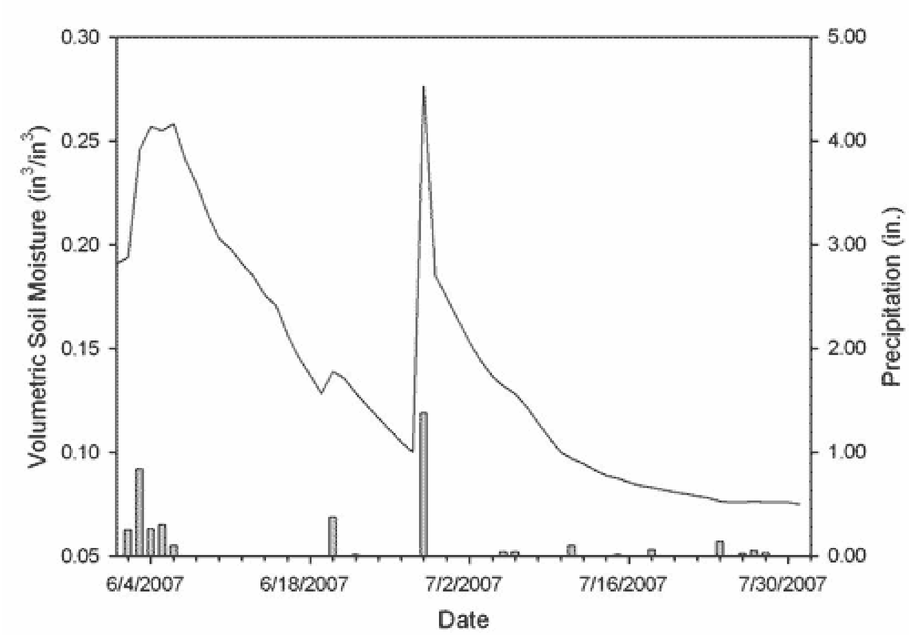


Figure 2. Palmer Drought Severity Index values across the United States as of July 28. (figure courtesy of NOAA Climate Prediction Center).

Figure 3. Volumetric soil moisture (inches^3/inches^3) at a 10-inch depth under grass and daily precipitation totals (inches) versus date at East Lansing, Michigan, June 1 through July 31 (data courtesy of Michigan Automated Weather Network and the Enviro-weather program).



Do I have enough soil moisture to make a crop?

Kurt Thelen
Crop and Soil Sciences

The dry conditions of the 2007 growing season to date have many wondering if they have enough soil moisture to finish out their corn and soybean crops. A few simple calculations can give us a pretty good idea whether or not we have a chance of making it to the finish line.

For starters, we know that a 150 to 200 bushel corn crop or 50 to 60 bushel soybean crop require approximately 20 to 24 inches of water. By adding up our seasonal rainfall and estimating the amount of water stored in our soil profile, we can get a pretty good idea if we have adequate moisture available to reach our yield goal.

For example, my field consists of a Blount loam soil. By checking a USDA Soil Survey or by looking up the USDA, Natural Resource Conservation Service web-based Soil Survey at: http://websoilsurvey.nrcs.usda.gov and following the prompts, I can get a good estimate of my soils water holding capacity. In my particular case with a Blount loam soil, the water holding capacity is listed as: 0.17 cm per cm in the top 36 inches of soil. The cm per cm unit is actually a straight percentage so:

Figure 2.

36 inches x 0.17 percent = 6.12 inches of available soil water in the upper 3 feet of soil assuming I start at field capacity in the spring.

The next step is to add in the amount of rainfall received since planting. If you don't record this information for yourself, you can use precipitation data recorded at the "Michigan Automated Weather Network" (MAWN) station nearest your field which can be accessed at: http://enviroweather.msu.edu/home.asp. Checking the MAWN website, I find that I have received only 6 inches of rainfall in my vicinity since planting. Assuming that I began the season with my soil moisture at or near field capacity, I calculate:

6 inches of rainfall received + 6.12 inches stored soil water = 12.12 total inches of available water.

This leaves me a water deficit of 8 to 12 inches short of the precipitation levels needed to meet my yield goal. What are the chances I'll get another 8 to 12 inches of rain while my crops can still benefit from it? By using 30-year average rainfall data I can get a pretty good idea. Thirty-year average precipitation levels are available at: http://climate.geo.msu.edu/. The 30-year average August rainfall in my area is about 3.8 inches. If August precipitation levels are near average, my total crop available precipitation would then be just short of 16 inches (12.12 inches +3.8 inches) which is still considerably short of the 20 to 24 inches desired. The 30-year average data also show that I could expect another 3.8 inches in September, but most of that would likely be too late for the corn plant to benefit in terms of grain yield. Therefore, it appears that 2007 precipitation levels will likely limit my corn and soybean grain yields below my targeted yield goals.

Of course these calculations should be considered "ballpark estimates" as actual soils vary considerably in terms of water holding capacity. Additionally, crop rooting depth will vary based on soil structure, crop genetics, nutrient status, and early season water levels.

Assessing drought stress effects on corn yield

Kurt Thelen
Crop & Soil Sciences

Effects of drought-stress on the corn plant

To date, the 2007 growing season in Michigan can be characterized as widely variable in terms of rainfall. Some parts of the state have experienced near ideal precipitation levels while others remain quite dry. Inadequate moisture during any period of growth can result in reduced grain yield. Nutrient availability, uptake and transport are impaired without sufficient water. Plants weakened by stress are also more susceptible to disease and insects. Severe moisture stress is indicated by leaf wilting that is alleviated only when the plants receive additional water.

Four consecutive days of visible wilting can reduce potential corn yield by 5 to 10 percent during the vegetative growth stage. Drought stress prior to tassel and silk appearance may result in small ear size. From approximately the 8-leaf to the 12-leaf stage (V8 to V12), potential kernel row number is determined in the corn plant. From the 12-leaf to the 17-leaf stage (V12 to V17), potential kernel number per row is determined. Moisture stress during the vegetative periods may reduce both ear length and the number of potential kernels on each ear. If ear size is reduced during this period, it cannot be corrected by relieving the moisture stress later in the season.

During silking and pollination, yield reduction after four consecutive days of wilting can be as much as 40 to 50 percent (see Table 1). Moisture stress during this period can result in a lack of synchronization between pollen shed and silking at pollination, because pollen grains may not remain viable and silking may be delayed. If a plant has tasseled and shed pollen but no blisters have appeared, it will be barren. A common result of prolonged moisture stress or moderate moisture stress during late pollination is the production of ears with barren tips. This occurs because the tip kernels were not pollinated or were aborted after pollination.

In order to determine harvest options for drought stressed corn, an assessment on potential grain yield should be conducted. Within one to three days after a silk is pollinated and fertilization is successful, the silk will detach from the developing kernel. Thus, you can carefully remove the husk leaves from an ear shoot, shake the cob, and estimate the degree of successful fertilization by observing how many silks shake loose from the cob.

Table 1. Effect of drought on corn yield

Stage of development	**Percent yield reduction (from 4 consecutive days of visible wilting)**
Early vegetative	5-10
Tassel emergence	10-25
Silk emergence, pollen shedding	40-50

Blister	30-40
Dough	20-30
Classen, M.M., and R.H. Shaw. 1970. Water deficit effects on corn. II. Grain components. Agron. J. 62:652	

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, you can assume that kernel fertilization occurred. If you are unsure whether fertilization has occurred, observe the kernels again in five to seven days. If the kernels were fertilized, the blisters will have rapidly increased in size. If fertilization did not occur, the kernels will not have increased in size. It is also possible to tell if fertilization has occurred by slicing the kernels longitudinally through the embryo side and looking for the young embryo. Only fertilized kernels will produce embryos. Most kernels that have been fertilized will continue to develop and mature if the plants get water.

Drought stress after pollination and fertilization can result in aborted kernels or poor kernel fill, causing low test weight and reduced yield. It may also predispose the plants to development of stalk rots.

Four fundamental stages of corn grain yield determination

Kurt Thelen
Crop & Soil Sciences

Although recent rains brought relief to some areas of the state, areas of droughty conditions still remain. In a recent article, we discussed the potential corn grain yield loss associated with dry soil conditions. This information is summarized in Table 1.

This article will further explore the fundamental stages of corn grain yield determination. Of course, corn grain yield involves the continuous interaction of genetic, climatic, soil, plant pest and nutrient factors present for a specific growing season. However, from a crop management standpoint, it is helpful to characterize the most critical stages of development in the life of a corn plant with respect to determining final grain yield. The following are four critical stages in the development of a corn plant that are fundamental to determining corn grain yield.

The first of these critical stages is emergence. Corn does not have the ability to compensate for poor stands as well as other crops such as soybeans. Establishing a uniform, optimum population stand is the first step in developing corn grain yield potential. Studies on the genetic evolution of corn indicate that modern hybrids tolerate field stress associated with higher plant populations better than their earlier genetic predecessors. Growers should continually evaluate the carrying capacity of their fields by putting in a few strip trials to determine the optimum plant population for each field. Keep in mind that as corn genetics continue to evolve, you will likely need to continually adjust your planting population upward to find that optimum plant population for each field. In general, much of the state had good to excellent conditions for corn emergence in 2007, and plant stands are quite good.

The second critical growth stage is when the plant determines the number of kernel rows and the number of potential kernels (ovules) per row. This is primarily determined during the rapid phase of corn vegetative growth, which generally occurs in early to mid-July in Michigan. The number of kernel rows per ear is heavily influenced by genetics and is generally determined by growth stage V12, which corresponds to the 12 leaf collar stage. The number of potential kernels per row is being determined at V12 and is usually completed a week to 10 days prior to silking (V17). The number of potential kernels per row is strongly influenced by field conditions. Managing corn to reduce environmental, pest, moisture and nutrient stress during this time will maximize the potential number of harvestable kernels. This stage, along with the pollination stage described in this article, determines the “sink” which the corn leaf canopy will work to fill with photosynthetically derived starch. Follow a plan to ensure adequate nutrient levels, and minimize stress from pests such as weeds and insects during this critical period to establish the potential for high yield. The hardest hit areas of the state likely suffered yield loss during this critical stage of ear size determination. Other areas of the state came through this stage of development in fairly good shape with less significant to minimal yield loss.

The third critical stage is pollination. Successful pollination is required to convert potential kernel numbers to actual developing kernels. Pollination occurs when a pollen grain is shed from the tassel, lands on an emerged silk, grows down the length of the silk and successfully fertilizes the ovule. It generally takes two to three days for all the silks on an ear to be exposed and pollinated. Pollen shed generally occurs in the late mornings and early evenings and the pollen shed period typically lasts from one to two weeks. From a management perspective, there is not a lot that can be done to ensure good pollination since it is highly dependent upon the weather. Droughty conditions can de-synchronize pollen shed and silk emergence and also can desiccate silks and pollen grains. This results in barren ears or in short ears with barren tips. Insect pests such as adult corn rootworm beetles can feed on emerging silks and reduce pollination, and therefore should be scouted during silk emergence. Finally, because the tassel and all leaves are completely exposed, the plant is especially vulnerable to hail damage at this stage. Most of the corn in the state has now completed the pollination stage of development. The high variability of rainfall across the state during this period has translated to high variability in pollination success. To assess pollination, remove the husk from developing ears and vigorously shake. Silks on successfully pollinated kernels will drop off and silks emerging from unpollinated kernels will stay fast.

The final critical growth stage for determining corn yield is the grain fill or kernel development period. The grain fill period which begins at pollination and ends at kernel black-layer formation generally takes from 60 to 70 days (855 to 1200 GDD) for Michigan conditions depending upon climate, planting date and hybrid relative maturity. The size and weight of harvested kernels are determined at this time and under adverse conditions, kernel number can also be reduced. Stress on the corn plant during the grain fill period can affect final yield by reducing either of these factors. Although field and machinery conditions can still influence final harvestable yield, the corn plant photosynthetic factory has completed its work at the kernel black-layer formation stage of development.

Table 1. Effect of four consecutive days of visible wilting on corn grain yield.

Stage of development	**Percent Yield Reduction** (from four consecutive days of visible wilting)
Early vegetative	5 - 10
Tassel emergence	10 – 25
Silk emergence, pollen shedding	40 – 50
Blister	30 – 40
Dough	20 – 30
Classen, M.M., and R.H. Shaw. 1970. Water deficit effects on corn. II. Grain components. Agron. J. 62:652	

Tips for 2007 corn silage harvest

1.Herb Bucholtz and Mike Allen
Department of Animal Science
Dairy Cattle Nutrition

This is a summary for corn silage harvest tips for 2007. For more detailed information, please read the article titled “Harvesting drought stressed corn for silage.”

1.Harvest at 30-40 percent whole plant dry matter (WPDM)

This is the most important information to know for making good corn silage. Bacteria present on the corn plants in the field ferment plant sugars contained primarily in the stalk to produce fermentation acids that preserve the corn silage. To ensure a vigorous and successful bacterial fermentation the dry matter (DM) content of the whole corn plant material at harvest is very important. The proper DM content for optimum fermentation is between 30 and 40 percent. If corn silage is wetter than 70 percent moisture (30 percent DM), excessive fermentation acids can reduce palatability and feed intake. Wetter silage is more likely to result in effluent loss, which is a huge potential environmental concern for Michigan dairy farms. If corn silage is drier than 40 percent DM, there might not be enough sugars available for adequate fermentation increasing DM losses and resulting in heating at feedout. In addition, if corn silage is too dry, kernels become hard and starch digestibility is reduced.

Determining the WPDM at the beginning and during harvest is the most critical and important harvest management practice to implement. Dry matter can be determined using a Koster™ moisture tester or microwave oven. A publication on for using a microwave for moisture testing can be obtained at: http://ianrpubs.unl.edu/range/g1168.htm

Kernel milk line has been in the past used as an indicator of when to harvest corn for silage. Kernel milk line is an indicator of kernel maturity, but is not a good indicator of WPDM.

2.Harvest chop height at 4.0 to 6.0 inches.

Some publications suggest chopping at 12 to 16 inches from the ground, which will increase the grain concentration and reduces the concentration of fodder in the silage. Implementing this 12 to 16 inches concept would increase the energy density but decrease the fiber content of the silage. While this practice might make sense when the price of corn grain greatly exceeds the cost of growing and feeding corn silage, many producers are concerned that dairy cow diets do not contain sufficient fiber and they purchase dry hay or straw to increase dietary fiber. This doesn't make sense because corn plant fodder is a good source of fiber and leaving 12 to 16 inches stalks and leaves containing potentially digestible fiber in the field while purchasing other perhaps less digestible fiber sources is a costly venture. MSU's recommendation is to harvest corn at 4 to 6 inches for silage.

3.Chop length - theoretical length of cut (TLC) of 0.25 to 0.5 inch

Kernels and cobs need to be broken and to accomplish this chop length may need to vary between 0.25 to 0.5 inch TLC for choppers without a processor depending on WPDM. A chop length of 0.25 inch should be used only for very dry corn plants to ensure that the kernels are nicked. Short chop-length silage will require inclusion of another forage source in the ration for adequate effective fiber. For choppers with a processor a 0.75 inch, TLC is recommended when WPDM is 30-40 percent. Processing when WPDM is less than 30 percent may result in mashing of the kernels and stalk and the processor rolls should be backed-off to prevent mashing.

4.Filling and packing

To prevent spoilage between filling layers, fill bunkers as rapidly and continuously as possible. Stopping for a day or more may result in spoilage layers that can depress feed intake. Pack bunkers continuously during filling to expel air that is trapped between plant particles.

5.Covering

Cover bunkers and tower silos as soon as filling is completed. Plastic covering will prevent exposure of the top silage surface to air and water and control the extent of spoilage in the top layers. Tucking the plastic around bunker sidewalls will prevent water from seeping into the silage which will help prevent sidewall spoilage.

6.Preventing potential leachate problems

Harvesting at 30-40 percent WPDM is the first step in preventing silage seepage. Harvesting at less than 30 percent WPDM for horizontal silos increases the potential for seepage. Vertical silos require higher WPDM to prevent leaching. After filling and covering is completed, take care to clean up plant material from around the bunker, bags, piles or tower silo. Implement a plan to direct water from the silage feed bunk area to a properly designed system to prevent possible environmental problems.

Harvesting drought stressed corn for silage

Mike McFadden, MSU Dairy Educator, Isabella County
Herb Bucholtz, Department of Animal Science, Dairy Cattle Nutrition
Mike Allen, Department of Animal Science, Dairy Cattle Nutrition

When to harvest for silage

Corn should be harvested for silage when the whole plant dry matter is between 30 and 40 percent. 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 percent.

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

Harvesting at whole plant dry matter above 40 percent (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 sufficient acid levels and may start heating during feed-out from the silo or bunker. In addition, silage drier than 40 percent 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 percent 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.

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

How to determine whole plant dry matter

The only way to accurately determine when the whole corn plant is at 30 percent 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 percent 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 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.

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

Plant part	**NO3 (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

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.

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

NO3		**NO3-N**		
ppm	Percent	ppm	Percent	**Feeding recommendations**
< 4,400	< 0.44	< 1,000	< 0.1	Safe to feed, non-toxic level
4,400-8,800	0.44-	1,000-	0.1-0.2	Limit the feed to less than 50% of ration dry

	0.88	2,000		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.
%=> ppm (multiply % by 10,000)			ppm=> % (divide ppm by 10,000)	

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
Cost is $12.00 per sample for chopped plant material or silage
http://www.css.msu.edu/SoilTesting.cfm

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).

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

Nitrogen substance	Chemical formula	Multiplication factor
Nitrate	NO3	1.00
Nitrite	NO2	1.35
Nitrate-nitrogen	NO3-N	4.43
Nitrite-nitrogen	NO2-N	4.43
Sodium nitrate	NaNO3	0.73
Potassium nitrate	KNO3	0.61

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.

Table 5. 1988 Michigan State University's analysis of for nitrates.

Material	Sample dates	Number 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 - 6000
D. Roberts, Michigan State University, Plant Diagnostic Clinic, 1988.				

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 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 concern.

Chopping height recommendations as related to nitrate toxicity

Some publications suggest that drought-stressed corn be chopped 12-16 inches above normal chopping height (4-6 inches) as a method to reduce nitrate concentrations. The lower third of the stalk may contain the highest nitrates concentrations (Table 2). Although, the lower third 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 percent 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 kennel 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.

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)	2387	2072
Precipitation (inches 5/1–9/1)	8.4	16.3
Dry Matter Yield (Tons DM/Acre)	4.01 **	9.49 **
NDF (% of DM)	40.8	42.2
ADF (sequential, % of DM)	19.4	21.8
Lignin (% of DM)	2.44 **	2.96 **
Lignin (% of NDF)	6.02 **	7.01 **
NDF Digestibility (%)	50.3 **	42.0 **
** differences were significant		
M.S. Allen, Department of Animal Science, Michigan State University, E. Lansing, MI.		

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.

Methods for determining dry matter of forages and grains

Herb Bucholtz
Department of Animal Science, Dairy Cattle Nutrition
Michigan State University
E. Lansing, MI 48824

Microwave method

Equipment Needed:

1) Microwave oven with turntable.
2) Microwave-safe plate: 7 to 9 inch diameter. Caution – Do not use paper plates as they may burn.
3) Gram scale: Capacity of at least 500 grams, accuracy at least 1.0 gram. Gram scales can be purchased from agricultural supply companies, drug and hardware stores.
4) Cup of water: Be sure container is microwave-safe. This will help prevent the sample from burning when the sample is nearly dry.

Procedure

1) Weigh the empty plate and record weight.
2) Place about 100 grams of chopped forage or cracked/ground grain on the plate.

Record plate plus sample weight.

3) Place in microwave for approximately 4 minutes. Set microwave on high setting.
4) After 4 minutes, record plate plus sample weight.
5) Place back in microwave for another 2 minutes.
6) Again, record plate plus sample weight
7) Repeat step # 5 until plate plus sample weight remains unchanged (+/– 1 gram).

Sample is now completely dried.

8) Subtract the plate weight from the plate plus sample weight.

Example of arithmetic calculations

1) Empty plate weighted = 200 grams.
2) Forage or grain sample plus plate weighs = 300 grams.

Sample weighted 100 grams [300 grams (plate + sample) - 200 gram (empty plate)]

3) Completely dried plate plus sample weighs = 250 grams.
4) Percentage dry matter = [250 grams (completely dried sample) – 200 grams (empty plate)] = 50 grams.

50 grams ÷ 100 grams = 0.5 X 100 = 50% Dry Matter

Additional information on tests

Koster Moisture Tester ™
Koster Crop Tester Inc.
3077 Nationwide Parkway
Brunswick, OH 44212-22361
330-220-2116 Fax: 330-220-1636
kostercrop@aol.com

web: www.kostercroptester.net

Summer annual forage grasses for emergency crops

Richard Leep
Crop and Soil Sciences

Summer annual grasses are used for summer pasture, green chop, hay and silage. Annual grasses are normally used as emergency forage. The most common annual grasses used in Michigan are sudangrass, hybrid sudangrass, sorghum-sudangrass hybrids and forage sorghum.

Desirable characteristics such as rapid growth, excellent drought resistance and good response to fertilizer and water, make summer annual grasses attractive to use in an overall management scheme for forage production.

Sorghum-sudangrass hybrids produce about the same amount of feed as sudangrass when used for pasture. When used for green chopped forage, yields of sorghum-sudangrass hybrids usually exceed sudangrass or forage sorghum. Forage sorghums are best suited for silage. Making sorghum-sudangrass into hay is difficult because of the slow drying time.

Sudangrass

True sudangrasses have fine stems, tiller extensively when conditions permit and can regrow rapidly. Thus, they are more suited to pasturing than other types of sorghum. Piper is a variety which has been in existence for years. Piper has low prussic acid content and is generally regarded as safe to graze.

Hybrid sudangrass

Hybrid sudangrasses result from a cross among true sudangrass strains that are available primarily as commercial varieties. They are similar to true sudangrass varieties, but yield slightly more in a three-cut green chop or hay system. Their prussic acid content is generally between that of Piper sudangrass and sorghum-sudangrass hybrids.

Sorghum-sudangrass hybrids

Sorghum-sudangrass hybrids are the most numerous of the various types of summer annual grasses. Most of these are available as commercial hybrids. They are high producing forage grasses, but more than 50 percent of their yield usually comes from their stems. Their rate of regrowth after repeated clippings or grazing is lower than that of sudangrass. Thus, sorghum-sudangrass hybrids sometimes gain or milk less than those consuming other summer annuals, apparently due to a lower energy content. When these hybrids are cut at immature stages, quality is higher, but yields are much lower.

Forage sorghum

Forage sorghums are usually tall growing, and mature late in the growing season. Often called “sweet sorghum,” forage sorghums often have sweet and juicy stems and many have relatively small grain heads.

Forage sorghums usually yield more silage dry matter per acre than corn without irrigation. However, yields of TDN per acre are usually lower from forage sorghums than from corn.

Grazing forage sorghums is not recommended. They usually contain much higher levels of prussicacid than other summer annual grasses and can be dangerous to graze even when plants are completely headed, especially when young shoots are present. Forage sorghums can be cut for hay, although their stems dry very slowly after cutting.

Utilization of summer annuals: Summer pasture

Sudangrass and sorghum-sudangrass can provide supplemental summer pasture when cool-season grasses go dormant and the feed supply is short.

Sudangrass and pearl millet produce better pasture than sorghum-sudangrass because they are usually leafier. They also provide a more uniform supply of feed for grazing and support higher daily gains or milk production. Sorghum-sudangrasses produce higher yields, but are better used to support livestock on maintenance or lower productivity levels.

Graze the summer annual grasses in a short, rotational grazing system. Subdivide fields into three or more pastures so that each pasture can be grazed down in 7 to 10 days. Stagger the date of planting each pasture by about 10 days so that grazing will begin on each pasture when growth is at the appropriate height. This rotation system allows maximum production of quality forage.

Graze sudangrass when it reaches 15-20 inches in height and sorghum-sudangrass hybrids when they are 18-24 inches tall. Danger from prussic acid poisoning will be low when grazing is delayed until grass is this tall. Graze down rapidly to 6 inches of stubble before moving livestock to a fresh pasture, and do not graze regrowth until 18 inches of growth accumulates. If growth is more than 36 inches tall, harvest as hay, green chop, or silage since grazing cattle will trample and waste much of the forage. Regrowth will be more rapid following cutting this taller growth than if it is trampled.

Summer grazing lasts about two months. During this time each acre of these pastures can provide feed for one to six mature dairy or beef animals. Grazing management and soil fertility and moisture will determine total production.

Sudangrass, sorghum-sudangrass hybrids, and forage sorghum pastures are not recommended for horses because kidney ailments may develop.

Utilization of summer annuals: Green chop

Sorghum-sudangrasses are well suited to a green chop program. Under a 3-4 cut system, the forages produce higher yields than other summer annual grasses. Field losses are less from green chopping than from grazing or haying. However, the fast rate of growth of sorghum-sudangrass results in variable amounts and quality of feed throughout the growing season. When grass is young and growing rapidly, it may contain 20 percent crude protein and produce a highly succulent feed. As the crop grows taller and nears maturity, the protein content may drop to seven percent or less, and a course, fibrous, low quality green chop is produced.

Nitrates can become a problem in a green chop program under certain growing conditions. Do not feed green chop that has heated in the wagon, feed bunk, or stack, or that has been held overnight. Nitrates are converted to nitrites as plants respire; nitrites are about 10 times more toxic than nitrates.

Utilization of summer annuals: Hay

For good quality hay, harvest sudans and sorghums before heads emerge or when they are 30-40 inches tall. These hays will contain slightly less protein than alfalfa hay and as much energy as good quality alfalfa hay. Use of a conditioner will aid in field drying. Field drying will usually take several days to dry to satisfactory levels.

Utilization of summer annuals: Silage

Forage sorghums for silage usually have about 75 percent of the energy value of corn silage per unit of dry matter, while other summer annual grasses have 60-75 percent of the value of corn silage. Most summer annuals need to be wilted or mixed with dry feeds to make satisfactory silage. Silage is often cut after frost to reduce moisture, especially with forage sorghums.

Seeding

Seedbed preparation

A firm, well-prepared seed bed is needed for good seed-soil contact and rapid germination. Conventional minimum, or direct drilling can be used for establishment.

Date of seeding

Sudangrass and sorghum are warm-season grasses. Seed should be planted into soils when average soil temperature is above 60 degrees F. Plan the seeding date to produce desirable feed when needed. Stagger planting dates to aid rotational grazing. It takes at least six weeks after planting before usable forage is available. Later plantings will result in lower yields due to summer droughts and fall frosts.

Planting rates

Recommended planting rates depend on row spacing. Broadcast and narrow-row spacing are preferred for sudangrass and sorghum-sudangrass hybrids because they result in shorter plants with finer stems. Total forage yield will be similar for different row spacing because sorghums and sudangrasses tiller. Removing the primary growing point at the first cutting enhances tillering. First-cut yields are usually higher for broadcast or narrow-row seedings than for 20-40 inch rows.

Planting depth

Seed to a depth of 1-2 inches, depending on soil moisture conditions. Seeds planted too deep do not emerge well and poor stands may result.

Fertilization

Annual grasses have fertilizer requirements similar to those of corn. With rapid growth, apply sufficient nitrogen at planting to ensure establishment and high first-cutting or grazing yields. Apply 40-80 pounds of nitrogen per acre at planting and an additional 50 pounds after the first cutting or grazing. Phosphorus and potassium should be applied based upon soil test recommendations.

Prussic acid poisoning

Cellular damage to sorghums and sudangrasses from frost, wilting, bruising, drought, excessive soil nitrogen, or deficiencies in soil phosphorus or potassium can result in prussic acid poisoning in cattle. Prussic acid poisoning consists of the following sequence of events: plant cells rupture and cyanic acid (HCN) forms from cyanogenic glucosides; cattle consume forage with elevated HCN levels; HCN is absorbed from the rumen; HCN binds to hemoglobin; asphyxiation and death occur. Poisoning is most likely after a frost when animals consume the leafy regrowth. Regardless of season, plants less than 18-24 inches tall should not be grazed. Suspect forage should be harvested as dry hay or silage. Both harvest methods tend to reduce hydrocyanic acid levels.

Nitrate poisoning

High dietary nitrate levels can overload the animal's ability to detoxify this chemical and can result in death due to asphyxiation. In the rumen, nitrate is reduced to ammonia, which is absorbed into the bloodstream or converted into microbial protein. High dietary nitrate levels that overload this microbial reduction system cause an accumulation of nitrite in the rumen. This nitrite is then absorbed into the bloodstream where it binds to hemoglobin in place of oxygen. This deprives the tissues of oxygen and causes abortions and asphyxiation.

Sorghums and sudangrasses can accumulate high levels of nitrate during environmental conditions that decrease plant growth rate, including water stress, lack of sunshine and high nitrogen fertilization. Plants usually absorb nitrogen as nitrates and synthesize protein. However, during stress, the synthesis rates decrease and nitrates accumulate. Cattle should not be fed forages with nitrate levels greater than 2 percent. Nitrate analysis can be obtained from numerous commercial laboratories.

Seed availability

Several commercial suppliers of seed carry varieties of sorghums, sudangrasses, hybrid-sudangrasses and sorghum-sudangrass hybrids. Check with your local supplier for availability and variety characteristics. Michigan State University does not routinely test varieties of annual grasses and therefore does not provide variety recommendations.