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In This Issue

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A Banner Year for Japanese and Green June Beetles

Author: John Obermeyer

Frustrations have been expressed about the numbers of Japanese beetles and their soybean defoliation this season. This compounds the weather woes that soybean has endured, i.e., too wet, too dry, too hot, yellowing from nutrient deficiencies, and the herbicides seemingly torching them. I guess the added Japanese beetle defoliation has been the breaking point for some and have resorted to "spray therapy" before treatment thresholds have been reached (see last week's Pest&Crop). For these producers wanting to "fix" ugly fields, I hope they sleep better at night. For many others waiting for the ECONOMIC treatment, but are getting antsy, consider that we are past the peak beetle emergence. Though Japanese beetle will be around most of the season, their populations will continue to decline. Consider the damage to the newest growth at the top of the canopy, don't let your eyes fixate on old damage. Happy scouting!

Comparing old and new growth damage may indicate that Japanese beetles are declining.

Interestingly, a "cousin" of the Japanese beetle is being reported higher than normal around farmsteads and homes this year, the green June beetle, *Cotinis nitida*. These beetles appear to be Japanese beetle on steroids, as their coloration is similar but they are much larger. Most noticeable is their audible-buzzing flight around yards and gardens. The adults, like Japanese beetle, will feed on multiple leaves and ripe fruit, but at much lower numbers. Too, the grubs are much larger than Japanese beetle and feed on mostly decaying matter in the soil. Often higher numbers can be traced to old wood lots where roots are rotting in the soil. Grubs, found while digging garden beds, etc., in the spring distinguish themselves by crawling on their back while making their escape. The grubs can occasionally be a pest of finely groomed turf, i.e., golf course putting greens, because of their burrowing and leaving uneven surfaces. Neither the grub or adult of the green June beetle has been known to cause significant damage to field crops.

Green June Beetle on sweet corn tassel

Green June Beetle grub "walking" on its back

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Western Bean Cutworm Moth Numbers Still Low, Though One Surprise

Author: John Obermeyer

Most of our pheromone trappers got their report in during this Independence Day holiday, see "Western Bean Cutworm Pheromone Trap Report." I am still surprised at the low numbers of moths being captured. Traditionally in places, where weekly captures would be in the hundreds, only dozens are being recorded this year. Assuming this trend continues, there should be substantially less corn ear damage this season. This is NOT a call to cease efforts on scouting for egg masses and/or newly hatched larvae in high-risk areas. Concentrate sampling efforts in pre-tassel corn, especially in fields of variable growth stages.

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Soil Sampling to Assess Current Soil N Availability

Authors: Jim Camberato and Bob Nielsen

Excessive rainfall and flooding often result in the loss of applied and soil-derived nitrogen (N). Nitrate-N is the form of N most likely to be lost from the crop root zone, either to tile drainage and groundwater via leaching or into the atmosphere via denitrification. Ammonium-N is not vulnerable to the same losses when incorporated into the soil.

Most of the N applied to soil is initially in forms other than nitrate. The exception is liquid N (28-0-0 or 32-0-0), of which 25% of the fertilizer product is nitrate-N, the remainder is ammonium-N (25%) and urea-N (50%). Anhydrous ammonia is 100% ammonium-N when it reacts with water in the soil. Manure contains mostly organic- and ammonium-N forms.

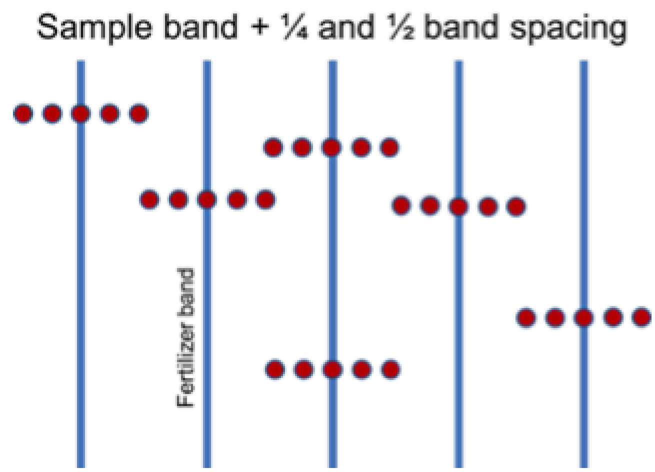
Ponded corn.

Unfortunately, no matter what forms of N are added to the soil, all of them eventually convert to nitrate-N. Time, temperature, soil type, N source, rate, and application method, and other factors determine how rapidly nitrate-N is formed. It is difficult to estimate the extent of nitrate formation because of the many factors affecting N conversion and their interaction.

It is even more difficult to then estimate how much of the nitrate-N was subsequently lost from the root zone. Soil sampling and measuring the concentration of nitrate- and ammonium-N remaining in the root zone is an alternative to guesstimating how much N was lost.

Soil Sampling Strategies

Soil nitrate-N and ammonium-N are quite variable and so obtaining a good representative soil sample requires many cores from relatively small field areas. The depth of sampling recommended is 1 foot in most soils. Consider collecting a separate deeper soil sample from between 1- and 2-foot soil depth for a more complete assessment of plant available N, especially in sandy soils where leaching through the soil profile is the predominant form of N loss.



Soil nitrate sampling.

Where fertilizer N was broadcast-applied rather than banded, collect 20 to 30 random soil cores per sample. If fertilizer N was banded rather than broadcast-applied, collect 15 to 20 groups of 5 soil cores each that proportionally represent areas with and without banded fertilizer (see illustration to right).

Handling Soil Samples Prior to Delivery to Soil Test Laboratory

Dry or refrigerate the soil samples as soon as possible to stop the soil microbes from altering the N levels. Spread the soil thinly on plastic to air dry and hasten drying with a fan if possible. If you choose to use an oven to dry the soil, keep the temperature below 250 °F. Alternatively refrigerate the samples and keep them cold through shipping to the laboratory.

Most soil testing laboratories offer soil N test analysis services, but contact them first to confirm and ask about any special procedures they recommend.

Soil samples.

Soil Test Laboratory Analyses

Ammonium-N is just as available to plants as nitrate-N, but typically little accumulates in the soil because it is readily converted to nitrate under most conditions. However, if N fertilizer was recently applied, there may well yet be some ammonium N available in the soil for plant use.

Significant levels of soil ammonium are most likely if anhydrous ammonia was the N source, a nitrification inhibitor such as nitrapyrin or dicyandiamide (DCD) was used, and/or soil pH was low (below 5.5). In these situations, low levels of soil nitrate may indicate little conversion of ammonium to nitrate, rather than simply loss of nitrate.

If soil test values for ammonium and nitrate are reported as "ppm" or "mg/L" nitrogen (NH_4-N or NO_3-N), then pounds per acre of available N are calculated by multiplying the test results by 4 when the sample depth was 1 foot. For other sample depths, divide the sample depth (in inches) by 3 and then multiply by the test results.

Example:
Soil NO_3-N in a 1-foot sample was reported to be 30 ppm.
Conversion from ppm to pounds per acre is (12 inches / 3) x 30 ppm = 120 pounds per acre.

If soil test values are reported directly as NH_4 or NO_3, then these values must be converted to an 'N' basis first. The calculations are: NH_4-N = (NH_4 / 1.2) and NO_3-N = (NO_3 / 4.5).

Example:
Soil NO_3 was reported to be 90 ppm.
Conversion from NO_3 to NO_3-N is (90 ppm NO_3 / 4.5) = 20 ppm NO_3-N.

Interpreting Soil Nitrate and Ammonium Levels

In our opinion, soil nitrate and ammonium levels can be used to guide additional N applications to fields subjected to saturation and flooding. However, there are admittedly no hard and fast research-based recommendations for this particular situation.

The primary tool for soil N sampling in the Eastern Corn Belt has been the pre-sidedress soil nitrate test (PSNT) which is most applicable as an indicator of N availability in soils where manure had been applied or a legume such as clover or alfalfa had been plowed down (Brouder & Mengel, 2003). For these field situations, the level of soil nitrate found is considered an index of N availability, i.e., an indicator of how much N is currently available AND how much N may become available from the manure or organic matter. When used in this context, soil NO_3-N levels greater than 25 ppm are thought to be adequate for optimum corn yield without the addition of more fertilizer N.

During the research that developed this soil test, sampling deeper than 1 foot or analyzing for exchangeable NH_4-N did not increase the predictive ability of the PSNT enough to warrant the extra effort. **However, when the intent is to assess the loss of N due to rainfall, we suggest that deeper sampling plus analysis for NH_4-N content can provide useful information to help growers decide whether additional fertilizer N is merited.** It is important to recognize that in this context, measurements of soil nitrate and ammonium following fertilizer N applications indicate current N availability only, because there is no manure- or legume-derived N to be released later in the season. Considering this fact, the commonly accepted 25 ppm NO_3-N critical level for manure- or legume-N fertilized soils may be too low for soils that have only received fertilizer N.

Leaching of soil nitrate is expected with ponding, flooding, or soil saturation, but not all of the nitrate will have been moved below the root zone. **A shortcoming of the 1-foot sampling depth is that it does not always reflect plant available N deeper in the profile, particularly when abnormal leaching occurs. This is why we suggest also sampling from the 1- to 2-foot depth for assessment of soil N availability, particularly in sandy soils**.

In our on-going N rate trials conducted throughout the state, the "normal" background levels of soil N in the upper 1 foot of mineral soils typically range from 5 to 10 ppm NO_3-N and 4 to 8 ppm NH_4-N for corn grown in rotation with soybean or corn without manure- or legume-derived N. Typically the deeper 1- to 2-foot soil samples would have slightly lower N levels.

Making a Decision

We suggest that the 25 ppm NO_3-N critical level for manure- or legume-N fertilized soils may be too low for soils that have only received fertilizer N and where N loss conditions have been severe. Where enough rainfall has occurred to cause substantial N loss, we suggest this level of rain has depleted the lower soil profile as well as the upper foot of soil.

This table includes estimates of expected soil NO_3-N levels with different fertilizer rates assuming "normal" background levels of nitrate and ammonium at the time of fertilization and a "normal" amount of movement below the one foot sampling depth (approximately 1/3 of the fertilizer N is moved below the 1-foot sampling depth but retained within the root zone with normal rainfall).

Table 1. Expected soil analysis levels of nitrate or nitrate plus ammonium in the upper 1 foot of soil for different rates of applied N fertilizer.

NOTE: Use the NO_3-N column if this is the only form of N measured in your sample. Add NO_3-N and NH_4-N levels together if both forms of N are measured in the soil sample and use the last column to assess N availability.

Fertilizer N applied prior to rains	Nitrogen analysis	
	NO_3-N	NO_3-N + NH_4-N
lbs/acre	ppm or mg/L N	
130	30	36
140	31	37
150	33	39
160	35	41
170	36	42
180	38	44
190	40	46
200	41	47
210	43	49
220	45	51
	*	**

NO_3-N = Nitrate nitrogen; NH_4-N = Ammonium nitrogen

* Assumes background level of ammonium at 6 ppm and "normal" levels of soil N below the 1-foot sampling depth.

** Assumes "normal" levels of soil N below the 1-foot sampling depth.

If the corn is healthy and the growing season is expected to be typical from here on out, we would suggest applying no more than 10 pounds of N for every 2 ppm reduction in soil sample N below the expected levels listed in the table.

Recognize that as a healthy crop moves through the rapid growth phase prior to pollination, soil N levels will naturally decrease in response to rapid N uptake by the plants. However, by the time a healthy crop reaches the V9 leaf stage (about 30 inches tall), only 19 lbs/ac N (equivalent to 5 ppm soil NO_3-N in a 1-foot deep sample) have typically been taken up the plants (Mengel, 1995). But, by the time a healthy crop reaches shoulder-high (~V15 or 60 inches tall), approximately 116 lbs/ac N (equivalent to 29 ppm soil NO_3-N in a 1-foot deep sample) have been taken up by the plants. With later corn the amount of N in the plant should be considered when evaluating soil N.

The following examples give you an idea of how the tabular information may be used to make this decision.

Example calculation when only NO_3-N is determined: Fertilizer N was applied at 160 pounds of N per acre in April as 28% UAN. Only soil NO_3-N analysis was requested because it was assumed that most of the urea- and ammonium-N had been converted to nitrate since temperatures were warm prior to the excessive rainfall. The expected NO_3-N level from the table above for a 160-lb N application is 35 ppm.

Laboratory results indicated only 20 ppm NO_3-N. The suggested N application rate would be:

((35 ppm – 20 ppm) / 2) x 10 = (15 ppm / 2) x 10 = 7.5 x 10 = 75 pounds per acre

Example calculation when both NO_3-N and NH_4-N are determined:

Anhydrous ammonia was applied at 160 pounds of N per acre in March. Since the N application was relatively recent, both NO_3-N and NH_4-N analyses were requested. The expected NO_3-N plus NH_4-N levels listed in the table for a 160-lb N application is 41 ppm.

Laboratory results indicated 15 ppm NO_3-N and 20 ppm NH_4-N for a total measured N level of 35 ppm. The suggested N application rate would be:

((41 ppm – 35 ppm) / 2) x 10 = (6 ppm / 2) x 10 = 3 x 10 = 30 pounds per acre

Evaluating Your Decision

Loss of N due to excessive rainfall and response of corn stressed by excess water and N deficiency is difficult to predict. Unfortunately we frequently find ourselves in this same situation asking how much N is needed and what will be the yield increase. Although we have conducted some planned experiments that apply N to N stressed corn it is difficult to plan experiments to evaluate N application to N stressed corn caused by excess rainfall. But now we have another opportunity.

If you decide to apply additional N to corn, consider leaving 3 applicator-width strips without additional N through the length of the field to evaluate the response to the additional N. The strips should be distributed randomly across the field, not positioned side-by-side. Compare the yield of these unfertilized strips to adjacent fertilized strips to determine the change in yield and profit due to fertilization. Collecting this data will help in making future decisions related to N loss and potential profit from supplemental N fertilization. For assistance in planning an evaluation of supplemental N consult: Purdue On-Farm Nitrogen Rate Trial Protocol at http://www.agry.purdue.edu/ext/ofr/protocols/PurdueNTrialProtocol.pdf

Sidedress N Application Rates

If no fertilizer N has been applied this season or soil N measurements suggest little N remains from fall- and spring-applied N, consider using our current N rate guidelines based on results of field trials conducted since 2006 throughout the state and based on the use of efficient methods and timings of N fertilizer application. This information is summarized at http://www.kingcorn.org/news/timeless/NitrogenMgmt.pdf.

The average Agronomic Optimum N Rate (AONR) for corn/soy in 53 trials conducted on medium- and fine-textured soils in southwest, southcentral, southeast, and westcentral Indiana was 208 lbs N / ac. The average AONR for 30 trials conducted on medium- and fine-textured soils in northwest and northcentral Indiana was 212 lbs N / ac. The average AONR for trials conducted on medium- and fine-textured soils in other regions of the state were 232, 251, and 263 lbs N / ac for central (23 trials), eastcentral (26 trials), and northeast (11 trials) Indiana, respectively. The average AONR for 16 trials on nonirrigated sandy soils was 202 lbs N / ac. At five Purdue Ag. Centers where we conducted paired trials of corn following soybean (corn/soy) and corn following corn (corn/corn) from 2007 to 2010, the average AONR for corn/corn was 44 lbs greater than for corn/soy while average corn/corn yields were 18 bu / ac less than the corn/soy yields. Economic optimum N rates for various combinations of N cost and grain price can be obtained from the article referenced above or the Corn Nitrogen Rate Calculator [http://cnrc.agron.iastate.edu].

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2018 Western Bean Cutworm Pheromone Trap Report

County	Cooperator	WBC Trapped Wk 1 6/21/18-6/27/18	Wk 2 6/28/18-7/4/18	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7
Adams	Roe/Mercer Landmark	0	0					
Allen	Anderson/Syngenta		0					
Allen	Gynn/Southwind Farms	0	0					
Allen	Kneubuhler/G&K Concepts	0	0					
Bartholomew	Bush/Pioneer Hybrids		1					
Clay	Bower/Ceres Solutions/Clay City	0						
Clay	Bower/Ceres Solutions/Bowling Green	0						
Clay	Bower/Ceres Solutions/Brazil	0						
Clinton	Emanuel/Boone Co. CES	3	0					
Clinton	Foster/Rossville		10					
Daviess	Venard/Venard Agri-Consulting/Washington	0	0					
Daviess	Venard/Venard Agri-Consulting/Elnora	0	0					
DeKalb	Hoffman/ATA Solutions	0	1					
Dubois	Eck/Dubois Co. CES	0	0					
Elkhart	Kauffman/Crop Tech Inc.		3					
Fayette	Schelle/Falmouth Farm Supply Inc.	0	1					
Fountain	Mroczkiewicz/Syngenta	12	196					
Fulton	Jenkins/Ceres Solutions/Talma	3						
Fulton	Randstead/Ceres Solutions	0						
Greene	Venard/Venard Agri-Consulting	0	0					
Hamilton	Campbell/Beck's Hybrids	0	0					
Hendricks	Nicholson/Nicholson Consulting		7					
Jasper	Overstreet/Jasper Co. CES	0	0					
Jasper	Ritter/Brodbeck Seeds	10	69					
Jay	Boyer/Davis PAC	1	0					
Jay	Shrack/Ran-Del Agri Services	0	1					
Jay	Temple/Jay Co. CES/Redkey							
Jay	Temple/Jay Co. CES/Pennville	0	0					
Jennings	Bauerle/SEPAC	0	0					
Knox	Bower/Ceres Solutions/Freelandville	0						
Knox	Bower/Ceres Solutions/Vincennes	0						
Kosciusko	Klotz/Etna Green	5	1					
Lake	Kleine	2	1					
Lake	Moyer/Dekalb Hybrids/Shelby	0	4					
Lake	Moyer/Dekalb Hybrids/Scheider	5	23					
LaPorte	Rocke/Agri-Mgmt. Solutions/Wanatah	1	3					
LaPorte	Smith/Co-Alliance, LLP/South Center	0	7					
LaPorte	Smith/Co-Alliance, LLP/Lacrosse	4	8					
LaPorte	Smith/Co-Alliance, LLP/Union Mills	8	17					
Marshall	Harrell/Harrell Ag Services/Plymouth	0						
Marshall	Harrell/Harrell Ag Services/Bremen	0						
Marshall	Klotz/Nappanee	6	11					
Marshall	Miller/Ceres Solutions/Plymouth	2						
Marshall	Smith/Co-Alliance, LLP/Argos	7	32					
Miami	Early/Pioneer Hybrids	4	26					
Montgomery	Delp/Nicholson Consulting	0						
Newton	Moyer/Dekalb Hybrids/Lake Village	1	5					
Porter	Tragesser/PPAC	2	11					
Posey	Schmitz/Posey Co. CES		0					
Pulaski	Capouch/M&R Ag Services	7	42					
Pulaski	Leman/Ceres Solutions	5	3					
Putnam	Nicholson/Nicholson Consulting	0						
Randolph	Boyer/DPAC	1	3					
Rush	Schelle/Falmouth Farm Supply Inc.	0	0					
Shelby	Fisher/Shelby County Co-op	0	0					
Shelby	Simpson/Simpson Farms	1	1					
St. Joseph	Barry/Helena	1	5					
St. Joseph	Battles/Mishawaka	0	0					
St. Joseph	Carbiener/Breman							
St. Joseph	Smith/Co-Alliance, LLP/Granger	3	53					
St. Joseph	Smith/Co-Alliance, LLP/New Carlisle	1	3					
Starke	Capouch/Medaryville	2	11					
Starke	Smith/Co-Alliance, LLP/Hamlet	9	34					
Sullivan	Bower/Ceres Solutions/Farmersburg	0						
Sullivan	Bower/Ceres Solutions/Sullivan	0						
Tippecanoe	Bower/Ceres Solutions/Lafayette	4						
Tippecanoe	Nagel/Ceres Solutions	0						
Tippecanoe	Obermeyer/Purdue Entomology	0	0					
Tippecanoe	Westerfeld/Monsanto Research Farm	6						
Tipton	Campbell/Beck's Hybrids	0	0					
Vermillion	Bower/Ceres Solutions/Clinton	0						
Wabash	Enyeart/Ceres Solutions	0						
Whitley	Boyer, Richards/NEPAC/Schrader	3	3					
Whitley	Boyer, Richards/NEPAC/Kyler	0	0					

* = Intensive Capture…this occurs when 9 or more moths are caught over a 2-night period

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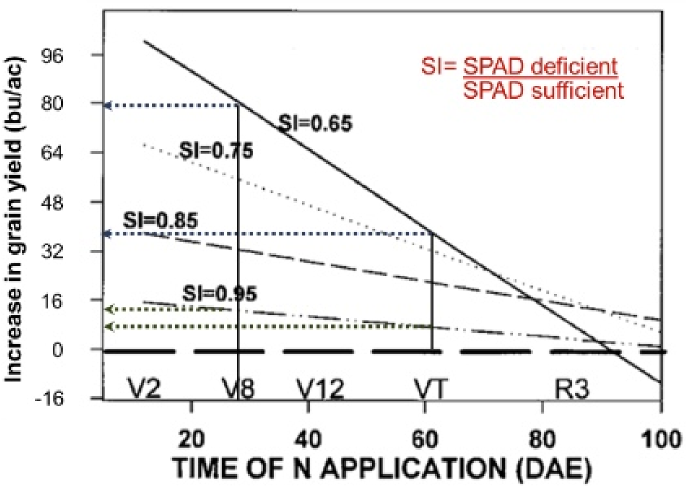
Late-Season Nitrogen Application for Corn

Author: Jim Camberato

Providing sufficient but not excessive nitrogen (N) to corn is difficult especially with fall and early spring fertilizer applications where N loss can vary substantially with the timing of the application relative to the occurrence of warm soil and excessive rainfall. Nitrogen deficiency occurs most growing seasons and often leads to an interest in applying N fertilizer beyond the growth stage and height where standard N application equipment can be used.

Nitrogen applied up to 2-3 weeks after silking to N deficient but otherwise healthy corn can result in increased grain yield. The greater the N deficiency and the earlier the N application the larger the yield increase. An irrigated 2-year study conducted in Nebraska illustrates this point well. (We gratefully acknowledge the support provided for research conducted by Dan Emmert and Eric Miller by the Indiana Corn Marketing Council, Pioneer Hi-Bred Int'l, A&L Great Lakes Labs (discounted analysis costs), Purdue Univ. Office of Ag Research Programs, and all of the Purdue Ag Center staff.)



Rates of N were applied from 0 to 300 lb N/ac at planting to establish different levels of N sufficiency. Nitrogen sufficiency (SI) was quantified with a SPAD chlorophyll meter by measuring greenness of the most recently collared leaf in sub-optimal N rates compared to the highest N rate (SI=1 indicates no N deficiency).

At V8 the application of N to corn with an SI=0.95 (slight N deficiency) increased yield about 14 bushels per acre (bu/ac. With greater N deficiency (SI=0.65) the yield increase was nearly 80 bu/ac (see figure to right).

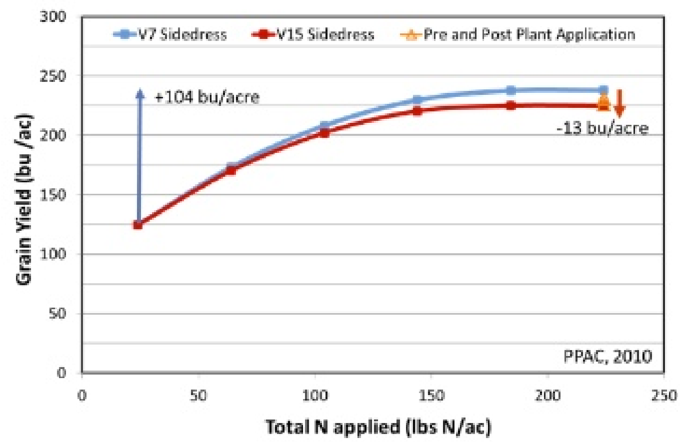
Nitrogen applications later in the season were not able to produce as great a yield increase as those obtained at V8. Nitrogen applied at tasseling (VT) to corn with an SI=0.65 increased yield less than 40 bu/ac. At an SI=0.95 at VT the increase in yield with N application was about 8 bu/ac.

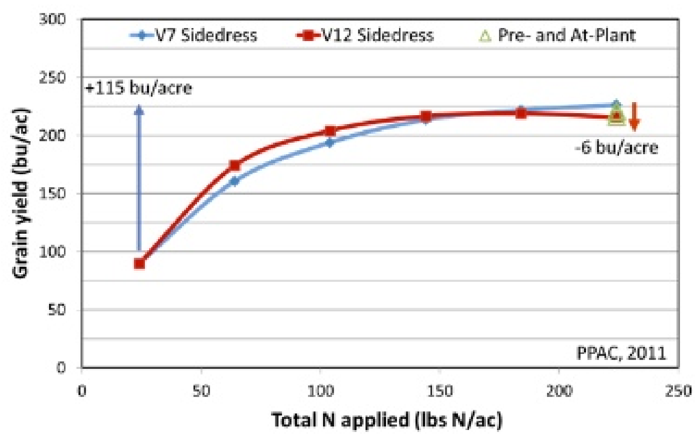
Irrigation provides a means to apply N, move it into the rootzone, and keep the rootzone moist; optimizing N uptake and grain yield response to late- season N. Limited rainfall in non-irrigated fields may hinder response to late-season N application.

Research in Indiana under rainfed conditions can be used to illustrate this point (Dan Emmert -M.S. thesis, 2009)[2]. Grain yield was increased 27 and 40 bushels per acre at two locations in west-central Indiana by a V13 N application of 175 lb/ac. Little rainfall occurring in the first 2 to 3 weeks after application and total rainfall after the N application was 10 an 15 inches, respectively for the two locations. Yield with the late-season N application was 114 and 139 bu/ac reflecting less than ideal conditions throughout the season.

With more timely and greater rainfall (0.3" of rainfall one and two weeks after the late-season N application and total of 20 inches after application), a yield increase of 64 bu/ac and a maximum yield of 184 bu/acre was realized in a study conducted in northwest Indiana.

With better growing conditions at this same location in 2010 and 2011 an additional 100 bu/ac were made by applying high rates of N at V15 and V12 to N deficient corn (see below–Eric Miller – M.S. thesis, 2012). Optimum yield ranged from 215 to 240 bu/ac.





The previous mentioned trials had little N applied early in the season so N deficiency was relatively strong and the yield response to applied N was large. Smaller responses should be expected with less severe N deficiency. Three on-farm trials with 50 to 150 lb N/ac delayed to V9 or beyond showed little to no yield benefit of holding back some of the N because N deficiency was minimal (Table 1).

Table 1. Effect of delayed N on corn grain yield at three on-farm locations. Timing, rate, and method of application varied at the different locations.

Sidedress N (lb/ac) at growth stage			Grain yield, bu/ac		
V3-V4	V9†	V12-V15	Brookston/Crosby 2015	Brookston/Crosby 2016	Blount/Pewamo 2016
200	0	0	204 a*	196 b*	
150	50	0		198 b	
150	0	0			197 a*
150	0	50 injection		197 b	
150	0	50 Y-drop®		202 a	
100	100	0	208 a		
100	50	50 injection	204 a	197 b	
100	50	50 Y-drop®		201 a	
100	0	50 dribble			195 b
100	0	50 Y-drop®			198 a
75	0	75 dribble			194 b
75	0	75 Y-drop®			194 b
50	150	0	208 a		
50	75	75 injection	206 a		

†All V9 applications were injected with a solid shank coulter on a high-clearance applicator.
*Means followed by different letters differ by LSD test with a probability of >90%.

Several effective methods can be utilized to apply N to tall corn. A solid shank applicator (pictured left) that injects N into a coulter slit a couple of inches deep into the soil prevents ammonia (NH3) volatilization from liquid urea-ammonium nitrate. Alternatively the same high-clearance applicator can be fitted with drop tubes or Y-Drops® to place the liquid N in a narrow band on the soil surface. Although NH3 volatilization may occur when liquid N is left on the soil surface the magnitude of loss is likely less than 5% of the N applied when banded in full canopy corn.

A solid shank applicator.

A high-clearance box spreader.

Granular urea can also be spread by airplane or high-clearance box spreader (pictured right). Fifteen to 30% of the N applied in broadcast urea may be lost to NH3 volatilization. Compensating for potential N loss by applying a higher N rate or by using a urease inhibitor to reduce NH3 loss (NBPT or NPPT) should be considered.

Differences among application methods in crop damage, speed of application, and other practical factors should also be considered when choosing among methods of application.

Irrigated corn provides the easiest opportunity to apply N to corn. Fertigating with liquid urea-ammonium nitrate is an efficient cost-effective way to provide late-season N to corn. Often 20 to 30 lb N/ac are applied per N application, but as much as 50 lb N/ac can be applied with sufficient dilution to avoid foliar burn. Adding N to irrigation water increases the importance of irrigation system application uniformity as water and N both have substantial impact on crop growth and yield. Since irrigation maintains high soil moisture, leaching and/or denitrification of N may occur with excessive irrigation or rainfall. Thus multiple small rates of N application are helpful in reducing N loss. Additional guidelines for fertigation can be found in Irrigation Fact Sheet #12.[4]

Summary

Corn has tremendous capacity to respond to late-season N application provided the plant is N deficient, but otherwise healthy. The earlier the application the better but profitable responses have been obtained as late as 2 to 3 weeks after tasseling. In non-irrigated systems there are advantages and disadvantages to each application method and source with no clear winners or losers. Injecting urea-ammonium nitrate into irrigation water is the most convenient application method when irrigation is available.

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Silk Development and Emergence in Corn

Author: Bob Nielson

- Corn produces individual male and female flowers on the same plant.
- The ear represents the female flower of the corn plant.
- Severe soil moisture deficits can delay silk emergence and disrupt the synchrony of pollen shed and silk availability, resulting in poor kernel set.

The corn plant produces individual male and female flowers (a flowering habit called monoecious for you corny trivia fans.) Interestingly, both flowers are initially bisexual (aka "perfect"), but during the course of development the female components (gynoecia) of the male flowers and the male components (stamens) of the female flowers abort, resulting in tassel (male) and ear (female) development.

The silks that emerge from the ear shoot are the functional stigmas of the female flowers of a corn plant. Each silk connects to an individual ovule (potential kernel). A given silk must be pollinated in order for the ovule to be fertilized and develop into a kernel. Up to 1000 ovules typically form per ear, even though we typically harvest only 400 to 600 actual kernels per ear.

Technically, growth stage R1 (Abendroth et al., 2011) for a given ear is defined when a single silk strand is visible from the tip of the husk. A field is defined as being at growth stage R1 when silks have emerged on at least 50 % of the plants. This whole field definition for growth stage R1 is synonymous with the term "mid-silk".

Silk Elongation and Emergence

Silks begin to elongate from the ovules 10 to 14 days prior to growth stage R1 or approximately at the V12 leaf stage. Silk elongation begins first from the basal ovules of the cob, then proceeds sequentially up the ear. Because of this acropetal sequence of silk elongation, silks from the basal (butt) portion of the ear typically emerge first from the husk, while the tip silks generally emerge last. Complete silk emergence from an ear generally occurs within four to eight days after the first silks emerge from the husk leaves.

As silks first emerge from the husk, they lengthen as much as 1.5 inches per day for the first day or two, but gradually slow over the next several days. Silk elongation occurs by expansion of existing cells, so elongation rate slows as more and more cells reach maximum size. Elongation of an individual silk stops shortly after pollen is captured, germinates and then penetrates the silk.

If not pollinated, silk elongation stops about 10 days after silk emergence due to senescence of the silk tissue. Unusually long silks can be a diagnostic symptom that the ear was not successfully pollinated.

Silks remain receptive to pollen grain germination up to 10 days after silk emergence, but to an ever-decreasing degree. The majority of successful ovule fertilization occurs during the first 4 to 5 days after silk emergence (see photos that follow).

Natural senescence of silk tissue over time results in collapsed tissue that restricts continued growth of the pollen tube. Silk emergence usually occurs in close synchrony with pollen shed, so that duration of silk receptivity is normally not a concern. Failure of silks to emerge in the first place, however, does not bode well for successful pollination.

Pollination and Fertilization

For those of you serious about semantics, let's review two definitions relevant to sex in the cornfield. Pollination is the act of transferring the pollen grains to the silks by wind or insects. Fertilization is the union of the male gametes from the pollen with the female gametes from the ovule. Technically, pollination is almost always successful (i.e., the pollen reaches the silks), but unsuccessful fertilization (i.e., pollen tube failure, silk failure, pollen death) will fail to result in a kernel.

Pollen grain germination occurs within minutes after a pollen grain lands on a receptive silk. A pollen tube, containing the male genetic material, develops and grows inside the silk, and fertilizes the ovule within 24 hours. Pollen grains can land and germinate anywhere along the length of an exposed receptive silk. Many pollen grains may germinate on a receptive silk, but typically only one will successfully fertilize the ovule.

Silk Emergence Failure

Severe Drought Stress. The most common cause of incomplete silk emergence is severe drought stress. Silks have the greatest water content of any corn plant tissue and thus are most sensitive to moisture levels in the plant. Severe moisture deficits will slow silk elongation, causing a delay or failure of silks to emerge from the ear shoot. If the delay is long enough, pollen shed may be almost or completely finished before receptive silks are available; resulting in nearly blank or totally blank cobs. Severe drought stress accompanied by low relative humidity can also desiccate exposed silks and render them non-receptive to pollen germination.

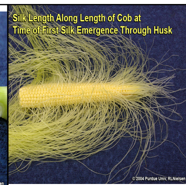
The severity of drought stress required for significant silk emergence delay or desiccation can probably be characterized by severe leaf rolling that begins early in the morning and continues into the early evening hours. Such severe leaf rolling is often accompanied by a change in leaf color from "healthy" green to a grayish-tinged green that may eventually die and bleach to a straw color.

Silk Clipping by Insects. Although technically not described as silk emergence failure, severe silk clipping by insects such as corn rootworm beetle or Japanese beetle nonetheless can interfere with the success of pollination by decreasing or eliminating viable or receptive exposed silk tissue. Fortunately, unless the beetle activity is nonstop for days, continued elongation of silks from the husk will expose undamaged and receptive silk tissue at the rate of about one inch or more per day.

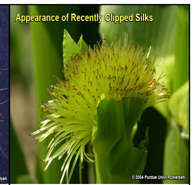
Silk "Balling". Occasionally, silks fail to emerge successfully because they fail to elongate in their usual straight "path" up the ear toward the end of the husk leaves. Instead, silk elongation becomes convoluted (twisted, coiled, scrambled) inside the husk leaves. This silk "balling" phenomenon is not well-understood and hybrids tend to vary in their vulnerability to this type of silk emergence failure. Two different pieces of circumstantial evidence are often associated with the problem. One is a physical restriction imposed on silk elongation caused by unusually"tight" or long husk leaves in certain hybrids. The other circumstance often correlated with silk "balling" is the occurrence of unusually cool nights during the time silk elongation is occurring, but prior to silk emergence. The physiological effect of such cool nights on silk elongation is not understood. It has been years since I last saw a field with a significant level of silk "balling" (Nielsen, 2000).

Silk elongation on the lower half of a V12 ear shoot; 10 to 14 days before silk emergence.

Silk elongation on the lower 2/3 of a V14 ear, about 4 days after V12; 6 to 10 days before silk emergence.



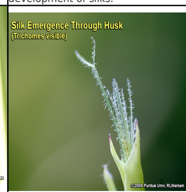
Variable silk length along length of cob at first silk emergence; illustrating the acropetal development of silks.



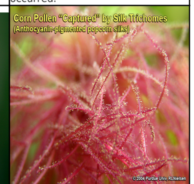
Silks recently clipped with a knife; note the discolored, non-receptive ends of the silks where the clipping occurred.

About 1.5 inches of silk elongation since being manually clipped about 15hrs previous.

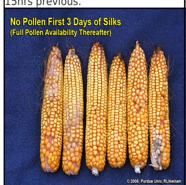
Western Corn Rootworm beetles (Diabrotica spp.) actively feeding on silks and pollen.



Trichomes visible on silks just emerging through husk leaves.



Pollen "captured" by silk trichomes on a popcorn hybrid with anthocyanin-pigmented silks.



Kernel set on ears where pollination was prevented for 3 days after first silk emergence, then allowed to proceed without interference.

Kernel set on ears where pollination was prevented for 4 days after first silk emergence, then allowed to proceed without interference.

Kernel set on ears where pollination was prevented for 5 days after first silk emergence, then allowed to proceed without interference.

Related Reading

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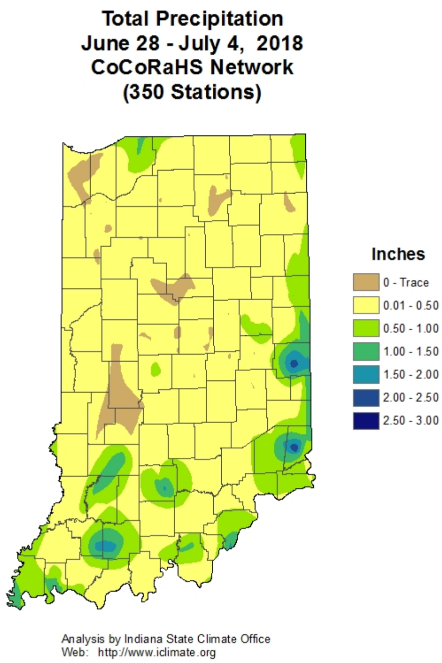

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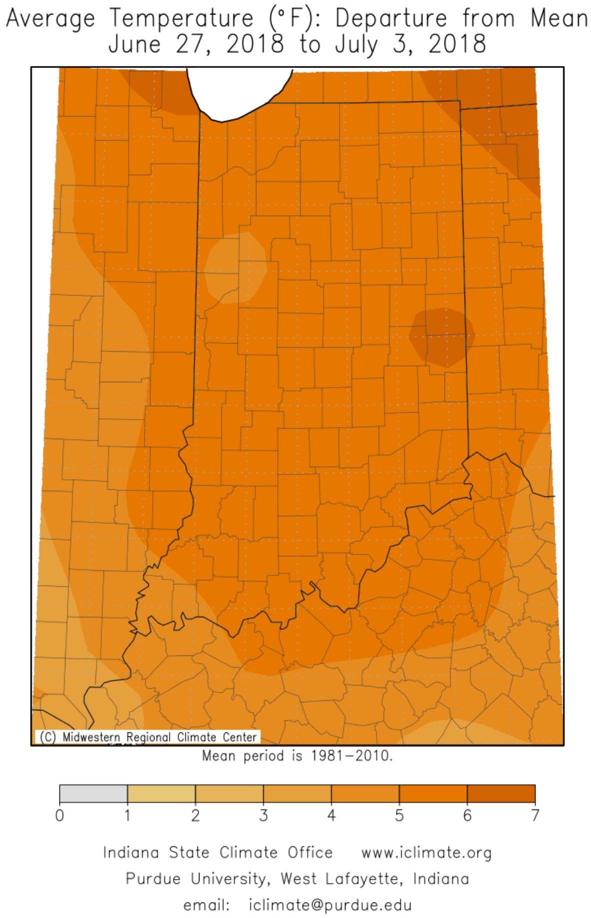
Average Temperature Departure from Mean June 27 – July 3, 2018



Average Temperature Departure from Mean June 27 – July 3, 2018