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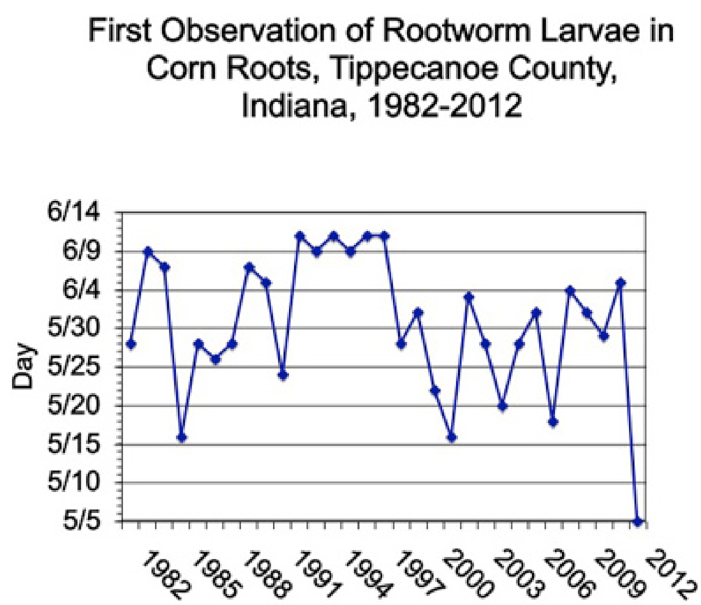
In This Issue

Insects, Mites, And Nematodes

Rootworm Hatch Underway…It's Early! - (*Christian Krupke and Larry Bledsoe*)

- Abundant first instar rootworms found in volunteer corn in Tippecanoe County this week, about 1 month earlier than typical
- Rootworm hatch in these areas estimated at May 4-6, 2012
- Rootworms need to find corn within 24 hours of hatch, those emerging in unplanted fields will die

For years Larry Bledsoe, Purdue Field Crops Research, has led an annual survey of corn roots in the spring to determine when rootworm hatch occurs in farms near the Purdue campus. Like most insect life stage changes, egg hatch is based upon temperature and given this year's spring temps we expected early emergence. For reference, in recent years that first hatch has occurred near the end of May. This year, the survey found nothing during a May 2 survey of volunteer corn roots, but a May 8 survey revealed many robust first instars that appeared ready to reach the second instar (three total instars).



This is the earliest emergence that Larry has observed in 35 years of being associated with field crops. This year's emergence is about 10 days earlier than the earliest recorded occurrence and about 1 month earlier than what has been observed during the recent past.

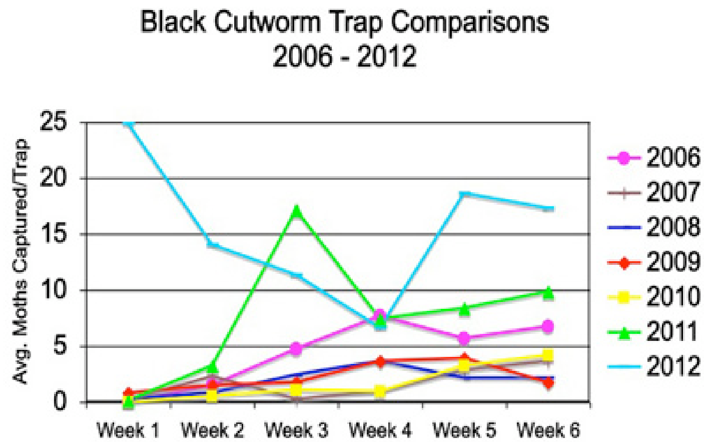
This isn't at all surprising, given the warm spring and atypically warm soils. The more important question is what it means for damage forecasts. Those warm March days that pushed rootworm emergence along also advanced our planting dates. A lot of corn was planted in early April (and most of the state is planted now), so many rootworms will have little trouble finding food upon emergence. However, unplanted or ungerminated fields will add up to 100% mortality for rootworms that don't find corn within 24 hours of leaving the egg. Rootworm larvae can survive on a few grassy weeds (foxtail, for example), but survival levels are poor and those weeds are scarce at this time of year. For practical purposes, they are dependent upon corn for survival. Note also that the emergence period is long – several weeks – so virtually all corn, regardless of planting date, will be vulnerable to pressure.

All in all, this is yet another confirmation that we are in uncharted territory for insect patterns and pressures this year. A very cool May could get us right back into an "average year" mindset, but for now things are happening more quickly and earlier than most of us can remember. Stay tuned!

What an Incredible Black Cutworm Catching Season – (*John Obermeyer*)

Every spring, dozens of cooperators throughout the state put forth considerable effort in trapping for the arrival and intensity of black cutworm moths. This year especially, they were very busy! I'm personally indebted to these faithful bug counters, hoping too you appreciate their efforts as reported in the "Black Cutworm Adult Pheromone Trap Report." If you recognize a name or two on this list of reporters, by county, please thank them!

As you can see from the accompanying graph comparing black cutworm moth catches from past years, 2012 has not only broken past records, it has blown the doors off. With this information, we've used the *Pest&Crop* the past weeks as a forum to get the alert out for pest managers to be scouting emerging corn. Amazingly, few reports have been received, and most of those of folks wondering, like myself, why high-risk fields (e.g., previously weedy) are not being damaged by black cutworm larvae. Certainly there is still time for black cutworm to make an unwelcome appearance, but as quickly as corn is responding to favorable growing conditions, it appears those damaged fields will be far and few between. A perfect example of how predicting an insect response to given conditions (e.g., numbers, temperatures, etc) is not an exact science. I still ponder…what happened to all those moths, eggs, and larvae?!?!



Nematode Updates - Corn Nematodes - (*Jamal Faghihi, Betsy Bower, Christian Krupke and Virginia Ferris*) -

- Weather conditions so far this year have not favored Needle nematode.
- Stunted corn with stubby roots on sandy soil may be symptoms of damage caused by Needle or Lance nematodes.
- Sampling for corn nematodes is best done about 4-6 weeks after corn germination.

Weather-wise this has been an unusual year and not favorable to Needle nematodes. We have just begun to see Needle nematodes in our samples from Southern Indiana. Your situation might be completely different so you need to judge for yourselves and decide if conditions in your area are favoring Needle nematode damage. Needle nematodes, the most yield-limiting nematodes in Indiana's corn, need a cool and wet spring and sandy soil to increase in population to economically damaging levels. Other nematodes, like Lance and Lesion nematodes, do not require those conditions to be a problem. While Needle nematode is parasitic to corn only, Lance and most Lesion nematodes can parasitize corn and soybean.

Symptoms

Under high nematode pressure from Needle nematodes, roots do not develop normally. The roots are truncated and the symptoms resemble those resulting from root inhibitor (dinitroaniline) herbicide injury. Similar symptoms are also present when Lance nematodes are causing a problem, but not so for Lesion nematodes. Symptoms for most plant parasitic nematodes include stunted corn, usually in patches that do not follow a uniform pattern in the field.

Stunted plants, especially on sandy soils, should have their roots examined

Healthy versus damaged plant by needle nematodes

Sampling

If you have had problems on corn before, and weather conditions change in the nematodes' favor, you might consider sampling for nematodes. In this case, you may wish to send the entire root system with adjacent soil to the Purdue University Nematology Laboratory for analysis. Samples must be kept cool and moist. The best time to sample for needle nematodes is 4-6 weeks after corn germination. The procedures for sampling soil are similar for most plant parasitic nematode species. Soil samples must be taken to a depth of 6-8 inches, as close as possible to the plant roots. A more detailed sampling procedure can be found on the following website: <http://www.entm.purdue.edu/nematology/samples.html>.

Processing fees

The processing fees are determined by the number and complexity of procedures required to determine the total number of plant parasitic nematodes in each sample. The processing charge continues to remain at $10/procedure. However, when both roots and soil samples are submitted, we have to follow two completely different extraction procedures to determine the final nematode counts, which we report as total count for important plant parasitic nematode species. Typically, the cost of processing most soybean soil samples to extract cysts and count cysts and eggs from the soil requires one procedure ($10/sample). But when roots and soil are both included (as is often true for corn samples), two procedures are required to determine the nematode counts ($20/sample).

Additional information and a sampling form can be downloaded and completed in excel format from our Nematology website: <http://extension.entm.purdue.edu/nematology/services.html>.

We will be able to respond much more quickly if you type in your email address.

If you have any questions about corn nematode or any other kind of plant parasitic nematodes, you can contact Jamal Faghihi at 765-494-5901 or send an email to jamal@purdue.edu. Soil samples for nematode analysis can be sent to: Nematology laboratory, Purdue University, Department of Entomology, Smith Hall, 901 W. State Street, West Lafayette, IN 47907-2089.

Black Cutworm Adult Pheromone Trap Report **Week 1 = 4/26/12 - 5/2/12 Week 2 = 5/3/12 - 5/9/12**							
County	**Cooperator**	**BCW Trapped**		**County**	**Cooperator**	**BCW Trapped**	
		Wk 1	**Wk 2**			**Wk 1**	**Wk 2**
Adams	Roe/Mercer Landmark	27*	33	Knox	Bower/Ceres Solutions/Vincennes	13*	
Allen	Anderson/Syngenta			Knox	Hoke/SWPAC	9	3
Allen	Gynn/Southwind Farms	19	5	Lake	Kleine/Kleine Farms	64*	98*
Benton	Babcock/Ceres Solutions	27*	10	Lake	Moyer - Shelby	13	20
Boone	Carrell	19*		Lake	Moyer - Schneider	39*	57*
Clay	Bower/Ceres Solutions - Brazil	1		LaPorte	Barry/Kingsbury Elevator	20*	20*
Clay	Bower/Ceres Solutions - Clay City	5		LaPorte	Rocke/Agri-Mgmt Solution	10	9
DeKalb	Hoffman/ATA Solutions	29*	20*	Newton	Moyer - Lake Village	4	8
Dubois	Eck/Purdue CES	2	4	Newton	RItter/Purdue CES		
Elkhart	Kaufman/Crop Tech	68*	26	Porter	Leuck/PPAC	39*	55*
Fayette	Schelle/Falmouth Farm Supply	21	7	Putnam	Nicholson/Nicholson Consulting	3	0
Fountain	Mroczkiewicz/Syngenta	12	12	Randolf	Boyer/DPAC	7	4
Fulton	Jenkins/N. Central Coop - Kewanna	30*	19	Rush	Schelle - Carthage	2	8
Fulton	Jenkins/N. Central Coop - Rochester	18*	18	Starke	Wickert/Wickert Agronomy Services	16*	6
Hamilton	Beamer/Beck's Hybrids - Atlanta	11	4	Sullivan	Bower/Ceres Solutions - New Lebanon	35*	15
Hamilton	Beamer/Beck's Hybrids - Sheridan	12	0	Sullivan	Bower/Ceres Solutions - Sullivan W	15*	
Hendricks	Nicholson/Nicholson Consulting	32*	26	Sullivan	Bower/Ceres Solutions - Sullivan E	13*	
Henry	Schelle/Falmouth Farm Supply - NewCastle	10*	5	Sullivan	Bower/Ceres Solutions - Farmersburg	6	
Henry	Schelle/Falmouth Farm Supply - Millville	23	15	Tippecanoe	Bower/Ceres Solutions	5	5
Jasper	Overstreet/Purdue CES	6	10	Tippecanoe	Nagel/Ceres Solutions	121*	99*
Jay	Shrack/RanDel AgriServices	3	9	Tippecanoe	Obermeyer/Purdue Entomology	8	0
Jennings	Bauerle/SEPAC	2	0	Tippecanoe	Westerfeld/Monsanto	11	6
Knox	Bower/Ceres Solutions/Fritchton	13*		White	Reynolds/ConAgra Snack Foods	0	3
Knox	Bower/Ceres Solutions/Freelandville	0		Whitley	Walker/NEPAC	17	24*
*=Intensive Capture...this occurs when 9 or more moths are caught over a 2-night period							

Black Light Trap Catch Report - (*John Obermeyer*)														
County/Cooperator	**4/24/12 - 4/30/12**							**5/1/12 - 5/7/12**						
	VC	**BCW**	**ECB**	**WBC**	**CEW**	**FAW**	**AW**	**VC**	**BCW**	**ECB**	**WBC**	**CEW**	**FAW**	**AW**
Dubois/SIPAC Ag Center								0	0	0	0	0	0	0
Jennings/SEPAC Ag Center	0	0	0	0	0	0	4	0	0	0	0	0	0	2
Knox/SWPAC Ag Center	0	7	5	0	0	0	40	0	2	0	0	1	0	10
LaPorte/Pinney Ag Center	0	2	0	0	0	0	22	0	0	0	0	0	0	150
Lawrence/Feldun Ag Center	0	0	0	0	0	0	5	0	0	0	0	0	0	4
Randolph/Davis Ag Center	0	0	0	0	0	0	15	0	1	0	0	0	0	20
Tippecanoe/TPAC Ag Center	0	0	0	0	0	0	9	0	0	0	0	0	0	27
Whitley/NEPAC Ag Center	0	0	0	0	0	0	11	0	5	0	0	0	0	679
VC = Variegated Cutworm, BCW = Black Cutworm, ECB = European Corn Borer, WBC = Western Bean Cutworm, CEW = Corn Earworm, FAW = Fall Armyworm, AW = Armyworm														

Weeds

Timing of Post-emergence Corn Herbicide Applications – (*Travis Legleiter and Bill Johnson)* –

A large portion of Indiana's corn acreage has been planted and has emerged in the last couple of weeks. In fact, we have observed corn in the V3 stage in the Lafayette area, and surely corn in the southern part of the state has advanced past this stage. Weeds are also emerging and post herbicide applications will be necessary within the next couple of weeks to month. Unlike post soybean herbicides there are a large number of herbicides available beyond the glyphosate products for weed control in corn. The large number of products is a positive when considering glyphosate-resistance management and prevention, but can also make timing and product application decisions more complicated since corn ear development can be greatly influenced by postemergence herbicides if they are applied too late in the growing season.

When choosing a post applied corn herbicide or herbicide combination, producers need to consider the weed species present, weed heights, AND crop growth stage. The majority of conventional post-applied corn herbicides are effective on select weed species and only at certain weed heights. Typically a combination of products or a pre-package of active ingredients is needed to achieve control of all weed species present. Producers should refer to herbicide labels for weed species controlled and recommended application heights; Table 4 of the 2012 Ohio and Indiana Weed Control Guide can also assist in choosing an effective herbicide option. Spraying weeds that are larger than the recommended label height can result in poor weed control.

The stage and height of corn at the time of post herbicide application is also important to keep in mind as applications outside of the labeled window can result in crop injury and/or yield loss. The type and amount of injury from an application beyond the labeled window is dependent upon the herbicide, other environmental stresses, and exact timing of application. Injury symptoms include: ear pinching, ear bottlenecking, internode stacking, onion leafing, rat tailing, brace root malformation, and green snap. Refer to the herbicide label and Table 1 for the appropriate crop stages for post emergence herbicide applications. Also, Bob Nielsen has an excellent article on how to stage corn growth stage and pitfalls that one can run into when lower leaves are missing <http://www.agry.purdue.edu/ext/corn/news/timeless/vstagemethods.html>.

Determining Corn Leaf Stages

When tank mixing products, follow the most restrictive label as far as determining the appropriate crop growth stage restriction.

Other items to consider to avoid crop injury based on our past experience:

1) Avoid using contact herbicides just prior to rain showers or applying these herbicides when there is a heavy dew to avoid washing the herbicide down into whorl.
2) Avoid applying growth regulator herbicides after several nights of cool temps (45 degrees or cooler).
3) Do not use UAN solutions as the carrier when applying atrazine premixes to spike stage corn.
4) Do not mix growth regulator herbicides with chloroacetamide herbicides and apply postemergence. These mixtures are fine if applied before corn emergence.
5) Do not apply ALS inhibitors past the V6 stage of corn growth.

Table 1. Post-emergence corn herbicide products and growth stage/crop height restrictions for applications as derived from Labels and 2012 Ohio and Indiana Weed Control Guide.

Herbicide	Trade Name	Corn Application Stage/Height[ab]
2,4-D ester or amine	Various	Broadcast: up to 8" Directed: up to tasseling
2,4-D + atrazine	Shotgun	Broadcast: spike to 8” Directed: 8” to 12”
atrazine	Aatrex and other various	Apply up to 12” corn
bromoxynil	Buctril, Moxy, and Boreclean	1 pt.: emergence to just before tassel 1.5 pt.: 4 leaf stage to just before tassel
bromoxynil + atrazine	Brozine	1.5-2 pt.: emergence to 12” corn 3 pt.: 4 leaf to 12” corn
carfentrazone	Aim	Broadcast: up to V8 stage Directed: up to V14 stage
clopyralid	Stinger	Emergence to 24”
clopyralid + fluroxypyr	WideMatch	Broadcast up to V5 corn

Table 1. Post-emergence corn herbicide products and growth stage/crop height restrictions for applications as derived from Labels and 2012 Ohio and Indiana Weed Control Guide.

Herbicide	Trade Name	Corn Application Stage/Height[ab]
dicamba + atrazine	Marksman, Sterling Plus, and other various	Spike to five-leaf or 8” corn
dicamba + diflufenzopyr	Status	4” to 36” tall or V2 to V10
flumetsulam + clopyralid	Hornet	Up to 20" or 6 collar corn
flumiclorac	Resource	2- to 10-leaf stage
fluroxypyr	Starane	Broadcast up to V5 corn
fluthiacet-methyl	Cadet	Apply up to 48" corn
glufosinate*	Liberty	Apply up to V7 stage
glyphosate + mesotrione + s-metolachlor**	Halex GT	Apply up to 30" or 8-collar corn
glyphosate + s-metolachlor**	Expert	Apply up to 12" corn
glyphosate**	Various	Emergence to 30" or 8-collar corn
halosulfuron	Permit, Sandea, and Halomax	Spike to layby stage
halosulfuron + dicamba	Yukon	Spike to 36" corn
halosulfuron + thifensulfuron	Permit Plus	1- to 5-leaf stage
imazethapyr + imazapyr***	Lightning	Broadcast: up to 20” or V6 stage Directed: until 45 days before harvest
mesotrione	Callisto	Apply up to 30" or 8 leaf stage
mesotrione + atrazine	Callisto Xtra	Emergence to 12" corn
nicosulfuron	Accent Q and NIC-IT	Broadcast: up to 20” or 6 collar corn Directed: 20” to 36” or 10 collar corn
nicosulfuron + rimsulfuron	Steadfast Q and Ironclad	Up to 20" or 6 collar corn
nicosulfuron + rimsulfuron + atrazine	Steadfast ATZ	Up to 12" or 6 collar corn
primisulfuron	Beacon	Broadcast: 4 to 20” corn Directed: 20” to before tassel emergence
primisulfuron + dicamba	NorthStar	Broadcast: 4” to 20” corn Directed: 20” to 36” corn or 15 days prior to tassel emergence
prosulfuron	Peak	Broadcase: up to 20” or 6-collar Directed: up to 30”
prosulfuron + primisulfuron	Spirit	Broadcast: 4 to 20” corn Directed: 4 to 24” corn
rimsulfuron + thifensulfuron + isoxadifen (Safener)	Resolve Q	20” or 6-collar stage
tembotrione	Laudis	Up to V8 stage
tembotrione + thiencarbazone-methyl	Capreno	Broadcast: V1 to V6 Directed: up to V7
topramezone	Impact and Armezon	Up to 45 days before harvest

[a]Crop stage and height restriction are for field dent corn. For popcorn and sweet corn crop stage and height restrictions refer to the herbicide label.
[b]Restriction statements including “or” should be interpreted as which ever occurs first.
* Apply to Glufosinate-resistant (Liberty Link) corn varieties only.
** Apply to glyphosate-resistant (Roundup Ready) corn varieties only.
*** Apply to imadazolinone-resistant (Clearfield) corn varieties only .

Agronomy Tips

Effects Of Flooding Or Ponding On Young Corn – (*Bob Nielsen*) -

Recent intense rainfall events (technically referred to as “toad stranglers” or “goose drownders”) have caused flooding of low-lying corn fields or ponding in poorly drained swales within fields. Other areas within fields, while not technically flooded or ponded, may remain saturated for lengthy periods of time. What are the prospects for recently submerged corn fields?

The sarcastic answer is that flooded crops will survive until they die. What I mean to say is that no one can tell you with certainty the day after the storm whether a ponded area of a corn field will survive or whether there will be long-term yield consequences until enough time has gone by such that you can assess the actual recovery of the damaged plants. We can, however, talk about the factors that increase or decrease the risks of severe damage or death to flooded soils.

- Plants that are completely submerged is at higher risk than those that are partially submerged.
  - Plants that are only partially submerged may continue to photosynthesize, albeit at limited rates.
- The longer an area remains ponded, the higher the risk of plant death.
  - Most agronomists believe that young corn can survive up to about 4 days of outright ponding if temperatures are relatively cool (mid-60›s F or cooler); fewer days if temperatures are warm (mid-70›s F or warmer).
  - Soil oxygen is depleted within about 48 hours of soil saturation. Without oxygen, the plants cannot perform critical life sustaining functions; e.g. nutrient and water uptake is impaired and root growth is inhibited.
- Even if surface water subsides quickly, the likelihood of dense surface crusts forming as the soil dries increases the risk of emergence failure for recently planted crops.
  - Be prepared with a rotary hoe to break up the crust and aid emergence.
- The greater the deposition of mud or old crop residues on plants as the water subsides, the greater the stress on the plants due to reduced photosynthesis.
  - Ironically, such situations would benefit from another rainfall event to wash the mud deposits from the leaves.
- Corn younger than about V6 (six fully exposed leaf collars) is more susceptible to ponding damage than is corn older than V6.

- This is partly because young plants are more easily submerged than older taller plants and partly because the corn plant›s growing point remains below ground until about V6. The health of the growing point can be assessed initially by splitting stalks and visually examining the lower portion of the stem (Nielsen, 2008a). Within 3 to 5 days after water drains from the ponded area, look for the appearance of fresh leaves from the whorls of the plants.

- Extended periods of saturated soils AFTER the surface water subsides will take their toll on the overall vigor of the crop.
    - Some root death will occur and new root growth will be stunted until the soil dries to acceptable moisture contents. As a result, plants may be subject to greater injury during a subsequently dry summer due to their restricted root systems.
- Concomitant (I found a new word in the dictionary!) with the direct stress of saturated soils on a corn crop, flooding and ponding can cause significant losses of soil nitrogen due to denitrification and leaching of nitrate N.
    - Significant loss of soil N will cause nitrogen deficiencies and possible additional yield loss.
    - On the other hand, if the corn dies in the ponded areas it probably does not matter how much nitrogen you've lost.
- Lengthy periods of wet soil conditions favor the development of seedling blight diseases, especially those caused by Pythium fungi (Sweets, 2008).
    - Poorly drained areas of fields are most at risk for the development of these diseases and so will also be risky for potential replant operations.
- Certain diseases, such as common smut and crazy top, may also become greater risks due to flooding and cool temperatures (Pataky and Snetselaar, 2006; Sweets, 2011).
    - The fungus that causes crazy top depends on saturated soil conditions to infect corn seedlings.
    - The common smut fungal organism is ubiquitous in soils and can infect young corn plants through tissue damaged by floodwaters. There is limited hybrid resistance to either of these two diseases and predicting damage is difficult until later in the growing season.

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Sulfur Deficiency In Corn – (*Jim Camberato, Stephen Maloney, and Shaun Casteel*[1])

Sulfur (S) deficiency has been diagnosed in corn and wheat in Indiana in recent years (see ref. 1). More than half the corn S deficiency experiments conducted in northeast Iowa since 2005 have responded to fertilizer S (see ref. 2). It is wise to consider S deficiency when troubleshooting corn growth problems.

Factors Affecting Sulfur Deficiency

Sulfur deficiency of corn and other crops may be becoming more prevalent because less S is deposited from the atmosphere to the soil due to reductions in power plant S emissions (Fig. 1). In addition, increased yields over time result in greater crop S removal from the field. Corn grain contains about 0.5 pound of S for every 10 bushels of grain, so about 10 pounds of S per acre is removed by corn that yields 200 bushel per acre. Additionally, less incidental S applications in fertilizers and pesticides may contribute to more S deficiency. Increases in no-till, early planting, and heavy residue from high yields have also been implicated in increasing the occurrence of S deficiency.

Soil Factors Resulting in Sulfur Deficiency

The main source of S in most soils is organic S. Each percent organic matter in the plow layer contains about 100 pounds of sulfur per acre. Organic S must be mineralized to sulfate-S (SO_4-S) to be taken up by crop plants, in much the same way that organic N is made available to crop plants. Therefore the lower the organic matter content of the soil the more likely S deficiency is to occur.

Since mineralization is a process carried out by microorganisms, soil temperature and moisture largely determine when and how much of the organic S is made available to the crop. Cold and excessively wet or dry conditions reduce microbial activity and reduce S availability from soil organic matter and crop residues. Thus, corn is more likely to be S deficient in the early spring before soil temperatures warm substantially, particularly with minimum tillage which results in colder soils.

Soybean and corn residues contain relatively low concentrations of S. In Stephen Maloney's research at Vincennes the 1.5 tons of standing soybean stover dry matter at harvest arising from a 40 bushel per acre crop contained less than 3 pounds of S per acre, a concentration about 0.08% S. In Eric Miller's recent research a 200+ bushel corn crop produced about 4.7 tons of stover dry matter per acre at 0.07% S, equivalent to less than 7 pounds of S in the stover. During the decomposition of crop residues which are low in S, inorganic S from the soil may be preferentially utilized by the microorganisms making it temporarily unavailable to the crop – a process called immobilization. Thus S deficiency may occur more frequently with large amounts of crop residue early in the growing season.

Sulfate-S is relatively mobile in most soils (similar to nitrate) because it has a double negative charge and is repelled by the negative charge of the soil, unlike nutrients such as potassium, calcium, or magnesium. Although SO_4-S can bind to iron and aluminum in the soil, these elements are much more likely to bind phosphate at the exclusion of SO_4-S. As a result, SO_4-S is easily leached from soils, especially sandy soils.

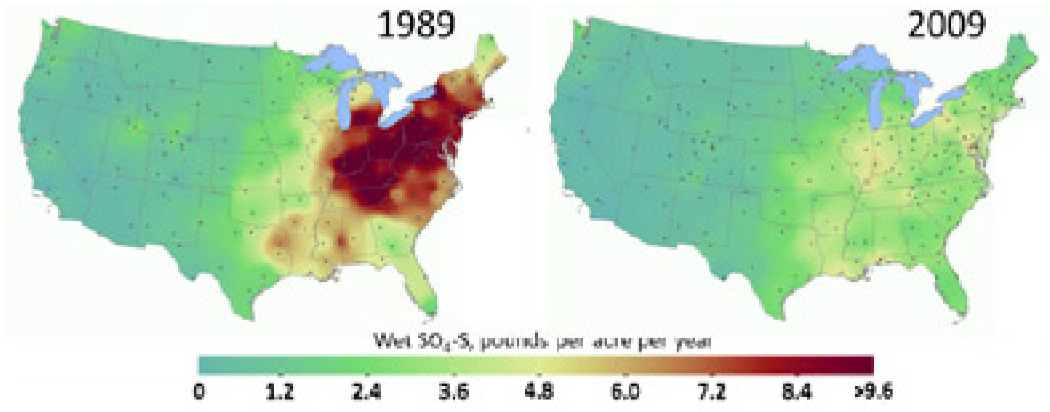


Figure 1. The amount of sulfate (SO_4^{2-}) deposited on the land in rainfall has been greatly reduced since 1989. Red colors indicate high deposition and green low deposition. Data from: <http://epa.gov/castnet/javaweb/wetdep.html>. (URL accessed April 2012).

At the field level the occurrence of S deficiency may be highly variable since soil S availability varies considerably with soil organic matter and texture. Sulfur deficiency is often seen in sandier, lower organic matter, and higher elevation areas of a field while lower lying, higher organic matter, and heavier textured areas typically have sufficient S.

Soil testing methods measure the SO_4-S form of S. Unfortunately soil testing is not particularly useful for predicting S deficiency because it does not take into account the organic S component that might become available to the crop. The SO_4-S component that is actually measured may also be leached from the soil between the time of sampling and the time of crop need. Sulfur deficiencies are notoriously transient because as the season progresses crops often access S deeper in the soil profile and warmer temperatures result in S mineralization from OM and crop residues.

Figure 2. Areas of sulfur deficiency (pale geen) and sufficiency (dark green) in an Indiana corn field caused by variations in soil properties. Young corn that is sulfur deficient may show striping as well as an overall yellow color. (*Photos courtesy of Jeff Nagel*).

Identifying Sulfur Deficiency in Corn

Sulfur deficient corn typically has an overall yellow appearance (see Fig. 2) similar to N deficiency. However S is not as mobile in the plant as N, so lower leaves do not show more severe deficiency symptoms than the upper leaves. If a S deficiency is misdiagnosed as a N deficiency the application of fertilizer N will make the S deficiency worse, so tissue sampling is recommended to positively identify which nutrient is deficient. In corn, S deficiency may also cause leaf striping (see Fig. 2) which is easily confused with magnesium, manganese, and zinc deficiency.

Tissue Sampling

The best way to identify a S deficiency is by tissue sampling from the area suspected of deficiency and a healthy area of the field for comparison. In plants less than 4 leaf collars, sample the whole plant beginning about ½" above the soil surface and collect 15 to 20 plants to represent each area. For larger plants, sample the youngest collared leaf (also referred to as the most recently matured leaf) and collect 10 to 15 leaves to represent the areas. Wash soil from the tissue samples with distilled or deionized water. If samples are contaminated by soil they can be rinsed quickly in cold distilled water, but do not overdo it because some nutrients, especially potassium, may be leached out of the tissue. Wet samples should be air-dried before shipping to the laboratory in paper bags.

In the plant, S is a component of two amino acids and occurs in protein in a ratio of 1 part S to about 15 parts N. Therefore, the N:S ratio of plant tissue as well as the S concentration are used to identify S deficiency. The lower the S concentration and the higher the N:S ratio the more likely S is deficient in the plant. Tissue S less than 0.12% and N:S ratio greater than 20:1 are most likely S deficient. Sulfur is most likely adequate when tissue S is greater than 0.20% and N:S ratio is less than 12:1. Tissue S and N:S values in between these levels can go either way – deficient or adequate.

A soil analysis is always helpful for distinguishing among possible nutrient deficiencies. One should keep in mind that the soil test for sulfate-S is not the most accurate, because of the mobility of SO_4-S in the soil and the release of S from soil organic matter. The results of a soil analysis might be most useful for ruling out the possibility of other nutrient deficiencies, than identifying S deficiency.

Correcting Sulfur Deficiency in Corn

Sulfur fertilizer should be applied as close to crop need as possible to reduce the chance it will be lost from the root zone by leaching. Often including S in a fertilizer program to avoid S deficiency is more efficient and less costly than correcting a S deficiency once it occurs. If S deficiency is anticipated, an application rate of 15 pounds of SO_4-S per acre is recommended on fine-textured soils and a rate of 25 pounds of SO_4-S per acre is recommended on coarse-textured soils, based on the most recent research conducted in Iowa (see ref. 2). Although some carryover of S may occur in silt loam soils it likely will be necessary to make applications of S every year on sandy soils, particularly if irrigated and high yielding.

Fertilizer Materials

There are several fertilizers available for correcting a S deficiency (Table 1). Adding ammonium thiosulfate to urea-ammonium nitrate solutions or blending ammonium sulfate with urea are convenient and cost effective ways to provide S in a timely manner. Sulfateof- potash-magnesia (sul-po-mag or K-mag) or potassium sulfate can be blended with muriate of potash to provide S and K. The inclusion of magnesium in sul-po-mag may be an extra benefit compared to potassium sulfate if soil magnesium levels are low. Generally these fertilizers are spread prior to planting therefore the SO_4-S might be lost from sandy soils before the time of crop need.

Table 1. Sulfur-containing fertilizers and their approximate composition (see ref. 3).

Fertilizer	%N	%P_2O_5	%K_2O	%S	%Mg	%Ca
Ammonium sulfate	21	0	0	24	0	0
Ammonium thiosulfate	12	0	0	26	0	0
Elemental sulfur	0	0	0	>90	0	0
Gypsum	0	0	0	17	0	22
Potassium magnesium sulfate	0	0	22	23	11	0
Potassium sulfate	0	0	50	18	0	0

Naturally-occurring mined gypsum and several by-product sources of gypsum can be applied to provide S as well. Gypsum if pelletized can be blended with other fertilizers or if ground, applied with a lime spreader. Unless pelletized, however, higher than necessary rates of S will be applied with gypsum which is difficult to spread at rates less than 500 to 1000 pounds per acre (85 to 170 pounds of S per acre assuming 17% S). If carryover of S occurs, the S will be utilized in later years. However, in sandy soils, where leaching is likely, the benefit in future years may be minimal.

Elemental S must be oxidized by soil bacteria to SO_4 before becoming plant available. Warm temperatures and good moisture and aeration are required for S-oxidizing bacteria to function. Sulfur oxidation is minimal at soil temperatures less than 50°F. Even at 75°F the oxidation rate of S is about 15% of that at 85°F, so peak rates of S oxidation do not occur until late spring. Since the availability of elemental S may be minimal in early spring, a fertilizer containing some SO_4 in addition to elemental S is preferred over a fertilizer with elemental S alone.

Effects of Sulfur Containing Fertilizers on Soil pH

Soil pH is lowered by elemental S, ammonium thiosulfate, and ammonium sulfate. The oxidation of elemental or chemically reduced S (thio-S for example) creates acidity which lowers soil pH. However, no acidity arises from the sulfate in any of the fertilizer materials including ammonium sulfate. With ammonium sulfate the conversion of ammonium to nitrate is the component that generates the acidity. When used to provide less than 30 pounds S per acre, the amount of acidity generated by each of these acidproducing fertilizers is equivalent to less than 100 pounds of limestone per acre. None of the S containing fertilizers in Table 1 increase soil pH.

References:

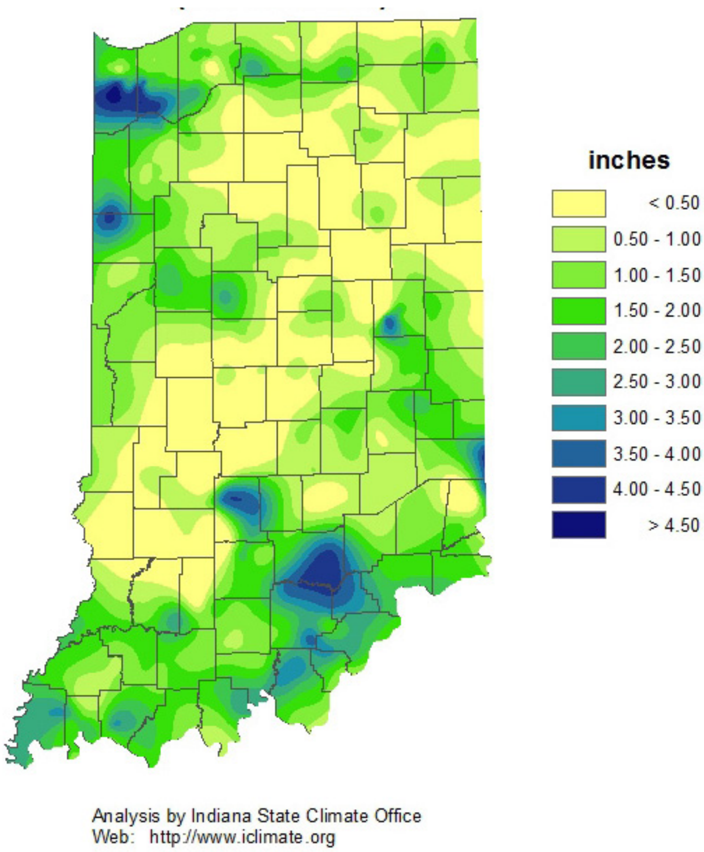
(1) Camberato, Jim and Shaun Casteel. 2010. Keep an eye open for sulfur deficiency in wheat. Purdue University Department of Agronomy, Soil Fertility Update. Available at: <http://www.agry.purdue.edu/ext/soybean/Arrivals/04-13-10_JC_SC_Sulfur_deficiency.pdf>. (URL accessed May 2012).

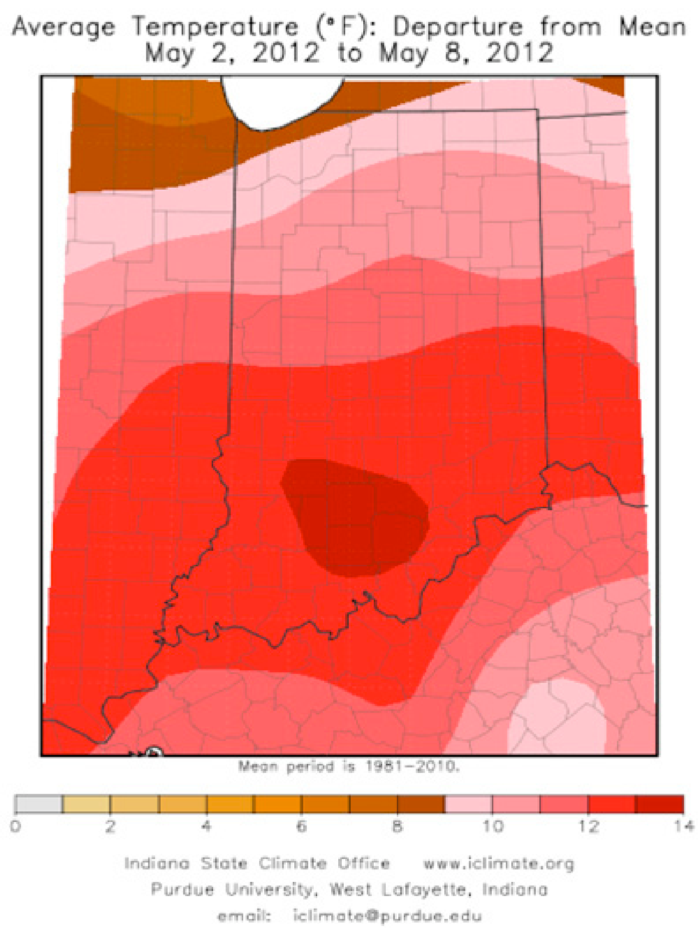
(2) Sawyer, J.E., B. Lang, and D.W. Barker. 2012. Sulfur fertilization response in Iowa corn and soybean production. Proc. of the 2012 Wisconsin Crop Manage Conf. 51:39-48. <http://www.soils.wisc.edu/extension/wcmc/2012/pap/Sawyer_1.pdf>. (URL accessed May 2012).

(3) Zublena, J.P., J.V. Baird, and J.P. Lilly. 1991. Nutrient content of fertilizer and organic materials. <http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-18/AG-439-18.pdf>. (URL accessed April 2012).

Weather Update

Total Precipitation
May 3-9, 2012
CoCoRaHS Network
(439 stations)





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