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Issue 8, May 22, 2015 • USDA-NIFA Extension IPM Grant

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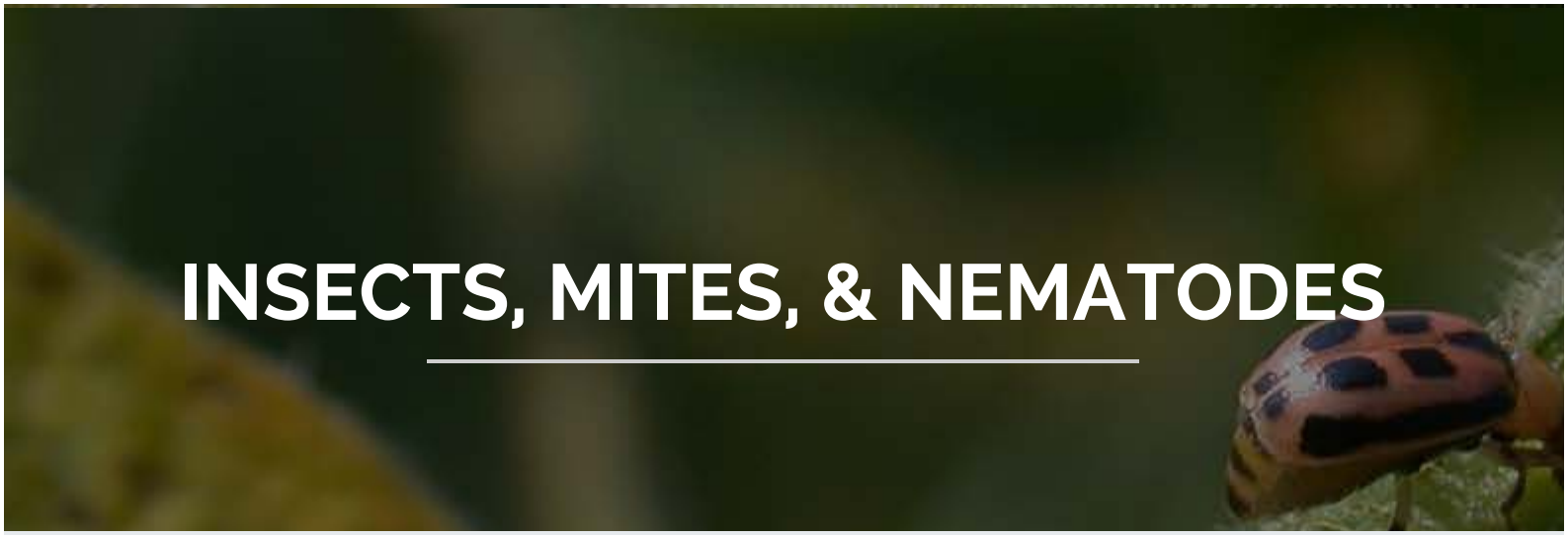

Nematode Update: Corn Parasitic Nematode – (Jamal Faghihi and Virginia Ferris) -

- **This has been a cool, wet spring, so conditions are right for the needle nematode to cause damage to corn grown in sandy soils.**

Needle nematodes, are the most yield-limiting nematodes in corn. This nematode requires cool, wet conditions to become a problem in corn. But some other nematodes, like lance and lesion nematodes, do not require these conditions to be a problem. This time of the year needle nematodes are looking for food and they are eager to attack young corn roots. So if conditions are right in your area with cool, wet and sandy soil, needle nematodes could be a problem this year. If you have had problems on corn before, you might consider sampling for nematodes. In this case, you may wish to send the entire root system with adjacent soil to the Nematology Laboratory, address below, at Purdue University for analysis. Samples must be kept cool and prevented from drying. The best time to sample for needle nematodes is 4-6 weeks after germination.

Under high nematode pressure, roots do not develop normally. The roots are truncated and resemble herbicide injury. Similar symptoms are present where lance nematodes are causing a problem. Lesion nematodes, however, will not cause the described root symptoms. Symptoms for most plant parasitic nematodes are usually in patches and do not follow a uniform pattern in the field.

Often needle nematodes disappear when soil temperature rises above 85°F. So the best time to sample for needle nematode is now. You can sample for other corn parasitic nematodes throughout the growing season.

You have to observe whether conditions that are favorable for needle nematodes and will enable them to cause yield loss. These conditions are specific to needle nematodes and do not apply to lance and lesion nematodes. The latter species feed throughout the season and they could be a problem in all types of soils and weather.

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. The cost for

nematode analysis for each sample remains at $10/procedure (if only soil samples are submitted). However, if we have to incubate the roots to extract internal nematodes an additional $10/sample will be charged. We published an article earlier this year
http://extension.entm.purdue.edu/pestcrop/2015/Issue1/
that described the sampling methods for various plant parasitic nematodes.

Additional information and a sampling form can be found on our Nematology website:
http://extension.entm.purdue.edu/nematology/services.html

Close-up comparison of healthy (above) and needle nematode damaged (below) corn seedling roots.

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Armyworm Pheromone Trap Report

County/Cooperator	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9	Wk 10	Wk 11	Wk 12
Dubois/SIPAC Ag Center	0	0	1	0	2	1	0					
Jay/Davis Ag Center	0	0	2	0	4	1	0					
Jennings/SEPAC Ag Center	0	0	0	0	1	0	0					
Knox/SWPAC Ag Center		0	0	0	1	0	0					
LaPorte/Pinney Ag Center	0	0	3	0	17	35	29					
Lawrence/Feldun Ag Center	0	2	0	1	0	11	3					
Randolph/Davis Ag Center	0	0	0	0	0	0	0					
Tippecanoe/Meigs	0	0	1	0	0	0	0					
Tippecanoe/Meigs (Hartstack)				7	548	406	58					
Whitley/NEPAC Ag Center	0	1	5	2	17	25	4					
Whitley/NEPAC Ag Center (Hartstack)						792	404					

Wk 1 = 4/2/15 - 4/8/15; Wk 2 = 4/9/15 - 4/15/15; Wk 3 = 4/16/15 - 4/22/15; Wk 4 = 4/23/15-4/29/15;

Wk 5 = 4/30/15-5/6/15; Wk 6 = 5/7/15-5/13/15; Wk 7 = 5/14/15-5/20/15

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Hybrid Maturities for Delayed Planting – (R.L. (Bob) Nielsen) -

Delayed planting seasons create a lot of frustrations for everyone involved with planting crops. One of the agronomic questions that comes up when planting is seriously delayed is whether farmers should consider switching from their normal full-season maturity hybrids to shorter-maturity hybrids. The question is based, of course, on the perceived risk of the crop not reaching physiological maturity before a killing fall freeze and the yield losses that could result. A related, and economic, concern with delayed planting of normal full-maturity hybrids is the risk of high grain moisture contents at harvest and the resulting costs incurred by artificial drying of the grain or price discounts by buyers.

Corn development (think growth stage progress) is very dependent on temperature (warm = fast, cool = slow). The accumulation of heat on a daily basis can be quantified on the basis of calculated Growing Degree Days or GDDs. Hybrids can be characterized by how many GDDs they require from planting to physiological maturity (kernel black layer). Conceptually, therefore, one should be able to estimate the GDDs remaining from a delayed planting date to the end of the season using long-term climate data and then choose hybrids with GDD ratings that should mature no later than the date you chose to define "the end of the season".

FYI: The GDD concept and calculation are described in a related article (Nielsen, 2012a). Interpretation of corn hybrid maturity ratings is also discussed in a related article (Nielsen, 2012b).

One "wrinkle" in this concept is that it appears that hybrids mature in fewer GDDs than expected when planted "late". Relative to a May 1 planting date, hybrids planted later mature approximately

6.8 fewer GDDs for every day of delay beyond May 1 (Nielsen et al., 2002). For example, a hybrid rated at 2700 GDDs from planting to physiological maturity and planted on May 31 will reach physiological maturity in less than 2500 GDDs after planting (e.g., 2700 - (30 days x 6.8)). That response of hybrid development relative to delayed planting means that normal full-maturity hybrids can be safely planted later than one would think and, consequently, means that growers can avoid switching to earlier maturity hybrids until planting dates later than one would think.

Estimating GDDs Between Two Dates at a Specific Location

The challenge in taking advantage of this relationship between hybrid GDD ratings and delayed planting lies with the estimation of available GDDs with delayed plantings for specific locations. Historical data for daily GDD accumulations exist for a limited number of weather reporting stations around the state, but accessing such data can be difficult. Currently, the Indiana State Climate Office (iClimate.org) does not offer an easy calculator for estimating the number of historical GDDs between two dates at a specific location.

The USDA-funded Useful to Usable (U2U) multi-state research and Extension project developed a GDD decision support tool that is available on the Web at https://mygeohub.org/groups/u2u/gdd. The GDD Tool estimates county-level GDD accumulations and corn development dates based on current and historical GDD data plus user selected start dates, relative hybrid maturity ratings, and freeze temperature threshold values. The GDD and corn development predictions are displayed graphically and in tabular form, plus the GDD accumulation estimates can be downloaded in a Comma Separated Value (.csv) format for you to work with in your own spreadsheet program. The GDD Tool is currently available for the states of North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, Ohio, Kentucky, and Tennessee.

Figure 1 shows a screen capture from that calculator in which I selected "Tippecanoe Co., IN", a start date (aka planting date) of May 31, a relative hybrid maturity rating of 112 "days", and a freeze temperature threshold of 28°F. The graph illustrates estimates of silking and black layer dates for the 112-day hybrid planted on May 31, as well as the range of the estimates. When you are viewing the actual graph on the Web site, estimates of GDD accumulations at specific dates "pop up" when you hover your computer mouse over parts of the line graph.

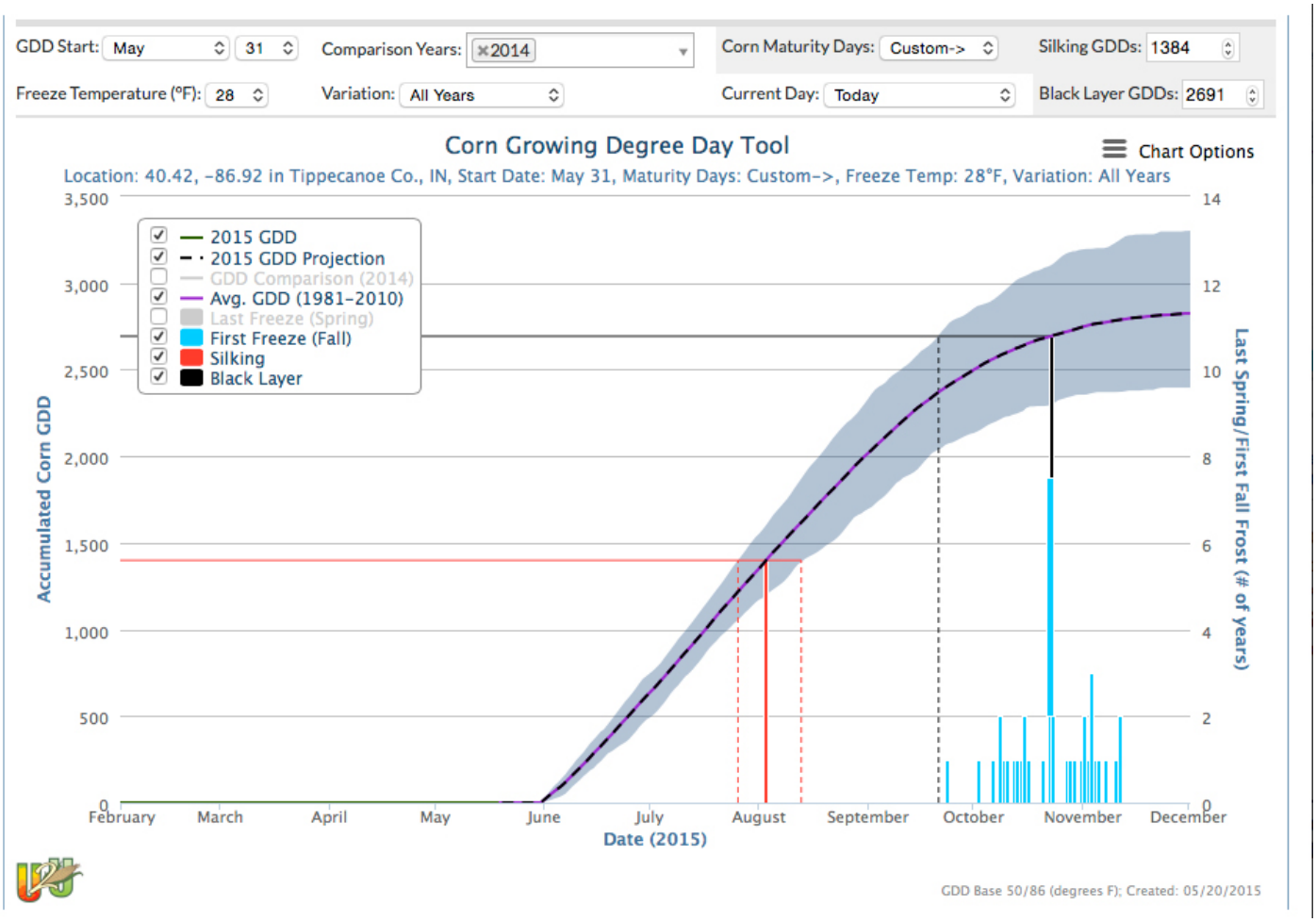

Figure 1. Screen capture of U2U GDD Tool graphical display of historical and estimated future GDD accumulations and predicted corn development stages for a 112-day hybrid planted May 31 in Tippecanoe County, IN.

WORD OF CAUTION: The U2U GDD Tool does not currently account for the "wrinkle" discussed earlier in this article wherein corn hybrids typically mature in fewer GDDs than expected when planted "late" (Nielsen et al., 2002). In other words, the GDD Tool assumes the same GDDs to silking and black layer for a given hybrid maturity whether planted April 20 or May 31. Consequently, you can be led astray by the Tool if you do not modify the "Black Layer GDDs" value in the Tool's input area. For example, the screen capture displayed in Fig. 1 for a 112-day hybrid with a GDD rating of 2691 planted in Tippecanoe Co. on May 31 indicates the hybrid would mature on about October 23 when the estimated GDD accumulation exceeded 2691. If, however, you manually change the expected "Black Layer GDD" value from 2691 to 2481 GDDs (30 days after May 31 x 6.8 fewer GDDs per day delay), the GDD Tool estimates the hybrid would safely mature on about September 30, well ahead of the usual fall freeze date.

Choice of "End of Season" Date

The choice of a date to represent the "end of the season" (abbreviated EOS) can be straight-forward or one of those "eyes of the beholder" decisions. If the main concern is to identify a "safe" hybrid maturity that will reach physiological maturity before a typical fall freeze date, then the spatial maps illustrated in the accompanying figures can be used to choose that date. Figure 2 depicts the historical average dates of the first 32°F temperature in the fall throughout Indiana, while Figure 3 depicts the historical average dates of the first 28°F temperature in the fall throughout Indiana.

TIP: Temperatures of 32°F or slightly higher typically result in leaf injury or death due to frost damage, but the corn plant technically will survive and be able to at least continue remobilizing stored carbohydrates from the stalk tissues to immature grain. A temperature of 28°F for several hours is considered to be lethal for corn plants.

Some growers may opt to select an "end of season" date earlier than the historical first fall freeze date to ensure that physiological maturity will occur earlier during a time period that may yet be conducive for grain drydown in the field and thus minimize their expenses of drying the grain artificially.

Hybrid Maturity Ratings for Delayed Planting

With an estimate of available growing season GDDs in hand, one can then identify approximate relative hybrid maturities that would be suitable for delayed planting (Tables 1 and 2).

Table 1 can be used to identify "safe" hybrid maturities on the basis of their GDD ratings, though it is important to recognize that the hybrid GDD ratings in this table are for GDDs from planting to physiological maturity. Recognize that some seed companies assign GDD ratings beginning at emergence, not planting. If your seed company is one of these, then add 115 GDDs to the hybrid GDD ratings and you will be in the proverbial "ball park" using this table.

EXAMPLE: Using the U2U GDD Tool, you determine that for Blackford County, Indiana, approximately 2485 GDDs will accumulate between a delayed planting date of May 20 and a selected EOS of Sep 21. Using Table 1, the approximate "safe" hybrid GDD rating that most closely matches 2485 (the 2500 value in column 1) and the May 20 planting date (column 4) is 2629. What this means is that, for the planting date and EOS date you selected, you could safely plant a hybrid with a GDD rating of 2629 from planting to physiological maturity.

Some folks are more comfortable with the relative "days to maturity" ratings for corn hybrids

(Nielsen, 2012b). Table 2 expresses the GDD values of Table 1 in terms of CRM ratings as defined by DuPont Pioneer. Recognize that I am not by any stretch of your imagination promoting Pioneer hybrids. I simply know that Pioneer assigns GDD ratings to their hybrids based on GDD accumulations between planting and physiological maturity. The mathematical relationship between their GDD ratings and their CRM ratings is pretty good and, thus, can be used to calculate approximate CRM ratings from known GDD ratings. If you are not comfortable using Pioneer's CRM ratings, then use the GDD ratings in Table 1.

EXAMPLE: If you continue on to Table 2, the approximate "safe" hybrid Pioneer CRM rating that most closely matches 2485 (the 2500 value in column 1) and the May 20 planting date (column 4) is 110. What this means is that, for the planting date and EOS date you selected, you could safely plant a hybrid with a Pioneer CRM rating of about 110.

PLEASE NOTE: Please understand that ratings for relative hybrid maturity (i.e., CRM, RM, "days to maturity", etc.) are notoriously inconsistent one seed company to another. Consequently, relationships between hybrid GDD ratings and their relative maturity ratings will vary one seed company to another. I believe the relationships listed in Table 2 are valid for Pioneer's lineup of hybrids, but cannot make the same claim for any other seed company's lineup of hybrids. Consult your seed dealer!

Caveats (e.g., disclaimers)

Recognize that actual GDDs deviate year to year from the historical "norm" because of natural variability in growing season temperatures. Also recognize that hybrids undoubtedly vary in their GDD response to delayed planting. Also recognize that hybrid GDD response to delayed planting in other parts of the country may differ from what we have documented in the eastern Corn Belt.

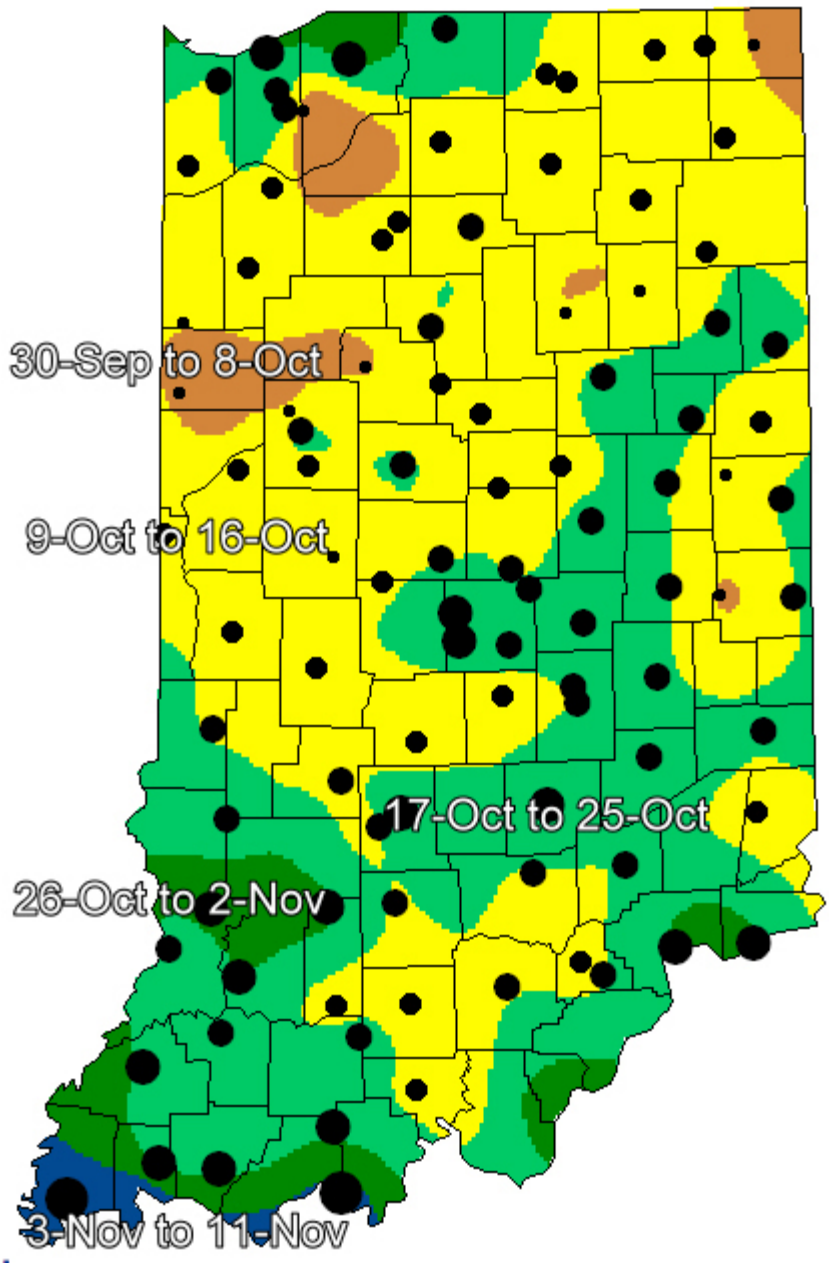

Figure 2. Average first fall dates of 32°F temperatures throughout Indiana. Interpolated data derived from spatial analysis of 1981-2010 normal data from Indiana and surrounding states. Brown: 30-Sep to 8-Oct, yellow: 9-Oct to 16-Oct; light green: 17-Oct to 25-Oct; dark green: 26-Oct to 2-Nov; blue: 3-Nov to 11-Nov. Spatial data source: National Climatic Data Center 1981-2010 US Normals Data.

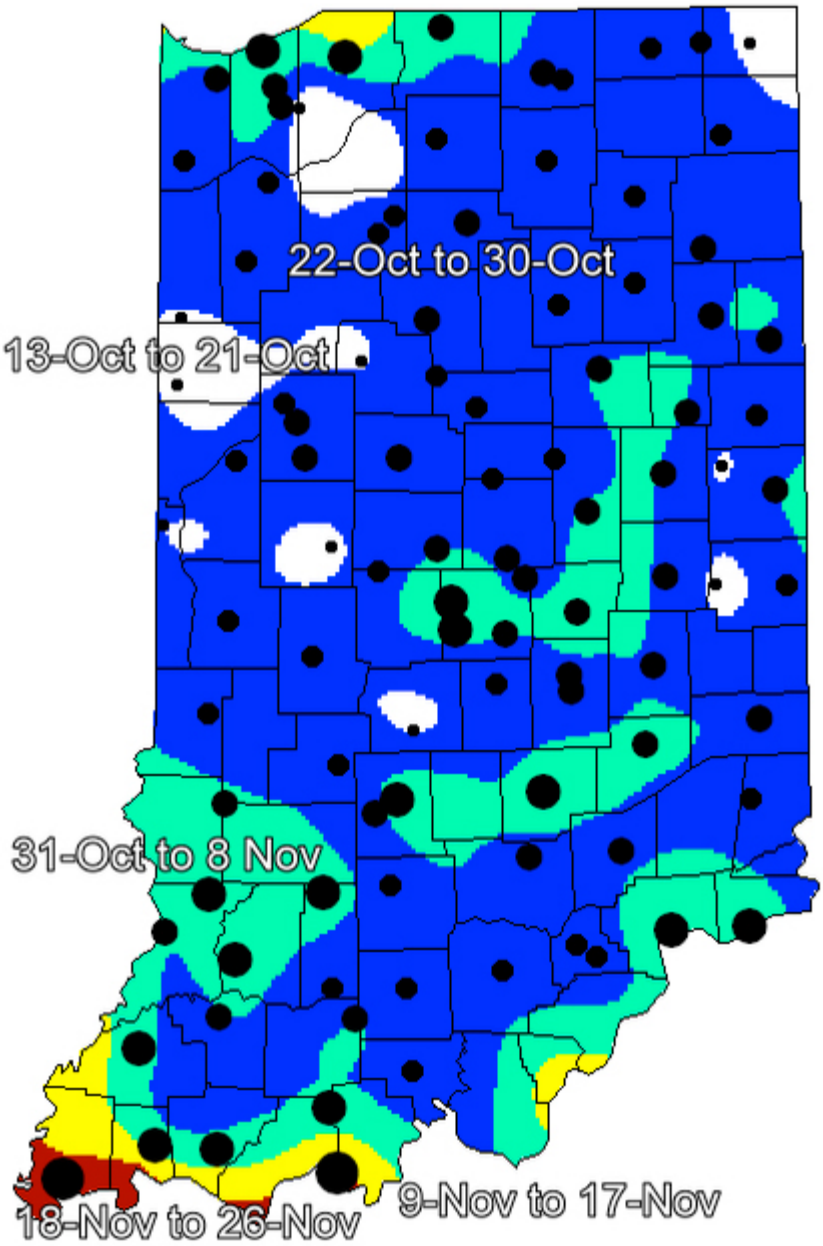

Figure 3. Average first fall dates of 28°F temperatures throughout Indiana. Interpolated data derived from spatial analysis of 1981-2010 normal data from Indiana and surrounding states. White: 13-Oct to 21-Oct; Blue: 22-Oct to 30-Oct; Green: 31-Oct to 8-Nov; Yellow: 9-Nov to 17-Nov; Red: 18-Nov to 26-Nov. Spatial data source: National Climatic Data Center 1981-2010 US Normals Data.

Table 1. Approximate equivalent hybrid GDD requirements for delayed planting relative to estimated actual GDDs available from delayed planting date to the end of the season (EOS).

Plt date>>	1-May	10-May	20-May	30-May	10-June
Available GDD from planting to EOS	Approx. equivalent hybrid GDD; adjusted for delayed planting				
2000	2000	2061	2129	2197	2272

2050	2050	2111	2179	2247	2322
2100	2100	2161	2229	2297	2372
2150	2150	2211	2279	2347	2422
2200	2200	2261	2329	2397	2472
2250	2250	2311	2379	2447	2522
2300	2300	2361	2429	2497	2572
2350	2350	2411	2479	2547	2622
2400	2400	2461	2529	2597	2672
2450	2450	2511	2579	2647	2722
2500	2500	2561	2629	2697	2772
2550	2550	2611	2679	2747	2822
2600	2600	2661	2729	2797	2872
2650	2650	2711	2779	2847	2922
2700	2700	2761	2829	2897	2972
2750	2750	2811	2879	2947	3022
2800	2800	2861	2929	2997	3072

End of season (EOS) defined by user, but may be based on expected first fall 32F temerature. Equivalent hybrid GDDs = Available GDDs adjusted for hybrid GDD response to planting delays beyond May 1 (Nielsen et al., 2002).

Table 2. Approximate maximum "safe" hybrid CRM for delayed planting relative to estimated actual GDDs available from delayed planting date to the end of the season (EOS).

Plt date>>	1-May	10-May	20-May	30-May	10-June
Available GDD from planting to EOS	Approx. hybrid CRM based on Plt Date & approx. available GDDs				
2000	82	85	88	91	94
2050	84	87	90	93	96
2100	87	89	92	95	98
2150	89	91	94	97	101

2200	91	94	97	100	103
2250	93	96	99	102	105
2300	95	98	101	104	107
2350	97	100	103	106	109
2400	100	102	105	108	111
2450	102	104	107	110	114
2500	104	107	110	113	116
2550	106	109	112	115	118
2600	108	111	114	117	120
2650	111	113	116	119	122
2700	113	115	118	121	125
2750	115	118	120	123	127
2800	117	120	123	126	129

End of season (EOS) defined by user, but may be based on expected first fall 32F temperature. Hybrid CRMs as defined by DuPont Pioneer and calculated on the basis of the relationship between GDDs from planting to physiological maturity and hybrid CRMs of 73 hybrids listed in DuPont Pioneer's 2012 hybrid characteristics table.

Related Reading

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Corkscrewed Mesocotyls & Failed Corn Emergence – (R.L. (Bob) Nielsen) -

Successful stand establishment of a corn crop relies on many factors, including the successful emergence of the seedlings. Seedling emergence occurs as a result of elongation of the mesocotyl that elevates the coleoptile or "spike" toward the soil surface. If successful, the appearance of the coleoptile at or near the soil surface is synchronized with the emergence of the first true leaf from inside the coleoptile.

The mesocotyl is the white tubular stem-like plant part located between the kernel and the base of the coleoptile. Technically, the mesocotyl is the first true stem internode of the young corn seedling. As the coleoptile nears the soil surface, exposure to the red wavelengths of solar radiation causes a change in the supply of one or more growth hormones from the coleoptile to the mesocotyl tissue and mesocotyl elongation comes to a halt (Vanderhoef & Briggs, 1978). If mesocotyl elongation and/or coleoptile emergence are compromised, the emergence of the leaves from the coleoptile may occur underground and remain trapped by the soil.

Reports of leafing out underground in 2012, the year of record early planting, are beginning to accumulate now that growers are beginning to walk their early-planted fields. Such "leafing out underground" is obviously viewed with great consternation by growers who were hopeful for perfect emergence of their crop. Obviously, emergence failure directly impacts effective plant population; one of the major yield components of corn. The extent of the emergence failure in affected fields appears to range from about 5 to 20 percent of the planted population. The magnitude of the effect on grain yield will depend on the initial seeding rate, the severity of the problem, and growing conditions the remainder of the season. Very few affected fields, however, likely merit a decision to replant.

Failure to emerge successfully can be caused by failure of the mesocotyl to successfully elongate and/or by soil restrictions that hinder successful penetration of the soil by the coleoptile. In extreme cases, elongation of the mesocotyl fails miserably, resulting literally in corkscrewed fiascos. Often, more than one of the following causal factors exist in a problem field and usually interact with each other to amplify the problem.

Kernel Position in Furrow: The coleoptile, the protective covering for the plumule leaves, emerges from the embryo side of the kernel and moves toward the dent end of the kernel by virtue of the elongation of the mesocotyl. The position of the kernel in the furrow with respect to the embryo face directly influences the initial location where the coleoptile emerges. If the kernel lands with the embryo face down in the furrow, the coleoptile emerges on the bottom side of the kernel, elongates horizontally until the mesocotyl "clears" the end of the kernel, then finally begins its upward ascent. Such an “upside-down” beginning might contribute to a seedling’s susceptibility to other corkscrewing causal factors.

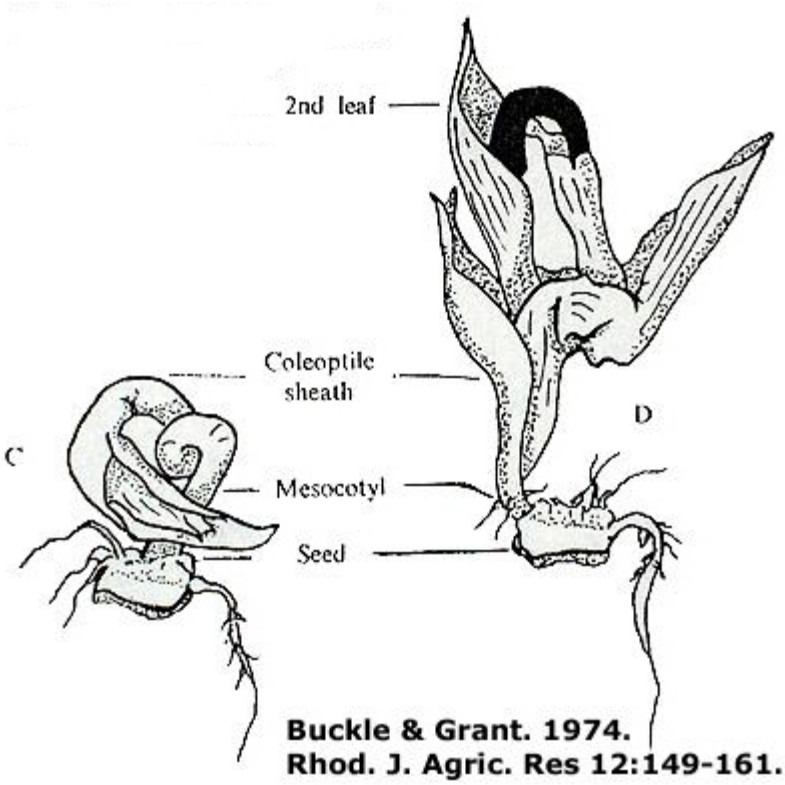
Restricted Emergence: Corkscrewed mesocotyl/coleoptile development can result when the coleoptile encounters resistance as the mesocotyl elongates. Severe soil crusting or otherwise dense soil surface and cloddy soil surfaces can cause such resistance. A combination of severe sidewall compaction plus press wheel compaction over the furrow can also restrict coleoptile emergence and force the mesocotyl to elongate in unusual directions.

Herbicide Injury: Certain herbicides, notably cell growth inhibitors like acetochlor, can affect seedling shoot development especially if weather or soil conditions are not conducive for rapid seedling growth. However when herbicide injury is suspected to be a contributing factor, cool soils and dense soil crusting are often also contributing factors, so is difficult to pin the blame

completely on the herbicide injury.

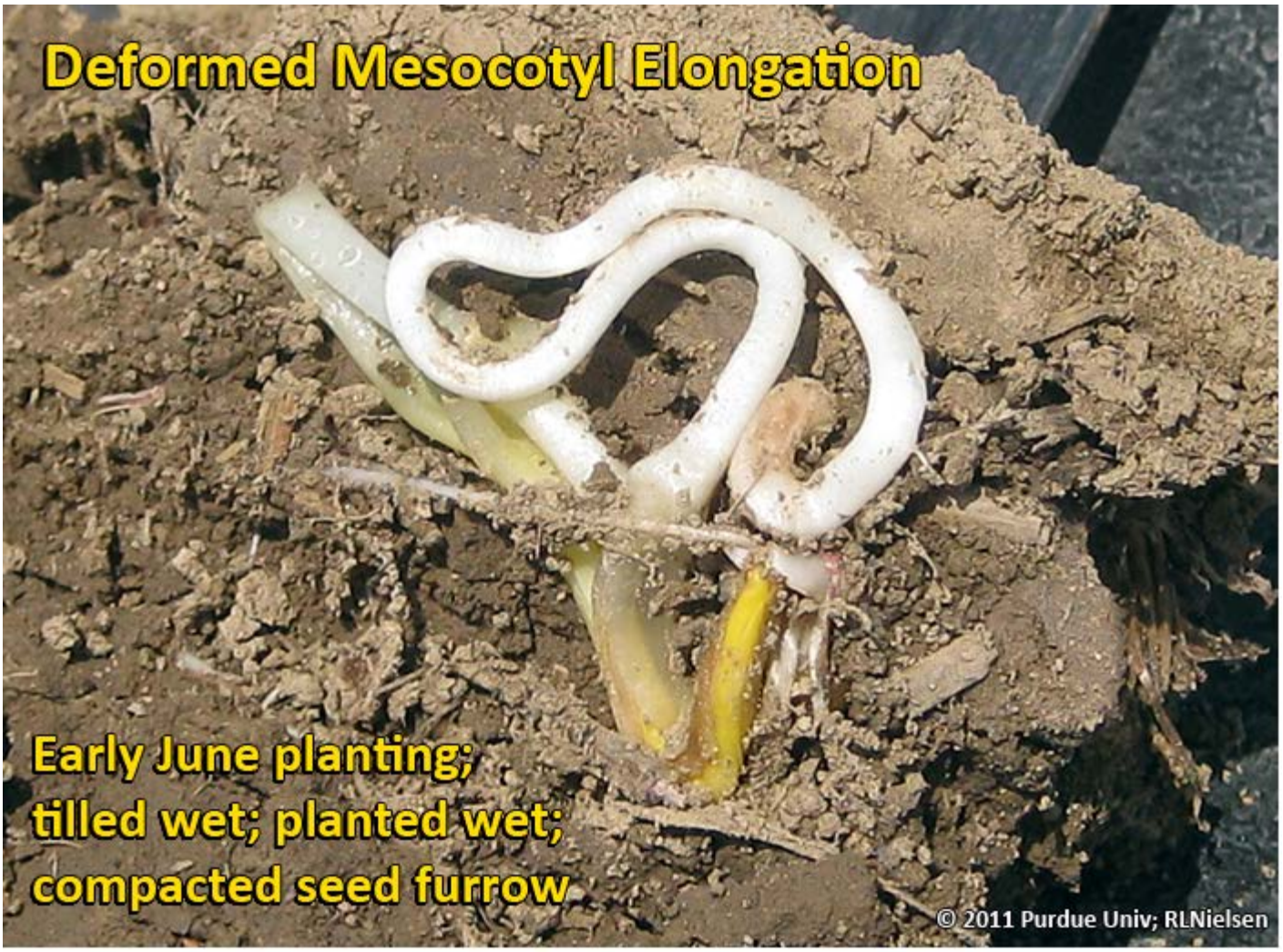
Cold Soils: Cold soils and/or wide fluctuations in soil temperatures throughout the day during the emergence process are also thought to be major contributing factors for the development of corkscrewed mesocotyl development (Buckle & Grant, 1974). The exact minimum soil temperatures that can cause such corkscrewed development are not clearly documented, but clearly it is not uncommon in Indiana for daily soil temperatures to dip as low as 40F during April and early May. Furthermore, bright sunny days can elevate bare soil temperatures quite high but still drop quite low the following night and thus result in a wide diurnal fluctuation in soil temperatures. Dry soils would be more prone than wetter soils to wide swings in daily soil temperatures.

Corny Trivia: Cold temperature injury that results in corkscrewed mesocotyls is not exactly the same as that which is referred to as "imbibitional chilling" injury. The latter refers to cold injury to the seed during the first 24 to 72 hours after planting when the seed is imbibes (aka absorbs) water. Imbibition of water causes the seed to swell. If seed cell tissue is very cold, it may become less elastic and thus may rupture during the swelling process. The most common symptom of such imbibitional chilling damage to seed cell tissue is often simply swollen seed with little to no evidence of germination progress. Conversely, seedlings with corkscrewed mesocotyls germinated successfully. The cold temperature damage occurred slightly later, during the early stages of mesocotyl elongation and affected the mesocotyl tissue, not the seed tissue.



Fig's C and D: Abnormal growth with wide fluctuations in soil temperature.

Natural curved mesocotyl elongation resulting from see placed embryo face down in furrow.



Deformed mesocotyl elongation early June planting; tilled wet; planted wet; compacte seed furrow.

Leafing out underground.

Deformed mesocotyl elongation early May planting; cold soils.

Deformed mesocotyl elongation mid-April planting; cold soils.

Related Reading

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Assessing Frost / Cold Temperature Injury to Young Corn – (R.L. (Bob) Nielsen) -

The risk of damaging spring frost events is one of the downsides to planting corn earlier than normal, but is one growers often accept when early spring field conditions are otherwise suitable for planting. However, the threat of low temperatures in late May or early June also raises the specter of frost or low temperature damage to young corn plants, regardless of planting date. Early morning temperatures in the 30s^{o}(F) coupled with clear calm conditions overnight certainly are favorable for frost formation on exposed surfaces, including leaves of young corn plants. In other words, temperatures do not need to drop to 32^{o} F or cooler in order for frost to form.

Frost crystals on a corn leaf at sunup

When significant frost develops on young corn plants, it is tempting to jump to the logical conclusion that significant plant mortality will soon follow. However, frost by itself is not a guaranteed "kiss of death" for young corn plants. What is more important is whether the temperature that accompanied the frost event was lethal or not. Most agronomists agree that "lethally cold" temperatures for young corn are those that dip to 28° F or lower for 1 to 2 hours.

The effect of frost on young corn when it is accompanied by temperatures no lower than about 30F is primarily damage and death of the exposed above ground leaf tissue. As long as the growing point of the young plant (aka the apical meristem) is still protected below the soil surface, the injured plant usually recovers from the effects of the superficial leaf damage.

Within a number of days of the frost event (more quickly with warm temperatures, more slowly if cool), elongation of the undamaged leaf tissue in the whorl will become evident. As long as the recovery is vigorous, subsequent stand establishment should be not be affected.

The bottom line for diagnosing the severity of frost or low temperature injury to corn is that you generally need to wait three to five days after the weather event before you can accurately assess the extent of damage or recovery. Injury to the crop can look very serious the day after the event or even two days after the event, but recovery is likely if there is no injury to the growing points of the affected plants.

Leaf injury due to frost 7 hrs after frost melted.

Leaf injury due to frost 12 hrs after frost event.

Leaf injury due to frost 60 hrs after frost event.

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Silver Leaf Symptom in Corn – (R.L. (Bob) Nielsen) -

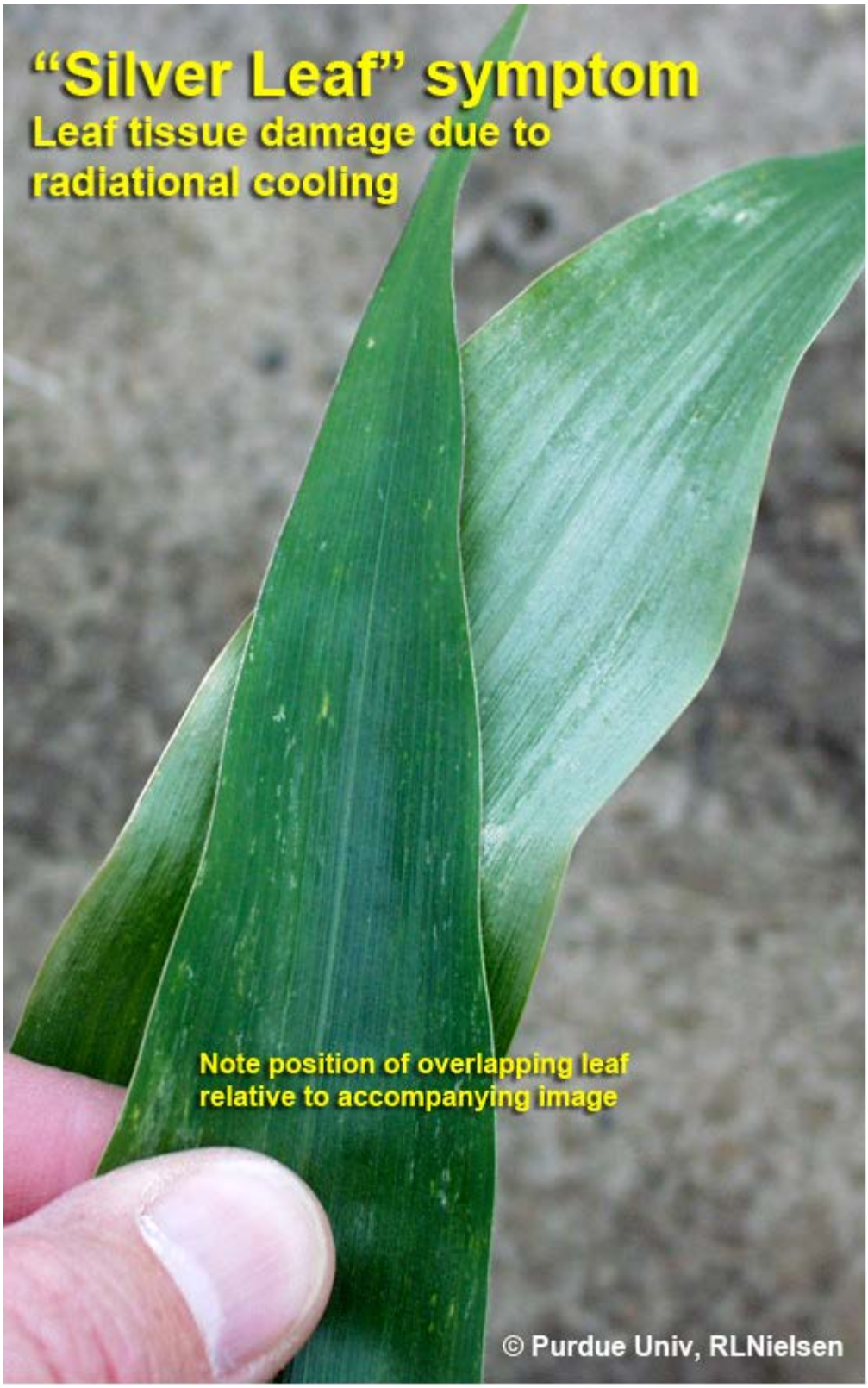
Forecasts of unusually low temperatures in late May or early June can set off warning bells for corn growers and lead to fearmongering about frost damage to young corn. Even if frost does not form during these cool nights, minor leaf surface damage can still occur as a result of radiational heat loss from the leaves during cool, calm, clear nights. Such leaf damage results in a curious leaf symptom that may remind you of freezer burn.

Rapid heat loss from terrestrial surfaces to the atmosphere (i.e., radiational cooling) can occur on clear, dry (low humidity), calm nights with temperatures in the low 40's° F or cooler. Minor levels of radiational cooling can damage the outer surfaces of corn leaves that are positioned horizontally or parallel to the night sky. The subsequent symptom of such minor chilling injury is often referred to as "silver leaf" in corn.

The "silver leaf" symptom indeed appears as a silvery or dull gray leaf surface. Any portion of a leaf that was not horizontal to the sky or that was protected by another leaf or plant part will not exhibit the symptom. The effect of this minor leaf damage is negligible, if any. The leaves will not die abruptly as will genuinely frosted leaf tissue. Continued expansion of the whorl will not be restricted in any way. New leaves that expand from the whorl will be normal in appearance. This symptom is more of a curiosity than a nuisance.

Related Reading

Nielsen, RL (Bob). 2015. Assessing Frost / Cold Temperature Injury to Young Corn. Corny News Network, Purdue Extension. http://www.kingcorn.org/news/timeless/FrostedCorn.html [URL accessed May 2015].



Silver leaf symptom, leaf tissue damage due to radiational cooling.

Silver leaf symptom, leaf tissue damage due to radiational cooling.

Silver leaf symptom, leaf tissue damage due to radiational cooling.

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Soybean Seedling Damage: Is There an Interaction Between the ILeVO Seed Treatment and Pre-emergence Herbicides – (Kiersten Wise, Purdue Univ., Daren Mueller, Iowa State Univ., Yuba Kandel, Iowa State Univ., Bryan Young, Purdue Univ., Bill Johnson, Purdue Univ., Travis Legleiter, Purdue Univ.) –

Farmers who were lucky enough to plant soybeans and spray pre-emergence herbicides in between rain events may now be seeing discolored or injured seedlings. Reports of fields with these issues are widespread across Indiana, Iowa, and surrounding areas, and many farmers and crop advisors are questioning if damage is more severe when pre-emergence herbicides are applied to fields that have been planted with seed treated with the new fluopyram fungicide seed treatment ILeVO.

Fluopyram fungicide

The fungicide fluopyram (ILeVO; Bayer CropScience) is currently marketed as a seed treatment to manage sudden death syndrome (SDS). This seed treatment can result in a discoloration on soybean cotyledons that can resemble disease or other abiotic stress such as herbicide injury (Figure 1). The discoloration occurs because the fungicide is moderately systemic within the soybean plant, so it will naturally move to the plants "sinks", the roots and cotyledons. This accumulation can result in phytotoxicity, causing the tips of the cotyledons to turn a yellow-brown color. This necrosis is typically uniform and present on every seedling grown from an ILeVO treated seed; however, environmental conditions may impact the frequency, uniformity and severity of the phytotoxicity observed. The phytotoxicity is not usually found on the unifoliate or trifoliate leaves. Research conducted by several Land Grant Universities and Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) demonstrated that this phytotoxicity, also referred to as a "halo effect", does not result in long-term soybean stunting or yield loss.

Figure 1. The fungicide fluopyram can cause cotyledons to turn yellow or brown. The soybeans in these images were not treated with a pre-emergence herbicide. Cool, wet conditions can increase the likelihood of seeing this "halo effect" from the fungicide seed treatment.

Pre-emergence herbicides

Pre-emergence herbicides can also cause soybean seedling damage, particularly when cool temperatures coincide with rain soon after seedlings begin to emerge from the soil. Pre-emergence herbicides, typically PPO-inhibitors (flumioxazin, sulfentrazone, saflufenacil; group 14) or photosynthetic inhibitors (metribuzin; group 5), can occasionally be injurious to plants growing in cold, wet soils. Soybeans are typically able to metabolize these herbicides, but when metabolism slows due to stress (i.e. cold temperatures) herbicide injury can occur (Figure 2). Pre-emergence herbicide injury also occurs when heavy rain events splash concentrated droplets of residual herbicide from the soil onto the emerged seedlings. Spotty necrosis can occur on any exposed portion of the plant where the splash event occurred and metribuzin can cause symptoms similar to the phytotoxicity caused by ILeVO. Pre-emergence herbicide injury is more likely to occur in sandy low organic matter (OM) soils than in loam or clay soils with higher OM. Also, some varieties of soybean are more sensitive to these herbicides than other varieties. Herbicide sensitivity information is available from some, but not all, seed companies.

Figure 2. Symptoms of PPO-inhibitor herbicide damage on soybean seedlings.

Interaction between pre-emergence herbicides and fluopyram (ILeVO)

Research funded by the North Central Soybean Research Program and supported by Bayer Crop Science began in 2014 to determine if phytotoxicity and the "halo effect" of ILeVO was more severe in the presence of pre-emergence herbicides. A trial was established near Wanatah, IN, and common pre-emergence herbicide treatments (Table 1) were applied to plots planted with a base seed treatment + ILeVO, or seed treated with only a base seed treatment (Trilex + Allegiance). The herbicide treatments were selected because of their high potential to cause injury to soybean seedlings. All plots were inoculated with the fungus that causes SDS. Non-herbicide treated checks were included for both ILeVO and base seed treatments. All treatments received a post-emergence application of glyphosate at a rate of 22 oz/A. Data were collected on stand, level of seedling injury (phytotoxicity), a measure of SDS severity (SDS index), and yield.

Table 1. Pre-emergence herbicides and rates for the 2014 trial near Wanatah, IN.

Herbicide treatment (group number)	Rate
Authority First (2 & 14) + Dual II Magnum (15)	8 oz + 1.33 pt
Valor XLT (2 & 14) + Dual II Magnum (15)	4.5 oz + 1.33 pt
Fierce (14 & 15)	3.5 oz
Canopy + Metribuzin (2 & 5)	6 oz + 8 oz
Verdict (14 &15)	5 fl oz
No herbicide treatment (check)	

Phytotoxicity was measured at the emergence-unrolled unifoliate leaves (VE-VC) stage. Phytotoxicity was measured on a 1-5 scale where 1 = healthy seedling, no injury, and 5 = total necrosis of the cotyledon (Figure 3).

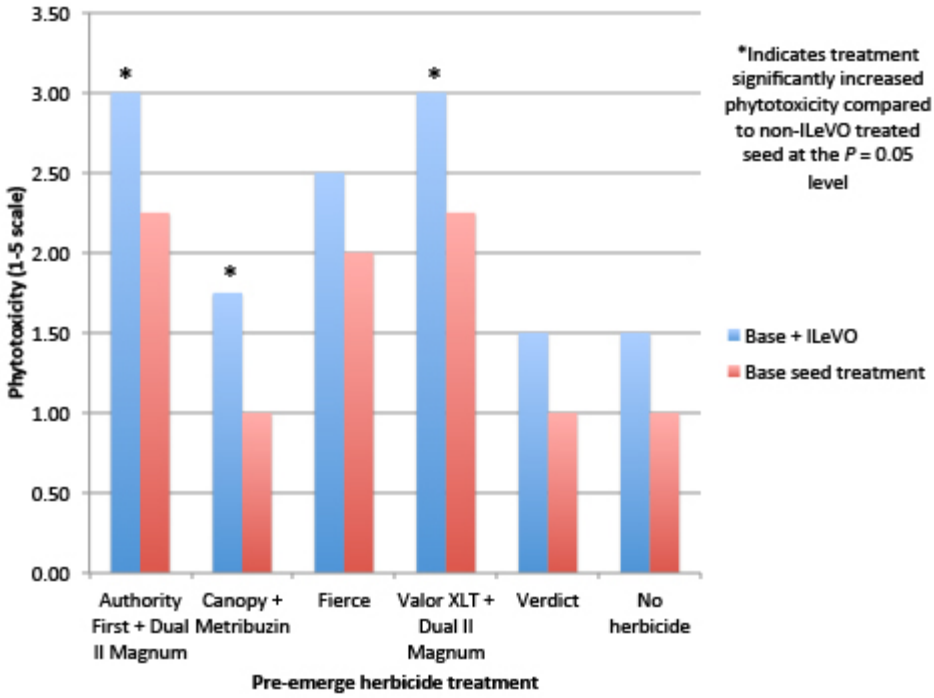

Figure 3. Phytotoxicity ratings of pre-emergence herbicide treatments for seedlings from ILeVO-treated seed compared to seedlings receiving only Trilex+Allegiance seed treatment in Wanatah, IN, 2014. Ratings were take at the VE-VC growth stage.

In the 2014 study, increased phytotoxicity was observed in seedlings resulting from ILeVO-treated seed (Figure 4). Phytotoxicity was more severe than non-ILeVO treated seed with several

herbicide treatments (Figure 5). However, this phytotoxicity did not impact stand by growth stage V4 (Figure 6).

Figure 4. Seedlings with ILeVO + pre-emergence herbicide treatment.

Figure 5. Seedlings with base seed treatment + pre-emergence herbicide treatment.

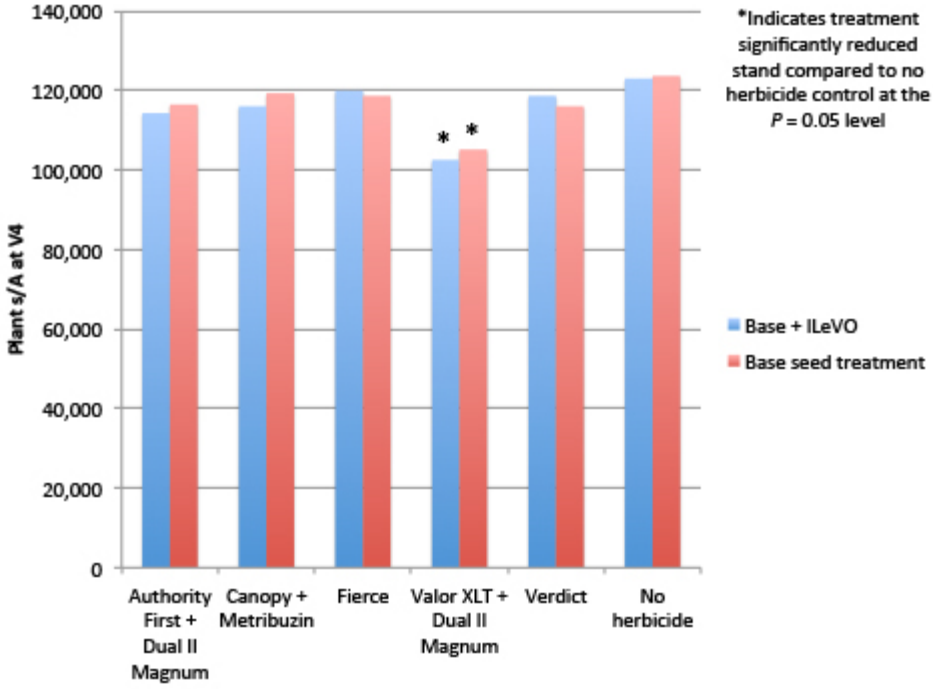

Figure 6. Impact of pre-emergence herbicides on soybean stand at growth stage V4 for seedlings with and without ILeVO seed treatment.

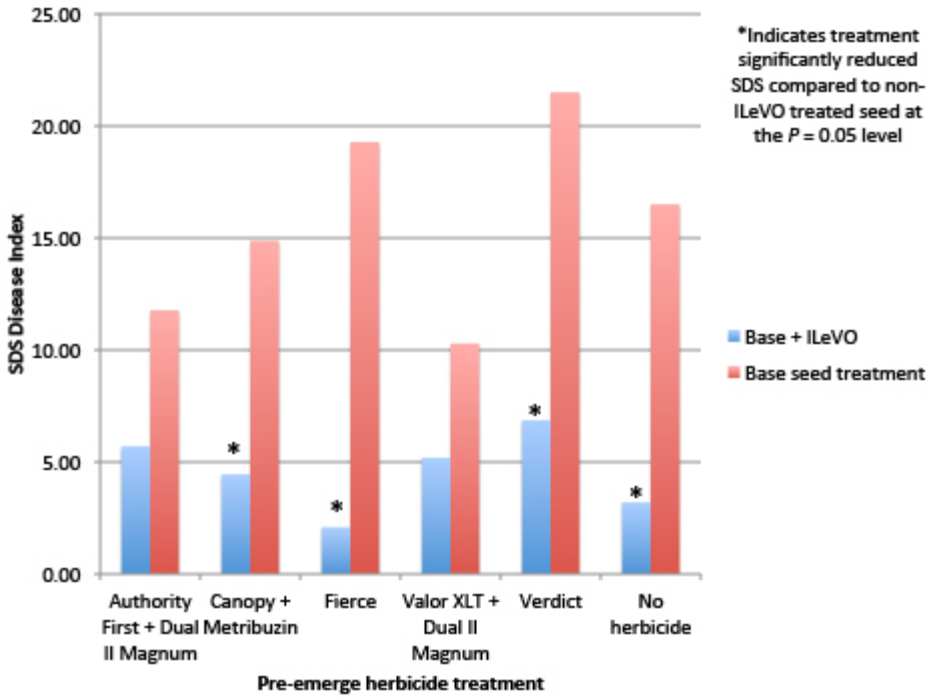

Figure 7. Sudden death syndrome was rated in the trial at growth stage R6. The SDS index is a measure of both SDS incidence and severity and higher index numbers indicate greater amounts of SDS. In 2014, SDS was reduced in treatments that had ILeVO-treated seed.

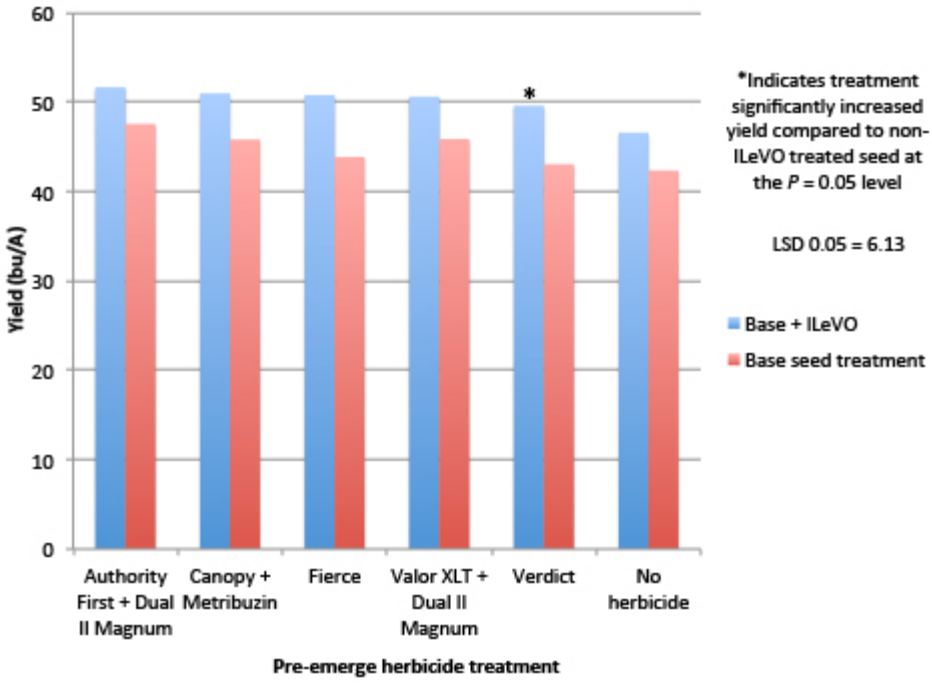

Figure 8. Treatments with ILeVO resulted in an average gain of 5 bu/A compared to the base seed treatment across all treatments.

Conclusions:

This is a one year, one location study, so the results should be interpreted accordingly. However, these preliminary results indicate that although phytotoxicity may be more severe when ILeVO is used with pre-emergence herbicide treatments, there is likely to be no effect on stand, and no reductions in yield. The conditions that favor the phytotoxicity of the halo effect and pre-emergence herbicide injury are also conditions that favor infection by Fusarium virguliforme, the fungus that causes SDS. Therefore, if fields that have had a history of SDS and were or will be planted under less than ideal environmental conditions, the inclusion of ILeVO in the seed treatment package may be a benefit that outweighs the shortterm injury to seedlings in the cotyledon stage. Furthermore, the use of residual PPO-inhibiting herbicides applied pre-plant or pre-emergence are part of the best recommendations we have for improving management of herbicide-resistant weed species such as waterhemp and Palmer amaranth.

Additional research on the interaction between pre-emergence herbicides and ILeVO seed treatment is underway in Indiana and Iowa in 2015. Early observations from Iowa and Indiana in 2015 are similar to the 2014 study in Indiana, where ILeVO does cause temporary phytotoxicity and pre-emergence herbicide applications slightly increase this damage. However, although this is

visually apparent, preliminary data from 2015 in Iowa indicates that applications of pre-emergence herbicides did not increase damage on seedlings from ILeVO-treated seed when compared to treatments that received no herbicide application. Herbicide by ILeVO interaction was not significant at P = 0.10 for cotyledon damage and plant establishment (Table 2).

Table 2. Phytotoxicity ratings and plant population at VC growth stage measured at Ames, IA in 2015. Phytotoxicity was measured on a 1-5 scale where 1 = healthy seedling, no injury, and 5 = total necrosis of the cotyledon.

	Phytotoxicity		No. of plants/sq. meter	
Herbicide treatment (rate)	Base seed treatment*	Base + ILeVO	Base seed treatment	Base + ILeVO
None	1.0	2.0	28.3	26.6
Authority First (7 oz/A)	1.0	2.4	26.0	28.3
Fierce (3 oz/A)	1.1	2.5	23.0	26.4
Verdict (10/A)	1.0	2.4	27.8	27.6
P > F	0.19	0.19	0.05	0.65

**Base seed treatment is Evergol Energy + Allegiance + Poncho/VOTiVO*

Here are a few other observations so far from 2015:

- The phytotoxicity from ILeVO does appear to be more severe compared to last year. Cool, wet conditions may lead to more phytotoxicity from ILeVO and pre-emergence herbicides.
- Soybean plants quickly outgrown ILeVO damage on the cotyledons; even a day or two makes a big difference. When we first observed plants at VE, damage appeared quite severe. However, as plants move into VC, the damage is less noticeable because the phytotoxicity does not appear on the unifoliate leaves (Figure 9). If you are walking your soybean fields and they are at VE, wait a few days to assess the field again. However, injury due to the PPO-inhibiting pre-emergence herbicides may still appear on the unifoliate leaves.
- Damage from seedling blights such as Pythium root rot, pre-emergence herbicides, and ILeVO can look very similar. ILeVO damage is usually only on the surface of cotyledons, so snap a few cotyledons and look for green on the inside to distinguish from other injuries or diseases. If you are still unsure of the cause of the damage observed, send a sample to a local diagnostic laboratory. Obtaining an accurate diagnosis will allow you to determine the best management strategies for your soybean field.

Figure 9. Phytotoxicity due to the ILeVO seed treatment is not commonly observed on the unifoliate leaves.

In this image you can see the halo effect on the cotyledon, but the unifoliate leaves have no injury.

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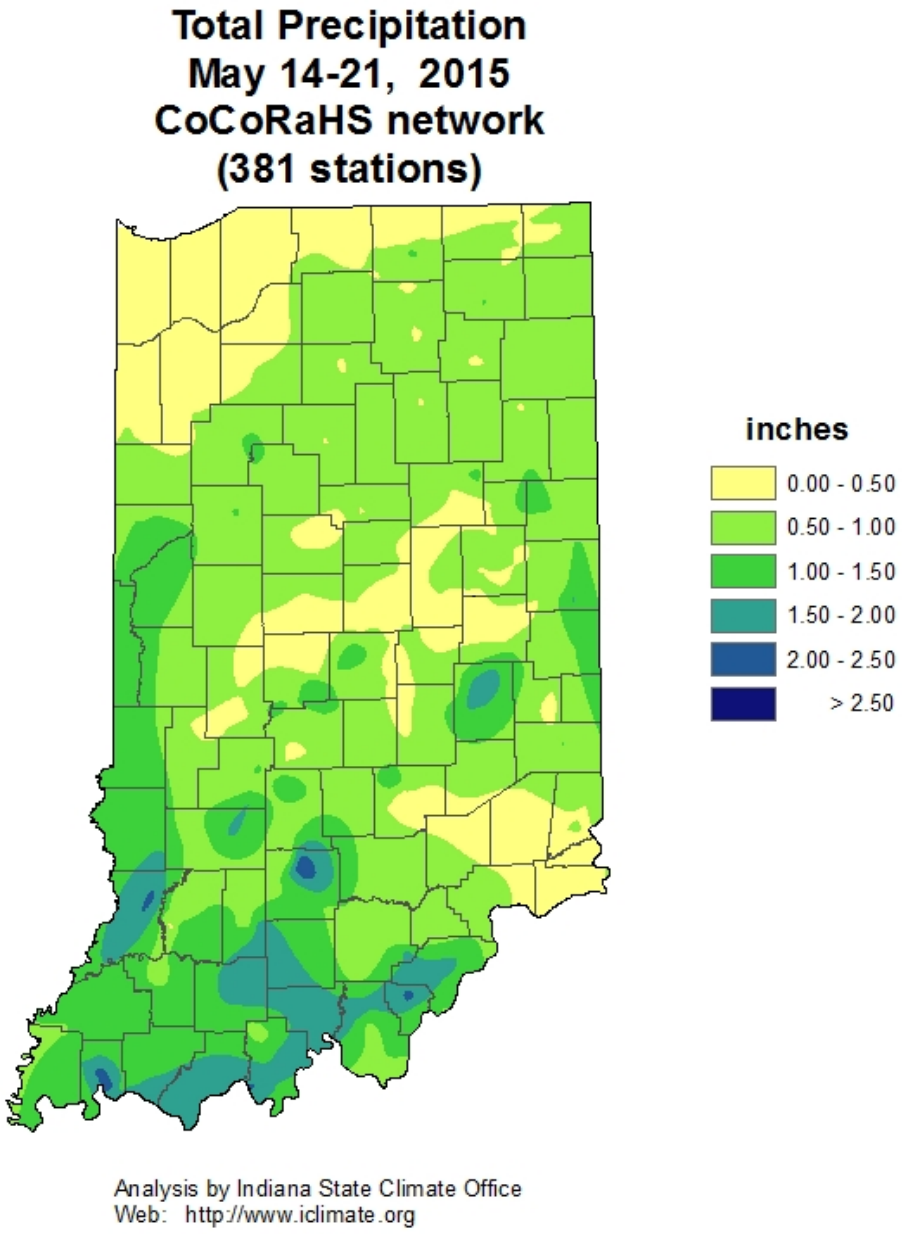
Total Precipitation
May 14-21, 2015
CoCoRaHS network
(381 stations)
inches
0.00 - 0.50
0.50 - 1.00
1.00 - 1.50
1.50 - 2.00
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> 2.50
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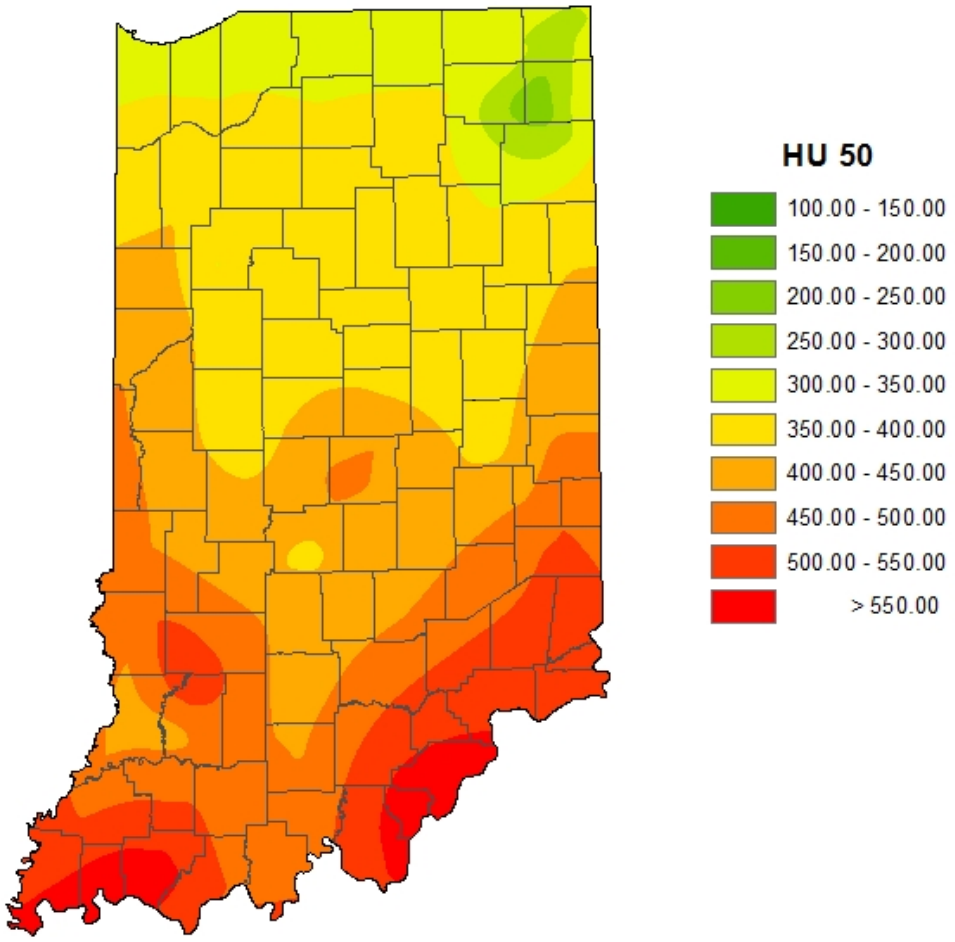
Heat Units Base 50
Since 13 April 2015



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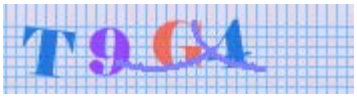

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