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# Pest&Crop newsletter

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In This Issue





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Editor: Tammy Luck | Department of Entomology, Purdue University, 901 W. State St., West Lafayette, IN 47907

# Armyworm Landing Spot Revealed

***Author: John Obermeyer***

In mid-June, we wrote in the Pest&Crop about the second surge of armyworm moths and suggested that dense, lush grasses (e.g., pasture) could be at risk. Though our pheromone trapping for armyworm ended at that time, Thomas Richards, NEPAC research farm (Whitley County), decided to continue monitoring out of curiosity. The mid-June moth count was 1674, the following week's counts were 959,2009,1613, then beginning to tail off at 528 a month later. Those were some high counts!

While driving a county road early this week, a very weedy field caught my attention. In stopping, I could finally tell that the field was planted into corn. In rows were spindles of stalks among the very heavy grass and broadleaf pressure. Entering the field, I didn't find any active armyworm larva, though the telltale signs of their leaf feeding were present. There were fresh wheel tracks in the field and the giant ragweed was drooping, so the producer obviously sprayed with an herbicide, perhaps with an insecticide as well. In pulling up a few grass clumps, I was able to find armyworm pupa. This field of "waist high" corn, based on midrib length, was a disaster, not just from the armyworm damage. Most intriguing was how the feeding nearly stopped at the adjoining "normal" cornfield, with only a few leaves damaged. BTW, even Bt-traited corn, at this growth stage (R2/3), would have little effect on an invasion of mature, "marching," armyworm. If you are wondering, the grasses along the road were also denuded, and there I did find a few live larvae still feeding.

Obviously, this mismanaged field is a "freak" among the sea of beautiful cornfields throughout Indiana. But what amazes me is how the armyworm moths, randomly flying the night skies, are able to target this field for egg deposition. We have seen similar situations in the early spring when small grains or grassy cover crops too are targeted. I suspect, there are other "back 40" cornfields that have sustained damage in a similar manner and will be revealed at harvest. At that time, perhaps the grazing deer will take the blame.

Happy Scouting!

The good news is that there is new leaf growth out of these whorls.

Armyworm feeding of corn and grass weeds, up to the adjoining field.

How to attract armyworm moths.

# 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 7/5/18-7/11/18 | Wk 4 7/12/18-7/18/18 | Wk 5 7/19/18-7/25/18 | Wk 6 | Wk 7 |
|---|---|---|---|---|---|---|---|---|
| Adams | Roe/Mercer Landmark | 0 | 0 | 0 | 4 | 0 | | |
| Allen | Anderson/Syngenta | | 0 | 9 | 12 | 6 | | |
| Allen | Gynn/Southwind Farms | 0 | 0 | 5 | 8 | 9 | | |
| Allen | Kneubuhler/G&K Concepts | 0 | 0 | 9 | 4 | 0 | | |
| Bartholomew | Bush/Pioneer Hybrids | 0 | 1 | 0 | 0 | 0 | | |
| Clay | Bower/Ceres Solutions/Clay City | 0 | 1 | 0 | 0 | | | |
| Clay | Bower/Ceres Solutions/Bowling Green | 0 | 0 | 0 | 0 | | | |
| Clay | Bower/Ceres Solutions/Brazil | 0 | 0 | 0 | 1 | | | |
| Clinton | Emanuel/Boone Co. CES | 3 | 0 | 0 | 1 | 1 | | |
| Clinton | Foster/Rossville | | 10 | 0 | 1 | 0 | | |
| Daviess | Venard/Venard Agri-Consulting/Washington | 0 | 0 | 0 | 0 | 0 | | |
| Daviess | Venard/Venard Agri-Consulting/Elnora | 0 | 0 | 0 | 0 | 0 | | |
| DeKalb | Hoffman/ATA Solutions | 0 | 1 | 11 | 27 | 23 | | |
| Dubois | Eck/Dubois Co. CES | 0 | 0 | 0 | 2 | 2 | | |
| Elkhart | Kauffman/Crop Tech Inc. | 6 | 3 | 58 | 39 | 5 | | |
| Fayette | Schelle/Falmouth Farm Supply Inc. | 0 | 1 | 0 | 0 | 0 | | |
| Fountain | Mroczkiewicz/Syngenta | 12 | 196 | 18 | 1 | | | |
| Fulton | Jenkins/Ceres Solutions/Talma | 3 | 0 | 26 | 12 | 3 | | |
| Fulton | Randstead/Ceres Solutions | 0 | 34 | 61 | 16 | | | |
| Greene | Venard/Venard Agri-Consulting | 0 | 0 | 0 | 0 | 0 | | |
| Hamilton | Campbell/Beck's Hybrids | 0 | 0 | 2 | 3 | 5 | | |
| Hendricks | Nicholson/Nicholson Consulting | 0 | 7 | 2 | 0 | | | |
| Jasper | Overstreet/Jasper Co. CES | 0 | 0 | 4 | 9 | 50 | | |
| Jasper | Ritter/Brodbeck Seeds | 10 | 69 | 72 | 17 | | | |
| Jay | Boyer/Davis PAC | 1 | 0 | | | | | |
| Jay | Shrack/Ran-Del Agri Services | 0 | 1 | 0 | 0 | 0 | | |
| Jay | Temple/Jay Co. CES/Redkey | 0 | 0 | 0 | 0 | | | |
| Jay | Temple/Jay Co. CES/Pennville | 0 | 0 | 0 | 0 | 2 | | |
| Jennings | Bauerle/SEPAC | 0 | 0 | 0 | 0 | 0 | | |
| Knox | Bower/Ceres Solutions/Freelandville | 0 | 0 | 0 | 0 | | | |
| Knox | Bower/Ceres Solutions/Vincennes | 0 | 0 | 0 | 0 | | | |
| Kosciusko | Klotz/Etna Green | 5 | 1 | 44 | 10 | | | |
| Lake | Kleine | 2 | 1 | 0 | 7 | 10 | | |
| Lake | Moyer/Dekalb Hybrids/Shelby | 0 | 4 | 52 | 20 | 11 | | |
| Lake | Moyer/Dekalb Hybrids/Scheider | 5 | 23 | 207 | 112 | 58 | | |
| LaPorte | Rocke/Agri-Mgmt. Solutions/Wanatah | 1 | 3 | 22 | 8 | 8 | | |
| LaPorte | Smith/Co-Alliance, LLP/South Center | 0 | 7 | 96 | 59 | 17 | | |
| LaPorte | Smith/Co-Alliance, LLP/Lacrosse | 4 | 8 | 106 | 88 | 22 | | |
| LaPorte | Smith/Co-Alliance, LLP/Union Mills | 8 | 17 | 204 | 335 | 45 | | |
| Marshall | Harrell/Harrell Ag Services/Plymouth | 0 | 12 | 36 | 18 | | | |
| Marshall | Harrell/Harrell Ag Services/Bremen | 0 | 4 | 24 | 12 | | | |
| Marshall | Klotz/Nappanee | 6 | 11 | 278 | 77 | | | |
| Marshall | Miller/Ceres Solutions/Plymouth | 2 | 85 | 80 | 64 | | | |
| Marshall | Smith/Co-Alliance, LLP/Argos | 7 | 32 | 273 | 113 | 28 | | |
| Miami | Early/Pioneer Hybrids | 4 | 26 | 116 | 39 | 5 | | |
| Montgomery | Delp/Nicholson Consulting | 0 | 0 | 3 | 3 | 5 | | |
| Newton | Moyer/Dekalb Hybrids/Lake Village | 1 | 5 | 75 | 20 | 17 | | |
| Porter | Tragesser/PPAC | 2 | 11 | 61 | 41 | 11 | | |
| Posey | Schmitz/Posey Co. CES/Cynthiana | 0 | 0 | 0 | | | | |
| Posey | Schmitz/Posey Co. CES/St. Phillips W | 0 | 0 | 1 | | | | |
| Pulaski | Capouch/M&R Ag Services | 7 | 42 | 345 | 114 | 32 | | |
| Pulaski | Leman/Ceres Solutions | 5 | 3 | 14 | 3 | | | |
| Putnam | Nicholson/Nicholson Consulting | 0 | 1 | 0 | 0 | | | |
| Randolph | Boyer/DPAC | 1 | 3 | | | | | |
| Rush | Schelle/Falmouth Farm Supply Inc. | 0 | 0 | 0 | 5 | 0 | | |
| Shelby | Fisher/Shelby County Co-op | 0 | 0 | 0 | | | | |
| Shelby | Simpson/Simpson Farms | 1 | 1 | 0 | 5 | 3 | | |
| St. Joseph | Barry/Helena | 1 | 5 | 46 | 68 | 41 | | |
| St. Joseph | Battles/Mishawaka | 0 | 0 | 28 | 4 | 0 | | |
| St. Joseph | Carbiener/Breman | 0 | 0 | 10 | 5 | | | |
| St. Joseph | Smith/Co-Alliance, LLP/Granger | 3 | 53 | 196 | 76 | 108 | | |
| St. Joseph | Smith/Co-Alliance, LLP/New Carlisle | 1 | 3 | 11 | 52 | 4 | | |
| Starke | Capouch/Medaryville | 2 | 11 | 2 | 1 | 5 | | |
| Starke | Smith/Co-Alliance, LLP/Hamlet | 9 | 34 | 233 | 215 | 22 | | |
| Sullivan | Bower/Ceres Solutions/Farmersburg | 0 | 0 | 0 | 0 | | | |
| Sullivan | Bower/Ceres Solutions/Sullivan | 0 | 3 | 0 | 0 | | | |
| Tippecanoe | Bower/Ceres Solutions/Lafayette | 4 | 56 | 20 | 5 | | | |
| Tippecanoe | Nagel/Ceres Solutions | 0 | 4 | 15 | 0 | 6 | | |
| Tippecanoe | Obermeyer/Purdue Entomology | 0 | 0 | 0 | 0 | 0 | | |
| Tippecanoe | Westerfeld/Monsanto Research Farm | 6 | 10 | 6 | 3 | 2 | | |
| Tipton | Campbell/Beck's Hybrids | 0 | 0 | 0 | 4 | 1 | | |
| Vermillion | Bower/Ceres Solutions/Clinton | 0 | 0 | 0 | 0 | | | |
| Wabash | Enyeart/Ceres Solutions | 0 | 0 | 2 | 1 | 0 | | |
| Whitley | Boyer, Richards/NEPAC/Schrader | 3 | 3 | 31 | 19 | 13 | | |
| Whitley | Boyer, Richards/NEPAC/Kyler | 0 | 0 | 16 | 4 | 4 | | |

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



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Editor: Tammy Luck | Department of Entomology, Purdue University, 901 W. State St., West Lafayette, IN 47907

# Update on Corn Diseases in Indiana

***Author: Darcy Telenko***

Corn diseases have been on my radar these past few weeks as I am just getting my boots on the ground in Indiana. Many aerial fungicide applications are going out around the region, corresponding to crop maturity and the uptick of grey leaf spot. As a result the biggest question I have received this week is, "Should we spray our corn for grey leaf spot?" Fungicides can be effective at reducing disease and protecting yield, but there are a number of factors that should be considered: the field history/previous crop, the amount of disease present in the field, hybrid susceptibility, weather conditions, and the price of corn and cost of fungicide application.

**Grey leaf spot** is probably the most prevalent disease issue this year to date. It is caused by the fungus *Cercospora zea-maydis*. Symptoms of grey leaf spot usually first appear in the lower canopy a few weeks before tasseling. The lesions are light tan in color and generally narrow and rectangular, and can be as long as 2 inches. As the lesions age they turn grey in color and are delimited by leaf veins (Fig. 1). This annual disease has become one of the most important foliar diseases in Indiana. Hybrid susceptibility and weather will have the greatest impact on the severity in a field. Fungicide options that are available for gray leaf spot would be a cost effective application in fields that have a history of disease and are planted to susceptible hybrids in no-till or reduced-till system. As a reminder, fungicide applications add an additional cost to corn production. Therefore, economic factors and other disease issues need to be considered before deciding to apply a fungicide to manage gray leaf spot. Previous research has determined the best time to apply fungicides in preventing yield loss with the most economic return occurs when fungicides are applied in response to disease at tasseling (VT) through early silking (R1).  More detailed information can be found in the Purdue Diseases of Corn – Grey Leaf Spot Extension publication https://www.extension.purdue.edu/extmedia/bp/bp-56-w.pdf.

Fig 1. Grey leaf spot on lower leaves in canopy of a field of continuous, no-till corn. (Photo credit: Darcy Telenko)

Purdue's Plant and Pest Diagnostic Lab (PPDL) this past week has received numerous corn samples that are positive for **Physoderma brown spot stalk rot**, and this disease has also appeared in our continuous and no-till corn research site. Physoderma brown spot is caused by the *Physoderma maydis*, the only class of fungi that produced zoospores (spores that have a tail (flagellum)) and swim free in water. *P. maydis* can survive in soil and crop debris for 2 to 7 years. The pathogen can be dispersed by the wind or splashed into the whorls of the developing corn. Corn is most susceptible to infection between growth stages V5 to V9. Therefore, even though we are seeing symptoms now as corn is past VT and moving into R-stages, infection occurred in standing water in the whorl. Dark purplish to black oval spots along the midrib of the leaf (Fig. 2) and on the stalk, leaf sheath and husks (Fig. 3) are distinguishing characteristic symptoms of Physoderma brown spot. In addition, infected leaves have numerous very small round or oval spots that are yellowish to brown and occur in bands across the leaf. Management options for Physoderma are limited, there are a few fungicides that are labeled for Physoderma control, but there is limited information if a fungicide application would be economical in Indiana. Rotation and tillage both can help manage residue where the pathogen will survive year to year – most susceptible sites are those in no-till and continuous corn.

Fig. 2a. An example of how Physoderma brown spot appears in the field.

Fig. 2b. Physoderma brown spot has distinctive dark purple oval spots along midrib and very small yellowish to brown oval spots occurring in bands. (Photo credit: Darcy Telenko)

Fig. 3a. A close up of the small yellow spots and dark purple oval spots along leaf mid-rib. (Photo credit: PPDL)

Fig. 3b. Purple spots inside the leaf sheath where water and zoospores collected in the whorl. (Photo credit: PPDL)

Fig. 3c. Dark purple spots along the outside of the leaf sheath. (Photo credit: PPDL)

We have found a few lesions of **northern corn leaf blight** in our research plots. I have not heard that there is much in the region. But as a reminder when scouting, northern corn leaf blight has distinctive long lesions (usually one to six inches in length) that are elliptical, starting as a light green and turning a pale gray or tan. Dark spores will be produced under moist conditions. See figure 4 as an example.

Fig. 4. Northern corn leaf blight. (Photo credit: Darcy Telenko)

**Southern rust** is slowly moving north. There are no official reports for Indiana, but there are three reports in Illinois and a most recent report out of Arkansas. The iPiPE program has a Crop Pest Program that is tracking the movement of southern rust. If you are interested in finding out where positive infections have been identified, visit http://ext.ipipe.org/ipipePublic/index.php#tags=Corn. Since this disease has had a slow start, I doubt it will be a big issue in Indiana this season. If you suspect field has southern rust, please send a sample to the PPDL for positive identification or contact myself or your local extension.

Several fungicides are available to help manage grey leaf spot, northern corn leaf blight, and southern rust, with a recommended application occurring at late vegetative stages through R1. The national Corn Disease Working Group has developed a very useful efficacy table for fungicides in corn which can be found at https://www.extension.purdue.edu/extmedia/bp/bp-160-w.pdf.

Again, I am just getting settled into Indiana. Please contact me or the PPDL with any major disease issues you may have this season. I am excited to be joining Purdue and look forward to continuing and expanding on the great work of my predecessors as I begin to build my field crop research and extension program.

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# Grain Fill Stages in Corn

***Author: Bob Nielsen***

The grain fill period begins with successful pollination and initiation of kernel development, and ends approximately 60 days later when the kernels are physiologically mature. During grain fill, the developing kernels are the primary sink for concurrent photosynthate produced by the corn plant. What this means is that the photosynthate demands of the developing kernels will take precedence over that of much of the rest of the plant. In essence, the plant will do all it can to "pump" dry matter into the kernels, sometimes at the expense of the health and maintenance of other plant parts including the roots and lower stalk.

A stress-free grain fill period can maximize the yield potential of a crop, while severe stress during grain fill can cause kernel abortion or lightweight grain and encourage the development of stalk rot. The health of the upper leaf canopy is particularly important for achieving maximum grain filling capacity. Some research indicates that the upper leaf canopy, from the ear leaf to the uppermost leaf, is responsible for no less than 60% of the photosynthate necessary for filling the grain.

Kernel development proceeds through several distinct stages that were originally described by Hanway (1971) and most recently by Abendroth et al. (2011). As with leaf staging protocols, the kernel growth stage for an entire field is defined when at least 50% of the plants in a field have reached that stage.

**Silking Stage (Growth Stage R1)**

Silk emergence is technically the first recognized stage of the reproductive period. Every ovule (potential kernel) on the ear develops its own silk (the functional stigma of the female flower). Silks begin to elongate soon after the V12 leaf stage (12 leaves with visible leaf collars), beginning with the ovules near the base of the cob and then sequentially up the cob, with the tip ovules silking last. Consequently, the silks from the base half of the ear are typically the first to emerge from the husk leaves. Turgor pressure "fuels" the elongation of the silks and so severe drought stress often delays silk elongation and emergence from the husk leaves. Silks elongate about 1.5 inches per day during the first few days after they emerge from the husk leaves. Silks continue to elongate until pollen grains are captured and germinate or until they simply deteriorate with age.

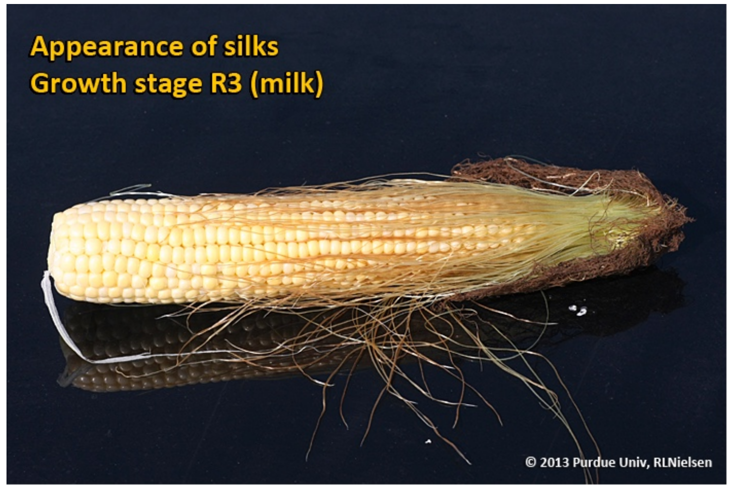
Silks remain receptive to pollen grain germination for up to 10 days after silk emergence (Nielsen, 2016b), but deteriorate quickly after about the first 5 days of emergence. Natural senescence of silk tissue over time results in collapsed tissue that restricts continued growth of the pollen tube. Silk emergence usually occurs in close synchrony with pollen shed (Nielsen, 2016c), so that duration of silk receptivity is normally not a concern. Failure of silks to emerge in the first place (for example, in response to silkballing or severe drought stress) does not bode well for successful pollination.

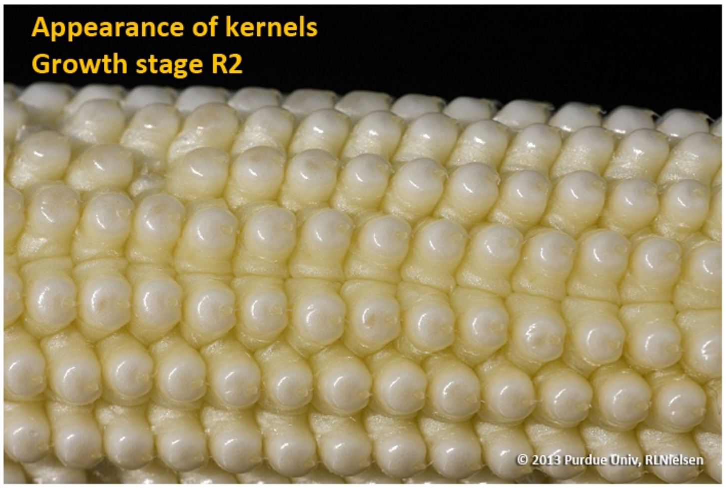
Pollen grains "captured" by silks quickly germinate and develop pollen tubes that penetrate the silk tissue and elongate to the ovule within about 24 hours. The pollen tubes contain the male gametes that eventually fertilize the ovules. Within about 24 hours or so after successfully fertilizing an ovule, the attached silk deteriorates at the base, collapses, and drops away. This fact can be used to determine fertilization success before visible kernel development occurs (Nielsen, 2016a).

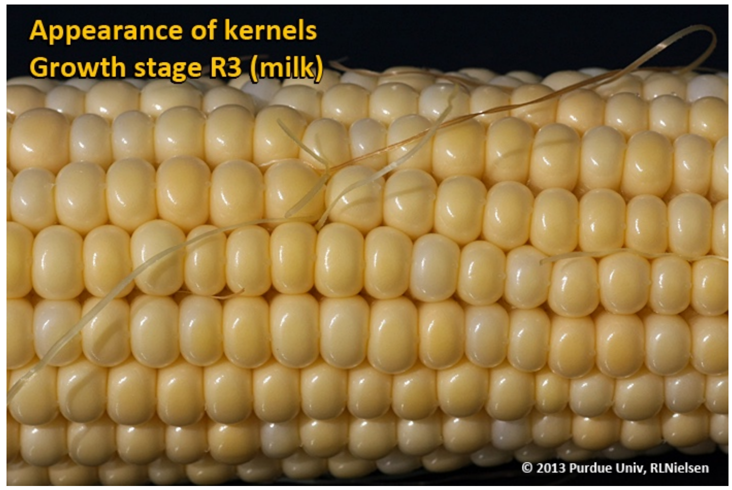


## Kernel Blister Stage (Growth Stage R2)

About 10 to 12 days after silking, the developing kernels are whitish "blisters" on the cob and contain abundant clear fluid. The ear silks are mostly brown and drying rapidly. Some starch is beginning to accumulate in the endosperm. The radicle root, coleoptile, and first embryonic leaf have formed in the embryo by the blister stage. Severe stress can easily abort kernels at pre-blister and blister stages. Kernel moisture content at the beginning of R2 is approximately 85 percent. For late April to early May plantings in Indiana, the thermal time from blister stage to physiological maturity is approximately 960 GDDs (Brown, 1999).

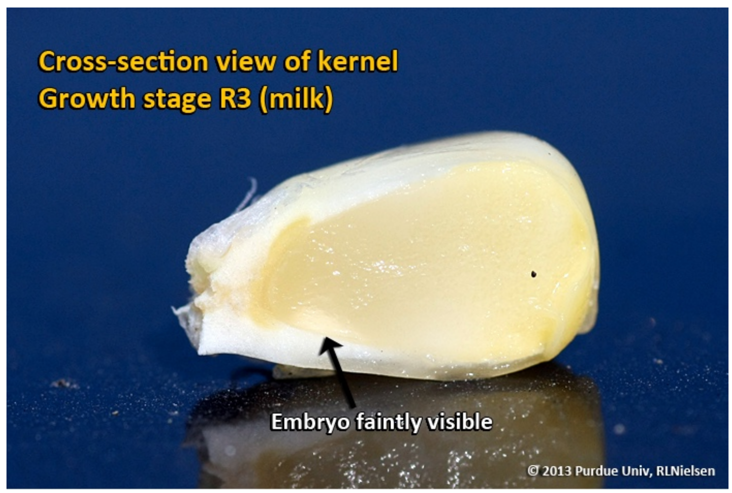



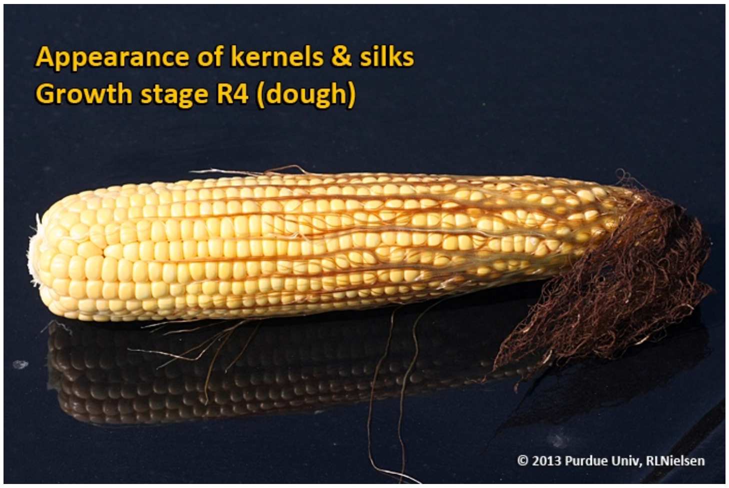

## Kernel Milk Stage (R3)

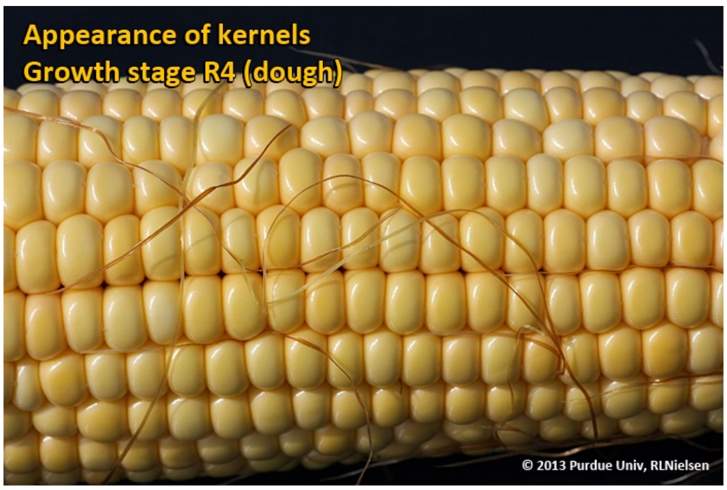
About 18 to 20 days after silking, the kernels are mostly yellow and contain "milky" white fluid. The milk stage of development is the infamous "roasting ear" stage, when you will find die-hard corn aficionados standing out in their field nibbling on these delectable morsels. Starch continues to accumulate in the endosperm. Endosperm cell division is nearly complete and continued growth is mostly due to cell expansion and starch accumulation. Severe stress can still abort kernels, although not as easily as at the blister stage. **Kernel moisture content at the beginning of R3 is approximately 80 percent**. For late April to early May plantings in Indiana, the thermal time from milk stage to physiological maturity is approximately 880 GDDs (Brown, 1999).

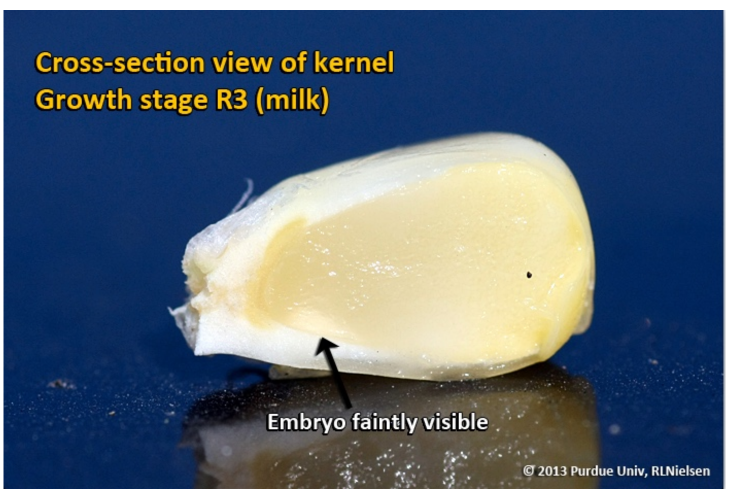



## Kernel Dough Stage (R4)

About 24 to 26 days after silking, the kernel's milky inner fluid begins changing to a "doughy" consistency as starch accumulation continues in the endosperm. The shelled cob is now light red or pink. By dough stage, four embryonic leaves have formed and the kernels have reached about **50 percent of their mature dry weight**. **Kernel moisture content is approximately 70 percent at the beginning of R4**. Near the end of R4, some kernels will typically be starting to dent. Kernel abortion is much less likely to occur once kernels have reached early dough stage, but severe stress can continue to affect eventual yield by reducing kernel weight. For late April to early May plantings in Indiana, the thermal time from dough stage to physiological maturity is approximately 670 GDDs (Brown, 1999).



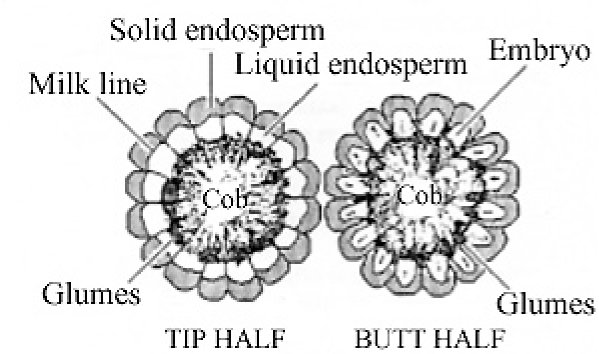




## Kernel Dent Stage (R5)

About 31 to 33 days after silking, all or nearly all of the kernels are denting near their crowns. The fifth (and last) embryonic leaf and lateral seminal roots form just prior to the dent stage. **Kernel moisture content at the beginning of R5 is approximately 60 percent**.

More importantly, **kernel dry matter content at the beginning of R5 is only about 45% of the eventual final** accumulation and there **remains approximately more 30 days before physiological maturity** occurs. This is sobering considering that farmers and agronomists alike often breathe a sigh of relief when the crop reaches R5 because of a mistaken and, frankly, emotional belief that the "crop is made" by this grain fill stage.



Description of the corn ear.

***Interesting Exercise:***

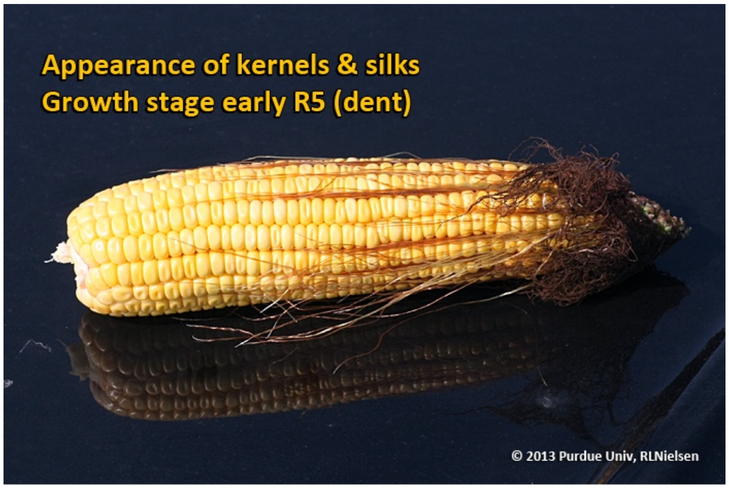
You can get a sense of the importance of the final 30 days of grain filling by calculating a number of "what-if" grain filling scenarios using the traditional pre-harvest yield estimation formula for corn with a range of kernel weight "fudge factors" from about 65 to 105 (representing kernel weights equivalent to 65,000 to 105,000 kernels per 56-lb bushel.)

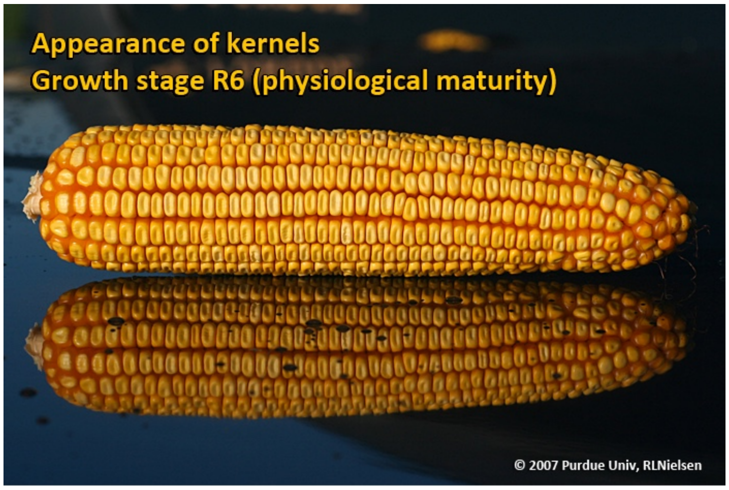
Within about a week after the beginning of R5, a distinct horizontal line appears near the dent end of a split kernel and slowly progresses to the tip end of the kernel over the next 3 weeks or so. This line is called the "**milk line**" and marks the boundary between the liquid (milky) and solid (starchy) areas of the maturing kernels.

For late April to early May plantings in Indiana, the thermal time from full dent (kernel milk line barely visible) to physiological maturity is approximately 350 GDDs (Brown, 1999). Thermal time from the half-milkline stage to physiological maturity for similar planting dates is approximately 280 GDDs. One of the consequences of delayed planting is that thermal time from the dent stage to physiological maturity is shortened, though this may simply reflect a premature maturation of the grain caused by the cumulative effects of shorter daylengths and cooler days in early fall or by outright death of the plants by a killing fall freeze.

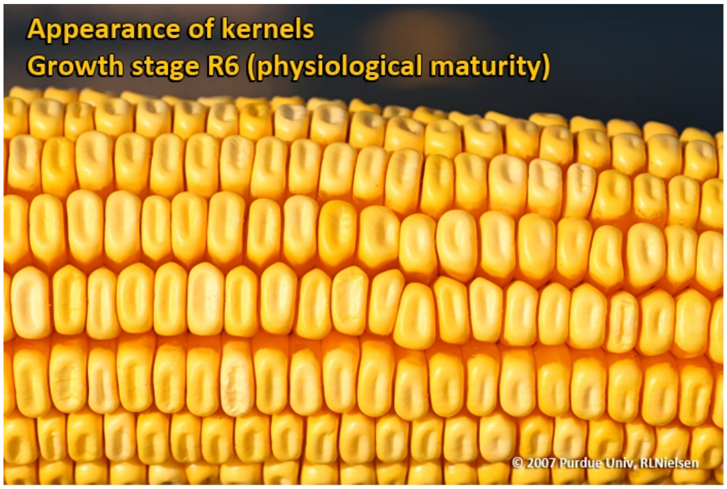
Severe stress can continue to limit kernel dry weight accumulation between the dent stage and physiological maturity. Estimated yield loss due to total plant death at full dent is about 40%, while total plant death at half-milkline would decrease yield by about 12% (Carter & Hesterman, 1990).

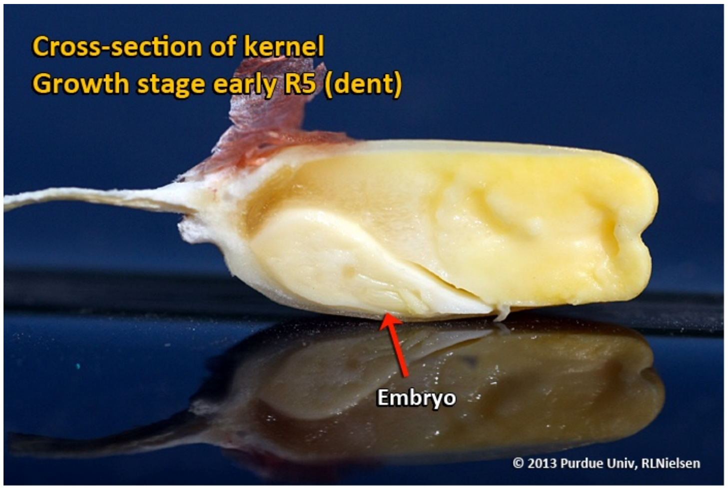
and growing conditions.

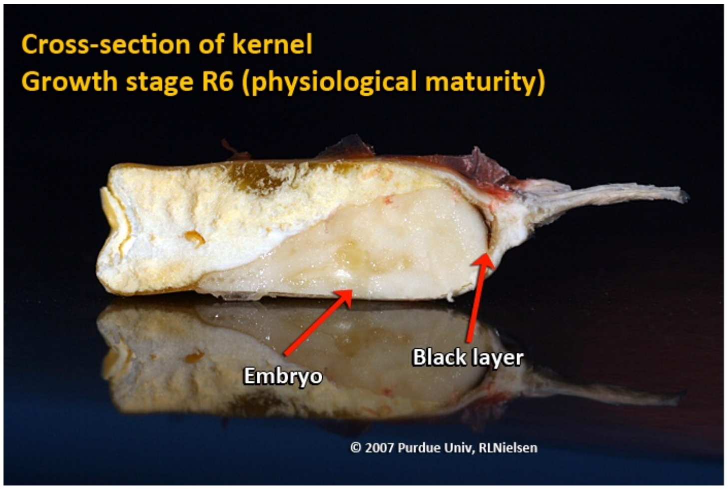







## Physiological Maturity (R6)

About 55 to 65 days after silking, kernel dry weight usually reaches its maximum and kernels are said to be physiologically mature and safe from frost. Physiological maturity occurs shortly after the kernel milk line disappears and just before the kernel black layer forms at the tip of the kernels. Severe stress after physiological maturity has little effect on grain yield, unless the integrity of the stalk or ear is compromised (e.g., damage from European corn borer or stalk rots). **Kernel moisture content at physiological maturity averages 30 percent**, but can vary from 25 to 40 percent grain moisture depending on hybrid and growing conditions.

## Harvest Maturity

While not strictly a stage of grain development, harvest maturity is often defined as that grain moisture content where harvest can occur with minimal kernel damage and mechanical harvest loss. Harvest maturity is usually considered to be near 25 percent grain moisture.

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# Effects of Severe Stress During Grain Filling in Corn

***Author: Bob Nielsen***

Yield potential in corn is influenced at several stages of growth and development. Ear size potential (number of potential kernels) is determined quite early, from about leaf stage V6 to V15 (knee-high to about shoulder-high). The next influential period for the corn crop is pollination. The period following successful pollination and finishing at kernel black layer is defined as the grain filling period in corn and represents the final important yield determination period. Grain fill stages in corn are described in an accompanying article.

Perfect conditions for ear size determination and pollination can be negated if severe stress occurs during the grain fill period. Yield loss during grain fill can occur from 1) stand loss, 2) incomplete kernel set, 3) decreased kernel weight, and 4) premature plant death.


## Stand Loss During Grain Fill

Yield loss due to stand loss during grain fill is usually greater than that due to stand loss occurring earlier during the vegetative phase. When stand loss occurs prior to pollination, ear size (number of kernels) on surviving plants may compensate in response to the lesser competition of a thinner stand. Additional compensation may occur during grain fill in terms of greater kernel weight. When stand loss occurs during grain fill, kernel number has already been set. Only kernel weight can compensate in response to the lesser competition of a thinner stand.


## Incomplete Kernel Set in Corn

The term “kernel set” refers to the degree to which kernels have developed up and down the cob. Incomplete kernel set is not always apparent from “windshield” surveys of a corn field. Husks and cob will continue to lengthen even if kernel set is incomplete. A wonderfully long, robust-looking, healthy green ear of corn can completely mask even a 100 percent failure of pollination or severe kernel abortion.

*TECHNICAL TRIVIA:*
***Pollination** is the movement of pollen from the tassels to the silks.*
***Fertilization** is the actual union of the male and female gametes once the pollen tube reaches the ovule.*


One of the causes of incomplete kernel set is **unsuccessful fertilization of the ovules during pollination**. Unsuccessful fertilization results in ovules that never develop into kernels and, subsequently, ears with varying degrees and patterns of incomplete kernel set. Many factors can cause incomplete pollination and distinguishing between them can be very difficult.

- Certain insects like corn rootworm beetles and Japanese beetles can interfere with pollination and fertilization by their silk clipping activities. These insects inadvertently clip silks as they feed on pollen captured by the silks. Unusually early or late pollinating fields are often particularly attractive to these insects.
- Drought stress may delay silk emergence until pollen shed is nearly or completely finished. During periods of high temperatures, low relative humidities, and inadequate soil moisture levels, exposed silks may also desiccate rapidly and become non-receptive to pollen germination.
- Conversely, silk emergence of some drought tolerant hybrids may occur several days prior to the availability of pollen from the tassels when soil moisture levels are favorable for crop growth. Although silks remain receptive to pollen germination for up to 10 days after emergence, they begin to slowly

- deteriorate (age, desiccation) after 4 to 5 days. Because the first silks to emerge are from ovules near the base of the cob, kernel set near the base of the cob may fail under these conditions. See my related article for more information.
- Unusually favorable conditions prior to pollination that favor ear size determination can result in ears with an unusually high number of potential kernels per row. Remember that silk elongation begins near the butt of the ear and progresses up toward the tip. The tip silks are typically the last to emerge from the husk leaves. If ears are unusually long (many kernels per row), the final silks from the tip of the ear may emerge after all the pollen has been shed.

Another cause of incomplete kernel set is **abortion of fertilized ovules**. Aborted kernels will be shrunken, mostly white, often with the yellow embryo visible; compared to normal plump yellow kernels. Unfertilized ovules, on the other hand, will result in visibly blank areas on the cob.

Kernels are most susceptible to abortion during the first 2 weeks following pollination, particularly kernels near the tip of the ear. Tip kernels are generally last to be fertilized, less vigorous than the rest, and are most susceptible to abortion. Once kernels have reached the dough (R3) stage of development, further yield losses will occur mainly from reductions in kernel dry weight accumulation.

**Kernel abortion can be caused by any stress that greatly limits photosynthetic rates and, thus, photosynthate availability during or shortly following pollination…**

- Severe drought stress.
- Excessive heat stress.
- Severe nutrient deficiencies (especially nitrogen).
- Extensive loss of green leaf tissue by foliar diseases like gray leaf spot (*Cercospora zeae-maydis*).
- Extensive loss of green leaf tissue from severe hail damage.
- Consecutive days of heavily overcast, cloudy conditions.

## Decreased Kernel Weight

Severe photosynthetic stress during dough (R4) and dent (R5) stages of grain fill reduces kernel weight and can cause premature kernel black layer formation. Decreased kernel weight can result from severe drought and heat stress during grain fill; extensive European corn borer tunneling (especially in the ear shanks); loss of photosynthetic leaf area by nutrient deficiency, hail, insects, or disease during grain fill; and killing fall frosts prior to normal black layer development.

Once grain has reached physiological maturity (R6), severe stress will have no further physiological effect on final grain yield per se. However, severe stress prior to R6 can weaken stalk tissue and predispose the plants to the development of stalk rots (see my related article). Weakened or rotted stalks combined with post-maturity damaging wind storms can easily result in significant mechanical harvest losses and, thus, less grain in the bin.

## Premature Plant Death

A killing fall frost prior to physiological maturity can cause premature leaf death or whole plant death. Premature death of leaves results in yield losses because the photosynthetic "factory" output is greatly reduced. The plant may remobilize stored carbohydrates from the leaves or stalk tissue to the developing ears, but yield potential will still be lost. Approximate yield losses due to premature death of leaves, but not stalks, range from 36, 31, and 7% when the leaf death occurs at R4 (dough), R5 (full dent), and half-milkline stages of kernel development, respectively (Afuakwa & Crookston, 1984).

Premature death of whole plants results in greater yield losses than if only leaves are killed. Death of all plant tissue prevents any further remobilization of stored carbohydrates to the developing ear. Whole plant death that occurs before normal black layer formation will cause *premature* black layer development, resulting in incomplete grain fill and lightweight, chaffy grain. Grain moisture will be greater than 35%, requiring substantial field drydown before harvest. Approximate yield losses due to premature whole plant death range from 50, 39, and 12% when the whole plant death occurs at R4 (dough), R5 (full dent), and half-milkline stages of kernel development, respectively (Afuakwa & Crookston, 1984).

A common misconception is that kernel black layer formation sometimes fails to occur following a frost or other late-season severe stress. Not true. FAKE NEWS! The kernel black layer always develops. Any severe stress that occurs during the grain fill period will cause premature kernel black layer formation and is related to the reduction in or termination of sucrose (photosynthate) availability to the developing kernels (Afuakwa et al., 1984).

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# Kernel Set Scuttlebutt

*Author: Bob Nielsen*

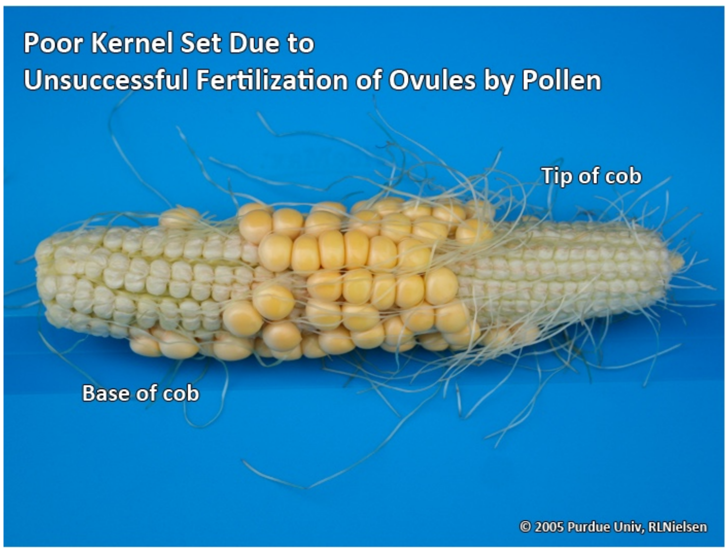
"Scuttlebutt": The cask of drinking water on ships was called a scuttlebutt and since sailors exchanged gossip when they gathered at the scuttlebutt for a drink of water, scuttlebutt became U.S. Navy slang for gossip or rumors. A butt was a wooden cask, which held water or other liquids; to scuttle is to drill a hole, as for tapping a cask.

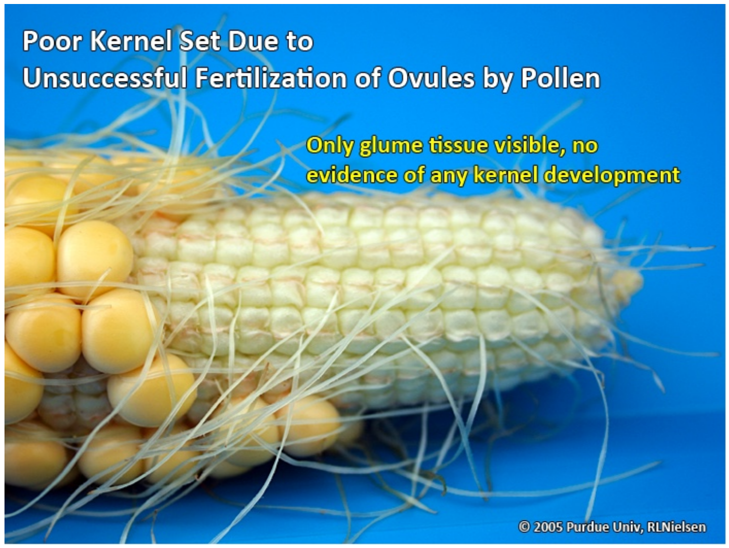
Nautical Terms and Phrases, NAVAL HISTORICAL CENTER, Washington DC 20374-5060.
Online at www.ussbrainedd630.com/terms.htm [URL accessed Aug 2017].

The post-pollination scuttlebutt overheard in coffee shops throughout Indiana during late summer often revolves around the potential for severe stress that might reduce kernel set or kernel size in neighborhood cornfields. Growers' interest in this topic obviously lies with the fact that the number of kernels per ear is a rather important component of total grain yield per acre for corn.

Poor kernel set, meaning an unacceptably low kernel number per ear, is not surprising in fields that are obviously severely stressed by drought, but can also occur in fields that otherwise appear to be in good shape. Good or poor kernel set is determined from pollination through the early stages of kernel development; typically 2 to 3 weeks after pollination is complete.

Problems with kernel set stem from ineffective pollination, ineffective fertilization of the ovaries, kernel abortion, or all three. Distinguishing the symptoms is easy. Determining the exact cause of the problem is sometimes difficult.




## Potential Yield Loss

The potential loss in grain yield caused by lower kernel numbers per ear can be estimated using the formula of the so-called Yield Component Method first described by the Univ. of Illinois many years ago (Nafziger, 2017; Nielsen, 2017a). For example, the loss of only 1 kernel per row for a hybrid with 16-row ears and a stand count of 30,000 ears per acre would equal a potential yield loss of approximately 5 bushels per acre (1 [kernel] x 16 [rows] x 30 [thousand ears per acre] divided by 90 [thousand kernels per bushel]).

## Ineffective Pollination / Fertilization

Poor kernel set may be caused by ineffective pollination (the transfer of pollen from the tassel to the silks) and/or the subsequent failure of the pollen's male gametes to fertilize the female gametes of the ovules on the cob. Ineffective pollination is characterized by an absence of noticeable kernel development. In other words, all you see is cob tissue. Pollination problems may be due to several stress factors, sometimes working together to influence kernel set.

Severe drought stress, aggravated by excessive heat, can delay silk emergence to the extent that pollen shed is complete or nearly complete by the time the silks finally emerge from the husk. Without a pollen source, ovule fertilization cannot occur.

Persistent severe silk clipping by insects such as the corn rootworm beetle or Japanese beetle throughout the active pollen shed period can also limit the success of pollination. The simultaneous effects of severe drought stress on silk emergence can easily amplify the consequences of severe silk clipping.




Severe drought stress coupled with excessive heat and low humidity can desiccate emerged silks to the point that they are no longer receptive to pollen grain germination. I suspect this is low on the list of possible stressors for Indiana most years (because of our typically high humidity levels), but may play a role in some fields once in a while.

Similarly, I doubt that pollen viability is usually an issue for Indiana cornfields because temperatures in the low 90's are usually not great enough to kill pollen.

Consecutive days of persistent rainfall or showers that keep tassels wet for many hours per day over several days can delay or interfere with anther exsertion and pollen shed. Such a weather period does not typically occur in Indiana, but the remnants of Hurricane Dennis that visited many parts of Indiana in early July of 2005 may have influenced kernel set in some fields that were trying to pollinate during that week as a result of the many days of showery humid weather (coupled with the excessive cloudiness and its negative effect on photosynthesis).

Exceptionally long potential ears resulting from good weather during ear size determination sometimes fail to pollinate the final kernels near the tip of the cob. Remember, butt silks emerge first and tip silks emerge last. With oversized ears, sometimes tip silks emerge after all the pollen has been shed.

An increasingly common hybrid trait in recent years is an aggressive silking habit that results in silks emerging from the husk leaves several days prior to the availability of pollen from the tassels. The trait is associated with drought tolerance in the sense that silk emergence delays are less likely under severe drought stress and, thus, silk/pollen synchrony is better retained. However, favorable weather during silk elongation tends to favor unusually early silk appearance that can result in silk aging / deterioration prior to the availability of pollen. The typical kernel set pattern associated with this situation is blank cob tissue near the basal end of the cobs.

## Kernel Abortion

Poor kernel set can also be a reflection of kernel abortion following successful fertilization of the ovules on the cob. In contrast to ineffective pollination or fertilization, initial kernel development obviously precedes kernel abortion, so the symptoms are usually shriveled remnants of kernels that may be whitish- or yellowish-translucent.

Kernel abortion results from severe stresses that greatly reduce the overall photosynthetic output of the plant during the first several weeks after the end of pollination as the kernels develop through the blister (R2) and milk (R3) stages of development. The risk of kernel abortion decreases significantly after the R3 stage of kernel development. Obvious photosynthetic stressors include severe drought & heat stress, consecutive days of excessively cloudy weather and significant loss of photosynthetically active leaf area (e.g., hail damage, leaf diseases, insect damage, nutrient deficiency).

Warm nights during pollination and early grain fill may indirectly affect survival of developing kernels. Research suggests that the increased rate of kernel development due to warmer temperatures lowers the available amount of photosynthate per unit of thermal time; which then becomes a stressor to kernel development particularly at the tip of the ear, leading to kernel abortion (Cantarero et al., 1999).

## Final Food for Thought

A plethora (meaning a whole lot) of blank cob tips can quickly ruin the joy of walking a cornfield in the middle of August. Before getting too bent out of shape over the missing kernels, remember to count the number of harvestable kernels on those ears. Sometimes, ears exhibit 1 to 2 inches of blank tips; yet still contain 16 rows by 30 to 35 harvestable kernels per row. Those are perfectly acceptable ear sizes in a year where dry weather has been a concern.

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# Consider Drought Motivated Irrigation Purchases Carefully

***Author: Lyndon Kelley, Irrigation Educator – MSU Extension/Purdue Extension***

Deck: Hot dry summers sometimes result in quick irrigation investment decisions that may be regretted.

Producers watching their crops suffer in drought conditions can be a powerful motivator to buy irrigation equipment. Irrigation equipment investments need to answer two question before a dollar should be spent:

- First, is it feasible, do you have the water supply and the land base/configuration to allow irrigation?
- Second, will the irrigation increase the average yield of the crops in the rotation to generate the additional dollar to pay for the system and additional annual operating cost associated with irrigation?

The irrigation water supply is often a challenge over looked in the heat of the moment during a drought. Without adequate water for your irrigation system, your investment becomes less valuable and often becoming discounted used equipment. In Michigan, constructing a large volume water (LVW) withdrawal without a registration could result in large fines. The Michigan LVW registration process may take minutes to months depending on the current status of the watershed you will be pulling from. The Indiana required registration process is a phone call to Indiana DNR and is not likely to become a limiting factor for a quick irrigation investment.

Water supplies need to be adequate for the production area. Michigan and Indiana water use by most crops and vegetable crops will near .25 inches per day for at least a few weeks each year. To adequately irrigate the .25” daily crop removal, your irrigation water supply needs the capacity to pump 5 gallons per minute per acre. At times of peak need a 500 gpm pump will run 24 hours a day seven days a week to replace the water used by 100 acres of crops.

Irrigation investments often have a long life but also require a long investment time period to work financially. Irrigation can often lift average yield 65-70 bushes on a five-year average on sandy and sandy loam soils. Loam soils with higher water holding capacities will often not increase average yield enough to justify irrigation investments. Often new irrigation investment that start in July will rarely come on line in time to greatly increase yield. Much of yield potential is set by mid-July making the concept of rescuing the year a fallacy.

Hot dry summers are good times to sell used equipment. Producers with little experience can be lured into an investment that can be better done with more planning. Be leery of used equipment that commonly shows up for sale in a dry summer. Parts from a wrecked pivot span can look very good if you’re not accustom to working on them.  Patching and straightening pipe and bracing can leave structural challenges and leaks. The high cost of labor and repair parts often results in a cost near the price of new. A traveler can be a low cost used purchase but replacement hose can easily be 2-3 time the cost of the salvaged gun and cart.

Typically, the prices on new irrigation equipment are at their highest in July and mid-August.  Through the fall, September rebates and incentives help to reduce cost. Field/fence row clearing and underground piping are other reasons that fall and winter are typical irrigation expansion seasons.

Irrigation investments need to be profitable. Long term yield increases or new irrigated crop options profit levels need to be greater than the annual ownership and operating cost of the irrigation system.

The lowest annual ownership and operating cost for irrigation systems are $130/irrigated acre or more and can easily double or triple with smaller field sizes, irregular shape fields, limited availability of water and the lack of three phase electric. For more information on Irrigation investments economics, including annual ownership and operating cost, a visit: https://www.canr.msu.edu/irrigation/#costs

Whether you’re new to irrigation or just looking for some insight before going further, take a look at MSU irrigation fact sheet number #11-Checklist for Irrigation Planning:
https://www.canr.msu.edu/uploads/235/67987/lyndon/11_Checklist.pdf

The site of a crop suffering in a drought can motivate producers into irrigation investments that would be better made with time and planning.

Reviewers;

Bruce MacKellar, MSU Extension Field Crop Educator

Steve Miller MSU-BAE Irrigation specialist

Roger Betz – MSU Extension Farm Financial Educator

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# Community Briefing: IN CCIA Agriculture Report

Hoosier farmers will have to adapt management practices and the types of crops they plant over the next several decades as they deal with the repercussions of climate change. That's according to a new report from the Indiana Climate Change Impacts Assessment team based at Purdue University.

The report, "Indiana's Agriculture in a Changing Climate," will be released during a **community briefing** from **10-11 a.m. Tuesday, July 31, at the Indiana Corn and Soybean Innovation Center**, 4750 U.S. 52, West Lafayette. The event is open to the public.

Rising temperatures and an earlier beginning to the frost-free season could beneficially expand the growing season in some parts of the state. However, heat and changes in precipitation patterns will create challenges for most sectors of Indiana agriculture.

"This report helps us understand how climate change will affect Indiana agriculture and gives us a sense of some of the adjustments that might need to be made," said Jeff Dukes, director of the Purdue Climate Change Research Center. "The report includes specific information on potential opportunities and drawbacks to row and specialty crops, soil health and livestock."

Purdue researchers specializing in agricultural water management, soil health, crop growth, crop diseases, invasive species, agricultural economics, heat stress and animal health contributed to the report. The lead author is Laura Bowling, professor of agronomy.

The Indiana Climate Change Impacts Assessment (IN CCIA) has compiled the latest scientific research into a series of easily understandable reports about climate change impacts in ten topic areas: climate, health, forest ecosystems, aquatic ecosystems, urban green infrastructure, tourism and recreation, agriculture, water resources, energy, and infrastructure.

The reports that have been previously released are available on the IN CCIA website at http://IndianaClimate.org. For more information about the IN CCIA, go to the website or follow on social media at @PurdueCCRC, #ClimateChange, #INCCIA.

Writer: Brian Wallheimer, 765-532-0233, bwallhei@purdue.edu

Source: Jeff Dukes, 765-494-1446, jsdukes@purdue.edu

Agricultural Communications: (765) 494-8415;

Maureen Manier, Department Head, mmanier@purdue.edu

Agriculture News Page

## Contact Details

- Melissa Widhalm
- mwidhalm@purdue.edu
- (765) 494-8191



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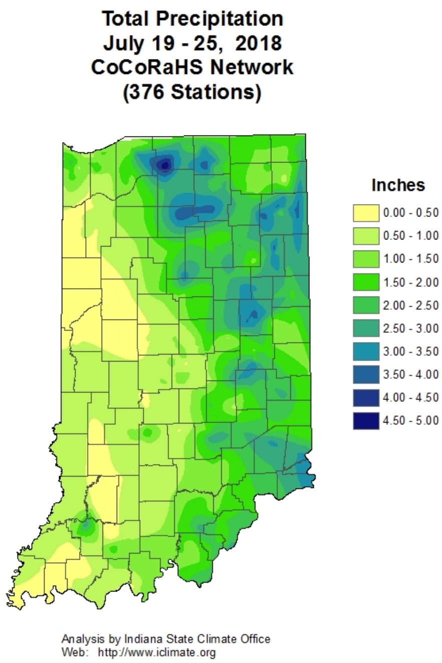
# Total Precipitation July 19-25, 2018



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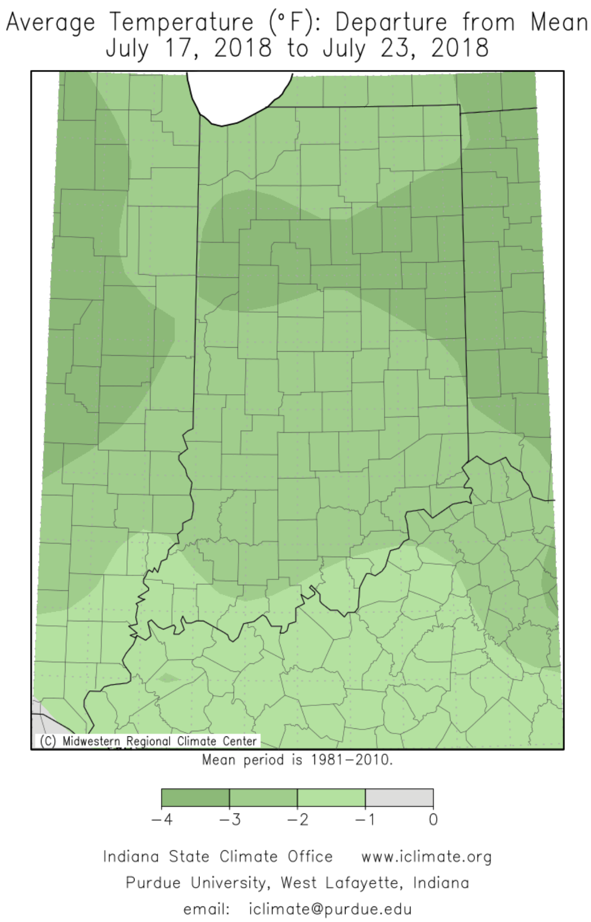
# Average Temperature Departure from Mean, July 17-23, 2018




Average temperature departure from mean July 17-23, 2018.