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Insects, Mites, and Nematodes

Soybean Aphid, Abbreviated Management Guidelines – (John Obermeyer and Larry Bledsoe)

- Aphids numbers still very low throughout the state.
- Sampling now should concentrate on newest soybean growth.
- Treatment threshold is 250 or more aphids/plant.
- Know your soybean growth stages!
- Approved soybean aphid insecticides and application methods given below.

Anticipation abounds throughout the state, especially in northern counties, concerning soybean aphid. High numbers or treatable levels of aphids do NOT exist anywhere throughout the Midwest as we post this issue of the *Pest&Crop*. North Central states' researchers are finding only very low populations amongst scattered fields. Though university treatment thresholds are unified, various un-named entities have confused producers with unfounded numbers and yield guarantees (see following article) with willy-nilly treatments. Please use the following guidelines:

Sampling: Count aphids, on the undersides of leaves, on at least 20-30 plants in various areas of the field. When

aphids are just beginning to colonize soybean plants, they will be concentrated on the newest growth near the top of the plant. Generally these are the leaves lighter in color and located just below the top of the canopy.

Aphid Number: Should you find an average of 250 or more aphids per plant during the early soybean



Newest soybean leaf



Soybean growth stages R3, R4, and R5

reproductive stages (R1-R4), a treatment is justified. During the pod-fill stages (R5-R6), unless plants are under drought stress, treatment may be needed with 500 or more aphids per plant. Do NOT treat soybean beyond the R6 stage of growth.

Treatment: Should control be necessary, complete coverage on the foliage seems to be the key. Ground driven rigs applying at least 20 gallons per acre with 40 PSI will help penetrate the canopy. Aerial application success is dependent on finished spray volume (we recommend 5 gallon/acre) and air movement into the canopy. Products labeled for soybean aphid control include Asana, Lorsban 4E, Mustang Max, PennCap, and Warrior. All of these insecticides are restricted use products. Please follow all label rate, application, and use directions.

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Soybean Foliar Insecticides, Perhaps a Big Mistake

- (John Obermeyer and Larry Bledsoe)

- Insecticide and herbicide applications generally don't coincide.
- Foliar insecticides affect all arthropods in the field, good and bad ones.
- An outbreak of plant suckers is possible after treating soybean fields.
- Insecticides only protect yield.

Some sales representatives have become "creative" in their pest management strategies. Producers are asking many questions about adding insecticides to post-applied herbicides or guaranteed yield programs being promoted by agricultural chemical companies. For some producers, last year's memory of yield reductions from soybean aphid has convinced them to give it a try. Obviously we're concerned about this willy-nilly approach in order to "improve" yields.

The optimum timing for controlling weeds and aphids will not be the same. No matter what rumors exist about longevity of insecticides, products will give at best two weeks of efficacy. The majority of post-applied herbicides have already gone on and the critical timing for aphid colonization is still yet to happen. On the other hand, waiting till aphids become a problem to apply herbicides will result in poor weed control. An herbicide application is dependent on good coverage of the plant canopy and reducing drift that means larger droplet size and lower pressures; however, insecticide application for aphids requires deep penetration into the foliage using higher volumes and pressures.

Lurking in many soybean fields are extremely low numbers of spider mites and soybean aphid. Treating soybean with an insecticide may tip the balance in the favor of spider mites and/or soybean aphid. In other words, natural enemies (a.k.a., good bugs) recover slowly from broad-spectrum insecticides compared to mites and aphids. In general, toxic levels of insecticide are absorbed by ingestion (eating treated leaves) and/or contact (walking over treated areas). Mites and aphids ingest only internal plant fluids. As well, except for mature females, they are relatively stationary on the bottom sides of leaves; obviously a difficult location to get thorough coverage. Also, surviving mites and aphids can repopulate fields at break-neck speed, certainly outpacing natural enemies.

A recent field day in east central Indiana brought this to light. With participants in small groups, we were able to intensely scout a soybean field for half an hour and tally the insects found. The intentions were to show and tell about soybean aphid. Since the "guest of honor" didn't show, our focus shifted. It soon became apparent that beneficial insects (pirate bug adults/nymphs, lady beetles, syrphid fly larvae, lacewing eggs, etc.) far outnumbered potential pests (thrips and potato leafhoppers). Any spider mites or aphids attempting to colonize this field would be under immediate attack by hungry predators. A "guaranteed" insecticide application in this field would set the stage in favor of sucking insects to colonize and quickly populate to threatening pest numbers.

Consider the source of these programs, companies wanting to sell product. The conditions of last year are not being duplicated this season. Last year's gamble on insecticide application preserved some yield being stressed by the combination of dryness during pod set/fill and soybean aphid feeding. However it must be emphasized that insecticides do NOT increase yield, they only preserve it. Any yield enhancing claims with insecticides are not only misleading but against the law. This one fact alone should make producers wary and monitor fields before treatments are made. Happy scouting and be informed!

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Potato Leafhopper Populations High - (John Obermeyer and Larry Bledsoe)

- Potato leafhopper reported in high numbers in alfalfa
- New alfalfa growth is most at risk to feeding damage
- Damage is already done once "hopper burn" is noticed

High populations of potato leafhopper in alfalfa fields have been seen and noted throughout the state. Undoubtedly, the warm and drier weather over the past weeks has contributed to this increase as the leafhoppers thrive in these conditions.

Producers are encouraged to inspect new growth soon after cutting for potato leafhopper; this is when alfalfa is most susceptible to feeding, leading to reduced yields and protein content. Remember, once the yellowing or "hopper burn" is seen, the damage has already been done. Refer to *Pest & Crop* #12, for sampling and management guidelines. For recommended insecticides see Extension Publication E-220, *Alfalfa Insect Control Recommendations* - 2004 which can be viewed at <www.entm.purdue.edu/entomology/ext/targets/e-series/e-list.htm>. A sampling video for potato leafhopper in alfalfa can be viewed at: <www.entm.purdue.edu/entomology/ext/fieldcropsipm/videos.htm>.



Black Light Trap Catch Report - (John Obermeyer)

County/Cooperator	6/22/04 - 6/28/04							6/29/04 - 7/05/04						
	VC	BCW	ECB	SWCB	CEW	FAW	AW	VC	BCW	ECB	SWCB	CEW	FAW	AW
Dubois/SIPAC							8							
Jennings/SEPAC			2				32							
Knox/SWPAC			8		2		3							
LaPorte/Pinney Ag Center			2				11	2	5					16
Lawrence/Feldun Ag Center							32			1		1		6
Randolph/Davis Ag Center		6	2				36	4						36
Tippecanoe/TPAC Ag Center														
Vermillion/Hutson														5
Whitley/NEPAC		2	6				326							

VC = Variegated Cutworm, BCW = Black Cutworm, ECB = European Corn Borer, SWCB = Southwestern Corn Borer, CEW = Corn Earworm, FAW = Fall Armyworm, AW = Armyworm

Weeds to Lookout For – (Bill Johnson and Glenn Nice)

As we move into the middle part of the summer, we want to take this opportunity to raise awareness of a few things to be on the lookout for as you assess weed control in corn and soybean fields.

Marestail. We have a number of field experiments at SEPAC (near Butlerville, IN) in Jennings county. At this site we observed very little emergence of marestail during the fall of 2003. However, we observed marestail emerging as early as mid-march 2004 and as late as the last week in June. It appears as though this weed is behaving primarily as a summer annual in SE Indiana this year. It is highly likely that it will emerge or has emerged after postemergence glyphosate treatments are made to Roundup Ready soybeans. So, it will be easy to confuse the late emerging plants with those that did survive a glyphosate treatment as truly resistant to glyphosate. In every field we have found glyphosate resistant marestail, we are able to find live plants interspersed with dead or damaged plants. The fact that marestail emerges over such a long time will make it difficult to confirm resistance in the field unless individual plants are marked before spraying them. If you are interested in determining if you have a resistant population, mark a few plants with flags or tape, spray them with a small field or pump up sprayer, and record the number of live and dead plants at 10 to 20 days after application. Marestail resistant to glyphosate is fairly common in SE Indiana (see this article for more details <www.btny.purdue.edu/weedscience/2004/articles/updatemarestail04.pdf>), but found much less frequently in other areas of Indiana.

Another observation this year on marestail is that north of I-70, it tended to behave more like a true winter annual, with most plants emerging in the fall and very little spring emergence.

Chickweed. Our field and written surveys conducted this past winter and spring have indicated that common chickweed is one of the most problematic winter annual weeds Indiana producers and crop advisors are currently trying to manage. In large plot field studies near West Lafayette in Tippecanoe county, we have observed quite a bit of chickweed that emerges in the spring and also as late as the last week of June. It was more commonly found in corn plots that received reduced rates of soil residual herbicides (particularly atrazine) and areas where our recent heavy rains diluted soil applied herbicides. It also appears that in these areas that still have a good canopy from corn, that this is an ideal environment for chickweed to survive until fall. This means that chickweed will have a good root system and a jump start on growth going into fall. In fields that

fit this scenario, it would be good to consider fall herbicide applications for chickweed management. Chickweed is typically easier to control with fall herbicide applications than with spring applications. Fall applied glyphosate and Express are both effective treatments.

Pokeweed. We have observed a number of fields where the pokeweed really took off in early June and reach 3 to 5 feet tall before it was sprayed. Although, we now observe a lot of dead above ground tissue, keep in mind that this weed is a perennial, the root balls can be very large, and effective control with one herbicide application is unlikely. As you walk soybean fields, look for new pokeweed sprouts from the base of “dead” plants, particularly in areas where soybean canopy development is poor. If live actively growing leaves are present and effective spray coverage can be achieved, consider a followup postemergence glyphosate or glyphosate + Classic or Synchrony application to further weaken these plants. If the soybeans are not Roundup Ready, Classic or Synchrony will provide the best control of the products available. If you have fields with heavy pokeweed pressure, another option to strongly consider would be a fall application of glyphosate, glyphosate + 2,4-D, or glyphosate + dicamba before any frost.

Lambsquarter. We are getting a few scattered reports of lambsquarter escaping glyphosate. In most of these cases, lambsquarter was allowed to reach 12 inches or more before it was sprayed, and the recent warm weather has caused this plant to harden off. Keep in mind that lambsquarter is one of the tougher weeds to control with glyphosate (or any other product for that matter). The best hope in these situations is to hope for some rain and cooler weather to allow these plants to begin growing again and spray with the highest labeled rate of glyphosate.

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The Infamous Giant Hogweed – (Glenn Nice)

I sent out a “heads up” not too long ago concerning the reported sighting of giant hogweed (*Heracleum mantegazzianum* Sommier) near Warsaw, Indiana. Although I had heard about this weed, I had not given it much attention before. Giant hogweed has some fame in some parts of the world. It even had a song written about it by the British rock group Genesis.

Identification:

As the name suggests, the first thing you may notice about giant hogweed is its stature. When it flowers the plant can reach a height of 10 to 15 feet (3 to 5 m; Figure 1.). The stems are hollow, 2 to 4 inches (5 to 10 cm) in diameter, with dark reddish-purple spots and bristles



Figure 1. Giant hogweed plant

(Figure 2). The compound leaves are deeply incised, and in some cases, it can grow up to a scary 5 feet (1.5 m) in width (Figure 3 and 4). Being in the carrot family, giant hogweed has a characteristic umbel floral arrangement. However, this umbel can be as large as 2.5 feet (76 cm) wide (Figure 5).



Figure 2. Giant hogweed stem



Figure 3. Giant hogweed leaf



Figure 4. Giant hogweed before flower production



Figure 5. Giant hogweed umbel inflorescence

Pictures source: Surry and Berks, 1977 and 2001, respectively. As seen on the BioImage: The Virtual Field-Guide (UK) web site; <www.bioimages.org.uk/HTML/T10402.HTM>

Giant hogweed is similar to the native cow parsnip (*Heracleum maximum* Bartr.); however, cow parsnip is smaller than giant hogweed (Table 1). Cow parsnip appears very hairy under the leaf whereas giant hogweed has small short hairs on the underside of the leaf. Giant hogweed will have reddish-purple spots on the stems, where as cow parsnip generally does not.

Table 1. Comparison between giant hogweed and cow parsnip.

	Giant Hogweed	Cow Parsnip
Height	10 to 15 feet	4 to 8 feet
Stem	hollow, 2 to 4 inches, dark reddish purple spots	hollow, often 2 inches at base
Leaves	compound leaves deeply incised, up to 5 feet wide, short hairs beneath leaf	compound leaves deeply incised, up to almost 1 foot, very pubescent beneath
Flower	umbel, up to 2.5 feet wide	umbel, 6 to 12 inches wide

Giant hogweed can live in a wide variety of areas. It might be found in areas of uncultivated waste land, vacant lots, along railroads, roads, and along creeks and streams. It often grows in wet areas.

Invasive Nature and Toxicity:

Giant hogweed is a perennial, and a member of the carrot family, Apiaceae. Giant hogweed is on the Federal Noxious Weed List, partially due to its aggressive invasive nature, spreading through tuberous root stalks and forming a solid canopy choking out many of our native plants. But more important is the possible impact on human health. This plant is to be treated like you would treat poison ivy. Giant hogweed produces a clear watery sap that can cause “photo-dermatitis,” sensitivity to sunlight (ultraviolet radiation). The results of this are swelling, severe blistering, and painful dermatitis. Avoid contact with exposed skin. One case of poisoning was in the 1970’s in Great Britain, where children contracted photo-dermatitis by playing with the stems of giant hogweed (2). If you come in contact with giant hogweed, wash with soap and water immediately. If you should happen to see this plant, contact your local county educator or Cloyce Hedge (chedge@dnr.IN.gov) at the Department of Natural Resources (DNR).

Control: Non-chemical

Digging up the plants appears to be the most effective non-chemical control method. Wear protective clothing when working around giant hogweed to assure the sap does not touch your skin. Cut plants below ground level. Try and remove the tap roots, for these can sprout into new shoots. Digging up giant hogweed will require repeated efforts and monitoring for regrowth, because it will be difficult to remove all the tuberous root stocks. Mowing may result in increased growth of giant hogweed. Repeated mowing could wear plants down by starving the roots, but vigilance would be required. Grazing and trampling by animals tolerant to the toxins in giant hogweed, such as cattle and sheep, can also

wear the plants down; however, one brochure on this plant stated that this would not control the plants (3).

Control of giant hogweed appears to be best achieved by using glyphosate. Repeated applications may be necessary. Several home-use glyphosate products can be purchased in local garden centers. Commercial glyphosate products can also be used, but if you don’t have the proper equipment or training to apply such products it might be best to seek help from an experienced applicator. If spray is allowed to come in contact with desirable plants, injury can occur. Control is most effective when plants are less than five feet tall and before they flower. If the plant has flowered, please remove the flowers to prevent giant hogweed from producing seed.

Background:

Originally from Asia, giant hogweed can now be found around the world, including Australia, several countries in Europe, the former Soviet Union, the US and Canada (2, 4). It is suspected to have made its way into these countries as an ornamental. Its size made it somewhat of an oddity and probably was imported by gardeners that wanted something unique. On the USDA plant database <<http://plants.usda.gov>> giant hogweed is reported in Maine, Michigan, New York, Pennsylvania, and Washington.

Fruit from this group of plants is often used as a spice in Iranian cooking and is mentioned in the Federal Noxious Weed Inspection Guide (2). Occasionally inspectors have found lots of seed from *Heracleum* spp. imported for ethnic food stores (2).

- 1) An illustrated Flora of the Northern United States and Canada 1913 (reprinted, 1970). N. Britton and A. Brown. Vol. 2 p. 635.
- 2) FactsSheet:HERACLEUM MANTEGAZZIANUM Sommier & Levier. FEDERAL NOXIOUS WEED INSPECTION GUIDE, Prepared by Dr. Randy G. Westbrook, Whiteville Plant Methods Center, Whiteville, NC. Accessed 6/30/04. NC. <www.ceris.purdue.edu/napis/pests/ghw/facts.txt>.
- 3) Homeowners Guide to Managing Giant Hogweed. Vermont agency of Agriculture and Food Markets. Accessed 7/1/04. <www.uvm.edu/mastergardener/pdf%20files/giant_hogweed_homeowners_brochure_Read-Only_.pdf>.
- 4) Non-Native Fresh Water Plants Giant Hogweed. Washington Department of Ecology. Accessed 6/30/04 <www.ecy.wa.gov/programs/wq/plants/weeds/aqua012.html>.
- 5) Giant Hogweed. King County, Natural Resources and Parks. Accessed 6/30/04 <<http://dnr.metrokc.gov/wlr/LANDS/weeds/hogweed.htm>>.

Plant Diseases

Rust on Corn - (Gregory Shaner)

- Rust is off to an early start this year

I first saw some common rust (*Puccinia sorghi*) in both seed corn and commercial hybrid corn a couple of weeks ago, but there were very few pustules. Weather over the past couple of weeks has probably been favorable for continued development of rust (temperatures often in the range of 61 to 77 °F and at least 6 hours of dew each night). From phone calls I have received others are seeing rust as well, and there is concern that there may be damage on some hybrids.

Common rust is a serious threat in seed corn production and on sweet corn. Producers of these crops routinely use foliar fungicides to keep it in check. In contrast, rust is usually not a concern on hybrid field corn. Genetic resistance protects most field corn hybrids from the disease.

Common rust can be recognized by the small, elliptical, cinnamon-brown pustules that erupt on both surfaces of the leaf blade. To a casual observer, small, circular spots that arise from many causes may look like rust. These spots may be early infections of several different leaf blight fungi or the result of injury. Close inspection of these spots will reveal whether they are rust or not. A rust pustule is a mass of cinnamon-brown spores, which form a powdery mass on the surface of the pustule. Pustules may be somewhat longer than 1/16 in. The fungus produces spores just beneath the leaf epidermis, and as their numbers multiply, they erupt through the epidermis. A torn flap of epidermis will often partially cover the pustule. The protruding mass of spores can just be discerned with the naked eye, but can be seen more clearly with a hand lens.

Rust is a polycyclic disease. The fungus does not survive the winters in the Corn Belt. It can only grow and produce spores on living plants of corn or teosinte (a close relative of corn). Spores produced in tropical or subtropical areas, where corn remains green throughout the winter, are carried north on the wind each spring and infect corn in temperate regions. The initial level of infection produced by these introduced spores is never enough to cause damage. However, each infection produces a pustule in about 7 to 10 days, and each pustule then produces several hundred spores each day. Wind disperses these spores; spores that land on healthy corn leaf tissue cause more infections, and the cycle repeats. Rust is capable of extremely rapid, exponential increase in the field.

This year, rust has perhaps appeared a bit earlier than normal (as it did in 2000). This, coupled with mild

temperatures and dew at night, may allow more rust than usual to develop early in the season.

The partial resistance to rust in most hybrids allows some pustules to form, i.e., the resistance is not “complete”. However, these pustules take longer to mature, are smaller, and produce fewer spores compared to a susceptible hybrid. The tissue surrounding the pustules may be distinctly pale-green or yellow. This resistance reduces the reproductive potential of the fungus, and rust will normally not become severe enough by the time the crop matures to cause significant damage. Mature leaves are often more resistant than young leaves. When rust starts developing before all leaves are developed and mature, even a hybrid that is normally resistant may develop enough rust to reduce yield.

In addition to checking the number and appearance of pustules in a field, a grower should also determine the resistance rating of the hybrid. This information may be available on the seed company’s Web site or in a catalog. If not, a grower should contact the seed dealer for this information.

Fungicides are an option for control of rust on hybrid field corn, but the cost should be considered carefully. The biggest uncertainties surrounding a decision to use a fungicide are the degree of resistance in the hybrid and the favorability of future weather for continued spread of rust. Weather forecasts for the next 10 days suggest that conditions will be generally favorable for rust, so if rust is established in a field and appears to be spreading, a fungicide should be considered.

There do not appear to be any well-worked out thresholds for deciding how much rust should be on a crop before a fungicide is justified. An article in the Pest Management and Crop Development Bulletin of the University of Illinois, dated 30 June 2000 <www.ipm.uiuc.edu/bulletin/pastpest/articles/200014h.html>, states that the whole-plant severity of rust should reach 15% within 2 weeks after silking to justify a fungicide, but the basis for this recommendation is not given. Seed corn producers use a much lower threshold—just a few pustules per plant—because inbreds are often much more susceptible than hybrids.

What does a severity of “15%” mean? Rust severity is a function of how many pustules occupy a unit area of leaf. A leaf covered with the maximum density of pustules has a severity of 100%. However, even on the most susceptible varieties and under the most favorable conditions, pustules can occupy only about 35% of the leaf area (the internal growth of the fungus extends beyond the region of sporulation and competition

between pustules limits their number). This level of rust—about 35% true leaf cover—is set at 100% and lesser amounts are rated accordingly. A severity of 15% over an entire plant is a lot of pustules, and my own feeling (without any real hard evidence from hybrid corn to back it up) is that this threshold may be too high.

Several fungicides are registered for use on corn. These include protectants such as mancozeb, maneb, and chlorothalonil (Bravo, Echo, Equus); and systemics such as propiconazole (Tilt, Propimax), azoxystrobin (Quadris), and a combination product of propiconazole and trifloxystrobin (Stratego). In a test we conducted on seed corn in 2000, only Quadris and an experimental fungicide chemically related to azoxystrobin showed curative activity against rust pustules that had already

erupted. Stratego was not evaluated in that test, but because it also contains a strobilurin fungicide, it may also have some curative activity. The other fungicides probably only protect against new infections. With any of these fungicides, it's important to apply them before rust pustules are too numerous. In that same seed corn trial in 2000, when an early application of Tilt (essentially no effect on rust) was followed by an application of Quadris at silking, by which time rust severity on the ear leaf was about 25%, the final severity of rust was only slightly less than severity on untreated corn and the yield was abysmal (7.8 bu / A). The same rate of Quadris applied at V11, when there were only a few pustules on the ear leaf, held rust severity to 5% and the yield was 44 bu / A.

Agronomy Tips

Yield Loss Potential During Grain Fill - (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 knee-high to about shoulder-high, or from about leaf stage V6 to V15. 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 determining time frame. Grain fill stages in corn are described in an accompanying article. Perfect conditions for ear size determination and pollinations can still 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) lightweight kernels, 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 that occurs 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, ear size has already been set. Only kernel weight can compensate in response to the lesser competition of a thinner stand.

Incomplete Kernel Set in Corn

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 shoot can completely mask even a 100 percent failure of pollination or severe kernel abortion.

One of the causes of incomplete kernel set is **unsuccessful pollination**. Unsuccessful pollination results in ovules that are never fertilized 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.

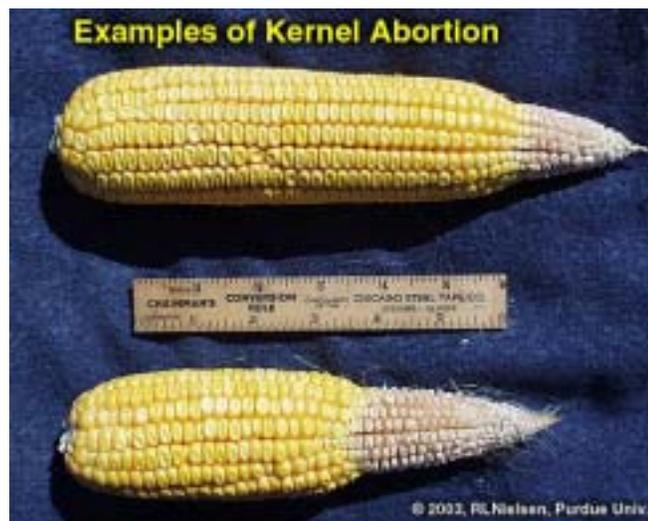
Certain insects like corn rootworm beetles and Japanese beetles can interfere with pollination and fertilization by their silk clipping action. These insects feed on pollen and subsequently clip silks as they feed on the pollen that has been captured by the silks. Unusually early or late pollinating 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 and become non-receptive to pollen germination.

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 are distinguished from unfertilized ovules in that aborted kernels had actually begun development. Aborted kernels will be shrunken, mostly white, often with the yellow embryo visible; compared to normal plump yellow kernels.

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 stage of development, further yield losses will occur mainly from reductions in kernel dry weight accumulation.



Examples of kernel abortion at tip of ears

Severe drought stress that continues into the early stages of kernel development (blister and milk stages) can easily abort developing kernels. Severe nutrient deficiencies (especially nitrogen) can also abort kernels if enough of the photosynthetic "factory" is damaged. Extensive loss of green leaf tissue by certain leaf diseases,



Closer view of aborted kernels

such as common rust or gray leaf spot, by the time pollination occurs may limit photosynthate production enough to cause kernel abortion. Consecutive days of heavily overcast, cloudy conditions may also reduce photosynthesis enough to cause abortion in recently fertilized ovules.

Decreased Kernel Weight

Severe stress during dough and dent stages of grain fill decreases grain yield primarily due to decreased kernel weights and is often caused by premature black layer formation in the kernels. 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 hail, insects, or disease early in grain fill; and killing fall frosts prior to normal black layer development.

Once grain has reached physiological maturity, stress will have no further physiological effect on final yield, because final yield is already achieved. Stalk and ear rots, however, can continue to develop after corn has reached physiological maturity and indirectly reduce grain yield.

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.

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.

Related References

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Grain Fill Stages in Corn - (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 will be 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 and lightweight grain, and encourage the development of stalk rot.

Kernel development proceeds through several relatively distinct stages (Ritchie et al., 1993).

Silking Stage (Growth Stage R1)

Some may argue whether silking should be labeled as a kernel growth stage, but nonetheless silk emergence is technically the first identifiable stage of the reproductive period. Silks remain receptive to pollen grain germination up to 10 days after silk emergence. Silk receptivity decreases rapidly after 10 days if pollination has not yet occurred. Natural senescence of silk tissue over time results in collapsed tissue that restricts continued growth of the pollen tube. Silk emergence usually occurs in close synchrony with pollen shed, so that duration of silk receptivity is normally not a concern. Failure of silks to emerge in the first place (for example, in response to silkballing or severe drought stress) does not bode well for successful pollination.



Kernel Blister Stage (Growth Stage R2)

About 10 to 14 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 is approximately 85 percent.



Kernel Milk Stage (R3)

About 18 to 22 days after silking, the kernels are mostly yellow and contain “milky” white fluid. The milk stage of development is the infamous “roasting

ear" stage, that stage where 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 is approximately 80 percent.



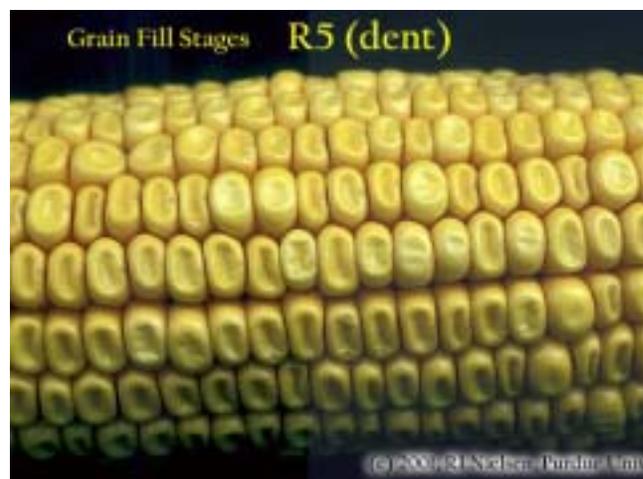
Kernel Dough Stage (R4)

About 24 to 28 days after silking, the kernel's milky inner fluid is 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 about 1/2 of the mature kernel dry weight is now in place. Kernel abortion is much less likely once kernels have reached early dough stage, but severe stress can continue to affect eventual yield by reducing kernel weight. Kernel moisture content is approximately 70 percent.



Kernel Dent Stage (R5)

About 35 to 42 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. A distinct horizontal line appears near the dent end of the 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. Severe stress can continue to limit kernel dry weight accumulation. Kernel moisture content at the beginning of the dent stage is approximately 55 percent.



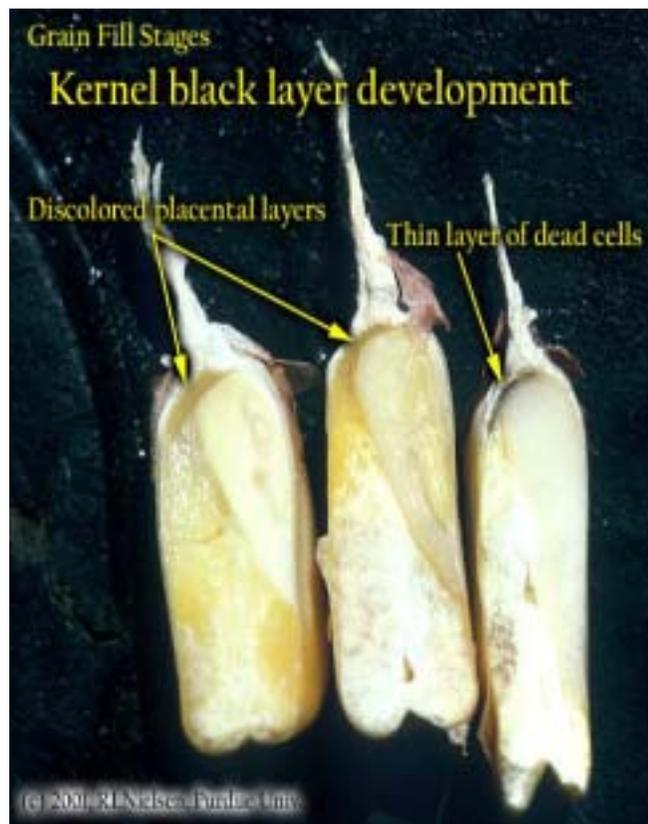
Physiological Maturity (R6)

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.

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.



Related References

Nielsen, R.L. (Bob). 2003a. **Silk Emergence.** Corny News Network, Purdue Univ. Online at <www.kingcorn.org/news/articles.03/Silks-0716.html>. (URL verified 7/5/04)

Nielsen, R.L. (Bob). 2003b. **Tassel Emergence & Pollen Shed.** Corny News Network, Purdue Univ. Online at <www.kingcorn.org/news/articles.03/Tassels-0716.html>. (URL verified 7/5/04)

Nielsen, R.L. (Bob). 2004. **Yield Loss Potential During Grain Fill.** Corny News Network, Purdue Univ. Online at <www.kingcorn.org/news/articles.04/GrainFillStress-0705.html>. (URL verified 7/5/04)

Ritchie, S.W., J.J. Hanway, and G.O. Benson. 1993. **How a Corn Plant Develops.** Iowa State Univ. Sp. Rpt. No. 48. Online at <<http://maize.agron.iastate.edu/corngrows.html>>. (last verified 7/5/04).

For other Corny News Network articles, browse through the CNN Archives at <www.kingcorn.org/news/index-cnn.html>.

For other information about corn, take a look at the Corn Growers' Guidebook at <www.kingcorn.org>.

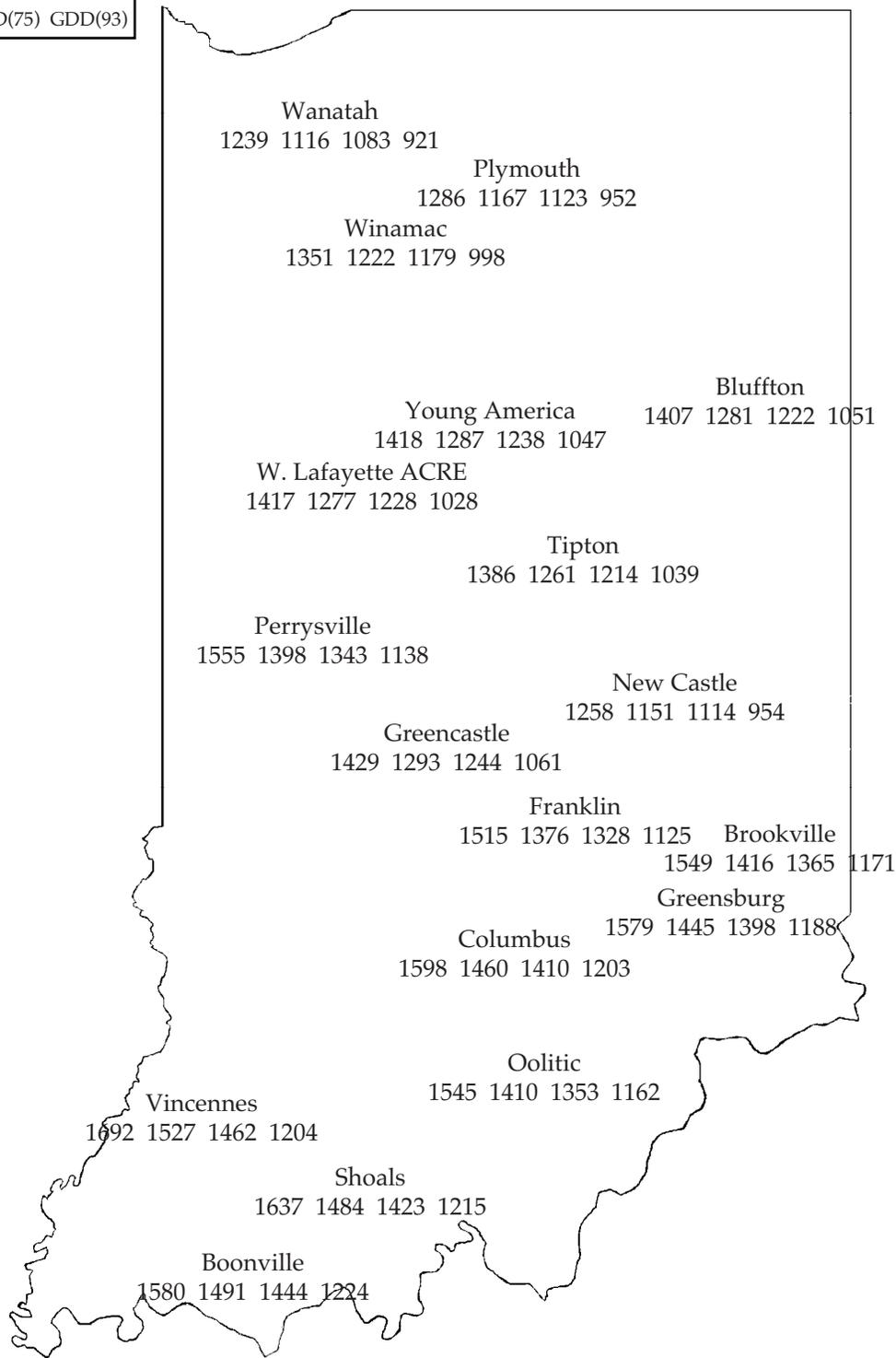
Weather Update

Temperatures as of July 7, 2004

GDD(5) = Growing Degree Days from April 7 (5% of Indiana's corn planted), for corn growth and development
 GDD(42) = Growing Degree Days from April 21 (42% of Indiana's corn planted), for corn growth and development
 GDD(75) = Growing Degree Days from April 30 (75% of Indiana's corn planted), for corn growth and development
 GDD(93) = Growing Degree Days from May 14 (93% of Indiana's corn planted), for corn growth and development

4" Bare Soil Temperatures 7/7/04

MAP KEY			
Location			
GDD(5)	GDD(42)	GDD(75)	GDD(93)



Location	Max.	Min.
Wanatah	89	71
Winamac	88	74
Bluffton	76	74
Chalmers	74	71
W Laf Acre	92	77
Tipton	84	75
Farmland	81	74
Perrysville	82	77
Crawfordsville	80	75
Liberty	92	72

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