North Central Ohio Agronomy Report
Erie Basin Extension Education & Research Area

Issue 8-11

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Dear Agricultural Producer:

Much of the earlier planted corn is now in the start of its "grand growth" stage where a new leaf collar emerges each two to three days and you can see the water marks on the stalks where stem elongation has occurred over night. This is some of the most impressive growth in the corn plant all season. You will find an article enclosed about the value of sunlight in crop yield potential. The information is very applicable to Ohio with the many cloudy days we have experienced during June. Rainfall patterns are becoming much more hit and miss as we get more summer weather.

Best regards,

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Helpful Links:
http://www.ipm.iastate.edu
http://agcrops.osu.edu
http://fcn.agronomy.psu.edu
http://precisionag.osu.edu
http://www.ipm.uiuc.edu
http://www.oardc.ohio-state.edu/ohiofieldcropdisease
http://www.entm.purdue.edu/Entomology/ext/targets/newslett.htm

NORTH CENTRAL OHIO AGRONOMY REPORT

A Few Thoughts on Postemergence Herbicide Applications

Tom Jordan, Bill Johnson, and Glen Nice, Botany and Plant Pathology
Purdue University Extension

To get the most out of a postemergence herbicide application, timing for weed height is critical. Most herbicide labels state that broadleaf weeds should be no more than 4 to 6 inches tall and grasses even smaller. That does not mean that you cannot spray taller weeds and be successful, but the taller the weed gets over label recommendation, the less the performance will be to your liking. Small weeds are easier to cover with an herbicide spray and their cuticles are thinner. Thus, more herbicide enters the plant. The taller the weed the less coverage you get, and the hotter and drier the conditions, the thicker the plant cuticles will be; thus the less efficacy you will get. Herbicide application timing is not always convenient to achieve, and some of the later emerging weeds may not fit the niche for a one-time postemergence application. You end up with some weeds being too tall, some not emerged, and some just right for the application. Did you ever wonder why an 18 inch to two foot or taller giant ragweed plant was so hard to control (let's not mention three to four feet tall)? The only way you got one that tall was to first have one three or four inches tall. The control of the small ones will always be greater than that of the taller ones.

In a year like this one, where heavy rains are sure to produce a multitude of late emerging weeds, it is imperative that scouting is done to identify individual weed species as they emerge and select the correct herbicide to control them. This may mean that you will need to make an additional application on a timely bases before the corn or beans are over the growth stage needed to ensure crop safety while catching the weeds at a small enough stage to get maximum weed control.

Timing for crop height is as critical as timing for weed height with postemergence herbicides when it comes to products like the plant growth regulators such as 2,4-D or dicamba and related herbicides or with amino acid inhibitor herbicides like the SU's and related products. Consider an area of about three square feet. When a corn plant is only about four inches tall, it occupies only a small portion of the area and the crop plant intercepts only a small fraction of the spray solution that covers that area. As the plant grows it occupied a much larger portion of the area and thus intercepts a higher quantity of the spray solution. These types of translocated herbicides move to the newly developing plant tissue in the crop plant. If brace roots are being developed, then an over application of a growth regulator herbicide can cause brace root damage. If the plant is three feet or taller it can act like a funnel and collect the spray solution directing it to the whorl of the plant where the newly developing tissue is likely to be the developing tassel or ear, where it could cause malformed tassels and or deformed ears.

Years in which crops are delayed due to heavy rains and flooding creates a difficult situation for weed control due to a number of weeds that would normally not be a problem in a field becoming more of a dominate problem. These weed will invariably germinate when you least want them to do so, causing your application timing to be off. Effort is needed to time postemergence herbicide application to control late emerging weeds while they are small and likewise not spray crop plants that are taller than the label recommends. Sometime this may call for drop nozzles.

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The Dirty Bakers' Dozen Weeds

Bill Johnson, Glenn Nice, and Tom Jordan, Botany and Plant Pathology
Purdue University Extension

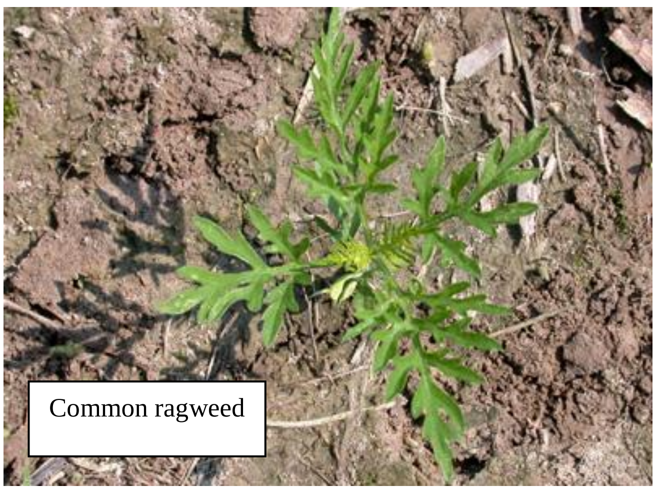
Ivy leaf morningglory

In a year like we have been experiencing, where heavy rains have delayed planting and the preemergence herbicides have been under pressure, we will in all likelihood see a number of weeds emerge in both corn and soybean fields. Some of the more common weeds that emerge late when preemergence herbicides have been subjected to heavy rains and particularly the grass component of the program has been weakened are:

1. Morningglories
2. Waterhemp
3. Burcucumber
4. Fall panicum
5. Common Ragweed
6. Giant Ragweed
7. Yellow Nutsedge
8. Shattercane
9. Crabgrass
10. Lambsquarters
11. Smartweeds
12. Nightshades
13. Barnyardgrass

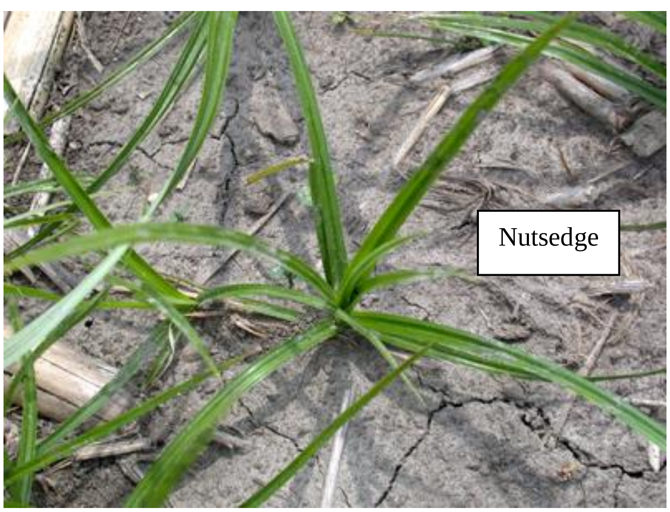
Waterhemp

Burcucumber in fence line



Common ragweed

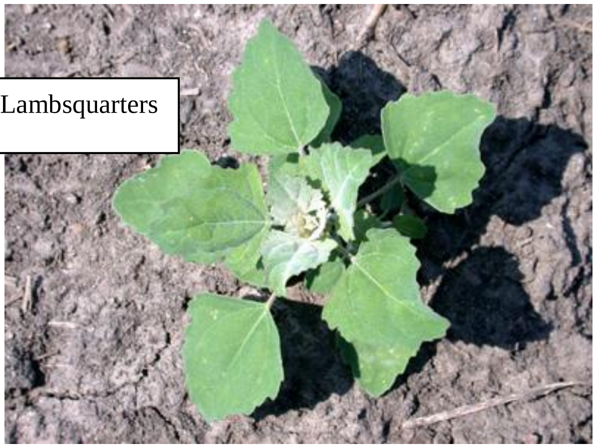
Giant ragweed



Nutsedge

Crabgrass

Several of these weeds not only emerge later in the season than our common weed populations, but they will also have multiple flushes throughout the first half of the growing season following each rain occurrence. A single application, or even a second application of glyphosate or Ignite may not be enough to control some of these weeds. Depending on the weed population mix in an individual field, additional herbicide choices may be needed to control these herbicides. There is a large choice of postemergence herbicides labeled for these weeds, but care is needed to make the right choice, and timing for weed height and corn growth stage in critical to make these herbicides work. This just may be the year to scout field for later emerging weeds and study the efficacy tables in the Weed Control Guide http://www.btny.purdue.edu/Pubs/WS/WS-16/ to select the proper herbicide that can control these late weeds. Sometime the application can be mixed with a standard post application, but this may be the year that an additional trip across the field is needed.


Lambsquarters


Smartweed


Nightshade

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Prevalence and Influence of Stalk Boring Insects on Glyphosate Activity on Indiana and Michigan Giant Ragweed

Bill Johnson, Glenn Nice, Botany and Plant Pathology
John Obermeyer, Entomology
Corey Gerber, Agronomy Department
Purdue University Extension

This article is a summary of a scientific study we published in the journal Weed Technology in 2007. If you want to read the leaded, full bodied version, see this citation: Ott, E. J., C. K. Gerber, D. B. Harder, C. L. Sprague, and W. G. Johnson. 2007. Prevalence and influence of stalk boring insects on glyphosate activity on Indiana and Michigan giant ragweed (Ambrosia trifida). Weed Technol. 21:526-531.

Introduction: Giant ragweed (GRW) plants have been shown to serve as a host to stalk boring insects (SBIs) such as the European corn borer (ECB), the stalk borer, the celery leaftier, the cocklebur weevil, the ragweed borer, and a longhorn beetle. In addition, we receive many questions regarding the influence of SBIs on glyphosate activity as well as the biology of SBIs that utilize GRW as a host. The objectives of this article is to report on some of the previous work we have done to 1) determine the prevalence, distribution and identity of SBIs in GRW at various times during the growing season in Indiana and Michigan, and 2) determine the influence of ECB, giant ragweed size, glyphosate rate, and spray carrier volume on GRW control with glyphosate under greenhouse conditions.

Materials and Methods: ***Field Survey.*** Four regions in Indiana (northeast, northwest, central, and southwest), and three regions in Michigan (central, southeast, and southwest) were surveyed once in August 2004 and once in June, August, and September of 2005. In each region, five random soybean fields where GRW plants were present at the time of sampling were selected arbitrarily for observations. In June 2005, five GRW plants 1-foot tall, and five GRW plants larger than 1 foot (up to 2 foot tall) were collected from each field and dissected to determine if SBIs or SBI tunnels were present. During the mid-August and mid-September sampling time, ten GRW plants protruding above the soybean canopy were arbitrarily collected from each field. Individual plant heights were recorded, and a visual subjective assessment was made regarding whether or not the GRW plant had escaped control with glyphosate. These plants were also dissected to determine if SBIs or SBI tunnels were present. During each of the sampling times, if SBIs were found, the insects were collected and preserved in vials containing 70% isopropyl alcohol. Insect specimens were identified with a dissecting microscope to the family level.

Greenhouse Study: GRW seedlings (1- to 2-inches tall) were collected from the Purdue University Agronomy Center for Research and Education near West Lafayette, Indiana and transplanted into pots with growth media. Pots were placed in the greenhouse under supplemental lights. When GRW plants were 4-inches tall, 2 to 4 newly hatched ECB larvae were placed on designated plants. The plants were sprayed with glyphosate when they were either 6- or 18-inches tall with various glyphosate rates (0, 0.38, 0.75, or1.5 lb ae/A), and spray carrier volumes (10 or 20 GPA). Ammonium sulfate was included in each glyphosate treatment. At 21 days after glyphosate treatment, all GRW plants were dissected to confirm ECB tunneling in the desired plants, and dried before dry weights were recorded.

Results and Discussion: ***Prevalence of SBIs and Tunneling in GRW:*** In August 2004, SBI tunneling was observed in 66 to 79% of the GRW plants examined in Indiana, and 35 to 64% of GRW plants examined in Michigan. In June 2005, SBIs and tunneling were observed in 10 to 26% of all GRW plants examined in Indiana and 4 to 30% of all GRW plants examined in Michigan. In August 2005, 54 to 88% of Indiana GRW plants and 48 to 70% of Michigan GRW plants exhibited SBI tunneling. In September 2005, 76 to 94% of all GRW plants examined in Indiana contained SBI tunneling, whereas 64 to 74% of all GRW plants sampled in Michigan contained SBI tunneling. During the August and September sample times, SBIs were found in 8 to 42% of the plants with SBI tunnels, suggesting that the SBIs previously present in GRW stems had completed larval development, pupated and emerged as adults from the GRW plants. Overall, insect tunneling and infestation levels were similar in both states in June. Slightly higher percentages of GRW plants contained insect tunnels in Indiana during the August and September surveys as compared to Michigan. Throughout the growing season, six SBI families were identified, three families from the order Coleoptera, and three families from the order Lepidoptera.

Frequency of Late-Season GRW Escapes with SBIs or SBI Tunneling: The percentage of GRW plants that survived a herbicide application and contained SBIs and/or SBI tunnels ranged from 28 to 40% in Indiana in August 2004. In Michigan during this same sample time, only 5 to 31% of GRW plants displayed herbicide injury and contained evidence of SBIs and/or SBI tunneling. Based on surveys, in August 2005, 28 to 62% of GRW escaped herbicide application in Indiana and contained evidence of SBI activity. Higher percentages of GRW plants with SBI tunnels survived a herbicide application in 5 out of 8 regions in 2004 and 5 out of 5 regions in 2005.

Greenhouse study: Glyphosate efficacy on 6-inch tall GRW plants was enhanced by ECB activity at the 0.38 and 0.75 lb ae/A rate at both carrier volumes. This occurrence is likely due to the following reason. The glyphosate treatments to 6-inch GRW were applied 5 to 7 days after the ECB were placed on the plants, at which time the plants were under considerable stress from the initial boring of the ECB into the small plant stems. Glyphosate efficacy at the 1.5 lb ae/A rate was not influenced by ECB activity. Results from the control of 18-inch plants did not show significant carrier volume effects. Glyphosate efficacy was reduced by the presence of ECB activity on 18-inch tall plants at the 0.38 and 0.75 lb ae/A rate (Table 2), but not at the 1.5 lb ae/A rate. Glyphosate had little effect on 18-inch tall plants with ECB activity at the 0.33 lb ae/A rate. On 18-inch tall plants, utilization of the 0.75 or 1.5 lb ae/A rates provided better control than the 0.38 lb ae/A rate.

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In summary, multiple insect families were found to utilize GRW plants as a host during the time window when the initial postemergence glyphosate applications were being made to soybeans in June of 2005. Although our survey did not determine if SBIs infested GRW before or after initial glyphosate applications were made, the possibility of SBI's having a negative influence on glyphosate efficacy is plausible based on the results of our greenhouse study. Five different insect families were identified at the

August sample times and is likely that they infest GRW after the initial postemergence glyphosate applications. However, they may have infested GRW before rescue sprays were made in July. Control failures with July applications could be due to a number of causes including environmental factors, inadequate rates for the large plants typically present during this spray timing, poor spray coverage of lower leaves due to the soybean canopy, and the high percentage of plants which contain SBIs and/or SBI tunnels.

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Alfalfa: Fertilize Annually

Information from Alfalfa Management Guide
North Central Regional Extension Publication

Determine needs

Alfalfa has a relatively high demand for some nutrients compared to other commonly grown crops. Each ton of alfalfa dry matter harvested removes about 14 pounds of phosphate (P_2O_5) and 58 pounds of potash (K_2O). This is the nutrient equivalent of 150 pounds of a 0-10-40 fertilizer. Each ton of alfalfa also removes the calcium and magnesium found in about 100 pounds of aglime. See table 4 for a complete list of nutrients removed. Since many of these nutrients are supplied from the native soil reserves, basing a fertility program on removals is not recommended.

Table 4. Pounds of nutrient removed per ton of alfalfa produced, dry matter basis.

nutrient	dry matter removed (lb/ton)
phosphorus (P)	6
phosphate (P_2O_5)	14
potassium (K)	48
potash (K_2O)	58
calcium (Ca)	30
magnesium (Mg)	6
sulfur (S)	6
boron (B)	0.08
manganese (Mn)	0.12
iron (Fe)	0.33
zinc (Zn)	0.05
copper (Cu)	0.01
molybdenum (Mo)	0.002

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Corn Development (Mid to Late Vegetative Stages)

Ohio State University Extension

Ear Initiation

There are as many potential ears as there are leaves on the plant since every stalk node has an axillary meristematic bud associated with it. While axillary buds exist at the upper six to eight nodes of the stalk, they normally never become active.

Careful dissection of stalks at about growth stage V10 will reveal 8 to 10 ear shoots above ground. Each ear shoot is attached at a stalk node, behind its respective leaf sheath. A single groove is visible on the side of a stalk segment (internode) that contains an ear shoot. At growth stage V10, the identifiable ear shoots are composed primarily of husk leaf tissue. The developing ears themselves are only a fraction of an inch in length at this time.

Initially, the lower ear shoots are bigger than the upper ones because the lower ones form first. Later on, the upper one or two ear shoots take priority over the others and become the harvestable ears. Development of the upper ear is favored over the lower ones because of hormonal "checks and balances", plus the proximity of the upper ear to the actively photosynthesizing leaves. Brace root development will rip off ear shoots at the lowest stalk nodes.

The uppermost, harvestable ear will normally be located at the 12th to 14th leaf. Damage to the upper ear prior to pollination will allow one or more of the lower ones to develop into the harvestable ear.

Ear Size Determination

Potential ear size (number of ovules) is an important factor that contributes to the grain yield potential of a corn plant. Severe plant stress may limit the potential ear size, and thus grain yield potential, before pollination has even occurred. Optimum growing conditions set the stage for maximum ear size potential and exceptional grain yields at harvest time. Ear size determination begins by the time a corn plant has reached knee-high and finishes 7 to 10 days prior to silk emergence.

Ear size is defined by the number of kernel rows per ear, the number of kernels per row and the weight per kernel. Total kernel number is determined by the number of kernel rows and the number of kernels per row.

Growth Stage V10 Until About 7 Days From Silk Emergence

1. Many ear shoots visible upon dissection at growth stage V10
    a. An ear shoot will develop at each above-ground stem node (joint) except the top 6 or 8
    b. Lower ear shoots develop first and are initially bigger than the upper ear shoots
    c. However, usually only topmost ear shoot will produce a harvestable ear

2. Potential ear size is determined during a 3 week period
    a. Kernel row number per ear is determined during V10 to V12
    b. Kernel potential per row (ear length) is determined from growth stage V12 to about 1 week before silking
    c. Stress during this period can reduce potential row number or kernels per row
        1) Every pair of rows equals about 20 bu/ac (assuming 40 kernel/row)
        2) Losing 1 kernel/row equals about 4.5 bu/ac (assuming 16 rows/ear)

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Soybean Growth and Development: R1 Stage: Beginning Flowering

Information from Soybean Growth and Development
Iowa State University Extension

R1 – One open flower at any node on the main stem: At R1, vertical root growth rates sharply increase and stay relatively high through R4 to R5 stage. Proliferation of secondary roots and root hairs within the top 0 to 9 inches of soil is extensive during this period, but roots in this zone generally begin to degenerate thereafter.

Plants at R1 are 15 to 18 inches tall and are in the V7 to V10 stage. In each axil, an axillary bud is present. Depending on the environment, this bud may develop into a branch, a flower cluster, or fail to develop. Flowering begins on the third to sixth nodes of the main stem, depending on the V stage at the time of flowering, and progresses upward and downward.

The branches begin flowering a few days later than those on the main stem. Flowering on a raceme occurs from the base to the tip. Basal raceme pods are always more mature than pods from the raceme tip. Flowering and pod set occur most often on primary racemes, but secondary racemes may develop to the side of the primary raceme in the same axil. The appearance of new flowers peaks midway between R2 and R3, and is nearly complete by R5.

Flower petals are purple or white and flowers are normally self-pollinated with less than one percent natural crossing. The flowering period of the indeterminate varieties is three to four weeks. This period usually begins six to eight weeks after seedling emergence. However, flowering may occur earlier if planted late.

Warm temperatures accelerate development, especially flowering. A full season soybean variety in Iowa will normally flower in the first 10 days of July. If there is a hot period in mid June, it can flower up to two weeks earlier. When this happens, and if there is good weather for the rest of the season, higher yields result because of the extended reproductive period. The soybean my flower 10 days earlier but it won’t necessarily mature 10 days earlier because of daylength controls. Generally, yield increases as the length of the flowering to maturity stage increases.

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Using Soil Test Results for More Than Just Nutrient

Figure 1. Variation in seedling size between healthy and affected seedlings (Photo credit: J Thomsen)

Recommendations

Amber Radatz, Nutrient Management Outreach Specialist with assistance from John Peters and Matt Ruark, of The Department of Soil Science, UW Madison and Dennis Frame of UW Discovery Farms
University of Wisconsin - Madison

Results from soil tests continue to be one of the most important indicators of current soil fertility and a great source of information when determining nutrient recommendations for an upcoming crop. Recently, soil test results are being used as a way for a renter to show the landlord positive change or maintenance in soil fertility levels throughout the life of a land lease. It's important to be very careful when using soil tests for these situations. An acre of soil to a 6-inch depth weighs about 1,000 tons, yet less than 1 ounce of soil is used for each test in the laboratory. Therefore, it is very important that the soil sample is representative of the entire field. Variability can result from a number of factors including: from the number of cores taken, the depth cores are taken from, time of year, and field moisture conditions.

Even though soil tests remain one of the most useful and basic crop and soil management tools we have, it is important to understand the limitations of the results for both accuracy and potential uses. Soil tests effectively distinguish soils with low and high probabilities of crop response for most nutrients (Bruulsema, 2004). The actual number presented to you on your soil test results sheet should be used to gauge that probability of crop response, and not necessarily as a finite value where one number is tremendously better or worse than another.

Here are some links to helpful resources with further information on the variability that might be present in your soil test results:
Effect of sampling time on soil test potassium levels, presented at 2010 Wisconsin Crop Management Conference: **http://fyi.uwex.edu/discoveryfarms/files/2011/06/Vitko-k-variability.pdf** , Vitko, Laboski, Andraski

Why are soil test potassium levels so variable over time in the Corn Belt?, International Plant Nutrition Institute website, Murrell : **http://fyi.uwex.edu/discoveryfarms/files/2011/06/murrell-k-variability.pdf**

Seasonal variability in soil test potassium, presented at 2005 Wisconsin Crop Management Conference, Laboski : **http://fyi.uwex.edu/discoveryfarms/files/2011/06/Laboski-k-variability.pdf**

Understanding the science behind fertilizer recommendations, International Plant Nutrition Institute website, Bruulsema : **http://fyi.uwex.edu/discoveryfarms/files/2011/06/fertilizer-and-soil-tests-bruulsema.pdf**

An excerpt from "Agronomic and Environmental Implication of Phosphorus Management Practices", Mallarino, Bundy : **http://fyi.uwex.edu/discoveryfarms/files/2011/06/An-excerpt-from-bundy.pdf**

Sampling soils for testing, UW Extension Publication #A2100, Peters, Laboski, Bundy : **http://fyi.uwex.edu/discoveryfarms/files/2011/06/A2100.pdf**

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Improving Soil Production Capacity and Resiliency

Dan Rossman, County Director for Gratiot County, Michigan
Michigan State University Extension

Organic matter aids in soil productivity through influencing nutrient cycling, water dynamics and soil structure.

This is a very exciting time in agriculture with advances in seed technology, new uses for corn and soybeans and soaring commodity prices. This is also a very risky time in agriculture with increasing costs for land, fuel, fertilizer, feed and other inputs. Part of a strategy to reduce your risk should include rigorous attention to the fertility and health of your soil.

It is basic to have your soil tested for pH, phosphorus and potassium at least once every three years. This will avoid problems with both yield losses due to deficiencies and money lost due to over applications. If your pH is high, then soil tests for zinc and manganese is recommended. Cleaner air emissions from industry have reduced sulfur in the rainfall and will likely be a bigger concern, especially on lighter sandier soils. Nitrate testing at sidedress time can also help fine-tune your nitrogen program. Getting your nutrient levels in order is very important to ensure good crop yields, but it does not stop there. For years we have over-looked possibly the most vital part of soil fertility and soil quality, which is the organic matter.

Organic matter is the vast assortment of carbon compounds in your soil. The compounds are the products of living organisms, like plants, animals and microbes. Nutrients are held in the soil by exchange sites on clays and organic particles. Organic matter can hold five times more nutrients than clay. As organic matter increases, a greater pool of nutrients can be held in the soil and be available for plants. Organic matter improves both water infiltration and water holding capacity of the soil. Acting like a sponge, it will absorb six times its weight in water. This is very valuable in years with dry summers like 2007.

Soil compaction can greatly reduce yields and increase tillage costs. Organic matter supports soil microbes that create substances that act as glues to form aggregates of smaller soil particles. These soil aggregates are what is important to provide good soil structure and soil tilth. With good soil structure, you get favorable pores for soil moisture and air. These pore spaces also provide an ideal conduit for plant roots to grow and thrive. The better the soil structure, the better the soil will hold up during adverse times with excessive soil moisture. A bonus effect would be reduced soil erosion. A couple of other benefits of organic matter include a quicker soil warm-up because of the darker soil color organic matter provides and the potential of supporting more beneficial organisms reducing plant pests and diseases.

Soil health cannot be improved over night, but the practices you do on your farm in regard to organic matter can have a dramatic effect on the future of your soil’s production capacity and resiliency. You can improve soil organic matter basically by two ways: adding more organic matter, and not losing the organic matter that you already have.

You can add organic matter by growing productive, healthy crops in a diverse rotation. Include in the rotation crops that produce a lot of roots, such as small grains and forages, and crops that produce lots of above ground residue, such as corn. Also include cover crops that will supply both, such as clover and rye. In all cases, limit the crop residue removal and leave it to add to the soil organic matter reservoir.

The loss of organic matter occurs primarily by two methods: tillage and erosion. Minimal tillage and no-till systems, cover crops, crop residues on the soil surface, filter strips and wind breaks are all examples that will reduce organic matter loss.

Not everything will fit into your farming operation. It is important to assess the condition of your farm’s soil and then consider those practices that make sense for you. Talk over ideas with others and gain from their experience. Put a plan together that you can follow, evaluate the practices that you change and fine tune your plan each year. Over time you can make a big difference in you soil’s production capacity and resiliency.

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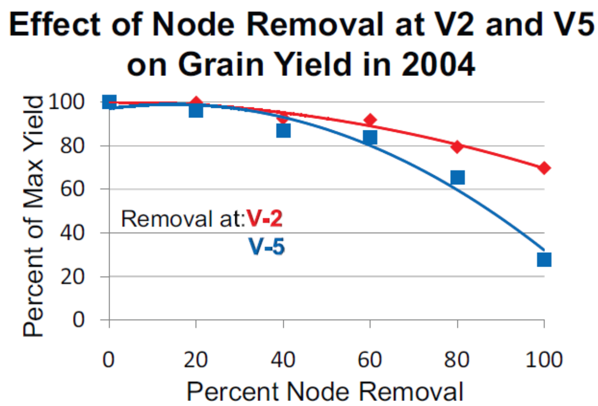
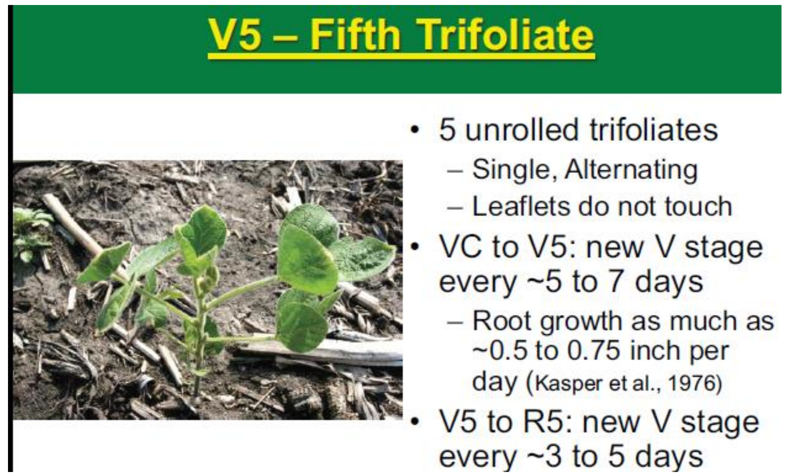
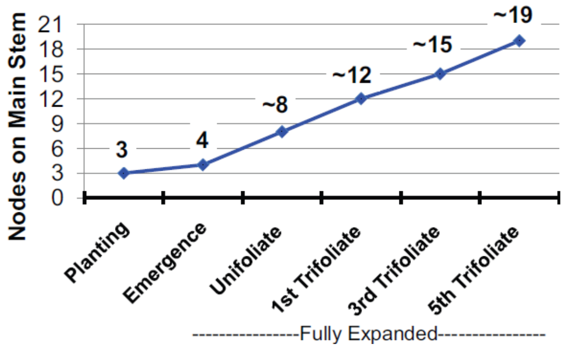
Soybean Physiology: How Well Do You Know Soybeans?

Shaun Casteel, Soybean Extension Specialist
Charts from Soybean Station Powerpoint
Purdue University



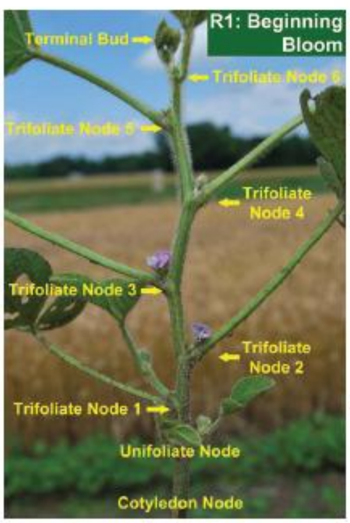


of Nodes Initiated on Main Stem



Reproductive Stages
R1: Beginning Bloom
R2: Full Bloom
R3: Beginning Pod
R4: Full Pod
R5: Beginning Seed
R6: Full Seed
R7: Beginning Maturity
R8: Full Maturity

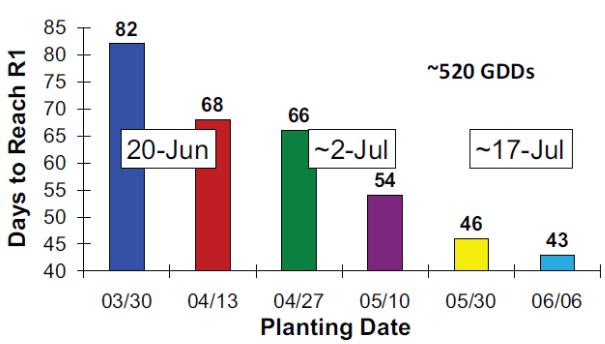
R1: Beginning Bloom



~Days to R7 - 70

- Open flower at **any node on the main stem**
- Flowering begins at 3rd to 6th node (V6 to V10 stage)
- Flowering period is 3 to 4 wk
  - Begins ~6 to 8 wk after emergence
  - Peaks R2 to R3; ends ~R5
- **Vertical root growth rates increase rapidly**
  - As much as 1.3 to 3.2 in/day (Kasper et al., 1976)

of Days from Planting to R1



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The Importance of Sunlight

Emerson Nafziger
University of Illinois Extension

Warm temperatures have helped bring the corn crop along nicely in Illinois, at least in fields and parts of fields where the plants have stayed above water. As we pass the longest day of the year in the northern hemisphere (June 21), with its maximum amount of sunlight, it's a good time to think about sunlight and its effect on the crop.

If we think of the crop as a yield-producing factory, sunlight is the fuel that powers it. But this is a factory that has to build itself. As leaves emerge from the whorls and green up as they open to the sunlight, they start to photosynthesize, producing the sugars that fuel all crop growth and yield. This in turn helps leaves and the rest of the plant to grow (add dry matter), helping the factory pick up speed. The factory needs to be at full speed, with a full light-gathering "roof" (crop canopy) by pollination time in order to produce maximum grain yields.

So the development of leaf area, collectively called the crop canopy, is critical to the growth process. We often say that the canopy "closes" at the time when we can't see soil anymore as we look down the rows from the end; the canopy seems to form a solid surface that covers the field. In 30-inch rows, this happens when the crop is about waist-high, generally at about stage V10. Fields planted in April or early May are at or nearing this stage now.

Though canopy closure would seem to be the point at which the crop begins to intercept all of the sunlight, that is not the case: a single leaf lets some of the light pass through, and leaves are not evenly distributed, so some amount sunlight is still reaching the ground. Plants need to develop a "leaf area index"--square feet of leaf per square foot of ground area--of 3 or more before the crop intercepts more than 95% of sunlight. In corn, this happens only when the crop is tasseled, at which time its exposed leaf area is close to the maximum.

Because the crop is growing so rapidly by stage V8 to V9, corn in narrow or twin rows does not have a very large or lasting advantage over 30-inch rows in the rate at which they increase leaf area and sunlight interception. While any such advantage is often positive, the difference in total sunlight intercepted by wide and narrow by the time plants reach full canopy is relatively minor--less than 10 percent. Pollination success and yield are determined after full canopy, and by then there is often no difference in light interception between wide-row and narrow-row corn.

Because sunlight is the driving force for all crop growth, there is considerable concern about the amount of sunlight and whether it may limit yields. The Water and Atmospheric Monitoring (WARM) program of the Illinois State Water Survey publishes monthly data on sunlight at a number of Illinois locations - **http://www.isws.illinois.edu/warm/datalist.asp** . The sunlight data are in a column headed "Total Solar Rad" with units of megajoules per square meter.

A megajoule (MJ) is a unit of energy equal to about 240 kilocalories or 0.28 kilowatt-hours. A square meter is about 10.7 square feet. The maximum sunlight received during a summer is about 32 MJ/square meter, and daily averages are typically about 3/4 of the maximum. In more familiar units, 30 MJ/square meter received on a sunny day is about 670 kcal/square foot or about 3/4 of a kilowatt-hour per square foot. That amount of sunlight energy is the equivalent of 33 megawatt-hours of electrical power per acre; in terms of chemical energy, it is the equivalent of some 14 tons of sugar per acre.

Table 1. Summer monthly totals of sunlight received at Champaign, Illinois, 2008-2010.

Month	MJ/m*m		
	2008	2009	2010
June	753	680	720
July	741	667	730
August	684	617	731
Total	2,178	1,964	2,181

Source: www.isws.illinois.edu/warm/datalist.asp.

Only about half the energy in sunlight is in the visible wavelengths; most of the rest is infrared (heat) or ultraviolet and is "invisible" to both our eye and to plants. Plants intercept more red and blue light than green light; they reflect or transmit much of the green light and so appear green. For a variety of reasons, the plant cannot convert sunlight to sugars with high efficiency. In fact, on a good day the plant will typically convert only about 2% of the sunlight energy into dry matter. But with so much energy falling on an acre in a season, very high yields are still possible.

Of the three most recent crop seasons, 2008 and 2010 had high sunlight and 2009 had low (Table 1), with the total over three months in 2009 about 10% less than the totals in the two high-sunlight years. In these three years, yields were highest in 2008 and lowest in 2010. In 2004, the highest average yield on record in Illinois came with only 1,987 MJ/square meters of sunlight over these three months, about the same as in 2009. So it's clear that while sunlight has an effect on productivity, it appears to be less important than temperature and rainfall. These factors are all correlated to some extent, making it difficult to single out the most important factor in determining yield.

Corn planted this year at the end of March at Urbana is at stage V12 and about chin-high now. The late-May planting is at V4 and less than a foot tall. Clearly, the amounts of sunlight that these two canopies will intercept during these longest days of the year differ vastly. But if the season lasts long enough and there is little water stress, the late-planted crop can still intercept enough sunlight to yield 80% or more of the early-planted crop. Both need careful attention to limit stresses and to keep the canopy in top shape in order to reach their potential.

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