Mid-Atlantic Regional Agronomist Quarterly Newsletter

June 2006

Dr. Richard W. Taylor, Editor
rtaylor@udel.edu
University of Delaware

Supporting Agronomists:
Dr. Wade Thomason, Va Tech
Dr. Bob Kratochvil, University of Maryland
Dr. Greg Roth, Penn State
Dr. Greg Binford, University of Delaware
Dr. Peter Thomison, Ohio State University
With Special Contributions from Molly Hamilton and
Colleagues at North Carolina State University

To subscribe or unsubscribe, please send your request to the editor at rtaylor@udel.edu
Comments, suggestions, and articles will be much appreciated and should be submitted at your earliest convenience or at least two weeks before the following dates: Jan. 31, April 30, July31, and October 31.

Table of Contents

Issue 1; Number 2

Factors Influencing the Probability of Residual Nitrogen Availability for Commodity Small Grain Cover Crop

Dr. Bob Kratochvil
Extension Specialist – Grain and Oil Crops
University of Maryland
Email: rkratoch@umd.edu

Maryland Department of Agriculture recently announced the addition of a commodity small grain component for their 2006-2007 cover crop programs. This will create a dual-purpose role (cover crop during the fall and winter; commodity grain crop during the spring) for small grains. To qualify for the $20 payment, farmers must not apply any fall nitrogen (N) when planting their small grain and they cannot apply spring nitrogen until March 1. Managing small grain this way has farmers questioning if a significant yield loss will occur if the usual practice of applying fall N for many of them is not followed. Additionally, they are asking if any residual N prediction tools other than a time-consuming soil test are available to help make the decision.

Many small grain farmers in the Mid-Atlantic routinely apply 15 - 30 lb N per acre with no consideration for the residual N that may be present when they plant either winter wheat or winter barley. Previous research conducted by Dr. Frank Coale and Dr. Robert Kratochvil (separate projects at the University of Maryland) indicated that small grain crops do not always demonstrate a yield response to fall N applications indicating that there are instances when residual N must be adequate for starting a small grain crop.

Though there are no field-tested prediction mechanisms for residual N other than a soil test currently available, there are a number of factors that producers can consider that may help them make the decision to participate in the commodity cover crop program. Additionally, with the rising cost of N, it is not just farmers interested in this new MD program who have interest in factors for assessing the probability that adequate residual N is available for starting small grains.

- **Soil type**

  Soils in the region are highly variable ranging from those that are quite sandy to those that are more silty or clayey in texture. Soil texture can affect a field's yield potential since it is directly responsible for water holding capacity and the ability to retain N. We all know that fields with sandier soils experience drought conditions earlier during dry periods and will exhibit crop N deficiency symptoms much sooner during periods of excessive rainfall than fields that have silty or clayey soil textures. The probability that residual N will be available for a fall planted small grain increases as the soil texture increases in its silt and clay content.

- **Previous crop and its yield**

  <u>Corn</u>—If a field of corn attained its yield goal, there is an increased probability that little or no residual N will be available for a small grain crop. However, there are often years when a field does not attain its yield goal due to a variety of factors (stresses) that affect crop growth and development and ultimately keeps the crop from consuming all the N with which it was supplied. For either case, the probability of residual N remaining cannot be solely predicted by the yield attained by the corn crop (see other factors below).

  <u>Soybean</u>—Soybean is a legume, i.e. it is capable of supplying its N requirement via N_2 fixation through a symbiotic relationship with a soil bacterium, *Bradyrhizobium japonicum*. A small grain planted after a soybean crop has a realistic probability of obtaining the N it requires from residual N that was not utilized by the soybean crop. And, the likelihood of residual N being available in the fall for a small grain will increase directly with the yield attained by the preceding soybean crop. The availability of fall residual N for a small grain crop should only be considered present for full-season or single-cropped soybeans. A double-crop soybean crop is generally harvested later than the optimum planting window for small grain reducing the commodity grain yield potential for the wheat or barley.

- **Precipitation received during preceding crop**

  Excessive total rainfall during the growing season for corn will decrease the probability that any residual N will remain after the corn is harvested. And, this probability decreases more the sandier the soil is for a field. Contrary to the excessive rainfall situation is a prolonged drought during the growing season that will affect growth and development of the crop. Slowed growth will reduce the N amount used by the crop and increase the probability that residual N is present following corn harvest. For soybean, both excessively wet and dry conditions will affect the probability that residual N for small grain fall planting is present. Both weather conditions generally cause stresses that impact soybean growth and development. Slower growth and development will reduce the amount of N_2 fixation that occurs reducing the probability of adequate residual N for small grain planting.

- **Amount of N supplied the preceding corn crop**

  Corn should be supplied N based upon the realistic yield goal for each field where it is grown. In situations where that yield goal is either over-estimated or crop stress did not allow the yield goal to be attained, there is a greater probability that residual N remains after the crop is harvested. If either the yield goal is under-estimated or if excellent growing conditions are realized during the crop year, there is a decreased probability that residual N will be available for a small grain crop.

- **Timing of N applications for the preceding corn crop**

  Corn should be supplied its nitrogen in a split application with approximately 20% of its total requirement supplied as a starter fertilizer and the remainder supplied in a side-dress application when the corn reaches the 5-8 leaf stage (~ 6-weeks after planting). Supplying N in this manner minimizes the potential for early season leaching loss of nitrogen during wetter than normal springs and guarantees that an adequate amount of N will be available during the rapid vegetative growth stages for the crop. In situations where 50% or more of the N is supplied prior to or at corn planting, there is a decreased probability that residual N will be available for fall planting of small grain.

- **Small grain planting date**

  It is recommended that winter wheat in Maryland not be planted until the Hessian fly-free date has passed. This date ranges from very late September in Washington County, Maryland to approximately October 12 on the Lower Eastern Shore of Maryland. Optimum yield will generally be realized when wheat is planted within a 3-week window following the respective fly-free date. The factors mentioned previously should all be considered for deciding the probability that residual N remains for starting wheat that is planted during the optimum window. If wheat is planted after the optimum window, it is recommended that no fall N be supplied since seedling growth will be relatively slow due to colder temperatures that occur as we proceed through the fall season. For barley, all factors previously mentioned for wheat should be considered. Initial planting date for barley can be approximately 1-week earlier than wheat.

And, regarding an alternative to a soil test for predicting residual N availability for wheat after corn, for the past two years, Maryland Grain Producers Utilization Board have funded a project for my Cropping Systems program that is evaluating potential prediction tools. During 2005-2006, an evaluation of the corn stalk nitrate test (CSNT) for predicting residual N is being conducted at four sites in Maryland. The CSNT was developed in the mid-west as a tool to determine if adequate N was supplied to attain optimum corn yield in a field. The hypothesis for my research is: if the CSNT can predict when adequate N was available for a corn crop, it also may predict if enough residual N remains to support the succeeding small grain crop without fall N.

During 2005, corn was fertilized at rates considered deficient, optimum, and excessive. At physiological maturity, corn stalk segments 8” long and cut 6” from the soil surface were collected and analyzed for nitrate content. Soil samples taken to a depth of 1 foot were collected after the corn was harvested and analyzed for soil-nitrate concentration. A good association between corn stalk nitrate concentration and soil nitrate concentration (R value = 0.64, n=96) was observed between corn stalk and soil nitrate concentrations. Wheat was planted on all sites during fall 2005. Each plot was split with one-half receiving 30 lb fall N and the other half getting no fall N. Yield measurements will be attained when the wheat is harvested during late June-early July 2006 and complete the first year assessment.

To determine if there is a more farmer-friendly tool for predicting residual N availability for wheat after corn than the CSNT, this project has been expanded during 2006-2007 to include three other techniques for measuring corn N use status. This summer, ear leaf chlorophyll content from pollination to black layer formation (~10 day intervals) will be measured on corn plots that will receive four different N rates ranging from deficient to excessive. During this same period, the number of green leaves below the ear will be counted. Additionally, a Green Seeker Optical Sensor will be used to optically measure N status in the corn crop for the same period. These measurements will be correlated with corn stalk and soil nitrate concentrations and finally with the wheat yield attained during 2007 with and without fall N to evaluate the potential for these prediction tools to assess residual N availability for planting wheat after corn. If this project is successful, there may soon be a yes/no way to predict the need for fall N for a small grain crop following corn.

Appropriate Seeding Rates for Hulless Barley in the Mid-Atlantic

Dr. Wade Thomason
Extension Agronomist – Grain Crops
Virginia Tech
Email: wthomaso@vt.edu

Introduction:

In an effort to recapture a share of this feed market, there has been an emphasis placed on the development of the more energy-dense hulless type of barley. Meanwhile, increased interest in the use of hulless barley cultivars in the manufacturing of food and fuel products has accentuated the desire to develop winter hulless barley varieties for both domestic and foreign markets. Hulless barley grows and looks like traditional barley until nearly mature. The glumes of hulless barley begin to separate from the seed when almost mature and become totally separated when the grain is combined.

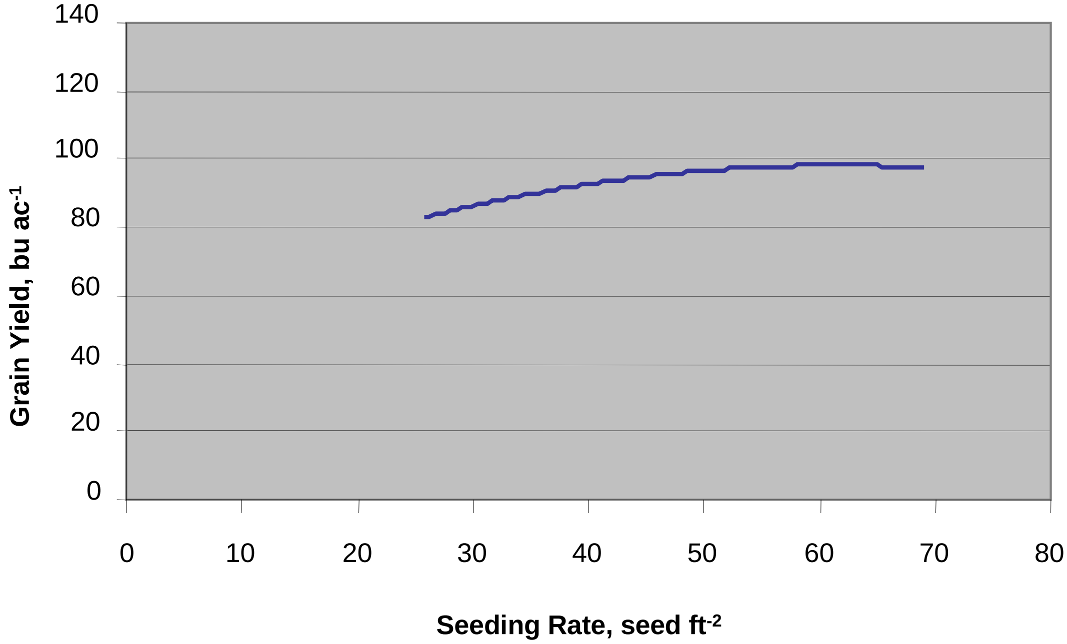
Seeding rate is known to significantly affect grain yield in both wheat and barley. Optimum seeding rates for traditional hulled barley in the Mid-Atlantic range from 28 to 33 seeds per square foot. The exposed endosperm of hulless barley makes damage more likely than with hulled barley types. In fact, emergence has been observed to be lower for hulless barley compared to hulled barley so seeding rates may need to be increased in response to this fact. Canadian researchers have reported lower yields for hulless barley when compared to hulled barley and that increasing seeding rate increased grain yield of some cultivars. The goal of this research is to refine and develop hulled and hulless barley seeding rate recommendations that optimize grain yield.

We evaluated 6 hulless and 3 hulled barley cultivars for response to seeding rate at Warsaw, Blacksburg, and Chatham, VA in 2003 through 2005. Seeding rates were from 25 to 70 seeds per square foot in equal increments planted in six or 7.5 inch rows.

Results and Recommendations:

Preliminary results (figure 1) demonstrate that seeding rates for hulless barley in a conventional, tilled seedbed should be at least 40 seeds per square foot (23 seeds per row foot in 7.5 inch rows) to approach optimum yields. Initial results support the conclusion that seeding at 45 to 50 seeds per square foot is appropriate for sites with high yield potential (>85 bushels per acre). Increased seeding rates are advisable when planting later than optimum and/or with no-tillage planting. Growers saving seed from a previous hulless barley crop should have a germination test performed on all seed lots.

Figure 1. Relationship between seeding rate and final grain yield for 6 hulless barley cultivars, 2003 – 2005.



"Patching In" Poor Corn Stands

Dr. Peter R. Thomison
Associate Professor—OSU Extension State Corn Specialist
The Ohio State University
Email: thomison.1@osu.edu

Ponding and poor drainage conditions have reduced corn stands in fields across Ohio, especially areas that received considerable rain since about May 11. The remaining plants in affected fields are often unevenly spaced within rows and not developing uniformly. Questions often arise as to whether to patch-in these poor stands, replant stands with poor emergence, or to protect late emerging plants during row cultivation. The following are some guidelines to consider in these situations based on findings of Illinois and Wisconsin research. A good source for more information on this subject is the National Corn Handbook Chapter 36, "Effects of Uneven Seedling Emergence in Corn" which is available on-line at http://www.agcom.purdue.edu/AgCom/Pubs/NCH/NCH-36.html

WHEN SHOULD YOU PATCH-IN A POOR STAND?

Growers will sometimes attempt to plant over or "patch in" a poor stand rather than kill the existing plants and replant at a full population. However, "patching in" is generally of limited benefit unless the surviving plant population is less than one half that of the original. The success of such an approach is even less likely late in the planting season (i.e. after June 1). Later planted corn cannot compete effectively with the remnants of the original plant population for sunlight, water, and nutrients. In these late planting situations, late emerging plants often function more like weeds, and contribute little to grain yield.

If you replant within 2 weeks of planting the original, patching-in may be a viable option. Yields will be similar to those from a uniform-emerging replanted stand, if you can get relatively uniform plant spacing within the row between the old and new plants. However, within 2 weeks of planting, it probably will be too early to determine what the final stand will be (and whether patching will be needed).

If you replant within 3 weeks after the initial planting, yield potential is about 10% greater if you tear up the field and start over with an even emerging stand rather than just patch-in the original stand. Balance this possible yield increase against the additional cost of tillage, seed, and dryer fuel.

SHOULD YOU REPLANT STANDS WITH UNEVEN EMERGENCE?

If the delay in emergence is less than 2 weeks, replanting will have a minimal effect on yields, regardless of the pattern of unevenness. However if one half or more of the plants in the stand emerge 3 weeks late or later, then replanting may increase yields by up to 10%. To decide whether to replant in this situation, estimate both the expected economic return of the increased yield compared to your replanting costs and the risk of emergence problems with the replanted stand.

For more information on replanting corn, check the CORN newsletter (May 30-June 6, 2006 C.O.R.N. 2006-15 ("Corn Replanting Considerations") available on-line at http://corn.osu.edu/

SHOULD LATE EMERGING PLANTS BE PROTECTED DURING ROW CULTIVATION?

If the delayed plants emerge only 1 " to 2 weeks late, use shields and avoid burying the late-emergers during cultivation. Protect plants emerging 3 weeks late if one half or more of the plants in the stand are late-emergers. If less than 1/4 of the stand emerges 3 weeks late or later, it probably will not pay to encourage their survival. Yields will be about the same whether or not these delayed plants are buried during cultivation.

Ponding Effects on Corn

Dr. Peter R. Thomison
Associate Professor—OSU Extension State Corn Specialist
The Ohio State University
Email: thomison.1@osu.edu

The recent rains have been beneficial for many corn fields across Ohio and the Mid-Atlantic region. Dry soil conditions were raising concerns about the efficacy of preemergence herbicide applications, and delayed emergence and uneven stands. However, in some areas, heavy rains resulted in localized ponding. If this ponding is limited, the injury resulting from the saturated soil conditions should be minimal given the relatively cool conditions we are currently experiencing. The following are some tips to consider when evaluating possible damage from water saturated soil conditions.

The extent to which ponding injures corn is determined by several factors including: (1) plant stage of development when ponding occurs, (2) duration of ponding and (3) air/soil temperatures. Prior to the 6-leaf collar stage (as measured by visible leaf collars) or when the growing point is at or below the soil surface, corn can usually survive only 2 to 4 days of flooded conditions. The oxygen supply in the soil is depleted after about 48 hours in a flooded soil. Without oxygen, the plant cannot perform critical life sustaining functions; e.g. nutrient and water uptake is impaired, root growth is inhibited, etc. If temperatures are warm during ponding (greater than 77° F) plants may not survive 24-hours. Cooler temperatures prolong survival. Once the growing point is above the water level the likelihood for survival improves greatly.

Even if ponding doesn't kill plants outright, it may have a long term negative impact on crop performance. Excess moisture during the early vegetative stages retards corn root development. As a result, plants may be subject to greater injury during a dry summer because root systems are not sufficiently developed to access available subsoil water. Ponding can also result in losses of nitrogen through denitrification and leaching.

If ponding in corn lasts less than 48 hours, crop injury should be limited. To confirm plant survival, check the color of the growing point. It should be white to cream colored, while a darkening and/or softening usually precedes plant death. Also, look for new leaf growth 3 to 5 days after water drains from the field. Sometimes the growing point is killed by bacterial infections during and after ponding, but plant growth continues in the form of non-productive tillers (suckers).

Disease problems that become greater risks due to ponding and cool temperatures include pythium, corn smut, and crazy top. Fungicide seed treatments will help reduce stand loss, but the duration of protection is limited to about 10-14 days. The fungus that causes crazy top depends on saturated soil conditions to infect corn seedlings. There is limited hybrid resistance to these diseases and predicting damage from corn smut and crazy top is difficult until later in the growing season.

Uneven Plant Height in Corn: Effects on Yield

Dr. Peter R. Thomison
Associate Professor—OSU Extension State Corn Specialist
The Ohio State University
Email: thomison.1@osu.edu

Uneven corn stands are a hot topic and receiving considerable attention across the Ohio and the Mid-Atlantic. In many corn fields, it's not unusual to see differences in plant growth stage and height within and between corn rows. Although much of the variability in plant height can be related to uneven emergence, it's important to recognize that plant height is not a reliable indicator of plant growth stage in corn. In some fields that show variability in plant height, tall and short plants may actually be at fairly similar stages of growth based on leaf collars.

The primary causes of delayed emergence and plant heights are probably soil moisture and temperature variability within the seeding depth zone. Other factors contributing to the problem include poor seed to soil contact due to cloddy soils, soil crusting prior to emergence, seeding depth, residue distribution, etc.

What impact will variability in plant height have on crop yields? It's been well documented that uneven emergence affects crop performance because competition from larger, early emerging plants decreases the yield from smaller, later emerging plants. According to one popular rule of thumb, if two neighboring plants differ by two or more leaves, the younger plant will almost always be barren or produce a nubbin ear at maturity. In a recent article in the Iowa State University *Integrated Crop Management* Newsletter (on-line at http://www.ipm.iastate.edu/ipm/icm/2006/6-12/cornheight.html), Roger Elmore and Lori Abendorf reviewed research from Europe, Canada, Argentina, and the U.S. to determine how later emerging plants performed within a field of normal emerging corn. The studies they described usually involved delaying the planting of a certain percentage of corn plants with a field to simulate variable emergence.

Research in Ontario indicated that when one of six (17%) plants was delayed in emergence by two leave overall yield was reduced 4 percent; when delayed by four leaves, 8 percent yield losses were observed. Plants neighboring late emerging plants only partially offset yield losses.

Illinois and Wisconsin research considered the response of corn when 25, 50, or 75 percent of the plants were planted either 10 or 21 days after the original planting date. Overall, grain yields were reduced 6 to 7 percent by a delayed planting of 10 days regardless of the percentage of plants delayed. However, when planting was delayed 21 days, yields were reduced 10 percent when 25 percent of the plants were delayed, 20 percent when 50 percent were delayed, and 23 percent when 75 percent of the plants were delayed.

Organic Grain Production: Part I

Dr. Ron Heiniger
Crop Science Extension Specialist
North Carolina State University
Email: ron_heiniger@ncsu.edu
and
Molly Hamilton
Crop Science Extension Assistant
North Carolina State University
Email: molly_hamilton@ncsu.edu

Organic production systems are based on management practices that promote and enhance farm biodiversity, biological cycles, and soil biological activity. Organic agriculture strives to minimize use of off-farm inputs and relies on management practices that restore, maintain, and enhance soil ecology and the farm landscape. Certified organic crops are produced in accordance with USDA rules governing organic production (www.ams.usda.gov/nop/).

Crop Sequence

An organic production system begins with selection of the best rotation sequence of production crops and cover crops based on the specific characteristics of the field. This usually requires combinations or rotations of crops that attract or harbor different insects and diseases, fix nitrogen (N), inhibit weed growth, and enhance the soil. Legumes or other broadleaf crops should be grown at least two of every five years. A well-developed cropping sequence should result in minimal problems with insects and plant diseases. The following crop sequences are recommended for organic grain crop production in North Carolina and should do well in the Mid-Atlantic region.

Wheat – Red clover (or other forage legume) – Corn. This rotation provides continuous ground cover, helps break up pest cycles, reduces warm-season weeds through the mowing of clover, and increases available N. Tilling the clover into the soil makes N available to the succeeding corn crop. However, in systems without livestock to convert the legume to a saleable product, the legume cover crop might have little economic value.

Wheat – Soybean – Corn. This rotation has many of the same advantages as the above rotation, but the soybean crop can be harvested and marketed. One disadvantage of this rotation is longer soil exposure since soybean is planted after wheat and harvested before corn. Weeds emerging in the soybean crop may be difficult to control, and less N will be fixed by the soybean crop. However, a cover crop could be incorporated into this rotation to provide ground cover when needed, or to expand the rotation beyond two years, or both.

Transitioning to Organic Cropping Systems

A switch to organic production from conventional agriculture requires a 36-month transition period. Experienced grain farmers can use their skills, knowledge, and experience with conventional grains as a base to build new proficiency with crop rotation, cover crops, mechanical weed control, record-keeping for certification, and marketing of organic crops. Most area farmers already have rotations that include corn, wheat, and soybeans. Such farms can go organic with little capital investment; however, mechanical weed equipment, separate storage facilities, or both may be needed for organic harvests. It is advisable to begin transitioning to organic with a relatively small acreage and carefully chosen fields. Fields with low weed, insect, and disease pressures and with relatively good soils give the best chance of success when starting with organic production. Fields with more intense pest problems or soil requirements may take more experience with organic production to be successful.

Organic Corn Production

Dr. Ron Heiniger
Crop Science Extension Specialist
North Carolina State University
Email: ron_heiniger@ncsu.edu
and
Dr. John Van Duyn
Entomology Extension Specialist
North Carolina State University
Email: john_vanduyn@ncsu.edu

Hybrid Selection

For organic growers seeking to identify appropriate corn hybrids, yield is not the primary consideration (Table 1). The key hybrid characteristics for organic corn production are:

Rapid early growth and vigor. Rapid early growth is essential in minimizing the effects of seedling diseases and insects, increasing root volume, and competing with weeds. In general, early growth is closely related to maturity date. Early- to medium-maturing hybrids (102 to 114 days) tend to exhibit better early growth than do late hybrids (longer than 115 days).

Standability. Standability is an important measure of how well the crop will stand under difficult environmental conditions. Because pests affect stalk strength, an organic hybrid needs to be able to resist lodging under stress.

Pest and disease resistance. Resistance to common seedling, leaf, and stalk diseases is an important characteristic for hybrids in organic production systems. Growers should select hybrids that combine good early growth characteristics with good resistance to diseases that are likely to be problems in their fields.

Stress tolerance. Stress tolerance is the ability to produce acceptable yield under drought or other environmental stresses. This characteristic is important since limited available N, often a problem in the early years of an organic system, can lead to nutrient and drought stress. Hybrids that can tolerate this stress will produce higher yields and compete more successfully with weeds.

Yield. The only reliable indicators of yield potential in organic systems will come from tests conducted using organic practices. Most of the hybrid comparisons done in organic systems use hybrids best suited to the upper Midwest, and there is only a limited amount of organic-yield test information available in North Carolina. Growers can conduct their own hybrid comparisons by selecting four to six promising hybrids and evaluating them under their own management practices. The best procedure is the strip test, where each test hybrid is grown adjacent to a standard hybrid. This pattern permits the yield data to be adjusted for soil variability. If a standard is not used, test hybrids can be alternated with the hybrid that has the best past performance.

Table 1. Evaluations of organic and untreated corn hybrids for relative maturity, seed vigor, early growth rating, standability, disease ratings, and stress tolerance.*

Hybrid	Relative Maturity	Seed Vigor	Early Growth	Standability Rating	Southern Corn Leaf Blight	Gray Leaf Spot	Stress Tolerance
Organic Hybrids							
NC+ 69R36	**115**	**8**	**6**	**7**	**6**	**5**	**7**
NC+ 62N37	**111**	**7**	**7**	**6**	**7**	**4**	**8**
NC+ 68F32	**112**	**7**	**6**	**6**	**7**	**4**	**7**
NC+ 60N37	**109**	**8**	**6**	**9**	**5**	**4**	**8**
Doeblers N509	**103**	**8**	**9**	**9**	**7**	**5**	**7**
Doeblers N640	**111**	**7**	**7**	**8**	**8**	**4**	**8**
Untreated Conventional Hybrids							
Pioneer 34K77	**107**	**7**	**6**	**6**	**7**	**4**	**7**
Pioneer 34B97	**108**	**6**	**6**	**6**	**6**	**5**	**7**
Pioneer 3394	**110**	**8**	**8**	**6**	**5**	**2**	**7**
Pioneer 33G26	**112**	**7**	**8**	**7**	**5**	**5**	**7**
Pioneer 33M54	**114**	**5**	**5**	**6**	**7**	**6**	**7**
Pioneer 32R25	**114**	**6**	**5**	**4**	**4**	**3**	**8**
Syngenta N65-M7	**109**	**5**	**6**	**6**	**4**	**6**	**8**
Syngenta N79-L3	**115**	**7**	**7**	**7**	**4**	**4**	**6**
Augusta A-4587	**116**	**5**	**5**	**7**	**6**	**4**	**7**

* Ratings are based on a scale of 1 to 10. A rating of 10 represents a plant with complete resistance or tolerance to disease or stress.

Planting Date

Planting date is a crucial factor in the success of an organic production system. Planting too early results in slow growth and increases the amount of weed competition, the incidence of seedling diseases, and the likelihood of damage from seedling insects. On the other hand, planting too late results in a greater risk of drought stress, increased insect damage from second and third generations of European corn borers, and reduced yield from a decrease in intercepted sunlight due to decreasing hours of daylight. The recommendations here attempt to balance these considerations. In the tidewater and coastal plain, plant organic corn between April 15 and May 15. In the piedmont, plant organic corn between April 20 and May 20.

Seedbed Preparation

Seedbed preparation should begin with a major tillage operation performed at least a month before planting. If cover crops are used, they may need to be killed and/or incorporated into soils earlier than one month before planting to allow for residue decomposition and to avoid seed corn maggots. Heavy applications of compost or manure should also be incorporated earlier. Follow up with at least two light tillage operations to create a smooth, weed-free seedbed. The final tillage operation should be performed on the day of planting to ensure that all germinated weeds have been destroyed when the seed is placed in the ground.

Plant Population

Plant population is another important factor in organic corn production, especially when corn is grown on sandy soils. Plant populations should be related to the moisture-holding capacities of each individual field. In organic systems, corn plant populations per acre should be 10 percent higher than populations in conventional systems. The higher plant population will increase light interception and reduce weed competition and the effects of pest damage. On soils with good-to-excellent water holding capacity, the goal is a stand of 30,000 to 33,000 plants per acre; on soils with average water holding capacity, 25,000 to 28,000 plants per acre; and on soils with poor water holding capacity, no more than 22,000 plants per acre.

Row Spacing

Narrow rows permit more uniform plant distribution and result in rapid closing of the canopy. In choosing a row width, balance the potential advantages that come from narrower rows against the additional machinery cost and management that a narrow row system demands. Because cultivation is the primary weed control measure in organic production, make row widths wide enough to permit the use of a tractor- mounted cultivator. Where weeds are not a major problem, use row spacing of 20 to 24 inches. Where weed control will require multiple passes of a cultivator, row spacing of 30 to 36 inches may be preferred.

Soil Fertility

Corn generally requires from 120 to 160 pounds of N per acre, 30 to 50 pounds of phosphorus per acre, 80 to 100 pounds of potassium per acre, and smaller amounts of sulfur and micronutrients to obtain optimum yield. Organic corn growers should design their systems so that the amount of nutrients added to the system offsets the amount removed in the grain or forage. Allowed fertility sources include animal manures, composts, cover crops/green manures, and sodium nitrate (for 20% of the crop's nitrogen need). The local offices of the USDA Natural Resources Conservation Service, the Cooperative Extension Service, or the Soil and Water Conservation District can provide guidelines on obtaining assistance with a nutrient management plan.

Weed Management

While tillage prior to planting can help reduce early-season weeds, many of the summer annuals will continue to germinate and grow. It is very important to start with a clean seedbed and to till the soil just prior to planting so that the crop begins with a head start on new weed seedlings. This will make it much easier to use cultivation to control grass and broadleaf weeds that are smaller than the corn. It is also important to take advantage of the ability of the corn canopy to shade the soil. Shade reduces the number of weeds germinating and slows their growth. Use of increased plant populations, narrower rows, row directions perpendicular to the path of the sun, and tall-growing hybrids all increase canopy density and lead to quick canopy closure. Remember that weed competition during the first four to six weeks after planting will cause the most damage in terms of yield reductions. Weeds that emerge after canopy closure will have little effect on yield, although they can make harvest more difficult.

Insect Pest Management

Cultural practices are very important for establishing a vigorous, full corn stand. Stand establishment can greatly influence pest populations as well as crop competitiveness and tolerance to pest feeding. In fields where pests are historically at high levels, do not plant organic corn if suitable, effective, and economical pest management options are not available. The key insect management practices for organic corn production are:

> <u>Crop rotation</u>. Rotations of at least two years and use of a non-grass crop will reduce the levels of many pests through starvation, interference with insect reproduction, or both. Rotation also gives the option of isolating corn crops from one year to the next. Rotation in large units with a minimum of 800 to 1,000 feet between current and previous corn is the most effective way to manage moderately mobile pests such as billbugs.
>
> <u>Control of insects with tillage</u>. Populations of wireworms, cutworms, grubs, seed corn beetle, and other pests can be reduced with winter or early spring disking and the accompanying bird feeding and exposure. The combined action of these factors can give meaningful protection to planted seed and small seedlings. Rapid germination and seedling grow-off. Rapid germination and seedling grow-off reduces the time corn seed and seedlings spend in the most vulnerable stage between germination and the six-leaf stage and helps the crop gain a size advantage over weeds. Losses to seedling insects and other pests can be reduced by promoting early germination through row-bedding, seeding at the recommended depth, hybrid selection for performance under cool conditions, and adequate soil fertility.
>
> <u>Crop maturity</u>. In corn, timely maturity of the crop almost always reduces insect damage. Certain pest insects and pathogens (for example, late-season corn borers and fall army worms) reach high levels in late July and August and may severely infest late-maturing corn. Timely planting and avoidance of late-maturing

hybrids (over 120 days) will reduce the level of pests attracted to the crop in late-season and prevent yield loss.

Hybrid selection. Rapid germination, early vigor, strong ear shanks, tight husks, resistance to stalk rots and other pests, strong stalks, and uniform performance over a wide population range are factors influenced by genetics that may reduce losses to insects.

Key Diseases and Management

Three key diseases—seed rots and seedling blights, stalk rots, and charcoal rot, which are usually controlled in conventional systems either by fungicides or management practices—can have significant impacts on organically grown corn. Growers should be aware of these diseases and select hybrids and management practices that reduce the risk they pose. While there are many other diseases that can attack corn, they rarely cause economic loss.

Seed rots and seedling blights caused by species of *Fusarium*, *Stenocarpella*, *Pythium*, and other fungi are often associated with the term "damping-off." These diseases are more prevalent in poorly drained, excessively compacted, or cold, wet soils. Planting old or poor quality seed with mechanical injury will increase seed rot and seedling blight, as will planting seed too deep in wet, heavy soils. Seed vigor ratings are often used to select hybrids with genetic resistance to seed rots and seedling blight.

Stalk rots (caused principally by the fungi *Stenocarpella zeae* and species of *Fusarium* as well as *Colletotrichum graminicola*) are present each year and may cause considerable damage, particularly if abundant rainfall occurs during the latter part of the growing season. Adequate fertility (particularly adequate potassium) is the key to controlling stalk rot.

Charcoal rot (caused by the fungus *Macro-phomina phaseolina*) becomes most evident with the onset of hot dry weather. Typically, when this disease occurs in North Carolina, soil fertility and pH are at very low levels. Supplying adequate nutrition and water is the principal means of control. Hybrid resistance in corn has not been documented.

Harvesting

Early harvesting usually avoids crop damage from pests or hurricanes and prevents field losses resulting from ear drop and fungal pathogens. Probably the most important reason for timely harvest is the potential for yield reductions resulting from ear loss and ear rots due to stalk lodging, ear drops, and reductions in kernel weight. Fungal diseases and mycotoxins that infect the corn kernel also cause more problems as harvest is delayed.

Organic Soybean Production

Dr. Jim Dunphy
Crop Science Extension Specialist
North Carolina State University
Email: jim_dunphy@ncsu.edu
and
Dr. John Van Duyn
Entomology Extension Specialist
North Carolina State University
Email: john_vanduyn@ncsu.edu

Variety Selection

Choosing a soybean variety also means choosing a maturity group appropriate for your area and cropping system. In organic production, an earlier-maturing (maturity group V for most of North Carolina) or mid-season variety (maturity group VI) is preferred over late-maturing varieties (Group VII or later). Contact your local agronomist in your area for the corresponding maturity group for your location. Early-maturing beans can avoid hurricane winds and moisture and associated disease problems and yield losses. Because of soil type and more frequent rains, the blacklands of North Carolina can use an earlier-maturing bean (Group V or earlier) without yield loss. However, farther west and on sandier soils, a later-maturing variety (Group VI or later) may be needed to get adequate yields. In the coastal plain, a Group VI or late V (or an earlier planting) will help avoid corn earworm (CEW) infestation during flowering. CEW is seldom a problem in the piedmont. Variety selection is also an excellent way to deal with nematode problems. Selecting varieties that are resistant to the species and race of nematode present in the field can limit the yield loss caused by these pests. It is also a good idea to choose at least two different varieties in order spread out the seasonal workload and risk. Organic farmers must be aware that transgenic beans are not allowed in certified organic production, and choose alternate varieties. Table 2 lists top-yielding non-GMO, feed-grade varieties in North Carolina through 2004, as noted by J. Dunphy in North Carolina Soybean Variety Information (2005, Extension publication CS-SB-15).

Planting Date

The key is to match planting date and variety maturity to the soil so that the row middles are lapped with soybean plants about 3 feet tall by flowering time. Planting earlier or planting a later-maturing variety can improve the likelihood of achieving this. Also, planting by the end of May with an early to mid-season variety can help the crop avoid insect and disease problems.

Row Spacing

Soybeans in row widths of 20-inches or less tend to have higher yields than soybeans in wider row widths. Narrow-row soybeans also lap the row middles sooner, making further weed control measures during the season unnecessary.

Table 2. Non-transgenic soybean varieties, relative yield over all locations, number of locations and years in variety trial.

Variety	Percent +/- Average*	No. of sites	First year	Last year	Variety	Percent +/- Average*	No. of sites	First year	Last year
Maturity Group IV					**Maturity Group VI**				
DP 4748 S	-13.0	2	2000	2000	665	6.4	25	2000	2003
					Boggs	-13.0	8	2004	2004
Maturity Group V					Dillon	2.5	29	2000	2004
5002T	-2.9	6	2003	2004	HBK 6600	-8.0	8	2000	2000
5601T	-3.1	13	2001	2004	NC-Roy	9.7	29	2000	2004
95B33	-5.1	14	2000	2001	Satelite	-9.7	22	2000	2002
AP 572STS	-8.9	8	2000	2000	Soyola	-0.1	25	2000	2003
Bolivar	-2.3	4	2004	2004					
DP 5110 S	-6.3	22	2000	2004	**Maturity Group VII and VIII**				
DP 5989	-4.0	22	2000	2002	Cook	3.8	15	2000	2004
Fowler	-3.5	28	2000	2004	N7001	0.6	18	2000	2004
Freedom	-16.2	4	2004	2004	N7102	-21.5	4	2002	2002
HBK C5894	-3.1	4	2004	2004	N7103	-8.7	8	2000	2002
Hutcheson	-4.3	35	2000	2004	NC-Raleigh	12.1	18	2000	2004
Ozark	-11.8	4	2004	2004					
SS 5200-STS	-17.0	16	2001	2003					
SS 597	2.4	15	2000	2001					
Teejay	8.4	4	2004	2004					
USG550nSTS	-14.0	13	2002	2004					

* Percent above (+) or below (-) average yield of all varieties of the same maturity group at the same locations in NC Official Variety Tests (OVT) in 2000 through 2004.

Plant Population

Weeds are the main pest that organic soybean producers are going to face, and a thick plant population will compete with weeds more effectively. Thicker populations have denser, earlier-closing canopies that out-compete weeds and do not allow enough light to penetrate for weed seed germination. Although a thick canopy increases the risk of disease, it is also the best way to maximize yields. Plant population in the field can vary widely and still achieve good yields. On 36-inch rows with a May planting date, an ideal plant population would be 6 to 8 plants per foot (about 100,000 plants per acre). In 20-inch rows, the recommended plant population is still 100,000 plants per acre, but the plant population per foot will be lower. If planting on 7-inch rows, 2 plants per foot (150,000 plants per acre) can achieve good yields. In other areas of the Mid-Atlantic region even higher plant populations (200,000 to 250,000 plants per acre) have been used to suppress weed competition and improve yields when adequate soil moisture is available. If planting in June, increase these seeding rates by 20 percent.

Soil Fertility

Organic fertility inputs, such as manure and compost applications, are usually unnecessary in soybean production because soybeans are nitrogen-fixing legumes and the crop can make use of any nutrients applied to, but not removed by, previous crops.

Weed Management

Organic weed management is more challenging in soybeans than in corn since the soybean foliage does not generally overlap and shade the row middles until later in the season. Generally, narrow rows and increased plant population can help the crop compete more effectively against weeds. When managing weeds in soybeans, consider also that different planting times for soybeans result in the plants competing against different sets of weed species. Weeds that emerge during the first four to five weeks after planting will cause the most damage in terms of yield reductions. Weeds that emerge after this time will have little effect on yield, although they may make harvest more difficult and will set seed.

Insect Pest Management

The organic soybean grower can normally rely on three factors to limit insect damage: reducing soybean attractiveness to pests, beneficial insects that reduce pest numbers, and the plant's ability to compensate for insect damage (tolerance). Important tactics used to reduce insect damage include the following five strategies:

> Rotation. Rotation helps reduce levels of pests like soybean colaspis and cyst nematode and often improves crop health. Avoiding pests through rotation of at least two years allows soybeans to tolerate the feeding of pests that later move into the field.
>
> Soil fertility and pH maintenance. Thin plant stands often have more corn earworms, but good growth reduces attractiveness. Reducing plant stress from low pH, poor fertility, or inadequate moisture will enable plants to better tolerate insect feeding.
>
> Variety selection and early planting. High caterpillar populations can often be avoided by early planting of an early-maturing variety (such as varieties from maturity groups III, IV, or V). These plantings will bloom and harden-off before the corn earworm moth flight from corn fields, and the plants will be unattractive to the moths. Also, early maturity can greatly reduce soybean looper, velvetbean caterpillar, and late stink bug infestations. In rare situations, stink bugs can be trap-cropped by early-maturity fields, leading to greater damage.
>
> Narrow rows. A complete canopy allows a higher level of biological control by insect predators, parasites, and diseases. Also, narrow-row soybeans seem to be less attractive to egg-laying corn earworm moths.

Remedial control. Group V or later-maturing varieties that are planted after late May can become infested by corn earworm moths moving from corn. Also, populations of leaf-feeding caterpillars (green cloverworm, soybean looper, and velvetbean caterpillar) may occasionally damage soybeans to above threshold levels. These worms are usually very late-season pests. In instances where caterpillar pests are not avoidable, insecticides approved for organic production, such as spinosads or *Bacillus thuringiensis* (Bt), may be successfully used.

Disease/Nematode Management

Nematodes are the main yield limiting soybean disease/nematode agent in North Carolina and much of the Mid-Atlantic region. However, Asian soybean rust is a possible problem, and, if present, will require much more intensive management to make organic soybean production viable.

Nematodes. The best way to avoid nematode damage is to plant varieties that are resistant to the nematode (and race) present in the field. These varieties can be found on the Web site www.soybeans.ncsu.edu/soyvar or from your local county Extension agricultural agent. Crop rotation of at least two years will probably help reduce soybean cyst nematode populations, but is not as useful when dealing with root knot nematode because it has multiple host plants. If nematode damage is suspected, soil samples can be sent to the NCDA&CS laboratory or appropriate laboratory in your state for a nematode assay.

Asian soybean rust. Asian soybean rust must be considered when managing for soybean disease. To manage organic soybeans for this potential disease in North Carolina, select early-maturity groups and/or plant early to get the plants out of the fields in time to avoid the rust inoculum. Do not, however, create such an early-maturing soybean crop that yields are reduced substantially.

For more information on soybean rust, go to one of these Web sites:
www.usda.gov/soybeanrust/ (USDA site on Asian soybean rust)
www.ces.ncsu.edu/depts/pp/soybeanrust/ (Soybean Rust Forecast Center at NC State University)
www.sbrusa.net (USDA online soybean rust tracking site)
www.attra.ncat.org/attra-pub/asian_soy_rust.html (Appropriate Technology Transfer for Rural Areas document on possible organic treatments for Asian soybean rust)

Understanding Soybean Growth Stages: I. Emergence--VE

Dr. Richard W. Taylor
Extension Agronomist
University of Delaware
rtaylor@udel.edu

With everyone attuned to the need for knowing the growth stage of a soybean crop because of Asian soybean rust and the use of fungicides at specific growth stages to boost yields, it is an appropriate time to review growth staging for soybeans.

First, there are a few definitions that need to be covered. Keep these available so that you can refer back to them during the growing season. This information will be based on the accepted system for staging soybeans that was developed by W. Fehr and C. Caviness and published in the scientific journals. Recently, there was a bit of a controversy when a new system that was published was found to differ at the reproductive stages from the Fehr and Caviness system but everyone for now has agreed to use the older system with respect to Asian soybean rust.

To use the system, you need to be able to identify the following terms. **Cotyledons**, also called seed leaves, are the two fleshy leaves that are seen first as the seedling emerges through the soil. A **node** is the slightly enlarged portion of the stem where a leaf develops and if the leaf has fallen off the plant the node can still be identified by the presence of a scar where the leaf was once attached. A **unifoliate leaf** is the first true leaves produced by a soybean plant and each leaf has one leaflet. The unifoliate leaves are opposite each other at the **first node** on the main stem. A **trifoliate leaf** is all leaves produced by the soybean plant after the unifoliates. Each trifoliate leaf is made up of three leaflets and the trifoliate leaves are attached to the stem in an alternate arrangement (one on one side of the stem and the next on the opposite side and so forth). A **fully developed leaf** is one in which the leaf immediately above it on the main stem has opened. A leaf is considered **open** when the leaf has unrolled sufficiently that the leaf edges are not touching. This topic will be covered again later along with photos to illustrate the point.

I will also cover how you stage a field in the next article but will begin this one with a description of two stages, one official and one in common use. The stage VP seems to be used to indicate that the beans have been planted but have not yet emerged. This is not an official term so you may see it used in a number of ways. The first official stage is called VE or emergence and occurs when the cotyledons or seed leaves are above the soil surface. A field is said to be in this stage when at least 50% of the plants are at or past the point when the cotyledons emerge above the soil surface. There is no official designation for when the beans begin to crack the soil surface but usually there is only a day or three between this occurring and VE. In the next article, I will include a photo to illustrate this point and we will move on to the next stage, VC or the cotyledon stage.

Understanding Soybean Growth Stages: II. Cotyledon--VC

Dr. Richard W. Taylor
Extension Agronomist
University of Delaware
rtaylor@udel.edu

As mentioned in the previous article, I will continue the description of soybean growth stages and illustrate the cotyledon stage with a few photos. You may wish to refresh your memory of the definitions covered earlier but the second stage observed in the field is called VC or the Cotyledon Stage. VC begins when the unifoliate leaves have unrolled sufficiently that the leaf edges do not touch (Photo 1-2 below). The stage continues until V1 or the First Node stage when there are fully developed unifoliate leaves at the unifoliate nodes which indicates that the first trifoliate leaves have unrolled sufficiently that the leaf edges do not touch.

Photo 1. Soybean plants in the VC or Cotyledon stage since the unifoliate leaves have unrolled sufficiently that the leaf edges to not touch and the next leaf (a trifoliate leaf) has not grown enough that the leaf edges of the three leaflets have unrolled enough to no longer touch (Photo courtesy of Cory Whaley).

Photo 2. Close-up of soybean plant in the VC or Cotyledon stage since the unifoliate leaves have unrolled sufficiently that the leaf edges to not touch and the next leaf (a trifoliate leaf) has not grown enough that the leaf edges of the three leaflets have unrolled enough to no longer touch (Photo courtesy of R. Taylor).

Understanding Soybean Growth Stages: III. V1 First Node and V2 Second Node

Dr. Richard W. Taylor
Extension Agronomist
University of Delaware
rtaylor@udel.edu

To continue the description of soybean growth stages, we now move on to the 'First Node' growth stage. Again, you should refresh your memory of the definitions covered in the first of this series so you will understand what a fully developed leaf is. V1 begins when the leaflets of the first trifoliate leaf to emerge have unrolled sufficiently that the leaflet edges do not touch (Photo 1 below). The stage continues until V2 or the 'Second Node' stage when the first trifoliate leaf becomes a fully developed leaf (Photo 2).

Photo 1. Soybean plants in the V1 or First Node stage at which time the leaflets on the first trifoliate leaf to emerge have unfurled enough so the leaflet edges no longer touch. This means that the unifoliate leaves are now fully developed leaves (Photo courtesy of Cory Whaley).

Usually by the V1 or V2 stage, you can identify small nitrogen fixing nodules on the soybean roots but they will generally be quite small. If soil pH is high and soil extractable manganese (Mn) is low, you also can begin so see interveinal chlorosis on the newest emerging leaves. Although the plants are very small and it may be difficult to have much Mn uptake by the plant if applied as a foliar spray at this young stage, adequate Mn is critical for rapid growth and eventual yield potential. When Mn deficiency symptoms appear at this early stage, two applications of foliar Mn will be needed for maximum yield. The first can go on with the first application of glyphosate but there are some precautions to follow to prevent Mn from interfering with weed control. Tests have shown EDTA Mn to be safe when mixed with Roundup sprays but other Mn products can reduce weed control if not handled properly. Always add ammonium sulfate at a rate of 1 to 2 percent by weight or 8.5 to 17 pounds per 100 gallons before either adding the glyphosate or techmangam. This will prevent the Mn products from binding to glyphosate and reducing its performance.

Photo 2. Close-up of soybean plant in the early V2 or Second Node stage. At this stage both the unifoliate and the first trifoliate leaves are fully developed. The plant is entering a period when enough leaf area is present that if adequate moisture, nutrients, and sunlight are available that growth will become very rapid (Photo courtesy of Cory Whaley).

Understanding Soybean Growth Stages: IV. V3 to V5—Third, Fourth, and Fifth Node

Dr. Richard W. Taylor
Extension Agronomist
University of Delaware
rtaylor@udel.edu

Continuing the description of soybean growth stages, we move to the 'Third', 'Fourth,' and 'Fifth Node' growth stages. Again, refresh your memory of the definitions covered in the first of this series so you will understand what a fully developed leaf is. V3 begins when the leaflets of the third trifoliate leaf to emerge have unrolled sufficiently that the leaflet edges do not touch (Photo 1 below). The stage continues until V4 or the 'Fourth Node' stage when the newly emerged third trifoliate leaf becomes a fully developed leaf (the fourth trifoliate leaf has emerged enough for the leaflet edges to no longer touch). The 'Fifth Node' stage occurs when counting from the soil level you have a set of unifoliate leaves (or leaf scars if these leaves have dropped off), and four fully developed trifoliate leaves (Photo 2).

Photo 1. Soybean plants in the V3 or Third Node stage at which time the leaflets on the third trifoliate leaf to emerge have unfurled enough so the leaflet edges no longer touch. This means that the fully developed leaves include the unifoliate leaves and the first and second trifoliate leaves (Photo courtesy of R. Taylor)

Usually by the V3 to V5 stage, you can easily identify nitrogen fixing nodules on the soybean roots. In beans planted from mid-May on will be either at or approaching this stage at the time you should be scouting fields (30 to 40 days after planting) to determine if soybean cyst nematodes are of concern and are reproducing on your soybean variety. Leaf area is usually sufficient by the V5 growth stage so that foliar manganese (Mn) applications can provide enough Mn to the plant to sustain growth until near the time the plant begins the reproductive phase. Yield reductions with Mn deficiency can be significant so scout fields carefully at this stage to allow time to treat early with Mn if a deficiency is present. Weeds should be controlled at least by the end of this growth period since competition for moisture, sunlight, and nutrients is becoming strong and weeds can significantly reduced yield potential.

In late-planted double crop beans, flowering can begin once the plant reaches the V4 stage of growth although in single-crop plantings flowering will not occur until the days shorten to the appropriate day length (actually the night's lengthen to the point at which the variety is triggered to turn reproductive) following the longest day of the year (June 21).

Photo 2. Close-up of soybean plant in the V5 or Fifth Node stage. At this stage a set of unifoliate leaves and four trifoliate leaves are fully developed. The plant is entering a period of rapid growth if adequate moisture, nutrients, and sunlight are available. Note that at low populations the plant is beginning to produce branches and additional trifoliate leaves on the branches. The branch leaves are not counted in the staging of soybeans. Only those leaves that occur on the main stem are counted for staging soybeans. (Photo courtesy of R. Taylor)

Understanding Soybean Growth Stages: V. V6 to RI—Sixth Node to Beginning Bloom

Dr. Richard W. Taylor
Extension Agronomist
University of Delaware
rtaylor@udel.edu

For double-cropped soybean varieties and early maturity group beans, beginning flower can occur after a minimum vegetative state or minimum amount of biomass has been reached or accumulated. This generally occurs sometime around the V4 to V5 growth stage. Currently in the field, some of our maturity group II soybeans are at R1 or beginning bloom. Once flowering has begun, we often ignore the V-stages but you can still use the V staging procedure to determine the number of nodes on the main stem; although from a management perspective for fungicides, diseases such as Asian soybean rust, and insect problems, the R staging is the important growth stage to recognize.

To continue soybean growth staging for the V-stages, count the number of nodes on the main stem with fully developed leaves. Remember that a leaf is fully developed when the leaf immediately above it on the main stem has opened so that the leaflet edges have opened or unrolled enough so that the leaflet edges do not touch. The V6 stage is illustrated in Photo 1 below.

Photo 1. Soybean plants in the V6 or Sixth Node stage at which time the leaflets on the sixth trifoliate to emerge have unfurled. This means that the fully developed leaves include the unifoliate leaves and the first to the fifth trifoliate leaves (Photo courtesy of R. Taylor)

Beginning Bloom or R1 occurs when there is one open flower at any node on the main stem **in at least 50% of the plants** in the field. Photo 2 shows a view of the flower buds that form in each leaf axil and Photo 3 shows a flower open and in bloom.


Photo 2. Close-up of leaf axil showing developing flower buds of a soybean plant. (Photo courtesy of R. Taylor)


Photo 3. Close-up of leaf axil with open flower on a soybean plant. (Photo courtesy of R. Taylor)

In general flowering in soybeans is triggered by the continuous decrease in day length and corresponding increase in night length for each successive day after June 21. Fewer hours of darkness are required to trigger flowering in a group II variety than in a group IV variety. Therefore, if planted on the same date, a group II variety will flower before a group IV variety. With all the recent advances in variety development, it will be interesting to see how closely the new cultivars hold to this effect. Also, determinate varieties reach R1 or Beginning Bloom and R2 Full Bloom at about the same time whereas the indeterminate varieties usually reach the R2 or Full Bloom stage 3 to 4 days after R1 or Beginning Bloom. Soybeans (full-season or single-cropped) usually flower for a period ranging from 3 to 6 weeks with determinate (group V and some group IV beans) varieties flowering for a shorter period of time than the indeterminate varieties.

Soybeans are very sensitive to drought and heat stress during the flowering stage so for irrigated beans this and pod development/seed fill is the time when the maximum effort should be made to alleviate moisture stress. Also, be sure to check for nodulation as flowering begins to be certain adequate nitrogen is available to the plant. Soybeans are sensitive to nutritional stress (especially manganese and potassium) so if symptoms have appeared prior to R1 be sure to apply enough to carry the crop through to maturity. Soybeans are also very sensitive to shading from tall-growing, uncontrolled weeds during this phase. Heavy weed infestations will compete for available water, nutrients, as well as sunlight and carbon dioxide so control your weeds prior to flowering.

Understanding Soybean Growth Stages: VI. R2—Full Bloom

Dr. Richard W. Taylor
Extension Agronomist
University of Delaware
rtaylor@udel.edu

The R2 or Full Bloom stage is illustrated in Photo 1 below. Full bloom occurs when an open flower occurs at one of the two uppermost nodes on the main stem with a fully developed leaf. At least half the plants in the field must be at this stage for the field to be called in full bloom. Stresses of any type become critical at this and later stages since they can severely limit the number of flowers, pods, or seed set by the crop. When and where possible, stress factors should be eliminated prior to bloom. Maximum yield potential generally occurs if canopy closure occurs ten days to two weeks prior to the bloom stage.

Photo 1. Soybean plants in the R2 or Full Bloom stage at which time blooms have open at one of the two uppermost nodes on the main stem with a fully developed leaf (Photo courtesy of R. Taylor)

Understanding Soybean Growth Stages: VII. R3 and R4—Beginning Pod and Full Pod

Dr. Richard W. Taylor
Extension Agronomist
University of Delaware
rtaylor@udel.edu

The R3 or Beginning Pod stage is illustrated in Photo 1 below. Beginning Pod occurs when a pod 3/16 of an inch (about 5 mm) has formed at one of the four uppermost nodes on the main stem with a fully developed leaf. At least half the plants in the field must be this stage for the field to be called in the Beginning Pod stage. Drought and other stresses at this stage can cause pod abortion or lead to pods with fewer seeds per pod that would have occurred with the stress. Some flowers are still blooming and can replace dropped pods if the stress causing pod drop is eliminated.

Photo 1. Soybean pod about 3/16 of an inch long (about 5 mm) at one of the four uppermost nodes on the main stem with a fully developed leaf looks very small. (Photo courtesy of R. Taylor)

Photo 2. Soybean plant in the R3 or Beginning Pod stage at which time a pod 3/16 of an inch long (about 5 mm) has formed at one of the four uppermost nodes on the main stem with a fully developed leaf (Photo courtesy of R. Taylor)

The Full Pod stage (R4) occurs when half the plants in the field have a pod ¾ of an inch long (about 19 mm long) at one of the four uppermost nodes on the main stem with a fully developed leaf. Flowering is about complete at this stage so stresses that cause serious pod drop and potential yield loss are unlikely to be made up other than by an increase in average seed size if the stress is removed. This limits the potential for yield recovery from stress conditions at this and later growth stages.

Photo 3. Soybean plant in the R4 or Full Pod stage at which time a pod 3/4 of an inch long (about 19 mm) has formed at one of the four uppermost nodes on the main stem with a fully developed leaf (Photo courtesy of R. Taylor)

Frequently, fungicide applications for soybean health and yield enhancement are applied at either the R3 or R4 growth stage. Yield response to this type of fungicide application usually averages from 3 to 6 bu/A; but, in demonstration and research trials across the country, the range has been from yield loss to large yield increases depending on the individual situation. In these trials, the frequency of yield responses and the actual yield responses suggests that this type of application under good growing conditions can usually return enough to cover the costs involved. In trials in this region, we have found about a 3 to 5 bu/A increase in each of the trials we've conducted. A possible downside has been a delay in maturity and increase in the number of green stems on beans at the time they reach harvest moisture. Although the fungicide applications should help soybean health at harvest, this factor was improved in only one of the three site-years in our studies.

In some trials we have out with the Delaware Soybean Board, the maturity stage of beans currently ranges from non-blooming (still in the V-stages) for late group IV and group V beans to the R4 or the full pod stage for group II beans. Many double-crop beans are either just emerging (VE, VC, or V1 stage) if planted in early July or are near the critical V4 stage when blooming occurs and may actually be at R1 or the R2 stage.

By the time full-season on single-cropped plants reach the high numbered V-stages, there can be a question as to how many nodes have been made by the plant. This often occurs in rapidly growing plants especially when initial growing conditions were favorable for rapid germination and growth. In such cases, the identity of the cotyledon nodes, the unifoliate nodes, and the first trifoliate note can be confused. In photo 4 below, note how the two lowest side branches off the main stem highlight the placement of the unifoliate nodes as 90 degrees from the other branches occurring at the trifoliate nodes. The trifoliate leaf nodes occur alternately up the main stem.

Photo 4. Soybean plant in the R6 or Full Seed stage showing side branches growing from unifoliate leaf nodes (lower two branches visible coming off the main stem) and at a 90 degree angle from the unifoliate leaf nodes is a side branch growing from the first trifoliate node (Photo courtesy of R. Taylor).

Understanding Soybean Growth Stages: VIII. R5 and R6—Beginning Seed and Full Seed

Dr. Richard W. Taylor
Extension Agronomist
University of Delaware
rtaylor@udel.edu

The R5 or Beginning Seed stage occurs when on 50% or more of the plants in a field you can find a seed 1/8 of an inch long (just slightly greater than 3 mm) in a pod at one of the four uppermost nodes on the main stem with a fully developed leaf (Photo 1). This occurs in pods earlier than we often think (Photo 2) as pods may be only an inch long. The tendency for most of us is to wait to call a plant in the R5 stage when we can either easily see the seed developing in the pod or can easily feel the seed in the pod. Usually by this point, the seed has grown to about a ¼ inch in length.

Photo 1. Soybean pods with seed that is 1/8th of an inch (about 3 mm) long at one of the four uppermost nodes on the main stem with a fully developed leaf is considered at the R5 or Beginning Pod stage (Photo courtesy of R. Taylor).

Photo 2. A comparison of seed size between a seed just at the R5 stage and seed in a soybean pod that can be felt and might be thought to have reached R5. Note seed at this later stage is slightly larger than a ¼ inch in size versus the 1/8th inch for R5 (Photo courtesy of R. Taylor).

The R6 or Full Seed stage begins when a pod that contains a green seed that fills the pod cavity occurs at one of the four uppermost nodes on the main stem with a fully developed leaf (Photo 3). Again, one-half of the plants in the field must be at this stage. Often this stage lasts longer than the other reproductive stages and, depending on weather and soil conditions, it can last many weeks. Towards the end of R6, soybean leaves begin to show a bright yellow color that often is accompanied by the shedding of the lowest leaves. Leaf drop follows leaf yellowing as scenescence of the crop begins (Photo 4). The next stage (R7) usually occurs when 80 to 90 percent of the leaves have fallen from the plants but when strobilurin fungicides have been applied leaf drop may be delayed past R7.


Photo 3. Soybean pods with green seed that fill the pod cavity completely on the uppermost four nodes on the main stem with a fully developed leaf (Photo courtesy of R. Taylor).

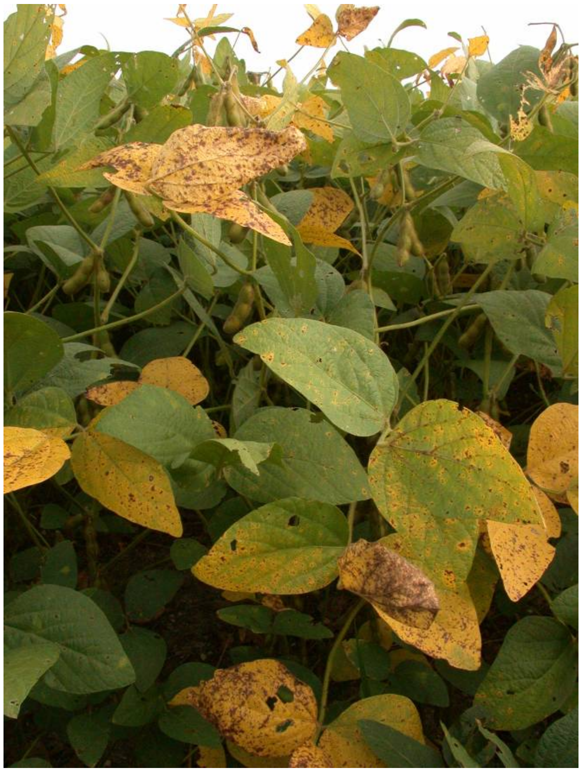


Photo 4. Soybean leaf drop begins towards the end of growth stage R6 and often shows up as an intense yellowing of the field (Photo courtesy of R. Taylor).

Understanding Soybean Growth Stages: IX. R7 and R8—Beginning Maturity and Full Maturity

Dr. Richard W. Taylor
Extension Agronomist
University of Delaware
rtaylor@udel.edu

The R7 or Beginning Maturity stage is illustrated in Photo 1 below but note that these beans had been sprayed with the fungicide, Headline, at the R3 stage and has resulted in delayed leaf drop. When fungicides have not been used, the soybeans at this stage often have dropped most if not all of their leaves. Limited yield increases will occur once this stage is reached since an increasing number of seed from this point on will have reached their full size and weight. On irrigated beans when soil moisture is adequate, irrigation should cease between the middle of R6 and R7 to allow the soil to begin to dry out for harvest. Stop irrigation at the earlier stage if there is enough moisture in the top and subsoil to carry the beans to maturity. With the price of diesel nearly double that of last year and the low price for soybeans, the earliest possible date for cutting off irrigation could be a more profitable choice this year rather than aiming to capture the maximum possible yield potential from the beans. Aerially seeded cover crops usually are flown on either in late R6 (Full Seed) stage or, where strobilurin fungicides have been used and leaf drop is unusually delayed, at this (R7) stage when about 20% of the leaves have dropped off the plants.

Photo 1. Soybean plants in the R7 or Beginning Maturity stage at which time at least one normal pod that has reached its mature pod color can be found on the main stem of 50% of the plants in the field (Photo courtesy of R. Taylor)

Full maturity occurs when 95% of the pods have reached their mature pod color (Photo 2). At full maturity, there is no longer an increase in yield due to seed fill since the abscission layer has formed cutting the beans off from the rest of the plant. From this point on, the process is essentially a matter of the seeds losing enough moisture to reach the point when they can be safely harvested, dried, or stored.

Photo 2. Soybean plants in the R8 or Full Maturity stage at which time 95% of the pods have reached their maturity pod color (Photo courtesy of R. Taylor)

Notices and Upcoming Events

June 29, 2006
Southern Piedmont Agricultural Research and Extension Center Annual Field Day
Concurrent tours highlighting the research programs in forages and tobacco. Registration will be from 9:00 to 9:30 am. Field tours will begin at 9:30 am. Please check http://www.vaes.vt.edu/blackstone for further details.

June 30, 2006
2006 Virginia Wheat, Barley, and Hulless Barley Yield Challenge Contest Entries due. Contact Molly Pugh at 757-421-3038 or email: mollypugh@cox.net with questions.

July 11, 2006
2006 Annual Meeting Northeastern Branch American Society of Agronomy, Soil Science Society of America, and Crop Science Society of America. Contact Greg Roth, PSU

July 27, 2006
Maryland Commodity Classic—This event is sponsored by the Maryland Grain Producers' Association and the Maryland Soybean Board. It will be held at the Queen Anne's 4-H Park near Centreville, MD. However, there will be a morning tour at the Wye Research and Education Center that will highlight 4 currently funded research projects by the two organizations. The morning tour will begin at 9:30 am. Events at the 4-H Park commence around 11:00 am but the highlights of the event are during the afternoon.

August 10, 2006
Virginia Ag Expo. Virginia Soybean Association and Virginia Corn Grower's Association annual field day. Beauregard Farm, Brandy Station, VA.

August 18, 2006
GEM Corn Hybrid National Meeting, Field tour in Smyrna, DE. Contact Dr. James Hawk, Department of Plant and Soil Sciences, University of Delaware, Newark, DE 302-831-1379 or email: jhawk@udel.edu

November 4, 2006
Equine Forage Conference, University of Delaware campus, Newark, DE. Contact Dr. David Marshall, davidlm@udel.edu

November 28-30, 2006
Mid-Atlantic Crop Management School to be held at the Princess Royale Hotel and Conference Center in Ocean City, Maryland. Contact Bob Kratochvil (rkratoch@umd.edu) or Richard Taylor (rtaylor@udel.edu) with questions or to obtain a registration booklet (available sometime in August).

January 22-27, 2007
Delaware Ag Week, Harrington, DE. Contact Ed Kee at 302-856-7303 or email: kee@udel.edu