



Mid-Atlantic Regional Agronomist Quarterly Newsletter

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Table of Contents

Issue 1; Number 3

Table of Contents.....	2
Managing Nitrogen and Sulfur Fertilization for Improved Bread Wheat Quality in Humid Environments	4
Introduction.....	4
Results and Recommendations:	5
Planting Wheat: Seeding Rates and Calibration	6
Organic Grain Production: Part II—Production Management for Organic Wheat and Small Grains.....	9
Variety Selection:.....	9
Planting Date.....	9
Rotation and Field Selection.....	10
Drill Calibration and Operation	10
Soil Fertility	10
Weed Management	10
Insect Pest Management	11
Disease Management	13
Avoiding Spring Freeze Injury	14
Troubleshooting Incomplete Ear Fill Problems in Corn.....	16
Potential for Stalk Rot and Lodging Problems in Corn	17
Salvaging Downed Corn.....	19
Estimating Corn and Soybean Yields	20
Frost Crack Seeding on Delmarva	22
Why are legumes often incorporated into hay or pasture fields?.....	22
Why do legumes help maintain low cost production from pastures and hay fields?.....	22
How do legumes help improve N-use efficiency?.....	22
Management and Principles for Frost Crack Seeding.....	23
Advantages of a Frost-Crack Seeding.....	25
Disadvantages of a Frost-Crack Seeding	25
Notices and Upcoming Events.....	26
Keystone Crops Conference	26
Equine Forage Conference.....	26
Mid-Atlantic Crop Management School.....	26
Delaware Ag Week.....	26
Delaware—Maryland Hay and Pasture Day.....	26
Dairy Day.....	26
Agronomy/Soybean Day.....	26
Tri-State Conservation Tillage Conference	26

Southwestern PA Tillage Conference.....	26
Corn, Soybean, and No-Till Conference.....	26
PASA Conference.....	26
Virginia Corn Growers, Virginia Soybean, and Virginia Small Grain Growers Associations' Joint Winter Meeting	27
Virginia Crop Improvement Annual Meeting.....	27
Hay & Forage Conference	27
National Grass Fed Beef Conference.....	27
Grazing & Forage Conference	27
PA No-Till Alliance Conference	27
Newsletter Web Address.....	27

Managing Nitrogen and Sulfur Fertilization for Improved Bread Wheat Quality in Humid Environments

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Introduction:

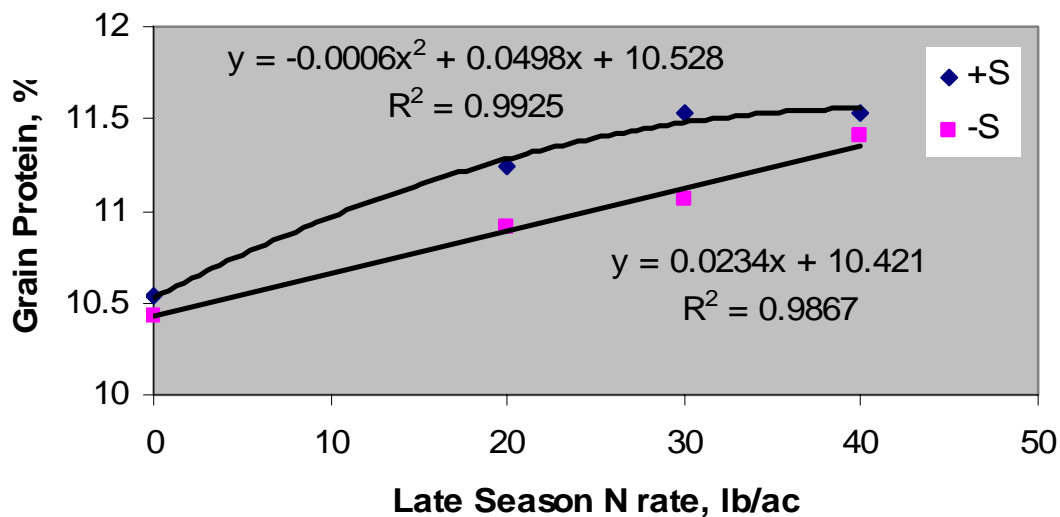
The wheat milling capacity in the Mid-Atlantic region of the U.S. is 2,900,000 Mg (3,195,800 U.S. tons) of grain per year. A large portion of this grain is imported by regional mills from other wheat growing areas, especially the Great Plains. Some millers use only hard wheat which is almost exclusively imported. Hard wheat and certain strong gluten soft wheat cultivars are suitable for use in making bread products. Because a higher value market exists for these types of bread wheat than soft wheat, producers are interested in using adapted cultivars and developing agronomic techniques to grow bread wheat in the Mid-Atlantic region. Millers in the Mid-Atlantic region are interested in obtaining locally grown bread wheat because transportation costs, and thus total cost, would be greatly reduced for grain produced in the region.

Since cultivars of soft red winter wheat (SRWW) grown under wet, humid environments are typically lower in grain protein than hard red winter wheat (HRWW) produced in drier areas and because relatively high grain protein levels are needed for bread production, both breeding and management techniques are required to increase grain protein concentration with minimal economic and environmental impacts. The current research was undertaken to determine the optimum rate and timing for late-season nitrogen (N) applications to bread wheat and to evaluate the effect of late-season foliar N and sulfur (S) applications on bread wheat yield, grain protein, and milling and baking quality in the humid Mid-Atlantic region. Field experiments were conducted in eastern Virginia using the French bread wheat cultivar 'Soissons'. Spring N was applied at GS 25 and 30 based on standard split application management practices. Late-season foliar N treatments consisted of 0, 20, 30, and 40 lb N/ac (0, 20, and 30 lb N/ac at Warsaw in 2001) applied as dissolved urea solution at 45 gal/ac at GS (Zadok's growth stage) 37, GS 45, or GS 54. Sulfur at a rate of 30 lb S/ac was applied at GS 30 randomly to four of eight replications.

Results and Recommendations:

Grain yields varied from 58 to 130 bu/ac over experiments yet a consistent relationship between late-season N application and grain yield was not observed for extremely high to low yielding environments. This inconsistent yield response to late-season N is similar to that reported by other researchers where N was not a yield-limiting factor. Since application of late-season N up to 40 lb N/ac did not decrease grain yield, late-season N applications can be made to enhance grain protein concentration without a detrimental effect on yield.

Grain protein concentration of Soissons was not altered significantly with the addition of 30 lb S/ac at GS 30 without late-season N; however, grain protein concentration increased an average of 0.2 percent when N was applied in conjunction with S (Figure 1). Based on the quadratic response observed when both N and S were applied, a greater incremental advantage of S was observed at lower N rates (20 and 30 lb/ac). Late-season N alone increased grain protein concentration but to a lesser extent than when the same N rate was applied to plots receiving S.



In summary, application of 30 to 40 lb N/ac between GS 45 and 54 to winter bread wheat cultivars grown in humid, high rainfall areas likely will result in consistent increases in grain and flour protein concentration as well as increased water absorption and improvements in bread loaf volume. Availability of S from soil and a desirable N:S ratio is critical when considering the positive interaction between N and S on grain protein quantity and quality.

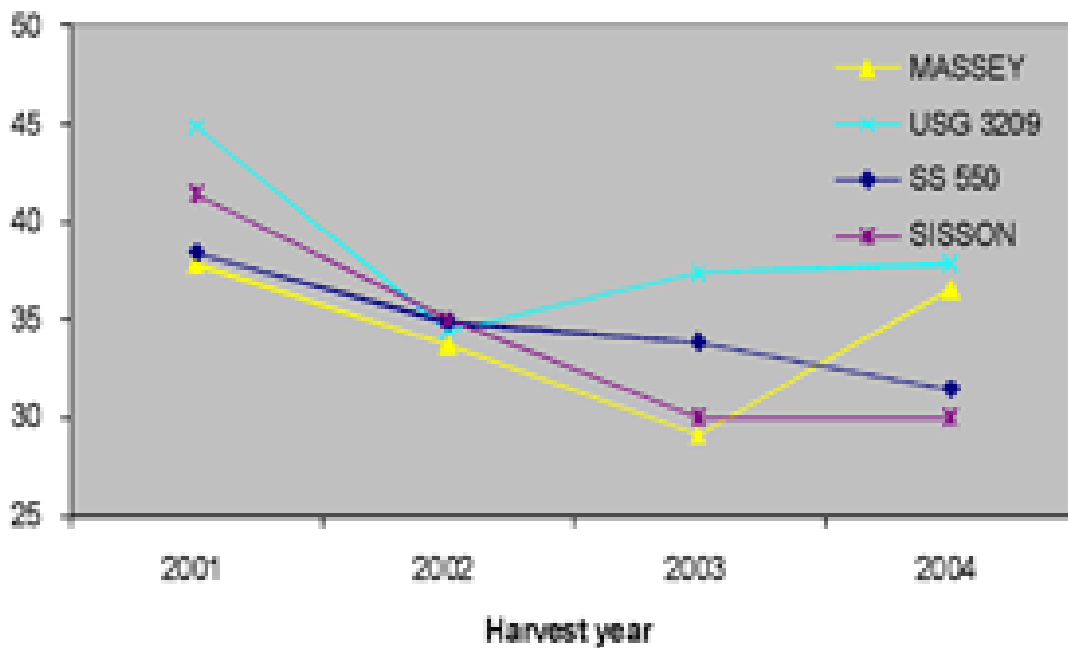
Planting Wheat: Seeding Rates and Calibration

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As much as 60% of the final yield potential for a wheat crop is determined at planting. Seeding too thinly, using poor quality seed, and uneven stands result in end of season yield losses that cannot usually be overcome.

It is important to plant on a seed per foot basis rather than on a weight per acre basis. Since wheat kernel size is known to vary by as much as 50% (12,000 - 18,000 seeds per lb) between varieties and years, it's easy to see how planting rates in terms of bushels per acre or lbs per acre without consideration of the seed size could result in low populations that reduce yields or high populations that increase seed cost. Planting 2 bushels per acre of seed that has 12,000 seeds per lb would result in a seeding rate of 33 seeds/ft²; conversely, planting 2 bushels per acre of seed that has 18,000 seeds per lb would result in a seeding rate of 50 seeds/ft². Big difference!

Differences in the number of seed per lb exist because seed weight or kernel plumpness is determined primarily by the environment in which it is grown and by the degree of cleaning. An example of this high degree of variability is illustrated by the following graph showing 1000 kernel weights for 4 wheat varieties over 4 years. All seed was cleaned to the same standard each year. Seed size obviously varies by variety, but also by year. The only way to truly understand this variability is to check.



Previous research in Virginia has determined that optimum yields result from a plant population of 22-25 vigorous plants per square foot. To reach this goal, multiply this value by the seed germination (%). This will account for those seed that do not emerge. Actual seeding rates will likely need to be 30-35 seeds/ft².

The following instructions indicate how to calibrate a drill for a particular seed lot.

Step 1: Select the proper seeding rate/row foot for your drill row width.

Row spacing (inches)	Seeding rate/row foot
6	18
7	20
8	22

Step 2: Calculate the number of seeds required in 50 feet of row. For example, in 7.5 inch wide rows and planting on time, an appropriate seeding rate would be 22 seeds per drill-row foot times 50 feet, which equals 1100 seeds planted every 50 feet of each row. Count 1100 seeds of each variety and put the seed in a graduated tube such as a rain gauge, or a clean tube or cup. Mark the level of the 1100 seeds in the tube.

Step 3: Hook a tractor to the grain drill so that the drive wheels of the drill can be raised off the ground with a jack, and the drive gears can be engaged. Raise the drive wheel so it clears the ground and turn the wheel several revolutions to be certain that everything is turning freely. Check all drill spouts and make sure there are no blockages.

Step 4: Determine the number of revolutions the drive wheel must turn to travel 50 feet. This can be done in one of two ways.

Option A: Measure the distance around the drive wheel. The distance can be measured directly with a tape measure.

- The number of tire revolutions per 50 feet is calculated by the following formula:
 - Inches traveled in 50 feet = 50 feet X 12 inches/foot= 600 inches.
- For example, if the distance around the tire measures 96 inches, the number of tire revolutions per 50 feet is calculated by the following formula:
 - Number of tire revolutions per 50 feet = 600 inches divided by 96 inches per revolution = 6.25 revolutions of the tire per 50 feet of travel.

Option B: Measure 50 feet in a field and count the number of revolutions the drive wheel makes in 50 feet. Always check the number of tire revolutions per 50 feet on soil conditions similar to those that will be experienced during planting.

Step 5: To calibrate the drill:

- a. Raise the drive wheel off the ground so it can be easily turned.
- b. Put at least a quart of seed of the lot to be calibrated over each of two adjacent drill spouts.
- c. Turn the drive wheel several revolutions so that seed is flowing through the drill and stop the wheel at a convenient mark such as the valve stem straight up or use a mark placed on the tire.
- d. Remove the rubber boot from the two drill spouts with seed and place a container under each spout to catch the seed. Catch the seed from each spout in a separate container.
- e. Adjust the seeding rate to a setting that is expected to be close and turn the drive wheel the appropriate number of turns for traveling a distance of 50 feet (determined in Step 4).
- f. Pour the seed from one row into the pre-calibrated tube from Step 2. Check the second row the same way.
- g. If the seeding rate is too high or too low, change the drill setting and repeat steps e and f in this list until the appropriate seed number is obtained.
- h. Steps d-g should be repeated on two additional rows on the opposite side of the drill if the drill is driven by more than one drive wheel.
- i. Remove seed from the drill and put in the next variety, or seed lot, to be calibrated.
Repeat the procedure

Organic Grain Production: Part II—Production Management for Organic Wheat and Small Grains

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Variety Selection:

As a general rule, only small grain varieties that have been successfully grown in your state for two years should be considered for production. Official Variety Test reports are available online from your land grant university or from your county Extension center. It is nearly impossible to pick a single best variety. Consequently, producers should plant two or more varieties every season in order to reduce their risks and maximize the potential for a high-yielding crop. The following are general guidelines for selecting varieties for organic wheat production:

- Check the *Official Variety Test Report* for a list of varieties tested for at least two years.
- To avoid spring freeze injury, eliminate early heading varieties in favor of medium- and late-heading varieties.
- If powdery mildew is common in your area, select varieties that are rated as “good” for powdery mildew resistance.
- If leaf rust is common in your area, select varieties that have “good” or “fair” resistance to leaf rust.
- If possible, avoid varieties that are rated “poor” for Hessian fly biotype-L.
- If wheat is being produced for the baking industry, it is a good idea to check variety selection with the end user.

Planting Date:

Not too early and not too late! Planting too early puts the crop at severe risk for powdery mildew, Hessian fly, aphids, and barley yellow dwarf virus. Planting too late will reduce yields, increase the risk of having a winter annual weed problem, and result in thin stands that will attract cereal leaf beetles. For the optimum planting times in regions of North Carolina, see the most recent edition of the *Small Grain Production Guide* or go online to <http://www.smallgrains.ncsu.edu/Guide/Chapter7.html>. For the optimum planting time in other states, contact your local county agricultural Extension agent for information.

Rotation and Field Selection:

Planting wheat into old wheat stubble is always a bad idea. Several major small grain diseases and Hessian fly are vectored on old wheat stubble. Short rotations put small grains at high risk to numerous soil-borne diseases and should be avoided in organic production. Additionally, as described in more detail below, the best way to avoid a Hessian fly problem is to plant at least one field (or ¼-mile) away from last year's wheat stubble and to avoid planting near an early-planted wheat cover crop. Fields with a history of Italian ryegrass, wild garlic, wheat spindle streak, or wheat soil-borne mosaic virus should be avoided.

Drill Calibration and Operation:

A good stand of wheat is the best defense against weeds and cereal leaf beetle, and is the best indicator of a high yield potential. A complete guide to seeding rate, drill calibration, planting depth, and other planting considerations can be found in the most recent edition of the North Carolina *Small Grain Production Guide* or go online to <http://www.smallgrains.ncsu.edu/Guide/Chapter6.html>. For the seeding rate information and other pertinent information from other states, contact your local county agricultural Extension agent.

Soil Fertility:

Wheat that yields 40 bushels per acre uses about 50 pounds of nitrogen per acre, 25 pounds of phosphate per acre, and 15 pounds of potash per acre. Wheat is a moderately heavy feeder, but not as heavy as corn. For best yield results, an organically approved nitrogen source (such as manure, compost, or a tilled-in legume) should be added at or before planting and again in the spring. In early spring, it is possible to test a wheat crop and determine how much additional nitrogen it needs to produce optimal yield. Organic growers may want to use tissue testing to determine whether the crop needs additional spring top-dress nitrogen.

Weed Management:

Essentially all weed control in organic wheat must be achieved in seedbed preparation before planting. Little to no cultivation is used in wheat after planting to kill emerging weeds, but a rotary hoe or tine weeder can be used before the crop emerges if needed. However, weeds usually cause fewer problems in wheat than in corn or soybeans because wheat is a strong competitor against weeds and is drilled in narrow rows that quickly shade the soil. Most wheat drills are set to plant rows that are 6 to 8 inches apart. Organic producers may want to take advantage of row spacing as narrow as 4 inches to help the wheat out compete winter annual weeds. Avoid planting organic wheat in fields with Italian ryegrass or wild garlic problems as these weeds can lead to quality problems in the harvested grain. Also, use caution with hairy vetch as a cover crop in fields where wheat will be planted because hairy vetch that reseeds can contaminate wheat grain with seeds that are similar in size and weight and that are difficult to separate.

Insect Pest Management:

Wheat fields are susceptible to many kinds of insects. Only a few species may become pests, and even when they do, they usually do not reach damaging above-threshold numbers. However, in some seasons or under certain circumstances, insect pests of wheat can be very damaging. The following insects may become abundant enough to cause significant injury to wheat crops: aphids (several species), cereal leaf beetle, Hessian fly, and armyworm (sometimes called true armyworm). Other plant-feeding insects, such as grasshoppers, chinch bugs, or fall armyworms, may occasionally damage wheat.

Wheat-feeding aphids

Aphid feeding potentially reduces yield, but usually not dramatically. Aphids are also vectors of barley yellow dwarf virus (BYDV), and this disease can be a serious concern. A complex of biological control agents accompanies aphids, including parasites, predators, and pathogens (mainly fungi). These biological control agents ordinarily exert a powerful controlling influence on aphid populations, especially in the spring, although it usually requires some time before the aphid populations “crash” due to the combined influence of these agents. Several cultural practices can help reduce the chance of aphid damage and BYDV infection in organic production.

Avoid early planting. Cool weather will slow aphid feeding and activity in the newly emerged crop, and reduces the chance that aphid-transmitted BYDV infections will occur. The aphid population may build up again in the spring, but these populations are less damaging because plants are larger, growing more rapidly, and are more tolerant to feeding and BYDV infection.

Avoid excessively high soil nitrogen levels. Aphids reproduce most rapidly on plants with high nitrogen content. Maintaining nitrogen levels within the prescribed agronomic level helps to avoid high aphid populations.

Select wheat varieties with BYDV resistance. If BYDV is a regular problem on your farm or on neighboring farms, a highly effective strategy is to select wheat varieties that are resistant to this disease. A list of wheat varieties and their resistance to BYDV can be found at this Web site: <http://www.smallgrains.ncsu.edu/Varieties/Varieties.html>

Armyworm

Armyworm moths are one of a few moths active in late winter and early spring. Armyworm caterpillars may cause serious defoliation and substantial head drop. They are most prevalent in the northeastern counties of North Carolina.

Management options. Few cultural management options are available for armyworm. Organic growers have the choice of accepting the feeding of armyworms or using an insecticide approved for organic production (such as a spinosad) in emergency situations. Accepting the feeding of armyworm is not likely to result in large yield losses unless

plants were defoliated early (before or during the heading period). For scouting information on armyworm, go online to <http://www.smallgrains.ncsu.edu/Guide/Chapter11.html>.

Cereal leaf beetle

The cereal leaf beetle (CLB) has one generation each year, and both the adult and larval stages eat leaf tissue on wheat and oats. They do not feed on barley, triticale, or rye. Leaf feeding by larvae during April and May can reduce yields. Cereal leaf beetle is an introduced pest, and few native biological control agents affect adult beetles, eggs, or larvae. A few generalist predators, such as lady beetles, appear to consume cereal leaf beetle eggs and, perhaps, young larvae in early spring. Parasite release programs have worked well in several other states, but so far have had limited success in North Carolina.

Cultural practices. Cereal leaf beetles prefer to attack a thin field full of little plants rather than a thick, lush field full of large, healthy wheat. To minimize the chances of beetle invasion, the organic producer needs to do everything possible to assure a thick, well tillered, healthy crop. This means good seed bed preparation, planting on time, using high quality seed, correct drill calibration, and getting good soil-seed contact at the proper seeding depth.

Insecticides. Insecticides approved for organic production (such as a spinosad) and labeled for cereal leaf beetle may be applied in emergency situations. For scouting information for cereal leaf beetle, check the most recent edition of the *Small Grain Production Guide* or go online:

<http://www.smallgrains.ncsu.edu/Guide/Chapter11.html>.

In addition, a special publication on this pest can be found at

<http://www.ext.vt.edu/pubs/entomology/444-350/444-350.html>.

Hessian fly

In recent years, Hessian fly infestations have caused extensive losses in many fields. Organic farmers should use several methods to minimize Hessian fly problems.

Rotation. Because the Hessian fly life cycle depends largely upon the presence of wheat stubble, using rotations that do not plant new wheat into or near a previous wheat crop's stubble will be the most effective way to prevent infestations. Additionally, since the Hessian fly is a weak flier, putting at least one field (or about ¼-mile) between new wheat plantings and the previous season's wheat fields can be a successful method of preventing new infestations.

Tillage. Disking wheat stubble after harvest effectively kills Hessian fly. Burning is not as effective as disking because many pupae will survive below the soil surface.

Careful use of cover crops. Serious Hessian fly infestations have occurred in areas where wheat for grain was planted near early-planted wheat for cover or early-planted wheat for

dove hunting purposes. In organic systems using cover crops, selecting a small grain other than wheat will reduce Hessian fly populations. Oats, rye, and triticale are not favorable for Hessian fly reproduction and do not serve as a nursery.

Plant on time. An early freeze may not be dependable, so do not delay planting until after the first freeze (often called the fly-free date). Often a “killing freeze” does not occur until it is later than most growers need to have wheat planted for agronomic purposes. Also avoid planting *before* the recommended planting dates.

Resistant varieties. Be sure to plant varieties that are resistant to the biotype of Hessian fly found in your area.

Disease Management:

The first step in solving disease problems is to identify the disease. Excellent small grain disease information and assistance with disease identification can be found in the latest edition of the *Small Grains Production Guide* or on the Web at

<http://www.smallgrains.ncsu.edu/Diseases/Diseases.html>.

Barley yellow dwarf virus. Barley yellow dwarf virus (BYDV) is the most important viral disease of wheat, oats, barley, and rye in this state. The virus is transmitted by aphids that spent the summer on nearby corn crops or host grasses. The best control measure in organic production is to plant varieties that are resistant to this disease.

Powdery mildew. One of the most yield-limiting factors in wheat production in many mid-Atlantic states is powdery mildew. This is especially true in the coastal plain, the southern piedmont, and some tidewater areas. Organic producers do not have the luxury of relying on conventional foliar fungicides like conventional producers.

Select resistant varieties. The best protection against powdery mildew is to select wheat varieties that are resistant to it. Organic producers who want high-yielding wheat must plant powdery-mildew resistant varieties. Wheat varieties grown in North Carolina are evaluated for disease resistance every year, and new disease-resistance ratings are published in the *Small Grains Official Variety Test Results* and posted on the Internet every July in time for growers to order the best varieties for the next year’s production.

Adjust planting date. A second defense against powdery mildew is to plant after the weather has turned cold. However, although powdery mildew does not grow in cold weather, neither does wheat. This means that late planted wheat may avoid powdery mildew, but it is also likely to suffer from lower yields and attack by cereal leaf beetle. It is important to not plant before recommended planting dates.

Leaf rust. Leaf rust is a foliar disease that attacks wheat late in the growing season. While leaf rust can occur anywhere in North Carolina, it is most likely to be a problem in the tidewater. Organic producers must select varieties with good resistance to leaf rust.

Variety resistance to leaf rust also deteriorates from year to year, so organic producers should check the most recent variety ratings every year before ordering seed.

Loose smut. Loose smut symptoms occur between heading and maturity. Infected seed appears normal. The fungus, which is found inside the embryo of the seed, will grow within the plant from germination until the seed heads emerge and smutted grains appear. Therefore, symptoms from an infection that occurs in one year will not be seen until plants from the infected seed mature in another year. Because loose smut is seed-borne, control measures focus on the seed to be planted. Certified seed fields are inspected for loose smut, and strict standards are enforced. Seed from fields with loose smut are rejected. Therefore, using certified seed is a highly effective way to avoid loose smut. Organic producers who use farmer-saved seed should never plant seed from a crop infected with loose smut.

Septoria leaf and glume blotch. Septoria leaf and glume blotch may occur at any time during the growth of the plant and on any portion of the plant. Rotation away from small grains for at least three years can lessen the severity of septoria. Plowing under wheat stubble will prevent infection from the previous wheat crop. Potash, copper, and magnesium should be kept at recommended levels. In some cases, septoria can be seed-borne, so certified seed can reduce introduction of the disease. Organic farmers should never save seed for planting if the wheat was infected with septoria.

Scab or head blight. Scab, a fungus that is seen as prematurely bleached heads or spikelets, can occur in all small grains. Of the small grains, wheat and barley are the most susceptible to this disease, and rye and triticale are the most resistant. Scab occurs and is spread to small grains in the spring. It also results in toxins (vomitoxin is most common) in the harvested grain. The first line of defense against scab is to plant wheat varieties with resistance to the fungus. Tillage practices that bury wheat or corn residues and rotations of at least three years are effective means of controlling scab in organic production. Planting several wheat varieties with different heading dates will stagger head emergence and flowering through the spring and reduce the chance that environmental conditions will be suitable to scab in all wheat fields. If scab is present, the combine may be adjusted so that the lightweight diseased grain is removed along with the chaff. This will not remove all the infected grain, but can help reduce mycotoxin levels in the grain going to market. Organic producers should never use farmer-saved seed if head scab was present in the crop that produced the seed.

Other small grain diseases. Several other small grain diseases can be problems in North Carolina. Growers in need of more detailed information should check online at <http://www.smallgrains.ncsu.edu> or with their local county agricultural Extension agent.

Avoiding Spring Freeze Injury:

Late spring freeze damage is a major factor in reducing yields of North Carolina wheat and can sometimes be a problem in other mid-Atlantic states. “Heading date” is an important

indication of how susceptible a variety will be to late spring freeze damage. Early-heading varieties are the most susceptible to freeze damage. Medium- and late-heading varieties are more likely to avoid spring freeze damage, and they generally produce higher yields than early- or medium early heading varieties. Heading date also indicates the best planting date for a wheat variety. Medium and late-heading wheat varieties tend to do best when planted at the start of the planting season, and should be the first varieties planted. Early and medium-early varieties tend to produce the highest yields when planted later in the fall. Wheat variety heading date information can be found online: <http://www.smallgrains.ncsu.edu/Varieties/Varieties.html>.

Troubleshooting Incomplete Ear Fill Problems in Corn

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Even as corn harvest winds down, there have been questions from growers about ears of corn with unfilled tips. In some cases, no kernels are evident on the last two or more inches of the ear tip. Several factors may cause this problem. The ovules at the tip of the ear are the last to be pollinated, and under certain conditions only a limited amount of pollen may be available to germinate late emerging silks. Pollen shed may be complete before the silks associated with the tip ovules emerge. As a result, no kernels form at the ear tip. Severe drought stress may result in slow growth of the silks that prevents them from emerging in time to receive pollen. Pollen feeding and silk clipping by corn rootworm beetles and Japanese beetles also contribute to pollination problems resulting in poorly filled tips and ears. I've observed this insect injury in late planted corn fields, especially field surrounded by early (late April/early May planted corn). In several fields, the damage has been extensive with many ears showing only a few scattered kernels.

Incomplete ear fill may also be related to kernel abortion. If plant nutrients (sugars and proteins) are limited during the early stages of kernel development, then kernels at the tip of the ear may abort. Kernels at the tip of the ear are the last to be pollinated and cannot compete as effectively for nutrients as kernels formed earlier. Stress conditions, such as heat and moisture stress, nitrogen deficiency, hail, and foliar disease damage, may cause a shortage of nutrients that lead to kernel abortion. Periods of cloudy weather following pollination, or the mutual shading from very high plant populations can also contribute to kernel abortion. Some agronomists characterize the kernel abortion that occurs at the end of the ear as "tip dieback". Kernel abortion may be distinguished from poor pollination of tip kernels by color. Aborted kernels and ovules not fertilized will both appear dried up and shrunken; however aborted kernels often have a slight yellowish color.

Is the presence of barren tips a major cause for concern? Not always. In many cornfields this year, the favorable growing conditions may have resulted in a larger number of potential kernels per row than normal. So even if corn ear tips are not filled completely, due to poor pollination or kernel abortion, yield potential may not be affected significantly, if at all, because the numbers of kernels per row may still be above normal. The presence of ears consistently filled to the tip may actually indicate that a higher plant population is needed to optimize yields.

Potential for Stalk Rot and Lodging Problems in Corn

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The dry weather that many areas of Ohio experienced in July and August is likely to increase the potential for lodging and stalk rot problems in corn. When stalk rot occurs late in the season as it often does, it may have little or no direct effect on yield. Nevertheless, stalk lodging, which results from stalk rot, can have such an impact on harvest losses that many plant pathologists consider stalk rots to be the most significant yield limiting disease of corn.

For a corn plant to remain healthy and free of stalk rot the plant must produce enough carbohydrates by photosynthesis to keep root cells and pith cells in the stalk alive and enough to meet demands for grain fill. When corn is subjected to severe drought stress, photosynthetic activity is sharply reduced as leaves roll tightly and plant growth slows. As a result, the carbohydrate levels available for the developing ear are insufficient. The corn plant responds to this situation by removing carbohydrates from the leaves, stalk, and roots to the developing ear. While this "cannibalization" process ensures a supply of carbohydrates for the developing ear, the removal of carbohydrates results in premature death of pith cells in the stalk and root tissues, which predisposes plants to root and stalk infection by fungi. Even mild, early season water stress during the pretassel stage of development can significantly increase root infection by stalk rot fungi and result in greater stalk rot at maturity. As plants near maturity, this removal of nutrients from the stalk to the developing grain results in a rapid deterioration of the lower portion of corn plants in drought stressed fields with lower leaves appearing to be nitrogen stressed, brown, and/or dead.

Other plant stresses which increase the likelihood of stalk rot problems include: loss of leaf tissue due to foliar diseases (such as gray leaf spot or northern corn leaf blight), insects, or hail; injury to the root system by insects or chemicals; high levels of nitrogen in relation to potassium; compacted or saturated soils restricting root growth; and high plant populations.

Most hybrids do not begin to show stalk rot symptoms until shortly before physiological maturity. It is difficult to distinguish between stalk rots caused by different fungi because two or more fungi may be involved. Similarly, certain insects such as European corn borer often act in concert with fungal pathogens to cause stalk rot. Although a number of different fungal pathogens cause stalk rots, the three most important in Ohio are *Gibberella*, *Collectotrichum* (anthracnose), and *Fusarium*. For more information on stalk rot in corn, consult the OSU Plant Pathology web site "Ohio Field Crop Diseases"

<http://www.oardc.ohio-state.edu/ohiofieldcropdisease/>) for more details and pictures of the disease symptoms associated with these pathogens.

The presence of stalk rots in corn may not always result in stalk lodging, especially if the affected crop is harvest promptly. It's not uncommon to walk corn fields where nearly every plant is upright yet nearly every plant is also showing stalk rot symptoms! Many hybrids have excellent rind strength, which contributes to plant standability even when the internal plant tissue has rotted or started to rot. However, strong rinds will not prevent lodging if harvest is delayed and the crop is subjected to weathering, e.g. strong winds and heavy rains.

A symptom common to all stalk rots is the deterioration of the inner stalk tissues so that one or more of the inner nodes can easily be compressed when squeezing the stalk between thumb and finger. It is possible by using this "squeeze test" to assess potential lodging if harvesting is not done promptly. The "push" test is another way to predict lodging. Push the stalks at the ear level, 6 to 8 inches from the vertical. If the stalk breaks between the ear and the lowest node, stalk rot is usually present. To minimize stalk rot damage, harvest promptly after physiological maturity (about 30% grain moisture). Harvest delays will increase the risk of stalk lodging and grain yield losses, and slow the harvest operation.

Salvaging Downed Corn

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During the late summer, cornfields across Ohio have been subjected to major rains storms and some storms have been associated with strong winds. Even a tornado in Pickaway County caused localized damage to fields—flattening corn in at least one field. For such injury, how much yield loss could be expected? For corn planted in April, most of the affected corn was well into the dent stage - perhaps only one to two weeks away from kernel black layer (when the kernel achieves maximum dry weight). Therefore, it's unlikely that the severe root lodging at this late grain fill stage had a major direct impact on grain yield (probably less than 10% yield loss).

However, significant field losses may occur when harvesting downed corn. Timing of harvest, proper combine calibration, special header attachments and safety will be especially important. The following is information addressing this topic from Iowa State University Extension “Reducing Harvest Losses in Lodged Corn Fields”
<http://ces.ca.uky.edu/lyon/anr/Reducing%20Harvest%20Losses%20in%20Lodged%20Corn%20Fields.htm>

Estimating Corn and Soybean Yields

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There are a number of methods for estimating corn and soybean yields and their accuracy depends on how much trouble you want to go to when coming up with the items used in determining the estimate. The more sites selected and the better the representation of the field, the more accurate the estimate. For corn, a yield estimate can be determined anytime after the milk stage although actual yield can be affected by such factors as drought that impact kernel size. By the dent stage, yield estimates should be fairly accurate for corn. Soybean yield estimates can be made from R6 or full seed stage onward but again late-season stresses can significantly change the accuracy of the estimate.

For corn, choose a minimum of 10 sites from a field and choose some good areas, bad areas, and average areas trying to obtain as representative a sample of the field as you can. At each site measure a length of row based on the row spacing (for 30-inch rows use 17 feet five inches of row, for 36-inch rows use 14 feet six inches of row, for 20-inch rows use 26 feet 1.6 inches of row). Within this length of row count the number of harvestable ears and select one average sized ear. On this ear count the number of kernel rows (typically 12 to 18) at the mid-point of the ear and the number of kernels per row (typically 30 to 50). Now multiply as follows:

$(\# \text{Kernels/row}) \times (\# \text{ rows per ear}) \times (\# \text{ ears per row length chosen based on row spacing}) \times (0.01116) = \text{Estimated Yield in bushels per acre adjusted to 15.5\% moisture.}$

For example on 30 inch rows, you select sites of 17 feet five inches of row and find that there are on average 23.2 ears per site and that these ears average 12 rows with 32 kernels per row (having ignored the tiny kernels at the very tips of the ear just to be conservative). The yield estimate you have come up with is $(32 \times 12 \times 23.2 \times 0.01116)$ or 99.4 bu/A.

For soybeans, the procedure is roughly similar although there often is more flex (variability) in some of the assumed components such as seed size (seeds per pound) and seeds per pod since these can be significantly impacted by environmental and other factors as the plants mature.

First, measure the length of row to be observed in at least ten locations in the field based on the Table 1. Count the number of harvestable plants in the correct length of row in the ten locations and obtain the average number of plants per row length. Multiply this number by 1,000 to obtain the number of plants per acre. Choose two or more representative plants from these locations and count the number of pods per plant, divide by the number of plants, and obtain the average number of pods per plant. Next, multiply the numbers obtained as follows:

$(\text{average \# pods/plant}) \times (\# \text{ plants per acre}) \times (2.5 \text{ seeds/pod}) \div 3000 (\text{seeds/lb}) \div 60 (\text{lb/bu}) = \text{bushels per acre}$

Table 1. Row length needed at various row spacing to be equivalent to one thousandth of an acre.			
Row spacing	Row length to measure	Row spacing	Row length to measure
6-inch rows	87 feet 1.4 inches	20-inch rows	26 feet 1.6 inches
7-inch rows	74 feet 8.1 inches	22-inch rows	23 feet 9.1 inches
7.5-inch rows	69 feet 8.4 inches	24-inch rows	21 feet 9.4 inches
8-inch rows	65 feet 4.1 inches	28-inch rows	18 feet 8 inches
10-inch rows	36 feet 3.6 inches	30-inch rows	17 feet 5 inches
12-inch rows	43 feet 6.7 inches	32-inch rows	16 feet 4 inches
15-inch rows	34 feet 10.2 inches	36-inch rows	14 feet 6.25 inches
18-inch rows	29 feet 0.5 inches	40-inch rows	13 feet 0.82 inches

For example on 15-inch row spacing, you counted an average of 145 plants in 34 feet 10.2 inches of row (times 1,000 equals 145,000 plants per acre) and an average of 25 pods per plant. Your estimated yield would be:

$$(25 \text{ pods/plant}) \times (145,000 \text{ plants per acre}) \times 2.5 \text{ seeds/pod} \div (3,000 \text{ seeds/lb}) \div (60 \text{ lbs/bushel}) = 50.3 \text{ bushels per acre Estimated Yield}$$

Please note that for the soybean yield estimate, we are using an average seed size and an average seed number per pod. You can improve this estimate possibly by counting the number of seeds per pod on the selected plants and dividing by the number of pods on the plants to obtain a better estimate of seeds per pod. Seed size is something not completely determined until close to physiological maturity or between the R7 and R8 growth stages but if growing conditions have been excellent (irrigated beans for example) you might lower the seeds/lb number to 2400 or if the crop has been injured by drought and the seed size is likely to be very small you can increase this number to 3600 to 4000 to account for these factors.

Frost Crack Seeding on Delmarva

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Why are legumes often incorporated into hay or pasture fields? There are many reasons but six important ones jump out at you. First, legumes maintain pasture productivity and improve pasture quality. Second, the legume component improves the protein yield from these fields. Third, the addition of legumes improves the nitrogen (N) use efficiency. Fourth, legumes help maintain low cost forage production for a more viable animal production system. Fifth, they improve the soil nutrient use balance since not only does the root system differ from grasses but legumes use different relative amounts of nutrients than grasses and the combination of the two creates a better balance in nutrient use. Finally, legumes can improve the seasonal forage distribution especially for certain grasses commonly used in the region.

Why do legumes help maintain low cost production from pastures and hay fields? Is it because the N supplied by the legume is free? No, actually there can be a substantial cost (not necessarily in dollars) involved with legume N. The final cost depends on the life expectancy of the legume and the productivity (yield) of the legume. The amount of N shared with any companion grass (or following grain/grass crop) will impact the real cost of the legume's N to the producer. Annuals that do not successfully reseed themselves can often have N cost of \$0.75 to \$1.50 per pound of fixed N. Long-term perennials such as alfalfa have a very high seeding year establishment cost considering the cost of seed, the required seeding rate, and the expense of establishment using no-till drills. If the alfalfa persists for many years, the cost of N can be competitive with the cost of commercial N but if the stand is lost early the N cost can be very high. Even if the stand persists for many years, the initial dollar investment can be daunting. When appropriate perennial legumes are combined with low cost establishment methods such as frost crack seeding and other management factors are optimized to maintain legumes in fields, the cost of legume N for forage production can be lower or at least competitive with commercial fertilizer N.

How do legumes help improve N-use efficiency? Rainfall in this region is often unpredictable and droughts of several weeks duration are frequent. During these times, yield response to applications of fertilizer N is well below the expected or ideal response. Recent research in New Jersey indicated little if any economic response to N application to hay fields in a dry year and in fact showed significant reduction in net return per acre. Using legumes in pastures and hay fields (when marketing conditions favor inclusion of a legume) can provide the grass component with available soil nitrogen during favorable conditions yet conserve N during drought conditions. This establishes a nitrogen cycle where N is stored in organic forms until favorable weather conditions encourage N mineralization that makes N available for grass growth.

The key management tools for maintaining legumes in forage systems are 1) pH maintenance, 2) soil fertility maintenance especially for calcium (Ca), magnesium (Mg),

phosphorus (P), potassium (K), molybdenum, boron, zinc, and copper, 3) proper harvest management, and 4) occasional reseeded. Reseedings can be via conventional tillage (often requiring total renovation of the field in question), no-till (using a no-till drill), reduced tillage (using broadcast seeding followed by shallow incorporation with a light harrow, disk, field aerator or other equipment that will minimize damage to the existing sward), or low-cost frost crack seeding.

Management and Principles for Frost Crack Seeding

Frost crack seedings are an inexpensive means of establishing or reestablishing legumes in pasture or hay fields. It is ideally suited to fields too small or irregularly shaped in which to use large equipment. It is most appropriate for use with small-seeded legumes such as white, ladino, or red clover although it has been used with grasses and on rare occasion with larger-seeded legumes such as hairy vetch and alfalfa (low probability of success). If done at the correct time and managed properly to improve the success rate, frost crack seeding can be a very inexpensive tool available to all forage producers regardless of size and level of technology.

To properly manage fields for successful frost crack seeding, begin your preparation the summer before by using the soil test results to determine if lime, P, and K should be applied. Maintain the pH at 6.0 or above in the top 2 inches of soil plus optimum levels of P and K. If fertility levels are below this threshold, fertilize in the late-summer to raise soil test values prior to a winter frost crack seeding.

Another management factor to consider ahead of time is weed control. Rotational grazing, proper continuous grazing, mowing to minimize weed seed production, or timely harvest practices (or clipping) can control most annual weeds and minimize the need for herbicides. Perennial weed problems can sometimes be reduced by incorporating mixed species grazing (adding in goats or sheep if grazing horses or cows) in pasture systems. Also in the fall, graze the pasture or mow the hay field to remove excess forage growth to increase light penetration to the soil and encourage forage establishment from frost crack seeding.

The principle involved in frost crack seeding is to seed during late winter or very early spring when freezing and thawing of the soil is producing frost action with ice crystals coming out of the ground and opening cracks in the soil. If the legume or grass is broadcast over the field surface the freezing, thawing, and refreezing will incorporate the seed to some degree into the soil to enhance germination. Also, the seed is present during a cool, moist time that favors legume germination before summer annual weeds germinate. Usually, this occurs between late January and late February although in some years there is not enough cold weather during the winter to favor frost crack seeding.

Broadcast the seed only when the snow is off the ground since rapidly melting snow can easily wash away the seed. Also, birds and rodents can feed on seed broadcast on the snow surface causing significant losses. Seed can be distributed over the field surface by a tractor-mounted or hand-held broadcast seeder or mixed with fertilizer (usually triple superphosphate) and applied.

In frost seedings, either the frost action or livestock activity are used to control competing vegetation, prepare a seedbed, cover the seeds, and provide seed to soil contact for germination. If there is not sufficient frost action after applying seed and animals are available, allow animals to walk the pastures to tread seed into the soil surface. This should be done only when the soil is firm enough so that the cattle or horses will not punch through the sod and push the seed too deep into the soil.

Grass seedings may not be successful with the frost crack method. It is likely that the smaller seeded grasses (timothy, Kentucky bluegrass, and orchardgrass) will be the most easily established with this method. The success rate can be increased if the field is mowed or grazed very short in the fall or winter before seeding. Results of the seeding often are not evident until at least midsummer. The legume or grass plants are very small early and will need as much sunlight and as little competition as possible early to allow them to become established. Fields kept at 4 inches or less by grazing will have a higher probability of success. In hay fields, even if the process is successful there will be many fewer surviving plants than in pasture situations and the benefits for yield or quality will be minimal.

Species selected for overseeding	Pasture	Hay
	Lb PLS/acre	
Ladino clover	¼ - ¾ mixed with sand	½ - 1 mixed with sand
White clover	¼ - ½ mixed with sand	NR*
Red clover	2 – 4	4 – 8
Birdsfoot trefoil	3 – 6	4 – 8
Alfalfa	NR*	NR
Annual lespedeza	10 – 15	10 – 15
Hairy vetch	15 – 30	20 – 45
Annual clovers (crimson, subterranean, etc)	10 – 15	NR
Ryegrasses	4 – 8	8 – 10
Orchardgrass	4 – 6	4 – 8
Tall fescue, Smooth brome grass, Reed canarygrass	NR	NR
Kentucky bluegrass	1 – 2	2 – 4
Timothy	2 – 4	4 – 6
Alsike clover—NR in horse pastures or in hay grown for sale to horse owners as alsike can cause photosensitivity in some horses	1 – 2	2 – 4

* , NR=not recommended

Of the legumes that have been successfully over-seeded into cool-season grasses, red clover is the most productive, ladino clover is the easiest and least expensive to establish, and annual lespedeza is the most versatile. Red clover generally will not survive more than two years due to

the buildup of disease organisms in the soil. White or ladino clover are shallow rooted with surface stolons but can survive for many years if adequate soil moisture is available and harvest management is favorable. Under the best conditions, frost seedings succeed in only 3 or 4 years out of five but remains a less expensive option for producers who must rent or otherwise obtain no-till seeders. The lack of good soil to seed contact increases the risk of failure but even in successful years it often means that although the percentage of legume is increased the legume stand is not uniform. This often is acceptable to grazers but not to hay producers.

Advantages of a Frost-Crack Seeding

The primary advantage of frost-crack seeding is the low expense involved since the equipment needed can vary from a simple bucket on very small fields to hand-operated spinner/spreaders and on to tractor operated spinners. When compared with the price of a no-till drill, the cost to frost-crack seed is dominated by the cost of the seed used to spread. Some producers use seed that has been left over from conventional seedings and may have a low germination rate; thereby using up a less valuable resource. Since the species that perform the best in this method of seeding are the small-seeded legumes and grasses, the seeding rates required are generally low so seed cost can be kept at reasonable levels. Because low seeding rates are used, producers sometimes have trouble setting the spinner spreader to deliver the small quantity of seed. In such a case, you can mix triple superphosphate, muriate of potash, or even sand with the seed to aid in spreading the proper amount of seed. If your seed is preinoculated or you have used an inoculum, spread the seed as soon as possible after mixing with fertilizer since the fertilizer can injure the live bradyrhizobium bacteria used as inoculum.

Disadvantages of a Frost-Crack Seeding

The major disadvantages are the usual low level of successful establishment, the inconsistency of results, the problem of predicting whether or not a given season will have freezing:thawing cycles after the seed has been applied to the field, and the seed expense when failures occur. Frost-crack seeding should **not be used** in place of pasture renovation but instead as a supplemental management technique to add legume to pastures or fields or to add additional grasses to the field. When seed costs are high or profit margins are low and renovation/legume additions are needed, avoid frost-crack seeding and use no-till or conventional techniques to establish forages with high-cost seed.

Notices and Upcoming Events

October 25 & 26, 2006

Keystone Crops Conference, Holiday Inn, Grantville, PA. Contact Amy Bradford at 717-651-5920 or abradford@pennag.com.

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 16 & 17, 2007

PAES Conference. Contact Mary Johnston at 814-234-8771 for more information.

January 22-27, 2007

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

Delaware—Maryland Hay and Pasture Day, Monday, January 22, 2007

Dairy Day on Wednesday, January 24, 2007

Agronomy/Soybean Day, Thursday, January 25, 2007

January 23, 2007

Tri-State Conservation Tillage Conference, West Middlesex, PA. Contact Joe Hunter at 814-333-7460 or jmh7@psu.edu for more information.

January 24, 2007

Southwestern PA Tillage Conference, Giannelli's II, Route 30, Greensburg, PA. Contact Leanne Griffith, Westmoreland Conservation District, 724-837-5271, ext. 211 or leanne@wcdpa.com for more information.

January 26, 2007

Corn, Soybean, and No-Till Conference, Holiday Inn, New Cumberland, Contact Greg Roth at 814-863-1018 or gwr@psu.edu for more information.

February 1-3, 2007

PASA Conference. Contact Mary Barbercheck at 814-863-2982 or meh34@psu.edu for more information.

February 7, 2007

Virginia Corn Growers, Virginia Soybean, and Virginia Small Grain Growers Associations' Joint Winter Meeting. Colonial Downs Racetrack, Providence Forge, VA. For more information contact: Molly Pugh at 757-421-3038.

February 14 to 15, 2007

Virginia Crop Improvement Annual Meeting. For more information contact: VCIA main office 804-746-4884.

February 27, 2007

Hay & Forage Conference, Grantville, PA. Contact Marvin Hall at 814-863-1019 or mhh2@psu.edu for more information.

February 28–March 2, 2007

National Grass Fed Beef Conference, Grantville, PA. Contact Marvin Hall at 814-863-1019 or mhh2@psu.edu for more information.

February 28, 2007

Grazing & Forage Conference, Grantville, PA. Contact Marvin Hall at 814-863-1019 or mhh2@psu.edu for more information.

March 13 & 14, 2007

PA No-Till Alliance Conference, Ramada Inn, State College, PA. Contact Jeff McClellan at 814-863-4260 or jtm23@psu.edu for more information.

Newsletter Web Address

The Regional Agronomist Newsletter is posted on several web sites. Among these are the following locations:

<http://www.grains.cses.vt.edu/grains/Articles/articles.htm>

or

www.mdcrops.umd.edu