



# Mid-Atlantic Regional Agronomist Quarterly Newsletter

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To subscribe or unsubscribe, please send your request to the editor at [rtaylor@udel.edu](mailto: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: February 28, May 30, August 30, and November 30. The editor would like to acknowledge the kindness of Mr. Todd White who has granted us permission to use his scenic photographs seen on the front cover page. Please go to [www.scenicbuckscounty.com](http://www.scenicbuckscounty.com) to view more photographs.

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## Wheat Test Weight Declines with Delayed Harvest

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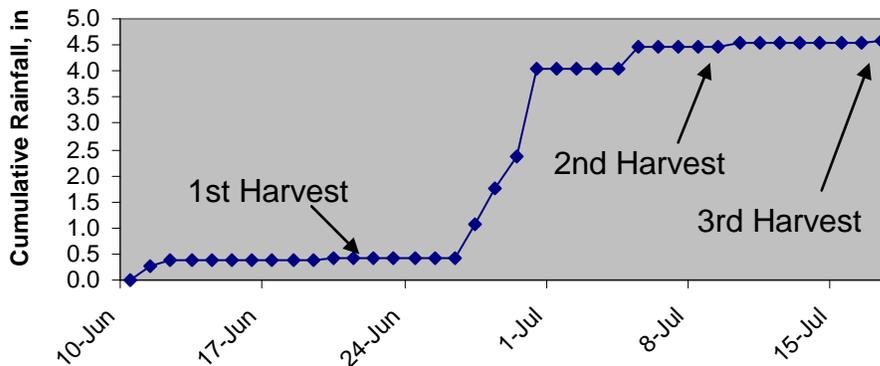
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Test weight is the weight of grain contained in a bushel volume. A wheat sample with test weight equivalent to less than 58 lbs. per bushel may be subject to dockage; resulting in a reduction in the price received for wheat. Test weight is a function of both genetics and environment. So, test weight varies among varieties and from year-to-year for a single variety.

At physiological maturity, wheat grain moisture is about 37%, however at this high moisture level, the grain is too soft for combine harvest. Most producers harvest when the grain has dried to between 15 and 13% moisture. Delayed harvest is common in Virginia because of climatic conditions around harvest time. Rainfall between maturity and harvest is known to lower grain test weight.

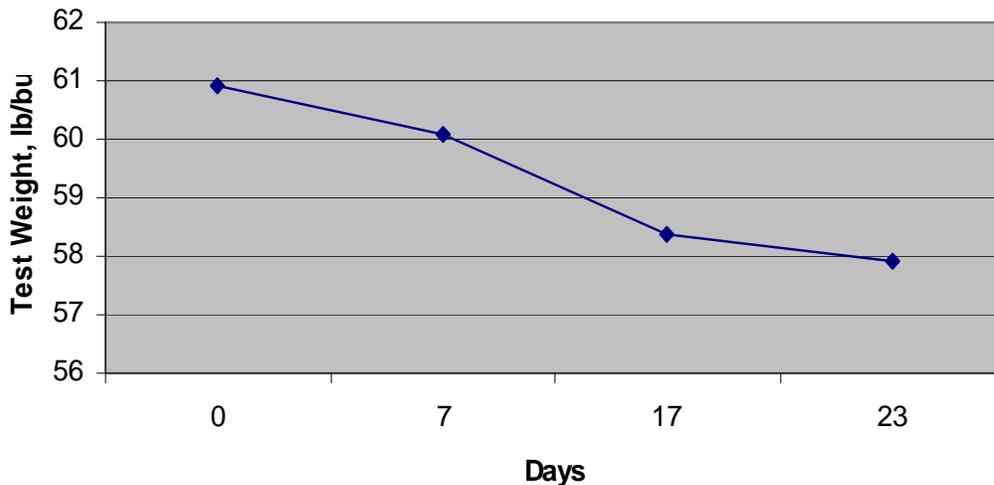
Last season, plots from a number of commonly grown varieties were not harvested, but left in the field at the Eastern Virginia Agricultural Research and Extension Center, to study the effects of post-harvest weather on grain quality. The dates of sampling and cumulative rainfall between samples are shown in figure 1. While the 2007 harvest season was relatively dry compared to some, the plots did experience four rainfall events during the course of the study.

Figure 1. Cumulative rainfall by delayed harvest date, EVAREC, Warsaw, 2007.



Rainfall reduces test weight because grain that absorbs water swells. When the grain dries and shrinks, it typically does not return to exactly the same size and does not “pack” as well as it originally did. This results in more space between grains and lower test weight. Figure 2 below illustrates the effects of wetting and drying on grain test weight. Consistent with reports from other researchers, we observed a loss of about 1 lb. per bushel in test weight with each rainfall event. The major influence is the number of wetting and drying cycles, not the total rainfall in each event.

Figure 2. Wheat test weight decrease with days after harvest maturity, EVAREC, Warsaw, 2007.



All varieties we evaluated last season responded similarly to weathering. This means that the main tool available to combat environmental conditions that cause poor test weights is choosing a variety with high genetic test weight potential.

Other than hoping nature provides ideal conditions, there are several things managers can do to increase the likelihood of harvesting high quality wheat.

- Be ready. Equipment maintenance and repair should be completed well ahead of planned harvest time.
- Timeliness depends on capacity. Attempt to have the combine, hauling, and storage/delivery capacity in place to harvest as much wheat as possible when weather is suitable. Understand the bottlenecks in your harvest operations and plan accordingly.
- Start early. Harvesting high quality, high test weight wheat may mean that some wheat must be harvested at above 15% moisture and dried prior to storage.
- Grow several (2 or more, depending on total acreage) wheat cultivars having distinctly different maturities (e.g. early, medium, late), which should reduce the risk and overall loss in test weight of the crop as a whole.

## **Wheat Lodging**

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During 2008, we have seen considerable lodging in wheat. It has been some years since lodging has been this pronounced which I believe is a testament to the way farmers have managed their nitrogen (N) in the region. The amount of lodging we have seen this year is the result of the extremely wet and windy conditions that occurred in the region (6-10 inches of rainfall between May 9 and 12) coupled with, in many cases, the excessive amounts of residual N that remained following last year's drought stricken corn crop. On top of this, you can add the spring N applied to this year's crop creating a situation perfect for lodging.

Low spots, turn rows, and areas that had overlap in N application have been especially susceptible. In Maryland, wheat began to head during the last week of April and continued during the first 10 days of May. This insured that the wheat was at a growth stage that made it susceptible to significant yield reduction attributable to this early lodging. Additionally, wheat at this stage is still prone to lodging for at least another month to six weeks in those areas of fields that have dense stands and have not yet lodged but could do so as the heads become progressively heavier.

Two types of lodging, stem and root, can occur. Stem lodging is the irreversible bending and breaking of the lower internodes. The tendency of a crop to have stem lodging is dependent on its straw length (plant height) and straw strength. Some of the factors that will increase the length of the stem include: the genetics of the cultivar; high N fertility level; low solar radiation (i.e. cloudy weather) during the formative growth; and stem diameter and stem-wall thickness (particularly the basal internodes). Root lodging is the failure of the root system to hold the plant upright allowing the plants to uproot (that is, bending or breaking of the roots). Typically, stem lodging will cause greater yield reduction due to restricted movement of water and nutrients in the plant but both kinds of lodging have negative impact on crop performance.

Severe lodging is costly due to its effects on grain formation resulting in yield loss, reduction in grain quality, and other harvest associated problems. It takes about twice the time to harvest a lodged crop than a standing one. Lodging alters plant growth and development. It affects flowering if it occurs just as the wheat is heading. It reduces photosynthetic capabilities of the plant which will limit carbohydrate assimilation. Severe lodging interferes with the transport of nutrients and moisture from the soil, ultimately reducing carbohydrate storage in the developing kernels. Lodging always results in some yield loss, and if permanent lodging occurs during the ten days following heading, the yield reduction can range between 15 and 40%. Yield losses from lodging become smaller as the crop matures, but losses will continue until the kernels are completely filled. Incomplete filling results in small and shriveled kernels, lowered carbohydrate content, and lower test weight. Lodging often contributes to uneven maturity, high grain

moisture content at harvest and loss of grain quality due to sprouting and possible grain molding. Excessive moisture can often delay start of harvest and may necessitate grain drying.

Lodging is generally the result of inadequate ability of the crop to stand and adverse weather conditions, such as the heavy rains and winds we have been receiving. It is a genetic characteristic that breeders are careful to select against due to its yield-limiting potential. A tall, weak-stemmed wheat cultivar has a greater tendency to lodge than a semi-dwarf variety with stiff straw which when under conditions of high rainfall and N fertility, are less prone to lodging than standard ones. Sometimes we see wheat varieties that are initially resistant to lodging (stand erect during favorable conditions) but then will lodge when exceptionally bad weather, such as heavy rain or wind, prevails. A crop that lodges early can recover somewhat (the partial lifting that sometimes is seen with a completely flat crop) through the formation of "elbow joints" at the lowest stem nodes. The cells on the lower side of the node elongate and force the stem to a more erect position. As plants mature, however, these stem cells mature and are no longer capable of elongation to enable plant recovery.

High N fertilization or high levels of residual N from a previous crop can cause wheat plants to be more susceptible to lodging. This is due to lush growth that also provides an excellent environment for the spread of diseases. In addition, increased plant densities, heavier seeding rates, and high amounts of moisture especially when followed by cloudy and humid conditions, have been found to increase the tendency of wheat to lodge. These conditions can result in lodging problems even when shorter varieties are planted.

Does all the above sound familiar for this year?

## **Barley Yellow Dwarf Virus found in Pennsylvania Wheat Fields**

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Barley Yellow Dwarf Virus (BYDV) has been found in several wheat fields in the northern Cambria County region of Pennsylvania. Although the disease can be symptomless in wheat, this year the characteristic yellowed foliage is very apparent. This disease can be confused with nutritional deficiencies, with the major difference being that BYDV has more severe symptoms are on the older leaves and symptoms begin at the tip of the newer leaves. The normal symptoms of the disease include stunted foliage growth, reduction in root growth, chlorosis, and striping from leaf tip towards the base. In wheat and oats, the plants may exhibit a reddening of older leaves (Refer to pictures).

This virus requires an insect vector to spread the disease. BYDV is generally vectored by three aphids: oat aphid (*Rhopalosiphum padi*), corn aphid (*R. maidis*), and the grain aphid (*Sitobion avenae*). Due to the warm fall in 2007, the aphids were active much later into the

season than usual allowing for large infections in the field and almost uniform appearance across the field. In both situations, the wheat showing the most severe symptoms followed potatoes. The high amount of phosphorus and potassium applied to the potatoes as well as pH below 6.5 helped to increase the symptoms within these fields. Neighboring wheat following corn fields planted at the same time are not showing as severe of symptoms, but are likely infected.

Many of the barley varieties have been bred with resistance to BYDV, but the disease can affect all cereals and grasses. Sources of the disease include orchardgrass, wild oat, ryegrass, sorghum, and other common grasses. Often these infected plants are symptomless. The main concern with an infection in wheat is that the aphids will be able to spread the disease to oats, which can be severely affected.

The expected yield reduction in infected plants is typically 5-20% in wheat, but data has indicated losses up to 79% in early infected wheat plants. There is no way to control the disease once established. The symptoms of the disease are more severe in plants that are exposed to drought stress, imbalanced fertility, or low pH. The keys to reduce BYDV is to plant resistant varieties after the Hessian fly free date, maintain pH and balanced fertility, and control volunteer wheat, barley, and oats that may act as a source for new infections. There has been some research that has found BYDV control can be accomplished through controlling the aphids, but aphid control is weather-dependant on temperatures in the fall (i.e. killing frosts) and arrival of the vectors in the spring.

## **Cautions with Alternative Liming Materials**

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Each year we receive questions on different materials being sold or given away as liming products. This has included waste lime, byproducts from industrial processes and manufacturing, lime-stabilized biosolids, wet limes, and waste materials from construction. Indeed, many of these materials may be effective in moderating soil pH, but it is critical to understand what is in these products or wastes, the chemistry of how they will react in the soil, and how they compare with standard agricultural liming materials.

Materials based on limestone such as waste limes and wet limes need to be directly compared to standard pulverized agricultural lime. To make valid comparisons you will need to obtain laboratory analyses of the materials, commonly done in state regulatory laboratories. A typical analysis will report the following: moisture percentage, calcium and magnesium percentages; total neutralizing value (also known as calcium carbonate equivalent), fineness reported as percentages passing different sieves (20, 60, 100 mesh for example), and effective neutralizing value which is based on a combination of fineness and total neutralizing value. The finer the

lime, the greater the effective neutralizing value. Wet limes will have more moisture and will spread in a different manner. You need to compare how much of the alternative material will need to be spread to equal the neutralizing ability of dry pulverized lime and adjust so true costs can also be compared. In addition, consider whether or not the material is based on high magnesium (dolomitic) or high calcium (calcitic) limestone.

Lime stabilized biosolids and other lime stabilized wastes also need to be compared to standard pulverized lime. Ask what type of lime and how much was used in the stabilization and get the analysis of the final product (stabilized biosolid). Most commonly quicklime (calcium oxide) or hydrated lime is used in the stabilization (other alkaline materials have also been used and are replacing lime in some treatment plants). Quicklime and hydrated lime have higher neutralizing values than pulverized lime. However, some of the lime is reacted in the stabilization process. The actual liming value will then need to be adjusted. A calcium carbonate equivalent should be provided by the source treatment plant. In addition, when applying biosolids, a nutrient management plan will need to be in effect to account for the other nutrients provided by the biosolids.

There are many industrial and manufacturing by-products that can be used as liming materials. These commonly have a base element (calcium, magnesium, sodium) in oxide, hydroxide, or carbonate form. Comparisons need to be made based on the basic element provided and the neutralizing ability of the material. One recent analysis we received was waste from an antacid manufacturer. It was high in moisture (40%), had 3 and 6 % calcium and magnesium respectively, had significant amounts of aluminum and iron, had a calcium carbonate equivalent of 42% and had an effective neutralizing value of 29%. While this material could be used to lime crop fields, you would need over 2.5 tons to equal a ton of pulverized lime. In addition, it is much higher in magnesium than “high mag” lime and only should be used on fields where magnesium fertilization is needed. This material would raise magnesium levels significantly in the soil.

Other products or wastes are sometimes touted as liming materials but really are not. Gypsum and crushed wallboard would be examples. These materials are calcium sulfate. While the calcium may fill exchange sites on soil colloids, the sulfate ion will not effectively neutralize the hydrogen that is released. Therefore, gypsum generally does not change soil pH appreciably.

Poultry manure is sometimes mentioned as having liming value. There are several basic minerals that are excreted in poultry manure, somewhat dependent on the quantity of minerals that are being fed to the birds. There is therefore no exact value for how much liming value that the manure will provide. The best measure of this will be to run frequent pH tests on fields that receive poultry litter and especially when the litter is from an egg operation that adds extra calcium to the poultry diet to ensure enough calcium is present for egg shell formation.

## Building Stronger Nutrient Cycles in Virginia's Pastures

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The cost of fertilizer is skyrocketing along with oil prices and there seems to be little relief in the current future. This spring nitrogen cost \$0.75 per pound actual nitrogen as urea. When I came to Virginia seven years ago, one pound of nitrogen as urea cost just over \$0.20. The cost of potash and phosphorus have also increased drastically. This spring potash cost around \$0.50 per pound and phosphorus was over 0.80 per pound. To keep grazing systems profitable we need to optimize the amount of commercial fertilizer we are applying to our pastures. This can be accomplished by building strong nutrient cycles in our grazing systems. The objective of this article is to give some ideas on how to improve nutrient cycling in your pastures.

*Grazing animals removing only small quantities of nutrients.* Over 90% of the nutrients consumed by livestock are recycled in the form of dung and urine. One cow-calf pair will remove approximately 10 lb phosphate and 1.3 lb potash per year. If we are stocked at 2 acres per cow-calf unit then our nutrient removal would be 5 lb phosphate and 0.7 lb potash per acre per year.

*Grazing animals will redistribute nutrients in pastures.* Overtime grazing animals can move nutrients from one area of the pasture to another through urine and dung deposition. This problem is the worst in large continuously grazed pastures where animals go out and graze then come back to shade and water areas where they urinate and defecate, thereby increasing the nutrient concentrations in these areas.

*Hay and silage remove large quantities of nutrients.* In contrast to grazing, making hay or silage removes large quantities of nutrients (Table 1). These nutrients must be replaced to maintain soil fertility, and stand health and productivity. Each ton of hay that is removed from a field takes with it approximately 15 lb of phosphate and 50 lb potash. In a good year a tall fescue-clover mix may yield 4 tons per acre and remove 60 lb phosphate and 200 lb of potash.

*Soil test your pastures.* We can not look at a soil and tell how much lime and fertilizer is needed. Applying fertilizer and lime without a soil test is simply guessing and could lead to an over or under application of nutrients. An over application of fertilizer is bad for your wallet and the environment. An under application of nutrients could lead to lower production and poor stand persistence. Regular soil testing needs to be a part of your grazing system. In most cases, pastures should be soil tested every two to three years. For more information on soil testing, contact your local extension office.

*Apply lime according to your soil test.* If money is a limiting factor, lime will give you the most return per dollar of investment. Lime not only neutralizes soil acidity, but also supplies calcium and magnesium, two very important nutrients needed for plant growth. Adjusting the pH of your pastures between 6.0 and 7.0 increases the availability of other soil nutrients needed

for plant growth and minimizes the availability of elements that can be toxic to plants. Lime also enhances legume growth and increases nitrogen fixation. Grass-clover mixtures require a soil pH between 6.0 and 6.4 and grass-alfalfa mixtures needed higher pH of 6.5 to 6.8.

Table 1. Approximate nutrient removal in pounds per acre for several commonly grown hay types at specified yield levels.

Nutrient	Species and Estimated Yield (tons/acre)			
	Alfalfa @ 5	Tall Fescue @ 3.5	Orchardgrass @ 3	Sorghum-Sudan @ 4
	lb of given nutrient removed/acre			
Nitrogen (N)	280	135	150	160
Phosphate (P <sub>2</sub> O <sub>5</sub> )	75	65	50	60
Potash (K <sub>2</sub> O)	300	185	185	288
Calcium (Ca)	155	30	30	35
Magnesium (Mg)	22	12	15	20
Sulfur (S)	25	14	13	14

*Data from Southern Forages, Fourth Edition, 2007 and NRCS Animal Waste Management, NEH-651, 1999.*

*Maintain nutrient levels at the medium soil test level or higher.* Once soil nutrient levels are in the medium range, yield is not limited. You can think of the soil as a bank for nutrients. The more nutrients you put in the more you can draw out. Adjusting fertility levels to the medium plus or high range provides a buffer that you can draw down on in bad year when cattle prices are low or inputs are high. These nutrients can then be returned in the good years. If you are balancing on medium soil test values, it is much more important to actively monitor soil fertility with regular soil testing and replace removed nutrients.

*Only apply fertilizer and lime if you are going to utilize the forage.* In order for fertilizer and lime to be a profitable investment you need to be in a position to utilize that forage. In grazing systems stocking rate and grazing method can greatly impact how much of the forage is utilized by the grazing animals. For example the utilization rate in a continuous grazing system may be less 30% compared to 70% for an intensively managed rotational grazing system.

*Strategically apply nitrogen fertilizer.* In some cases a spring application of nitrogen to all of grass pastures may not be the best choice. In most years we have too much forage to efficiently utilize during the spring months and applying nitrogen makes this problem even worse. Targeting applications to promote growth when you need forage may be a more effective strategy. For example you may want to apply some nitrogen in late winter or early spring to stimulate early spring grazing. On the other hand you may want to apply some nitrogen in late spring to push cool-season grass growth more into the summer months.

*Incorporate and maintain legumes in your pastures.* Legumes have always been an important part of grazing systems, but with the increase in nitrogen prices their use is has become critical. Legumes increase forage quality and yield, improve animal performance, dilute the toxic endophyte in tall fescue, and bring nitrogen into grazing systems through symbiotic nitrogen fixation. The value of the nitrogen fixed by legumes is shown in Table 2.

Table 2. The amount and value of nitrogen fixed by various legumes.

Legume	N Fixed lb/acre/yr	Value of Fixed N (\$/acre/year)	
		N cost=\$0.60/lb	N cost=\$0.80/lb
Alfalfa	150-250	90-150	120-200
Red Clover	75-200	45-120	60-160
Ladino Clover	75-150	45-90	60-120
Annual Lespedeza	50-150	30-90	40-120

*Adapted from Southern Forages, Fourth Edition, 2007.*

*Use rotational stocking.* Utilizing rotational grazing management maintains a healthier sod with a stronger root system. The increased size of the root system allows plants to explore a greater soil volume for water and nutrients. In addition, rotational grazing allows you to control animal movement and nutrient distribution within the grazing system. Smaller paddocks and more frequent rotation reduces selective grazing, improves forage utilization, and distributes urine and dung more uniformly over the pasture areas.

*Use organic nitrogen sources.* In grazing systems, organic nitrogen sources can be a very cost effective soil amendment. The nitrogen in these sources must be mineralized to a plant available form making them a slow release nitrogen source. In addition to the nitrogen, they can also provide phosphorus, potassium, micronutrients, lime, and organic matter. One issue when using these sources is that phosphorus can build up in the soil. When these sources are applied on a nitrogen basis, more phosphorus is applied than is needed for plant growth. In some cases the use of organic nitrogen sources is limited by the amount of phosphorus in the soil. Table 3 shows the amount of various nutrients contained in three commonly used organic nitrogen sources.

Table 3. Total Nitrogen (N), plant available N (PAN), phosphorus (P2O5), potassium (K2O), calcium (Ca), and magnesium (Mg) contained in three commonly used organic nitrogen sources.

Nitrogen Source	Total N	PAN	P2O5	K2O	Ca	Mg
			lb per dry ton			
Pelleted Biosolids	130	78	66	8	50	8
Digested Biosolids	106	32	114	5	40	7
Broiler Litter	80	40	100	118	70	20

*Data from ongoing research being conducted at the Southern Piedmont AREC.*

*Buy hay instead of making it.* Hay contains significant quantities of phosphorus and potassium along with organic matter. When you buy hay and bring it onto your farm you are also bringing nutrients and those nutrients have a value. For example if we assume that each ton of hay has 15 lb P2O5, 50 lb K2O, and some organic matter, at current fertilizer prices, the value of the hay strictly from a fertilizer standpoint would be more than \$35 per ton. In many cases, buying hay and feeding it on your poorest paddocks can build fertility in a very cost effective manner.

Building stronger a nutrient cycle in your pastures is not something that happens overnight, but rather it is a slow and gradual process that can take years. This process requires

not only the addition of soil amendments, but more importantly good grazing management that will keep nutrients uniformly distributed across your pastures. As the nutrient cycles strengthen on your farm and legumes increase in your pasture swards, the need for commercial fertilizer inputs will lessen.

### **“Drought Proofing Your Pastures” Conference Available on DVD**

This winter’s *Virginia Forage and Grassland Council’s Winter Forage Conferences* were well attended with more than 400 people participating in the “Building Robust Grazing Systems-Drought Proofing Your Pastures” conferences that were held around Virginia. Topics included selecting drought tolerant forage species, managing pastures for increased drought tolerance, getting your stocking rate right, crabgrass-annual ryegrass systems, cost effective fencing and watering systems, and feeding strategies as part of a drought management plan. If you missed this meeting don’t despair, we were able to capture all of the presentations as Camtasia videos and they along with handouts and an electronic copy of the proceedings are available on two DVD set. All you need to do is to slip the DVDs into the DVD drive on your computer and click on the talk you would like to hear or the handout you would like to view. For more information on purchasing a DVD set from the *Virginia Forage and Grassland Council* please contact Margaret Kenny at [makenny@vt.edu](mailto:makenny@vt.edu).

### **Bread Wheat, Organic Production Workshop, and Three State Organic Grains Tour**

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A **Bread Wheat and Organic Production Workshop** will be held at the Mountain Research Station in Waynesville, NC on **June 24** from 4-7 p.m. There is increasing demand for bread wheat and organic wheat in NC. At this workshop, information on hard wheat varieties (bread wheat) that perform well in the southeast will be presented by a USDA wheat breeder. A wheat agronomist and a farmer who is growing the varieties commercially in NC will talk about commercial production techniques. Organic wheat production will also be covered, and an organic wheat farmer will discuss his experience. Conventional and organic wheat buyers will be in attendance to answer marketing questions. Registration for this workshop is \$10 and includes dinner. To register, call 919-513-0954 or go on-line to: [www.cefs.ncsu.edu/calendar2008.htm](http://www.cefs.ncsu.edu/calendar2008.htm).

An **Out-of-State Bus Tour** will take place from **July 24 to the 26<sup>th</sup>**. We will tour 4 organic grain farms in three states where we will see, first-hand, how these farmers handle production. The tour will also highlight organic no-till grain production. We will be touring two farms on the Eastern Shore of Maryland on the 24<sup>th</sup>: Mason’s Heritage Farms has around 400 acres of

organic corn and soybean production with a significant amount of no-till organic acreage; and Fair Hills Farm which has a 400 acre organic rotation of corn, soybeans, and hay. On the 25<sup>th</sup>, we will travel to the Rodale Institute in Pennsylvania and visit their 333 acre farm and research plots. No-till organic grain production techniques will be emphasized since the Rodale Institute is one of the innovators of this production strategy. We will tour one farm in Virginia on the 26<sup>th</sup> on the way back to Raleigh. Hillsborough Farm is a 400 acre organic corn and soybean farm, also with significant no-till acreage. Registration for this tour is \$75 and includes accommodations, travel, and most meals. If you wish to have a single room, registration is \$150. For an application to register, go to: [www.cefs.ncsu.edu/calendar2008.htm](http://www.cefs.ncsu.edu/calendar2008.htm). Call Molly Hamilton (828-273-1041) for more information about this tour.

## **Sprayer Traffic Damage to Narrow-Row Reproductive-Stage Soybeans**

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## Introduction

Asian soybean rust is changing how we produce soybeans throughout the country. Although the disease has yet to move into the Mid-Atlantic States early enough to cause yield loss, we are generally prepared to spray fungicides if necessary. Many growers have already begun regularly treating their soybeans with fungicides at or soon after pods begin to form (the R3 stage). Some feel they are getting yield increases with these sprays. In our small-plot and on-farm research, we see significant yield increases about 1/3 of the time. We can usually relate those yield increases to control of diseases such as frogeye leaf spot or *Cercospora* blight, and usually when we grow susceptible varieties. Sometimes the yield increase can easily justify the fungicide application. Other times, it will barely cover the cost of the application.

Many growers that treat their soybean with fungicide generally assume that the yield increase will at least cover the cost of application. Then, occasionally, they will get a big yield bump. So, in the end, they are profiting from fungicide application.

But, do we realize the full cost of spraying reproductive-stage soybeans? With soybean rust, cost is not really an issue. If soybean rust moves into our area before the full-seed stage (R6), then we will definitely spray. The return will be greater than the cost because of the disease's destructive nature. But, what about other diseases such as frogeye leaf spot, *Cercospora* blight, brown spot, anthracnose, pod and stem blight, etc.? These diseases will not cause nearly the yield loss that rust will cause. Whether to spray or not becomes more complicated. What about insect pests? This is less complicated than disease since we have thresholds established for most of our insect pests. And thresholds are based on costs and returns. But, do we know the full cost of the application?

Would you spray if the cost of spraying is higher than the return on the investment? Of course not! That is one of the main tenets of integrated pest management (IPM). Plus, it's just good economics. But, are we accounting for all the costs? Some are. Some are not. If we're just accounting for the cost of the pesticide and not the labor, machinery, and fuel it takes to make a trip over a field, then we are not accounting for all the costs. Likewise, if we account for the pesticide and application costs, but don't account for any damage to narrow-row soybean from running over pod and seed producing plants, then we are not fully accounting for the costs.

Do we know the costs of damaging narrow-row soybean during the reproductive stages? Actually, there is very little data available. Most studies in the past have focused on vegetative stage damage (i.e., from herbicide applications). A few experiments have evaluated the damage up to flowering or pod development, but not many and non in the Mid-Atlantic region. Furthermore, we don't know how full-season versus double-crop planting will respond or if drilled soybeans respond differently than soybeans planted in narrow rows.

The purpose of this article is to encourage you to consider all costs associated with pesticide applications made during the reproductive stages. We will also share with you the results of research conducted in Virginia and Delaware that evaluated tire traffic damage to full-season and double-crop soybean grown in 7.5-, 15-, and 30 or 36-inch rows.

**Past Research:** There have been two major wheel traffic studies in soybean published in the scientific literature. The earlier study was conducted in Iowa (Wilken and Whigham, 1986). In that study, researchers drove a tractor through soybean planted in 14-inch rows at one of six development stages from emergence through full-pod (R4). These researchers found that yield was not reduced until traffic treatments were applied at full flower (R2). There was always yield compensation from neighboring rows, so the yield loss was not equal to the amount of loss that would have occurred if the damaged row was removed at harvest. For instance, 22% of the plot (2 of 9 harvested rows) was damaged, but yield was only reduced by 7 and 13% at R2 and R4. In another study conducted in Indiana (Piper et al., 1989), wheel traffic treatments were applied weekly beginning at emergence through flowering (R1). Four of 14 harvested 8-inch rows were damaged (29% of the plot), but maximum yield loss was only 9% when the traffic was applied at R1. Neighboring rows again compensated for the damaged ones, but not completely when applied at late vegetative or during flowering.

Keep in mind that the percent yield loss from those experiments was loss in a small plot. If extrapolated out to larger spray boom lengths, then the yield loss per acre would have been less than 2%. More recent research (unpublished) from Missouri and Indiana show similar results. Yield losses in those experiments generally range from 1 to 4%, depending on spray boom width.

**2005-2006 Experiments in Virginia and Delaware:** Full-season and double-crop experiments were conducted at Suffolk, VA and Georgetown, DE during the last two growing seasons. At each location, soybeans were planted in 7.5-, 15-, and 30- or 36-inch row spacing. Half of these plots received wheel traffic at the R4 (late pod) to early R5 (beginning seed) development stages. We chose these stages assuming that this is when soybean rust would most likely move into the Mid-Atlantic States. Four rows were damaged in the drilled plots, two were damaged in the 15-inch rows, and no rows were damaged in the 30- or 36-inch rows. In addition, one half of the plots received Quadris® fungicide treatment at the same time that the row damage occurred. The Georgetown site was irrigated; the experiments at Suffolk were rain fed. The results of these experiments are shown in Table 1.

A few things are worth noting. Our yield losses are generally higher than that found in the Iowa and Indiana studies. The range in yield loss was also quite large. As little as 12% reduction occurred in some treatments, while up to 29% reduction occurred at the 2005 double-crop test in Suffolk. Yield compensation from neighboring rows occurred in 4 of 5 experiments via increased number of pods (not seed size). No compensation occurred in the 2005 double-crop test. In that experiment, an 18-day period of high temperatures and no rainfall preceded the wheel traffic treatment at that location. Rainfall was not received until 4 days after the wheel traffic treatment. This 3-week period of hot and dry conditions was likely responsible for lack of compensation from neighboring rows and the higher yield loss.

We hypothesized that drilled soybean would compensate better because wheel traffic removed 25% less total area of soybean than in the 15-inch rows. For example, after wheel traffic, there was a 22.5-inch gap in drilled and a 30-inch gap in 15-inch soybean between the undamaged rows. In 3 of the 5 locations, this was the case. One of the exceptions has already

been mentioned. In that experiment, no yield compensation took place regardless of row spacing due to the dry weather conditions. At the irrigated Georgetown, there was more yield loss in the drilled soybean than those planted in 15-inch rows. Why this occurred cannot be explained. For the most part, the drilled plots suffered less yield loss.

Table 1. Calculated percent yield loss from tire traffic to two 15-inch rows or four 7.5-inch rows to small plots and if sprayer was 60 to 120 feet wide. Wheel traffic removed 25% of the rows in all plots except 15-inch row spacing at Georgetown, where wheel traffic removed 29% of the rows.

Cropping System	Year	Location	Row Spacing	% Yield Loss/Plot	Sprayer Boom Width			
					45	60	90	120
Full Season	2005	Suffolk	7.5	12.6	2.8	2.1	1.4	1.1
			15	20.9	5.6	4.6	2.8	2.3
			36	--- <sup>x</sup>	---	---	---	---
	2006	Suffolk	7.5	12.1	2.6	2.0	1.3	1.0
			15	21.2	4.8	3.5	2.4	1.8
			36	---	---	---	---	---
	2006	Georgetown	7.5	20.6	4.6	3.4	2.3	1.7
			15	16.6	3.2	2.4	1.6	1.2
			30	---	---	---	---	---
Double Crop	2005	Suffolk	7.5	29.0	6.4	4.8	3.2	2.4
			15	25.5	5.6	4.3	2.8	2.1
			36	---	---	---	---	---
	2006	Suffolk	7.5	11.5	2.6	1.9	1.3	1.0
			15	15.5	3.4	2.6	1.7	1.3
			36	---	---	---	---	---
Average (Full-Season & Double-Crop)			7.5	17.6	3.8	2.8	1.9	1.4
			15	19.9	4.5	3.5	2.3	1.7
			30	---	---	---	---	---

<sup>x</sup>Wide rows suffered no significant yield loss with wheel traffic.

There was no clear trend with cropping system; the double-crop experiments had both the highest and lowest yield losses. Instead, these data indicated that environmental conditions are most important in the compensatory potential of soybean damaged by traffic. Yield losses were

lowest in the 2006 double-crop experiment, where with the exception of the Georgetown experiment; there was the least amount of water stress during pod development. Yield losses in the 15-inch rows at the irrigated Georgetown location were also low. At the other extreme, under hot and dry conditions at the 2005 double-crop experiment, yield losses were highest.

No yield loss occurred from sprayer traffic in 30- and 36-inch rows. But, yields of soybean planted in wider row spacing were lower and approximately equal to narrow-row plots damaged by wheel traffic in 4 of 5 locations. When adjusted for the sprayer boom width, the yield loss from using wide rows was greater than loss due to wheel traffic in narrow rows. Therefore, there is a disadvantage of using wide rows to avoid wheel traffic damage in most cases. Only in the irrigated Georgetown site did soybean planted in the wider rows yield the same as those planted in narrower rows with no wheel traffic. At this site, an indeterminate variety was planted in 30 inch rows, a slightly narrower row width than the 36 inch rows used in Suffolk. This site is also farther north. These factors may have contributed to the differences, but lack of water stress at the Georgetown site is likely the main reason for the lack of row spacing response. Irrigated conditions provide for more leaf area. Under high rainfall or irrigated conditions, soybean planted in wide rows is more likely to meet minimum leaf area requirements.

When prorated to 45-, 60-, 90-, and 120-foot booms, yield loss averaged 3.8, 2.8, 1.9, and 1.4% for the 7.5-inch rows, and 4.5, 3.5, 2.3, and 1.7% for the 15-inch rows, respectively. The range on either side of these average losses is almost half of those amounts. For instance, yield losses varied from 1.9 to 4.6% loss using a 60-foot spray boom. Depending on yield potential and sprayer boom width, a grower could lose less than one to several bushels in yield.

Fungicide application increased yield by 3.2 and 2.3 bushels per acre in the 2006 Suffolk and Georgetown full-season tests, respectively (6.5% and 4.4%, respectively). Yields were not affected by fungicide at the other sites.

**Result Summary:** To summarize these results, one may expect between 1 and 6% loss from running over soybean rows in the Mid-Atlantic region. The amount of loss will depend on the sprayer boom width, row spacing, and environmental conditions. There will likely be less of a loss in drilled rows than in 15-inch rows because the resulting gap is smaller (22.5 inches versus 30 inches). Environmental conditions before and after the damage will affect the amount of compensation from neighboring rows. If we were to assume a 2% loss to traffic, the monetary loss that one would need to factor into their spray decision is shown in Table 2 and 3. As you see, the cost of running over soybean rows can be quite large, even when we assume a minimal loss by using a wide boom width. With today's soybean prices hovering around \$8 per bushel, we need to definitely take this added cost into consideration. Of course, with \$8 soybeans, it does become easier to justify the fungicide - if yields can be increased.

Table 2. Monetary loss from sprayer traffic damage to soybean at differing yields and prices, assuming a 2 percent yield loss.

Bu/Acre	\$/Bushel				
	\$5.00	\$6.00	\$7.00	\$8.00	\$9.00
20	\$2.00	\$2.40	\$2.80	\$3.20	\$3.60
25	\$2.50	\$3.00	\$3.50	\$4.00	\$4.50
30	\$3.00	\$3.60	\$4.20	\$4.80	\$5.40
35	\$3.50	\$4.20	\$4.90	\$5.60	\$6.30
40	\$4.00	\$4.80	\$5.60	\$6.40	\$7.20
45	\$4.50	\$5.40	\$6.30	\$7.20	\$8.10
50	\$5.00	\$6.00	\$7.00	\$8.00	\$9.00

Table 3. Monetary loss from sprayer traffic damage to soybean at differing yields and prices, assuming a 2 percent yield loss.

Bu/Acre	\$/Bushel					
	\$9.00	\$10.00	\$12.00	\$14.00	\$16.00	\$18.00
20	\$3.60	\$ 4.00	\$ 4.80	\$ 2.80	\$ 6.40	\$ 7.20
25	\$4.50	\$ 5.00	\$ 6.00	\$ 7.00	\$ 8.00	\$ 9.00
30	\$5.40	\$ 6.00	\$ 7.20	\$ 8.40	\$ 9.60	\$10.80
35	\$6.30	\$ 7.00	\$ 8.40	\$ 9.80	\$11.20	\$12.60
40	\$7.20	\$ 8.00	\$ 9.60	\$11.20	\$12.80	\$14.40
45	\$8.10	\$ 9.00	\$10.80	\$12.60	\$14.40	\$16.20
50	\$9.00	\$10.00	\$12.00	\$14.00	\$16.00	\$18.00

**Solutions to Traffic Damage:** There are several solutions to preventing traffic damage. The first is too late for most of this year’s crops. That solution is to install tramlines for the sprayer to run. Not only will tramlines prevent the damage, it will help prevent pesticide overlap which has been estimated to be 2 to 7% in fields without a GPS guidance system. So, tramlines have extra savings. If you don’t have a tram system installed on your drill and you are spraying by ground, you may want to consider installing such a system in the future.

A second solution is aerial application. Aerial application has been shown to provide adequate pesticide coverage to reproductive-stage soybeans. Plus, more acreage can be covered in less amount of time.

Another option, although not necessarily a solution, is to factor the extra costs into economic thresholds. In the least, this should be done. As stated earlier, thresholds are established for most insect pests, so this can be easily done. Disease thresholds, due to the preventative nature of fungicides, are more complicated. To utilize disease thresholds, it will be necessary to develop a predictive model based on current and future environmental conditions. We will also have to take into consideration the variety being used (i.e., whether it contains a good disease package or not). I'm not sure if we are able to do this yet. We know the cost of the fungicide. We know the cost of the application. I've given you the expected cost of running over soybean rows. But, we cannot yet consistently predict the yield benefit. For now, we will just have to use our expected (or hoped for) yield increase from using a fungicide.

In conclusion, insecticide or fungicide sprays can improve our soybean profitability. But, running over soybean while they are producing pods will increase our application costs via a yield loss. Solutions to this damage include tram lines, aerial application, and the inclusion of these costs into our economic thresholds. It is very important that you account for the increased application costs associated with reproductive-stage pest management decisions. Know your costs. Evaluate the research data. And, only make pesticide applications if they can be economically justified.

## **Fat Liver and Reproductive Dysfunction in the Post Partum Cow**

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### **Introduction**

Fatty liver problems are positively correlated with diminished health and reproductive performance in transitional dairy cattle. Fatty liver infiltration generally occurs in association with negative energy balance in the post partum period. Duration and severity of negative energy balance is also positively correlated with reproductive dysfunction. Reproductive function (dysfunction) and metabolic and nutrient metabolism are controlled by hormonal axis governing follicle growth and ovulation as well as metabolic functions. The two endocrine axes do not work independently as they have overlapping areas of interaction. Disturbances in one or both axis are manifest as ketosis, fat liver, weight loss (> 0.5 BCS) decreased follicular growth, decreased follicular steroidogenesis, delayed ovulation, anovulation, cystic follicular degeneration, decreased conception rates, decreased pregnancy rates and increased early embryonic death.

### **Negative energy balance and metabolic responses**

Negative energy balance is a ubiquitous problem in the modern dairy industry. It occurs most often during the first months post partum. It seems likely that selection for high lactation

has inadvertently selected for metabolic regulatory events directing a fall in body condition score (BCS) during the post partum period. These metabolic events and the genetics associated with their control safely carry most cattle through heavy lactation demands, negative energy balance and the associated weight loss without developing severe ketosis and fatty liver problems. However, when regulatory events of energy metabolism fail during negative energy balance, cows develop severe, prolonged ketosis with fat infiltration into the liver. Aside from the immediate health problems associated with ketosis and fat liver, there are problems that confound reproductive function and lower pregnancy rates.

Metabolic adaptation to negative energy balance occurs in the liver, muscle, mammary gland and fat stores. The adaptability of fat makes sense because it is the major site of energy storage in cattle. Stored fat consists of triglycerides synthesized and stored as fat tissue during periods of positive energy balance. Positive energy balance occurs during mid- and late lactation periods and the dry period. During periods of negative energy balance (early lactation) triglycerides stored in fat are broken down and released in the blood as glycerin and non-esterified free fatty acids (NEFA). NEFAs are subsequently transported to peripheral tissues and the mammary gland for use in energy and milk fat production, respectively. Much of the NEFA is also picked up by the liver and either broken down into ketone bodies or reassembled by the liver into triglycerides for storage as fat in the liver. When blood sugar levels are normal or high (positive energy states with high levels of rumen propionic acid production) the liver utilizes NEFA for triglyceride synthesis and export to peripheral tissues. When blood glucose is low (negative energy state and/or low propionic acid production in the rumen) triglycerides synthesized in the liver from NEFA are either stored within the liver as fat or redistributed to peripheral tissues for use in energy or fat synthesis. Intense negative energy states associated with high levels of lactation can mobilize overwhelming amounts of fat from peripheral fat stores. This can result in fat overwhelming the liver and, if severe enough, liver malfunction.

Muscle tissue utilizes ketones and NEFA instead of glucose for energy during periods of heavy lactation associated with negative energy balance. This may conserve blood sugar (glucose) during negative energy balance and thereby preserving blood glucose for lactose production by the mammary gland. Preservation of blood glucose levels also blocks NEFA release from fat and therefore lowers NEFA input to the liver. During negative energy states muscle tissues also release muscle proteins into the blood during periods of heavy lactation and/or fetal growth, particularly in face of low or imbalanced (RDP:RUP) dietary protein consumption. Muscle protein is utilized for milk protein synthesis or growth of fetal tissue late in gestation.

### **When metabolic adaptation to negative energy balance fails**

Many postpartum problems including reproductive failure are closely linked to energy management practices during the dry period and later in the first 6-8 weeks post calving. Ketosis (clinical or subclinical) and fat infiltration of the liver reflect energy management problems and signal the onset of infectious, metabolic and reproductive problems during the post partum period. Thus most ketosis in high producing dairy cattle can be regarded as an indicator of metabolic imbalance, negative energy balance and peripheral fat mobilization. Cows with mild to moderate fatty liver show moderate negative energy balance whereas cows with severe fatty

infiltration develop severe negative energy balance. In the first month post partum, 30-40% of cows show moderate fatty liver infiltrates whereas 5-10% will show severe fatty liver degeneration. Thus, as high as 50% of post partum cows develop significant levels of fat infiltration into the liver. The following chart (modified from Bobe et al., 2004) summarizes the relationship between fat liver infiltrates, ketosis and the clinical impact on health and disease.

<b>Liver condition</b>	<b>Liver fat content</b>	<b>Urinary ketone</b>	<b>Effect on DMI and milk production</b>	<b>Relative effect on health and reproduction</b>
normal	<1%	None	none	None
Mild fatty liver	5%	Mild	slightly decrease	Mild
Moderate fatty liver	10%	moderate	Problematic decrease	Moderate
Severe fatty liver	>10%	Severe and prolonged	Nearly complete loss	Severe and prolonged

### **What is fatty liver?**

Fat liver is the deposition of triglycerides into liver cells. Triglycerides are the principle storage form of fat synthesized from non-esterified free fatty acids (NEFA) delivered to the liver during mobilization of peripheral fat stores following negative energy states. High producing dairy cows inevitably enter a state of negative energy balance when nutrient intake far exceeds lactation drain. Post partum negative energy balance occurs in cattle overfed or maintenance fed during the dry period. As DMI decreases close to parturition, blood levels of NEFA and ketones tend to rise. Interestingly, the post partum rises of these indicators of peripheral fat mobilization can be much higher in cattle fed too heavily during the dry period compared to cattle fed normally during the dry period. NEFA flow into the liver where they can either be assimilated into liver fat, metabolized for energy or broken down into ketone bodies. Thus increased blood levels of NEFA and ketone bodies (betahydroxybutyrate and acetoacetate) are often present coincidentally with hepatic fat synthesis leading to the progressive deposition of fat in the liver. Liver fat infiltration in normal and overfed cattle occurs several weeks prior to parturition and persists for several weeks after calving. Liver infiltration occurs in all post partum cattle but is much greater in overfed cattle.

Failure to adapt to negative energy balance may involve all tissues normally involved in energy metabolism. Peripheral fat stores in over conditioned cattle may be prone to mobilize NEFA into the blood and liver much faster than fat tissues of cattle with lower BCS. This may simply reflect the larger mass of fat tissue in over conditioned cattle rather than something particularly wrong with the tissue itself. However, there is some evidence that fat in over conditioned cattle may be less responsive to the anti-lipolytic effect of hormones like insulin. This so-called insulin resistance makes it difficult for over conditioned cattle to reverse fat mobilization and lower NEFA blood levels. As a result the liver could become overwhelmed with NEFA and start storing fat.

Recent evidence suggests failure to adapt to negative energy balance in prepartum over fed, over conditioned cattle also involves mal-adaptation in the liver. Over conditioning alters

hepatic gene expression to favor hepatic triglyceride synthesis from incoming NEFA rather than NEFA breakup into ketones for energy. As a consequence, NEFA mobilized from peripheral fat in over conditioned cattle may be resynthesized into triglycerides by the liver and subsequently stored as liver fat. Unlike livers of over fed cattle, livers of normally conditioned cattle are conditioned to channel incoming NEFA into energy production rather than intra-hepatic fat production. Many times fatty infiltration of the liver begins a week or two prior to parturition in association with increased propensity of fat to more rapidly release NEFA into the blood.

**Producers should be aware fat stores may be more readily mobilized into NEFA in overconditioned cattle. Livers of over conditioned cattle may be conditioned by overfeeding to store fat mobilized from peripheral fat stores. This transfer of fat from peripheral fat tissue to the liver has costly consequences on reproductive function and post partum health.**

### **The relationship between Negative Energy Balance, GH, blood IGF-1 levels and reproductive function**

Negative energy balance post partum also directly impacts blood levels of insulin levels, insulin growth factor 1 (IGF-1) and somatotropin (ST). These hormones deserve mention in discussions of reproductive dysfunction because they regulate follicle growth and welfare even though their primary role is in nutrient partitioning and metabolism. Generally speaking, well nourished animals tend to have relatively high levels of IGF-1 and insulin and lower levels of GH. Prior to parturition, blood levels of GH are low but then rise after calving. In contrast, insulin and IGF-1 levels are high prior to calving but then drop off quickly after calving. Later in lactation, blood levels of IGF-1 and insulin begin to rise while GH levels drop. IGF-1 levels are dictated (in part) by the state of negative energy and protein balance. The more negative the state of energy and protein balance, the lower the IGF-1 levels. GH levels are inversely related to IGF-1 levels so that early in lactation as IGF-1 levels drop, GH levels automatically rise.

IGF-1 is manufactured and secreted by the liver following GH stimulation. IGF-1 functions at the follicular level to stimulate follicle growth, maturation and estrogen synthesis. Thus, IGF-1 is critical for development of a fully competent follicle capable of ovulation. Follicular levels of IGF-1 are heavily dependent upon liver synthesis of IGF-1 and to a smaller extent on IGF-1 synthesis by the follicle itself. In general, the larger follicles tend to collect higher amounts of IGF-1. Regardless, any liver problem arising from fat infiltration of the liver decreases IGF-1 availability to the follicle and leads to follicular incompetence. Higher blood levels of IGF-1 in the first 2 weeks post partum are positively correlated with shorter days in milk to conception and luteal function in dairy cattle. In fact, it has been suggested IGF-1 levels in blood of post partum cattle may be a good indicator of energy status and reproductive proficiency. **Therefore levels of liver generated IGF-1, driven by GH stimulation of competent liver function impact reproductive function. Producers should be aware any damage to the liver by fat infiltration will lower hepatic synthesis of IGF-1 and therefore negatively impact follicular function. Low IGF-1 levels are highly associated with anovulation, weak heats and prolonged days in milk to first conception in cattle.** It appears these problems arise because follicles do not develop sufficiently to enable adequate production of estrogen. Follicular estrogen is important in induction of follicle ovulation and strong estrous behavior at the time of

heat. This cross over function of IGF-1 is partially why negative energy balance promotes reproductive dysfunction.

GH (and therefore bovine somatotrophic hormone (rBST)) effects on follicular competence appear to be mediated primarily through GH stimulation of liver IGF-1 production or elevated blood glucose levels that directly stimulate follicle growth. Repeated, daily administration of rBST trigger increased numbers of follicles to develop through the early stages of follicle growth. However, the follicles do not go on to develop into fully competent, ovulatory follicles. All the data available on rBST effects on reproductive performance suggest there is unlikely to be significant practical gains or losses in reproductive function. The major effect may be to increase lactation energy drains and potentiate the detrimental effects of negative energy balance on reproductive proficiency.

### **Reproductive consequences of liver infiltration with fat.**

Risk of fatty liver infiltration in over conditioned dairy cattle begins several weeks prior to parturition. Fatty liver is associated with lower blood glucose, higher NEFA and ketone body levels during this period. **The data is compelling in that cows with elevated blood ketone levels associated with clinical or subclinical ketosis are predisposed to reproductive failure 60 to 160 days later.** Elevated ketone levels as early as 3 weeks before to 9 weeks after freshening tend to be associated with reduced pregnancy rates at first service after freshening. **The reduction in pregnancy rate appears to be most significant in cows with elevated ketone levels in the first and/or second week post partum. Moreover, the risk of reproductive failure is additive in that clinical or subclinical ketosis in both weeks post partum creates a greater risk of reproductive failure on first services than ketosis in either week alone. Moreover, higher levels of ketones in the blood are associated with a progressive and proportional decrease in first service pregnancy rates.** The only positive side of ketosis is the negative effect on pregnancy rates is highest immediately after the voluntary wait period and diminishes with increasing DIM after the voluntary wait period. Pregnancy rates will eventually recover from the erosive effect of ketosis. Unfortunately, the recovery in pregnancy rates (in cows with elevated ketone levels in the first two weeks) arrives around 140-160 DIM. Thus, the final recovery in pregnancy rate is very costly to producers. Reproductive failures are manifest as delayed first ovulation after freshening, prolonged days in milk (DIM) until first service and increased DIM until confirmed pregnant. Elevated ketones also appear to slow embryonic growth and development.

High lactation demands for energy as well as protein cause cows to mobilize peripheral stores of fat (from fat tissues) and protein (mostly from muscle mass). These tissue components are utilized for energy sources, glucose synthesis, milk fat and milk protein synthesis. Cows can be expected to lose 75-80 lbs of weight (0.5BCS) during heavy lactation stress while showing elevated blood levels of NEFA, ketones and triglycerides. Increased triglyceride (fat) storage in the liver can hinder hepatic synthesis and secretion of insulin growth factor 1 (IGF-1) and glucose. Since IGF-1 is a key factor in follicle growth and a fundamental determinant of follicle ovulation in the first post partum estrus day 10 post calving, fatty liver infiltrates can lead to diminished follicle growth and delayed ovulation. Cows with fatty liver also have decrease ability to synthesize cholesterol esters which are the substrates taken up by luteal and follicular

cells to synthesize estrogen and progesterone. Diminished follicular estrogen synthesis leads to weak estrous behavior, delayed ovulation and/or anovulatory heats. Less than adequate follicle growth can lead to formation of small corpus luteal bodies after ovulation and during pregnancy. Small corpus luteal bodies lack luteal tissue and therefore cannot produce large amounts of progesterone. Lower than normal progesterone synthesis leads to several reproductive problems. Inadequate progesterone levels create significant problems during timed artificial insemination programs. Corpus luteal tissue must be present on the ovary for prostaglandin to function in timed ovulation-synchronization programs. Inadequate progesterone synthesis due to small corpus luteal bodies in one cycle can lead to weak or total absence of estrous behavior in succeeding cycles. The reason is that estrogen-induced estrous behavior has an absolute requirement for progesterone priming. Poor follicle growth can also lead to inadequate tissue mass in the post ovulatory corpus luteal body. Progesterone levels can be low enough that pregnancy cannot be sustained because it is terminated by early embryonic death. **Producers should be aware fat infiltrates in the liver result in decreased follicle growth, smaller follicle size, delayed ovulation, anovulation, decreased follicular steroidogenesis and increased early embryonic death. The take home message is that fat infiltrates in the liver increase the risk of reproductive failure.** Impaired milk production, health and reproductive functions persist for weeks after hepatic levels of fat have returned to normal.

Elevated levels of liver triglycerides (fat) impair another important area of liver function: this is the detoxification of ammonia by conversion to urea for excretion in the urine. The site for this function is the liver. Livers overloaded with triglycerides may fail to adequately convert ammonia into urea for excretion in the urine. Supplies of dietary protein are broadly characterized into rumen degradable protein (RDP) and rumen un-degradable protein (RUP). RDP is in large measure converted to microbial protein as rumen bacteria utilize RDP in conjunction with rumen degradable carbohydrates as substrate to grow. The microbes are passed to the lower gastrointestinal tract where they are killed, digested and absorbed as metabolizable protein available for tissue and milk protein synthesis. How much RDP is converted into microbial protein is dependent upon total dietary protein content, RDP content and carbohydrate content in the ration. Normally producers should try to keep RDP levels at 10-11% of dietary dry matter to obtain a balance between RDP and rumen fermentable carbohydrates that maximizes RDP incorporation into microbial protein. When imbalance occurs, excess RDP is broken down for energy, releasing ammonia in the rumen. Ammonia is absorbed, passed into the liver and detoxified by conversion to urea. Within hours of excess RDP consumption, ammonia levels rise in the rumen and ammonia and urea levels rise in the blood and all tissue of the body. **Producers should be aware levels of ammonia and urea in blood, tissues and milk are most sensitive to changes in total dietary protein, most notably those changes impacting dietary RDP. Producers should know how much total protein and RDP is present in transition diets. This becomes even more urgent if fatty liver infiltration is a problem in fresh cows. fat livers cannot detoxify ammonia. Elevated ammonia sustains tissue ammonia levels.**

Sustained levels of tissue ammonia secondary to fatty liver infiltration have direct effects on fertility. Ammonia is associated with lower levels of progesterone synthesis by corpus luteal tissues. Though ammonia levels rise in follicles and follicular fluid, ammonia per se appears to have minor direct effects on folliculogenesis and follicle development. Ammonia does inhibit conceptus growth and development in the first 3-4 weeks of pregnancy. Slow growing embryos

early in pregnancy may add to early embryonic death problems because small embryos with inadequate tissue mass may fail to signal pregnancy to the dam. Thus, fat livers that inefficiently convert ammonia to urea create fertility problems that may target post conception embryonic development.

### **Risk factors for fatty liver**

**Nutrition:** One of the greatest risk factors for onset of fatty liver is pre-partum over conditioning (BCS  $\pm 4.0$ ). During the post partum period, decreased DMI, most disease problems and diet changes tend to increase fat deposition in the liver more so in cows with over conditioning BCS compared to normal BCS. Obese cows generally experience a greater negative energy balance during this period due to their inability to maintain high energy (DMI) intakes. The higher mass of fat tissue in over conditioned cattle leads to increased levels of leptin secretion by fat tissues. Leptin functions in nutrient partitioning by depressing appetites and energy intake. This effect potentiates negative energy balance in heavy cattle. Although leptin is regarded as a modulator of the energy and nutrient partitioning system, leptin activities also spill over and affect the reproductive axis that regulates folliculogenesis, ovulation, luteal tissue formation, steroidogenesis, conception and embryonic survival. Leptin often suppresses folliculogenesis and steroidogenesis.

Feed restriction (voluntary or involuntary) secondary to postpartum disease, ration changes or high levels of dietary concentrates are associated with increased risk of fatty liver. The effectiveness of feed restriction to precipitate liver fat infiltrates depends on the risk factors for cows to enter negative energy balance. This of course is greatest during the early post partum periods when lactation induced energy losses are greatest. The more obese the cow (overfeeding energy for prolonged late lactation periods) the greater the risk of developing fatty liver infiltrates even during short post partum periods of reduced DMI.

Inadequate protein nutrition in late pregnancy has also been associated with fatty liver problems during the post partum period. Dry cow diets with 12% or lower protein content tend to result in lower milk yields, lower milk protein and may predispose cattle to post partum fat infiltration of the liver. Diets with 15-16% protein fed 6 weeks prior to parturition favor higher milk yields, higher milk protein and lower fat infiltration content in livers. Dry cows receiving high energy but low protein diets developed more severe fatty liver problems compared to dry cows receiving high energy, high protein diets. Late pregnancy dietary protein supplements can reduce the incidence of post partum ketosis. Dietary protein supplementation (particularly with rumen bypass or un-degradable proteins) during the dry period may help the liver clear fats by helping the liver generate carrier proteins essential to transport fats from the liver to peripheral tissues. It appears levels of dietary lysine and methionine (in rumen bypass proteins) may be the critical protein component as these amino acids are utilized in liver synthesis of fat carrier proteins. These carrier proteins help mediate fat transport to peripheral tissues and away from the liver. Dry cows fed diets supplemented with rumen protected (rumen un-degradable) amino acids or proteins were associated with significantly less fat content in livers and lower ketone levels in blood several weeks post partum. Lower hepatic fat content and ketosis is particularly important given the observation that high ketone levels in the blood within the first 7-14 days postpartum are often associated with anovulation in the first post partum estrus (day 10 post

partum). Anovulatory first post partum estrus is associated with a 60 day delay in onset of post partum estrus and ovulation.

**Management Risks:** Poor quality silage with elevated betahydroxybuturate content will decreased DMI and propels cows into negative energy states. Poor ration preparation enabling rumen acidosis or poor feed bunk management practices that allow cows to run out of feed will promote fatty liver infiltrates through their effect on rumen health and SARA. Conditions that promote disease problems such as retained placenta, metritis, mastitis, lameness, SARA and displaced abomasums decreased DMI, promote negative energy balance and promote fat liver infiltrates by augmenting fat mobilization from peripheral fat stores and increased uptake by the liver. Generally, disease and management problems promoting lower DMI and higher negative energy status promote fatty liver infiltrates.

### **Prevention of fatty liver**

There are several general recommendations producers might consider to prevent fatty liver infiltrates. Producers should strive to (1) avoiding obesity in dry cows (2) promote high DMI intake of transitional diets (3) maintain post partum uterine, mammary and limb health and (4) consider dietary supplementation. The first 3 require sound ration formulation and preparation, good feed bunk management practices and skills and clean, disinfected calving facilities.

Dietary supplementation targets increased energy intake to more closely match energy intake to heavy lactation drains. Moreover, supplementation should serve to elevate blood glucose levels thereby diminishing the metabolic drive to elevate blood NEFA by excessive mobilization of peripheral fat stores. Blood glucose levels can be directly elevated by use of gluconeogenic agents such as corticosteroids or glucagon. Both prevent fatty liver infiltration by driving glucose synthesis and elevating blood glucose levels. Oral prepartum administration of propylene glycol or glycine drenches for several days prepartum promote propionate production in the rumen. Rumen propionate is readily converted to glucose by the liver and thereby elevates blood glucose levels. Elevated glucose increases insulin secretion thereby preventing NEFA mobilization from peripheral fat stores. As a result liver infiltrates of fat are diminished. Some evidence suggests propylene glycol is most effective in preventing fatty liver infiltrates when administered as a drench rather than a feed additive. Cows drenched with propylene glycol during negative energy balance tended to show elevated levels of blood glucose, insulin, IGF-1 and lower levels of blood NEFA and liver fat. These changes suggest propylene glycol administration during transition periods improves metabolic status during negative energy periods. However, propylene glycol treatment did not significantly improve follicle growth or follicular steroidogenesis sufficiently to impact ovulation rates. Thus, even though propylene glycol can positively impact metabolic status, changes in metabolic status that fail to offset low dry matter intakes associated with severe negative energy states are unlikely to lead to the persistence of reproductive dysfunction.

Dietary supplements such as glycerol and calcium or ammonium salts of propionate may help by driving glucose production in cattle. These agents will drop plasma NEFA and betahydroxybutyrate levels as they elevate blood glucose. These supplements have the advantage in that they are not as labor intensive in preventing liver fatty infiltrates as propylene

glycol drenches. Monensin fed prepartum may diminish the risk of fatty liver because it promotes rumen bacterial production of propionate. Rumen propionate production and delivery to the liver favors hepatic glucose synthesis. The resultant elevation in blood glucose acts to slow peripheral fat mobilization and therefore acquisition of fat by the liver. Though feeding monensin prepartum does increase blood glucose, the increase may not be as great as that seen in the post partum period. The reason is not clear although high fetal requirements for glucose in late gestation may blunt the beneficial effects of prepartum monensin on blood glucose levels. Regardless, prepartum rises in blood glucose may reduce blood ketone levels as monensin usually lowers blood levels of acetoacetate, beta-hydroxybuterate and NEFAs. The metabolic effect is greatest during early lactation which is exactly when metabolic problems have negative consequences on ovarian activity. Unfortunately, the data are still inconclusive in how the metabolic effects of monensin translate into improved reproductive performance. Monensin can decrease days to first ovulation after freshening but may not necessarily improve first service conception rates.

## **Conclusion**

Producers should be aware fat liver infiltration is a ubiquitous problem in modern dairy cattle. Prolonged and deep shortages of energy intake lead to moderate or severe fat infiltration of the liver, rising ketone and NEFA levels in the blood and reproductive dysfunction. The associated drop in blood glucose, IGF-1 and increase in insulin resistance can directly impact follicular growth, development and steroidogenesis. These events may translate into anestrus, weak estrus behavior, delayed ovulation, anovulation and/or early embryonic death. Ration and feed bunk strategies designed to elevate rumen production of propionic acid, elevate blood glucose and enhance DMI should be considered whenever reproductive failure becomes an issue. Producers should avoid high body condition scores in dry cattle and manage rations, feed bunks and housing conditions to maximize post partum DMI. Pre- and post partum dietary supplementation with propylene glycol, glycerol or monensin is likely to benefit metabolic problems and may positively impact reproductive performance.

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## **Notices and Upcoming Events**

### **June 24, 2008**

**Bread Wheat and Organic Production Workshop**, Waynesville, NC. Mountain Research Station. To register, call 919-513-0954 or go on-line to: [www.cefs.ncsu.edu/calendar2008.htm](http://www.cefs.ncsu.edu/calendar2008.htm)

### **July 1, 2008**

**Weed Twilight Tour**, Landisville, PA. Landisville Research Farm. Contact 717-270-4391

### **July 2, 2008**

**Penn State No-tilling for Success Field Day**, Landisville, PA. Southeast Research and Extension Center. Contact Jeff Graybill at 717-394-6851

### **July 7, 2008**

**Warm Season Grass Pasture Walk**, Morris' Choice Bison Ranch. Contact the Baltimore County Cooperative Extension Service at 410-666-1022 or the Baltimore County Soil Conservation District at 410-666-1188 x 3

### **July 10, 2008**

**Penn State Rock Springs Agronomy Weed Tour**, State College, PA. Penn State Agronomy Research Farm. Contact Bill Curran at 814-863-1014

### **July 22 and 23, 2008**

**Agronomic Field Diagnostic Clinics**, State College, PA. Penn State Agronomy Research Farm. Contact Dwight Lingenfelter at 814-865-2242

**July 24, 2008**

**Maryland Commodity Classic**, Centreville, MD. Queen Anne's 4-H Park and morning tours at the Wye Research and Education Center. For tickets contact Lynne Hoot (MGPA) at 410-956-5771

**July 24-26, 2008**

**Organic Grain Production Three State Bus Tour**, Maryland Eastern Shore, Pennsylvania, and Virginia. Register at [www.cefs.ncsu.edu/calendar2008.htm](http://www.cefs.ncsu.edu/calendar2008.htm) or for more information call Molly Hamilton at 828-273-1041.

**July 30, 2008**

**Virginia Forage and Grassland Council Summer Conference**, Weed Control in Pastures: The Soil, Plant, and Animal – An Integrated Approach. Rahine, VA. Contact [makenny@vt.edu](mailto:makenny@vt.edu) or 434-292-5331

**July 31, 2008**

**Virginia Forage and Grassland Council Summer Conference**, Weed Control in Pastures: The Soil, Plant, and Animal – An Integrated Approach. Blackstone, VA. Contact [makenny@vt.edu](mailto:makenny@vt.edu) or 434-292-5331

**August 14, 2008**

**2008 Virginia Ag Expo**, Billy Bain Farms, Dinwiddie County, VA. Registration required. Contact Virginia Ag-Expo, 17000 Sandy Point Road, Charles City, VA 23030

**October 8-9, 2008**

**Mid-Atlantic Dairy Grazing Conference and Organic Field Day-Adding Value to Grass Based Dairy Enterprises**, Plecker Workforce Center at Blue Ridge Community College, Weyers Cave, VA. Contact [stanleyt@vt.edu](mailto:stanleyt@vt.edu) or 540-245-5750

**January 5-10, 2009**

**Delaware Ag Week**, Harrington, DE. Contact Dave Hansen at 302-856-7303 or email: [djhansen@udel.edu](mailto:djhansen@udel.edu) **Delaware—Maryland Hay and Pasture Day, Evening Program for Part-time Hay and Pasture Producers, Dairy Day, and Agronomy/Soybean Day**

**February 17-18, 2009**

**Pennsylvania Professional Crop Producers Conference**, State College, PA. Contact Marvin Hall at 814-863-7043

### **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](http://www.mdcrops.umd.edu) Click on Newsletter

### **Photographs for Newsletter Cover**

To view more of Todd White's Bucks County photographs, please visit the following web site:

[www.scenicbuckscounty.com](http://www.scenicbuckscounty.com)