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Please note that Issue 4, Numbers 1, 2, and 3 were not published. Articles submitted for Issue 4, Number 1 are being published in this issue. The editor extends apologies for the lapse.

Ten Crop Management Practices for Optimizing Profit

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For the past couple years, we have been bombarded with mostly negative economic news. Following many years of positive economic growth, a bad economy is a relatively new concept to many mainstream Americans. For farmers, dealing with economic uncertainty seems to be an annual event even during the so-called "good times" since they are faced with many factors that are out of their control. During the past year, commodity prices have reached unprecedented highs followed by dramatic drops. At the same time, inputs costs seemed to go in only one direction, up. Paying attention to details can help optimize profit. The following ten crop management practices should be on your "must-do" list.

1. **Equipment maintenance:** Go over your planters, sprayers, and harvesters during the offseason. You rely on this equipment to properly place your seed into the soil, put out crop protection products and nutrients during the growing season, and harvest the fruits of your labors. Make sure your equipment is in good condition when you go to the field.

2. **Variety/hybrid selection:** This is another important off-season activity. Review as much information as you can find regarding performance of varieties and hybrids in your region. A major aspect of your decision-making process should be an assessment of the level of stability that varieties/hybrids have shown. Stability is a measure of variety/hybrid performance at a number of locations and/or years. A stable variety/hybrid has performed better than average at a majority of testing sites. Though stability is not 100% accurate, a variety/hybrid that has good stability has a better than average likelihood to perform well under your growing conditions.

3. C**hoose more than one variety/hybrid:** There are numerous benefits realized by choosing more than one variety/hybrid for your farm. It allows you to spread the harvest maturation of your crops so they are not ready to harvest at the same time. It can help you avoid potential disease problems, such as wheat scab, that are specific to a crop growth stage. Choosing soybean varieties that range in maturity from early-maturity group (MG) 3 to mid-MG 4 help spread your risk against yield loss caused by periods of summer drought.

   Choosing more than one hybrid can help you reduce seed costs, i.e. non-GMO corn hybrids generally cost less than stacked trait hybrids. There are still good performing conventional hybrids available and you must maintain a non-Bt refuge of 20% of your corn acreage.

4. **Take advantage of early-season discounts:** Do not wait until it is time to spray or plant to order your chemicals and seed. Many companies offer early-bird specials with additional discounts if you pay early. Ordering seed early is an opportunity to both get the varieties/hybrids that you want and reduce your per acre seed cost. Determining your

chemical needs early should also mean that you have considered your pest issues and you will have the products on-hand to effectively manage them if and when they appear.

5. **Plant on time:** Planting your crops on time allows them to use the full growing season. Winter wheat and barley should be planted early enough to emerge and establish 1-2 tillers. The optimum windows for planting winter wheat are based upon the Hessian-fly free dates that vary across Maryland and the region. For Central and Western Maryland, an initial starting date is during the last week of September to first week of October. For the Eastern Shore, the initial dates are during the first couple weeks of October but check with your local county agricultural Extension agent for the dates in your area. Generally, you have approximately three-weeks following the fly-free date for your area that are considered the optimum planting window.

   Corn can be planted once soil temperature (2-3" depth) reaches 50 degrees F. The dates this usually occurs will vary from mid-April (lower Eastern Shore) to mid-May (Garrett and Allegeny counties in Maryland). For most of the Eastern Shore and Central Maryland, a yield reduction of approximately 1% per day for every day planting is delayed after May 15 is a good rule of thumb.

   Optimum dates for planting full season soybean occur during the first three weeks of May. Double-crop (DC) soybeans should be planted as soon after the small grain is harvested as possible. This favors planting DC soybeans after barley. July 10-15 is considered to be late for planting DC soybeans because by this date you must hope for a late first killing frost to ensure the crop reaches maturity.

6. S**etup and calibrate your equipment in the field:** After spending time and money maintaining your equipment during the off season, take time to set it up properly once you get to the field. This does not mean just the first field. For planters, soil type, soil condition, previous crop residue, and seed size are some of the factors that make it necessary to calibrate and visually assess seed placement frequently. Do the same with harvesting equipment. Different varieties and hybrids make it necessary to adjust harvesting equipment to accommodate changing harvest moisture content and crop conditions that influence mechanical harvest grain loss.

7. **Use optimum seeding rates:** With constantly increasing seed costs accompanying multi-stacked corn hybrids and Roundup Ready 2 soybean varieties, it is important to have crop seeding rates that attain optimum yield. Over or under-seeding can be costly. For most situations, a corn seeding rate to attain an emerged plant population of approximately 28,000/acre should be fine. For fields that are frequently drought prone, a plant population below 28,000 may be needed. If you supply irrigation and have highly productive soils, populations approaching 30,000 – 34,000 may be needed.

   Soybeans can adjust to a fairly wide-range of populations. For full-season soybean, an emerged plant population of 120,000 to 140,000/acre should produce optimum yield. For double-crop soybean, you may want to increase the emerged population goal to 140,000 to

160,000 plants/acre to account for the small grain residue and drier conditions usually present when at double-crop planting.

For small grains, your seeding rate goal should be for 1.25 to1.5 million emerged small grain seedlings/acre. This translates to 17 to 20 plants per foot of row if planting on 7-inch row spacing.

8. **Soil test:** This is one of the cheapest investments you can make to monitor and address the production potential of your fields. Soil tests inform you about the nutrient status of your fields. They allow you to maintain the pH and concentrations of other essential nutrients at optimum levels. The rapid rise in the cost of fertilizer has many considering reductions in some important crop producing nutrients such as phosphorus and potassium (potash). Do not mine your soils without knowing what is happening in your fields. Maintaining your soils at the optimum levels for nutrients will guarantee your crops will not suffer from nutrient deficiencies that could have been avoided.

9. **Have a realistic yield goal:** Supplying an adequate amount of the hardest to manage nutrient, nitrogen (N), is important to optimize corn and small grain yields. The first step in determining the N rate for your crop is to identify a "realistic" yield goal. "Realistic" yield means the average yield you have observed for a field over a number of years when normal growing conditions occurred, not the maximum yield you have seen during those 1 or 2 exceptional years. Once the yield goal is identified, you can estimate how much N your crops will require. A good rule of thumb for estimating N requirement for corn and small grains is 1 lb N/bu of anticipated yield. After you have estimated the total N requirement, subtract the N credits from this total for a previous soybean or alfalfa crop and for manure applications to your fields. Your solution is the amount of N to supply using commercial fertilizer.

10. **Use timely applications of N:** There is no doubt that following water, N is the most important crop nutrient needed to maximize crop growth. Alfalfa and soybean, both legumes, can produce their own N so managing it for those crops is easy. However, for corn and small grains, it is the plant nutrient of highest consumption. Nitrogen is difficult to manage because it is subject to numerous loss pathways. To attain the most efficient use possible for this nutrient it is important to supply it when the crop can best use it, i.e. when these crops are in their rapid growth phases. Corn should receive no more than 25 percent of its total N requirement at or just prior to planting. The remainder should be supplied in a sidedress application that occurs about 5-6 weeks after crop emergence.

If a field has a history of legume and/or manure use, do a Pre-Sidedress Nitrate Test (PSNT) prior to the sidedress application to determine how much N may be available. You may be surprised how much is there.

For small grains, the necessity of supplying a small amount of N when you plant is questionable because in many cases there is an adequate amount of residual N remaining from the previous crop to carry the wheat or barley through to spring. For small grains, the most important aspect of N management is to supply the N in the spring, ~ 50 percent of the

total N needed when the crop begins to green up and the remaining 50 percent as the crop begins to joint.

Are Non-Transgenic Corn Hybrids a Viable Alternative to Stacked Trait Hybrids?

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As was noted in a December 2008 newsletter article, transgenic corn hybrids are now the most widely grown hybrids in Ohio. According to the USDA-Economic Research Service (http://www.ers.usda.gov/data/biotechcrops/) in 2008, two thirds of the state's corn acreage was planted to transgenic corn hybrids with 37 percent of total acreage planted to stacked trait hybrids, 17 percent to herbicide tolerant hybrids, and 12 percent to some type of Bt hybrid. It appears likely that in the near future that the availability of non-transgenic corn hybrids will be limited and that acreage of non-transgenics corn will continue to decline. However, many corn growers in Ohio (in 2008 one third of the corn acreage was non-transgenic) are still interested in growing non-transgenic corns. Some of these growers want to take advantage of the premiums offered for non-GMO corn (about $0.50 or more per bushel) and others want to grow non-GMO corn to reduce seed and herbicide costs associated with traited corn. Growers who have not experienced serious problems with rootworm and corn borer and who have controlled weeds effectively with traditional herbicide programs question the need for transgenic hybrids. Non-GMO corn producers cite increasing difficulties locating non-transgenic corn hybrids and are concerned that the yield potential of non transgenic corn hybrids is lower than that of transgenic corns especially stacked trait hybrids.

These concerns are understandable since there has been a perception among some growers that stacked trait corn hybrids are higher yielding irrespective of insect pest pressure. A frequent comment I've heard is "stacked trait hybrids are doing more for us than protecting yields." One explanation for this perception is that some seed companies are no longer developing non-transgenic versions of certain hybrids. So, when a new high yielding hybrid is introduced it's only available with stacked traits and certain single traits (e.g. a Roundup resistant version). As

a consequence, some believe that in order to optimize yields with the newest "genetics" you need to plant stacked trait corn hybrids. Another explanation for the perception is that the gene stacking itself enhances yields. Different genetic backgrounds respond differently to insertion of transgenes. Yields of some transgenic hybrids are lower than the non traited isogenic hybrid whereas others are higher. I'm unaware of any research indicating stacking traits per se increases yield.

In 2008, nearly all the hybrids entered in the Ohio Corn Performance Test (OCPT) contained one or more transgenic traits with over 60 percent of the entries containing three or more traits. To provide non-GMO corn producers with information on the performance of non-transgenic corn relative to that of transgenic hybrids, we asked seed companies entering the OCPT for non-transgenic hybrids that we could include in the 2008 regional tests. A total of 18 non-transgenic hybrids were evaluated in addition to 214 transgenic corn hybrids. At the eight test locations across Ohio (with three sites in the Southwest/West Central region, two in the Northwest region and three in the Northcentral/Northeast region) average grain yields of transgenic and non-transgenic hybrids in the early maturity tests differed by 2 to 14 bu/A with the transgenic hybrids showing slightly a higher yield at only one of the eight sites; average grain yields of transgenic and non-transgenic in the full season maturity tests differed by 1 to 12 bu/A with the transgenics showing higher yields at four of the eight sites. Differences in stalk lodging between the transgenic and non-transgenic hybrids at the eight test sites were negligible. A comparison of average OCPT plot yields of the non-transgenic hybrids with that of hybrids containing one or more events (16 different events and combinations of events) revealed that the non-transgenic corn yielded as well as most events and better than some.

One of the seed companies participating in the 2008 OCPT, provided us with two non-transgenic hybrids (a 109- and a 110-day hybrid). In addition, they provided six different "versions" of these two hybrids each containing one or more transgenic traits - Roundup Ready (RR), Yield Gard (YG) corn borer (CB) Bt, RR+YGCB, "YG Plus" (CB + root worm (RW) Bt), RR+YGPlus, and YGVT3. We compared the performance of these hybrids at seven OCPT sites to determine effects of transgenic traits on agronomic performance under different growing conditions. Yields of the 110-day hybrids, (yields averaged across the seven isogenic hybrids and seven test sites) were 26 bu/A greater than that of the 109-day hybrids. However, yields, averaged across test locations, were not significantly different among the isogenic hybrids. Yields of non-transgenic hybrid yielded as well as the stacked corn hybrids. At two of the seven test sites, there were significant differences among the 109-day isogenic hybrids for stalk lodging with hybrids containing RR+YGPlus, and YGVT3 showing significantly greater stalk lodging (51 and 64 percent, respectively) compared to the non-transgenic hybrid (6 percent). These differences in stalk lodging were not present for the 110-day hybrids.

Results of the 2008 OCPT and isogenic corn hybrid evaluations suggest that non- transgenic (non-GMO hybrids) are available that will yield competitively with many transgenic corn hybrids, including stacked trait hybrids, in the absence of corn borer and rootworm pressure. Growers interested in identifying high yielding hybrids for non-GMO grain production should consider accessing the Ohio Corn Performance Test website http://oardc.osu.edu/corntrials/. Once a region or test location is selected, the sort feature under "Traits" can be used to find "NON-GMO" hybrids.

Arrested Ears and Other Ear Oddities Revisited

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In 2007, and to a lesser extent 2006, there were localized reports of "arrested ear" development in several Corn Belt states, especially Illinois and Indiana. Arrested ears were characterized by a range of symptoms. Some ears exhibited varying degrees of stunting with limited kernel formation. Some ear shoots carried either no ear or only the short remnant of an ear. Often silks were absent or limited.

Arrested ears usually occurred in fields that had been treated with various fungicides, herbicides, insecticides, foliar nitrogen, and various spray additives. However, some of the most pronounced arrested ear damage was associated with foliar fungicide applications made with ground equipment during the two week period prior to tasseling. In the various postmortem assessments, it was noted that arrested ear injury frequently occurred in fields where the foliar treatments included non-ionic surfactants. Now there is preliminary evidence from evaluations conducted in 2008 that suggests that the cause of some of these arrested ear problems may actually be due more to surfactants than fungicides.

Dr. Bob Nielsen at Purdue University evaluated the effects of a number of pesticides and spray additives on ear development in 2008. Three fungicides, one insecticide, a commercial non-ionic surfactant, crop oil concentrate, glyphosate, ammonium sulfate, and 2,4-D were applied in various combinations over the canopy of corn at approximately the V14 stage of leaf development (approximately 5 ft tall and 1 - 2 weeks prior to tasseling). Dr. Nielsen's demonstrations revealed that neither fungicide alone or in combination with just an insecticide resulted in any severely arrested ears. The addition of crop oil concentrate or non-ionic surfactant to fungicides alone or fungicide + insecticide resulted in a frequency of severely arrested ears ranging from 3 to 35 percent. Further addition of glyphosate with a fungicide/insecticide/non-ionic surfactant combination resulted in 60 percent or greater arrested ears. Reductions in cob length ranged from 6 to 48 percent with the application of the various foliar pesticide and additive combinations.

Dr. Emerson Nafziger at the University of Illinois performed tests that compared an untreated check with a nonionic surfactant applied at the labeled rate of 0.25 percent and at 0.5 percent (2X rate), Headline fungicide at 6 oz per acre applied by itself and with each of the two non-ionic surfactant rates, and CoRoN foliar N by itself, at 4 gallons per acre. The foliar treatments were applied at V13-14. According to Dr. Nafziger, in plots with damage, symptoms ranged from slight ear size reduction and oddly angled ear shanks to complete loss of ears. Most common damage symptoms included "bouquet" ears formed by small ears trying to develop from the same shank as the main ear. The results showed that most of the damage came from the non-ionic surfactant by itself, and that increasing the concentration increased the amount of damage.

Headline fungicide by itself did no injury compared to the untreated check, but adding fungicide to the non-ionic surfactant increased the damage by about 10 percentage points. About 10 percent of the plants in the 0.5 percent non-ionic surfactant treatment had no ears at all, regardless of whether Headline was used.

In trials conducted at the the OSU Western Agriculture Research Station near S. Charleston we evaluated Headline fungicide applications at various vegetative stages including V12-14. Non-ionic surfactants were not included in these treatments. No ear abnormalities or injury was observed.

Results of the Purdue and Illinois work indicate non-ionic surfactants applied at approximately V13-V14 can adversely affect ear development in corn. For more details and some excellent pictures documenting the injury potential from such pretassel applications check the following:

Nafziger, E. 2008. More ear oddities, and a possible cause. The Bulletin, Univ. of Illinois. [on-line]. Available at http://www.ipm.uiuc.edu/bulletin/article.php?id=1033
 (URL accessed 3/2/09).

Nielsen, R.L., W. Wise, C. Gerber. 2008. Arrested ears resulting from pre-tassel applications of pesticide & spray additive combinations. Corny News Network, Purdue Univ. [on-line]. Available at   http://www.kingcorn.org/news/articles.08/ArrestedEars-1209.html (URL accessed 3/2/09).

Pasture Associated Laminitis: "Between a Rock and a Hard Place"

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To say that one is stuck "between a rock and a hard place" emphasizes that there are two opposing alternatives or forces which are restricting one's ability to make a wise decision. Many times the opposing alternatives or forces are in their own right, both good. One such situation commonly occurring in equine management is the pasture turnout decision, especially spring turnouts. The evidence is undeniable; the health benefits are unsurpassed for our horses to be turned out on pasture 24 hours a day and every day. But equally undeniable, unrestricted grazing of lush pastures is a formula for disaster. The spring turnout situation places horse owners between a rock and a hard place, forcing us as horse caretakers to make a choice that we do not want to make. Horses and horse pastures together offer the prerequisite for a "perfect storm". Unfortunately, the ship wreck to follow is predictably troublesome health consequences with either option. If we find ourselves within the pasture-turnout "between a rock and a hard place"; the greater understanding we possess of the biology at work and of the unwanted consequences of our lack of understanding, the greater the chances we have of avoiding a preventable medical disaster.

Let's start by answering the question: Just what are the predictable and dangerous consequences of either keeping my horse in confinement or giving him free access to pasture? Horses by design and function are animals adapted to the wide open spaces. They are social animals constantly on the move. As grazing animals, they are what we call: "Continuous grazers" or "trickle feeders". This means their entire digestive system, from teeth to stomach to small intestines to large intestine to fecal balls is designed to consume, process, and eliminate small quantities of roughage type foods continuously throughout the day and night. This is in contrast to ruminant grazers such as cows, sheep, deer, etc.; who graze a more limited locality then find a place to lay down and re-chew (ruminate) what they have just grazed. Research demonstrates, voluntarily horses with free access to food will go longer than 1½ hour between meals. Therefore, to remove a horse from its designed intent; that is, to remove a horse from their natural environment of continuous feeding, constant movement, social contact, and non-confinement is to effectually place stress upon that horse. These stresses act as triggers of disease, and depending upon which system in the horse undergoes the greatest stress, that system is most likely to exhibit a functional breakdown…disease.

Some of the most common confinement stressor associated diseases are: colic, gastric ulcers, repetitive movement problems (so called stereotypy's), sleep deprivation, foot-hoof problems such as contracted heals or under-run heals, respiratory diseases (for instance heaves), teeth problems, nutritional deficiencies, and the list goes on. For instance, we have solid research to verify that horses will not lie down unless they are confident about their surroundings. Solitary stall confinement housing for many horses is not comfortable surroundings. Stall size, lack of herd mate interaction, ventilation issues, bedding issues all contribute to confinement stress. The confinement may lead to sleep deprivation and poor performance. Research also confirms horses are designed to be in groups. Grouped horses may experience levels of stress, but this is normal, or natural, or a good stress; a solitary confined horse experiences bad stress! A possible resultant disease: repetitive movement problems…so called stereotypy…also called "vices".

We have solid research indicating pasture is curative for equine gastric ulcer syndrome for a high percentage of the cases. The cure is generally within two weeks of pasture turnout with no supplementary medication. Research authenticates in the young, developing horse, that free access to open space is essential for bone, ligament, and tendon developmental health. We also know horses on pasture have far fewer colic episodes and far fewer respiratory issues. The conclusion is firmly fixed; horses were designed for turnout and are healthiest when they have free access to wide open spaces with plenty of horse to horse interaction. So where is the situational "between a rock and a hard place"? The snag is the horse is equally not adapted to what I'll call free-choice, lush pasture access. By free-choice, lush pasture access; I refer to this region's spring horse pasture state where the pasture is nutrient dense, succulent, and has a high plant density. This type of pasture allows a horse to lower his head at sunrise and eat until sunset with hardly taking a step. Here in lies the predicament. An "eat-till-you-burst" pasture condition is regarded as the most powerful trigger recognized for laminitis (founder) in the horse. The question becomes how the pasture challenge can be managed to prevent causing more problems. From a health-management perspective, it appears as though we are in a position we cannot untangle: laminitis or gastric ulcers, laminitis or colic, laminitis or a stereotypy, laminitis or heaves, and so on. I can assure you the management solution is not simple and there is no single

solution that fits every case. Let us start by trying to better understand the pasture-horse biological complexity that is such an effective trigger for pasture associated laminitis (PAL).

Delaware horse owners and regional veterinarians report that the emotional and financial toll associated with laminitis in our area is great. Nationwide, the USDA National Animal Health Monitoring System (NAHMS) reports that nearly 50% of the reported cases of laminitis in the United States occurred in animals kept on pasture suggesting pasture as the causative trigger to laminitis. In contrast, the NAHMS report identified situations typically associated as common triggers to laminitis such as grain overload, colic, diarrhea, and retained placenta caused less than 15% of the U. S. laminitis-founder cases. A recent comparable research paper out of the England reported that 61% of their laminitis cases were pasture associated. What is there about our pastures that are on the one hand so healthy for our horses, and on the other hand, potentially so devastating? The answer lies partially in the plant's biology, and partially in the horse's biology.

Pasture plants use the energy from sunlight to produce simple sugars such as glucose, sucrose, fructose, and the like. Plants then take these simple sugars and utilize them to build more complex structural carbohydrates such as cellulose and hemicellulose. Cellulose and hemicellulose are called structural carbohydrates because they are used within the plant to hold the plant upright and give supporting shape to the plant leaves. These structural carbohydrates are commonly known to us as fiber or roughage. When plants produce simple sugars in excess of their need for building structural carbohydrates, they convert these excess sugars into storage carbohydrates and sequester them in storage parts of the plant to be used later. Plant seeds like oats, corn, and so on, many of which we use as horse feeds, are themselves plant carbohydrate storage vessels. The storage carbohydrates are more chemically complex than simple sugars but not as chemically complex as the structural carbohydrates.

Two key examples of storage carbohydrates are starches and fructans. Starch is nothing more than a whole bunch of glucose sugar molecules hooked together by a chemical bond into a chain. Starch is the major storage carbohydrate produced by plants. Interestingly, common cool-season grasses, such as timothy, Kentucky bluegrass, tall fescue, orchard grass, and perennial ryegrass, accumulate the unique carbohydrate 'fructan' as one of their storage carbohydrates. Fructans help increase cold tolerance in the cool season grasses as they bind to fragile cell membranes and prevent them from being damaged by freezing. Common warm-season grasses on-the-other-hand, grasses like bermudagrass, crabgrass, and many of the native grasses accumulate starch as their principal storage carbohydrate.

That is a very simplistic overview of pasture plant biology; now a quick summary of equine digestion, specifically carbohydrate digestion, before we link the two biologies together and form some pasture management principles.

As continuous grazing animals, horses are designed to digest plant structural carbohydrates as their essential source of energy. For the horse, the major structural carbohydrates are the cellulose and hemicellulose parts of the plant. Cellulose and hemicellulose are the most important source of fiber or roughage for horses and are not digested in the horse's small intestine. Instead they pass on through the small intestine and end up in the large intestine, what

we call the hindgut of the horse, specifically the cecum and large colon. Here they are acted upon by microflora (principally fermentation species of bacteria) living within the horse's hindgut large intestine. These special fermentation bacteria are especially adapted to digest the fiber that the horse would otherwise be incapable of digesting. Through a fermentation process, the cellulose and hemicellulose are converted into usable energy molecules called volatile fatty acids (VFA's). The horse's hindgut large intestine will absorb these VFA's where they can be directly used for energy by some cells (like muscle cells). Nevertheless, most of the VFA's are turned into glucose within the liver for later energy use. A normal horse will obtain from 30-70% of their daily energy needs from VFA's. The exact percentage is highly dependent upon the horse's diet, such as the amount and ratio of grain and hay/pasture the horse is receiving daily. The more roughage-fiber a horse eats, the more the horse will use VFA's for energy. Also, the more a horse uses VFA's for energy, the healthier the horse will be.

The starch that plants produce, in contrast, is digested within the horse small intestine. Inside the horse's small intestine, digestive enzymes split the starch into the elemental parts (glucose—sugar) for absorption. Again since the horse is foremost a grazer, the gut is naturally programmed to digest structural carbohydrates, i.e. roughage-fiber. The biological effect of a digestive system adapted to digesting grass leaves and stems is such that the same system is adapted very poorly as a starch digester. This means that in a horse fed a high starch diet (grains or rich grasses) much of the starch will escape digestion in the small intestine and find its way back to the hindgut large intestine. Starch in the hindgut large intestine creates havoc by entering into the fermentation cycle. Starch fermentation takes place much too quickly and in the process releases harmful gasses, acid products, and other toxic products. These toxins continue killing off the good digestive bacteria ultimately altering the sensitive fermentation environment. This fermentation altering development may lead to a fermentation crisis; a crisis if left unchecked will ultimately set into motion a cascade of events, a biological breakdown if you will, which ultimately results in laminitis.

Recall the earlier statement concerning cool-season grasses and their production of non-structural carbohydrates called fructans. Horses do not have an enzyme within the small intestine that can digest fructans. Thus, all the fructans that a horse eats reaches the hindgut intact. Again in the hind-gut, fructans undergo rapid fermentation initiating that aforementioned cascade of events leading to laminitis. Research has clearly verified the fact that feeding large amounts of starch and/or fructan and their subsequent fermentation in the hindgut cecum and large colon can cause laminitis.

Knowing this little bit of plant biology and horse digestive biology, how can we better manage horses to permit them as much access to the great, healthy benefits of pasture without filling them with too much fructan and starch leading to laminitis?

Most cases of PAL occur in the spring and fall. Why is this? Plants are biologically preprogrammed at these times of the year to make large amounts of carbohydrates, including starch and fructans. We all, through personal lawn care experiences, know this cycle since lawns like pastures are lush in the spring and fall. This means that if horses overeat when pastures are lush and depending on the grass species in the pasture, many fructans and/or starch will get into the hindgut fermentation cycle.

Just how easy is it for horses to overeat? **An interesting fact is that for most horses and ponies doing minimal work or minimally exercised, grazing on lush pastures for just 6 hours supplies 100% of the horse and pony's daily energy requirements.** Unfortunately even though the horse or pony may have ingested enough energy calories in 6 hours to meet their daily energy requirements, they have not fully satisfied their biological chewing need. As a trickle feeder constantly on the move, horses appear to have a biological need to chew for 12-14 hours per day or more. Deny a horse this biological chewing need and the horse will often head for the fence or stall door to chew. The challenge becomes to somehow limit free access to lush pasture and, at the same time, to satisfy the hard-wired biological requirements for social interaction, chewing time, and freedom to move about.

This conflict of principles can be managed in several ways. The least acceptable but most effective technique is to place the horse in a stall after the horse has grazed enough to meet its daily energy requirement. This is the point when the horse manager is literally caught between a rock and hard place. Sacrifice lots, muzzles, or poor quality pastures offer some alternatives. A manager that allows their horses to graze for 6 hours and then fast for 18 hours will often find that other problems have been created. Therefore, if restricting grazing time is your management choice, I suggest restricting grazing to 2-4 hours per day. This will supply approx. 50% of the horse or pony's energy needs. Complete the horse or pony's diet by feeding 1% of their body weight with a laboratory tested average quality grass hay. This will provide adequate chewing time, especially if you divide the hay into two equal portions.

Another option is that you can use warm-season grasses at high-risk times of year as the preferred pasture. Grazing warm-season grasses effectively reduces the fructan level, but does not necessarily reduce the overall starch amount so the horse can still be taking in too much lush pasture. Previously foundered horses or ponies require special management attention along with your veterinarian's input. These animals may need to be completely restricted from lush spring and fall pastures.

Not all horses are equally sensitive to PAL. Horses differ in their phenotype (body types) and metabolic profiles (the easy keeper). Easy keepers require special precautionary attention. The same is true with horses with high body condition scores (BCS), that is, an overweight horse or pony. Likewise, for ponies and horses having or suspect of having metabolic syndrome and/or insulin resistance, these animals require proactive precautionary steps. It appears that being overweight and/or having insulin resistance lowers the trigger threshold to PAL for horses and ponies.

A couple of additional points to keep in mind in closing:

- It takes 2-3 weeks for large intestinal microbe adaptation (i.e. the fermentation bacteria) to occur when changing to a different feed type or source. Therefore, when switching pastures, introducing horses to new pastures, introducing new hays, changing hays, or introducing horses to new feed sources of any type, make changes slowly and gradually over two or three weeks. For new pasture introductions, starting off at one hour per day is plenty. Gradually increase grazing time by increments not to exceed one hour per day

or one hour every other day to your set goal grazing limit. I also suggest feeding some hay prior to daily turnout as this will somewhat satisfy your horse's appetite and he will be less likely to gorge on fresh grass.

- Provide free access to fresh water and salt.
- If additional vitamins, minerals, or protein are necessary to balance a pasture-based diet, use a vitamin mineral protein supplement designed for "pasture" supplementation; or for "horses on a forage-based diet".
- Monitor body condition score and weight monthly. Re-calculate feed amounts (grazing time allotments) monthly based on changes noted and desirable BCS and body weight.
- Muzzle the horse or pony if you can't restrict pasture time and for horses and ponies with high BSC horses. Muzzles permit horses and ponies to graze small amounts of grass continuously throughout the day, dramatically limiting total pasture intake. Horses can drink while wearing a muzzle. Muzzles do require close animal supervision as not all horses tolerate wearing a muzzle.
- If the horse has a minimal need for more pasture forage, you may not need to have an aggressive pasture fertilization program. Be careful with this recommendation, as neglecting pasture maintenance may lead to stressed pasture plants followed by weed invasion. Also, poorly maintained pastures tend to die out in summer, leaving the horse nothing but an overgrazed pasture for food.
- Remember: Starch and fructan concentrations are difficult to predict on pastures and it is impossible to know the tolerances of individual horses. Be proactive!
- Exercise…Exercise…Exercise! Most horses get insufficient exercise. Horses by design are animals adapted to the wide open spaces. They are social animals constantly on the move. Recently, scientists have monitored horse movements in the wild using global positioning satellite technology. They have made the discovery that horses routinely walk 25, 50, and up to 100 miles per day in their travels from place to place and activities interacting with other horses. This is one reason why horses in the wild rarely founder. They are in constant motion and constantly on the move. As previously stated, the natural horse is programmed to eat a little, and then move a little and so on. You can use this knowledge to relieve confinement stress even when feeding hay in your stall. Instead of throwing all their hay in a pile, spread it around the wall perimeter of the stall. It will take a little extra effort but the horse will be less stressed having been given the opportunity to move as he eats. You can also use our biological horse knowledge as encouragement for you to exercise you horse on a regular basis. I suggest that you exercise the horse at least five days per week. As to how far and how long? Horses were designed to move, you must provide the opportunities.

Survey of Nematode Populations and Prevalence in Virginia Corn Fields, 2007 and 2008

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Reports of nematode damage in eastern Virginia corn fields, especially in the Middle Peninsula, have increased in recent years. Diagnosing the symptoms of nematode damage to corn can be difficult because they are similar to many other problems. Root injury caused by nematodes can result in symptoms that are similar to nutrient deficiencies, soil compaction, root rots, herbicide carryover, and other problems. In fact, nematode feeding is often only diagnosed when most of these other, similar, problems are ruled out. Of course, the only way to diagnose nematode problems in corn is through soil samples analyzed by a qualified nematode testing lab.

Shifts in nematode populations are expected with farming practices that include: conversion to continuous no-till; the movement away from wheat in the crop rotation; changes in corn genetics; and the conversion from in-furrow insecticide/nematicide treatments to seed-applied treatments in corn.

The Virginia Corn Board provided funding to Virginia Cooperative Extension to conduct a nematode survey in 2007 and 2008, and 150 samples from fields with some type of production problem from 21 counties in eastern Virginia were submitted. Over the 2 years, based on current nematode thresholds and

recommendations, 45 samples (30%) indicated a nematode problem, while 38 samples (39%) indicated a possible nematode problem. Stubby root and lance were the most common nematode species found. Lesion nematodes were fairly common, while root-knot and dagger were less common. Damaging levels of sting nematode, a species that can cause significant yield loss in sandy soils, were found in several samples from Southampton County. Given our current nematode thresholds, our survey indicates that nematodes are causing some yield loss in some corn fields.

Soil samples were taken from **suspected problem areas** during the growing season and sent to the Virginia Tech Nematode Laboratory for characterization. Nematode species were reported on each sample and populations above thresholds for crop damage will be flagged. Thresholds for damage are based on previous field surveys and on-farm tests in the decades of the 1980's and 1990's and are listed at http://ipm-www.ento.vt.edu/nipmn/VA-IPM/updates/nematode/frames.html. It is important to note that these samples were not taken randomly, but from suspected problem areas.

Producers who suspect a nematode problem are encouraged to contact their local extension agent or agricultural supplier so that soil samples and/or root samples can be submitted for a definite diagnosis. The best time to take soil samples for diagnostic assays in corn is June and July. Soil samples for predictive assays should be taken before November 20th.

The following table provides a summary of the results. The key for the recommendation column is as follows: A—Nematode problem not detected; B—Possible nematode problem; C—Nematodes are a problem; control options are advisable. Numbers are reported as the number of nematodes per 500 cc's of soil (approximately one pint.)

Table 1. Nematode kind, number, and recommendation by county, 2007.

County	Lesion	Root-knot	Cysts	Stubby root	Dagger	Stunt	Sprial	Lance	Ring	Sting	Pin	Recommendation
Chesapeake	0	0	220	150	0	100	790	240	0	0	0	C
Chesapeake	210	0	140	60	30	110	690	160	0	0	0	C
Chesapeake	210	0	10	60	30	50	360	140	0	0	0	C
Dinwiddie	30	0	10	440	330	0	0	0	0	0	0	C
Essex	50	0	0	40	40	20	0	430	0	0	0	C
Essex	40	90	0	40	30	90	150	410	0	0	0	C
Essex	280	0	0	0	10	40	390	400	0	0	0	C
Greensville	0	0	0	520	0	990	30	120	0	0	0	C
Northumberla	10	0	0	300	20	290	0	110	0	0	0	C
Prince George	40	1720	0	360	30	290	610	130	10	0	0	C
Prince George	560	0	0	0	0	40	400	30	0	0	0	C
Southampton	0	0	0	20	0	0	0	0	0	480	0	C
Southampton	0	10	0	30	0	20	10	0	0	190	0	C
Southampton	0	0	0	360	0	0	0	310	0	80	0	C
Southampton	0	0	0	20	0	160	10	30	0	40	0	C
Southampton	0	0	0	10	0	100	0	60	0	20	0	C
Southampton	0	0	0	110	10	0	0	0	0	10	0	C
Southampton	0	10	0	840	20	380	0	0	60	0	0	C
Southampton	0	10	0	960	0	440	10	0	10	0	0	C
Surry	0	0	0	0	0	410	0	1360	0	0	0	C
Surry	70	530	0	180	0	170	130	150	0	0	0	C
Chesapeake	180	0	80	40	70	150	1170	100	0	0	0	B
Dinwiddie	20	0	40	110	0	0	130	10	0	0	0	B
Essex	70	10	0	10	10	0	600	200	0	0	0	B
Essex	0	0	0	0	0	250	160	150	0	0	0	B
Essex	100	0	0	0	0	180	160	100	0	0	0	B
Essex	320	0	50	0	0	0	180	80	0	0	0	B
Greensville	20	0	0	40	0	50	0	40	20	0	0	B
Greensville	0	130	0	180	0	30	3030	50	0	0	0	B
King & Queer	0	140	0	0	0	70	40	110	0	0	0	B
Northumberla	330	0	0	0	10	0	300	240	0	0	0	B
Prince George	0	210	0	20	10	80	10	20	0	0	0	B
Surry	0	0	0	110	0	320	0	0	0	0	0	B
Surry	10	60	0	80	10	0	0	0	0	0	0	B
Amelia	0	0	0	10	0	610	0	10	0	0	0	A
Dinwiddie	0	0	0	10	0	200	0	0	0	0	0	A
Essex	0	0	0	0	0	110	130	70	0	0	0	A
Essex	50	0	0	0	0	90	180	40	0	0	0	A
Essex	40	0	30	0	0	20	130	10	0	0	0	A
Greensville	0	0	0	0	0	0	0	10	70	0	0	A
Greensville	0	0	0	0	0	30	0	40	0	0	0	A
Mathews	130	90	0	10	0	20	190	0	0	0	10	A
Prince George	0	0	0	0	10	0	0	0	0	0	0	A
Prince George	0	0	0	0	0	140	440	0	0	0	0	A
Surry	10	0	0	0	0	30	20	0	10	0	0	A

Table 2. Nematode kind, number, and recommendation by county, 2008.

County	Lesion	Root-knot	Cysts	Stubby root	Dagger	Stunt	Sprial	Lance	Ring	Sting	Pin	Recommendation
Northumberland	0	0		0	0	0	0	0	0	0	0	A
Essex	0	0		0	10	180	470	90	0	0	0	A
Greensville	0	10		0	60	30	0	0	10	0	0	A
Franklin	40	0		0	0	0	110	0	0	0	0	A
Essex	20	340		0	10	0	20	0	0	0	0	A
King George	10	0		0	10	280	120	40	0	0	0	A
Westmoreland	40	0		0	30	540	550	30	0	0	0	A
Westmoreland	60	0		0	0	0	480	0	0	0	0	A
Surry	0	20		10	0	910	0	0	0	0	0	A
Prince George	0	0		0	0	190	0	20	0	0	0	A
Prince George	0	0		0	0	0	0	190	0	0	20	A
Prince George	10	0		0	20	120	0	0	0	0	0	A
Hanover	30	20		0	0	0	150	50	0	0	0	A
King William	40	40		0	0	0	20	0	0	0	0	A
King William	10	220	24+30	30	0	0	30	0	0	0	0	A
Caroline	40	350		0	0	0	0	0	0	0	0	A
Caroline	50	10		0	0	0	0	40	0	0	0	A
King and Queen	30	180	0+180	10	80	50	310	50	0	0	0	A
Essex	10	80	3+0	0	0	0	0	0	0	0	0	A
Essex	0	10		0	0	0	0	10	0	0	0	A
Essex	40	60		0	10	10	10	10	0	0	0	A
Caroline	50	10	0	0	0	0	0	0	10	20	0	A
Essex	80	430	0+170	10	0	0	0	0	0	0	20	A
Caroline	80	0	0	0	0	0	10	0	0	10	0	A
Essex	110	0	0	0	0	0	0	20	0	0	0	A
Suffolk	60	0		0	0	0	0	0	0	0	0	A
Suffolk	0	0		0	0	0	0	0	0	0	0	A
Suffolk	0	0		0	0	0	0	0	0	0	0	A
Hanover	130	0		90	0	1030	20	50	0	0	0	B
Prince George	100	100		50	0	330	350	110	10	0	0	B
Prince George	20	0		20	20	20	30	10	0	0	0	B
King William	10	0		160	0	100	30	190	0	0	0	B
Greensville	0	0		20	0	10	0	0	0	0	0	B
Greensville	10	10		180	20	20	0	30	20	0	0	B
James City	20	0	0+430	110	0	200	40	270	0	0	0	B
Caroline	20	0		10	0	0	60	170	0	0	0	B
Caroline	0	70		0	0	10	20	280	0	0	0	B
Caroline	30	0		80	0	30	10	180	0	0	0	B
Essex	10	0		0	70	100	250	100	0	0	0	B
Northumberland	0	0		0	30	20	140	240	0	0	0	B
Gloucester	10	190		190	10	550	230	10	0	0	0	B
King William	10	10		20	10	120	0	10	0	0	0	B
Caroline	0	0		20	10	180	80	0	0	0	0	B
King and Queen	40	570		0	0	0	0	0	0	0	0	B
Southampton	0	0		50	10	40	0	0	20	0	0	B
Dinwiddie	180	1420		20	0	40	460	50	20	0	0	B
Surry	0	10		90	0	270	30	0	0	0	0	B
Surry	0	0		130	0	510	10	0	0	0	0	B
Surry	0	70		70	0	920	10	110	0	0	0	B
Surry	10	0		60	0	980	70	130	0	0	0	B
Surry	0	0		20	0	60	0	0	0	0	0	B
Franklin	140	0	0+20	0	10	10	120	100	0	0	0	B
Southampton	0	0		30	0	230	240	80	0	0	0	B
Hanover	190	0		40	0	250	30	40	0	0	0	B
King William	0	0		30	0	690	0	130	0	0	0	B
Hanover	0	0		20	90	10	160	80	0	0	0	B
Gloucester	40	0		30	40	30	460	30	20	0	0	B
King and Queen	40	90	0+150	20	50	20	200	70	0	0	0	B
Sussex	0	150	916+4550	30	0	560	80	270	0	0	0	B
Caroline	0	1390	0	0	0	0	0	0	0	70	0	B
New Kent	100	40	188+370	30	0	100	10	40	0	0	0	B
King William	0	0		130	0	150	0	90	0	0	0	C
Charles City	60	0		0	0	0	0	650	0	0	0	C
Caroline	10	0		30	10	10	10	370	0	0	0	C
Essex	10	0		200	0	100	10	60	0	0	0	C
King William	60	0		40	0	0	0	740	0	0	0	C
King William	0	0		270	0	0	0	460	0	0	0	C
Southampton	20	0		0	0	0	1190	0	40	10	0	C
Southampton	0	10		20	0	660	0	0	0	50	0	C
Middlesex	90	0		0	210	0	40	160	1920	0	300	C
Lancaster	0	0		0	60	10	240	320	0	0	0	C
Middlesex	20	0		280	20	70	0	480	0	0	0	C
King and Queen	20	50		0	0	0	0	0	1810	0	0	C
King and Queen	0	0		190	40	20	10	20	0	0	0	C
King and Queen	0	0		250	0	270	100	50	0	0	0	C
Southampton	10	0		0	0	0	0	0	0	50	0	C
Southampton	0	0		3090	0	330	40	0	20	0	0	C
Hanover	40	0		0	0	80	3500	650	0	0	0	C
Hanover	520	0		50	0	280	1020	530	0	0	0	C
King William	0	0		90	0	1140	10	1500	0	0	0	C
Dinwiddie	770	40		0	30	270	830	0	0	0	0	C
Hanover	220	0		20	100	320	770	410	0	0	0	C
King William	0	0		40	0	760	0	320	0	0	0	C

Suggested New Year's Resolutions for 2010

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Do you have nothing much going on this New Year other than enjoying the holiday season? Are you tired of the same old New Year's resolutions that are so easily forgotten? Why not have some fun with an entirely different set of New Year's resolutions? Take a few hours this coming weekend and sit down with your pasture and hay field management plans and review them to see what changes might be in order this coming year. You don't yet have a pasture or hay field management plan? Then, I suggest you pull out all the information you have for your fields and take a few minutes to write such a plan. It does not need to be elaborate although if you're into details there's no reason you can't put in lots of details rather than just doing a broad description of what you'd like to accomplish with your pasture and hay fields this coming year.

Why not have fun with the project and actually make at least some of the items in your plan into New Year's resolutions?

Resolution 1. I will check the most recent soil test reports for each of my fields and make sure that they will be no older than 3 years by the end of 2010. If any reports will be out of date, I'll go out and pull a new soil sample the first nice weekend this year so I will know the nutritional status of all my fields.

Note: If you frequently apply nitrogen (N) on top of the pasture or hay field or if you don't normally check the surface two inches for a buildup in the acidity level, you should take two samples for each management unit with a 0 to 2 inch sample to test for soil pH and a 0 to 4 or 0 to 6 inch sample to test for other nutrients (phosphorus, potash, the secondary nutrients, and the micronutrients). Remember that limestone moves downward through the soil very slowly so it's critical to catch drops in soil pH before it extends too deeply into the soil.

Resolution 2: After checking my soil test reports and my nutrient management plan, I promise to do a better job of fertilizing my pastures and hay fields in the coming year.

Note: The one area that many of us may want to cut back in is on the fertilizer bill especially for potash (K). With the high potash prices, this often seems to be an easy place to make cuts but remember that potash does wonders for your forage plants. The nutrient helps with water balance in the plants in case of droughts, it helps plants grow better and survive during stresses, it winterizes plants to help them survive the winter months, and many other things. Your soil test levels don't have to be high for potash but do try to keep them in the medium or optimum range.

Resolution 3. I will save a little money on my pasture fields this year by frost-crack seeding ladino or red clover into them this spring when temperatures are still fluctuating above and below freezing during the day and night cycles.

Note: The fluctuating temperatures required for successful frost-crack seeding usually occurs between mid- to late- February and some time in March. Fact sheets are available to help you with this process. Also if you raise beef cattle on pasture and you have wet areas in the pasture, another good small-seeded legume choice is alsike clover. Alsike clover should be avoided if you have horses that graze the same pastures since some horses are sensitive to alsike clover and can develop photosensitivity resulting in severe blisters and sores. Success with frost-crack seedings can be enhanced by dragging the pastures after the seed is broadcast to get better soil to seed contact. A method with a much higher success rate is to no-till seed with a no-till drill in early spring. If you didn't heavily graze the pasture last fall or early winter in preparation for overseeding with legumes, either clip the pastures very close before seeding or graze the residue heavily for the first couple of weeks after seeding but remove animals once the new seedlings emerge to protect them. This will allow more light energy to reach the new seedlings and help them establish better and faster.

Resolution 4. Since I don't plan to overseed with more legume seed this year, I'll get my pastures off to an early start by applying a small amount of N as early as my nutrient management plan and the law allow.

Resolution 5. I will use a rotational grazing system this year to improve my pasture's quality and productivity.

Note: The quality of feed that your animals consume as well as the quantity of forage available to them can be greatly increased by moving from a continuous grazing system to a rotational grazing system especially if the management effort is applied to move to a more intensive rotational grazing system. These systems do require a lot more management input but can be very effective at increasing your available forage and providing your livestock with highly nutritious grazing.

Resolution 6: When I use a rotational grazing system, I will inspect each paddock before and after I rotate my livestock through it so I'll know how well the forage plants are growing and recovering. I will then adjust my rotation plans according to the growth rate of the pasture.

Note: One way to overgraze a pasture is to use a set calendar of so many days on the paddock and so many days off the paddock before the next grazing cycle. The pasture is a dynamic system that depends on many variables some controlled by you such as fertility but most controlled by nature (rainfall, temperature, pests, etc.). You will need to learn how to adjust your grazing cycle to environmental conditions. Need help with this, talk to neighbors or other farmers who use rotational grazing successfully.

Resolution 7: I will consider using pastures which have mostly tall fescue (endophyte-free or the new friendly endophyte varieties) for accumulation of fall-saved forage so I can extend my grazing into the late fall or early winter.

Note: Few producers take advantage of this characteristic of tall fescue but this plant can actually improve in quality and palatability if it is allowed to grow ungrazed during the fall and

then grazed in late November and December. The sugar content of the plant is thought to increase so animals actually graze it better in the late fall and early winter than at other times. To fall-accumulate tall fescue, you should choose a tall fescue field (endophyte-free or friendly endophyte variety), apply 50 to 75 pounds of N per acre in mid- to late-August to stimulate growth, and withhold grazing until late fall following frost.

Resolution 8: For your last resolution of the New Year: I promise to walk my fields more often during the year to watch them grow and observe when they need me to change something about my management plan to help them grow better.

Spring Grass: A Grazier's Dream and Nightmare

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Spring can often be one of the most challenging times of the year for graziers. Grass growth goes from zero to full speed in a matter of weeks and in many cases our animals have a hard time keeping up with it. This results in lower quality forage that is less palatable; and, in the case of endophyte infected tall fescue, contains higher levels of the toxins that reduce animal performance. The growth of new forage is also delayed by not removing the existing vegetation. The following suggestions can help you to control spring growth and get the most out of your pastures when the grazing is good.

- *Implement rotational grazing*. To fully use the spring flush of pasture growth **YOU** must be in control of grazing. In a continuous grazing system, the cows are in charge.

- *Start grazing before you think the pastures are ready*. One of the most common mistakes that graziers make is waiting to long to start grazing in the spring. If you wait until the first paddock is ready to graze, by the time you reach the last paddock it will be out of control.

- *Rotate animals rapidly*. The general rule is that if grass is growing rapidly then your rotation should be rapid. This will allow you stay ahead of the grass by topping it off and keeping it in a vegetative state.

- *Do not apply spring nitrogen*. Applying nitrogen (N) in the spring will actually make the problem of too much grass at once even worse. In many cases, you are better off to save your N for stockpiling in the fall.

- *Remove most productive paddocks from rotation and harvest for hay*. Graze all paddocks until the pasture growth is just about to get away from you and then remove those productive paddocks from your rotation and allow them to accumulate growth for hay harvest.

- ***Increase stocking density in the spring***. If it is possible, a good option for using spring growth is to increase your stocking density. This allows you to harvest more of the available forage and convert it into a saleable product. This can be done by adding some stockers or thin cull cows to your rotation and then selling them when pasture growth slows.

- ***Even-out seasonal distribution of forage by adding a warm-season grass***. This option is probably best applied east of the Blue Ridge Mountains as you move into the Southern Piedmont and Coastal Plains regions of Virginia and in other coastal areas in the region if adequate land area is available. Adding a well adapted warm-season grass that produces the majority of its growth in July and August would allow you to increase your season long stocking density to better use the spring flush of pasture growth.

- ***Bush-hog out of control pastures***. The benefits of clipping include maintaining pastures in a vegetative state, encouraging regrowth, and controlling weeds. Clipping pastures cost money, so make sure that the primary reason for bush-hogging is pasture management, not aesthetics.

There is not a one-size fits all when it comes to grazing. One of the most important features to build into your grazing system is flexibility. This will allow you to adapt as the situation changes. Grazing systems are not static entities, but rather dynamic works of art that evolve as your skill level increases.

Biodiversity Tastes Good and Might Even be Good for You

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A recent article in Science Daily (Jan 14, 2009) got my attention. I have been studying aspects of biodiversity in pastures from about 10 years now. For example, we have planted diverse mixtures of forage species (e.g., 10, 15 species) to see whether they could boost forage yield and quality. I have often wondered whether these diverse mixtures also might benefit the cattle that eat them.   The article in Science Daily sheds some light on this issue.

A group of researchers from England has been studying how different pasture types affect lamb and beef quality. They have gotten some interesting results. In one study, they evaluated meat quality from lambs that grazed four pasture types: 1) common perennial ryegrass pasture, 2) salt marsh, 3) heather grassland [think blueberry bushes and grasses] and 4) a native, moorland pasture. The last three would be considered unimproved pasture types.

All pastures produced good quality lamb. Lamb meat from unimproved pastures generally had more vitamin E and beneficial fatty acids (e.g. CLA) compared with the perennial ryegrass pasture. Some research suggests that CLA (conjugated linoleic acid) may have anti-carcinogenic

effects in humans. A taste panel also rated lamb produced from unimproved pastures as more flavorful and pleasant smelling compared with improved perennial ryegrass pasture.

Why the difference? The authors suggested a link to the diverse forages available to lambs on unimproved pastures. The salt marsh, heather grassland and moorland had on average 31, 51 and 60 different plant species, respectively. Ryegrass pastures only had 10 species. Possibly, a more diverse diet consumed by lambs in the unimproved grassland produced these beneficial meat qualities. Whatever the cause, it is an intriguing result.

Research supports the idea that grass-fed or finished meat may be healthier than feed-lot produced meat. No studies (I think) have looked at this biodiversity linkage. Of course, more work needs to be done to confirm these results. If the findings hold true though, grass-fed livestock producers may want to consider managing their grasslands for higher biodiversity.

Anestrous, Anovular Cattle, Synchronization Programs and Reproductive Efficiency

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Pregnancy rate is a function of conception rate and estrous detection rate. In the average herd practicing observational estrous detection, rates of estrous detection generally run between 45-55%. In herds with acyclic, anovulation and anestrous cattle, estrous detection rates can fall precipitously below 45%. Moreover, increased errors in estrous detection result in insemination of cattle that are not in heat. Accordingly, timed artificial insemination programs (TAI) such as Ovsynch and Presynch-Ovsynch have been developed and implemented to increase estrous detection rates to 100%. Hence, the popularity of TAI programs in reproductive management on the modern dairy production units.

With voluntary wait periods set at 45-60 days post partum, TAI programs are often initiated by 45 days post partum to achieve first service dates at 60-75 days in milk (DIM) in the complete absence of estrus detection. The principle drawback to this management approach is the absence of specific knowledge about the cyclicity, ovulatory and fertility status of cattle undergoing service in TAI programs. This can present challenges to reproductive management programs because anovulatory cattle entering TAI programs typically have lower conception rates and higher rates of early embryonic death (EED) during the first 50-60 days post insemination.

Anestrous and anovulatory cows are transition cows that lack estrous behavior, do not cycle, and cannot ovulate. Anestrous or anovulatory cattle are typically encountered by 45 DIM when clinical reproductive performance tends to terminate. Anovulatory cattle continue to develop and grow follicle waves but fail to show estrus and successfully ovulate. Anestrous, anovulatory cattle have fewer pregnancies/breeding, fail to cycle and ovulate at 60-100 DIM, show poor

follicle development with variable and many times smaller follicle size, generate oocytes with poor development and quality, show higher incidence of anovulatory follicles and cystic follicles and typically generate follicles and corpus luteal bodies with lower capacity for steroidogenisis. Once transition cattle move from the anestrous condition and start to cycle, the first ovulatory estrus is often associated with lower conception rates, multiple ovulations, and production of poor quality oocytes and embryos. These cattle often demonstrate shortened luteal phases of the cycle (11 days) and therefore increased percentage of irregular length cycles after resuming cyclicity. Lastly, they benefit from Ovsynch but not Presynch components of a synchronization program.

Herds with difficulties managing cows prepartum and in the transition period typically experience increased prevalence of anovulatory and anestrous cows by the end of the voluntary wait period. These anestrous, anovulatory problems are associated with deep and prolonged nadirs in negative energy balance during the transition period. Prevalence of anovulatory cattle entering into the TAI programs may run as low as 8% in well managed herds or as high as 50-60% in inadequately managed herds. The median level of anovulatory cattle in commercial dairies may lie closer to 18-29% as determined by 2 consecutively low serum levels of progesterone determined 2 weeks apart in commercial herds (Moreira et al., 2001, Pursley et al., 2001). Most evidence indicates anovulatory cattle present a substantial problem and challenge to reproductive efficiency in modern dairies. Prevalence within each herd will depend upon the successful management of nutrition, ration formulation, and transition cow programs across herds. The incidence of anovulation is generally greater in primiparous cattle rather than multiparous animals (Chebel et al., 2006) but reports exist with data showing just the opposite incidence as well. In one report, 37% of primiparous cattle compared to only 16% of multiparous animals were anovulatory (Gumen et al, 2003). There is a strong, negative and linear relationship between the incidence of anovulation and BCS. Most cows greater than 3.5 BCS tend to be ovulatory whereas as many as 50-60% of cows with BCS ≤ 2.25 tend to be anovulatory (Gumen et al., 2003, Chebel et al., 2006).

Anovulatory cows are very capable of growing waves of follicles similar to normal animals but the waves do not culminate in production of an ovulation. Failure to ovulate can be attributed to less than normal follicle function and estrogen synthesis by slowly growing follicles in anovulatory cows. Estrogen is a key hormone involved in the induction of pre-ovulatory surges of GnRH and LH that trigger follicular ovulation. Anovular cattle show less than normal production of estrogen as well as an insensitivity of the GnRH and LH releasing centers of the brain to estrogen. For years, it has been known that fertility is very low on the first insemination after re-establishing ovulation and cyclicity in anovular cattle. At least part of the low fertility has been associated with a lack of progesterone stimulation from the corpus luteum of the preceding cycle. (By definition, anestrous cattle lack a preceding cycle with the accompanied ovulation; and, therefore, do not produce a corpus luteum (CL) to synthesize and secrete progesterone.) The secretion of progesterone during preceding cycles maintains the sensitivity of GnRH and LH producing centers in the brain to estrogen stimulation. When there is no progesterone stimulation during anestrus and anovulation in cattle, low or even normal levels of estrogen produced by anovular cows cannot trigger the ovulatory release of GnRH and LH. As a result these cattle remain anestrus, anovulatory and infertile for prolonged periods post partum.

Smaller than normal follicle growth may also lead to undesirably small corpus luteal body formation after ovulation. Smaller than normal corpus luteal body formation can lead to low or inadequate synthesis of progesterone and a lack of follicular selection or ovulation. Follicle selection and growth in preparation for ovulation is partially controlled by a progesterone mediated limitation on hormones that drive follicle growth. In concert with progesterone effects on follicular growth hormones, only one follicle in a wave of many follicles develops to ovulatory size. A lack of follicular selection occurs in the absence of sufficient progesterone synthesis. As a result, two or more follicles in a follicular wave achieve dominance and ovulate. Low progesterone levels from a lack of cyclic activity increase the frequency of twinning in groups of anovular cattle that begin to cycle. Ovulation of smaller, poorly developed follicles also impacts post conception fertility by enhancing EED. Inadequate estrogen synthesis by the selected, dominant follicle that is smaller than normal fails to prepare secretory function of the uterine glandular structures for the synthesis and secretion of nutrients and growth factors necessary to sustain the fetus early in the post insemination period. Smaller sized corpus luteums that accompany ovulation of small, poorly grown follicles results in inadequate progesterone secretion. Low progesterone levels in these cattle fail to properly stimulate uterine gland to secrete nutrients and growth factors supporting fetal growth after insemination. Thus abnormal follicular and corpus luteal body development in poorly cycling, anovulatory cattle can lead to inadequate growth of the conceptus during the first weeks of pregnancy. Inadequate fetal growth results in weak fetal signals of pregnancy to the dam thereby increasing the risk the dam will not recognize fetal presence in the uterus and destroy the corpus luteal body of pregnancy. This results in the high prevalence of fetal death and return to estrus (EED) typically associated with anovulatory cattle that begin to cycle.

There are a number of functionally important differences between ovulatory and anovulatory populations of cattle that impact reproductive efficiency and ultimately dairy profitability. Insemination rates of acyclic cattle can be as low as 30% of those in normally cycling animals over a 21 day period of visual estrous detection. More importantly, errors in estrus detection in groups of anovulatory cattle can be as high as 75% compared to only 5% error in cycling animals. Errors in estrous detection increases the likelihood acyclic cattle are inseminated at times that are not close to ovulation. Clearly this error with asynchronous insemination indicates tremendous problems with estrous detection in anovulatory cattle.

An issue of economic and practical significance is the ability of TAI programs to produce pregnancies in groups of anovulatory cattle. Herds with higher than normal amounts of anovulatory cows benefit from TAI programs because the first and/or second GnRH injection of Ovsynch for example will drive follicle growth and dominance in cows that otherwise would not achieve follicle growth due to greater than desirable nadirs in negative energy balance and loss in body condition (more than 0.5 BCS loss during the first 30-45 DIM). Follicle growth and dominance driven by exogenous sources of GnRH in Ovsynch or Presynch, Ovsynch programs triggers many anovulatory cows to ovulate and achieve pregnancy when in the absence of these hormones pregnancy is not an option. Studies clearly indicate that anovulatory cows respond to the first dose of GnRH of Ovsynch by forming luteal tissue from preexisting follicles. Thus, even though anovulatory cattle tend to possess follicles with variable and often smaller than normal size, these follicles have the capacity to ovulate, form luteal bodies and secrete progesterone just as the larger sized follicles in normally cycling ovulatory cattle. In addition,

most (94% anovulatory and 97% ovulatory) cattle can respond to the second dose of GnRH in the Ovsynch program with ovulation (Gumen et al., 2003). The practical and important outcome for producers however is the success of synchronization when TAI programs like Ovsynch and Presynch, Ovsynch are implemented at the end of a 45 voluntary wait period where the two populations of cattle, ovulatory and anovulatory enter the synchronization protocols. The data shows 80-90% of the lactating, ovulatory groups are successfully synchronized (Fricke and Wiltbank, 1999). Synchronization of anovulatory groups may be somewhat less consistent as rates as high as 90% and as low as 50-70% have been reported for anovulatory cattle (Cartmill et al., 2001). In spite of the relatively high rates of synchronization in ovulatory and anovulatory cattle, conception rates and pregnancy rates tend to lie around 30-35% in ovulatory animals and 10% in anovulatory animals. Synchronization programs appear to drive ovulation and synchronization comparably well in both groups but fertility remains lower in anovulatory groups.

Never the less, many anovulatory cows fail to achieve pregnancy following TIA. The reasons are incompletely understood but are associated with some important observations of practical significance. Acyclic, anovular cows generally (but not inevitably) have lower BCS and lose > 0.5 BCS during the transition period. Low BCS has also been shown to be associated with though not causally related to lower pregnancy rates 33 and 61 days after TAI. Never the less, many anovular cattle successfully synchronized during Presynch, Ovsynch that did not become pregnant possessed BCS comparable to anovular cattle with good BCS that became pregnant after TAI. Thus, even though lower BCS is linearly associated with anestrous and anovulation, low BCS is clearly neither directly causal nor even necessary for development of anovular problems in most transition cattle (Moreira et al., 2000, Lopez et al., 2005, Sterry et al., 2006). Besides BCS, the cyclic condition of cattle entering TAI programs is closely associated with fertility and pregnancy rates in synchronized cattle. Acyclic, anovulatory cattle show fewer pregnancies per service at 30 and 60 days post TAI compared to cycling herd mates in the TAI program. Pregnancy loss due to early and late embryonic death is also considerably greater at 30 and 60 days post TAI in acyclic, anovulatory cows compared with cyclic, ovulatory cattle (Sterry et al., 2006).

Diagnosis of anovulatory cows can be achieved by strategic determination of progesterone levels in blood or milk. Normally cycling cows form a minority of follicles selected from a large number of follicles in a wave of developing follicles for rapid growth and maturation into dominant follicles. A single dominant follicle is ultimately formed that achieves the ability to ovulate and form a functional corpus luteal body. Anovulatory cows do not develop a dominant follicle that is induced to ovulate and form a large, functioning corpus luteal body. Therefore, failure of corpus luteal body formation is a hallmark sequella of anovulation and lends itself to two diagnostic approaches. One can utilize ultrasound to determine the presence or absence of a corpus luteal body on the ovary when a CL is predicted to be present on the ovarian surface. Alternatively, one can determine progesterone levels during the time when a functioning corpus luteal body should be active on the ovarian surface.

TAI programs lend themselves to these two diagnostic approaches because ovulatory, cycling cows should always possess a normally functioning corpus luteal body on the ovarian surface at distinct periods during the TAI program(s). Cows placed on a Presynch, Ovsynch

program to generate the first post partum ovulation are expected to possess a large corpus luteal body on the ovarian surface at the time of the first Ovsynch dose of GnRH that follows the second PGF2α dose of the Presynch program. Alternatively, cows in the Presynch, Ovsynch or the Ovsynch program should possess a large corpus luteal body on the ovarian surface the time of the administration of the second dose of PGF2α in the Ovsynch protocol. Thus, transrectal ultrasound of TAI cows should show a corpus luteal body during either of these times and would render a diagnosis of ovulatory and cyclic cows. Cows lacking a corpus luteal body by transrectal ultrasound would be diagnosed as acyclic and anovulatory.

Synchronization protocols like Ovsynch or Presynch, Ovsynch induce ovulation in cows diagnosed as anovulatory. Data from one study (Sterry et al , 2009) showed 81% (127/156) of anovular cows synchronized with a Presynch, Ovsynch program were induced to ovulate after the second dose of GnRH. Four other cows in the same trail showed evidence of cyclicity 4-11 days post AI but apparently failed to ovulate a follicle after the second dose of GnRH. High progesterone levels in these four animals indicated they may have failed to destroy a functional corpus luteum in respond to the second PGF2α dose of the Ovsynch program or ovulated a follicle and developed a corpus luteal body earlier than anticipated either 5-5 days prior to the second PGF2α dose or seven days before the second dose of GnRH in the Ovsynch program. In either case, these four animals plus the other 123 showed synchronization programs can induce follicular activity and ovulation in cattle that were otherwise unable to develop cyclic activity and ovulate follicles in the post partum period. Thus, producers should understand post partum anovulatory cattle can be rendered cyclic and ovular with synchronization programs as TAI programs will resolve pre-existing anovular conditions. Whether or not anovular cattle rendered ovulatory by synchronization programs are fertile, conceive and retain pregnancies similar to ovulatory cattle submitted for TAI is doubtful. Synchronization of anovulatory cattle with Ovsynch produces pregnancies ranging between 22-26% of the anovular cows submitted for TAI. (Sterry et al, 2009).

In a recent report of 127 anestrous cows placed into a (Sterry et al.,2009) Presynch, Ovsynch program, 30% were confirmed pregnant 31 days after timed insemination. Of the other 96 anovular cow not pregnant in the TAI program, it was unknown how many simply failed to conceive and how many conceived but developed EED prior to pregnancy confirmation on day 31. Poor quality embryos as early as five days post conception fail to achieve rapid rates of growth by day 16. Small, slow growing embryos send a weak fetal-derived signal of pregnancy that may not stop the dam from recycling. As a result embryonic mortality may occur before day 16 after conception in otherwise anovular cattle. Indeed, EED may be evolving into serious cause of reproductive inefficiency in most cows and especially anovular cattle (Sartori et al., 2002). When pregnancy confirmation was performed at 28 days and 50-60 days after insemination of ovular and anovular cattle, loss of early pregnancies between these two periods ranges between 10-20%. The loss of pregnancies 30 to 50 days post TAI was 31% in anovular cattle compared with a much lower 16% in ovular cattle (Stevenson et al., 2006).

Clearly, anovulatory cows produce lower than desirable pregnancy rates in TAI programs. EED may become the primary cause for low pregnancy rates in anovular cows (as well as normally cycling, ovular) after TAI. Significant amounts of data suggest there may be problems with the embryo itself. Oocyte growth, development and maturation appears to be less than

optimal with overly small or large follicles on the ovaries of anovular cattle. Since synchronization programs force follicles with poorer quality oocytes to ovulate, fertilization of poor quality oocytes at the time of TAI may produce the lower grade embryos noted to exist as early as five days post insemination. Some evidence exists to support the contention that poor quality oocytes may be an important element in the infertility problems of anovular cattle.

An association has also established between pre-insemination levels of progesterone, post fertilization progesterone levels, and pregnancy. The higher the level of maternal progesterone prior to and four and 11 days after insemination, the greater the likelihood of pregnancy. Heavily lactating anovular cattle possess slower growing, smaller follicles than ovular cattle. Steroidogenisis (particularly estrogen synthesis and secretion) by small follicles on ovaries of anovular cattle can be lower than normal. As a result, these cattle are often anestrus or show weak estrous behavior. More importantly, lower than normal estrogen synthesis could result in an ill prepared uterine endometrium that lacks sufficient ability to synthesize and secrete nutrients and growth factors that sustain fetal growth. Poor quality, slow growing fetal tissues fail to signal pregnancy and promote EED. In addition, forced ovulation of the smaller, slower growing follicles during synchronization of anovular cattle could result in insufficient luteal cell mass in the post ovulatory corpus luteal body. Moreover since anovular cattle (by definition) have not cycled, they lack corpus luteal tissue and therefore enter synchronization programs with low serum progesterone levels. Even ovular, cycling cows can present to TAI with lower than desirable progesterone levels because livers of heavily lactating animals clear steroids (progesterone) from the blood more rapidly than livers of moderately producing animals. Low progesterone levels prior to follicular ovulation and insemination trigger problems with follicular development and ovulation. In fact, acyclic cattle lacking progesterone prior to ovulation have increased frequency of multiple ovulations with twinning and ovulation of small, underdeveloped follicles. These problems are associated with increased failure of fertility. Smaller than normal luteal mass is accompanied by lower than normal progesterone levels in the blood shortly after TAI. Lower progesterone levels post TAI in anovular cattle could compound pre-existing, hostile intrauterine problems established with low estrogen production by further limiting uterine gland secretion of nutrients and growth factors supporting fetal growth. Anovular cows with very low progesterone levels tend to destroy corpus luteal bodies more readily than cows with higher progesterone levels. A high percent of anovular cows therefore show shortened estrus cycles (after TAI) characterized by severely shortened luteal phases (11 day) in comparison with longer luteal phases (16 days) of normally, cyclic, ovulatory cattle (Gumen et al., 2003). The increased susceptibility of the luteal body to destruction 11 days post conception in TAI of anovular cattle would result in increased incidence of early embryonic death.

Several approaches have been designed in an attempt to reverse problems with anovulatory cows entering TAI programs. Synchronization protocols such as Ovsynch and Presynch, Ovsynch successfully trigger ovulation in a majority (but not all) anovulatory or ovulatory cows submitted for TAI. Ovulation is forced through the exogenous administration of pharmacologic doses of GnRH rather than depending on the physiologic release of endogenous GnRH that depends upon the presence of progesterone and estrogen. Thus, synchronization programs over ride the failure of pre-ovulatory GnRH and LH secretion that occurs in anovulatory cattle. Never the less, the outstanding problem with anovular cattle in TAI programs is fewer pregnancies per

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timed insemination with higher rates of pregnancy loss occurring 6-60 days after timed insemination. These observations, in light of the relatively high prevalence of poor quality embryos five days post TAI imply pregnancy loss rather than ovulation and oocyte fertilization *per se* underlie low pregnancy rates in anovulatory cattle entering TAI programs. Accordingly, recent efforts have been directed at attaining higher retention of pregnancies after TAI. One approach involved the administration GnRH shortly after insemination in TIA. In trials involving the administration of GnRH day 4, day 5 or day 11 to 14 post insemination, the desired effect was to induce a second ovulation following the first ovulation induced by the second GnRH of Ovsych. The goal was to generate a second ancillary corpus luteum and enhance post TAI progesterone production. Elevated progesterone production should supplement progesterone production by the corpus luteum ovulated at the time of TAI and sustain pregnancy. As stated earlier, the corpus luteum formed by the follicle ovulated during Ovsynch may be smaller than desirable and produce insufficient progesterone to support pregnancy and optimal fetal growth in the first 16 days of pregnancy. An accessory corpus luteum would be expected to correct insufficient amounts of progesterone production in these animals. In addition, since corpus luteal bodies of anovulatory cattle are more susceptible to early destruction and shortened life spans, an accessory corpus luteum might insure some level of luteal tissue would persist on the ovarian surface to sustain the pregnancy after TAI. Collectively, the different trials resulted in very mixed effects on pregnancy rates. More work is required before this procedure can be recommended for use in commercial dairy cattle.

Intra-vaginal progesterone releasing inserts (CIDR) containing 1.38g of progesterone (P4) have been employed pre-or post TAI insemination in an attempt to improve conception and pregnancy rates in anovulatory cattle. Progesterone inserts are associated with resumption of cyclicity and ovulation in anovular cattle presumably because the exogenous progesterone replaces the progesterone that is absent in acyclic cattle lacking a corpus luteal body. Progesterone inserts have been placed during Presynch as well as Ovsynch protocols in synchronization programs. Again, the effect on pregnancy rates has been inconsistent.

In one large multi-centered study cows received Ovsynch alone or received Ovsynch and a CIDR insert at time of the first GnRH dose of Ovsynch. The insert was removed within two hours of the second dose of PGF2α of Ovsynch. Pregnancy rates across all centers were greater in cows synchronized by Ovsynch + CIDR compared to Ovsynch only. In this particular study, the proportion of non-cycling, anovular cows varied from 6% to as high as 41% across different herds. CIDR insert improved pregnancy rates by 5-10% in Ovsynch cows that received a CIDR (50%) compared to Ovsynch cows not receiving a CIDR (40%). However, the CIDR effect was not universal across all non-cycling cows or cycling cows that received a CIDR. Rather CIDR associated improvement in 56 day pregnancy rates occurred in cycling and non-cycling, anovular cows *that showed no evidence of a functioning corpus luteum at the time of the second dose of PGF2α of Ovsynch*. CIDR inserts did not benefit non-cycling, anovular cows induced to cycle with the first dose of GnRH in Ovsynch or cycling cows that had been set up by the first dose of PGF2α and GnRH to respond to the second doses of PGF2α and GnRH in Ovsynch with ovulation (Stevenson et al., 2006). Since these events occur across any Ovsynch program in commercial herds with cycling as well as anovular, non-cycling cows, producers can expect supplementing Ovsynch with CIDR inserts to improve pregnancy rates in some but never 100% of cows entering an Ovsynch program supplemented with CIDR inserts. The amount of

pregnancy rate improvement with CIDR inserts could be expected to fall off with higher percentages of anovular transitional cows in the herd. Anovular, acyclic transitional cows do not respond nearly as well as cycling cows to the first dose of GnRH expected to induce and support corpus luteal formation in Ovsynch cows. Part of the improvement in cyclic and acyclic cow fertility induced by pre-insemination CIDR inserts could be attributed to a reduction in EED specifically in the two groups of animal cited above that lacked corpus luteal function by the second Ovsynch dose of prostaglandin. Supplemental progesterone from CIDR inserts pre-insemination of acyclic, anovular cows actually enhanced follicular growth before ovulation and TAI. This could improve corpus luteal growth and function, resulting in higher production and more sustained levels of progesterone in support of uterine functions sustaining the post TAI pregnancy. The take home message from this type of data is that 30 and 60 day pregnancy rates are almost always lower for non-cycling transition cows compared to cycling cows. EED induced erosion of pregnancy rates during the 6-30 days and 30-60 days of pregnancy is greater in acyclic, anovular cows compared to cycling cows. CIDR supplemented Ovsynch programs may of benefit in herds with high numbers of acyclic, anovular cows but can be expected to benefit only a portion of the population of acyclic, anovular cows and cyclic cows entering the Ovsynch program.

The insertion of progesterone inserts during the Presynch protocol of a Presynch, Ovsynch program increase cyclicity in anovulatory cattle (Chebel et al., 2006). Never the less, 30 and 60 day pregnancy rates were not improved over those cattle not receiving the progesterone inserts during Presynch. Several studies recorded improved pregnancy rates in Resynch cattle receiving progesterone inserts 14-21 and even as late as 28 days post insemination (Chebel et al., 2006). Clearly the effect of supplemental progesterone after insemination was to reduce the high incidence of EED in anovulatory cattle. Insert mediated progesterone supplementation appears to improve fetal survival in heavily lactating animals that have developed anovular problems. Thus, progesterone inserts may be beneficial pre-insemination because they initiate cyclicity and can improve fertility in acyclic and cyclic cows lacking corpus luteal bodies at the time of PGF2α in Ovsynch. The post insemination use of inserts may also benefit pregnancy rates by reducing the erosive effect of EED on reproductive efficiency in acyclic cattle.

In conclusion, entry of anovular and anestrous cattle into synchronization programs can force ovulation and even cyclicity in cattle that would not otherwise ovulate. Therefore, submitting anestrous, transition cows to synchronization and TAI programs results in some pregnancies that otherwise would not occur in the absence of synchronization. Never the less, the infertility and low pregnancy rates associated with anovular cows are incompletely resolved even in synchronization as fertility and 30 to 60 day pregnancy rates can remain low even though synchronization induces ovulation. Strategic use of GnRH or progesterone inserts have been employed to improve the reproductive efficiency of anovular cattle in TAI. Different strategies have met with variable success at improving reproductive efficiency. Collectively, results from many of these investigations suggest fertility and improved pregnancy rates are largely dependent upon some level of spontaneous cyclicity and sustained endocrine events governing follicular growth, ovulation and luteal tissue activity. Anovulation and anestrous conditions negatively impact each of the areas of reproductive function resulting in increased frequency of abnormal cycle lengths, multiple ovulations per cycle, nonexistent heats, and errors in heat detection and costly increases in EED. Synchronization and TAI is a tool offering partial

recovery from anovulatory problems but avoiding anovulation and anestrous conditions in transition cows by careful management of pre-and postpartum health, rations, feed bunks and comfort is likely to be an equally or even more productive approach to this problem.

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Embryonic Survival, Embryonic Death and Subfertility in Lactating Dairy Cattle

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Introduction

Low pregnancy rates in heavily lactating cattle are a fact of life in the modern dairy industry. Since pregnancy rate is derived as the heat detection rate times the conception rate, anything lowering either heat detection efficiency and/or conception rate lowers pregnancy rates. However, a causative factor lowering pregnancy rates that many producers fail to consider in sub-fertility problems is sub-optimal pre- and post implantation embryonic survival. Even though fertilization rates in most dairy cattle typically range between 75 and 100%, pregnancy rates in the same cattle may range between 30-50% 25-65 days post fertilization. Thus, pregnancy losses after fertilization and up to 65 days post breeding have been estimated to be as high as 60%. Often times early embryonic death remains undetected in herds performing pregnancy diagnosis with ultrasound or rectal palpation at 28 and 30-32 days post insemination. Many times early embryonic death manifests itself as unexplained returns to estrus 21-65 days post pregnancy diagnosis. In reality, early embryonic death, return to estrus with regular or irregular inter-estrus intervals is often evidence of inadequate circulating levels of progesterone immediately after conception. Progesterone is the steroid hormone generated by the corpus luteal body that forms from the ovulated follicle. The corpus luteum serves to sustain pregnancy for eight of the nine months of gestation in cattle. Embryonic death can appear as two functionally defined patterns: embryonic death occurring prior to 16 days of gestation is early embryonic death and that occurring after 17 days of gestation is defined as late embryonic or fetal death. Low levels of progesterone 4-6 days post ovulation and insemination are associated with reduced pregnancy rates and regular returns to estrus after insemination. Low levels of progesterone stall embryonic growth resulting in smaller than normal embryos. Small embryos struggle to inhibit luteolysis at or after day 16 post insemination. As a result, the corpus luteal body is destroyed; the cow loses the pregnancy and returns to estrus 21 days after her breeding date. If the corpus luteum is retained after day 16, the cow would remain pregnant and not return to estrus.

Incidence and Prevalence of Early Embryonic Death

Early embryonic death has been defined as any death of an embryo within the first day 16-17 days post fertilization. Day 16 is the day when the fetus must present an *in-utero* signal to the dam that a pregnancy has developed in the uterus. When the fetus fails to deliver the signal of pregnancy, the embryo dies and is reabsorbed by day 16-20 post fertilization while the dam returns to estrus. Early embryo death follows one or more series of events that begin with a poor quality embryo on day 4-6 post insemination that fails to thrive and grow properly by day 16 post fertilization. Because most early embryonic deaths occur prior to day 16-17 post

fertilization, they are unlikely to result in irregular or prolonged inter-estrous cycle lengths. Typically these cattle return to estrus within 21 days of insemination and are usually perceived as conception failures rather than pregnancies that failed due to early embryo death. Since the advent of ultrasound and embryonic flushing in early pregnancy, it has become clear that embryonic death and poor quality embryo development are not unusual events in lactating cattle. In fact, early embryonic death accounts for a majority of pregnancy losses. Fertilization rates may range between 55-88% in lactating cattle and 90-100% in non-lactating cattle and heifers, respectively. In the same highly fertile group of animals, six day old embryonic quality and viability was shown to be low in lactating cattle and higher in heifers and non-lactating cows: only 30-50% of the embryos collected from lactating cattle were good quality, viable embryos. In contrast, a much higher 70-83% of day 6 embryos collected from heifers and non-lactating animals were good quality viable embryos. Thus, as much as 50-70% of day 6 embryos may be poor quality, degenerative embryos in lactating animals. This indicates many pregnancies are doomed to fail as early as six days post insemination because poor embryo quality is a serious problem in cattle under lactation stress. The mechanism(s) underlying poor, nonviable embryo development in early pregnancies of lactating animals is (are) not clear but probably stem(s) from negative energy balance, poor quality ova formation, high rates of progesterone clearance in livers of lactating animals and loss of body condition score. The pie chart, slightly modified from Diskin et al. (2006) demonstrates Diskin's distribution of events that follow insemination and produce a 40% pregnancy rate in Holstein cattle. Clearly, early embryonic death seriously erodes pregnancy rates in lactating cattle.

Reproductive Events Eroding Pregnancy in Holstein Cattle

40% Delivery of Full Term Calf

10% Conception Failure

43%

Early Embryonic Death

7%

Late Embryonic Death
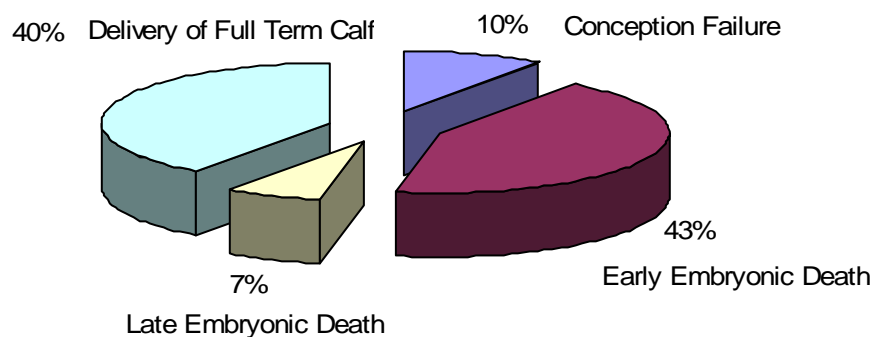
Incidence and Prevalence of Late Embryonic Death

Maternal recognition of pregnancy and therefore the fetal signal to the dam that prevents any further cycling by the dam occurs at day 16 post fertilization (See below). Evidence indicates 50-65 day pregnancy rates generally lie around 30% while fertilization rates in most normal cattle range between 75-100%. These pregnancy rates are found in cattle inseminated by timed artificial insemination as well as cattle receiving embryonic transfer (Sartori, 2006). This suggests the 30% pregnancy rate may not be simply due to fertilization failure. Problems with

early (day 1-8) embryonic development or failure of the early fetus to signal pregnancy to the dam by day 16 will cause fetal death and re-absorption that can lower pregnancy rates. Factors impacting late fetal survival after day 16 post fertilization also impact pregnancy rates. Many later deaths occur between 24 and 85 days of gestation and may be unnoticed in herds where very early pregnancy diagnosis is practiced. Late embryonic death nearly always results in delay of return to estrus post insemination and therefore will increase the percent of irregular and prolonged inter-estrous cycles in a herd. Late embryonic death rates have been estimated to cause a loss of approximately 7-8% of all pregnancies.

What is the Fetal Signal that Notifies the Dam of a Pregnancy?

The early embryo signals pregnancy to the dam by simply blocking lysis of the corpus luteal body formed 15-17 days earlier at the time of ovulation. In the absence of pregnancy, the uterus synthesizes and releases sufficient prostaglandin $F_{2\alpha}$ on day 15-17 of the estrous cycle to lyse the corpus luteal body in preparation for the cow to re-enter a new cycle and return to estrus 4-5 days later. In many ways, the uterus recycles a cow using a process similar to what producers employ through the use of prostaglandin $F_{2\alpha}$ administration to lyse the corpus luteal body in PreSync and OvSync programs. However, if conception occurs and embryo development proceeds, the process of uterine induced luteolysis is blocked. During the first 16 days post fertilization, the new embryo must undergo an explosive rate of growth that enables the embryo to produce and secrete a protein called interferon tau (IFNπ) into the uterus. In fact, the levels of IFNπ increase in the uterus as a direct consequence of the rate of tissue growth and increase in embryonic mass between day 10 and 16 post fertilization. IFNπ is the fetal signal that blocks prostaglandin $F_{2\alpha}$ production by the uterus. As a result the corpus luteal body does not become exposed to prostaglandin $F_{2\alpha}$ and is retain on the surface of the ovary during pregnancy. As long as the embryo grows properly and remains viable, prostaglandin production by the uterus does not occur and the corpus luteum body persists. The corpus luteal body produces copious amounts of progesterone that subsequently stimulate glands in the uterine wall to produce and secret growth factors and nutrients that drive continued embryonic growth and development. *__Luteal body inadequacy (dysfunction) likely adversely impacts embryo development due to inadequate nutrient and growth factor production by the uterine glands.__*

In addition to its role in signaling pregnancy, IFNπ also stimulates a variety of activities that support cellular proliferation and embryonic growth. INFπ aids in preparation of the uterine wall (endometrium) for embryo attachment and implantation around day 18-20 post fertilization. Two of the key growth factors supporting early embryo development, insulin growth factor 1, and insulin growth factor 2 (IGF 1, IGF2) are heavily produced by the uterine wall and secreted into the uterine lumen during days 1-16 of the post fertilization period. IGF is also a potent regulator of intermediary metabolism in the cow and is widely recognized as an important mediator of follicle growth, development and maturation. IGF stimulates the newly formed day 10-16 embryo to produce and secrete large amounts of INFπ. Thus, *in utero* IGF activity at the time of early fetal growth and signaling of pregnancy to the dam is an important component of fertility. In addition poor follicle growth, poor follicle development, anestrus, anovulation and poor conception rates are all associated with lower than normal levels of IGF 1 in the blood and follicle. It may be that poor follicle growth, poor corpus luteal body formation and lower than normal levels of progesterone production could lead to low levels of IGF1 stimulated IFNπ

production by the embryo. Low IFNπ production results in a failed signal of pregnancy and early loss of the embryo. *Poor quality embryos arising from poor quality oocytes and/or inadequate endocrine stimulation of uterine development during the peri-and post fertilization period will significantly increase the risk of a weak fetal IFNπ signal of pregnancy. The weak signal increases the risk of early embryonic death and lowered pregnancy rates.*

What Endocrine Events have been Associated with Embryonic Death in Lactating Cattle?

Reduced circulating levels of progesterone and estrogen have been associated with increase risk of embryonic death. Higher circulating progesterone levels on day 6 post fertilization are associated with higher 30 and 60 day pregnancy rates in inseminated cattle. Ultrasound data on follicular size showed ovulation of small follicles (<10mm in diameter) was associated with lowered conception rates following insemination. Follicles that are too large were also associated with very low conception rates. Conception rates clearly increase with increasing follicle size up to but no larger than 19mm in diameter. The causal effect stems from the observation that circulating progesterone levels on day 7 post fertilization are higher in cows ovulating larger rather than smaller follicles. Low circulating progesterone levels favor ovulation of smaller than normal follicles. The larger follicles develop into larger, more competent corpus luteal bodies that secrete higher amounts of progesterone (Sartori et al 2002, Vasconcelos et al 2001.). In contrast, smaller follicles often develop into smaller corpus luteal bodies associated with lower circulating progesterone levels seven days after fertilization and onset of embryonic development. In a sense, cattle can become luteal body competent or luteal body incompetent. Smaller ovulating follicles, smaller corpus luteal bodies and low progesterone levels are associated with lower pregnancy rates in TAI animals 25-30 days post insemination. There is a positive relationship between embryonic survival, size of an ovulatory follicle, size of the corpus luteal body and the amount of circulating progesterone secretion. Many trials have shown low circulating progesterone levels that were supplemented with exogenous progesterone increased pregnancy rates. The effect of supplemental progesterone was greatest when progesterone was administered within the first 10 days of gestation (Mann 2006). Thus, events leading to ovulation of smaller follicles (slow follicular growth) in natural as well as timed artificial insemination programs could diminish pregnancy rates through a reduction on corpus luteal size and reduced progesterone secretion at the time of or immediately after insemination. Lower progesterone levels will impair embryonic development and growth. Delayed or less than desirable embryonic growth is in turn, an increased risk for early embryonic death because the fetal signal of pregnancy is too weak. *The real take home message is that producers need to manage energy and dry matter intake in transition cows to sustain healthy follicular growth. Avoid severe and prolonged nadirs of negative energy balance. Avoid losses in body condition scores (BCS) greater than 0.5 BCS (150 lb body weight loss) in the transition period.*

Management of transition cow diets and energy intake to sustain good rates of follicular growth may be confounded by another problem in heavily lactating transition cows. Cows with high amounts of DMI (properly managed transition cows) also metabolize and excrete estrogen and progesterone much faster than dry cows and heifers with lower DMI. Transition cows with adequate size of follicles and corpus luteal bodies may be producing enough steroids but the higher rates of steroid clearance by the liver renders these cows with lower than expectable

levels of circulating steroids. These animals ovulate very small follicles (low circulating progesterone) or excessively large follicles (low circulating estrogen). Premature oocyte maturation (low progesterone) in small ovulatory follicles or over extended oocyte maturation (low estrogen) in very large follicles leads to poor quality embryo formation after fertilization. Poor quality oocytes lead to poor quality embryos that fail to thrive in the post fertilization period. As a result, these poorly growing embryos may be lost because of a weak INFπ signal of pregnancy to the dam.

Nutrition, Energy Balance and Embryonic Death in Lactating Cattle

The tremendous increase in milk yields generated through genetic selection has produced significant problems in energy balance of modern dairy cattle. Cattle of high genetic merit are predisposed to mobilize peripheral fat stores as they progress into deepening negative energy problems with heavier lactation demands in the transition period. Endocrine events that are triggered by or cause changes in nutrient and energy partitioning during negative energy balance also spill over and antagonize reproductive events. Unquestionably, the negative energy balance during transition periods generates tremendous disturbances in the endocrine mechanisms driving the onset of first estrus and ovulation after parturition. Most veterinarians and producers recognize the deeper the energy nadir, the greater the time interval between parturition and the onset of first estrus and ovulation after calving. Deep, prolonged nadirs in negative energy balance during transition periods are a recipe for reproductive failure due to the onset of anovulation, anestrus, weak estrus, delayed ovulation and multiple ovulations in lactating dairy cattle. Deep nadirs in negative energy balance also lead to increased frequency of early embryonic death and conception failures 30-65 days post insemination. The data suggests negative energy balance impacts two key targets of reproductive function that predispose cattle to early embryonic death. These targets, oocyte quality and embryo quality are not mutually exclusive. Oocyte quality, functionally defined as the ability of an oocyte to develop into an embryo has been shown to deteriorate in cattle under heavy lactation stress and cattle of high genetic merit for milk yields. Embryo quality is in many ways dependent upon oocyte quality as poor quality oocytes beget poor quality embryos. However, intrauterine problems can also impact embryo quality independent of oocyte quality.

Negative energy balance coupled with excessive weight loss is associated with a number of sustained endocrine and metabolite changes. Cattle with poor energy balance mobilize peripheral fat stores leading to increased amounts of circulating ketones and nonesterified fatty acids (NEFA) and lower circulating amounts of glucose, insulin, leptin and insulin like growth factor 1 (IGF-1) in the blood. These changes, in particular the low insulin, IGF-1 and glucose that accompany negative energy balance are all directly or indirectly linked to slow follicle growth, ovulation of small follicles and complete failure of follicular ovulation. Hormone and metabolite changes in the blood are also reflected in the intra-follicular fluid bathing oocytes in growing follicles (antral fluid). The intra-follicular changes (elevated follicular NEFA, low follicular glucose, IGF-1 and insulin) have been implicated in impeding several key events in oocyte maturation that must occur around the time of ovulation. Problems at this stage in oocyte maturation may not necessarily impede fertilization but can lead to poor embryonic growth immediately after fertilization.

Slow growing follicles show diminished ability to synthesize and secrete estrogen, take longer to ovulate and ovulate poor quality oocytes. Several events in oocyte development are hindered in follicles under-secreting estrogen. As a result, the oocyte may become fertilized but cannot negotiate the first stages of embryonic growth. In addition, follicles of lower estrogenic capacity do not supply sufficient estrogen to adequately prepare the uterine wall and oviducts to support a new embryo. Consequently, poor quality follicles with their oocytes mat result in embryonic death and embryonic re-absorption within the first few days after fertilization. Should the degradation of the estrogenic abilities of these follicles become too great, delayed ovulation can move to anovulation, weak estrus behavior and finally anestrus.

Since poor oocyte quality can lead to low embryo quality, it is no surprising embryos obtained from heavily lactating cattle are slow to grow and develop and often on-viable. Indeed *embryonic deterioration tends to be greatest in heat stressed cattle under heavy lactation stress*. In contrast, embryos obtained from mature, non-lactating cattle or heifers show considerably greater levels of viability and growth qualities (Sartori et al., 2002, Leroy et al., 2005). These data imply embryo growth and survival characteristics are curtailed in dairy cattle under heavy lactation stress. Some of the deterioration in embryonic quality may arise within the uterine environment itself and therefore not always be related to follicle and oocyte problems. The lack of sufficient IGF-1 production by the oviduct under stimulation by lower than desirable levels of estrogen and progesterone from poorly growing follicles has already been mentioned as a potential problem for early embryonic development. IGF-1 potentiates early embryonic growth by promoting cell division in the first few days post fertilization. This growth generates a large enough mass of embryonic tissue to produce and secrete a strong INFπ signal of pregnancy to the dam. In the absence of growth, the INFπ signal is weak or nonexistent and the embryo is lost.

High dietary protein intakes are also associated with inferior reproductive efficiency. High intake of improperly balanced proteins are associated with a 20-30% erosion in 30-60 day conception rates. Early embryonic death is the most important contributing factor even though oocyte quality may also be eroded by high levels of urea in follicular fluids. Excessive dietary intake of soluble, rumen degradable protein results in too much ammonia and urea production in the rumen and liver, respectively. As a result, blood levels of these metabolites rise from a normal 12-14 mg urea per ml in the blood and milk to levels as high as 20-22 mg urea per ml of blood or milk. Since amounts of urea in blood, follicular fluid and uterine fluid are correlated, one could expect oocyte and embryo exposure to high amounts of urea as amounts in the blood rise. Even though urea amounts higher than 19-20 mg per ml of blood or 115mg per ml of milk are considered a threat to reproductive efficiency, reproductive losses tend to increase proportionally to rising amounts of urea in the blood or milk. Oocytes collected from cattle with high amounts of blood ammonia in the follicle and blood developed into slow growing embryos after the first few days post fertilization (Sinclair et al., 2000). Urea *per se* directly inhibits oocyte maturation, fertilization rates and oocyte ability to develop into an embryo after fertilization. High amounts of ammonia and urea in the female reproductive tract acidify the intrauterine pH and alter the phosphorous, potassium, magnesium and zinc composition of the fluids in the oviduct and uterus. These changes may create an environment that erodes the ability of an embryo to grow and thrive during the first days post conception. Seven day old embryos flushed from cattle with two weeks of elevated blood urea prior to insemination resulted in low recipient conception rates. This suggests embryo damage occurs within one week of

embryonic development in dams with excessive protein intake (Rhoads et al., 2006). Thus, producers need to carefully balance transition diets to maximize energy intake and balance amounts of rumen degradable protein with rumen undegradable protein.

Conclusion

Early embryonic death can account for a high percent of conception failures in lactating dairy cattle. When heat stress compounds lactation stress, embryonic death rates rise even higher. Early embryonic death occurs by day 16 post fertilization because of problems with oocyte and embryo quality. A major event contributing to poor oocyte and embryo quality is a severe, sustained nidar in negative energy balance in transition cows. Dietary intakes of excessive amounts of protein, particularly rumen degradable proteins will further contribute to early embryonic death rates. Both events erode oocyte development and maturation as well as intrauterine growth and development of the embryo as early as six days post fertilization. Early embryo death is a problem that plaques reproduction management schemes based on estrus detection as well as those based on timed artificial insemination. Although progesterone supplementation with CIDR inserts may reduce the incidence of early embryonic death, the effect is weak and inconsistent. Producers are best served by striving to balance rations for total as well as rumen degradable and undegradable protein, maximize dry matter intake and reduce heat stress in transition cows.

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Virginia Forage-Beef Summit Hits a Home Run

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Harlan Hughes, Livestock Economist from the University of North Dakota, Emeritus, told fathers in the audience that they have no more experience than their sons in today's beef market. Hughes outlined the current economic situation in the United States and then talked about the impact that ethanol production is having on today's beef market. He said that he expects corn prices to remain high for the next five to seven years. This translates into higher cost of gains in feedlots and lower calf prices for cow-calf producers in states like Virginia. Hughes said that cow-calf producers need to control production costs, but at the same time keep production high. He said that states that can produce an 850 pound calf on grass are going to be winners and Virginia appears to have the resources to do just that.

Scott Greiner, Animal Scientist from Virginia Tech, talked about cow size, efficiency, and profitability. Greiner concluded that from an 800 cow dataset from southwest Virginia that cow size is relatively poor indicator for calf weaning weight. Some of the largest cows in this herd were weaning some of the smallest calves and some of the smallest cows were producing largest calves. In the end, he concluded that in order to make informed decisions out our cowherd genetics, we need to collect performance data, not at the herd level, but rather at the cow level.

Robert Shoemaker, a beef producer from Faulkier County, talked about setting profitable stocking rates for today's economic environment. Shoemaker described several low cost strategies for increasing carrying capacity that he uses on his farm. The first is rotational stocking. He said that this pasture management practice is not new, but is grossly under utilized on Virginia's beef cattle operations. He felt that simply implementing rotational stocking could increase forage production by 30 to 40 percent. A second management strategy that he talked about is improving pasture fertility in order to optimize grass growth. Shoemaker felt that importing nutrients in the form of bought hay was a cost effective way to build fertility in grazing systems.

Chris Teutsch from Virginia Tech's Southern Piedmont Research Station talked about cost effective strategies for building and maintaining soil fertility in pastures. Teutsch stressed the importance of understanding and managing nutrient cycles in grasslands. He said that grazing livestock remove relatively small quantities of nutrients, but can redistribute nutrients within a pasture if grazing is not controlled. Teutsch also stressed the importance of incorporating legumes into grazing systems since legumes not only fix N from the air to a plant available form, but also increase animal performance. He stressed that we have always known that having legumes in our pastures was important, but with today's fertilizer prices, they are a critical part of profitable cow-calf operations.

"2009 Virginia Forage-Beef Summit" Available on DVD

This past winter's *Virginia Forage and Grassland Council's Winter Forage Conferences* were well attended with more than 340 people participating in the "Virginia Forage-Beef Summits" that were held around the state. Topics included a keynote and closing address on changes happening in today's beef markets, cow size, efficiency, and profitability, setting stocking rates for profitable cow-calf operations, and building and maintaining soil fertility in times of high input costs. 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 DVD. All you need to do is to slip the DVD 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 this year's or last year's winter conferences, please contact Margaret Kenny at 434-292-5331 or makenny@vt.edu.

Notices and Upcoming Events

January 18-23, 2010
Delaware Ag Week, Harrington, DE. Contact Emmalea Ernest at 302-856-7303 or email: emmalea@udel.edu

> **Delaware—Maryland Hay and Pasture Day (1/19/10), Evening Program for Part-time Hay and Pasture Producers (1/18/10), Equine Pasture and Nutrient Management Session (1/19/10), and Agronomy/Soybean Day (1/21/10)**

January 20, 2010
Southern Maryland Hay and Pasture Conference, Izaak Walton League Center near Waldorf, MD. Registration will be $15 per person before January 15 and $20 after the 15th. Checks should be made payable to University of Maryland and sent to Mr. Ben Beale at Ben Beale at 301-475-4481, University of Maryland Extension, PO Box 663, Leonardtown, MD 20650 or on the Web at http://www.mdforages.umd.edu

January 21, 2010
Tri-State Hay and Pasture Conference, Garrett College, McHenry, MD (near Deep Creek Lake). Registration will be $10 per person by January 15 and $12 after the 15th. Checks should be made payable to Garrett EAC and sent to Forage Conference, University of Maryland Extension, 1916 Maryland Highway, Suite A, Mtn. Lake Park, MD 21550 or by phone at 301-334-6960. Program information is available on the web at http://www.mdforages.umd.edu

January 25-28, 2010
Virginia Winter Forage Conferences
- Monday, January 25th at the Brandy Station Fire Hall, Brandy Station VA
- Tuesday, January 26th at Mrs. Rowe's Country Buffet, Mt. Crawford, VA
- Wednesday, January, 27th at the Southern Piedmont Agricultural Research and Extension Center, Blackstone, VA
- Thursday, January 28th at the Wytheville Meeting Center, Wytheville, VA.

For more information or to register for the conference, contact Margaret Kenny (makenny@vt.edu) at (434) 292-5331 or view the brochure at vaforages.org/wp-content/uploads/2009/10/2010-VFGC-Winter-Conferences-Beef-Brochure.pdf. The $25 early registration fee must be postmarked by Jan. 1, 2010. After New Year's, the registration fee is $35 per person.

March 5-6, 2010
Maryland Cattle Industry Convention/Hay & Pasture Conference , Sykesville, MD. For more information or registration contact Dr. Scott Barao, Executive Vice President, PO Box 259, Sykesville, MD 21784 or call 410-795-5309 (office), 443-745-1618 (cell), 410-795-5915 (Fax) or by email sbarao@marylandcattle.org More information will be posted on the web at http://www.marylandcattle.org/ when the program is finalized.

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/ Look for Mid-Atlantic Regional Agronomy Newsletter

or

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