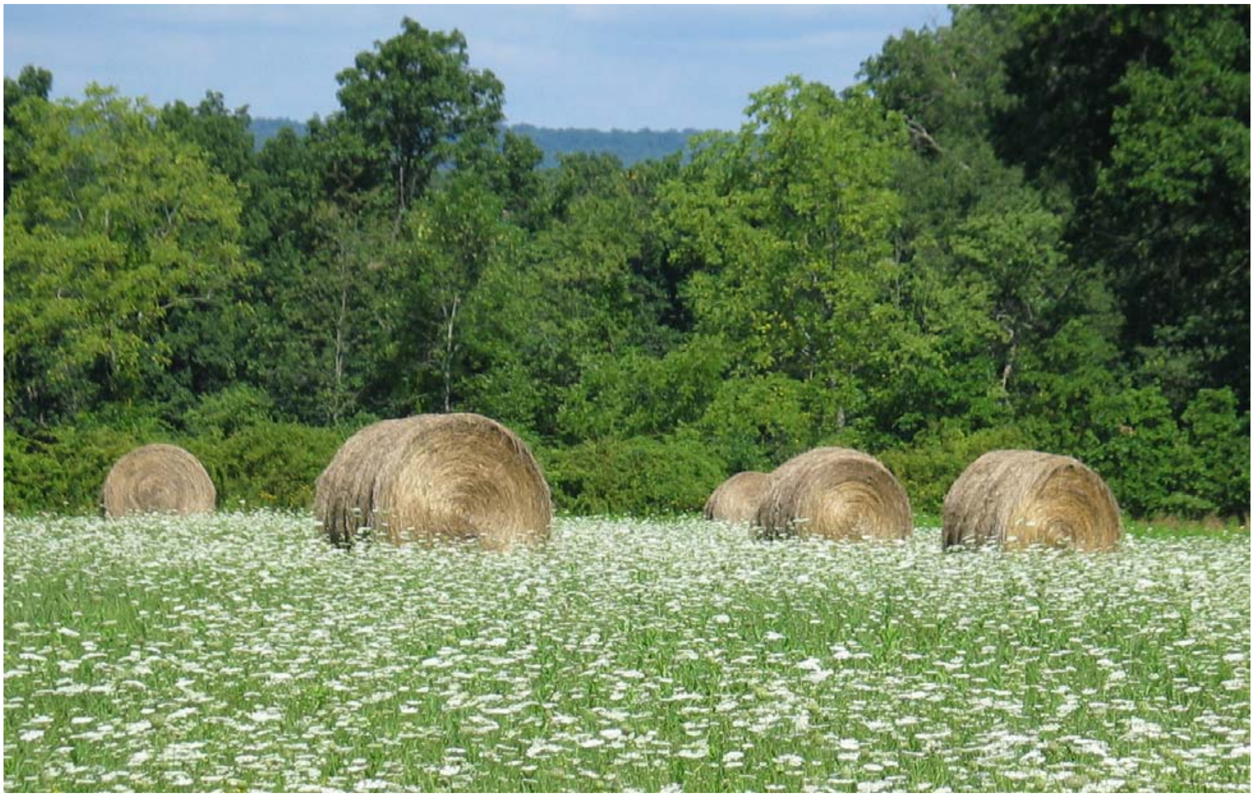

Mid-Atlantic Regional Agronomist Quarterly Newsletter

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To subscribe or unsubscribe, please send your request to the editor at rtaylor@udel.edu Comments, suggestions, and articles will be much appreciated and should be submitted at your earliest convenience or at least two weeks before the following dates: February 28, May 30, August 30, and November 30. The editor would like to acknowledge the kindness of Mr. Todd White who has granted us permission to use his scenic photographs seen on the front cover page. Please go to www.scenicbuckscounty.com to view more photographs.

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2013 Ohio Corn Performance Test: Regional Overviews

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In 2013, 240 corn hybrids representing 28 companies and 33 commercial brands were evaluated in the Ohio Corn Performance Test (OCPT). Four tests were established in the Southwestern/West Central/Central (SW/WC/C) region and three tests were established in the Northwestern (NW) and North Central/Northeastern (NC/NE) regions (for a total of ten test sites statewide). Hybrid entries in the regional tests were planted in either an early or a full season maturity trial. These test sites provided a range of growing conditions and production environments.

The 2013 growing season throughout much of Ohio was characterized by favorable conditions for corn growth and development. Rainfall was generally below normal in May but was near normal to well above normal in June and July, during mid-to-late vegetation stages, pollination, and early grain fill. Near normal to below normal temperatures in July and August mitigated the impact of dry conditions in August and Sept. At most test sites, rainfall was below normal in Sept. and above normal in October. Persistent rains in October delayed harvest at several locations. A severe wind storm on July 10 resulted in widespread root lodging and some localized green-snap damage. Plants in most root lodged fields recovered within 1 to 2 weeks after this wind event. Stalk and root lodging at harvest was generally negligible. However lodging was greater at test sites harvested after storms on October 31 that were accompanied by strong winds. Disease and insect pests were not a significant factor at most test sites. At Washington CH, gray leaf spot was severe but appeared late in the season.

Record high yields were achieved at most test locations due to ample and timely rainfall and moderate temperatures which created near stress-free growing conditions for most of the growing season. Averaged across hybrid entries in the early and full season tests, grain yields in the Southwest and West Central region and the North Central and Northeast region were 239 bu/A, whereas yields in the Northwest region were 248 bu/A. At the Hebron and Upper Sandusky test sites in the SW/WC/C and NW regions, respectively, there were several hybrids with average yields of 300 bu/A or greater. Performance data for South Charleston in the SW/SC region and Bucyrus in the NC/NE region are not presented. At these sites, excessive rainfall (S. Charleston) and wind damage (Bucyrus) created variable field conditions resulting in inconsistent yields.

Tables 1 and 2 provide an overview of 2013 hybrid performance in the early maturity and full season hybrid trials by region. Averages for grain yield and other measures of agronomic performance are indicated for each region. In addition, the range in regional test site averages is shown in parentheses. Complete results are available online at: http://www.ag.ohio-state.edu/~perf/ and http://www.oardc.ohio-state.edu/corntrials/ .

As you review 2013 test results, it's important to keep the following in mind. Confidence in test results increases with the number of years and the number of locations in which the hybrid was tested. Avoid selecting a hybrid based on data from a single test site, especially if the site was characterized by abnormal growing conditions (like drought stress and record high temperatures). Look for consistency in a hybrid's performance across a range of environmental conditions. Differences in grain moisture percentages among hybrids at harvest can provide a basis for comparing hybrid maturity. Yield, % stalk lodging, grain moisture, and other comparisons should be made between hybrids of similar maturity to determine those best adapted to your farm. Results of the crop performance trials for previous years are also available online at: http://www.ag.ohio-state.edu/~perf/archive.htm

Table 1. A regional overview of the early maturity 2013 Ohio Corn Performance Test.

Region	**Entries**	**Grain yield (Bu/A)**	**Moisture (%)**	**Lodging (%)**	**Emergence (%)**	**Final stand (plants/A) mean/range**	**Test weight (lbs/bu)**
SW/WC/C	67	234 (207-259)	18.4 (16.4-20.5)	0 (0-6)	96 (87-99)	37500 (33500-40900)	58.6 (54.6-61.5)
NW	67	246 (207-265)	17.3 (15.8-19.1)	2 (0-14)	96 (87-100)	36600 (30600-40800)	59.1 (54.9-61.3)
NE/NC	57	238 (222-255)	21.1 (17.5-24.0)	9 (0-45)	90 (75-96)	34900 (27200-38900)	55.6 (52.6-58.8)

Table 2. A regional overview of the full season 2013 Ohio Corn Performance Test.

Region	Entries	Grain yield (Bu/A)	Moisture (%)	Lodging (%)	Emergence (%)	Final Stand (plants/A) mean/range	Test weight (lbs/bu)
SW/WC/C	76	244 (224-262)	20.0 (18.3-23.6)	0 (0-1)	95 (87-99)	36200 (32700-41100)	58.0 (54.7-60.4)
NW	96	251 (217-273)	18.6 (16.5-20.8)	1 (0-10)	96 (88-99)	37100 (32600-41100)	58.8 (55.3-61.7)
NE/NC	61	240 (214-265)	23.7 (22.0-29.5)	6 (0-30)	93 (82-98)	35300 (31300-39700)	54.2 (51.3-58.6)

What is Enogen Corn?

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I've received several questions recently concerning "Enogen corn". This is a special type of corn developed by Syngenta for ethanol production. It contains a transgene from a bacteria that produces alpha amylase, an enzyme that breaks down corn starch into sugar. Presently alpha amylase enzyme is added to corn in a liquid form during the ethanol production process. Corn hybrids with the Enogen trait technology (i.e. Enogen corn) express alpha amylase enzyme directly in the corn kernel, eliminating the need for liquid alpha amylase in dry grind ethanol production. Various trade publications indicate that only 10-20% of an ethanol plant's total corn supply would need to be Enogen grain to produce the amount of alpha amylase required to break down corn starch to sugar.

According to Syngenta, use of the Enogen grain saves the cost of adding liquid enzymes, and facilitates the processing of higher dry solids levels, increasing yield and throughput (http://www.syngenta.com/country/us/en/agriculture/seeds/corn/enogen/about/pages/enogen-trait-technology.aspx). In addition Syngenta reports that use of Enogen grain results in measurable reductions in water, electricity and natural gas usage on a per gallon basis.
Enogen corn has been receiving attention locally because Syngenta recently announced it has signed a commercial agreement with Three Rivers Energy, LLC that operates the ethanol plant in Coshocton, Ohio, to use grain containing Enogen trait technology following the 2014 corn harvest. Syngenta has similar agreements with ethanol plants in other states. Farmers who grow Enogen under contract may receive premiums of about 40 cents per bushel over other corn. A local farm publication indicates that about 12,000 acres will be under contract in Ohio for the first year.

Unlike other transgenic corns introduced for insect and herbicide tolerance, Enogen corn was specifically developed for industrial purposes – ethanol production. A number of organizations ranging from the North American Millers Assoc. to the Union of Concerned Scientists opposed USDA's 2011 approval of Enogen hybrids. These organizations warned that mixing (comingling) of Enogen corn with corn used for food could have significant adverse impacts on food product quality and performance, e.g. crumbling corn chips (resulting from starch breakdown caused by alpha amylase activity in Enogen grain).

Syngenta has established a stewardship program to prevent contamination of commodity grain by Enogen grain (http://www.syngenta.com/country/us/en/agriculture/seeds/corn/enogen/stewardship/pages/stewardship-protocols.aspx). Management practices that farmers under contract would be required to follow include planting buffers of non-Enogen corn around fields planted to Enogen corn, storing the Enogen grain in separate bins, and cleaning planters and combines between uses.

Syngenta indicates that the agronomic performance of hybrids containing Enogen trait technology is similar to conventional (non-Enogen hybrids) and that Enogen hybrids with insect and herbicide tolerance traits are available. I'm not aware of any university/extension tests that have evaluated the performance of hybrids with and without the Enogen trait.

Chemical Management of Slugs in No-till Corn and Soybean Systems

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Introduction

Slugs continue to be a major pest of concern in no-till corn and soybean production systems. An integrated approach to slug management is being investigated by the Mid-Atlantic Working Group including the evaluation of current and new slug management options. The following report is a summary of chemical management studies in Delaware from 2010 through 2013.

Evaluation of Lannate LV to Control Slugs on Corn, 2010

In 2010, interest was expressed in evaluating the efficacy of Lannate (methomyl) LV for slug management in no-till corn systems. Although data from Europe indicated that Lannate LV may provide some level of slug control, no information was currently available in the United States regarding efficacy, length of control and the best timing for an application. A trial was conducted in a commercial no-till corn field with a history of slug problems. This trial was a cooperative effort between Don Ganske, DuPont Development Representative and Joanne Whalen and Bill Cissel, University of Delaware.

The objective of this trial was to evaluate the efficacy of Lannate LV (methomyl) to control slugs at three different application timings: 1) late evening, 2) after dark and 3) early morning. Plots 20 ft long by 9 ft wide were replicated four times and arranged in a randomized, complete block design. The trial was conducted in a commercial no-tillage corn field located near Middletown, DE. Corn was planted into heavy wheat-soybean stubble and slug pressure was rated as moderate to severe. Treatments were applied on 3-leaf stage corn using a CO_2 pressurized backpack sprayer equipped with a 6 nozzle boom on 18 inch spacing delivering 20 gpa at 35 psi. A one ft. x one ft. shingle trap was placed in the center of each of the plots in an attempt to estimate the slug population for each plot following the application of treatments. Visual slug counts were taken at night, 2 days after application by recording the total number of slugs found on 10 consecutive plants from each plot. Five days after treatment, 10 plants from each plot were examined for slug feeding injury on the newest emerged whorl leaves and the total numbers of slugs found under the shingle traps were recorded. Data were analyzed using Proc GLM and means were separated by Tukey's mean separation test (P=0.05)

Table 1. Slug Management with Lannate LV in No-Till Corn, 2010.

			Number Slugs per 10 Plants May 21 (2 DAT)		May 25 (5 DAT)		
					%	Number Slugs per Shingle Trap	
Treatment Timing	**Treatment**	**Rate/ Acre**	**Grey Garden**	**Marsh**	**Damaged Plant**	**Grey Garden**	**Marsh**
Early Evening (6:55 PM)	Lannate LV (2.4 SL)	1.5 pt	2.25b	0.00a	87.5a	1.25a	1.00a
Late Evening – (9:40 PM)	Lannate LV (2.4 SL)	1.5 pt	3.75b	0.25a	80.0a	0.25a	0.25a
Early Morning (5:15 AM)	Lannate LV (2.4 SL)	1.5 pt	2.75b	0.25a	100.0a	0.25a	1.25a
Untreated Check	--	--	24.5a	0.75a	92.5a	0.25a	0.75a

Means in the same columns followed by the same letter are not significantly different (Tukey's; P=0.05)

Conclusions: At two days after treatment, there were significantly fewer grey garden slugs in each of the treatments compared to the untreated check (Table 1). At five days after treatment, there were no significant differences between the treatments and untreated check for the percentage of plants with slug feeding injury and slug counts under the shingle traps. Overall, grey garden slugs were the prominent species causing damage to the corn plants. Although some level of control was observed, this study indicated that additional information is still needed to determine timing and length of control.

At all three application timings, weather conditions were favorable for slug activity on the plants. For the evening applications, slugs were present at both application timings because it was extremely still and there was free moisture on the leaves. We have observed that slugs are not out on plants at night even under slightly breezy conditions. For the morning application, weather conditions were foggy /dewy resulting in early morning slug presence on plants. This year's results lend support to the conclusion that Lannate LV acts as a contact material only and residual control is limited. It appears that slugs need to be present on the plants at the time of application to provide any level of suppression. However, more data was still needed to determine the best way to use Lannate LV as a slug management tool.

Evaluation of Lannate LV to Control Slugs in Corn, 2012

Joanne Whalen and Bill Cissel – University of Delaware

(1). Replicated Study: The unusually warm winter and spring conditions in 2012 were extremely conducive to slug problems. Since limited information was available on the proper application timing of Lannate LV as well as length of control for slug management in no-tillage corn systems, a second study was conducted in 2012. Plots were established in a field located near Wyoming, DE with heavy wheat-soybean stubble and history of severe slug problems. The field was treated with Deadline M-Ps on April 28 by the cooperating grower. An untreated strip was left in the most severely damaged section of the field and plots were placed in this strip. Plots 10ft wide (4 rows) by 17.5ft long were arranged in a randomized, complete block design with four replications. Treatments were applied on 2-3 leaf stage corn with a CO_2 pressurized backpack sprayer equipped with a 6 nozzle boom delivering 16.9 gpa at 40 psi.

Treatments consisted of (1) Lannate LV at 1.5 pt/acre applied at dusk (7:40 PM) on May 3, (2) Lannate LV at 1.5pt/acre applied at dawn (5:40 AM) on May 4 and (3) an untreated check. Slug populations were monitored at night by visually inspecting all the plants in the center two rows of each plot and recording the number of slugs. The predominant species was the grey garden slug. Pre-treatment damage assessments were done by looking at the damage on the entire plant. Post treatment damage assessments were performed by counting the number of plants with newly damaged whorl leaves in the center two rows of each plot. A plant was rated as damaged only if the newest emerged leaves had active slug feeding damage. Data were analyzed using Proc GLM and means were separated by Tukey's mean separation test (P=0.05).

Table 2. Slug Management with Lannate LV and Deadline MPs in No-till Corn, 2012.

			Percent Damaged Plants			**Mean Number Slugs/35 ft. of row**	
Treatment	**Rate/A**	**Application Timing**	**May 2 Pre-trt**	**May 7 4 DAT**	**May 10 7 DAT**	**May 2 Pre-trt**	**May 6 3 DAT**
Lannate LV (2.4SL)	1.5 pt	Dusk (7:40 PM)	79.33a	49.27ab	40.19a	5.25a	11.5a
Lannate LV (2.4SL)	1.5 pt	Dawn (5:40 AM)	87.82a	42.8b	45.94a	4.0a	9.75a
Untreated Check	---	---	87.77a	65.8a	53.92a	7.5a	15.0a
Deadline M-Ps	10 lbs (Apr.28)	Main Field by Grower	50.0 (April 27)	9.2 (May 3)	9.0 (May 17)	---	1/ 50 plantsl(May 6)

Means in the same columns followed by the same letter are not significantly different (Tukey's; P=0.05).

Conclusions: At four days after treatment, the percent damaged plants were significantly greater in the untreated check compared to the Lannate LV application applied at dawn (Table 2). Weather conditions were extremely foggy and dewy when the application was made at dawn and slugs were active on the plants. It was slightly breezy at the time of the dusk treatment and slugs were not active on the plants. The Lannate LV treatment applied at dusk was not significantly different from the untreated check for percent damaged plants. There were no significant differences between either treatment timing at seven days after treatment for the percent damaged plants and at three days after treatment for the number of slugs per 35ft row (Table 2).

Lannate LV appears to have provided some level of control when applied at dawn but not at dusk. This is due to the fact that slugs were active on the plants at dawn but not at dusk lending support to the fact that Lannate is providing contact control. It did not provide extended control as evidenced by the lack of difference in plant damage at seven days after treatment. Overall, slug pressure remained moderate to high regardless of the treatment timing and the percent damaged plants and severity of damage remained at levels that were capable of causing economic losses. As indicated in Table 2, the Deadline M-Ps applied by the producer to the main part of the field provided very good control as evidenced by the reduction in the number of plants damaged at 19 days after treatment and the low number of slugs present on 50 plants at 8 DAT.

(2) 2012 Lannate Grower Demonstration – Commercial Field: We also evaluated the effectiveness of a Lannate LV application in a second commercial field with heavy wheat-soybean stubble and history of severe slug problems near Dover, DE. In this field, Lannate LV and Deadline M-Ps were compared. Pre-treatment damage assessments were done by looking at the damage on the entire plant. Post treatment damage assessments were performed by counting the number of plants with newly damaged leaves. Two hundred plants were sampled for plant damage in each treatment area (10 consecutive plants in 20 locations). Treatments were applied on May 5 with the Lannate LV treatment being applied at 5 AM when slugs were active and the Deadline M-Ps being applied mid-day. Corn was in the one-leaf stage. The grower did not feel that the Lannate LV was providing control so decided to treat the Lannate LV demonstration area with Deadline M-Ps as well.

Table 3. Comparison of Lannate LV and Deadline MP-s in a Commercial Demonstration, 2012.

			Percent Damaged Plants	
Treatment	**Rate/A**	**Timing**	**Pretreatment – May 4**	**Post Treatment – May 7**
Lannate LV	1.5 pt	5 AM – May 5	71.3	82.0
Deadline M-Ps	10 lbs	Middle of the Day - May 5	67.0	20.0

Comments: Although replicated plots indicate that Lannate LV provides some level of control, Lannate LV applications in this commercial field in Delaware as well as commercial fields in Maryland and Virginia in 2012 resulted in poor control. In many cases, fields were re-treated with Deadline M-Ps with good results.

Overall Summary from 2010 and 2012 Results

As a general summary, information from replicated trials and grower experiences indicate that:

(a) Lannate LV may provide 2-4 days control maximum which can vary with weather conditions at the time of application.
(b) At 5-7 days after treatment in our two research trials, the percent damaged plants in the Lannate LV treated plots was not significantly different from the untreated plots. This would indicate that Lannate LV provides short residual control.
(c) Based on our results, Lannate is providing contact control only; and therefore, slugs must be present at the time of application.
(c) Additional information is needed on proper timing of Lannate applications related to weather conditions and slug activity.
(d) Based on observations in commercial situations, the Deadline M-Ps provided the most consistent control and provided longer residual control in both years. Lannate LV is providing some level of control, better than liquid nitrogen applied at night; however, more research is needed.

Chemical Control of Slugs in Corn and Soybeans, 2013

Joanne Whalen, Bill Cissel and Phillip Sylvester – University of Delaware

In addition to metaldehyde, there are now a number of iron-based products with federal labels for slug management including Sluggo, Ferroxx and IronFist. Sluggo and IronFist have federal and state labels and have recently been marketed in our area. In 2013, Ferroxx had a federal label but did not have a state label. Limited local replicated data is available for the use of these products in corn and soybeans. Therefore, trials were established in corn and soybean systems to compare these products to both metaldehyde (Deadline M-Ps) and Lannate LV. The soybean trials were supported by the Delaware Soybean Board.

(1) Chemical Control to Manage Slugs in Field Corn: Replicated research plots were established on a commercial no-tillage corn field with a history of slug problems located near Middletown, DE. Plots were 20 ft long by 15 ft wide, arranged in a randomized, complete block design with four replications.

Treatments consisted of (1) Lannate LV at 1.5 pt/A, (2) Sluggo at 20 lb/A, (3) Iron Fist at 20 lb/A, (4) Ferroxx at 20 lb/A, (5) Deadline M-Ps at 10 lb/A, and (6) an untreated check. Treatments were applied on May 9 to spike stage corn with severe slug feeding damage. The Lannate LV treatment was applied at dusk (8:45 pm) using a CO_2 pressurized backpack sprayer equipped with a six nozzle boom on 18 inch spacing delivering 16.9 gpa at 40 psi. There was no measurable wind speed with high relative humidity, making the weather conditions favorable for slug activity at the time the Lannate LV application was made. The dry formulations were broadcast using a hand seeder calibrated for each product. The percent damaged plants was determined by examining every plant in the center three rows of each plot and noting feeding injury on the newest emerged whorl leaves.

At 25 days after treatment (DAT), plant vigor was evaluated by measuring the height of five consecutive plants in each of the center three rows of each plot. Yield was determined by hand-harvesting the ears from the center two rows of each plot on September 9. The ears were shelled and kernel weight was adjusted for moisture using a Dickey John moisture tester.

Table 4. Chemical Control to Manage Slugs in Field Corn, 2013: Percent Damaged Plants.

		Percent Damaged Plants*				
Treatment	**Rate/A**	**May 8 Pre-Treatment**	**May 13 4 DAT**	**May 16 7 DAT**	**May 21 12 DAT**	**June 3 25 DAT**
Lannate LV	1.5 pt	91[a]	77[a]	88[a]	100[a]	65[a]
Sluggo	20 lb	79[a]	49[ab]	64[ab]	90[a]	48[ab]
Iron Fist	20 lb	87[a]	42[b]	40[bc]	89[a]	26[ab]
Ferroxx	20 lb	91[a]	56[ab]	54[abc]	87[a]	36[ab]
Deadline M-Ps	10 lb	74[a]	34[b]	13[c]	31[b]	10[ab]
Untreated check	--	74[a]	76[a]	91[a]	100[a]	40[b]

*, Means in the same columns followed by the same letter are not significantly different (Tukey's; P=0.05).

Conclusions: At 4 and 7 days after treatment, the percent damaged plants were significantly greater in the untreated check compared to the Deadline M-Ps and Iron Fist treatments (Table 4). At 12 days after treatment, only the Deadline M-Ps treatment had significantly fewer damaged plants compared to the untreated check. There were no significant differences between the average plant height and yield when comparing all treatments to the untreated check.

(2) Chemical Control to Manage Slugs in Soybeans: The following study was funded by the Delaware Soybean Board. Slug management in no-tillage soybeans can be a challenge because slugs often feed below ground, severing the hypocotyl and killing the plant before it has a chance to emerge. Usually, the problem is not identified until the soybeans have failed to emerge, at which point the field has likely experienced a significant stand reduction.

Rescue treatments to prevent additional stand losses and damage to emerged plants has traditionally included a broadcast application of metaldehyde bait (e.g.Deadline M-Ps). There are additional available slug management products in the marketplace but there is limited local data evaluating efficacy of these products in soybeans. As a result, two replicated research trials were established to evaluate efficacy of the available slug control products to manage slugs in soybeans.

The first trial was established on a commercial soybean field located near Middletown, DE with severe above and below ground slug feeding. The objective of this trial was to evaluate each of the products ability to control slugs as a rescue treatment.

The second trial was established in a soybean field located at the Delaware State University's Smyrna Outreach and Research Center with a history of slug problems. The objective of this trial was to evaluate the efficacy of each of the products applied preventatively when conditions are favorable for slug activity and the likelihood of having a problem is high.

(A) Soybean Trial 1: Rescue Treatment

Replicated research plots were established in a commercial no-tillage soybean field with severe slug pressure. At the time of treatment, there was both below ground and above ground slug feeding on the soybean plants. Plots were 15 ft wide x 20 ft long arranged in a randomized, complete block design with four replications.

Treatments included (1) Lannate LV at 1.5 pt/A, (2) Sluggo at 20 lb/A, (3) Iron Fist at 20 lb/A, (4) Ferroxx at 20 lb/A, (5) Deadline M-Ps at 10 lb/A, and (6) an untreated check. The Lannate LV treatment was applied on June 4 at 5:15 pm using a CO_2 pressurized backpack sprayer equipped with a 6 nozzle boom delivering 16.9 gpa at 40 psi. It was hot and sunny with an average wind speed of 4.7 mph, making the conditions unfavorable for slug activity at the time the Lannate LV application was made. The dry formulations were made using a hand seeder calibrated for each of the products.

Pre-treatment and post-treatment evaluations included stand counts and percent damaged plants. Stand counts were determined by counting the total number of plants in the center two rows of each plot and reported as plants per acre. The percent damaged plants was determined by examining the number of plants within the center two rows with slug feeding damage on the newest growth. Yield was calculated by harvesting the center two rows from each plot and reported as grams per plot.

Table 5. Soybean Trial 1 (Rescue Treatment), 2013: Stand Counts.

		Stand Count (plants per acre)*				
Treatment	**Rate/A**	**June 4 Pre-Trt**	**June 10 6 DAT**	**June 13 9 DAT**	**June 18 14 DAT**	**June 26 22 DAT**
Lannate LV	1.5 pt	83,823[a]	68,389[a]	80,150[a]	79,715[a]	68,389[a]
Sluggo	20 lb	69,117[a]	77,972[a]	90,605[a]	87,991[a]	90,605a
Iron Fist	20 lb	73,529[a]	63,162[a]	59,242[a]	79,715[a]	72,745[a]
Ferroxx	20 lb	67,647[a]	84,942[a]	90,605[a]	90,605[a]	95,832[a]
Deadline M-Ps	10 lb	67,647[a]	75,975[a]	87,991[a]	90,605[a]	95,832[a]
Check	--	80,882[a]	56,193[a]	59,242[a]	60,984[a]	61,855[a]

*, Means in the same columns followed by the same letter are not significantly different (Tukey's; P=0.05).

Table 6. Soybean Trial 1 (Rescue Treatment), 2013: Percent Slug Damaged Plants.

		% Slug Damaged Plants*				
Treatment	**Rate/A**	**June 4 Pre-Trt**	**June 10 6 DAT**	**June 13 9 DAT**	**June 18 14 DAT**	**June 26 22 DAT**
Lannate LV	1.5 pt	71.2[a]	83.4[a]	46.3a	42.0[ab]	34.2[a]
Sluggo	20 lb	92.6[a]	64.1[a]	20.5[c]	36.1[b]	21.8[ab]
Iron Fist	20 lb	79.9[a]	50.4[a]	22.1[bc]	35.0[b]	18.6[ab]
Ferroxx	20 lb	92.9[a]	58.4[a]	20.1[c]	30.8[bc]	21.3[ab]
Deadline M-Ps	10 lb	65.6[a]	55.0[a]	17.7[c]	15.2[c]	9.6[b]
Check	--	74.6[a]	88.1[a]	44.8[ab]	56.6[a]	28.8[a]

*, Means in the same columns followed by the same letter are not significantly different (Tukey's; P=0.05).

Conclusions: There were no significant differences between treatments for stand count at any of the sampling dates (Table 5). In addition, no significant differences in yield were found between the treatments and the untreated control. At 9 days after treatment, the Sluggo, Ferroxx, and Deadline M-Ps treatments had significantly fewer plants with slug feeding damage compared to the untreated check (Table 6). At 14 days after treatment, the percentage of plants with new feeding damage was significantly less for all the treatments compared to the untreated check except the Lannate LV treatment. The Deadline M-Ps treatment provided the greatest length of control being the only treatment that was significantly different compared to the untreated check for the percentage of damaged plants at 22 days after treatment.

(B) Soybean Trial 2: Preventative Treatment

This trial was conducted to determine if a preventative treatment can be applied prior to plant emergence to reduce losses from slugs. This trial was established in a soybean field located at the Delaware State University's Smyrna Outreach and Research Center with a history of slug problems. The field was determined to be at risk for slug problems based on field history, pre-plant slug sampling results, and favorable weather conditions for slug activity at the time of planting. Plots were 15 ft wide x 20 ft long arranged in a randomized, complete block design with four replications.

The treatments included (1) Sluggo, (2) Iron Fist, (3) Ferroxx, (4) Deadline M-Ps, and (5) an untreated check. Treatments were applied on June 25 prior to plant emergence using a hand seeder calibrated for each product. The percent damaged plants was determined by counting the total number of plants and the number of plants with new slug feeding damage in two random, three foot sections per plot. Slug pressure was low to moderate and shortly after plant emergence, the weather conditions quickly became less favorable for slug activity.

Table 7. Soybean Trial 2 (Preventative Treatment), 2013: Percent Damaged Plants.

Treatment	Rate/Acre	Percent Damaged Plants* July 3 8 DAT	July 11 16 DAT	July 17 22 DAT
Sluggo	20 lb	6.8[a]	0[a]	0[a]
Iron Fist	20 lb	9.1[a]	0[a]	0[a]
Ferroxx	20 lb	3.7a	0[a]	0[a]
Deadline M-Ps	10 lb	3.2[a]	0[a]	0[a]
Check	--	35.8[b]	0[a]	0[a]

*, Means in the same columns followed by the same letter are not significantly different.

At 8 days after treatment, all of the treatments had significantly fewer damaged plants compared to the untreated check (Table 7). However, at 16 and 22 days after treatment, there was no new slug feeding damage on any of the plants, regardless of the treatment. The drastic reduction in slug activity is likely a result of the hot weather conditions that may have caused slugs to move deeper in the soil profile and caused the plants to grow rapidly. Additional data needs to be collected to determine if this is a suitable management strategy when weather conditions are favorable for slug activity over prolonged periods of time and under heavy slug pressure.

Frost Seeding Pays Big Dividends

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Frost seeding, also called overseeding, is an excellent way to incorporate legumes into a pasture. Preparation for frost seeding starts in the previous growing season. Pastures that will be frost seeded need to be grazed close prior to seeding. Since the seed is broadcast, there must be spots of bare soil showing so that there is soil/seed contact. If there is residue on the soil, it will be difficult for the seed to reach the soil and the young seedlings to grow through the residue.

There are several advantages of frost seeding legumes into grass pasture. Yields are higher with grass-legume mixtures. There will be higher tolerance to drought if a legume with a taproot (e.g. red clover) is seeded into the pasture. Legumes fix nitrogen which is used for fertilizer in grasses. By incorporating legumes into a grass pasture there will be a major reduction in fertilizer costs because no additional nitrogen is needed if legumes make up 30% of the total sward on a dry matter basis. Past research has shown that legumes increase animal performance by increasing forage quality of pasture swards. Even more important to producers in Virginia is the dilution effect from adding legumes to endophyte infected tall fescue stands. The addition of legumes increases animal performance and improves conception rates.

Seed selection is important to insure that the frost seeding generates a stand. Alfalfa does not frost seed as well as white and red clover and should be drilled if possible. Red and white (ladino) clovers work well in frost seeding. Red clover is a key pasture legume because it is easily established with frost seeding. It is a short lived perennial with of a life of 2-3 years. One disadvantage of red clover is that it does not self-reseed consistently. White clover is well adapted to short, close grazing and produces high quality forage. Another important advantage of white clover is that it re-seeds. There are three types of white clover available, common or Dutch, intermediate or grazing type, and ladino or large type. The use of intermediate or ladino types is recommended. The ladino types will produce 3-5 times as much dry matter compared to the common white clover. Although the intermediate white clovers producer less dry matter than the ladino types, they tend to be more tolerant to grazing.

The seeding rates on a per acre basis are as follows: red cover 8-10 pounds and white clover 1-2 pounds (VA Tech Agronomy Handbook, 2000). A mixture of red and white clover is often used at a rate of 4-6 lb./A and 1-2 lb./A for red and white clover, respectively. The cost of frost seeding a mixture of red and white clover is approximately $30 per acre (Table 1). The value of the nitrogen fixed by this clover mixture will be around $100 to 120/A/year (Table 2). It is important to remember that clover shares its nitrogen with the grasses in pastures indirectly. In a healthy grassland ecosystem ruminant livestock graze legumes and then deposit the nitrogen back onto the pastures in the form of dung and urine. With good grazing management a strong and vigorous nutrient cycle develops overtime.

Soil fertility plays a major role in determining the success of frost and the maintenance of clovers in pastures. A current soil test takes out the guesswork and prevents the producer from under or over-applying lime and fertilizer, either of which will decrease your efficiency and profitability. Virginia Tech soil test laboratory recommendations are based on research conducted for Virginia soils and climate. “Red and white clovers require soil pH levels from 6.0-6.4 while alfalfa requires a pH of 6.8 or higher. Fertility levels for phosphorus and potassium should be in the med+ to high- ranges.” [(1)] Soil testing needs to be done in the fall prior to seeding. Lime may be applied in the fall to bring pH up to desired levels. The table below lists value and amount of nitrogen fixed by several legumes.

Table 1. Cost of frost seeding legumes.

Crop	**Seeding rate Lb./acre**	**Seed cost $/Lb.**	**Total seed cost ($)**	**Spreading cost ($)**	**Total cost $/acre**
Red clover	10	2.40	24	10	34
White clover	2	4.00	8	10	18
Red and white	5 and 2, respectively	2.40 and 4.00	20	10	30

Table 2. Value and amount of nitrogen fixed by various legumes[2].

	N fixed	**N value, $, @**		
Crop	**Lb./acre/year**	**0.55/Lb. N**	**0.65/Lb. N**	**0.75/Lb. N**
Alfalfa	150-250	$83-138	$98-163	$113-188
Red clover	75-200	$42-110	$49-130	$56-150
White clover	75-150	$42-83	$49-98	$56-113

Frost seeding is generally done in late winter since freezing and thawing of the soil is required to incorporate the seed into the soil. There must be good seed/soil contact for the seed to germinate and produce a viable seedling. In Virginia, pastures should be frost seeded starting in early February and ending in early March.

Frost seeding legumes enables producers to improve the quality and yields of their pastures. Furthermore by maximizing grazing efficiency, producers can maximize recycling of nitrogen, phosphorus and potassium that will reduce purchase fertilizer inputs for their pastures.

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A Few Do's and Don'ts When Frost-Crack Seeding Pastures

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As a new year begins and winter advances, it is not too early to begin to think of improving your pasture's productivity, quality, and percentage ground cover (soil coverage). One inexpensive method of accomplishing these goals is to frost-crack seed legumes in late winter or very early spring. The legumes most suitable for use in frost-crack seedings are ladino and white clover, alsike clover although do not use this species in pastures where horses graze, red clover, and possibly birdsfoot trefoil (also not recommended for horse pastures). Large seeded legumes such as the grazing-type of alfalfa are not successfully frost-crack seeded.

Legumes contribute higher protein levels to pastures, share nitrogen with companion pasture grasses, raise digestible energy levels, add diversity to the pasture ecosystem, and improve the mineral uptake/balance in pasturage. Legumes, especially ladino/white clover, will improve soil protection as well.

If you are considering frost-crack seeding to thicken or improve your pastures, then a review of some of the dos and don'ts that apply to this practice is in order.

Do's:

- Plan ahead and obtain the needed seed and rhizobia inoculant by early February

- Use either fresh (with an unexpired expiration date) rhizobia inoculant on the legume seed or use lime-coated pre-inoculated seed that is not more than 9 months since it was inoculated and lime coated. If older than 9 months, new inoculant should be applied just prior to seeding using a commercial sticking agent.

- Choose the legume species or variety best adapted to your location and grazing style.

- Frost-crack seed at the end of winter or in early spring when daytime temperatures are above freezing and nighttime temperatures fall below freezing so that the surface soil goes through freezing and thawing cycles that will help work the small seeds into the top few millimeters of soil.

- Closely mow the area or heavily graze the area before seeding to remove any excess vegetation and maximize sunlight penetration to the soil surface.

- After seedling emergence in the spring, watch the new seedlings closely and mow the pasture to the height of the legume if the pasture grasses begin to significantly shade the new seedlings.

Don'ts:

- Do not attempt frost-crack seedings with large seeded legumes and grasses. Although small seeded grasses such as timothy and very vigorous grasses such as ryegrass and festulolium have been frost seeded successfully according to producer reports, results have been very variable and probably would not justify the seed expense.

- Do not mix inoculated seed with fertilizer since many fertilizers will cause salt injury to the rhizobia bacteria and often kill the bacteria due to osmotic pressure.

- Do not broadcast seed on snow covered pastures.

- Do not broadcast seed just prior to a predicted or expected snow, ice, or rain storm since the risk of seed loss is great if runoff occurs.

- Do not mow or graze below the height of the newly establishing seedlings until the anchoring root system is well established and sufficient top growth has occurred to sustain the seedlings.

Also consider using a no-till drill to incorporate or improve a legume component in the pastures. No-till legume seedings are more frequently successful than frost-crack seedings. Some producers report additional recruitment of new legume seedlings in the second spring following an initial frost-crack seeding. Many legumes contain a significant proportion of hard seed that is broken during the following winter period permitting the seed to germinate the second spring following frost-crack seeding.

Regardless of your method, your goal should be to maintain at least 70% soil coverage in your pastures and hay fields to ensure you protect your soil resource, maintain pasture productivity, and reduce the incursion of weed species.

Feeding Value of Brown Midrib (BMR) Corn in Ruminants

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Introduction

Corn is the most widely used forage crop in the U.S. and corn silage usually comprises the bulk of the roughage portion of dairy diets. Corn is a popular forage crop because it is high-yielding, very palatable to animals, high in energy content, relatively easy to grow and preserve as silage, and is well-adapted to mechanization from planting to feeding.

Brown midrib (BMR) is a genetic trait found in corn and a number of forage species [i.e. sorghum, sudangrass, pearl millet, and now alfalfa (not technically the same trait but new varieties with low lignin concentration are becoming available)] and is characterized by plants having lower lignin content. Corn plants with the BMR trait show reddish to brown pigmentation of the center midrib on the underside of the leaf and thus the name 'BMR' was coined from this phenotypic trait for grasses with this type mutation in the lignin biosynthesis pathway. In grasses, the pigmentation or color starts to become visible in plants at the 4-6 leaf stage. The color is also seen in the stem as lignification becomes apparent in rind and vascular bundles. Leaf pigmentation fades as the plant matures but remains in the stalks. Although the trait is considered as recessive (the recessive gene must be expressed on both pairs of the chromosome for the full effect to occur), whole plant corn containing any of the BMR genes will always exhibit the reddish brown coloration on the leaf and stalks.

Occurring as a natural mutation, the first BMR corn was discovered in 1924 from a 1-yr self-pollinated line of northwestern dent corn at the University of Minnesota. The impact of this gene comes about since it involves changes in the expression of certain enzymes involved in lignin biosynthesis. In effect, the BMR gene interferes with lignin production in the plant and results in these forages having lower lignin content than their conventional counterpart. The BMR gene has little to no effect on the concentration of other important plant quality components in corn such as crude protein (CP), neutral detergent fiber (NDF)—often associated with voluntary intake, acid detergent fiber (ADF) and ash.

To date, four BMR mutant genes called alleles have been identified in corn and have been labelled *bm1*, *bm2*, *bm3*, and *bm4*. Each mutated allele has different impacts on the production of lignin which is a very complex pathway. However at the current time, most BMR corn hybrids used and commercialized by the seed industry have the *bm3* allele that generally induce lower lignin concentrations and higher NDF digestibility than the other *bm* genes.

For over 35 years, numerous research studies in ruminant nutrition have studied the use of corn hybrids with the low lignin (BMR) trait. Following will be a review of some of the benefits and drawbacks on the use of BMR corn in ruminant nutrition. The article will also try to provide some suggestions on how BMR corn can be successfully used in dairy production systems.

Lignin Composition and Plant Function

What is lignin and what is its function in plants? Lignin is an important highly complex compound found in plants and makes it possible for non-aquatic (dry land) plants to exist. Of the biopolymers found in plant cell walls, lignin is the only one that is not composed of carbohydrate (sugar) monomers. Instead, lignin is made up of complex polymers of aromatic alcohols (coumaryl, coniferyl and syringyl alcohols) known as monolignols. How these alcohols bond to each other is quite variable so lignin is often a mixture of many different complex molecules and lacks a defined primary structure. Lignin works with the other cell wall fiber components such as cellulose to provide a structural function in plants that could be analogous to that of epoxy resin (the lignin) and glass fibers (cellulose/hemicellulose) in a fiberglass boat. Lignin is providing the stiffness and rigidity to the cell wall but in the process it reduces the digestibility of these fibers for ruminant animals. Another function of lignin is that it prevents the absorption of water by cellulose and hemicellulose and therefore allows the efficient transport of water in the vascular tissues. Lignin also helps form a barrier against attack by insects and fungi.

How does the amount and composition of lignin vary among plants? Each species, sometimes even within hybrids/varieties, vary in lignin concentration and composition with developmental stage and environmental conditions. High temperature favor rapid growth and this accelerates the degree of lignification in plants. Most recently genetics has become important in determining the impact of lignin on plant growth and quality.

Plant synthesis of lignin is thought to be an essential evolutionary adaptation as plants transitioned from an aquatic to a land environment. Lignin differs from cellulose and hemicellulose in the cell walls by being hydrophobic and this plus the crosslinking of lignin with other cell wall components restricts water absorption to the cell wall and makes it possible for the vascular tissue to conduct water efficiently in plants. Lignin also provides mechanical support for stems and leaves and by wrapping together the cellulose and hemicellulose components in the cell walls, lignin provides the structural strength and rigidity needed by plant cell walls. Unfortunately, this binding process also impacts forage quality for the ruminant animal. The lignin acts as an antiquality factor by restricting the access ruminant microbes have to the bonds between the sugar molecules (polysaccharides). By limiting the enzymatic action of the ruminal microbes, lignin reduces the overall digestibility of the fiber or NDF fraction of forages and thus limits the amount of potential energy that ruminant animals can obtain from cellulose and hemicellulose.

Effects of Feeding BMR Corn Silage in Dairy Production

Since the discovery of BMR corn, a number of studies have been conducted to assess and compare its nutritive value with that from non-BMR corn silage. The initial work showed that the trait not only reduced the lignin content in the silage but this was accompanied with improvements in fiber digestibility measured both *in vitro* (in the laboratory) and *in vivo* (in the animal). The research from the late 1970's into the late 1990's showed that the *bm3* allele mutation used in commercial hybrids was lowering the lignin content by about 1.1 percentage units and was increasing the *in vitro* NDF digestibility by 8.4 percentage units over that in non-BMR corn silage hybrids.

For example, silage from BMR corn stover increased voluntary dry matter intake, dry matter digestibility, cell wall and ADF digestibility, and increased the energy content of the corn stover when fed to lambs and as compared to non-BMR corn stover silage. For wether sheep fed corn silage from whole plant or stover corn, the digestibility of dry matter (DM), energy, ADF, NDF, and cellulose was greater for BMR corn than for that of non-BMR corn. Likewise, feeding trials conducted in dairy heifers showed improvements in dry matter intake (DMI) and digestibility of DM, cell wall and nutrients, average daily gain and feed efficiency in favor of BMR corn. Beef cattle as feedlot steers or heifers when fed BMR and non-BMR corn silage also showed that intake, average daily gain (ADG), and feed efficiency was higher for feedlot cattle fed the BMR corn silage when diets contained no supplemental concentrate. Addition of concentrate supplement at 2% of body weight (BW) to both corn silage treatments reduced the advantage of BMR corn over non-BMR corn to an insignificant level. In this latter study, the authors suggested that the rumen microorganisms preferentially used the more readily available energy in starch before using the energy of the fiber components of the cell wall.

Most of the studies on BMR corn silage have been conducted on dairy cows since they have a specific requirement for fiber; and of the ruminant classes of livestock, dairy cows have the highest requirement for energy and nutrients. Thus, dairy cows need to consume substantial amounts of feed to meet the nutrient demands involved in producing milk. The difficulty comes about in that the fiber provided by forages in the dairy cow diet usually limits voluntary feed intake since there is a positive relationship with feed bulk density and ruminal physical fill. When the rumen has reached the maximum capacity for physical fill, movement of digesta out of the rumen must occur before intake can resume. Therefore, forages that contain the BMR trait with its enhanced fiber or NDF hydrolysis have been of interest to researchers and dairy producers since the discovery of the BMR traits.

In much of the literature, dairy cows fed brown midrib corn silage showed greater feed efficiencies and higher actual and fat-corrected mild yield than cows fed conventional or non-

BMR corn silage. Several researchers have also found that cows that have a higher milk yield to begin a study responded better to the brown midrib corn silage. Work at the University of Delaware also showed that cows fed BMR corn silage had better performance than cows fed even high-cut corn silage (leaving an 18 to 20 inches of plant stalk at harvest) or the normal low-cut silage (leaving 4 to 6 inches of plant stalk).

Transition cows have been shown also to benefit from brown midrib corn silage diets. The positive effects of feeding BMR corn silage during the transition period persisted and resulted in substantial carry-over effects after cows returned to non-BMR corn silage diets. Moreover, cows fed brown midrib corn silage had tendencies for reduced immune-mediated disorders, somatic cell counts, and linear score during the transition period.

Disadvantages of Using BMR Corn in Dairy Production

Although characteristics from the brown midrib trait have been shown to be beneficial to cows, the low lignin content of BMR corn confers some adverse effects on various agronomic traits of the plant. BMR corn has been seen to have reduced early hybrid vigor and standability as well as increased susceptibility to lodging and stalk breakage. In general, the BMR trait is not used in corn hybrids grown for grain but is more suited for use in those hybrids recommended for silage production.

Reduction in total dry matter yield with BMR corn hybrids has also been observed and can be a significant cause for concern to dairy farmers. Overall in the studies conducted on BMR corn, the BMR hybrids produce 10 to 15 percent less dry matter compared with their non-BMR conventional counterparts. Some studies report substantially higher yield reduction such as a 31 percent lower yield for BMR corn versus non-BMR corn found at the University of Delaware by Lim et al. (2012). Generally, BMR corn hybrids do not handle stress conditions as well as the non-BMR corn hybrids. Variability in yield reduction using BMR corn hybrids is possibly associated with topographical features, soil type, and agronomic practices employed. In brief, concerns with lower yield per unit of land planted with BMR corn hybrids exist and do pose production risk especially to dairy producers that have limited land for forage production.

Conclusions

The lower lignin content and more digestible fiber fraction of BMR corn silage speeds digestion and improves the proportion of the cellulose and hemicellulose that the rumen microorganisms can digest. This provides the dairy cow with additional energy possibly satisfying its energy requirements with less feed. This nutritional characteristic of BMR corn silage is very beneficial especially for high-producing dairy cows whose high energy demands must be met by higher intakes. This attribute of BMR corn silage is an advantage to cows in the early or peak lactation stage. These cows are usually in negative energy balance because voluntary dry matter intake lags milk production.

Because of the high fiber digestibility, BMR corn silage can offer an advantage of formulating diets with a higher forage to concentrate ratio. This can reduce the high cost of grain inputs. Higher forage to concentrate ratio diets can reduce the cases of subacute ruminal acidosis and other metabolic disorders. Savings from reduced veterinary costs, unwanted culling, and the purchase of replacement heifers can occur. Feeding the highly digestible corn silage from BMR hybrids can reduce manure output and improve the farm nutrient management efficiency.

Still the reduced yield potential of BMR corn hybrids is an obvious reason why BMR corn usage has not been widely adapted. Although the low yield associated with BMR corn silage hybrids is partially offset by its high feeding value, the farmer must be assured of adequate forage production on the farm. A careful audit of the supply of land on which to grow forage, the quality of the soil on this land, and on-farm yield evaluations to determine a realistic yield potential for BMR corn hybrids will be necessary wherever the supply of land available for forage production is considered not to be adequate for full adoption of BMR corn hybrids. Limited land will dictate whether the farmer can totally or partially allocate land to producing BMR corn silage.

Lim et al. (2012) did find that one possible approach is to interplant BMR corn hybrids with conventional or non-BMR corn hybrids. Interplanting alternate rows of BMR corn and non-BMR corn increased the dry matter yield by 15 percent; and when this 50:50 silage mix was fed to dairy cows, the cows consumed less dry matter (about 3.3 lb/day) but produced a similar amount of milk (106 lb milk/day) as compared with cows fed 100 percent non-BMR corn silage. Interplanting BMR and non-BMR corn hybrids of similar maturity may be a feasible practice to reduce the risk of low yield associated with planting pure BMR corn silage stands and yet still maintain a higher efficiency of production.

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Energy Intake, Adiposity (Body Condition) and Average Daily Gains: Metabolic/Nutrient Interactions with Reproductive Function Driving Onset of Precocious Puberty in Beef Heifers

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Introduction

Age at the onset of puberty is highly related to prepubertal energy intake and average daily gains. Indeed, nutrient restriction during the often forgotten or neglected post natal period, stall growth, delays onset of reproductive maturity, and the onset of cyclicity and fertility in heifers. Important work over the past 4-5 years has begun to delineate pathways whereby centers sensing nutrient and metabolic status interact with higher centers in the brain orchestrating follicle growth, maturation and ovulation in the gonads (Amstalden et al., 2011).

Work across a variety of animal species strongly indicates these higher centers of neurologic and endocrine function in the brain are anatomically integrated and impacted by nutrient status very early in the neonatal and prepubertal adolescent periods of growth. As a result, the onset of puberty in heifers is quite sensitive to nutrient and metabolic input very early in life. The nutrient effect can augment the onset of puberty before 300 days in heifers undergoing high rates of average daily gain (ADG) or delay the onset of puberty past 300 days in heifers experiencing lower ADG. Importantly, the data shows heifers can consume sufficient energy to drive different rates of gains in body weight but only those achieving *high rates* of ADG achieve precocious puberty. Growth *per se* is not the issue. Thus nutrient levels high enough to sustain high rates of growth during the 3-7 months of prepubertal development is a key factor (Gasser et al., 2006a, 2006b, 2006c, 2006d).

Production Implications of Precocious Puberty

The onset of reproductive maturity results from the integrated activities of the endocrine and nervous systems in heifers (Amstalden et al., 2011). Attaining puberty in an early and timely fashion increases profitability and productivity in the beef industry. Typically, beef heifers are weaned by 7 months of age and then receive minor amounts of nutritional, health and pasture management until breeding. The end result can be low average daily gains and costly delays in the onset of puberty. Newer strategies of management show calves weaned at 4 months of age and fed to achieve high rates of ADG will achieve early onset of puberty as early as 9-10 months of age enabling high fertility at the time of breeding at 14-15 months. Onset of puberty in beef heifers is affected by genetic factors as well as environmental elements such as nutrition, housing, peri- and postnatal health management and growth rates. Heifers with accelerated growth rates and ADG between 3 and 7 months of age reach puberty at a lighter BW and earlier age than heifers fed to gain weight at lower rates of ADG during the 3-7 months post weaning period. So, accelerated growth during early calf hood reduces age at puberty and encourages the onset of precocious puberty. Forced compensatory weight gains after 3-7 months may not have the same effect because neuroendocrinologic development in the brain that may be most amenable to "nutritional imprinting" very early in heifer development (Gasser et al., 2006a–d, Allen et al., 2012). Accordingly, post weaning growth rates are an important determinant for the age at the onset of puberty and pregnancy rates at the time of breeding. Much work lead to recommendations that heifer growth rates should be sufficient to achieve 60-65% of adult BW by the time of breeding.

The goal for timely breeding should be to achieve peak heifer fertility at 13-15 months of age. Since heifer fertility is known to improve over the first 3 post pubertal estrous cycles, the practical goal is to achieve puberty at 10-12 months of age. The strategy enables heifers to calve at a very cost effective industry standard of 2 years of age. These recommendations assumed BW (rather than age) was the primary determinant for the onset of puberty.

Accordingly, nutritional recommendations have been designed to drive prepubertal weight gains targeted toward these goals. Many diets designed to sustain these growth rates contained cereal grains because of the low cost for these ingredients. However, rising costs for these particular components in the current market place have reduced the cost effectiveness of these ration strategies and render them unsustainable. Accordingly, new, more cost effective feeding strategies have been pursued to achieve early onset of puberty more cost effectively.

What landmarks or objectives should producers expect to achieve that ensure early onset of puberty, conception at 14-15 months and calving at 24 months of age? Assuming mature BW is 1,250-1,300 lb, most beef breeds need to achieve puberty at 40-45% (500-530 lb) of mature BW, conceive at 60-65% mature BW (750-780 lb) and then calve at 85-90% mature BW (figure 1). Reaching these goals requires ADG between 1.60-1.90 lb/day. To ensure first parturition occurs at 24 months of age, heifers also need to enter precocious puberty between 8-10 months of age, and then conceive at 14-15 months of age. Figure 1 clearly shows heifers with low ADG will never achieve any of these milestones.

Recent data from modern breeds and genetics shows the proportion of mature weight achieved at the onset of puberty actually ranges between 56%-60% and is breed dependent (Freetly et al., 2011). Proportion of mature body weights for the onset of puberty for Hereford, Angus and Brahman breeds are 56%, 58% and 60% of mature weight. Practically however, *proportion of mature BW rather than absolute BW* is a better predictor of the onset of puberty.

There is also some flexibility in how weight gain profiles can occur over the prepubertal period so long as the target weight of 56%-60% mature BW at breeding is achieved. It has been known for a long period of time that the timing and the pattern of prepubertal growth rates does not need to generate a steady, even pattern of daily gains throughout the entire prepubertal period to achieve 56%-60% mature BW at breeding. The flexibility stems from the fact that onset of puberty consistently occurs at 56-60% of mature BW no matter how the pattern of gain is achieved.

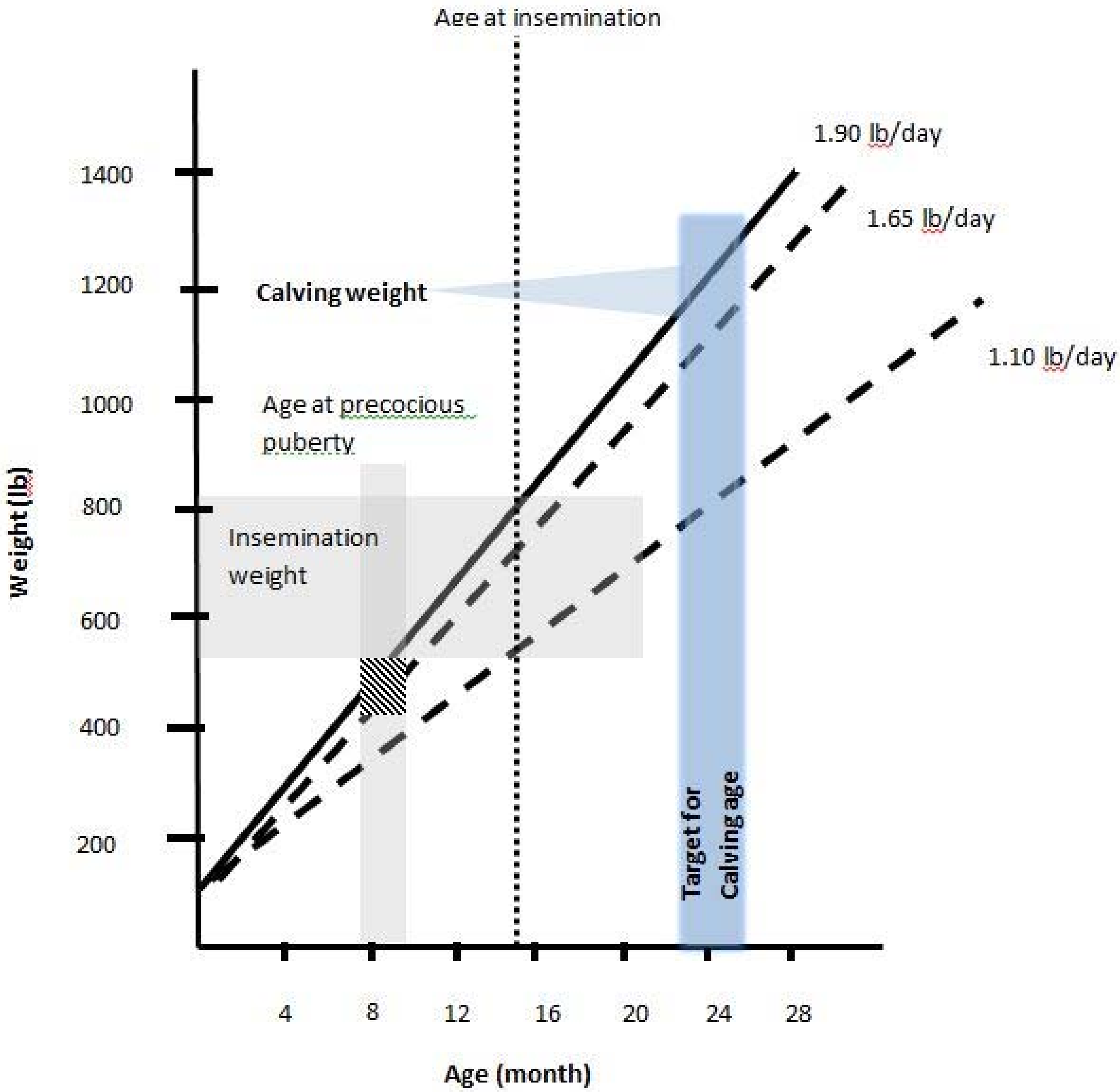

Figure 1. Higher rates of average daily gain (ADG) in heifers during the prepubertal period (1.61-1.90) produce heifers that enter into puberty at a desirable age of 8-10 months (precocious puberty). Lower rates of ADG (1.10) do not promote adequate gains in body weight that support the onset of precocious puberty by the 8-10 month window. Note the cross hatched area ( ) marks the ideal weight and age for onset of precocious puberty.

Lynch et al. 1997 divided weaned heifers into two groups: one group (EVEN GAIN) was fed to achieve even average daily gains (ADG) of 0.45 kg/day across a 5-6 month post weaned period. The second group (LOW GAIN_HIGH GAIN) was fed to achieve ADG of only 0.24 lb/day for 4 months followed by a feeding regimen that achieved ADG of 2.0 lb/day for 2 months. Regardless of feeding regimen and patterns of ADG both groups of spring born, post weaned heifers achieved puberty at the same proportion of mature body weight and nearly the same age (Lynch et al. 1997).

The production advantage was the LOW GAIN-HIGH GAIN groups achieved puberty on considerably less feed than the EVEN group. Indeed, newer developments suggest nutrient regimens designed to produce a prepubertal “stair-step” pattern of weight gain works well to drive the onset of precocious puberty in beef heifers. In these regimens lower weight gains are acceptable earlier in the prepubertal period so long as growth rates later in the prepubertal period are accelerated to compensate for the lower growth rates earlier in the postnatal period. The onset of precocious puberty can be driven by feeding high energy (concentrate) diets very early and then again later in the early weaned, prepubertal animal (Cordoso et al., 2013).

Practically however, when compensatory weight gains are not achieved later in low ADG animals during the early prepubertal period, heifers will arrive at the weight goal of 56-60% mature BW at an older, more costly age. This of course translates into the onset of puberty in older heifers and the onset of maximum breeding fertility at older ages. Some evidence suggests heifers could be fully developed and enter the breeding season at 50-55% of mature BW (Funston et al., 2004). Fertility at the time of breeding in these groups (especially those at the start of the breeding season) however, may be lower than those entering the breeding season later at 56-60% mature BW (Funston et al., 2011).

Heifers targeted for higher rates of gain (1.5-1.60 lb/day) to achieve targeted breeding weights by spring breeding season may be placed on standard dry lot diets generated with reasonable quality hay (12% protein) supplemented with concentrate. Rations consisting primarily of ensilage will produce even greater gains but run the risk of generating obese, overweight heifers with excessive fat accumulation in the mammary glands (Capuco et al., 1995, Silva et al., 2000).

Excess fat deposition in the mammary gland can decrease gland development and diminish milk yields. Interestingly, high rates of ADG attributable to non-adipose tissue deposition do not appear to impair mammary development. Discussions about high prepubertal ADG, BW and BCS always raise concerns about effects on mammary gland development because gland development during the prepubertal and peripubertal periods does impact milk yields.

Normally, gland growth is proportional to gains in BW during the 1-2 month neonatal period and involves growth of ducts and supporting tissues. After 2 months, mammary growth surpasses gains in BW and involves ducts and fat tissues. Duct growth is critical for development of secretory tissue later during gestation. The onset of puberty whether precocious (8-10 months) or normal (11-12 months) normally slows mammary development.

Although high rates of ADG enable earlier onset of puberty, a body of conflicting work (Daniels et al., 2009, Meyer et al., 2006, Davis-Rinker et al., 2008, 2011) exists about the effects of high ADG on mammary development in heifers. Some reports indicate planes of nutrition associated with growth rates of 1.5 lb-1.6 lb/day may damage mammary gland growth and development, while others show no effect of 2.0 lb/day gain on glandular development while still other reports of ADG as high as 2.3 lb/day hinder growth of mammary tissues. Regardless, excess fat accumulation in the mammary gland of beef breeds does reduce milk yields. These heifers very often wean lighter calves and experience much greater prevalence of dystocia during the first calving.

Effect of Nutrition and ADG in the Pre- and Post-puberty Periods on the Onset of Puberty

Many studies have clearly established prepubertal and post pubertal energy intake and ADG impact the onset of precocious puberty (puberty at less than 300 days of age) (Radcliff et al., 1997, Schillo et al., 1992, Gasser et al. 2006a,b,c,d). Gasser (2006a,b,c,d) showed the effect of energy intake and ADG on onset of puberty was most pronounced in the early post-natal period (3-6 months of age) and had considerably less effective during the adolescent period immediately before the onset of puberty (6.5-13 months of age). Precocious puberty occurred on average at 9 months of age when heifers were fed high energy diets and showed higher ADG at 4-6 months of age. Heifers fed low energy diets and therefore achieving lower ADG during 4-6 months of age did not achieve puberty until 11 months of age. Delays in the onset of puberty in heifers on low energy diets during the 4-6 month prepubertal period were not corrected when these heifers were switched to higher energy diets 6.5-13 months immediately before the onset of puberty.

The take home message is that the onset of precocious puberty is driven by high energy intake and higher ADG in the 4-6 month post weaning period. Compensatory gains later in the post puberty period may not completely reverse the delay in onset of puberty associated with lower energy diets and poorer ADG at 4-6 months of age. The rate of growth after 5-6 months of age can be increased in poor gaining heifers at 3-6 months without much effect on the onset of puberty. Note, ADG was not the issue because all heifers gained weight and grew. The important concept is that only those energy levels great enough to support higher rates of ADG support earlier onset of puberty.

Neuroendocrine Factors Supporting Reproductive Development and the Onset of Puberty

Onset of puberty in heifers is initiated in higher centers in the brain that control release of gonadotropin releasing hormone (GnRH). Producers are very familiar with this hormone through its use in Ov Sync and, Pre Sync programs and treatment of cystic follicular degeneration in adult cows. Prepubertal increases in amplitude and frequency of pulsatile GnRH release from reproductive centers in the brain mark the onset of precocious puberty (Figure 2) at 8-10 months of age.

Recently, a number of studies have begun to untangle the complex interactions between fat stores, metabolic/nutrient sensing systems and the reproductive centers in cattle (Gasser et al., 2006a, 2006b, 2006c, 2006d, Allen et al., 2012, Armstalden et al., 2011, Redmond et al., 2011). These interactions integrate nutritional/metabolic status with the state of fertility (see Figure 3a-c). An important issue is recognition that fat synthesizes and secretes a hormone called leptin that signals the size of fat stores (therefore BCS) to nutrient/metabolic sensors in the brain.

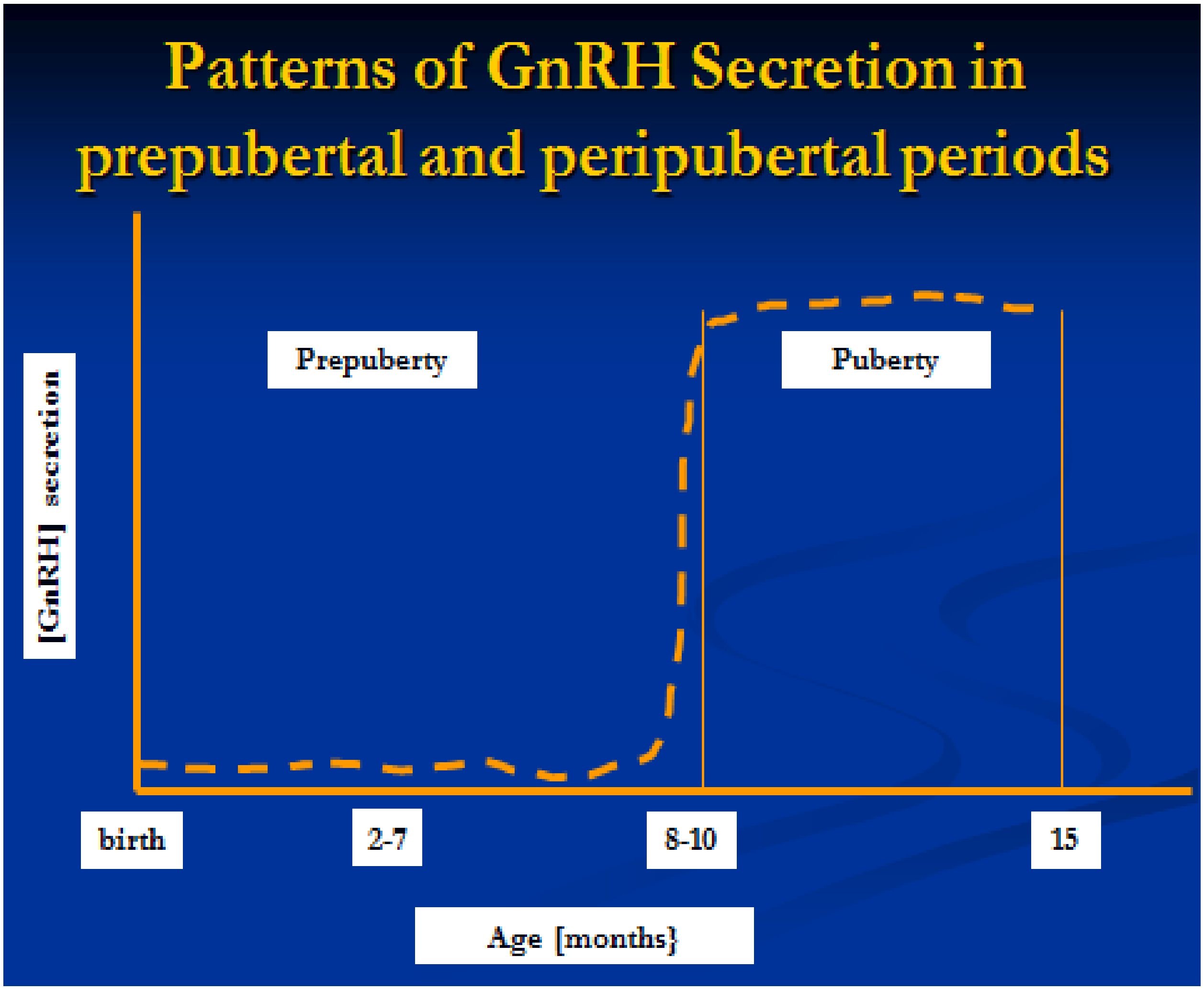

Figure 2. Low amounts of GnRH during the prepuberty period change to high amounts of hormone release at the onset of precocious puberty and cycling in heifers. Changes in GnRH are regulated by signals that integrate metabolic/nutrient sensing centers with reproductive centers in the brain.

These nutrient/metabolic sensors regulate dry matter (appetite) and energy intake. In addition the metabolic/nutrient sensing centers are anatomically "hard wired" by nerves to neighboring centers in the brain that control reproductive development, cyclicity, follicle growth, follicle development and ovulation (figure 3a). Higher energy intake increases fat stores (higher BCS) and therefore leptin signals to the metabolic/nutrient sensing centers.

In the context of higher energy intake and therefore BCS, the metabolic/nutrient sensing centers increase positive signals while decreasing braking signals to reproductive centers (Figure 3b). The net effect is to increase reproductive center output in the form of increased GnRH secretion that eventually drives ovarian functions such as folliculogenisis, ovulation, steroidogenisis, ovulation and the onset of puberty. Thus, growth rates, the size of adipose depots and BCS are closely related to the onset of puberty in heifers. The hard wiring between higher centers in the brain partially explains why growth restriction and lower ADG in prepuberty heifers delays the onset of puberty.

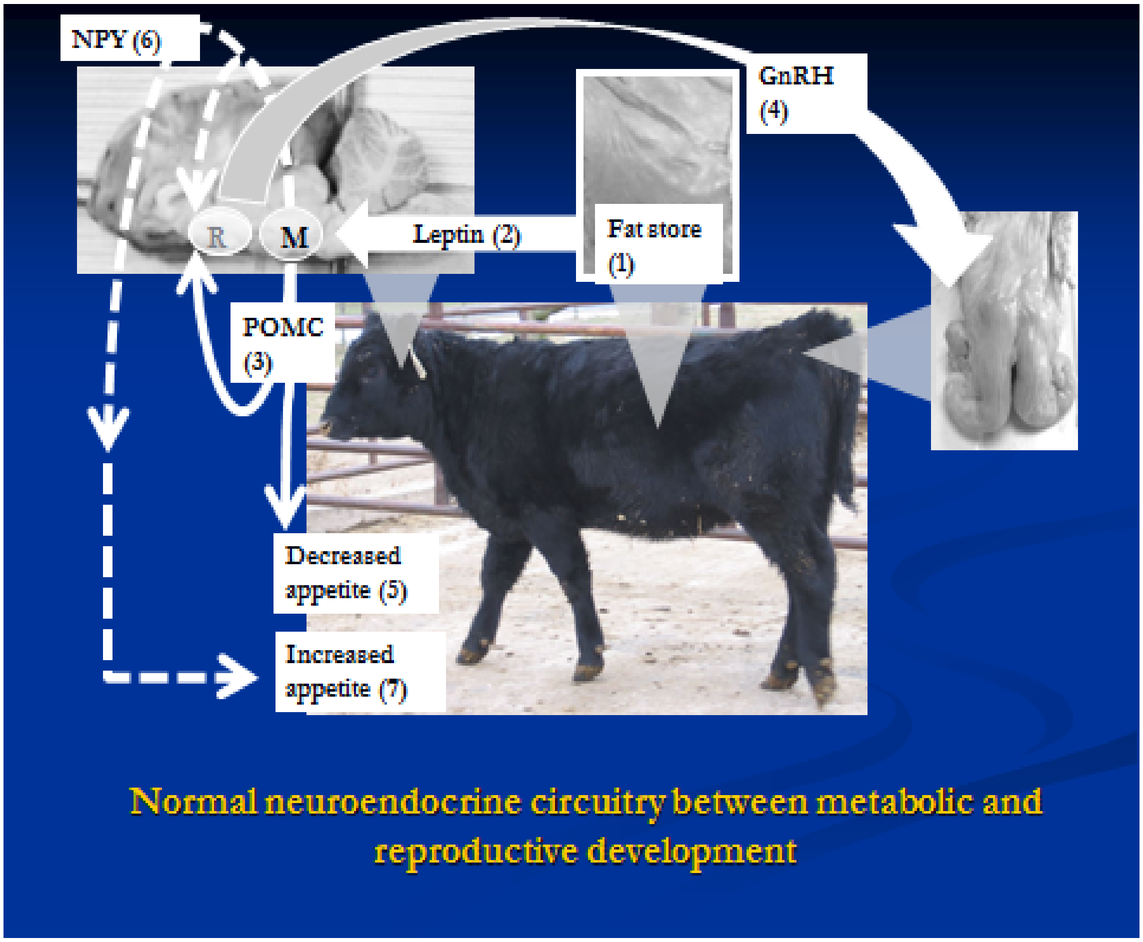

Figure 3a. Energy intake controls average daily gain (ADG) and fat depot size (1, adiposity). Fat (1) controls circulating leptin levels (2). Circulating leptin levels control POMC signals (3) from metabolic centers (M) in the brain that then up-regulate reproductive center (R) release of GnRH (4) as well dampen appetite (5) and dry matter intake (7),(DMI). Leptin (2) also controls metabolic center (M) release of NPY (6) that brakes GnRH (4) release from reproductive centers (R) and increases appetite (7) and DMI.

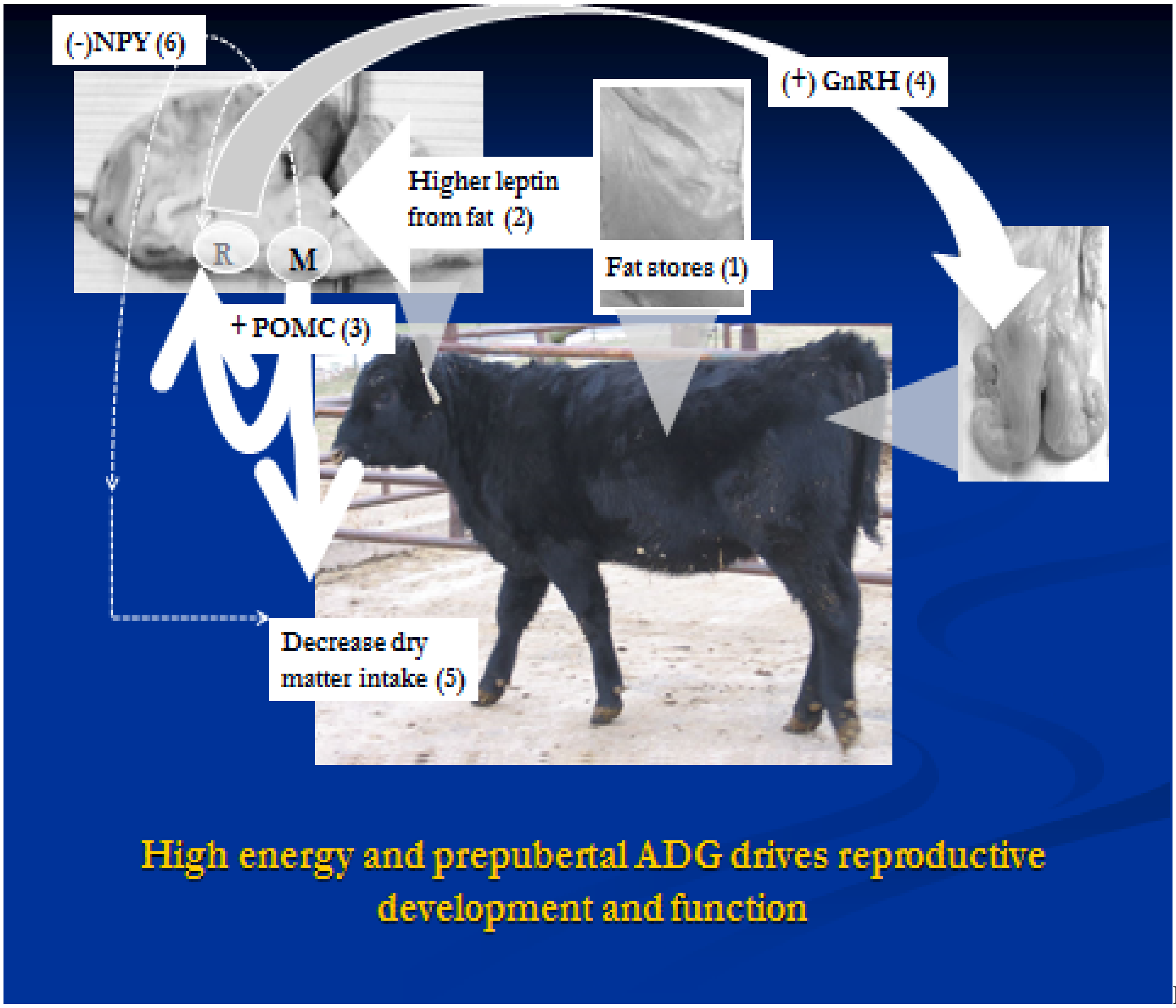

Figure 3b. Higher energy intake, increases fat depots (1) and elevates leptin levels (2). Higher leptin increases metabolic center (M) release of POMC (3). Higher levels of POMC stimulate reproductive center (R) release of GnRH (4) while decreasing dry matter intake (5, DMI). Higher leptin (2) also reduces metabolic center release of NPY (6). This releases the NPY mediated brake on GnRH (4) release from reproductive centers (R) while reducing the stimulation of appetite and DMI (5).

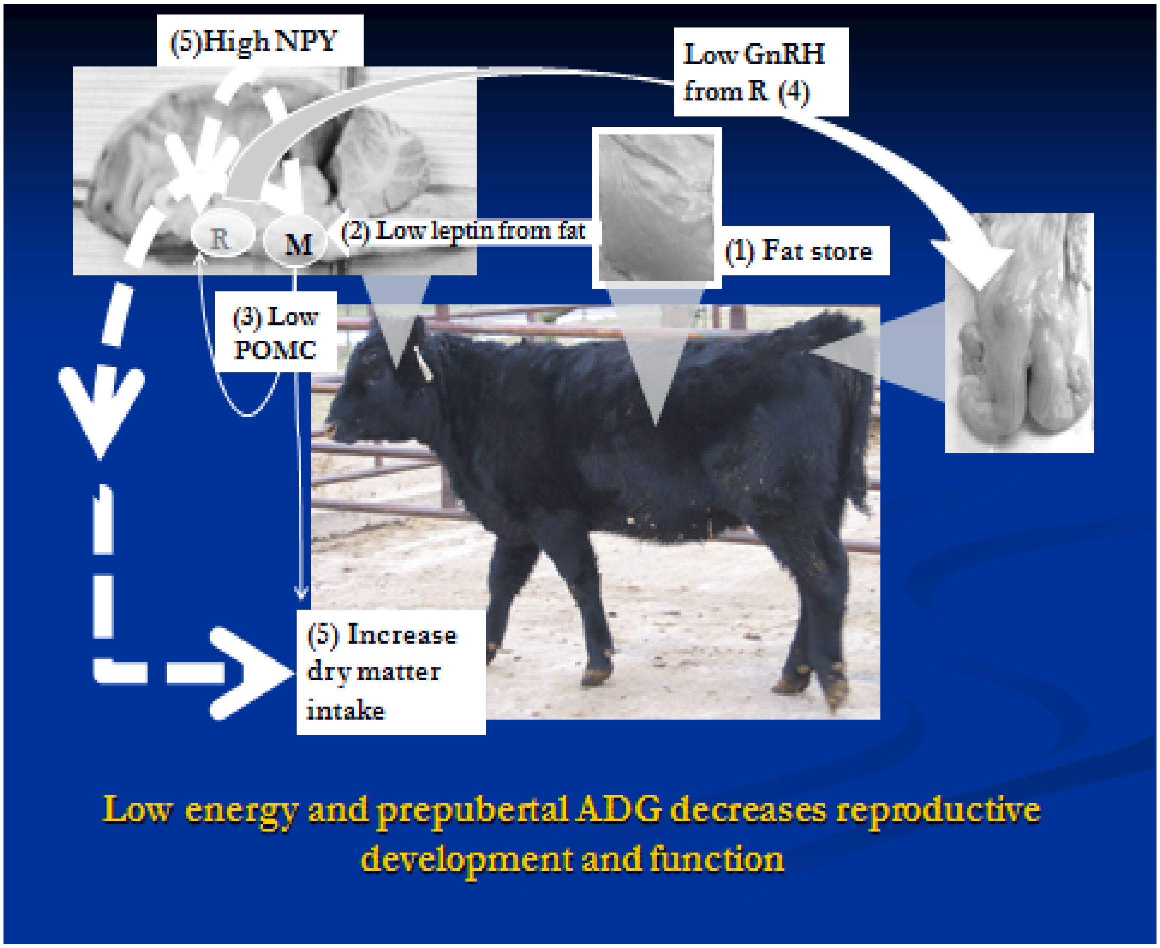

Figure 3c. Lower energy intake, leads to less fat depot (1) that decreases (2) leptin levels. Lower leptin decreases metabolic center (M) release of POMC (3). Lower POMC decreases reproductive center (R) release of GnRH (4) while increasing dry matter intake (DMI) (5). Low leptin also increases metabolic center release of NPY (5). Higher NPY increase the inhibition of GnRH release from reproductive centers (4) while increasing appetite and DMI (5).

Conclusion

Young stock can be nutritionally pushed into precocious puberty by feeding diets designed to achieve higher ADG and BCS. ADG and BCS however, need be monitored closely to ensure age-dependent changes in ADG and BCS are neither too little nor too big. Excessive ADG and BCS may lead to underdevelopment of mammary glands and obesity at 24 months and first calving. ADG and BCS that are too low lead to delayed puberty, delayed conception and first calving past 24 months of age. Heifers should achieve precocious puberty at less than 300 days of age and 40-45% of body weight. Onset of puberty at this age enables breeding 3 or more estrous cycles after the first estrus of puberty. Higher growth rates after 7 months of age may not completely restore reproductive advantages to levels garnered by heifers with higher growth rates prior to 6-6.5 months of age. Calves experiencing the entire spectrum of neonatal and pre-pubertal disease problems show delayed gains and greater age at first calving. Poorer nutrition, greater disease problems and other environmental factors that diminish ADG for longer periods of time in the prepuberty period can be expected to delay the onset of puberty and extend age at first calving.

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Notices and Upcoming Events

May 28. 2014
Delaware Pasture Walk, Location to be announced but in southern Kent County, Delaware. For more information contact Susan Garey by email Truehart@udel.edu or Dan Severson by email Severson@udel.edu or call your county extension office in Delaware.

June 4, 2011
Delaware Webb Farm Pasture Walk, Webb Farm off Route 273 in Newark, DE. For more information contact Susan Garey by email Truehart@udel.edu or Dan Severson by email Severson@udel.edu or call your county extension office in Delaware.

November 18-21, 2014
Mid-Atlantic Crop Management School, Ocean City, MD. Contact either Bob Kratochvil by email at rkratoch@umd.edu or Richard Taylor by email at rtaylor@udel.edu.

August 2014
Soybean Diagnostic Field Day, University of Delaware Research and Education Center, Georgetown, DE. For more information contact Dr. Mark VanGessel at mjv@udel.edu.

January 12-15, 2015
Delaware Ag Week, Delaware State Fairgrounds, Harrington, DE. More information will be available in future issues of the newsletter.

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

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Photographs for Newsletter Cover

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