Advances in Silage Preservation

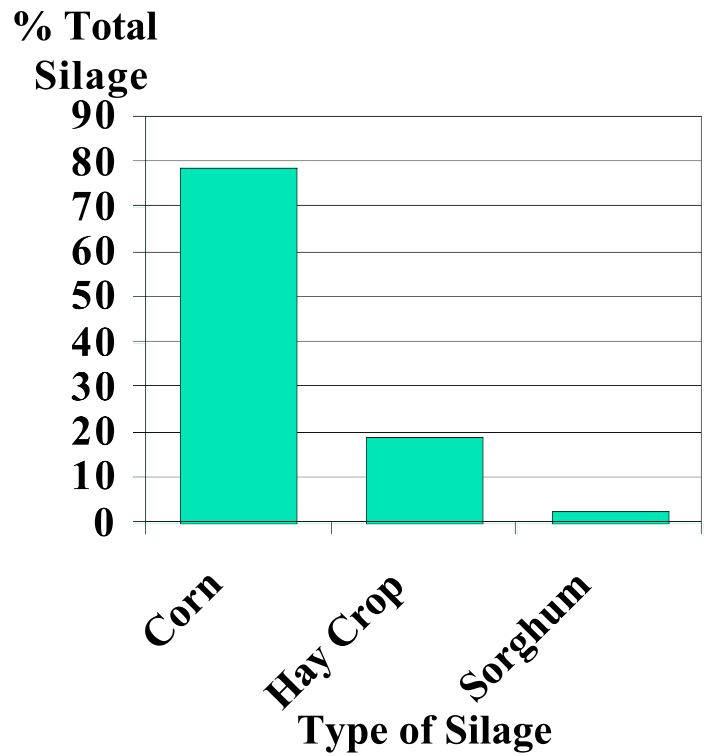
R.E. Muck

US Dairy Forage Research Center

USDA, Agricultural Research Service

Importance of Silage

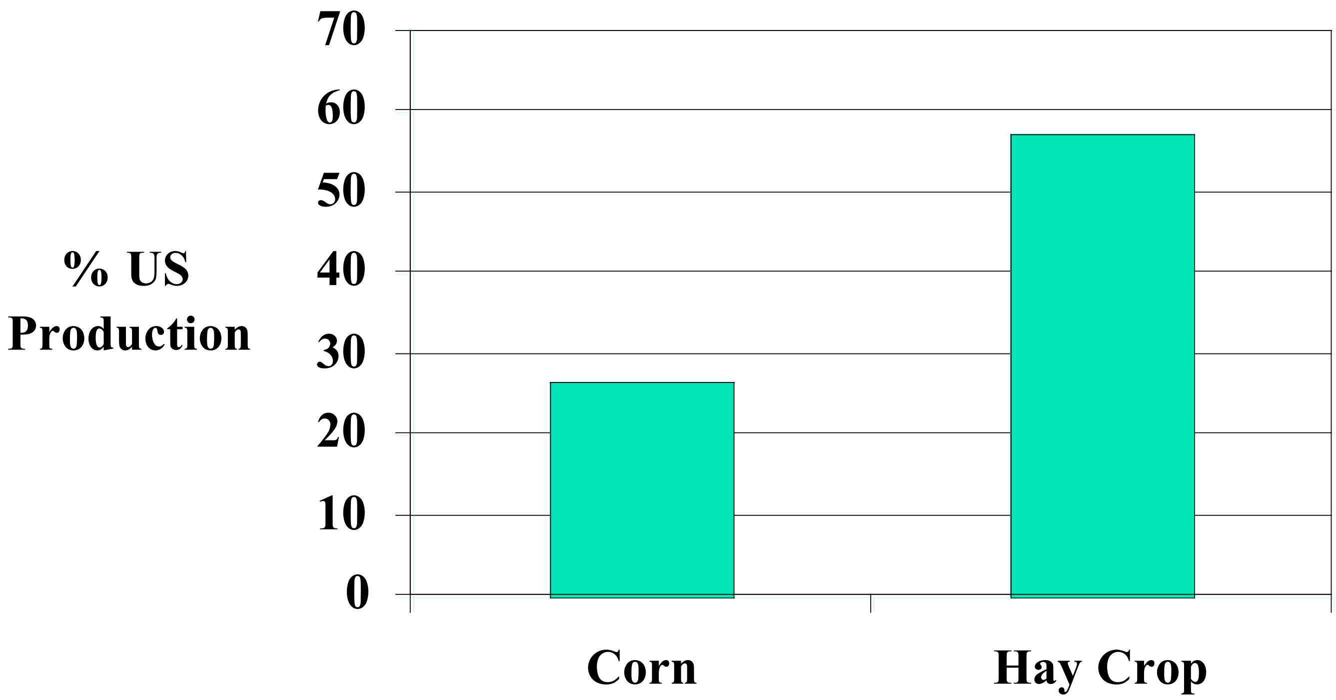
- 47 million tons dry matter preserved as silage in 2002 in the U.S. (NASS, 2003)



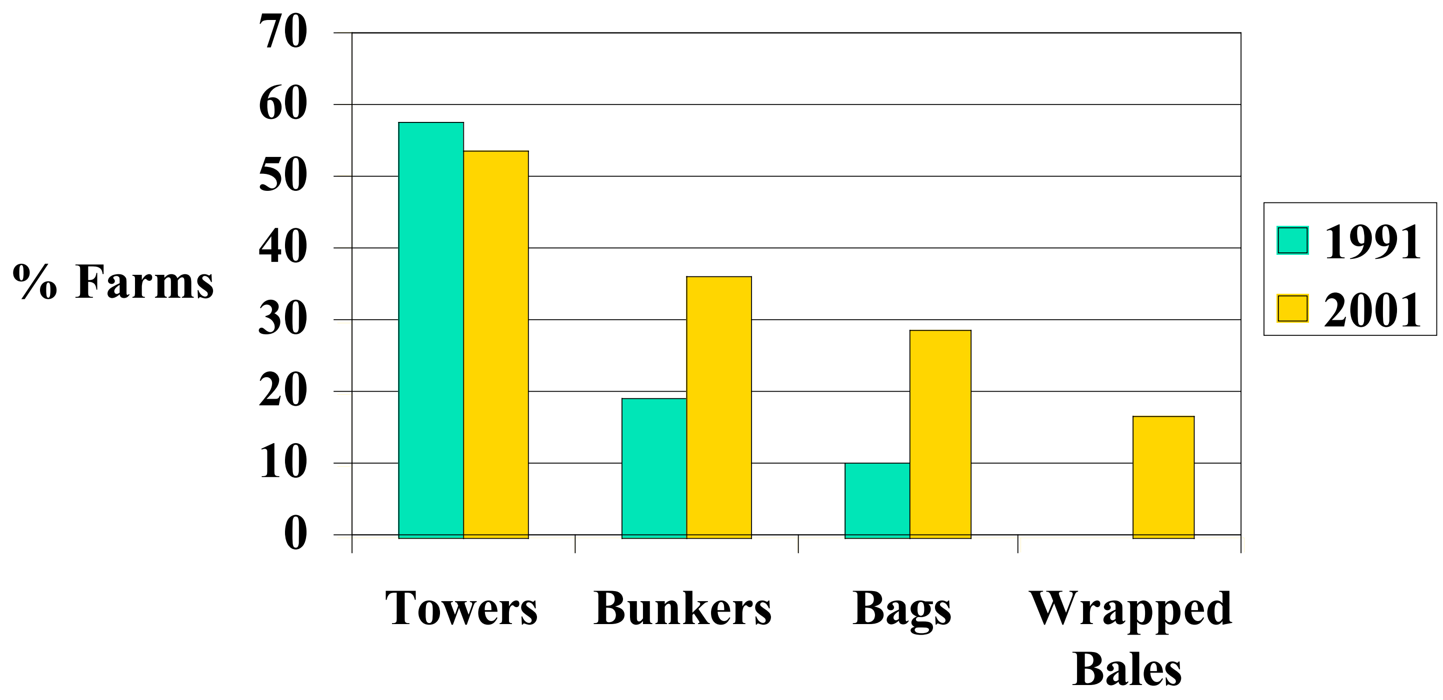
NASS Estimates Are Low

- Hay crop silage only from 8 states:
  - MI, MN, NY, PA, VT, WA, WV, WI
- Small grain silages not estimated
- High moisture grain not estimated

Importance of Silage in Our 4-State Area



Ensiling Trends on US Dairy Farms (Hoard's, 2002)



Implications of Ensiling Trends

- Crops are being ensiled wetter
  - Greater chance for clostridial (butyric acid) fermentation
  - Silage effluent
- Movement to silo types needing more management skills

Focus of Talk

Issues important to managing newer silo types

- Clostridial (butyric acid) silage
- Bunker density
- Bag density, losses
- New inoculants - *Lactobacillus buchneri*

Clostridial Silage

- Any silage with butyric acid > 0.5% DM
- Caused by clostridia that convert sugars or lactic acid to butyric acid
- Other clostridia convert amino acids to ammonia, amines

Problems With Clostridial Silage

In the silo:

- Increased DM loss
- Loss of energy

In the cow:

- Reduced intake
- Ketosis

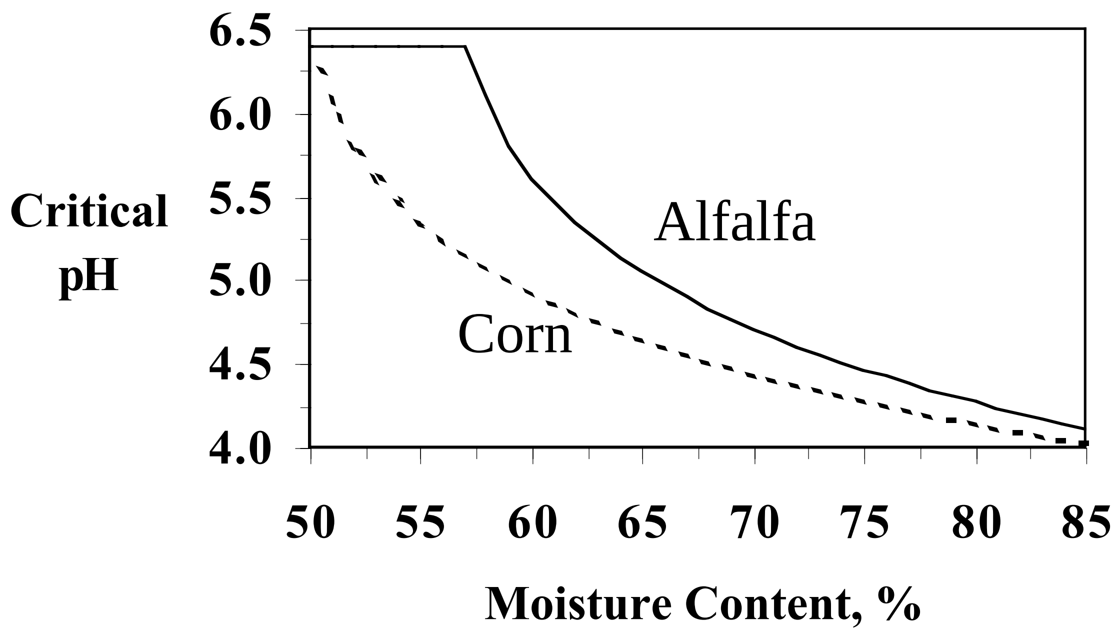
Causes of Clostridial Silage

- Sufficient clostridia on the crop at ensiling
- Insufficient fermentation that does not stop their growth

Sources of Clostridia

- Soil and manure
- Avoid soil contamination
- Manure
  - Applied to alfalfa soon after cutting does not raise the number of clostridia on crop at harvest
  - Once regrowth has begun: potential problem

How Much Fermentation is Needed to Stop Clostridia?



Moisture Content to Avoid Problems

- Corn
  - Not an issue except in spoiled areas
- Alfalfa
  - Bunkers, bags: < 65% moisture (70% in good conditions with rapid fill)
  - Wrapped bales: < 60% moisture

“I have a clostridial silage. What should I do?”

- If possible, you want to use rapidly.
  - Silage will get more clostridial with time
- However, not to transition and early lactation cows
  - Risk of ketosis
- Replacement heifers, far-off dry cows, late lactation cows
  - 50 g butyric acid/day per animal (Oetzel, UW)
  - Utilize fermentation analysis to formulate ration

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- **Bunker density**
- Bag density, losses
- New inoculants - *Lactobacillus buchneri*

Density

Important to:

- Reduce storage cost
- Increase dry matter recovery
- Reduce heating problems

Important Factors for Bunker Density - 168 Silo Survey

- Tractor Weight
- Packing Time
- Layer Thickness
- Height of Silage
- Moisture Content

Bunker Density Calculator

www.uwex.edu/ces/crops/uwforage/storage.htm

bunkdensity_master1-13-02.xls

	A–E	F	G–H
1			Spreadsheet to Calculate Average
2			Silage Density in a Bunker Silo(English Units)
3			Brian Holmes(1) and Richard Muck(2)
4			(1) Biological Systems Engineering Dept. and
5			(2) US Dairy Forage Research Center
6			University of Wisconsin-Madison
7	Bunker Silo Wall Height (feet) (zero for silage pile) =	10	13-Jan-02
8			
9	Bunker Silo Maximum Silage Height (feet) =	12	Values in yellow cells are user changeable
10			
11	Silage Delivery Rate to Bunker (T AF/Hr) =	25	Typical values 15-200 T AF/hr
12			
13	Silage Dry Matter Content (decimal ie 0.35) =	0.35	Recommended range of DM content = 0.3-0.4
14			
15	Silage Packing Layer Thickness (inches) =	6	Recommended value is 6 inches or less
16			
17	Packing Tractor - Each Tractor / Tractor Weight (lbs)		Tractor Packing Time (% of Filling Time)
18	==		
19	Tractor # 1 — Typical tractor weight is 10,000-60,000 lbs	30000	100
20	Tractor # 2 — Typical tractor weight is 10,000-60,000 lbs	0	0
21	Tractor # 3 — Typical tractor weight is 10,000-60,000 lbs	0	0
22	Tractor # 4 — Typical tractor weight is 10,000-60,000 lbs	0	0
23	Proportioned Total Tractor Weight (lbs) =	30000	
24	Average Silage Height (feet) =	11.0	Values in green cells are intermediate calculations
25	--		
26	Packing Factor =	591.6	Values in pink cells are results of calculations
27	Est. Average Dry Matter Density (lbs DM/cu ft) =	17.1	Density greater than 14 lbs DM/cu ft is recommended
28			Density greater than 28 lbs DM/cu ft is unrealistic
29			
30	Maximum Achievable DM Density (lbs DM/cu ft)=	25.7	
31			
32			
33	C:\my documents\BJHolmes spreadsheets this computer\Silage Storage\bunkdensity_master1.xls		
34			

English Units | Metric Units

Ready | Sum=0.35 | SCRL | CAPS | NUM

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21	**Tractor # 3** Typical tractor weight is 10,000-60,000 lbs	0	0
22	**Tractor # 4** Typical tractor weight is 10,000-60,000 lbs	0	0
23	**Proportioned Total Tractor Weight (lbs) =**	30000	
24	**Average Silage Height (feet) =**	11.0	Values in green cells are intermediate calculations
25	--		
26	**Packing Factor =**	295.8	Values in pink cells are results of calculations
27	**Est. Average Dry Matter Density (lbs DM/cu ft) =**	12.7	Density greater than 14 lbs DM/cu ft is recommended
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22	Tractor # 4 — Typical tractor weight is 10,000-60,000 lbs	0		0
23	Proportioned Total Tractor Weight (lbs) =	40000		
24	Average Silage Height (feet) =	11.0		Values in green cells are intermediate calculations
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26	Packing Factor =	295.8		Values in pink cells are results of calculations
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22	Tractor # 4 — Typical tractor weight is 10,000-60,000 lbs	0		0
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25	--			
26	Packing Factor =	418.3		Values in pink cells are results of calculations
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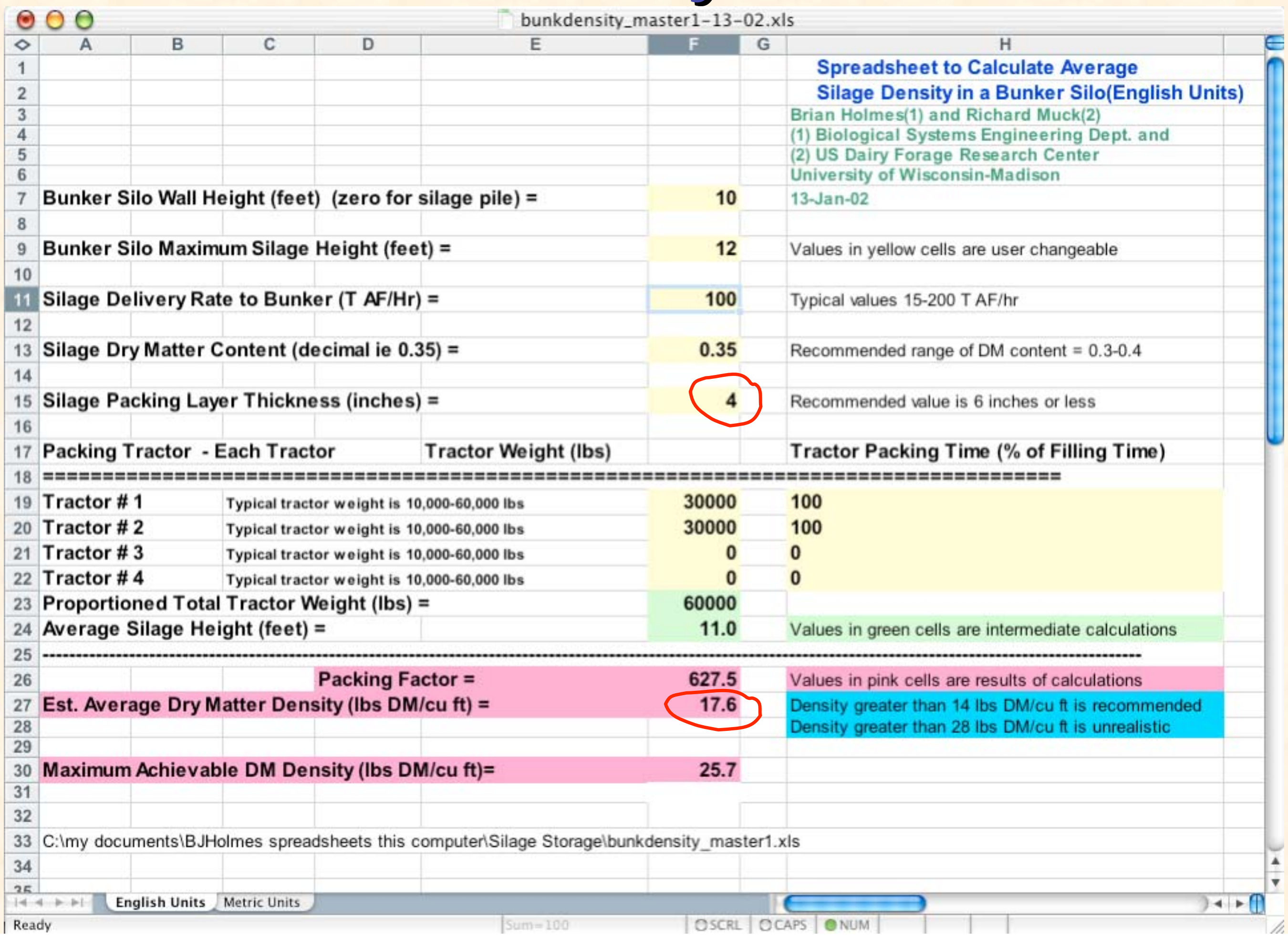

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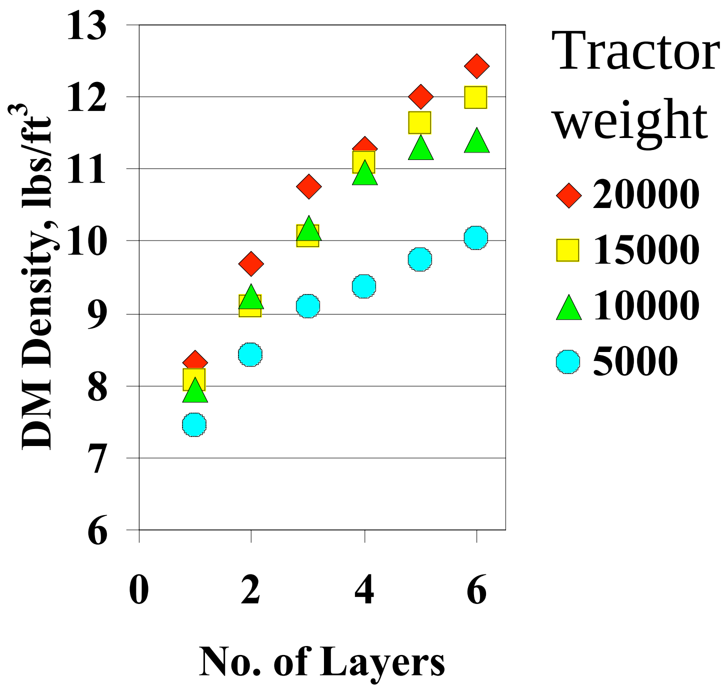
English Units | Metric Units

Studies to Confirm Survey Results

- Pilot-scale trials as pictured at right
  - Alfalfa
  - Corn
- Eventually farm-scale experiments

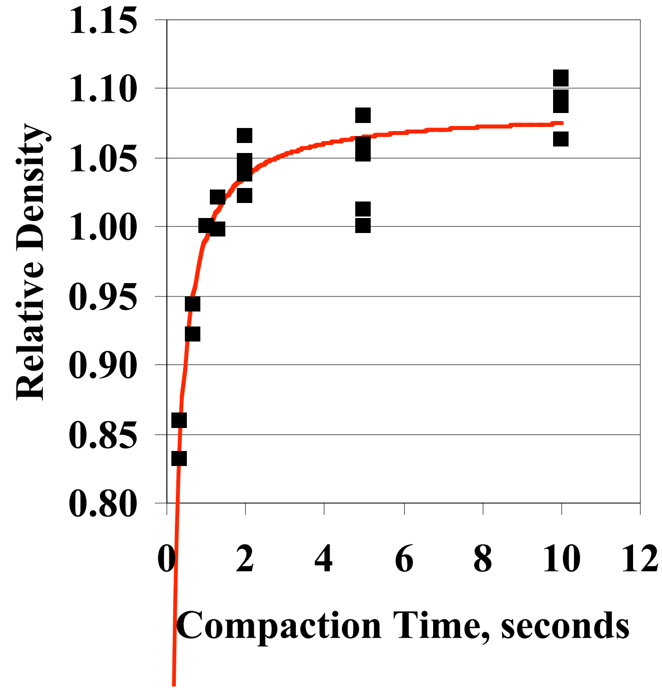
Preliminary Pilot-Scale Results

- Tractor weight makes a large difference on density
- Differences increase with each additional layer
- Layer thickness not as important as in survey



Preliminary Pilot-Scale Results

- Time is important
- But each added pass produces a smaller increase in density
- How time is achieved does not appear important



Preliminary Pilot-Scale Results

- So results are not completely similar to survey results
- Which are correct?
  - Don't know! Reason to do the field-scale trials.
- When we do know, we will update the Bunker Density Calculator

Focus of Talk

Issues important to managing newer silo types

- Clostridial (butyric acid) silage
- Bunker density
- **Bag density, losses**
- New inoculants - *Lactobacillus buchneri*

Bag Silos

- Little except for sales literature on density and losses from bag silos
- Yet both are critical in decision making
  - Comparing silo types when adding capacity
  - Managing feed inventory once you have them

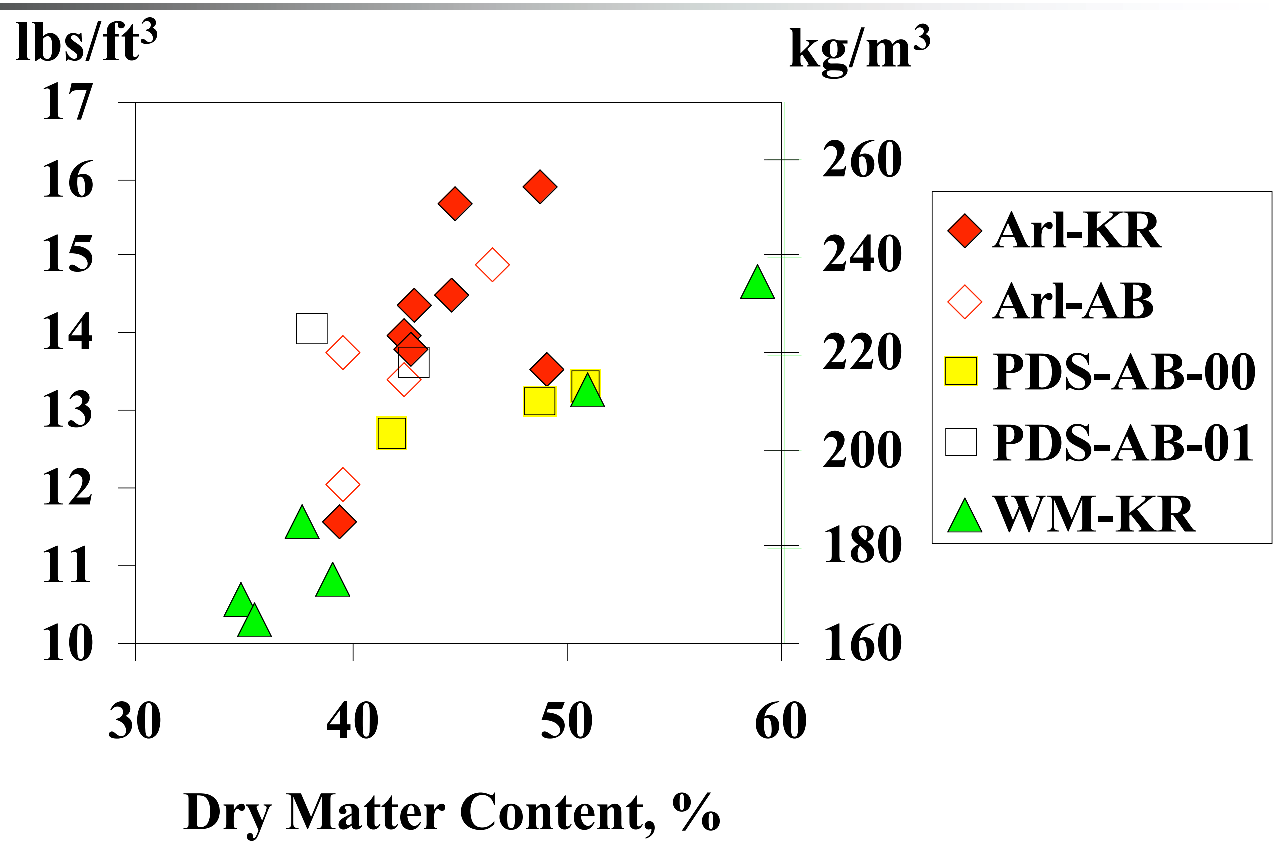
Objectives

- Monitor filling, emptying of bag silos to:
  - Measure densities and losses
  - Determine factors affecting each

9 ft. Kelly-Ryan

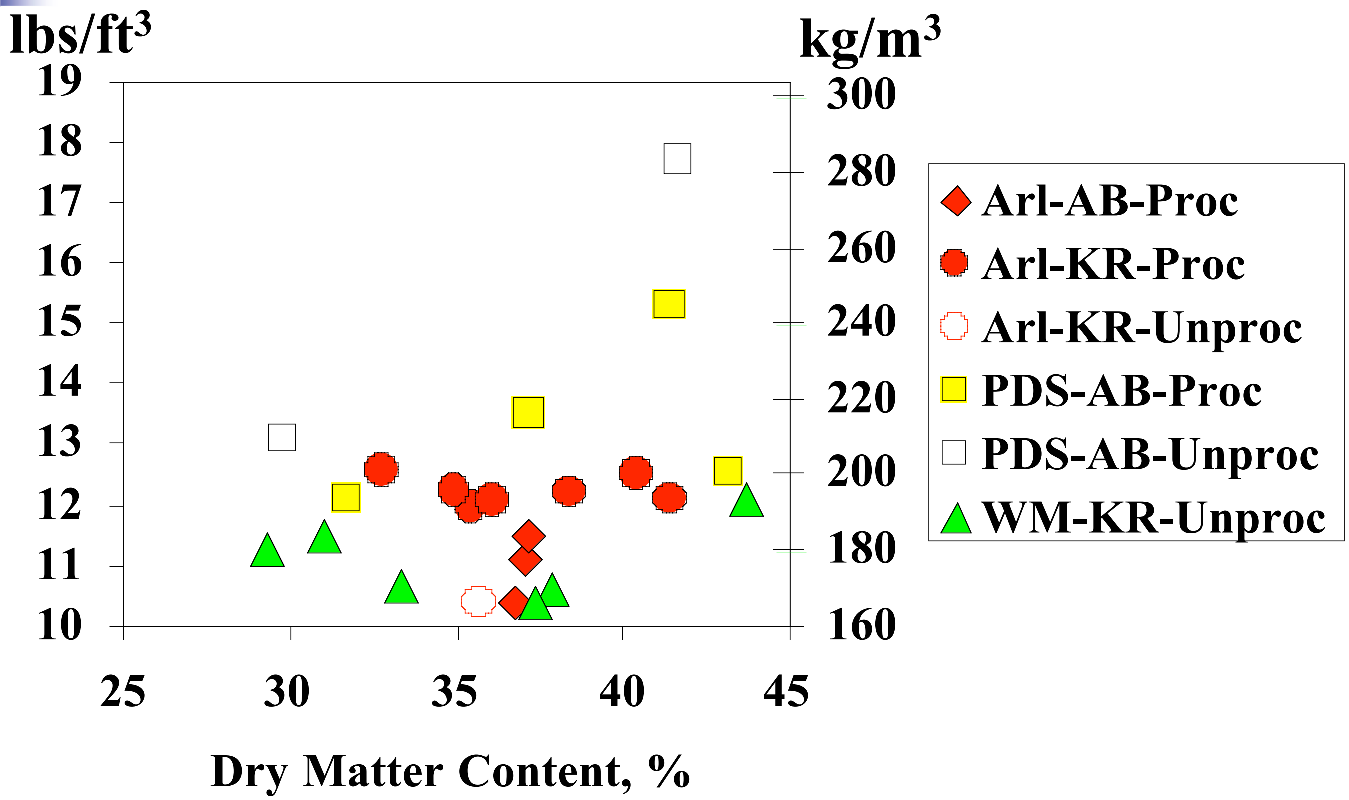
8 ft. Ag Bag

Dry Matter Densities in Hay Crop Silages



Average slope=0.19 lbs DM/ft^3-% DM

Dry Matter Densities in Corn Silages

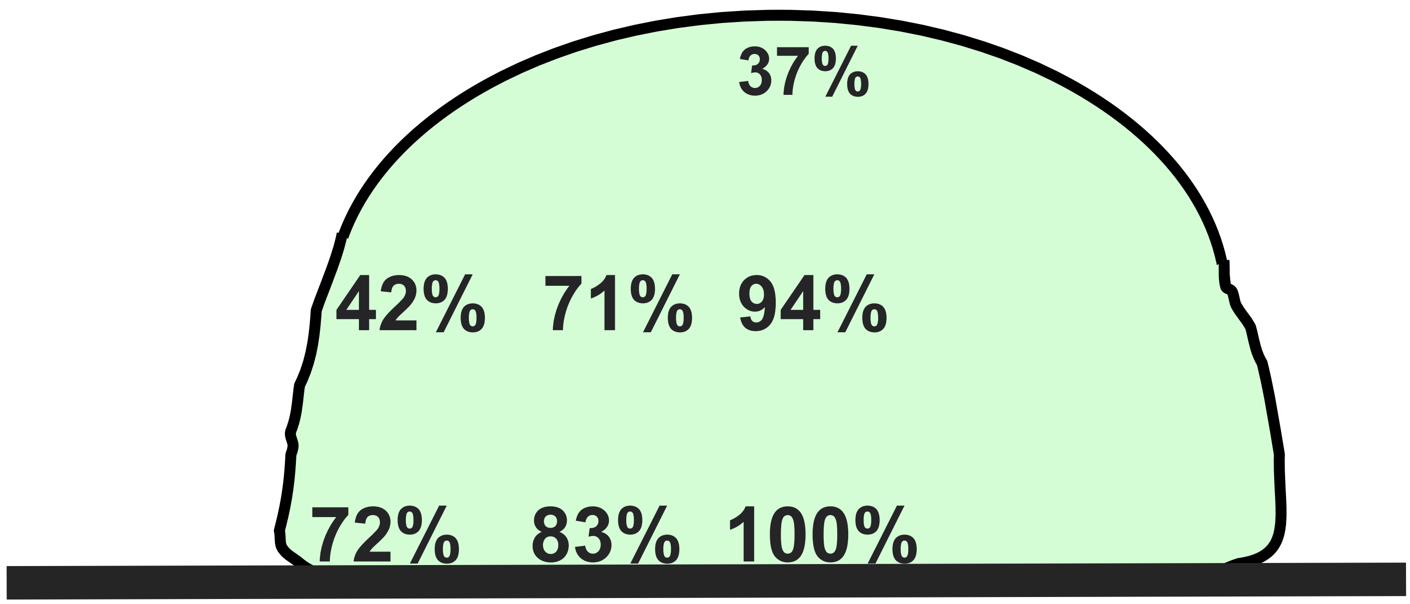


Average slope=??

Average DM Densities (lbs/ft^3)

Bagger	Station	Processed	Hay	Corn
8’ Ag Bag	PDS	Yes		13.4
		No	13.1	15.4
9’ Ag Bag	Arl	Yes	13.5	11.0
9’ K R		Yes		12.2
9’ K R		No	14.2	10.4
9’ K R	WM	No	11.6	11.1

Density Variation on the Face

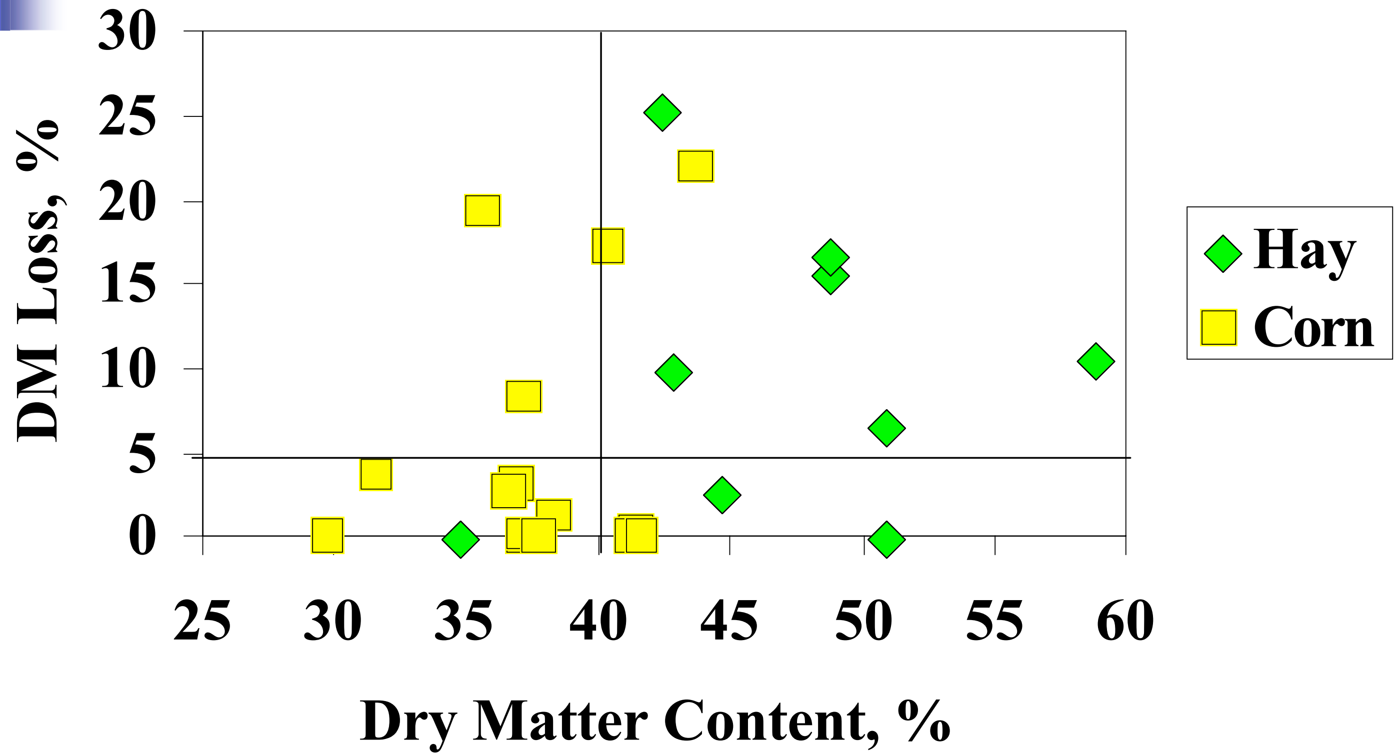


Range of Losses (% DM) 24 Bags

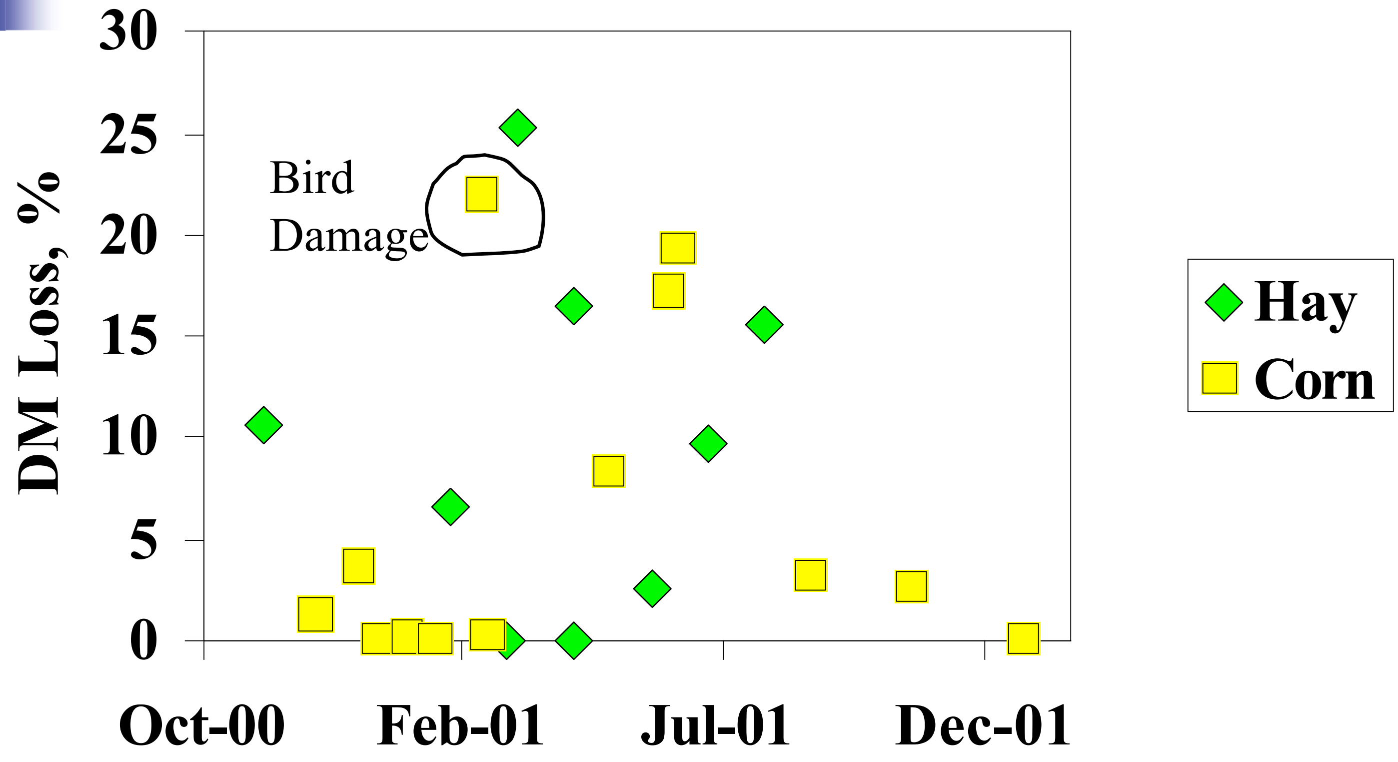
Type	Range	Average	Average w/o Worst 6*
Gas/Uncollected	-0.3 to 22.8	9.5	8.7
Spoilage	0.0 to 25.4	6.9	2.7
Total	-0.3 to 39.9	16.4	11.4

* 25% loss or more

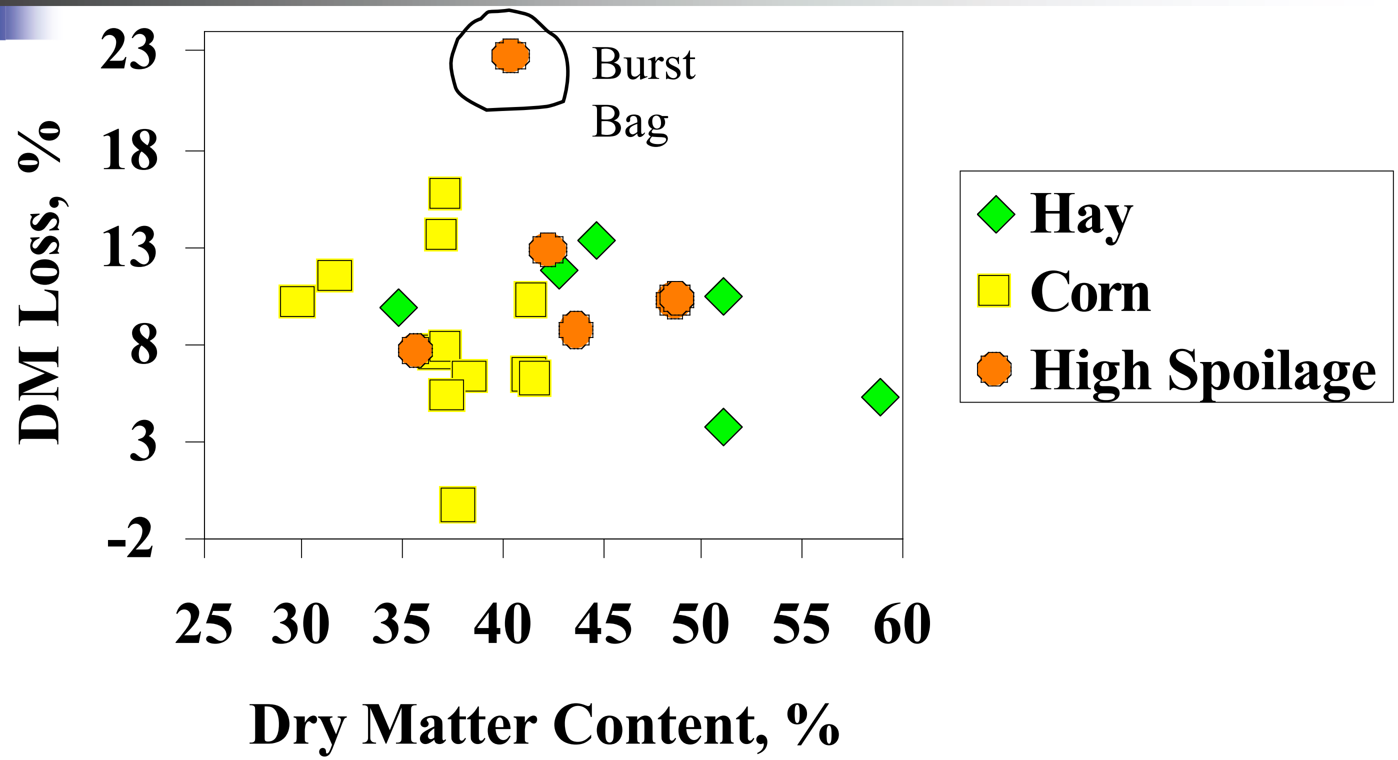
Spoilage Losses *vs.* DM Content



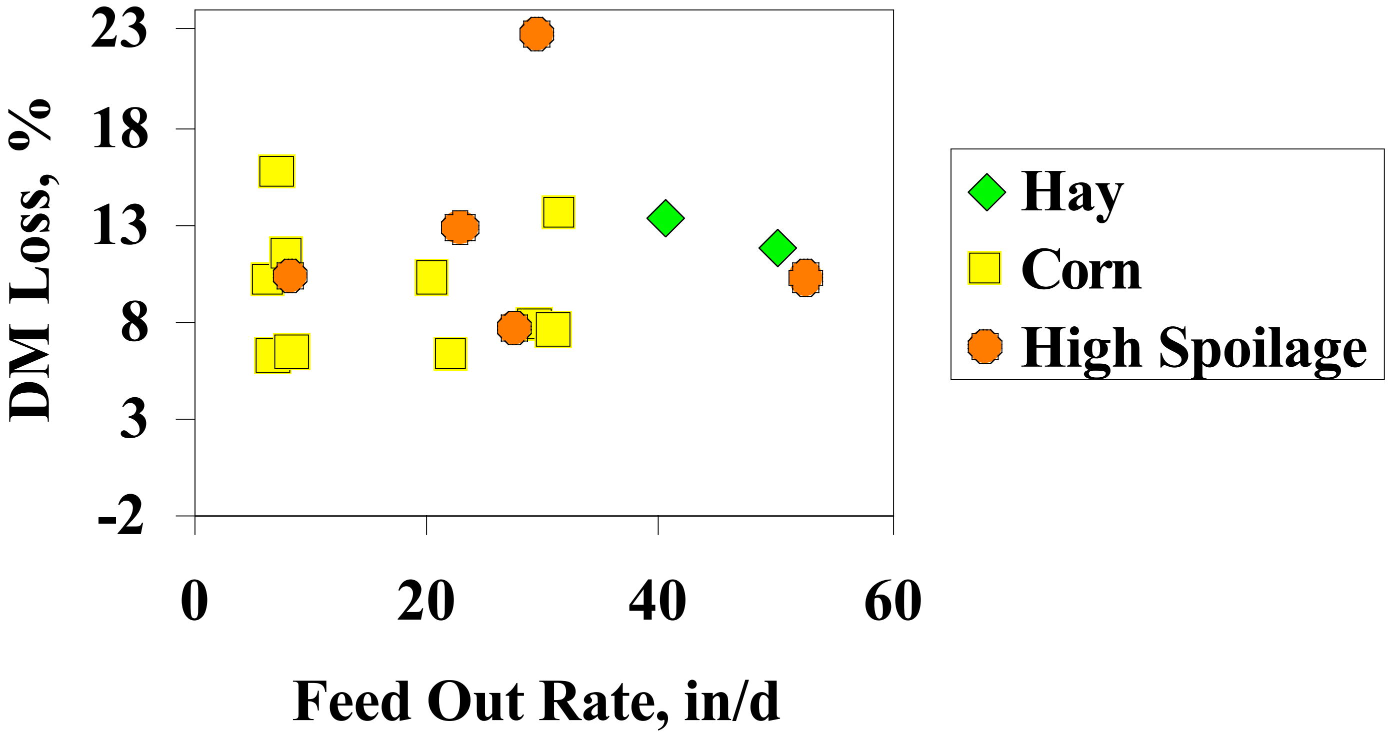
Spoilage Losses *vs.* Emptying Mid-Point Date



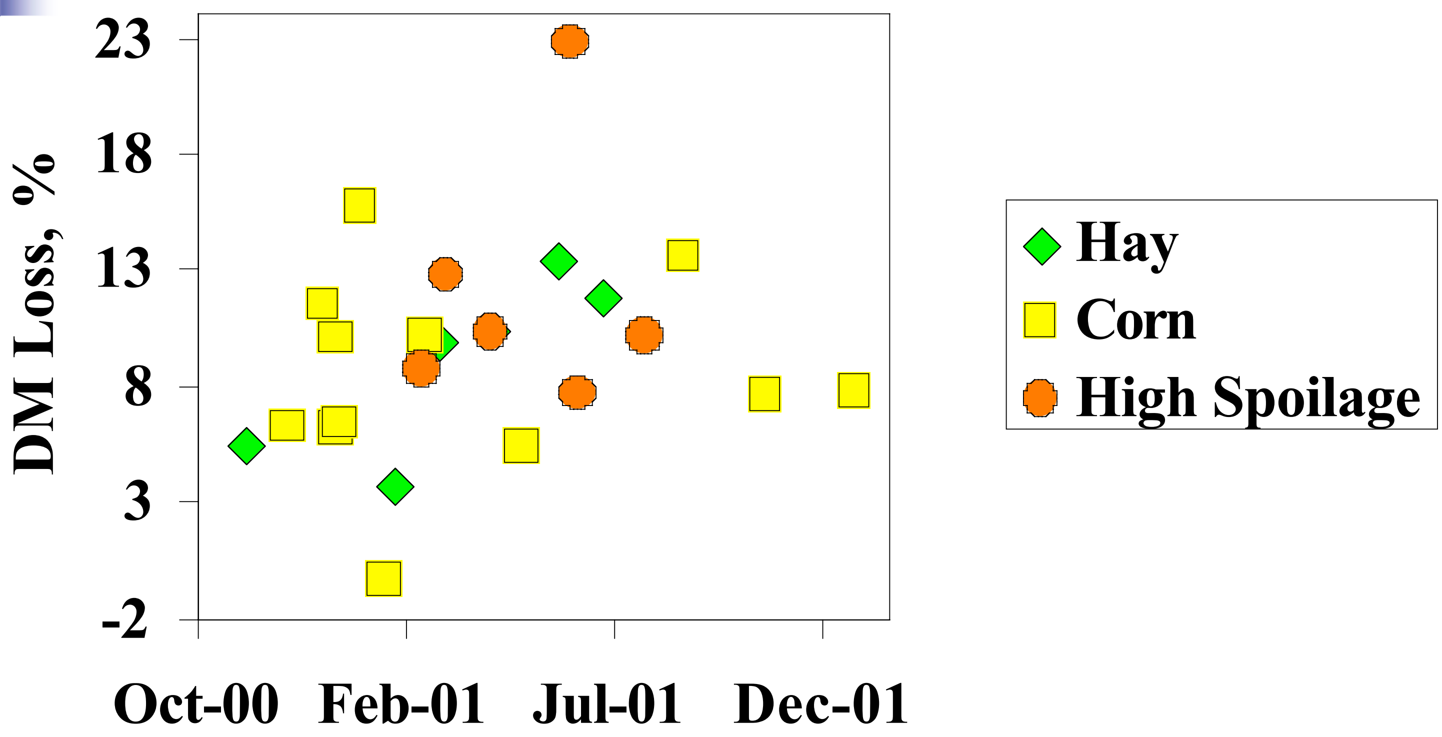
Gaseous/Uncollected Losses *vs.* DM Content



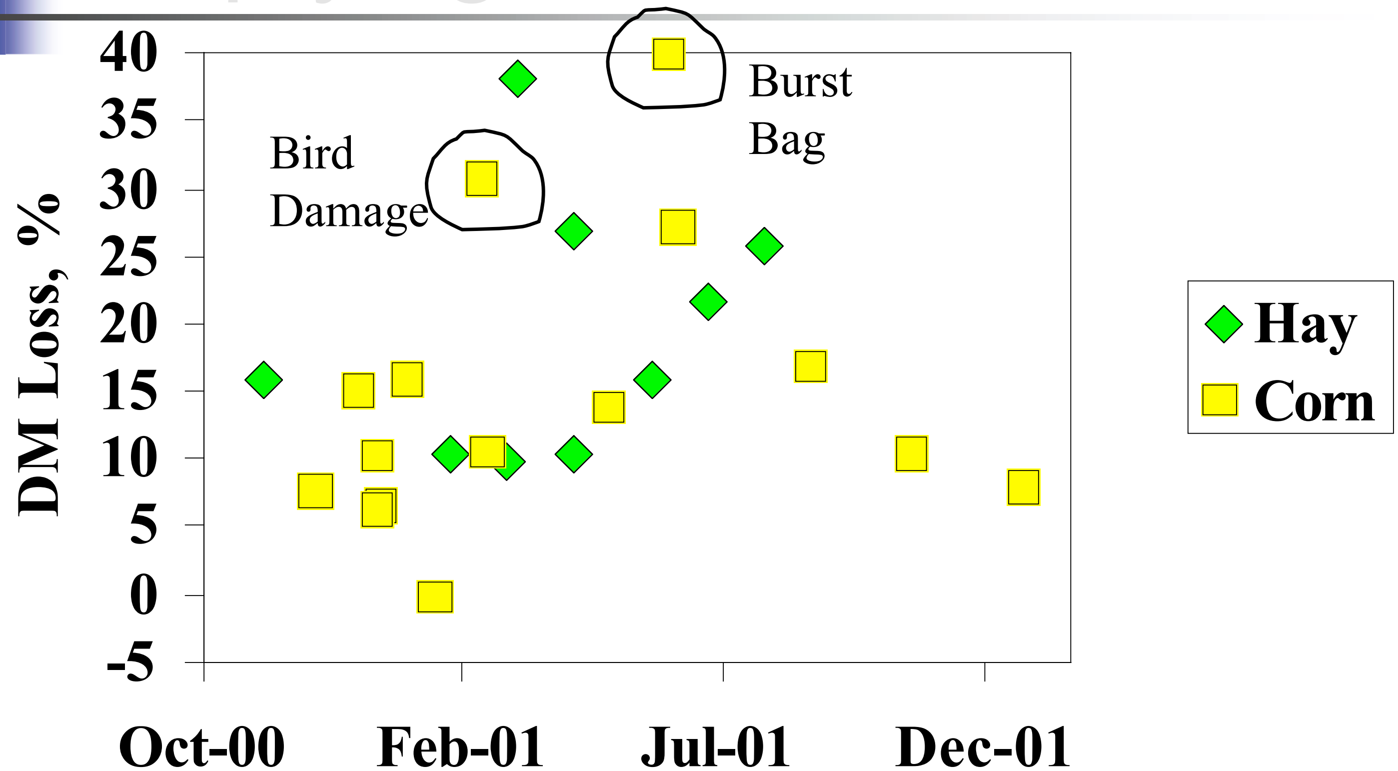
Gaseous/Uncollected Losses *vs.* Feed Out Rate



Gaseous/Uncollected Losses *vs.* Emptying Mid-Point Date



Total Losses *vs.* Emptying Mid-Point Date



Focus of Talk

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- Bag density, losses
- **New inoculants - *Lactobacillus buchneri***

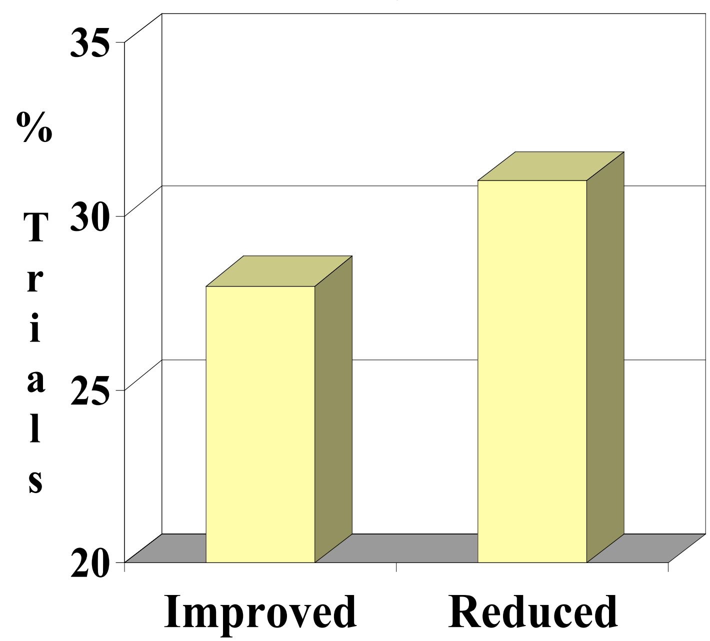
Standard Silage Inoculants

- Homofermentative lactic acid bacteria
- Shift fermentation to lactic acid, away from acetic acid & ethanol
- Guarantee a fast fermentation
- Improve DM recovery: 2-3%
- Improve animal performance: 3-5%

However, One Problem!

- Inoculants can reduce aerobic stability or bunk life
- Reductions are largely in corn and small grain silages

Aerobic Stability in All Silages as Affected by Inoculants



(Muck and Kung, 1997)

What Changes Are Occurring in Inoculants?

- Inoculant industry is looking for solutions to the aerobic stability problem
- Potential solutions:
  - Better standard inoculants with the ability to kill spoilage microorganisms
  - Heterofermentative LAB: *Lactobacillus buchneri*
  - LAB plus chemical inhibitor

L. buchneri Silage Inoculants - *Expectations*

- Can convert lactic to acetic
- Improve aerobic stability
- Higher pH
- Improve DM recovery but less than with a homofermenter
- Improve animal performance compared to a heating untreated silage; high acetic could be negative

Pilot-Scale Results

pH and Fermentation

Treatment	pH	Lactic	Acetic	Ethanol
Untreated	3.64	7.3	1.8	0.9
Standard A	3.71	8.9	2.3	2.0
Standard B	3.65	8.1	2.0	1.3
Standard C	3.62	7.5	1.6	1.0
Enhanced A	3.64	8.2	1.8	0.9
L. buchneri A	4.01	3.8	7.0	1.1
L. buchneri B	3.84	6.5	5.5	1.2

(Muck, 2002)

Pilot-Scale Results

Relative aerobic stability, hours

Treatment	1999	2000	2001
Untreated	0	0	0
Standard A	16	-13	-39
Standard B	-4	-20	-6
Standard C	-25	-6	-9
Enhanced A	-24	-27	29
L. buchneri A	142	100	811
L. buchneri B	103	22	454

(Muck, 2002)

Pilot-Scale Results

Dry matter losses, %

Treatment	1999	2000	2001
Untreated	33	16	14
Standard A	29	20	14
Standard B	27	18	12
Standard C	26	17	14
Enhanced A	25	21	17
L. buchneri A	30	18	17
L. buchneri B	32	17	21

(Muck, 2002)

Field-Scale Results

Dutch Corn Silage Trial

Characteristic	Untreated	L. buchneri
pH	3.88	3.92
Lactic Acid, % DM	4.8	4.7
Acetic Acid, % DM	1.2	1.9
Yeasts, log(cfu/g)	7.1	5.7
Aerobic stability, hour	9	41

Field-Scale Results

Dutch Corn Silage Trial Performance

Characteristic	Untreated	L. buchneri
DM Intake, lbs/day	45.9	45.0
Milk, lbs/day	85.5	85.5
Fat, lbs/day	3.61	3.61
Protein, lbs/day	2.77	2.83

Other L. buchneri Lactation Trials

- Aerobic stability: consistently increased
- Acetic acid:
  - Consistently increased; 0.4, 5.7 and 5.9% DM in high moisture corn, alfalfa and barley silages
- Dry matter intake: no effect
- Milk production: no effect
  - Avg. production: 69, 89 and 57 lbs./day for 3 studies

Overall Results with *L. buchneri* Silage Inoculants

- Slightly higher pH; increased acetic acid
- Aerobic stability: consistent increases
- Slower growers: 45-60 days storage time before having much effect on aerobic stability
- Dry matter recovery: most likely intermediate between untreated and standard inoculants
- Animal performance: no effects yet in trials

Goals In Using Inoculants?

Choice of inoculants depends on goals:

- Make a good silage perform better
- Aerobic stability improvement

Make a Good Silage Better

Standard inoculants are the best route to improve DM recovery, animal performance

- Good fit for hay crop silages
- Less likely to be successful on corn
  - Harder to get consistent improvements
  - Bunk life issues when they work

Aerobic Stability Problems

- Is the problem a management problem that can be solved without an additive?
- If not, *L. buchneri* looks like a good alternative to propionic acid or anhydrous ammonia
  - Safer to handle
  - Competitive cost
  - Similar effects on DM recovery, animal performance with all three additives

Final Issues with Using Any Inoculant

- These products work only if the bacteria go on the crop alive!
  - Store them properly: generally cool and dry
  - Don’t use chlorinated water to dilute unless the chlorine level is less than 1 ppm
- These bacteria cannot move around; they depend on you to spread them uniformly

Questions?