U.S. Dairy Forage Research Center

USDA, Agricultural Research Service

Silage Density and Dry Matter Loss of Bag and Bunker Silos

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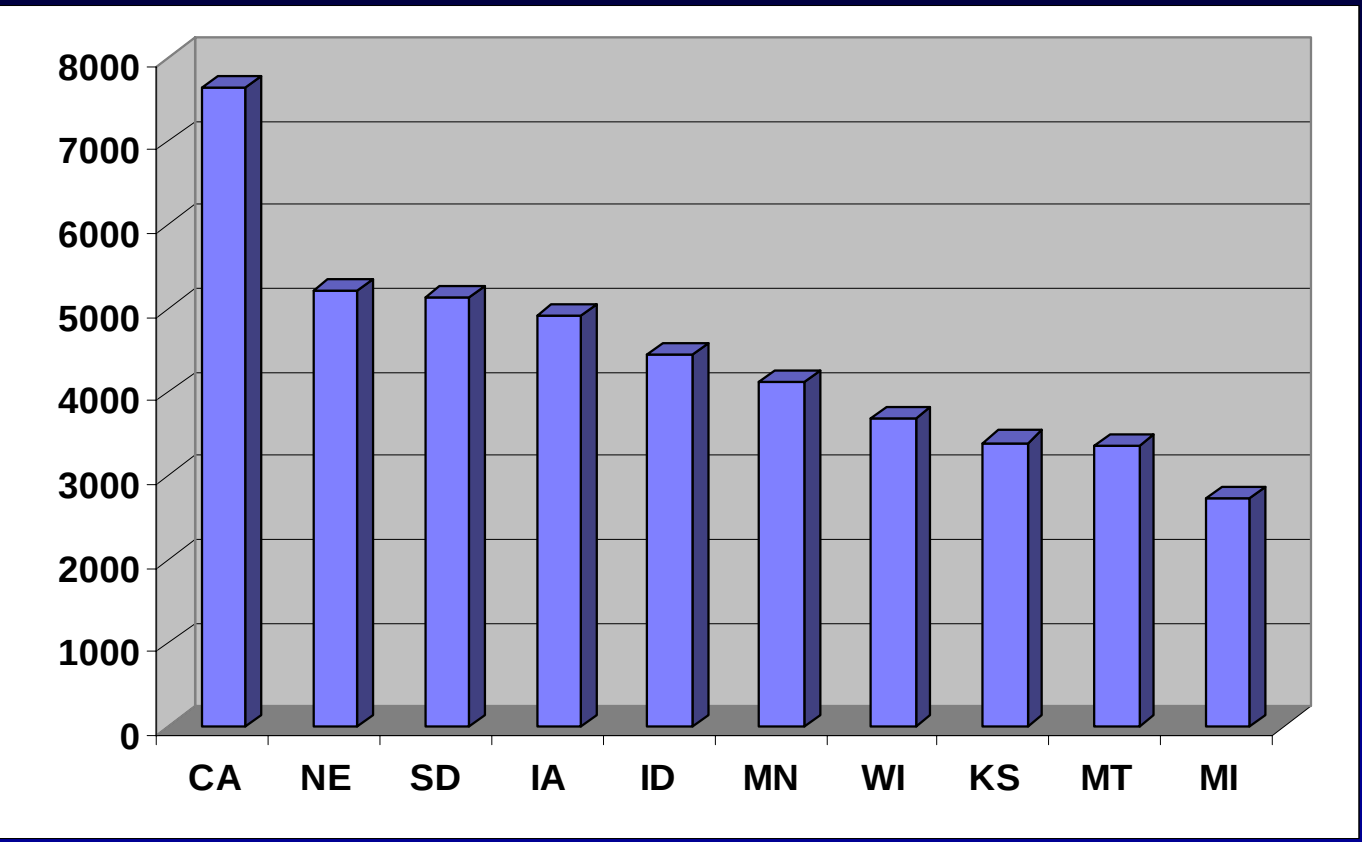
Silage Density and Dry Matter Loss of Bag and Bunker Silos

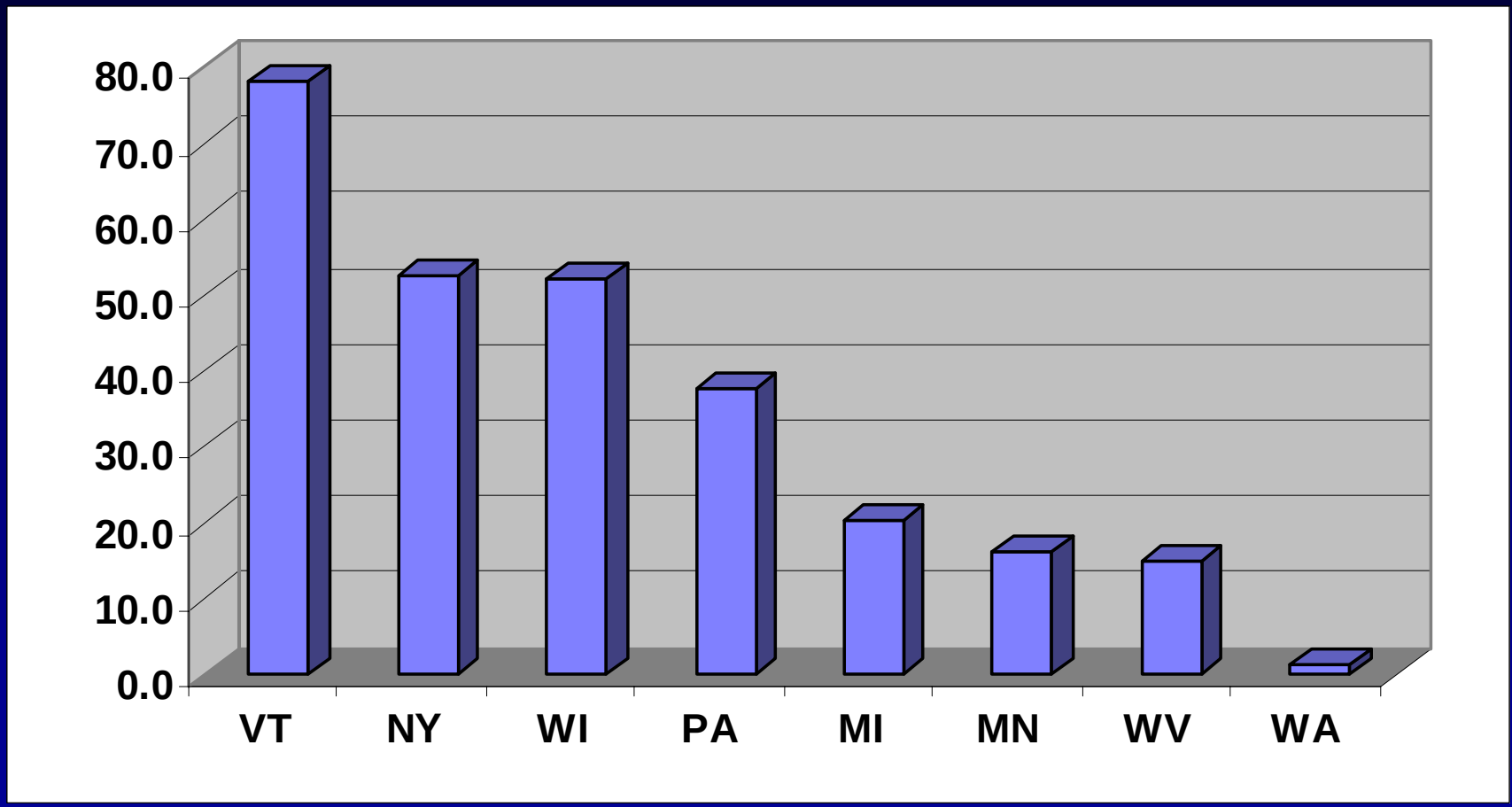
- Introduction
- Silo bag study
- Bunker research and educatio

Leading Alfalfa Hay Production States, 1,000 tons, 2003



- Top 10 States
  - 58 % of U. S.
  - 60 % of Acre
  - 4 states NC
  - 6 states West
  - 5 Lead Dairy

Percent of Total 2003 Alfalfa Production - Haylage



Why Density and Losses?

Important to:

- **Determine true cost of storage**
- **Estimate feed inventory**
- **Determine critical management practices**

However, little but sales literature is available

Objectives

Monitor filling and emptying of pressed bag silos to:

- **Measure densities and losses**
- **Determine factors affecting each**

Methods

- **3 research farms in area (Arlington, Prairie du Sac, West Madison) have used baggers for several years**

- **3 machines: 9 ft. Kelly-Ryan, 8 ft. Ag Bag, 9 ft. Ag Bag (rental)**

Kelly-Ryan

8 Foot Ag Bag

Filling

- **All loads:**
  - **Weighed**
  - **Marked on bag and length measured**
  - **Sampled for moisture**
  - **Composited samples across loads for particle size, CP, NDF, ash**

Emptying

- All silage weighed (both good and spoiled)
- A sample per filling load: moisture and various quality characteristics

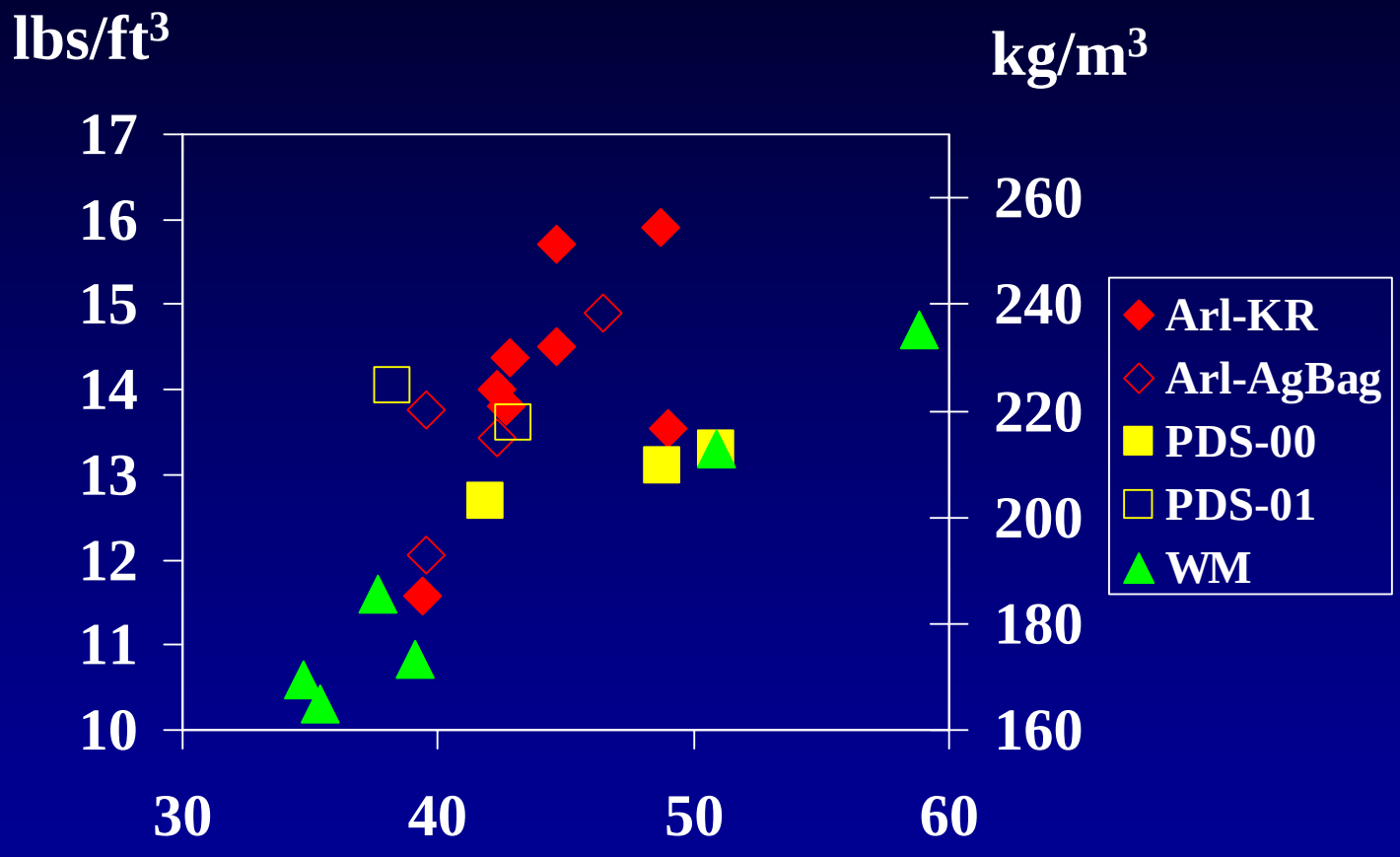
Number of Bags Losses Analyzed/Made

Bagger	Research Station	Hay	Corn
8’ Ag Bag	Prairie du Sac	2/5	5/6
9’ Ag Bag	Arlington	0/4	3/3
9’ Kelly Ryan	Arlington	4/8	4/8
9’ Kelly Ryan	W. Madison	3/7	3/6
Total		9/24	15/23

Average Hay Crop DM Densities

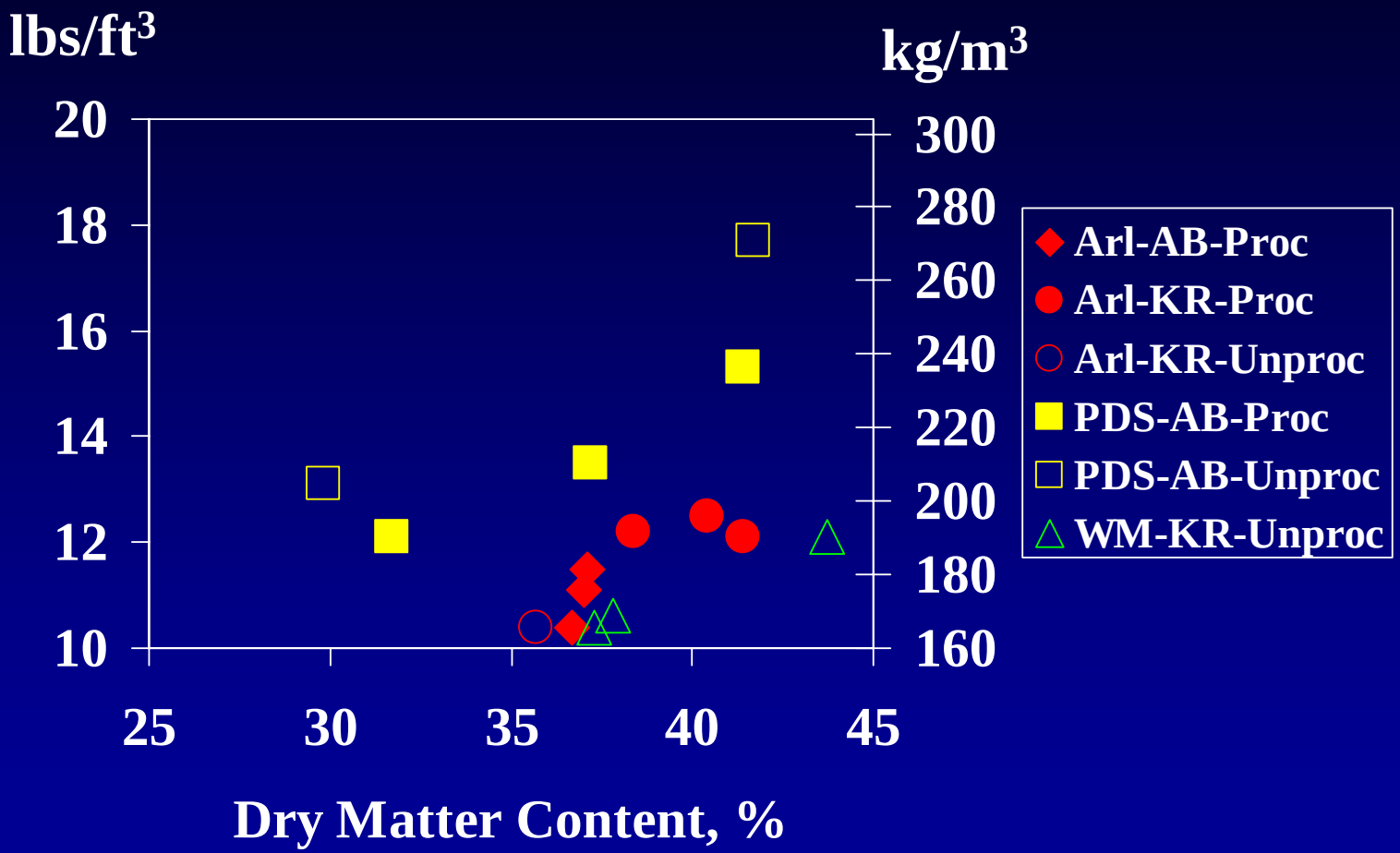
Bagger	Research Station	lbs/ft^3	kg/m^3
8’ Ag Bag	Prairie du Sac	13.1	210
9’ Ag Bag	Arlington	13.5	217
9’ Kelly Ryan		14.2	227
9’ Kelly Ryan	W. Madison	11.6	186

Dry Matter Densities in Hay Crop Silages



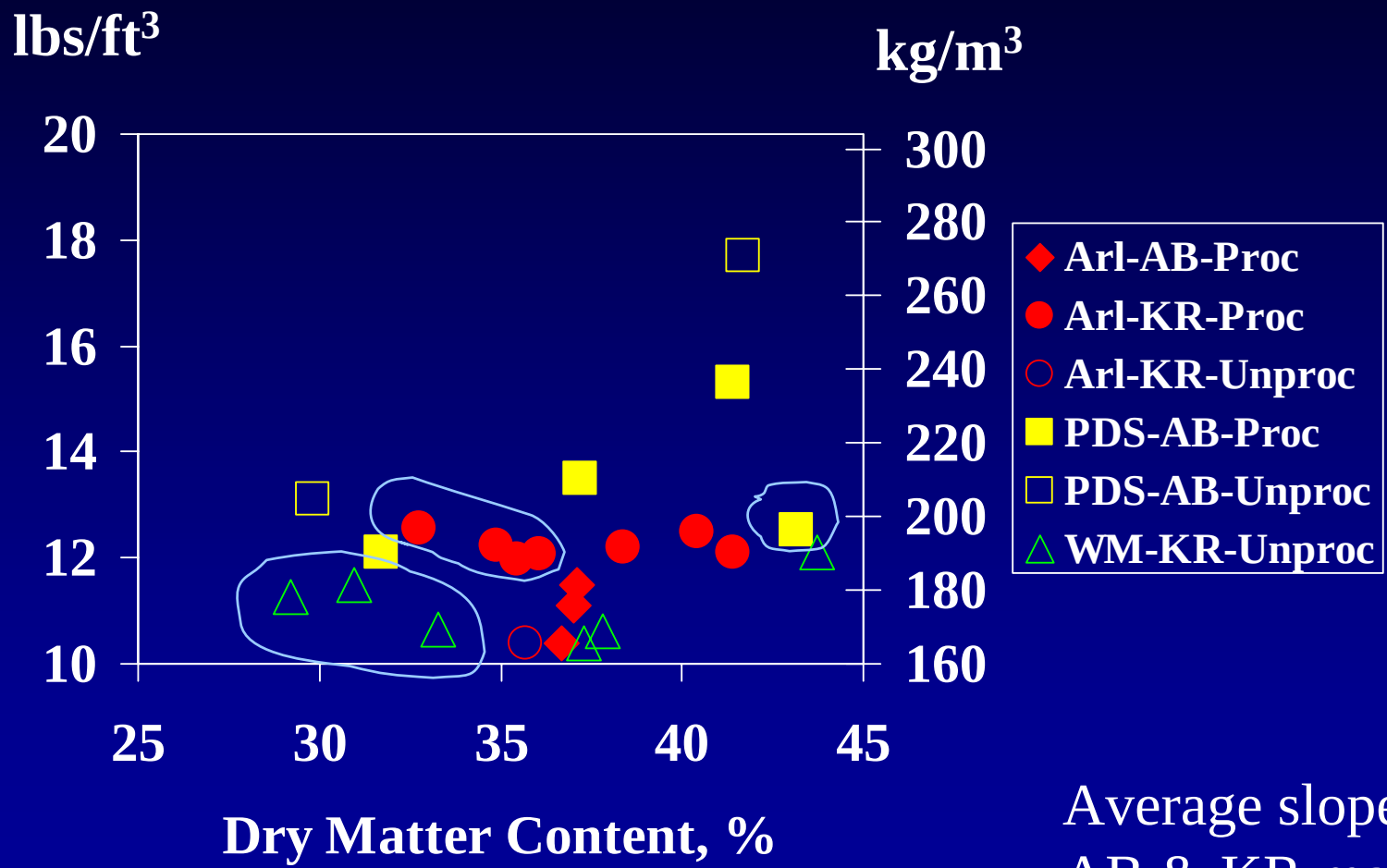
Average slope=0.19 lbs DM/ft^3 / % DM

Dry Matter Densities in Corn Silages - 2000



Average slope=0.33 lbs DM/ft^3 / % DM

Dry Matter Densities in Corn Silages - 2000, 2001



Average slope=??
AB & KR may have different slopes

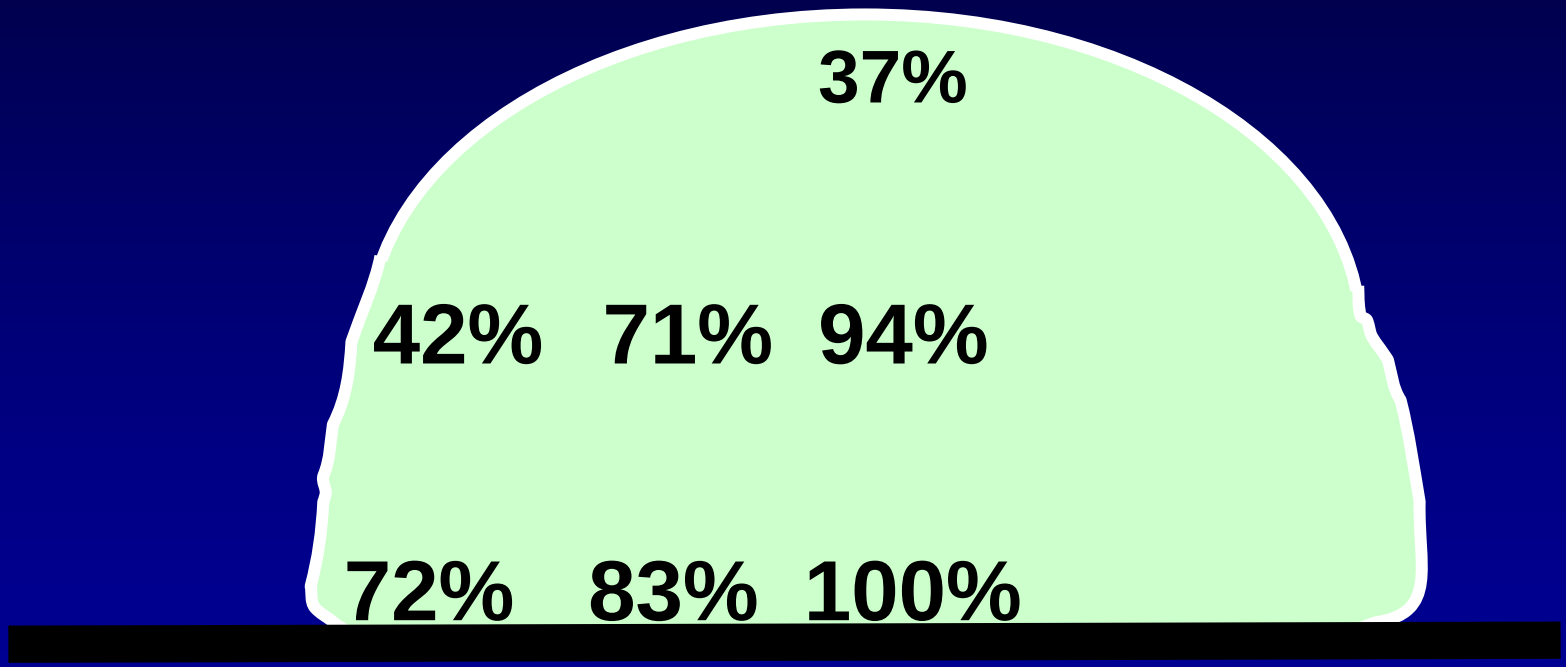
Average Corn DM Densities

Bagger	Station	Processed	lbs/ft^3	kg/m^3
8’ Ag Bag	PDS	Yes	13.3	214
		No	15.4	246
9’ Ag Bag	Arl	Yes	11.0	176
9’ K R		Yes	12.2	196
9’ K R		No	10.4	167
9’ K R	WM	No	11.1	178

Average DM Densities (lb/ft^3)

Bagger	Station	Processed	Hay	Corn
8’ Ag Bag	PDS	Yes		13.3
		No	13.1	15.4
9’ Ag Bag	Arl	No/Yes	13.5	11.0
9’ K R		Yes		12.2
9’ K R		No	14.1	10.4
9’ K R	WM	No	11.6	11.1

Density Variation on the Face



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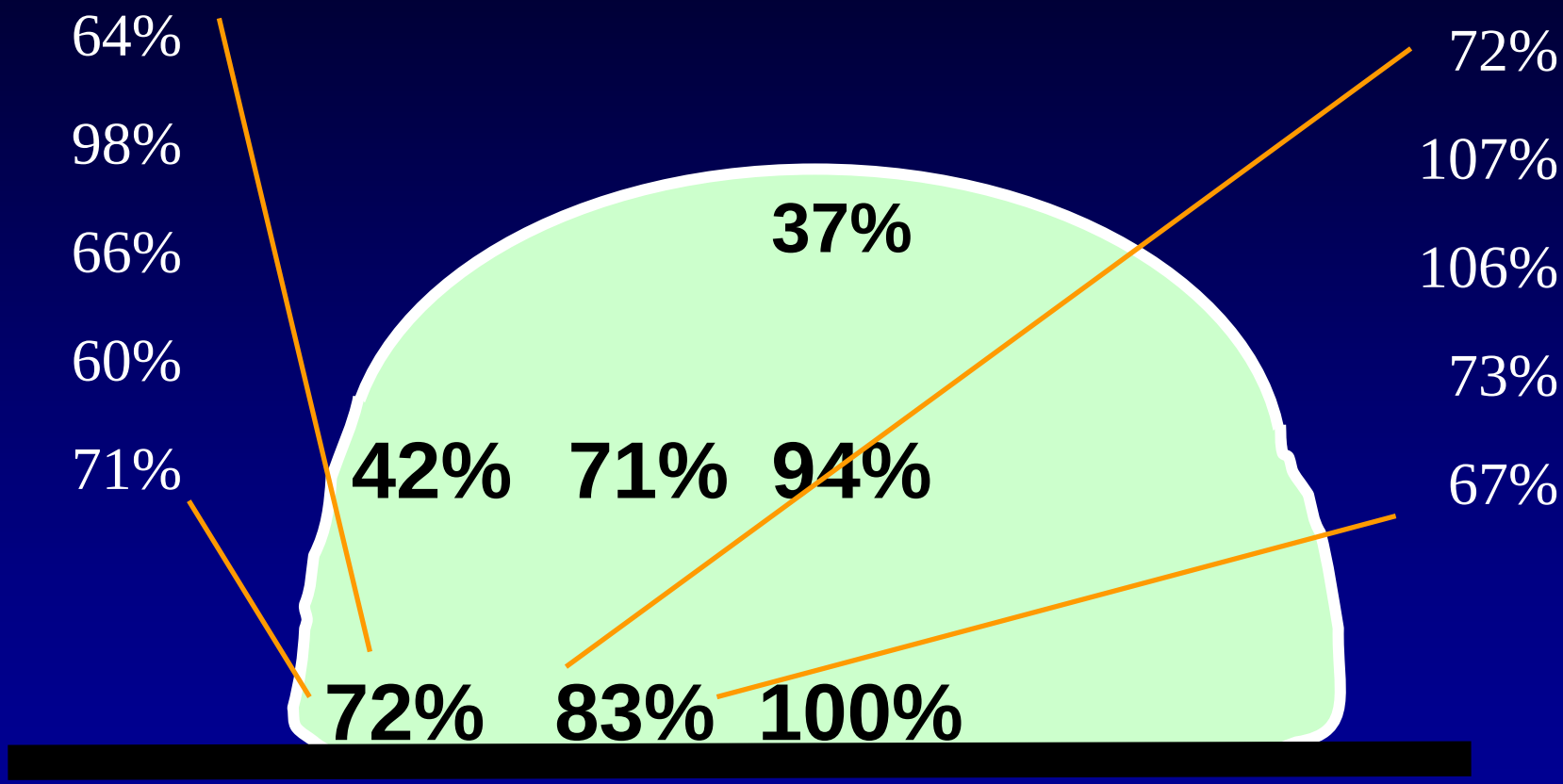

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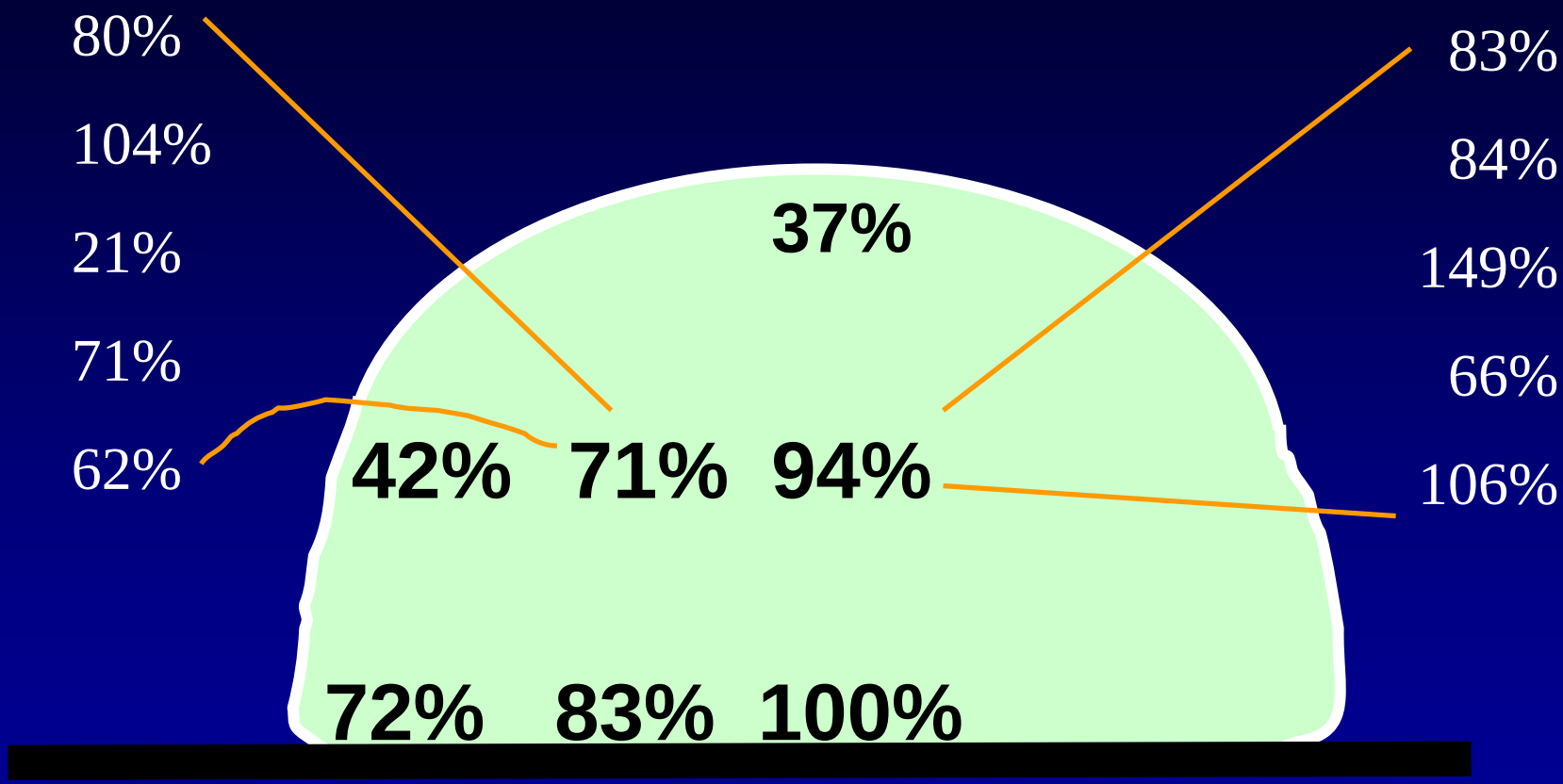


Losses

- **Invisible & Uncollected = Filling + Removal + Gaseous + Seepage (Not Collected) =**

  Total DM in - Total DM removed

- **Spoilage = Silage not fed (moldy)**

- **Total Loss = Invisible & Uncollected + Spoilage**

Range of Losses (% DM)
24 Bags

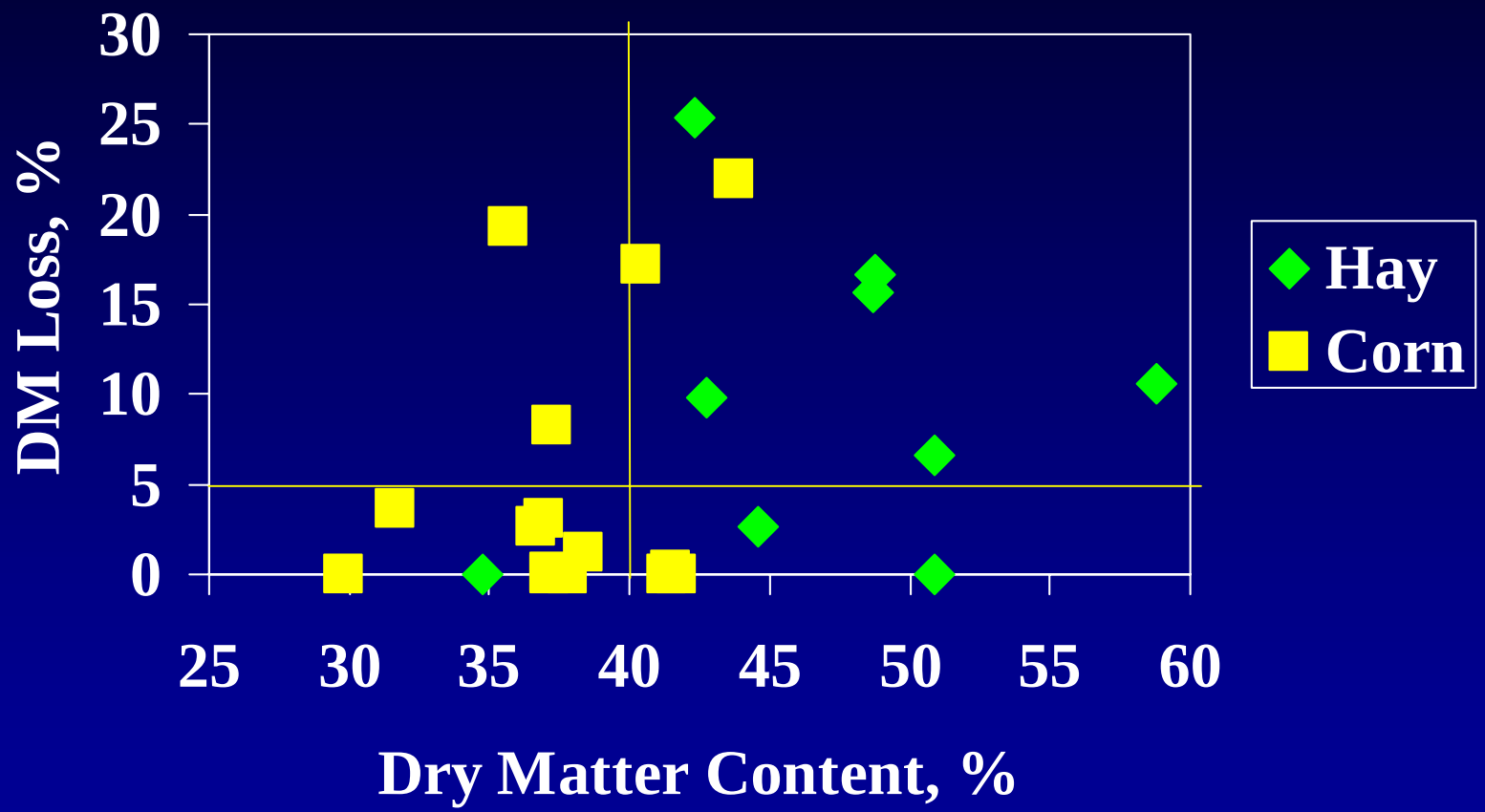
Type	Loss Range	Loss Average	Loss Average w/o Worst 6*
Inv. & Uncol.	-0.3 to 22.8	9.5	8.7
Spoilage	0.0 to 25.4	6.9	2.7
Total	-0.3 to 39.9	16.4	11.4

* 25% loss or more

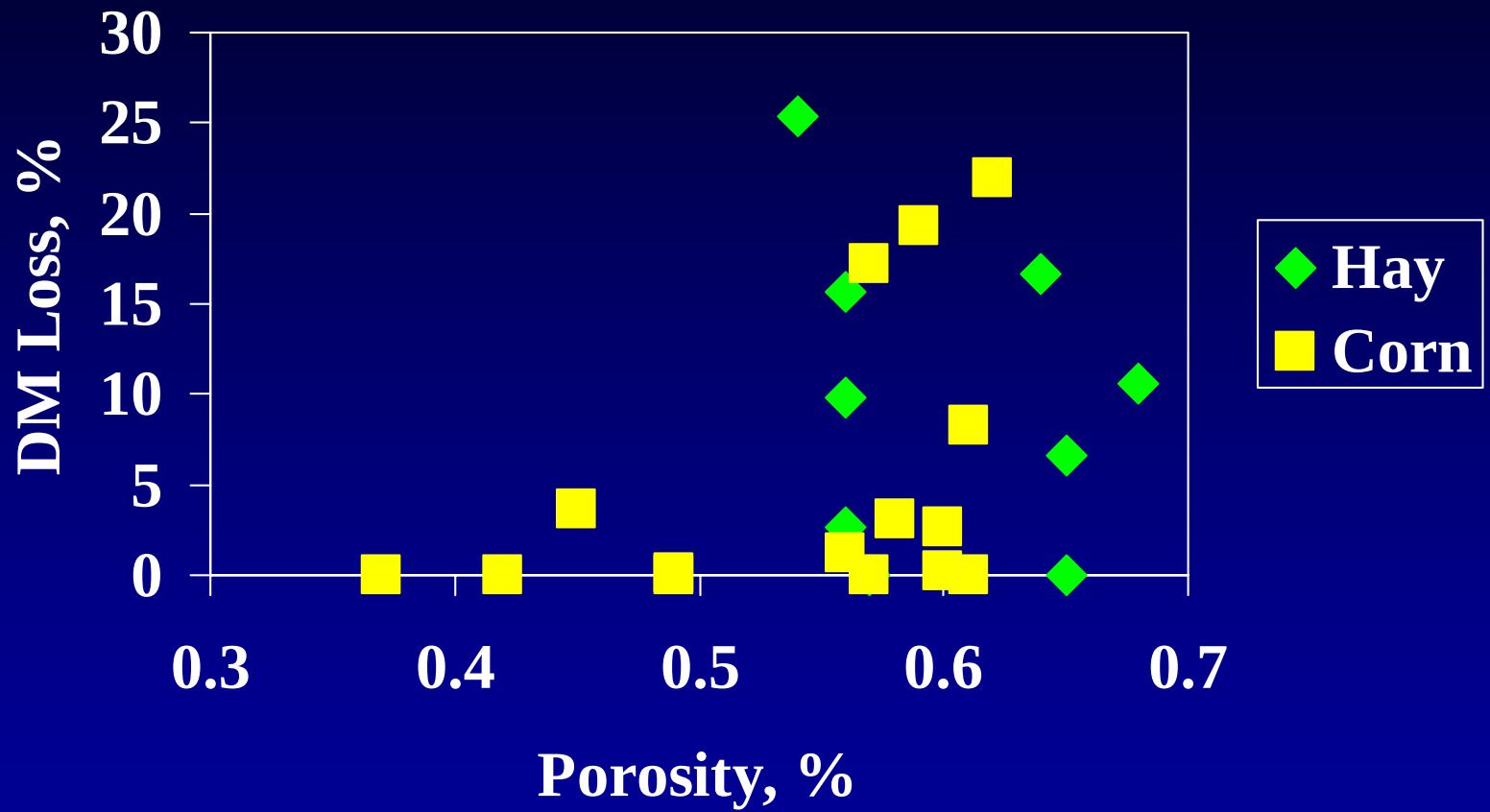
Issues With The Worst Six Bags

Total % Loss	Spoiled (% Loss)	% DM	When Fed	Removal Rate (in./day)	Comments
39.9	17.2	40.4	27 June	29	Bag burst
38.2	25.4	42.3	30 March	23	?
30.6	21.9	43.7	12 March		Bird damage
27.1	19.3	35.7	3 July	28	?
26.9	16.6	48.8	1 May	8	Similar bag
					Total = 11%
25.9	15.7	48.7	20 Aug	53	?

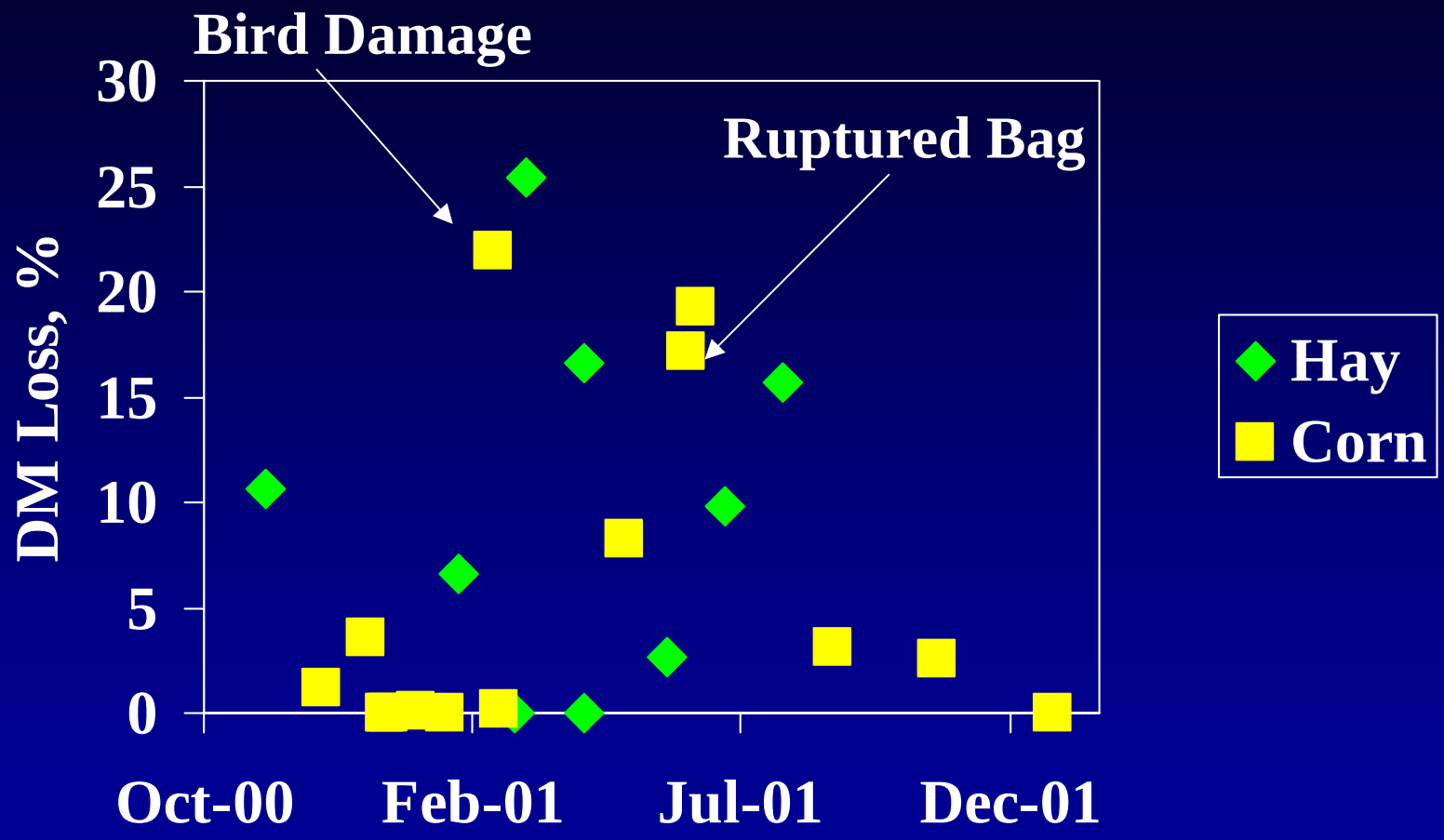
Spoilage Losses *vs.* DM Content



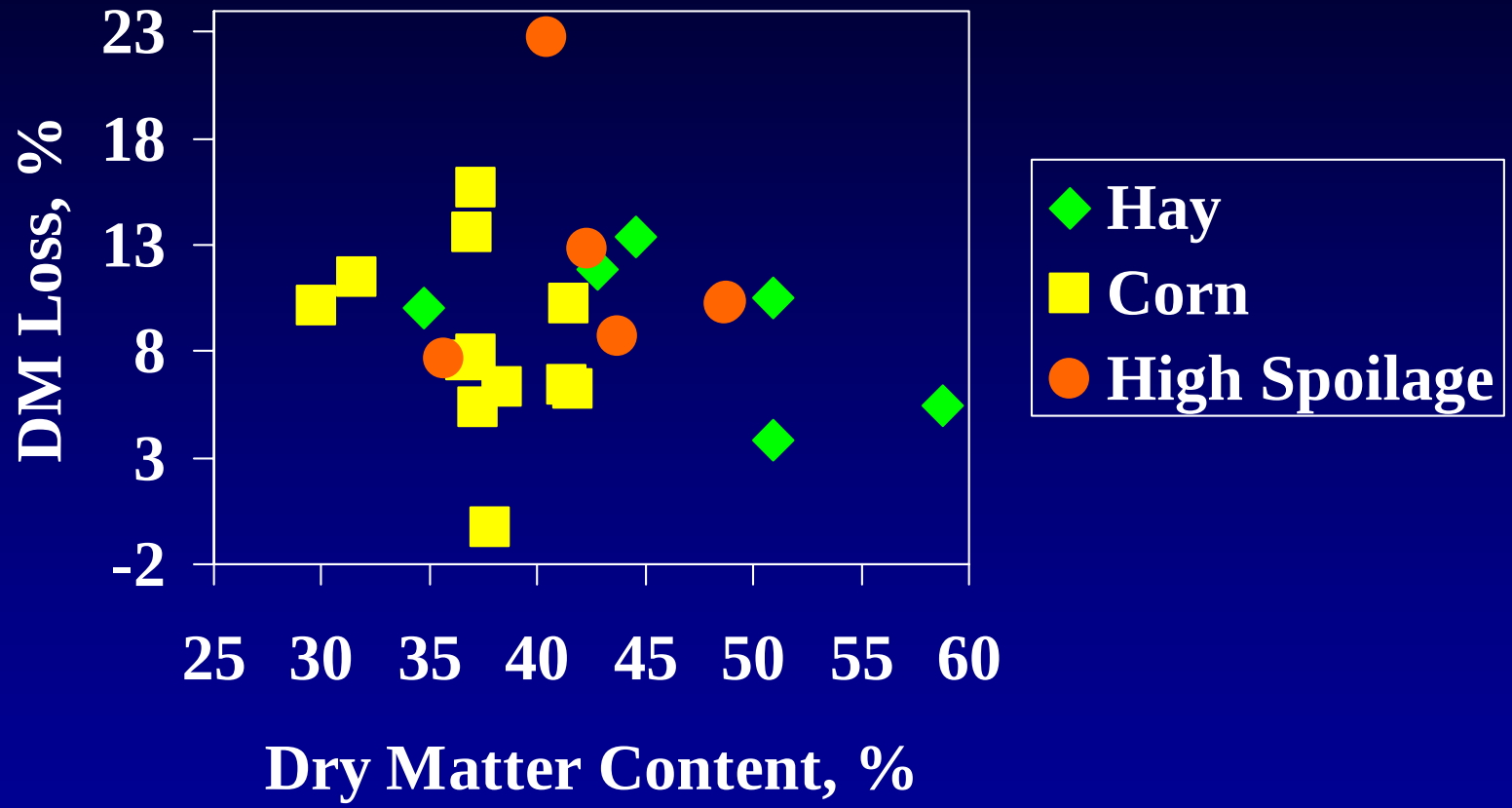
Spoilage Losses *vs.* Porosity



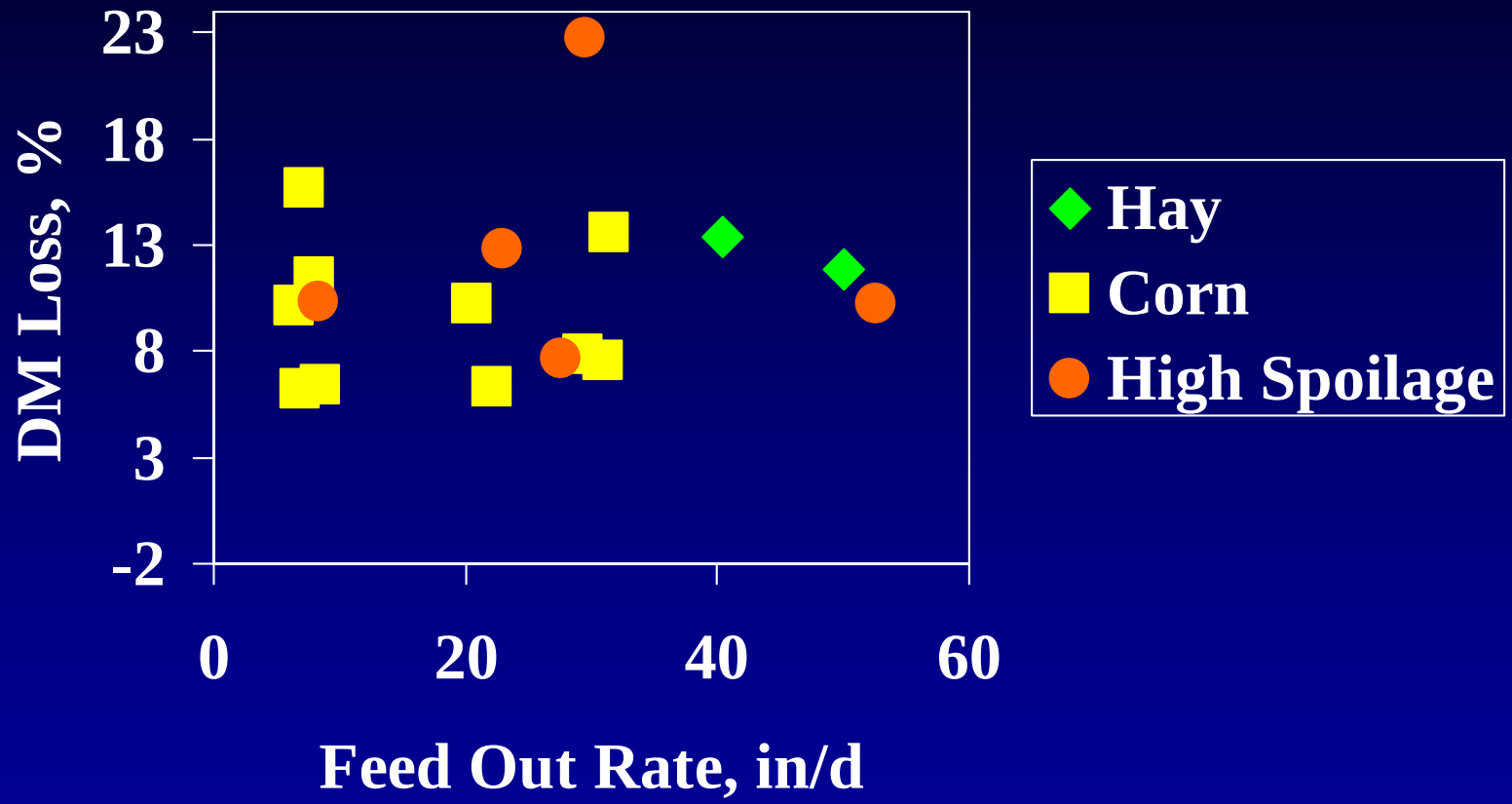
Spoilage Losses *vs.* Emptying Mid-Point Date



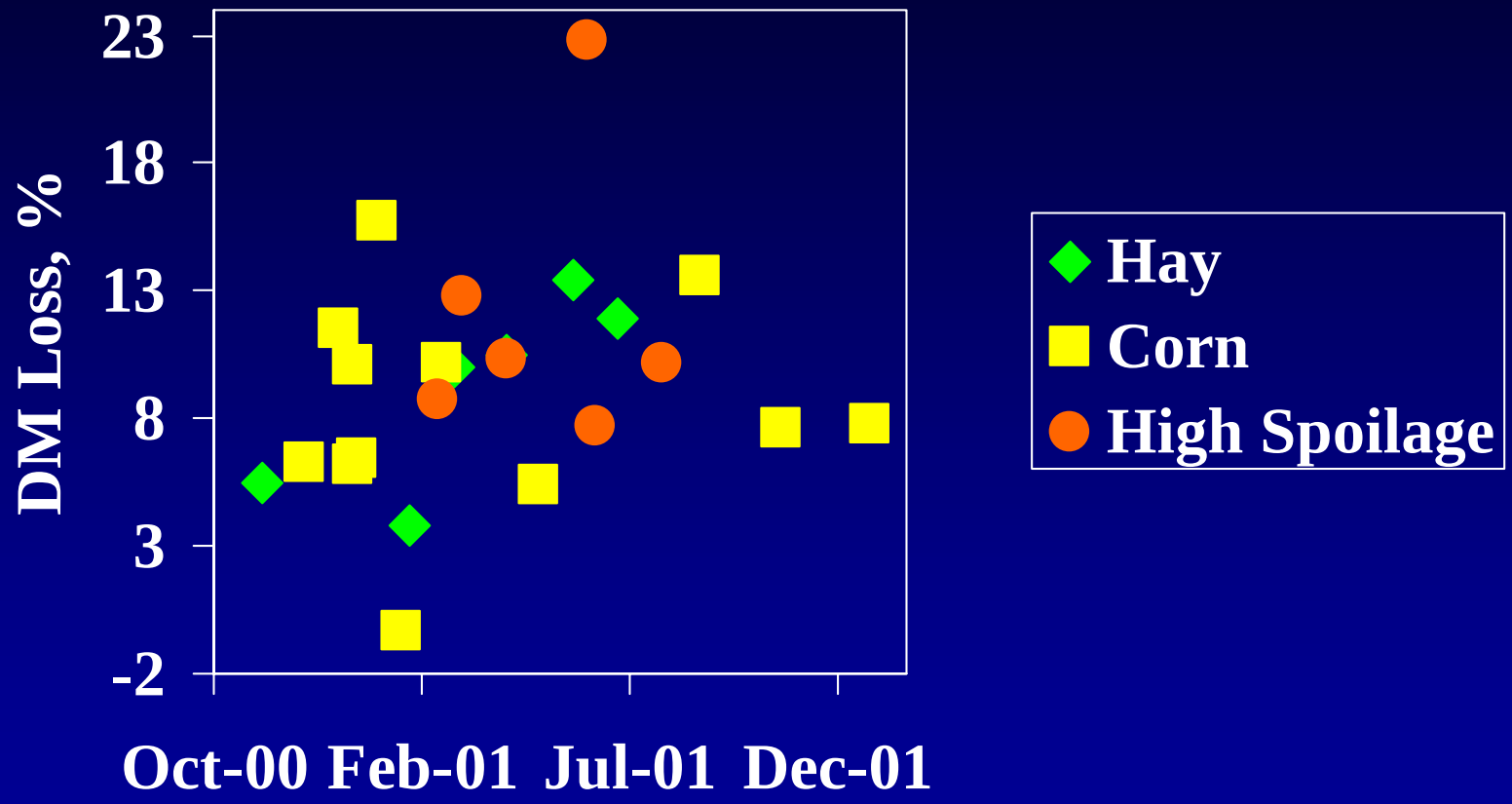
Invisible & Uncollected Loss *vs* DM Content



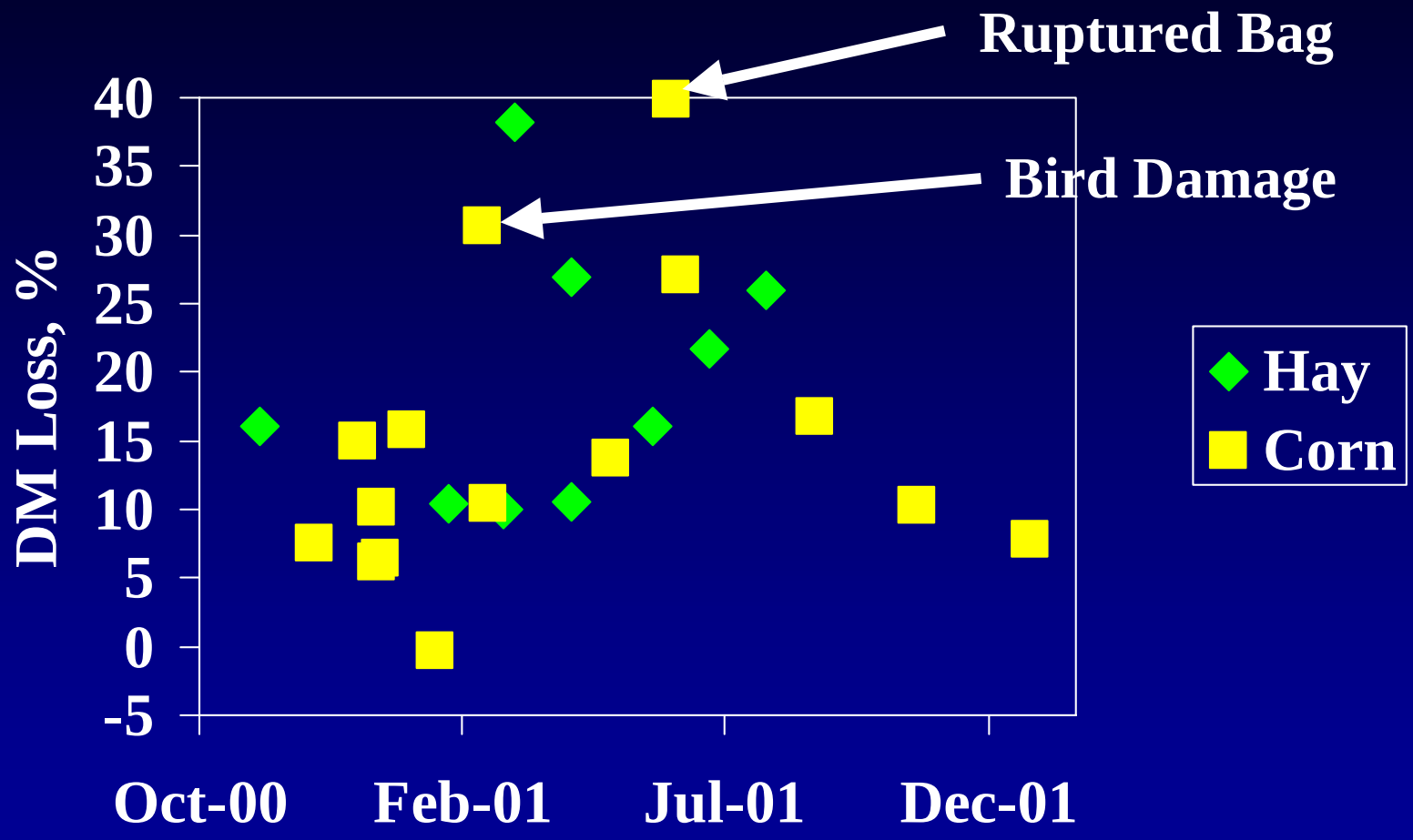
Invisible & Uncollected Loss *vs Feed* Out Rate



Invisible & Uncollected Loss *vs* Emptying Mid-Point Date



Total Losses *vs.* Emptying Mid-Point Date



Summary

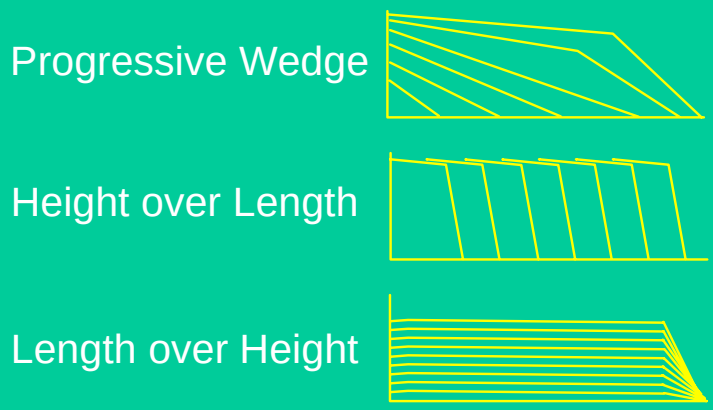
- **Density in hay crop silage: 12.5 lbs DM/ft^3**
- **Density in corn silage: higher with one bagger, lower in other relative to hay crop**
- **DM density lower the wetter the hay crop; less certain relationship in corn**

Summary

- **Average total losses were 16.4%, but 11.4% without 6 bags with major losses (>25%)**
- **Spoilage in dry (>40% DM), porous silages**
- **More problems with spoilage in summer**
- **Evidence that good management necessary for low losses**

Management of Bunker Silos

- **Harvest**
  - **maturity, moisture, chop length, rapid chop**
- **Filling**
  - **fill rapidly, pack tight, cover completely and quickly**



Management of Bunker Silos

- Harvest
- Filling
- Packing
  - Spread in thin layers
  - Average tractor weight
  - Silage height
  - Packing time/wet ton

Management of Bunker Silos

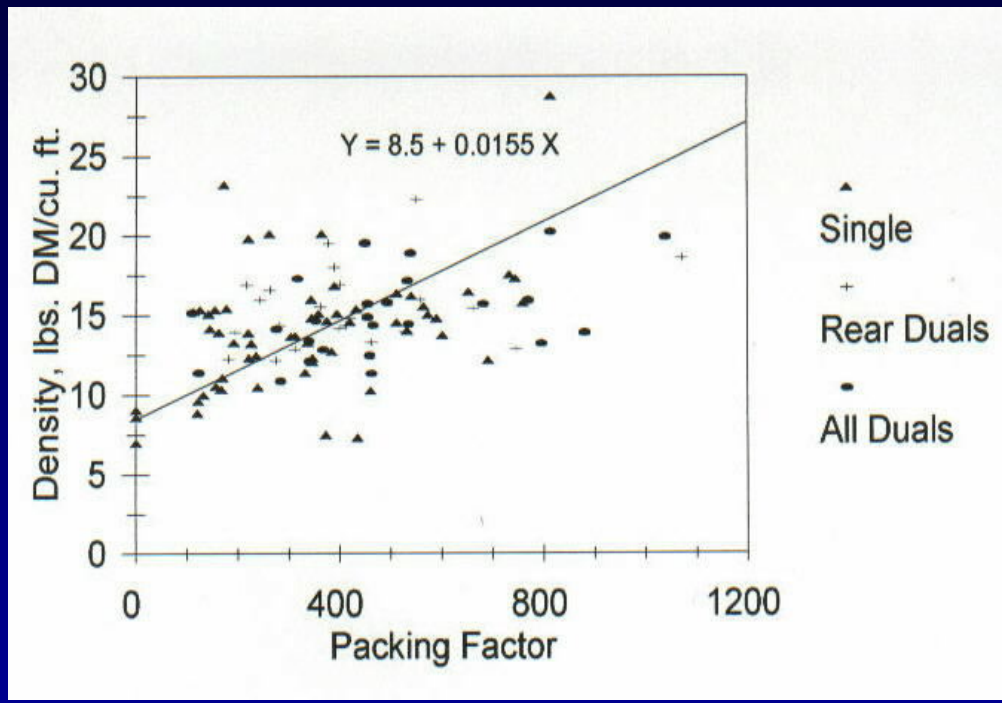
Dry matter loss as influenced by silage density.

Density (lbs DM/ft^3)	DM Loss, 180 days (%)
10	20.2
14	16.8
15	15.9
16	15.1
18	13.4
22	10.0

SOURCE: Ruppel, K. A. 1992. MS thesis Cornell University, Ithaca, NY

Management of Bunker Silos

- Harvest
- Filling
- Packing
  - Spread in thin layers
  - Average tractor weight
  - Silage height
  - Packing time/wet ton
- Interaction of fill & pack



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

Silo Management

- **High packing density needed**
  - **Density & dry matter content → porosity**
  - **Porosity set rate of air movement into silo**
  - **Higher the density, greater silo capacity**

Silo Management

Characteristic	Hay crop silage (87 silos)		
	Average	Range	SD*
Dry matter (%)	42	24-67	9.50
Wet density (lbs/ft^3)	37	13-61	10.90
Dry density (lbs/ft^3)	14.8	6.6-27.1	3.80
Avg. particle size(in)	0.46	0.27-1.23	0.15

*SD=standard deviation

SOURCE: Holmes and Muck, 1999.

Silo Management

Characteristic	Corn silage (81 silos)		
	Average	Range	SD*
Dry matter (%)	34	25-46	4.80
Wet density (lbs/ft^3)	43	23-60	8.30
Dry density (lbs/ft^3)	14.5	7.8-23.6	2.90
Avg. particle size(in)	0.43	0.28-.68	0.08

*SD=standard deviation

SOURCE: Holmes and Muck, 1999.

Dry Matter Density Variation

DMD (lbs/ft^3) = (8.5 + PF x 0.0155) x (0.818 + 0.0136 x D)

Where average depth (D) and packing factor (PF) are calculated as:

D = avg. silage depth (ft) = height at wall + height at center) /2

PF = (W/L) x N X DM/C

W = Proportioned average tractor weight (lbs) for all tractors

L = Layer thickness (inches) of the spread but unpacked

N = Number of tractor-packing equivalents, where N = 1 one

DM = Dry matter content (decimal)

C = Crop delivery rate (T AF/hr) to the silo

Forage Harvester Average Capacity

	Capacity (T AF/hr)	
Forage harvester type	Hay	Corn
Pull, 250 HP	60	110
Self-propelled, 450 HP	100	180

SOURCE: Shinners, 2001

Improving Silage Density*

Variables changed	DMD(lbs/ft^3)
No change	12.3
+20,000-lb tractor 50% time	12.7
+20,000-lb tractor 100% time	13.1
+5,000 weight to 30,000-lb tractor	13.0
+5,000 weight to both tractors 100% time	14.1
Reduce layer thickness 6 to 4-inches	14.5
Both tractors 100% time & reduce layer to 4	15.6
+5,000 lb to 30,000-lb & reduce layer to 4	15.5
+5,000 lb to tractors 100% time & reduce	17.1

**Forage delivery rate increased from 50 to 100 T AF/hr*