Corn Silage Compared to Other Forages

- Advantages
- Palatable forage
- High dry matter yield and energy content
- Consistent quality
- Less labor and machinery (one harvest). Lower cost per ton of dry matter
- Manure management
- Flexibility, dual purpose

- Disadvantages
- Few established markets
- Relatively low in protein
- High transportation costs
- Must be fed on or near farm
- Expensive storage facilities
- Limited production on erodible soils due to conservation requirements

Desirable Forage Characteristics

- What makes a good forage? (Carter et al., 1991)
  - ✓ High yield
  - ✓ High energy (high digestibility)
  - ✓ High intake potential (low fiber)
  - ✓ High protein
  - ✓ Proper moisture at harvest for storage
- Ultimate test is animal performance
  - ✓ Milk2000 is our best predictor for performance (Schwab - Shaver equation)

Corn Silage

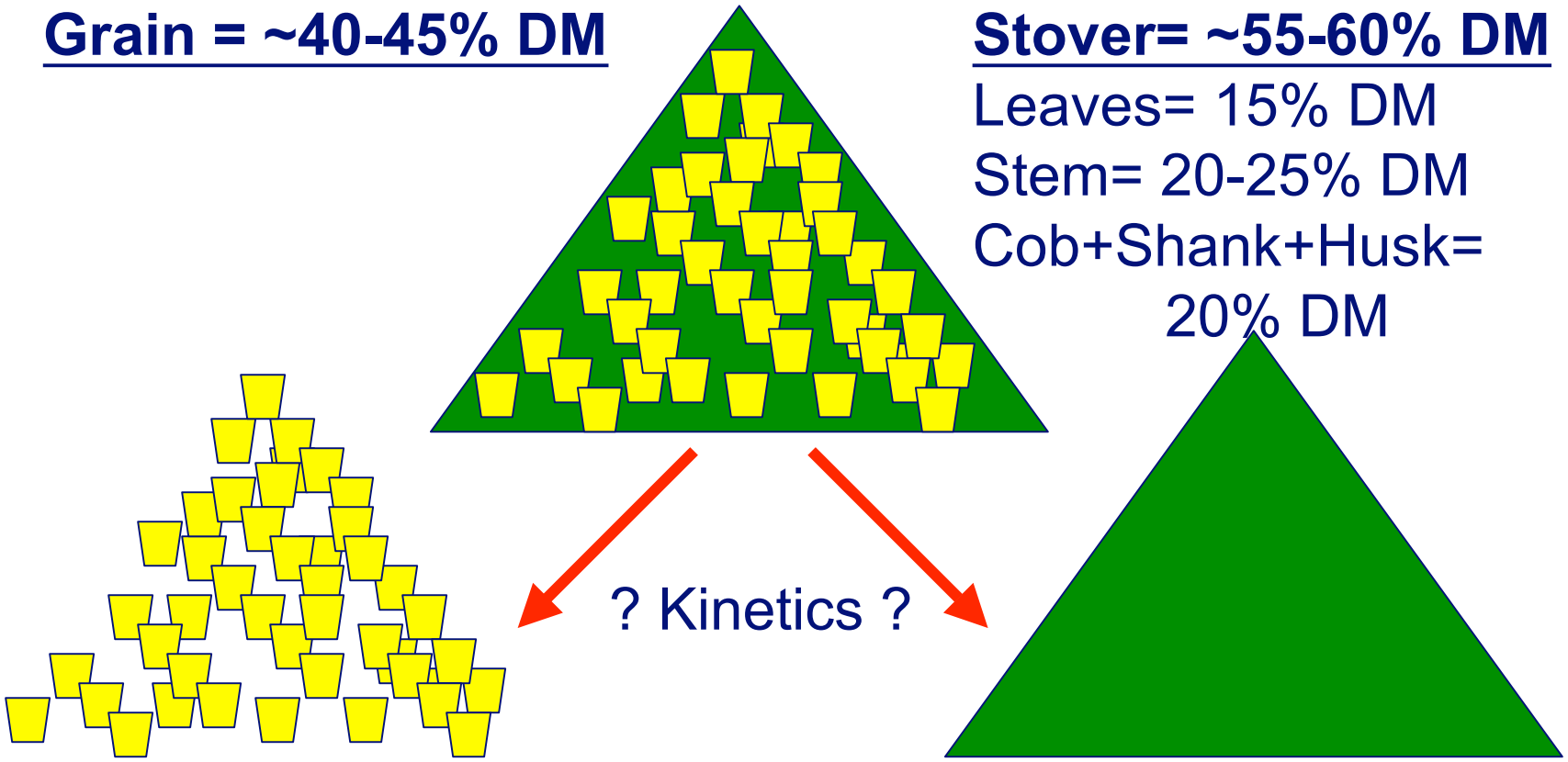
Grain = ~40-45% DM

Stover= ~55-60% DM

Leaves= 15% DM

Stem= 20-25% DM

Cob+Shank+Husk= 20% DM



80 to 100% digestible

- Kernel maturity
- Starch digestibility

40 to 55% digestible

- Cell wall digestibility

Yield and Digestibility of Corn Plant Parts

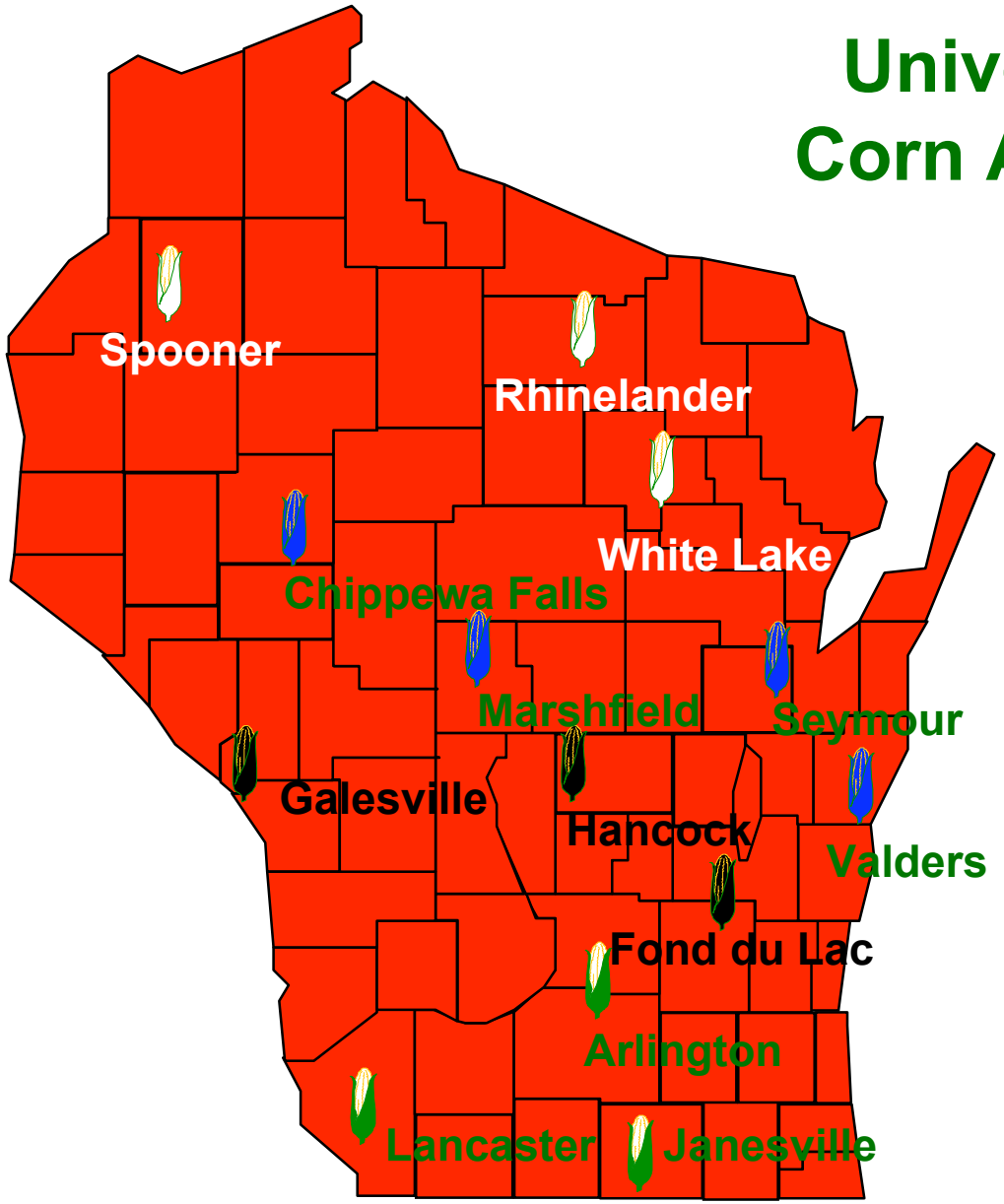
Tissue	Percent Yield	Digestibility (%)
Leaf blades	11	73
Leaf sheaths	4	63
Stalk+tassel	19	60
Cob+husk+shank	22	72
Kernels	44	94
Whole plant	100	71

Adapted from Deinum and Struik, 1989

Key Management Practices That Make Corn Forage Production Profitable

1) Hybrid selection
2) Proper timing of harvest
3) Remembering that a trade-off exists between yield and quality for management decisions
4) Cutting height
5) Slightly higher plant populations than what is normally used for grain production
6) Early planting date
7) Adequate soil fertility – predicted by soil sampling
8) Narrower row spacing increases yield
9) Pest control
10) Crop rotation

University of Wisconsin
Corn Agronomy Program



2002 Wisconsin Corn Performance Trials
Silage Summary

Location	1992-2001 N	1992-2001 Yield	2002 N	2002 Yield	Percent change
Arlington	438	9.4	56	8.8	-7
Lancaster	386	7.8	56	8.6	10
Fond du Lac	352	8.6	65	8.7	1
Galesville	352	8.3	65	9.8	18
Chippewa Falls	4	7.3	53	8.0	8
Marshfield	408	6.8	53	8.0	18
Valders	387	6.7	53	5.5	-18
Rhinelander			17	7.0	
Spooner			34	8.3	

Wisconsin Corn Hybrid Silage Performance Trial Measurements

- Agronomic
  - ✓ Yield: Tons Dry matter / A
  - ✓ Moisture: %
  - ✓ Kernel milk stage: %
- Quality (NIR)
  - ✓ Crude protein : %
  - ✓ Acid detergent fiber: %
  - ✓ Neutral detergent fiber: %
  - ✓ *In vitro* true digestibility: %
  - ✓ Cell wall digestibility: %
  - ✓ Starch content: %
- Performance index
  - ✓ Milk per ton: The amount of milk production from one ton of silage using the quality measures. (Estimate is based on a standard cow body weight of 1350 pounds and milk production level of 90 pounds milk per day at 3.8 percent fat.)
  - ✓ Milk per acre = Milk per ton X Dry matter yield per acre

Calculating Milk per Ton
Milk per Acre = Yield x Milk per Ton

Milk1991

- Dry matter intake estimated using NDF
- Net energy of lactation (Mcal/lb) estimated using ADF

Milk1995

- Dry matter intake estimated using NDF
- Net energy of lactation (Mcal/lb) estimated using IVD

Milk2000

- Dry matter intake estimated using NDF and Cell wall digestibility
  - ✓ Base dry matter intake adjusted 0.374 lb. per 1% unit change in CWD above or below the trial average CWD (Allen et al.)
- Starch digestibility is adjusted for dry matter content and kernel processing
- Net energy of lactation (Mcal/lb) estimated using multi-component summative equation approach

2002 Wisconsin Corn Hybrid Performance Trial Results
Table 13. South Central Zone - Early Maturity Silage Trial.
100 DAY RELATIVE MATURITY OR EARLIER, BASED ON COMPANY RATING (FOND DU LAC = FON, GALESVILLE = GAL)

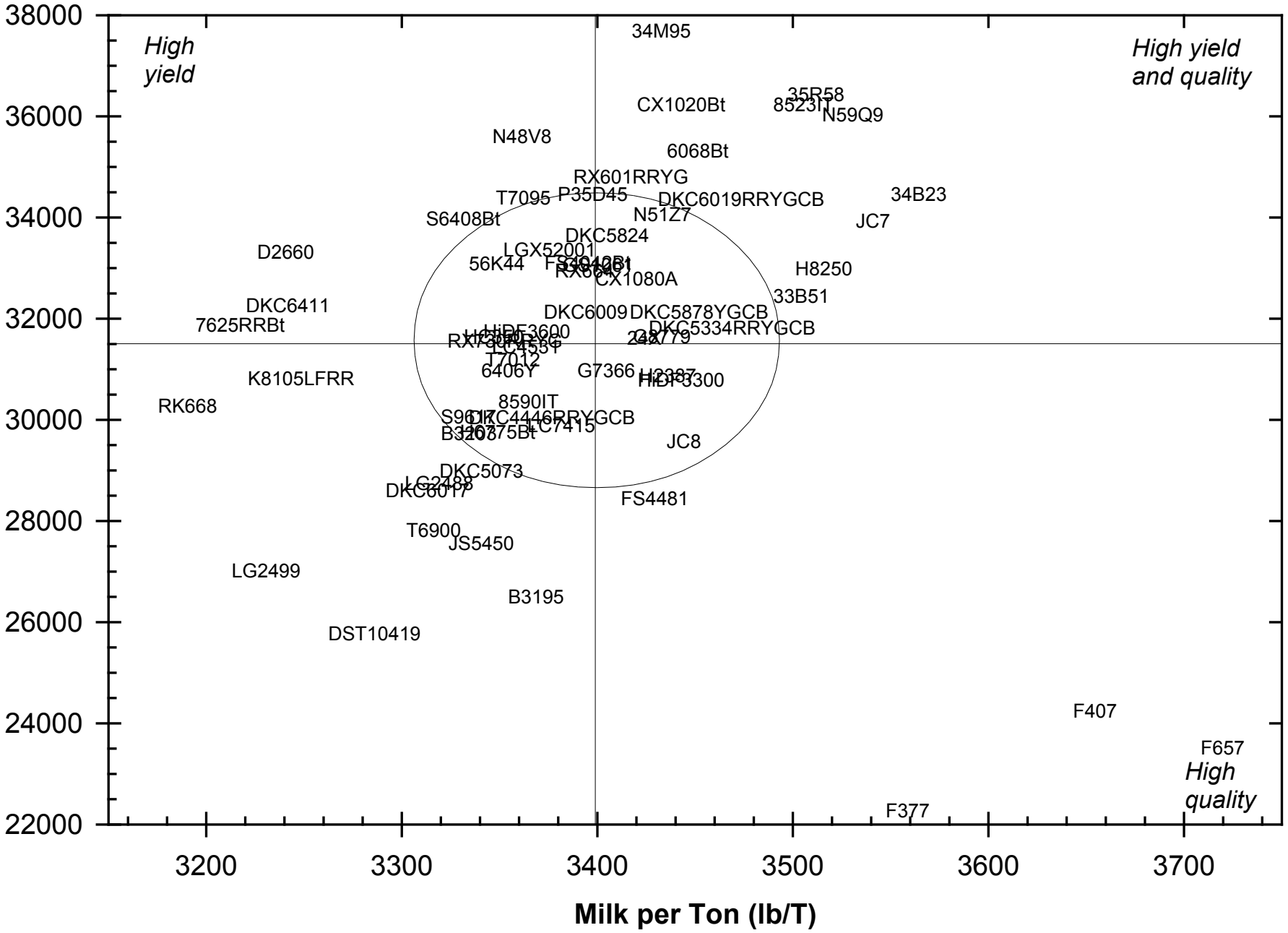
		2002													2001					
		AVERAGE											FON	GAL	AVERAGE			FON	GAL	2 Year Average
		Yield	MILK PER		Moist	Kernel Milk	CP	ADF	NDF	IVD	NDFD	Starch	Yield	Yield	Yield	MILK PER		Yield	Yield	Yield
BRAND	HYBRID	T/A	TON	ACRE	%	%	%	%	%	%	%	%	T/A	T/A	T/A	TON	ACRE	T/A	T/A	T/A
Dekalb	DKC4446	8.8	3380	30000	48.1	20	6.6	25	49	82	63	37	7.5	10.2 *						
Golden Harvest	H2387	8.9	3440	30900 *	54.7	20	7.5	23	46	82	62	37	7.3	10.5 *						
Dairyland	HiDF3300	8.9	3440	30800 *	55.7	20	7.2	24	46	83	62	37	8.0	9.8 *						
Golden Harvest	H6775Bt	8.8	3350	29800	57.0	20	7.2	25	47	81	60	35	7.5	10.1 *						
100-DAY HYBRID TRIAL AVERAGE##					58.7															
Growmark	FS4042Bt	9.7 *	3400	33100 *	58.9	30	7.0	25	47	82	61	37	9.3 *	10.2 *						
La Crosse Forage	LC7415	8.8	3380	29900	59.2	40	7.6	25	47	81	60	35	8.3	9.3	8.1	2870	* 23400	7.7	8.5	8.5
Garst	8779	9.2	3430	31600 *	59.3	30	6.9	25	47	82	61	36	8.3	10.0 *	9.0	2770	24900	7.7	10.2	9.1
Battleground	3195	7.8	3370	26500	59.4	30	7.3	25	48	81	61	34	7.1	8.6						
LG Seeds	LG2488	8.6	3320	28700	61.5	30	7.4	26	50	80	60	32	7.8	9.4						
Dekalb	DKC5073	8.7	3340	29000	62.0	40	7.1	25	47	81	59	35	8.5	8.9						
NK Brand	N48V8	10.7 *	3380	36100 *	63.2	40	7.1	28	52	80	62	27	10.2 *	11.1 *	10.6 *	2720	29000 *	9.7 *	11.6 *	10.7 *
Battleground	3203	8.9	3330	29700	63.9	50	7.4	27	50	80	60	32	8.9	8.9						
MEAN		9.0	3380	30500	58.6	30	7.2	25	48	81	61	34	8.2	9.8	8.9	2720	24100	8.0	9.7	9.4
LSD(0.10)**		1.2	NS	5800	5.2	10	0.5	3	5	2	2	5	1.0	1.4	0.7	130	2700	1.0	1.1	0.6

Average whole plant moisture of all hybrids in the trial as rated by the Minnesota Relative Maturity Rating System. Ratings are rounded to 5 day increments.

* Hybrids that performed statistically similar to the highest hybrid in the trial.

Shaded results provide the best estimate of relative hybrid performance.

Relationship between milk per acre and milk per ton of corn hybrids in South Central WI during 2002.



What Do We Want in Grain versus Forage Hybrids?

Trait	Grain	Forage
Grain yield	High	Adequate
Forage yield	Adequate	High
Hybrid range	60 bu/A	8,000 lb Milk/A
Stalks	Standability	Digestibility
Leaves	Unknown	Digestibility
Kernel hardness	Hard	Soft
Plant drydown	“Stay-green”	Synchronous
Plant maturity	“Full-season”	5-10 d longer

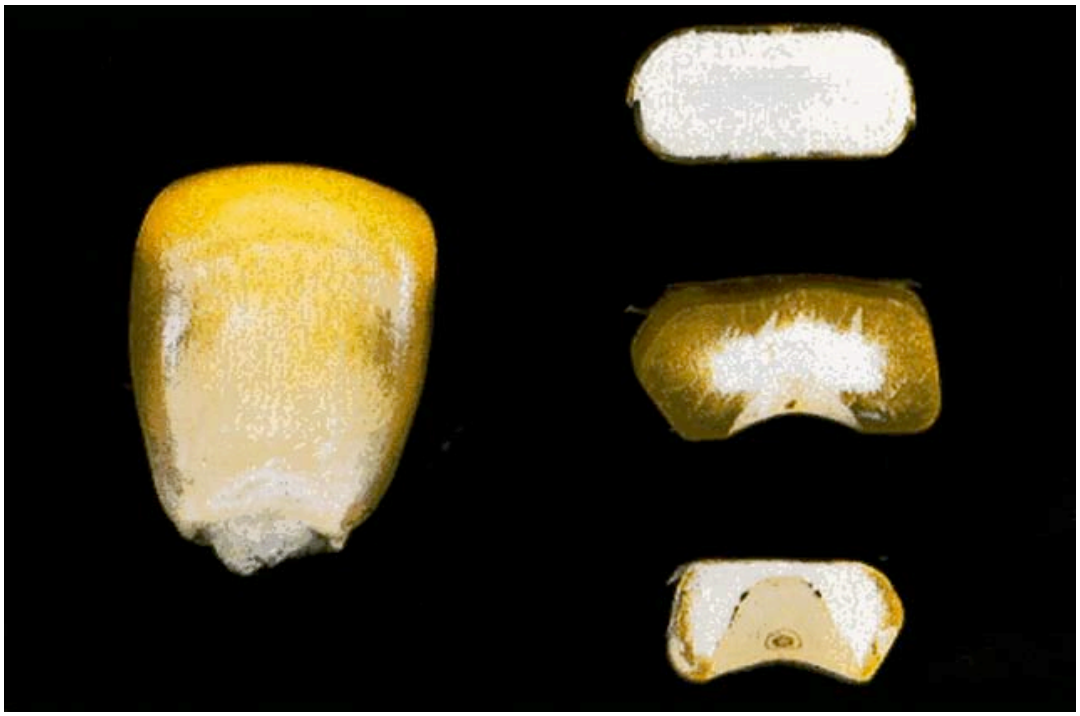
Criteria for Selecting Silage Hybrids

- Grain yield: allows flexibility (dual purpose)
- Whole plant silage yield
- Relative maturity: 5-10 days later than grain hybrids
- Standability: allows flexibility
- Pest resistance
- Silage quality

"Variation for silage yield and quality exists among commercial hybrids in Wisconsin."

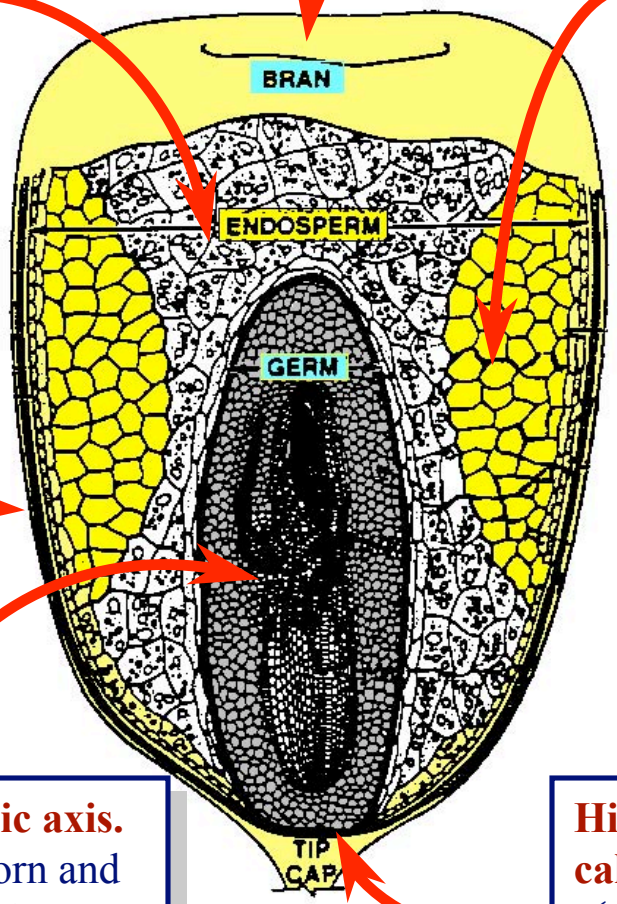
Factors that Affect Starch Availability in Corn or Corn Silage

- Grain type (flint vs dent)
- Starch polymers
- Endosperm type
- Test Weight: highly related to texture but determined at grain maturity, not typical silage harvest maturity
- Kernel Texture
- Particle Size
- Processing
- Moisture
- Fermentation



Dent (due to soft floury endosperm)

Floury endosperm.
✓More "open" in structure yet opaque in appearance.
✓Dent corn has about equal proportions of horny to floury starch (vs popcorn w/ mostly vitreous starch.



Vitreous endosperm.
✓Also called horneous, corneous or hard endosperm.
✓Primary starch in flint corn.
✓Source of dry milling grits.
✓Tightly compacted and translucent.
✓Higher in CP than floury starch.
✓More of this starch in mature, high test weight kernels.
✓The last starch laid down in the kernel during the last few weeks of development.

Pericarp(bran)

Germ scutellum and embryonic axis.
✓Germ larger in short season corn and in HOC (at the expense of starch).
✓In HOC, each 1% unit increase in oil, expect 1.3% unit lower starch.

Hilum or abscission layer.Also called black layer.
✓Caused by collapse and compression of several layers of cells at physiological maturity.
✓Cool weather can cause premature BL.

Diagram Source: Hoseney, 1986. Principles of Cereal Science and Technology. Am Assoc of Cereal Chemists, St. Paul, MN

Brown-midrib Hybrids

- Single genes
  - ✓ bm1, bm2, bm3, bm4
  - ✓ First discovered in 1924
- Less lignin
  - ✓ higher digestibility
- Agronomics??
- Many studies show an increase in intake, milk yield, or body weight
  - ✓ +2.8 kg/day milk yield (Oba and Allen, 1999)
- Effects seem somewhat unpredictable in real life
  - ✓ Most benefits seen with high-producing animals consuming high-forage diets

Leafy Hybrids

- Single gene, Lfy
- 2 to 4 more leaves above the ear
- Increased dry matter production
- Quality improvement?
  - ✓ Softer kernels
- Animal feeding trials
  - ✓ No overall advantage for lactating dairy cows
    - Kuehn et al., 1998
    - Bal et al., 1998

High-quality Protein

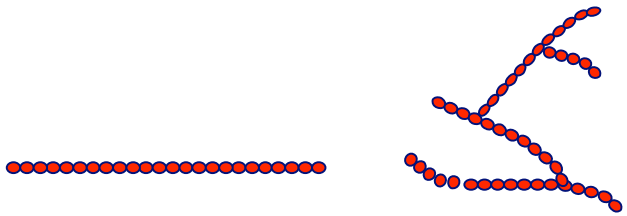
- Single genes
  - ✓ Opaque2 (o2)
  - ✓ Floury2 (fl2)
- Increased lysine and tryptophan
- Softer kernel texture
- Decreased endosperm size - Agronomics?
- Animal feeding trials
  - ✓ Opaque2 - No effect on milk production
    - Andrew et al., 1979
    - Beek and Dado, 1998

High-oil hybrids

- High ratio of embryo to endosperm
- Oil has 2.25 X more energy than starch
- High oil means >6% oil
  - ✓ Normal corn - 3.5 to 5%
- Top-cross hybrids
  - ✓ 7 to 7.5% oil
- Animal feeding trials
  - ✓ No effect on milk production
    - Atwell et al., 1988
    - Spahr et al., 1975
    - La Count et al., 1995
    - Dhiman et al., 1996

Waxy Hybrids

- Single gene - wx1
- Amylose replaced by amylopection



Amylose Amylopectin

- Primary used in wet milling and as feed grain
- No known advantage for use as silage

Other Corn Hybrid Types

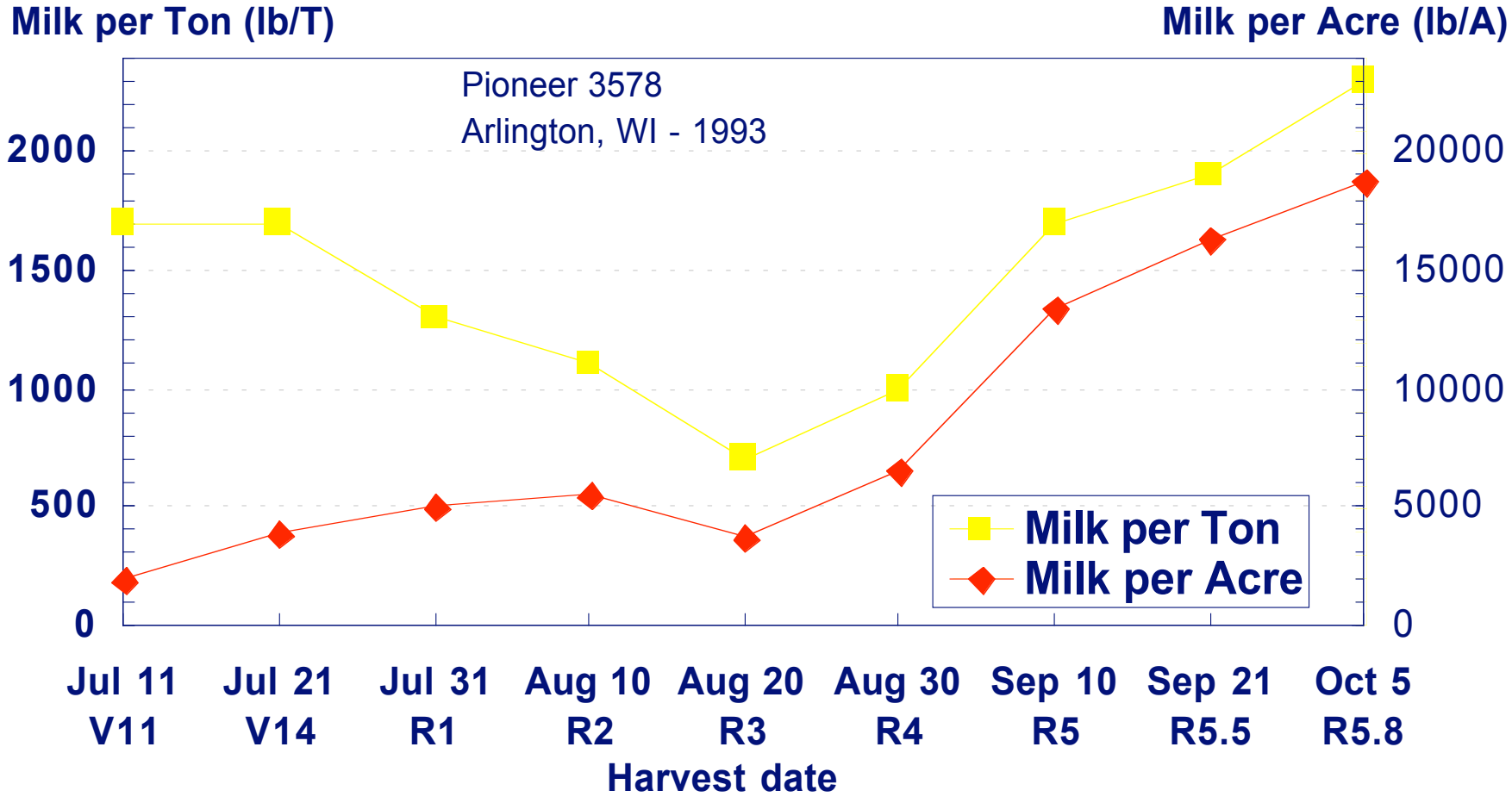
- Dwarf corn
- “Sugar” corn
- Profusely-tillering
- Autotetraploid
- Teosinte
- Sweet corn
- Pop corn

Questionable value due to lower yield and poorer agronomics.

How Should We Manage Corn Grown for Grain versus Silage?

Trait	Grain	Silage
Plant population	26,000-30,000	2,000-3,000 more
Planting date	Early	Early to 7 d later
Row spacing	3-5% w/ narrow	7-9% w/ narrow
Soil fertility	Adequate	Greater
Pest resistance	Important	More important
Cutting height	Ear	Yield v Quality
Harvest timing	Drying cost	Sour v Moldy

Corn Silage Yield and Quality Changes During Development



Summary

- Many ways to achieve high quality corn silage
  - ✓ Many ways to “skin the cat”
  - ✓ Hybrid selection depends upon objectives of farmer
  - ✓ Management and hybrid selection go hand-in-hand
- Future direction
  - ✓ Starch degradation
  - ✓ Stover digestibility (digestion kinetics)
  - ✓ Continued improvement of Milk2000
  - ✓ Key: Animal feeding verification studies