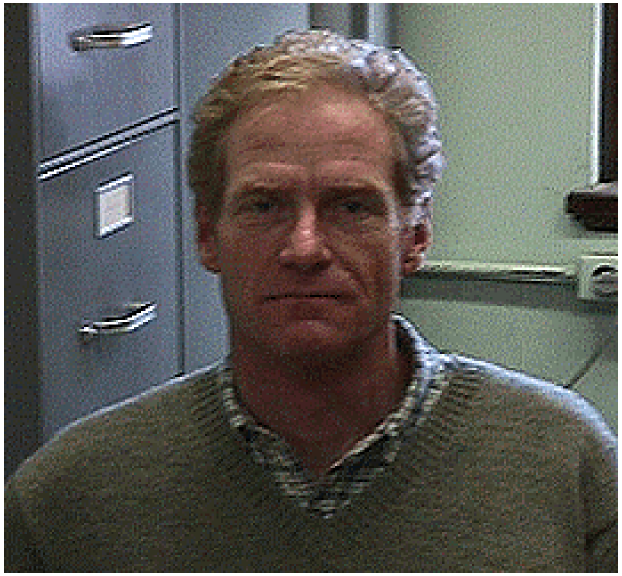
Corn Silage Research - Where have we been and where are we going?

Joe Lauer
University of Wisconsin

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)

The UW Corn Silage Team



Dr. Jim Coors
Corn Breeder

Dr. Randy Shaver
Dairy Nutritionist

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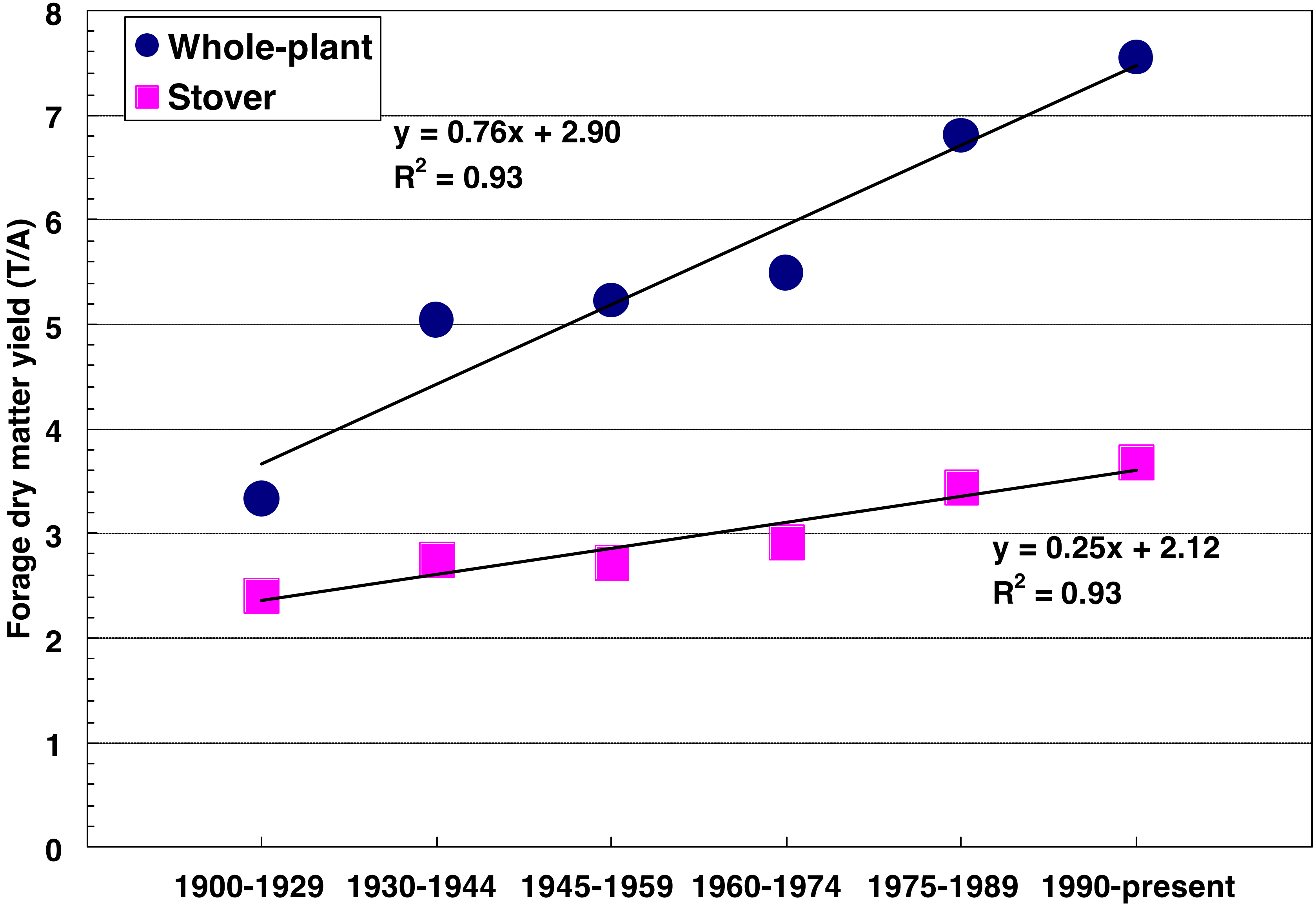
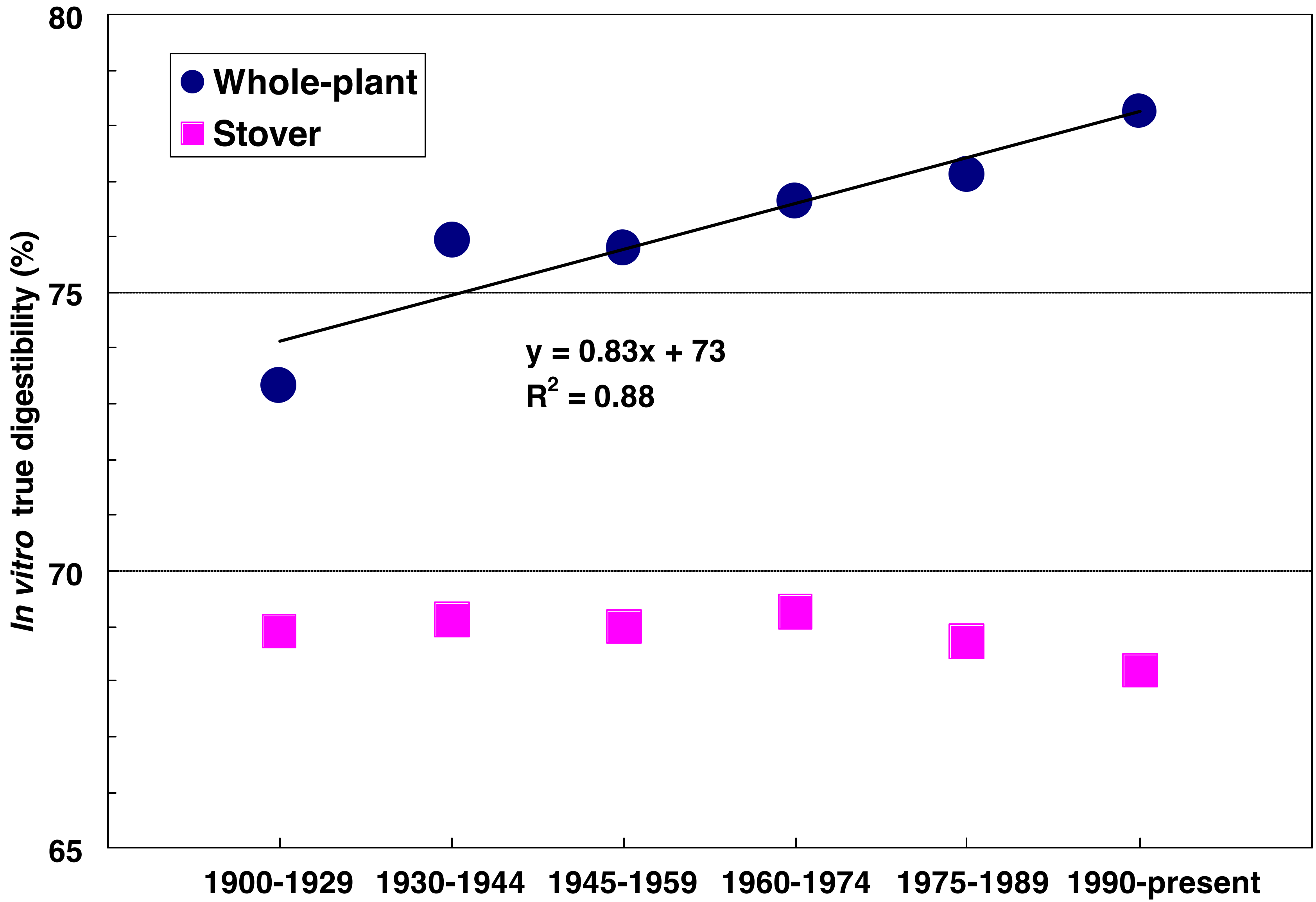
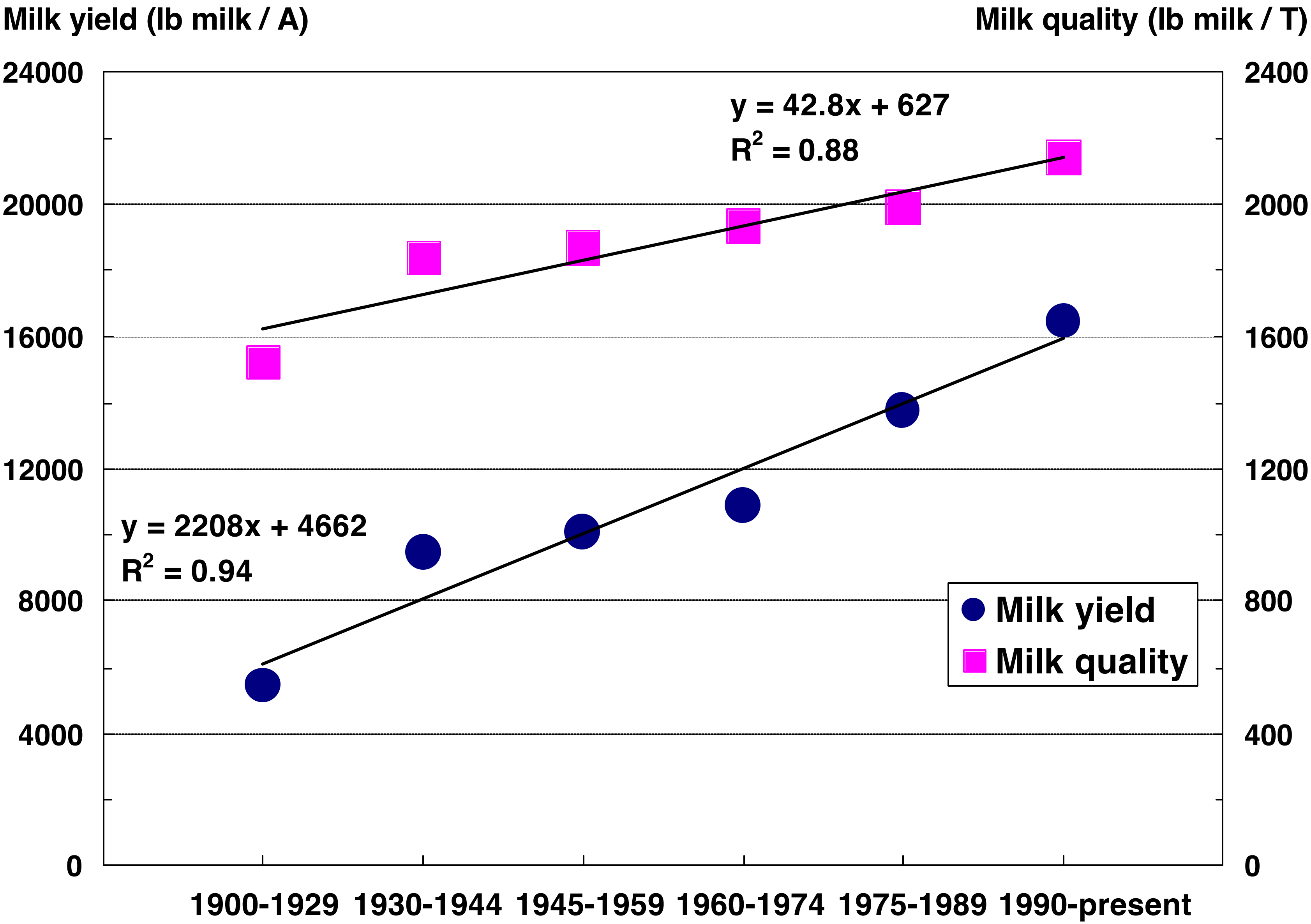


Relationship between corn forage dry matter yield and era of release for whole-plant and stover.

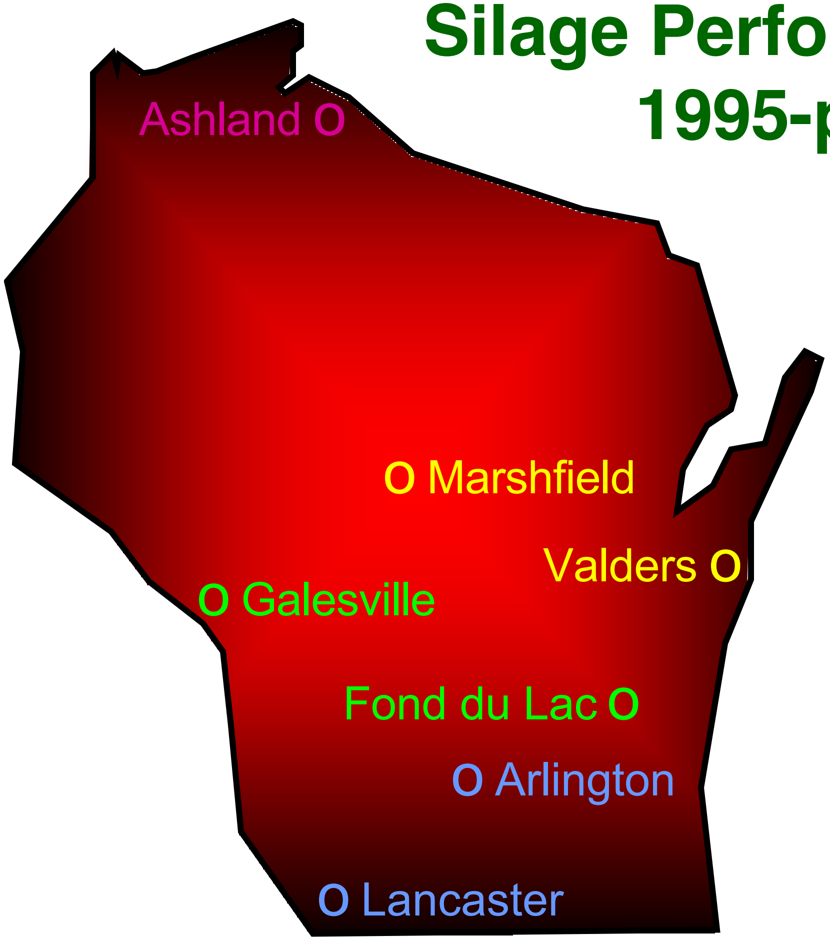


Relationship between corn forage *in vitro* true digestibility and era of release for whole-plant and stover.



Relationship between corn forage milk yield/quality and era of release.

Wisconsin Corn Hybrid Silage Performance Trials 1995-present



NIRS Global Equation Calibration for *in vitro* True Digestibility (602 samples submitted)

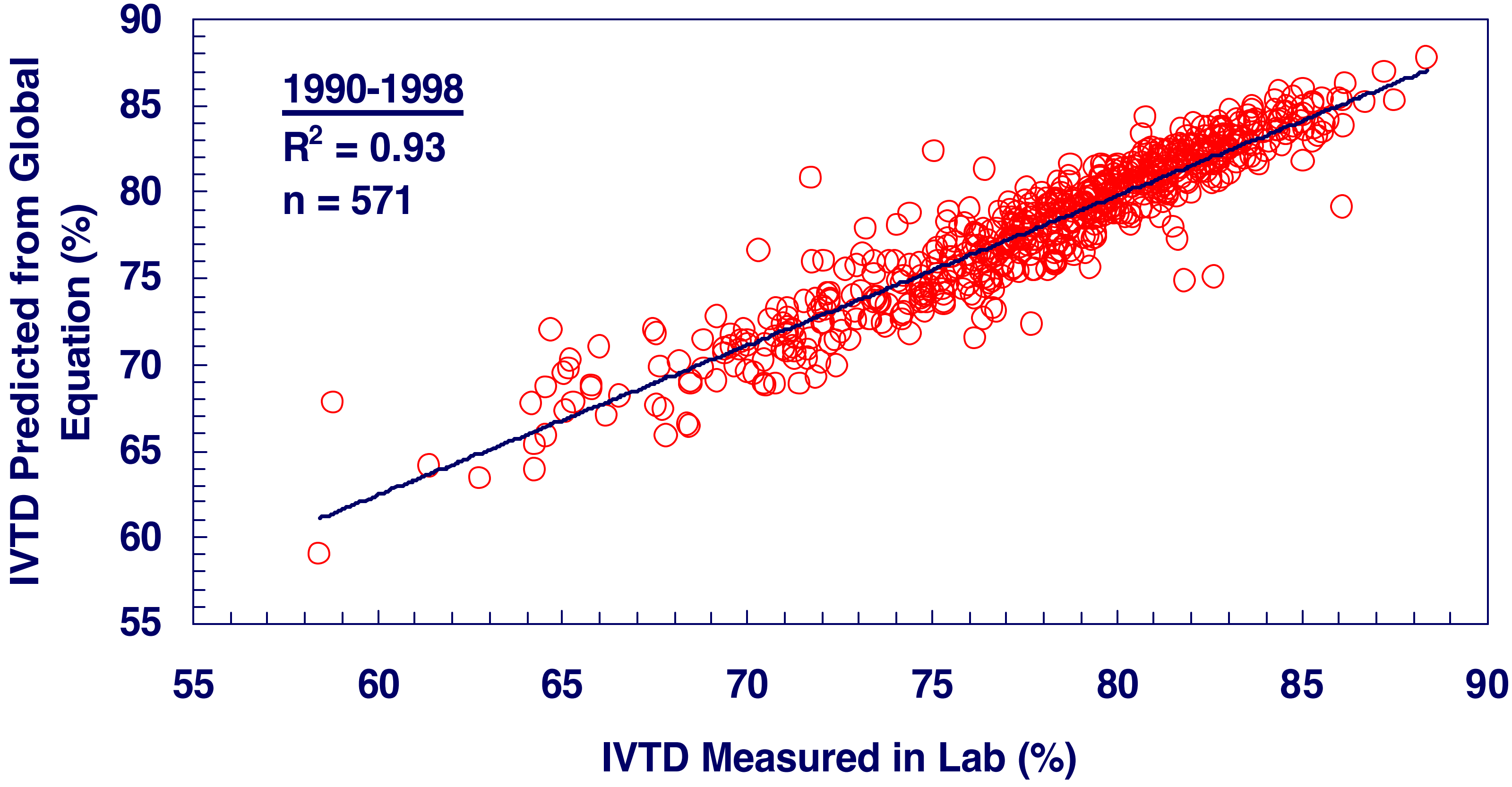


Table 15. North Central Zone - Early Maturity Silage Trial 2000

BRAND	HYBRID	Yield T/A	Moist %	Kernel Milk %	CP %	ADF %	NDF %	IVD %	CWD %	Starch %	MILK PER TON	MILK PER ACRE	MAR Yield T/A	VAL Yield T/A
Trelay	2008	8.3 *	55.3	30	7.0	25	52	72	46	28	2670	22300 *	8.3 *	8.3 *
Carhart's Blue Top	CX8500A	7.4	58.7	50	7.3	24	49	73	46	29	2770 *	20700	7.9 *	7.0
NK Brand	N27-M3	7.0	59.2	30	7.1	24	48	74	45	31	2810 *	19800	7.4	6.7
Pioneer	39D81	5.2	59.6	10	7.1	26	53	71	45	26	2620	13600	5.7	4.6
Renk	RK394	7.8 *	59.6	30	7.0	28	55	70	46	24	2580	20200	8.3 *	7.3
Dairyland	Stealth 1280	7.7 *	59.9	30	7.1	25	52	72	45	28	2690	20800	8.3 *	7.1
85-DAY HYBRID TRIAL AVERAGE##			60.3											
LG Seeds	LG2367	7.3	60.4	30	6.9	26	53	72	47	27	2700	19800	8.3 *	6.3
Carhart's Blue Top	CX290A	7.4	60.6	40	7.2	22	46	75	45	34	2900 *	21300	7.2	7.5 *
Dairyland	Stealth 1289	7.0	60.7	20	8.1	28	55	70	46	24	2570	18100	7.3	6.7
Brown	2080	6.8	61.3	40	7.0	23	48	74	45	31	2830 *	19200	6.5	7.1
Carhart's Blue Top	CX1187A	6.9	61.4	30	7.2	25	51	73	46	29	2780 *	19200	6.8	7.0
90-DAY HYBRID TRIAL AVERAGE##			62.9											
Dekalb	DKC39-45	7.1	63.8	40	6.8	23	47	74	45	31	2920 *	20600	6.7	7.4 *
NK Brand	N2555BT	7.1	64.2	40	7.4	26	51	72	45	27	2760 *	19800	7.7 *	6.6
Ramy Seed	PG1455	8.6 *	64.6	60	7.3	25	50	73	46	28	2850 *	24500 *	8.7 *	8.4 *
Golden Harvest	H6675	8.2 *	66.4	40	7.7	25	50	72	44	26	2780 *	22900 *	8.4 *	8.1 *
MEAN		7.3	61.1	40	7.2	25	51	72	46	28	2750	20200	7.6	7.1
LSD(0.10)**		0.9	3.9	10	0.5	3	4	3	1	4	200	3100	1.1	1.1

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

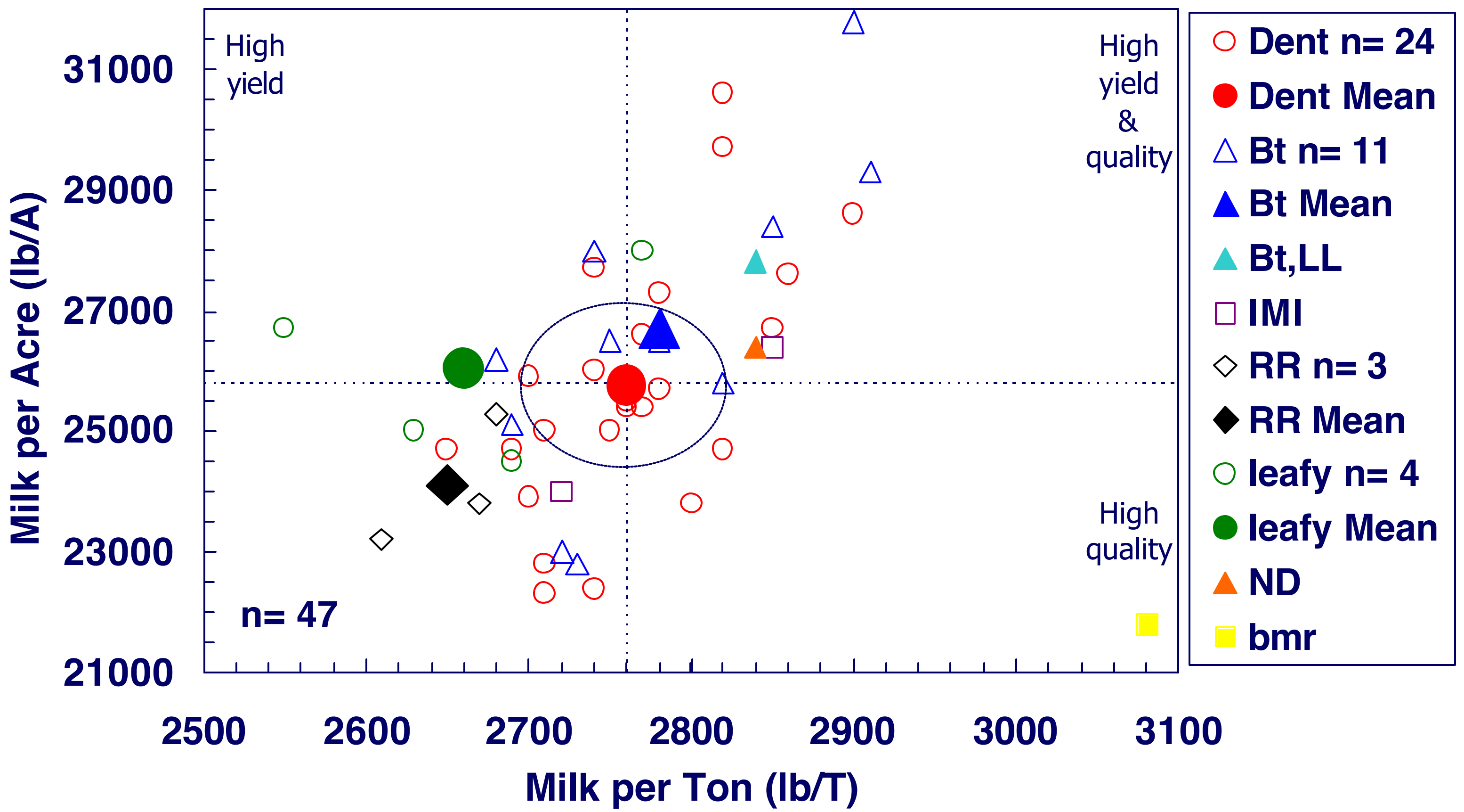
Milk1995

- 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

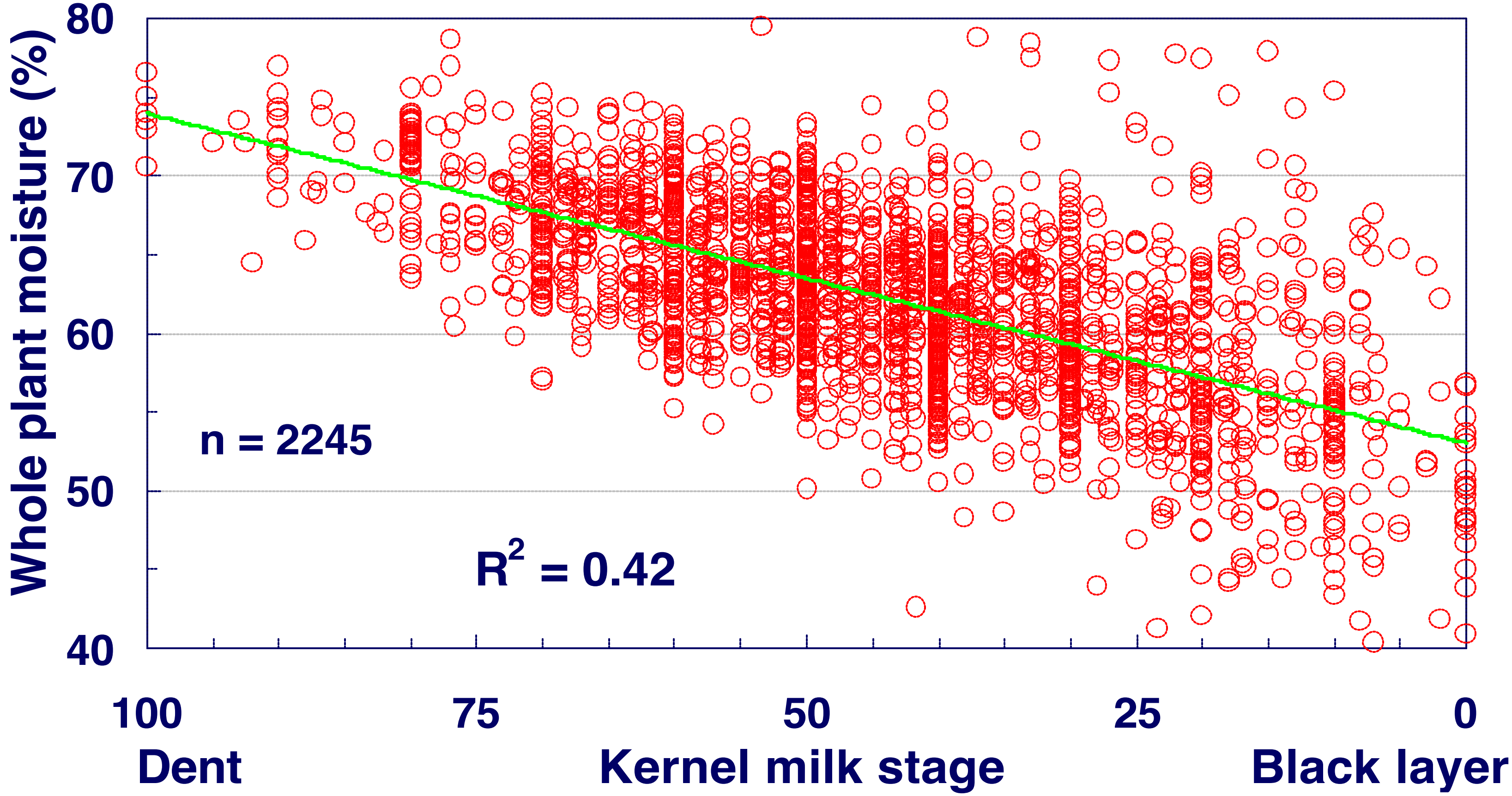
2001 Wisconsin Corn Hybrid Performance Trial Results – Table 12 Southern Zone,
Late Maturity Trial at Arlington and Lancaster



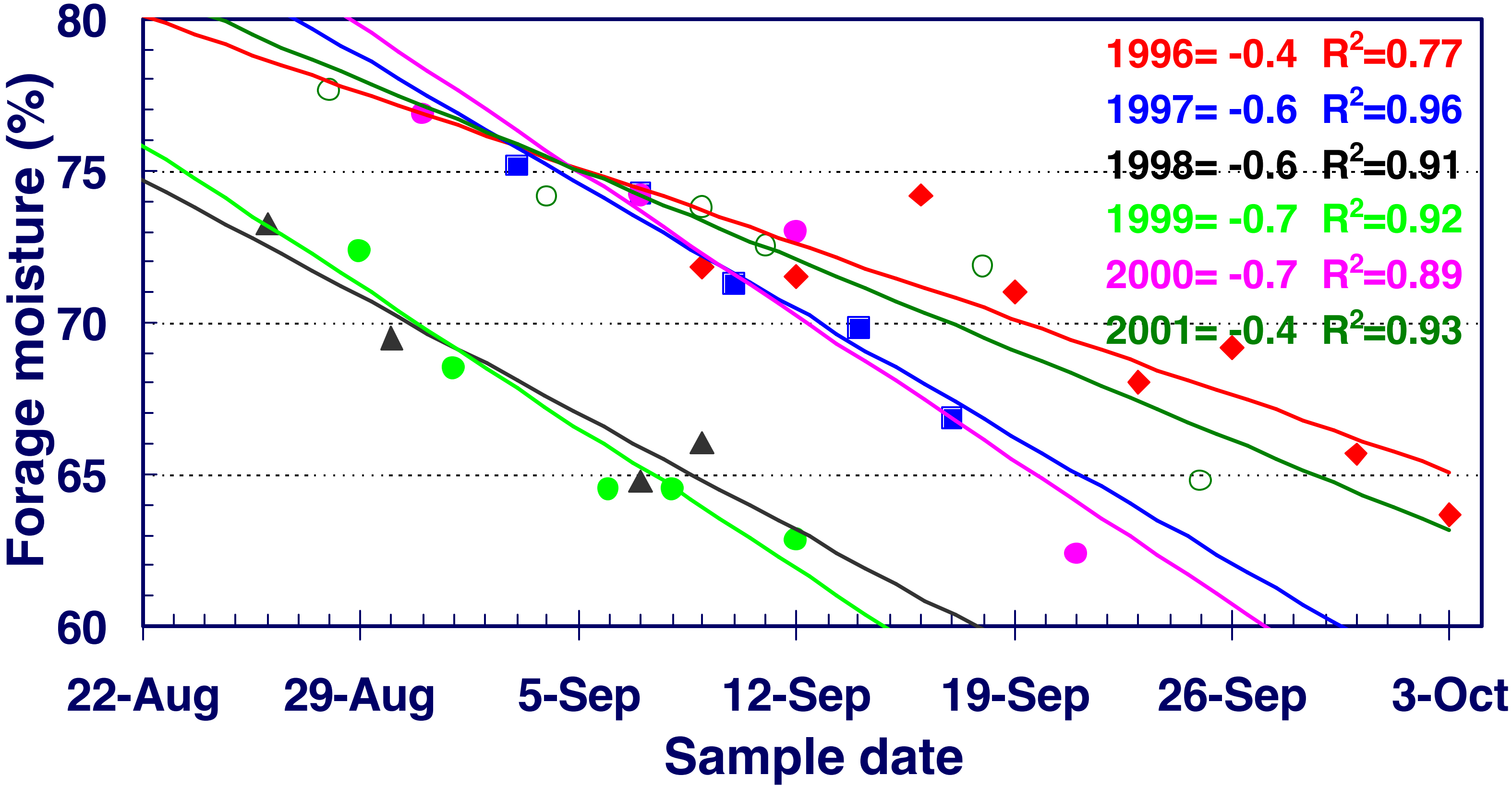
SELECT

http://corn.agronomy.wisc.edu/select/

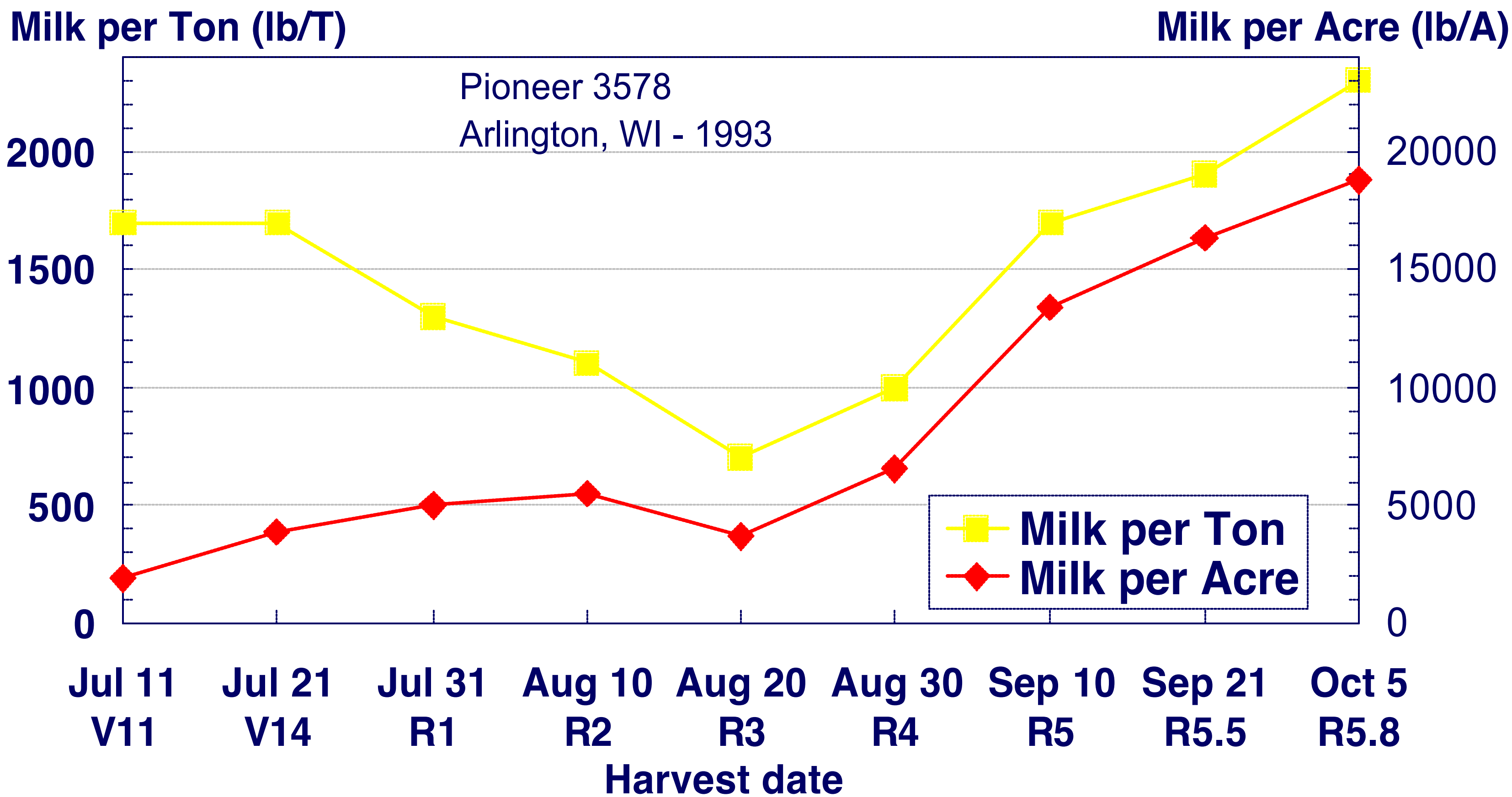
Relationship Between Forage Moisture and Kernel Milk Stage (1990 - 2000)



Corn Silage Drydown Rate in Manitowoc County, WI.



Corn Silage Yield and Quality Changes During Development



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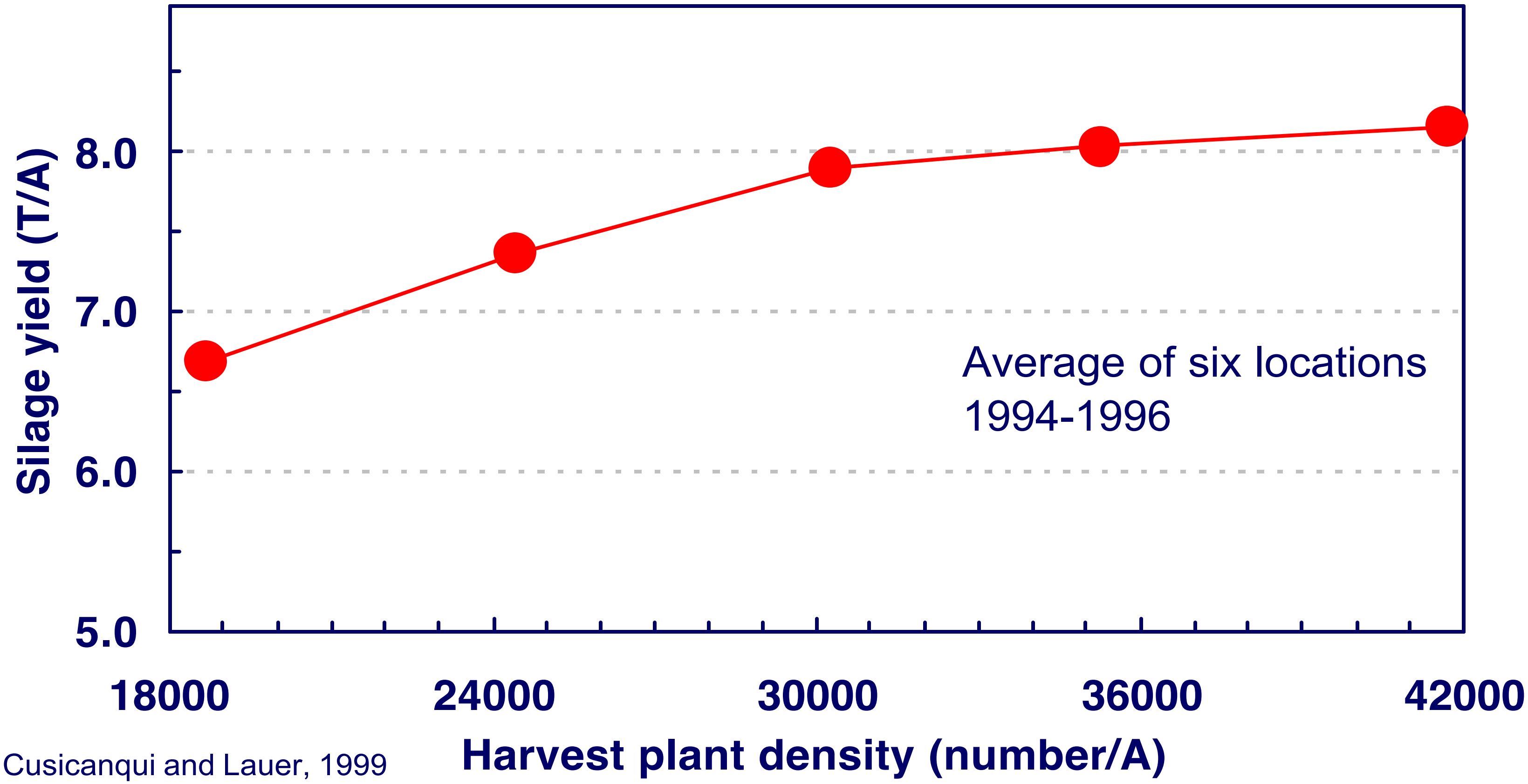
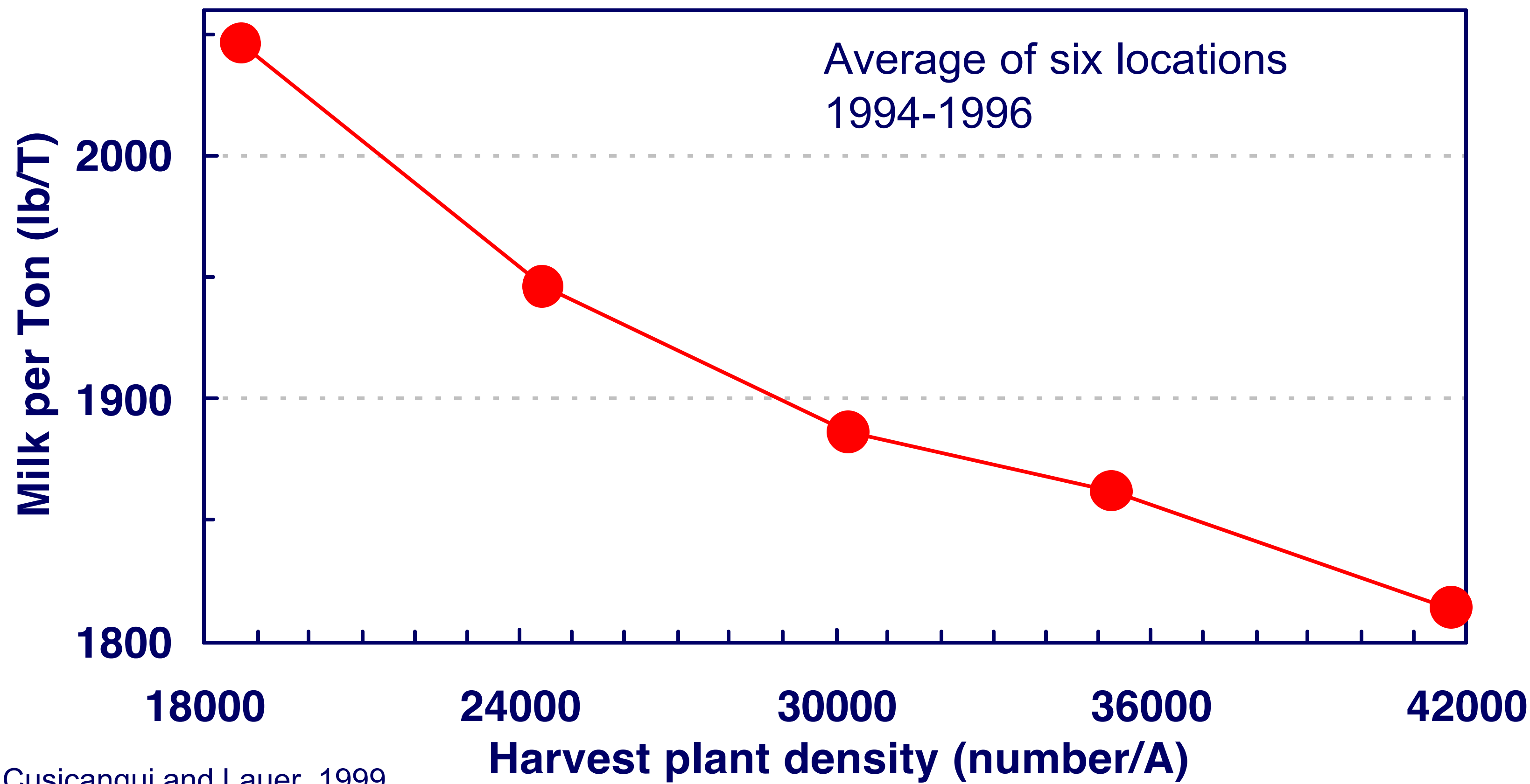
Relationship between corn silage yield and plant density in WI



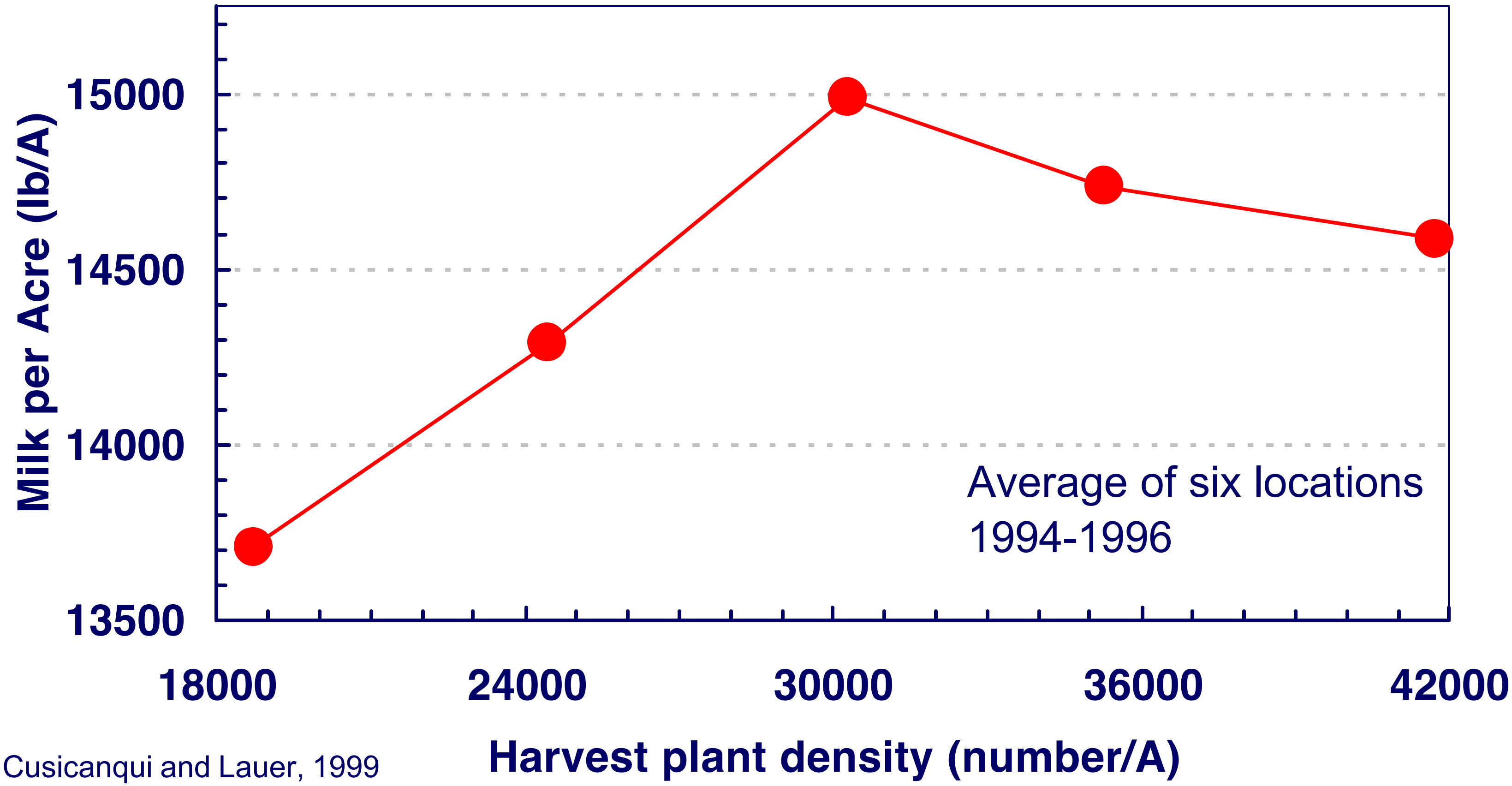
Cusicanqui and Lauer, 1999

Relationship between corn silage Milk per Ton and plant density in WI



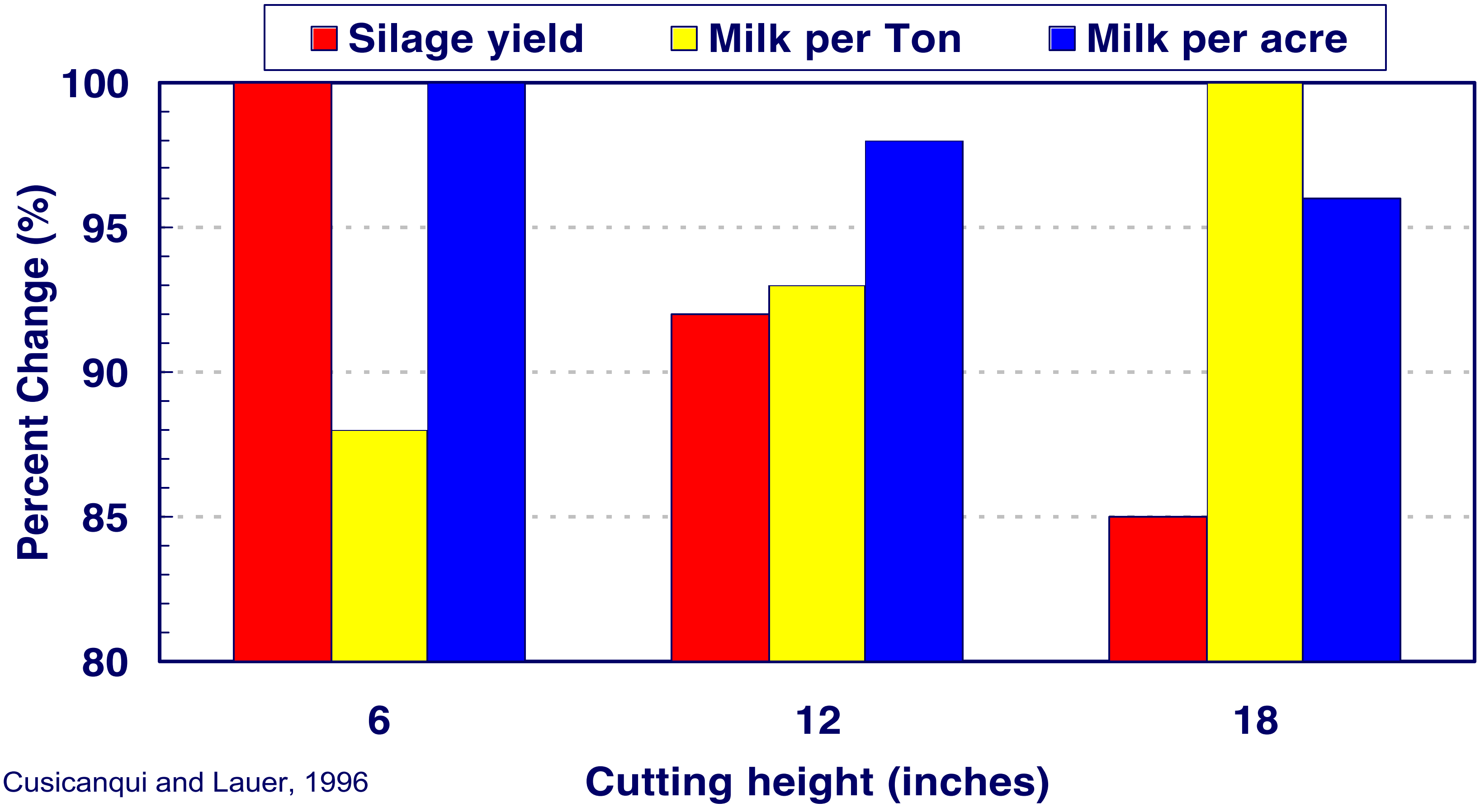
Cusicanqui and Lauer, 1999

Relationship between corn silage Milk per Acre and plant density in WI



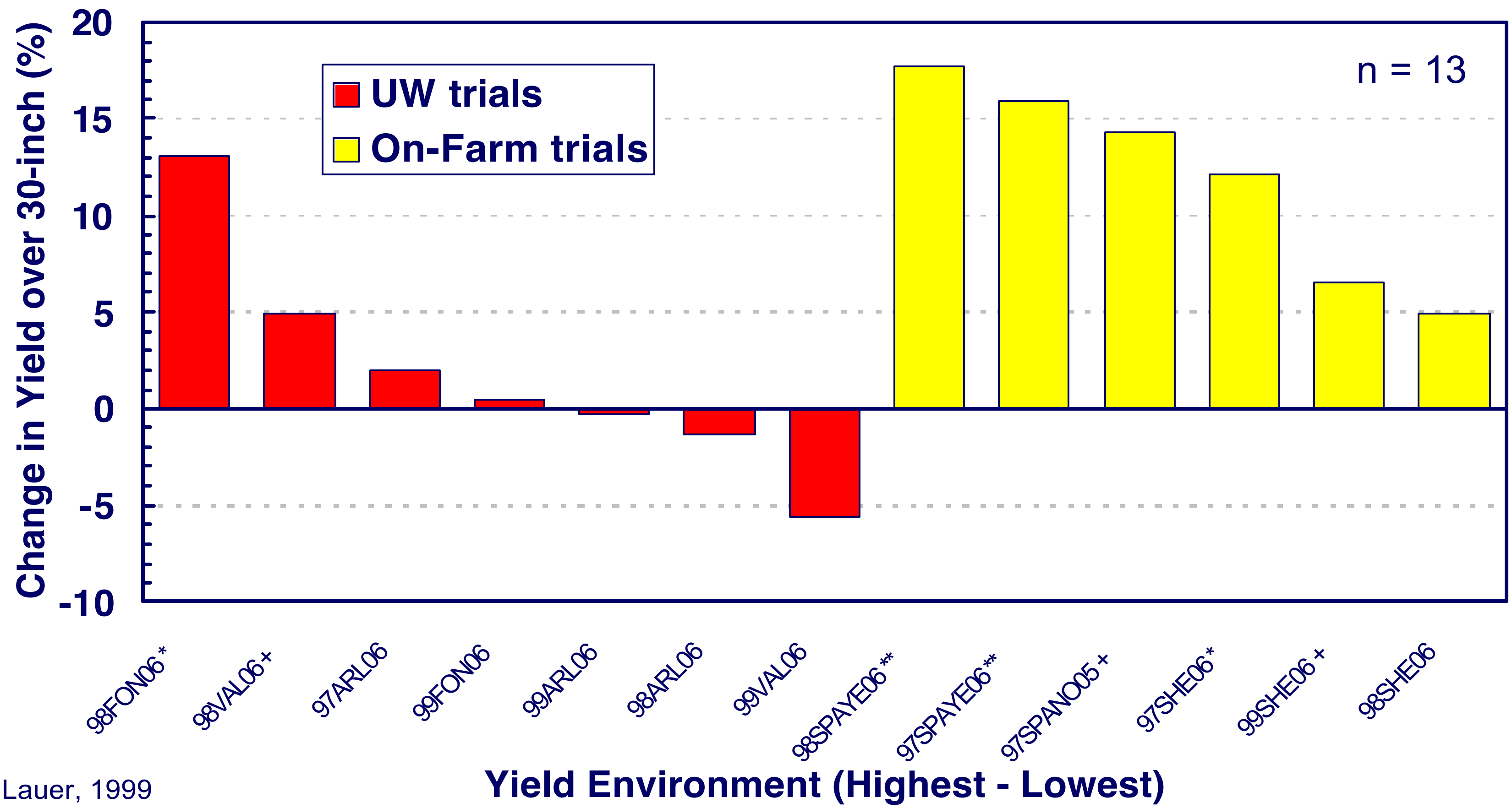
Cusicanqui and Lauer, 1999

Relative change in silage yield & quality at different cutting heights during 1996



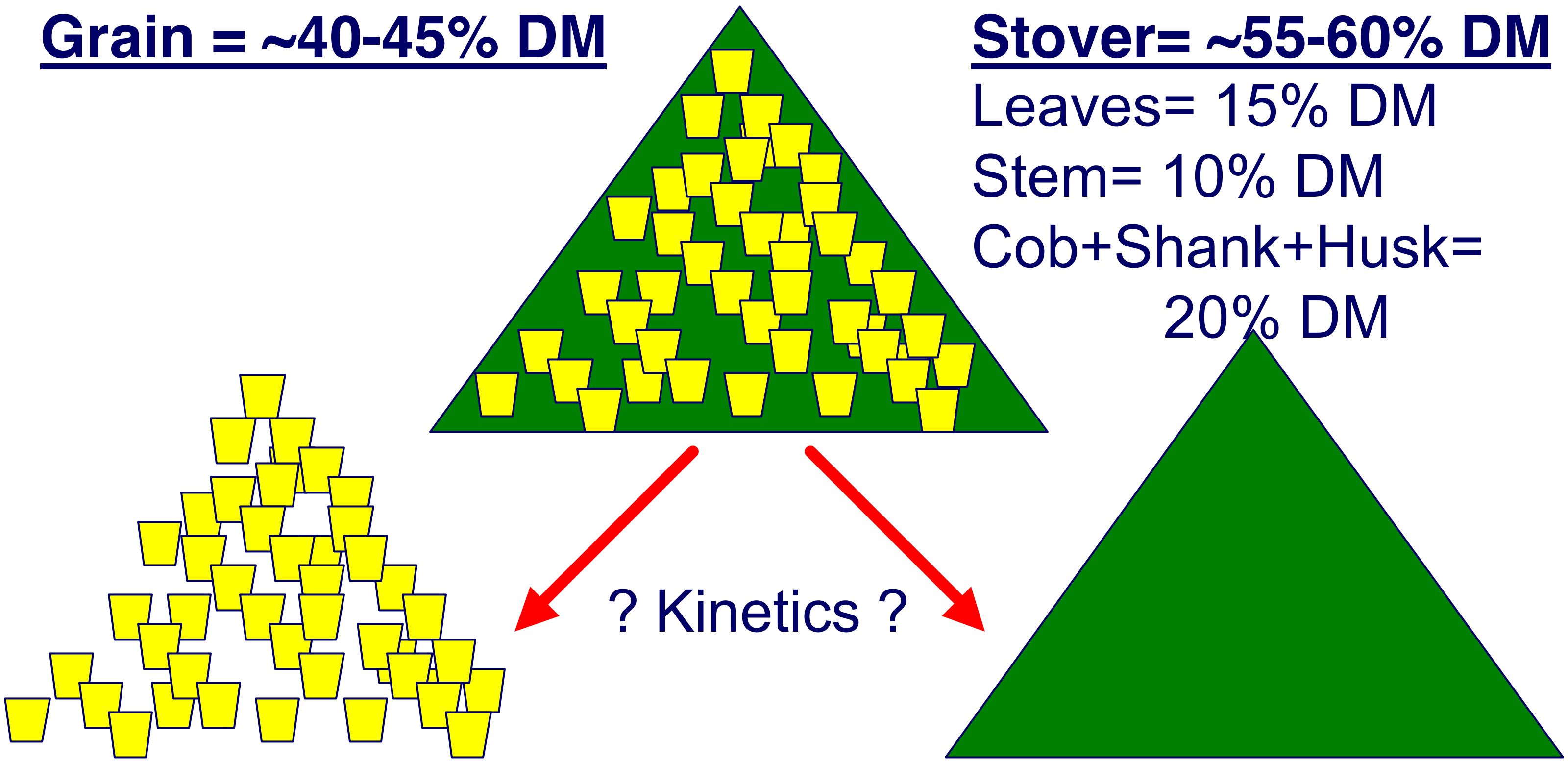
Cusicanqui and Lauer, 1996

Corn Silage Yield Response to Row Spacing in WI (UW and On-Farm trials)



Lauer, 1999

Corn Silage

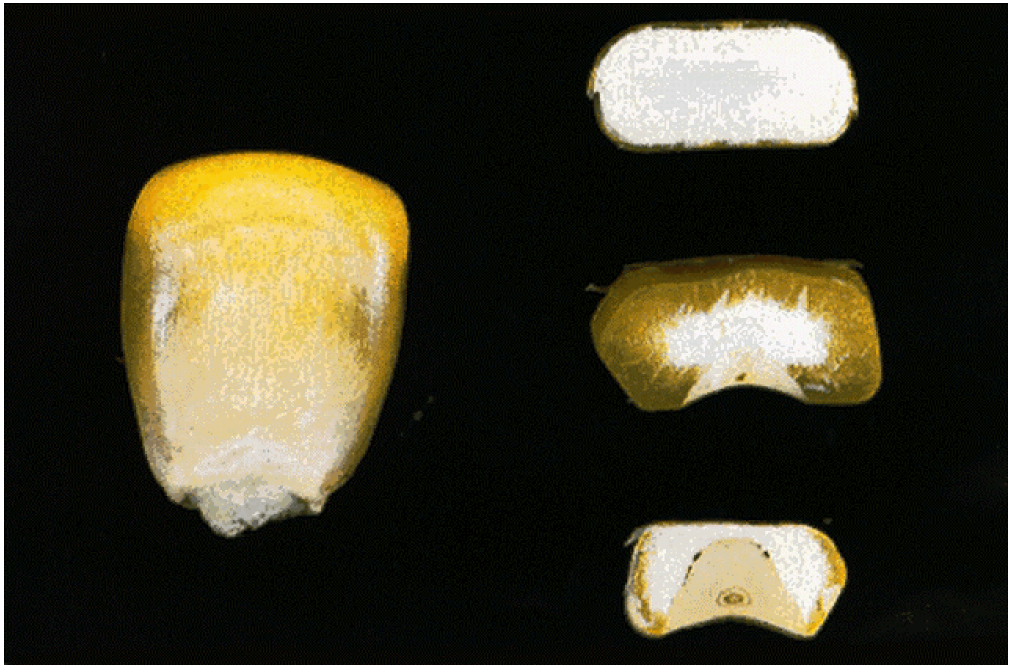


80 to 100% digestible
• Kernel maturity
• Starch digestibility

40 to 55% digestible
• Cell wall digestibility

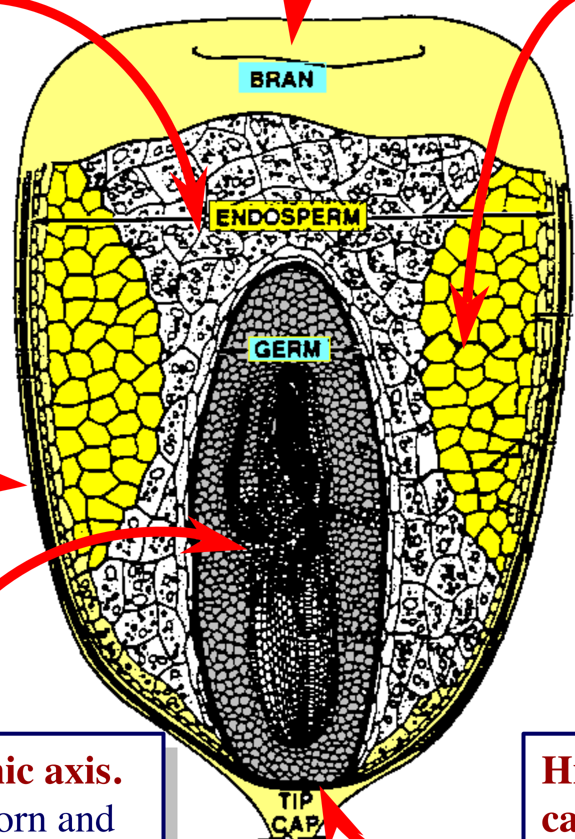
Factors that Affect Starch Availability in Corn or Corn Silage

- 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.



Pericarp(bran)

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.

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

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

What Do We Want in Grain versus Silage Hybrids?

Trait	Grain	Silage
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

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Yield and Digestibility of Corn Plant Parts

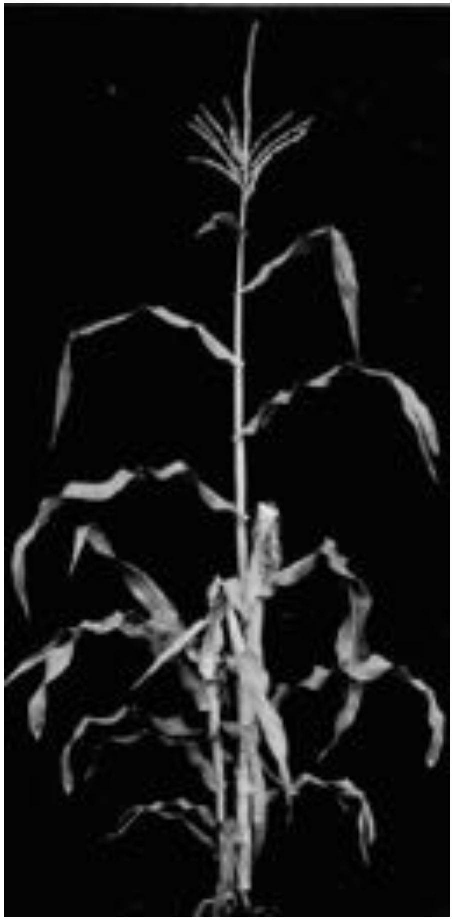
Tissue	Percent Yield	Digestibility (%)
Leaf blades	11	73
Leaf sheaths	4	63
Stalk+tassel	19	60
Cob+husk+shank	22	72
Kernels	44	94
Whole plant	100	71

Adapted from Deinum and Struik, 1989

Brown-midrib Hybrids

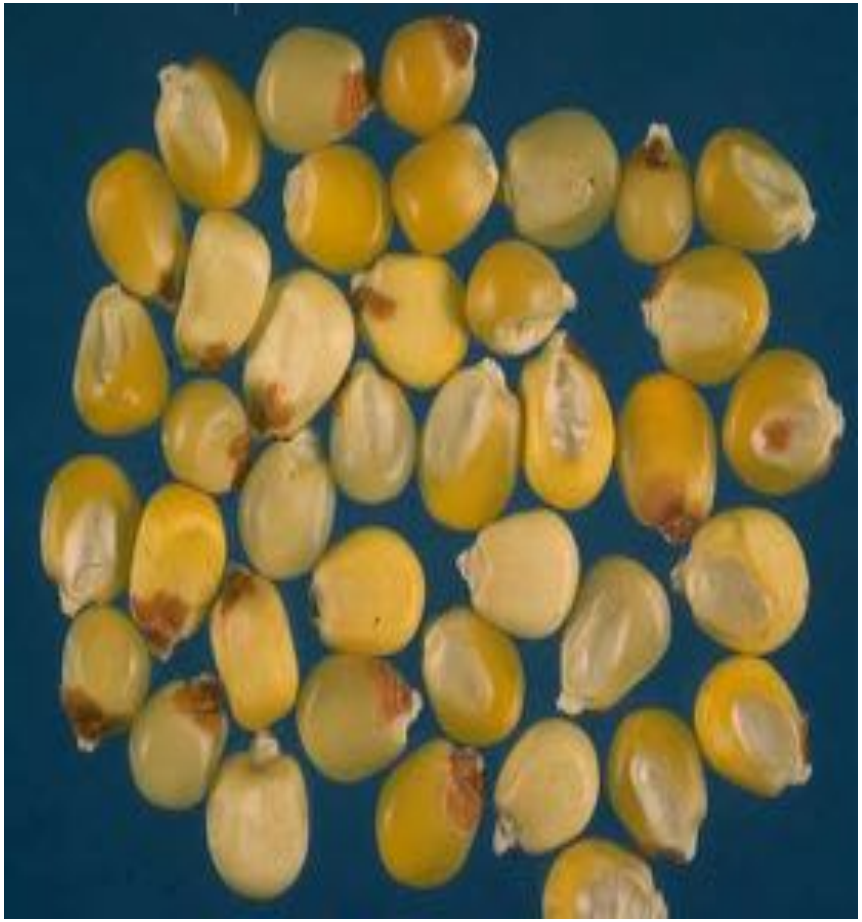
- Single genes
  - ✓ bm1, bm2, bm3, bm4
  - ✓ First discovered in 1924
- Less lignin
  - ✓ higher digestibility
- Agronomics??
- Many studies show an increase in intake, milk yield, or body weight
  - ✓ +2.8 kg/day milk yield (Oba and Allen, 1999)
- Effects seem somewhat unpredictable in real life
 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



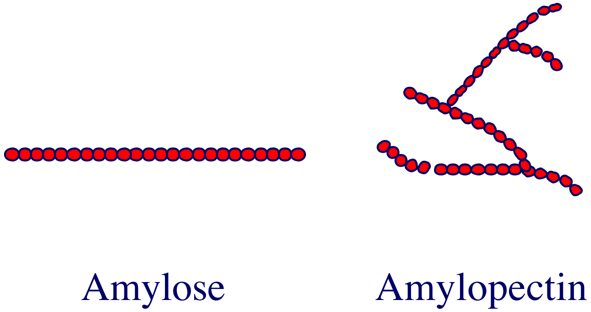
- Single genes
  - ✓ Opaque2 (o2)
  - ✓ Floury2 (fl2)
- Increased lysine and tryptophan
- Softer kernel texture
- Decreased endosperm size - Agronomics?
- Animal feeding trials
  - ✓ Opaque2 - No effect on milk production
    - Andrew et al., 1979
    - Beek and Dado, 1998

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



- 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

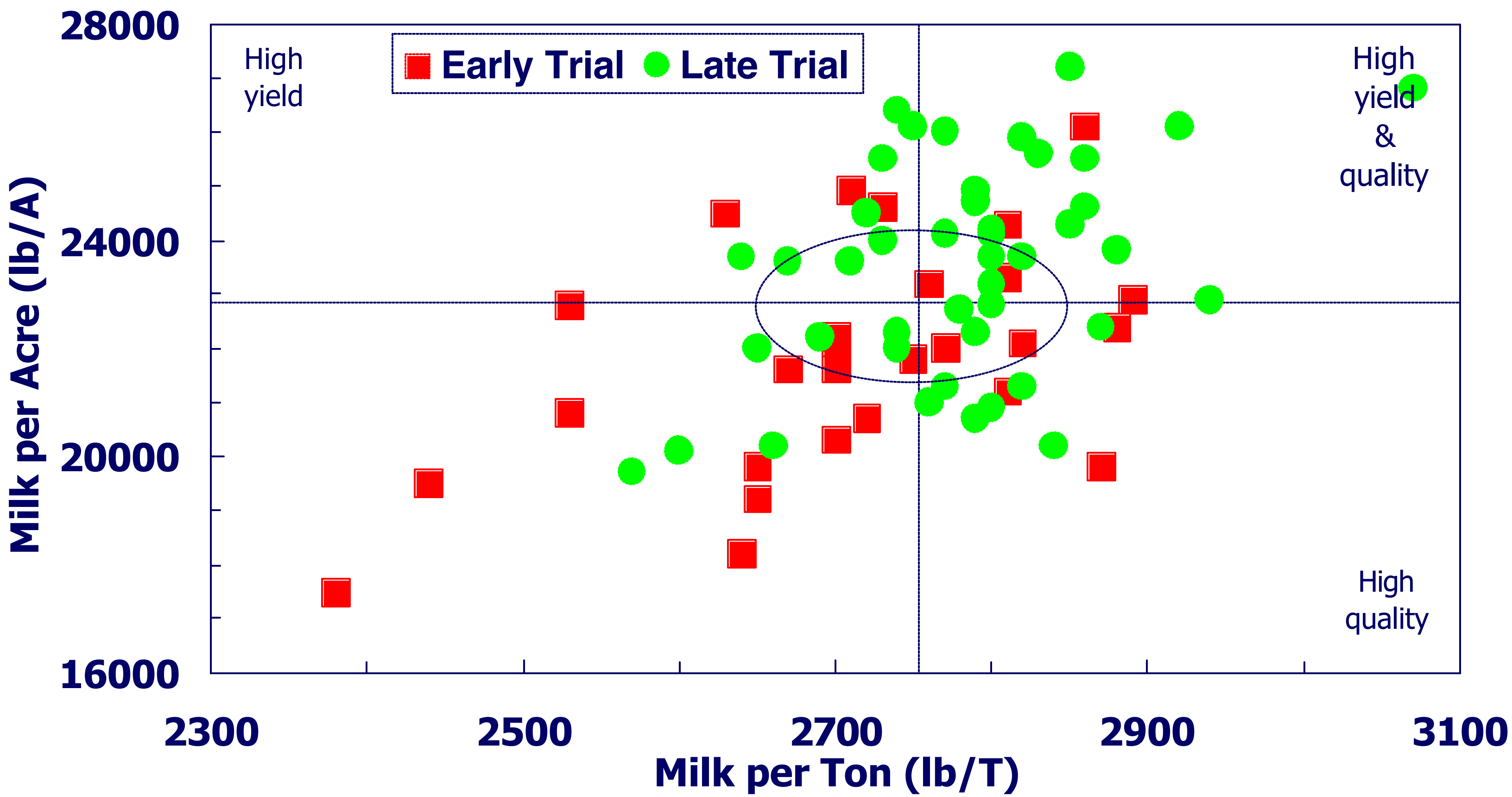
Wisconsin Corn Hybrid Silage Performance Trial Measurements

- 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
  - ✓ <u>Milk per ton:</u> 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.)
  - ✓ <u>Milk per acre</u> = Milk per ton X Dry matter yield per acre

Selection of high and low quality corn silage check hybrids

- 1995 to 1997
  - ✓ Checks selected using data derived by UW silage consortium
- North Central zone:
  - ✓ High: Pioneer 3757E
  - ✓ Low: Mycogen 4120
- South Central zone:
  - ✓ High: Pioneer 3573
  - ✓ Low: Pioneer 3527
- Southern zone
  - ✓ High: Cargill 4327
  - ✓ Low: Pioneer 3417
- 1998 to 2000
  - ✓ Selection pressure for yield (must be 1.05 times better than the trial average)
  - ✓ Sorted by NDF to pick high and low
  - ✓ Emphasis on CWD and Milk95 per Ton
  - ✓ Hybrids change every year
- 2001 and beyond
  - ✓ Same as above, except emphasize Milk2000 per Ton

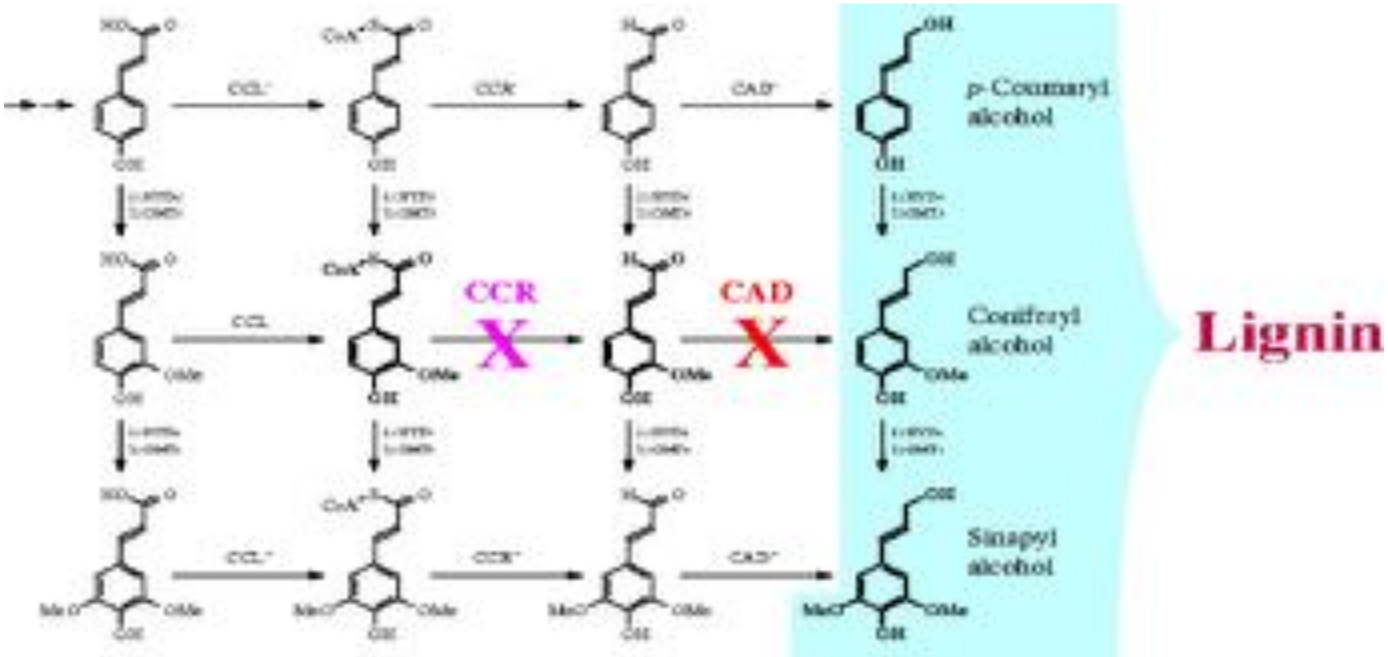
Corn Hybrid Silage Performance in the South Central Production Zone - 2000



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

What's Next?



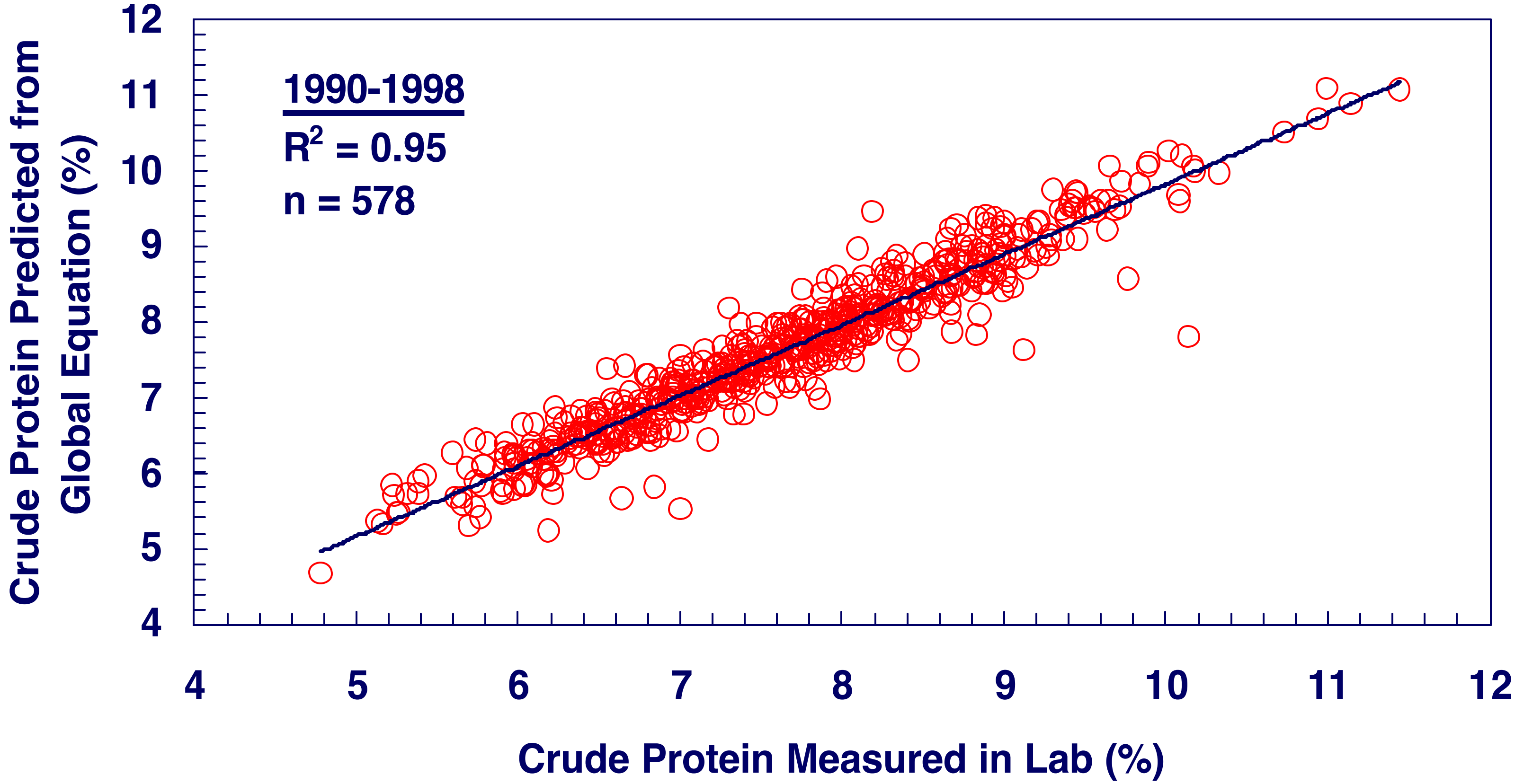
CCL
CCR
CAD
p-Coumaryl alcohol
CCR
X
CAD
X
Coniferyl alcohol
Lignin
Sinapyl alcohol

What's Next?

- Improved dry matter production & adaptation
- Increased digestibility on DM and fiber basis
- Increased protein
- Modified kernel texture

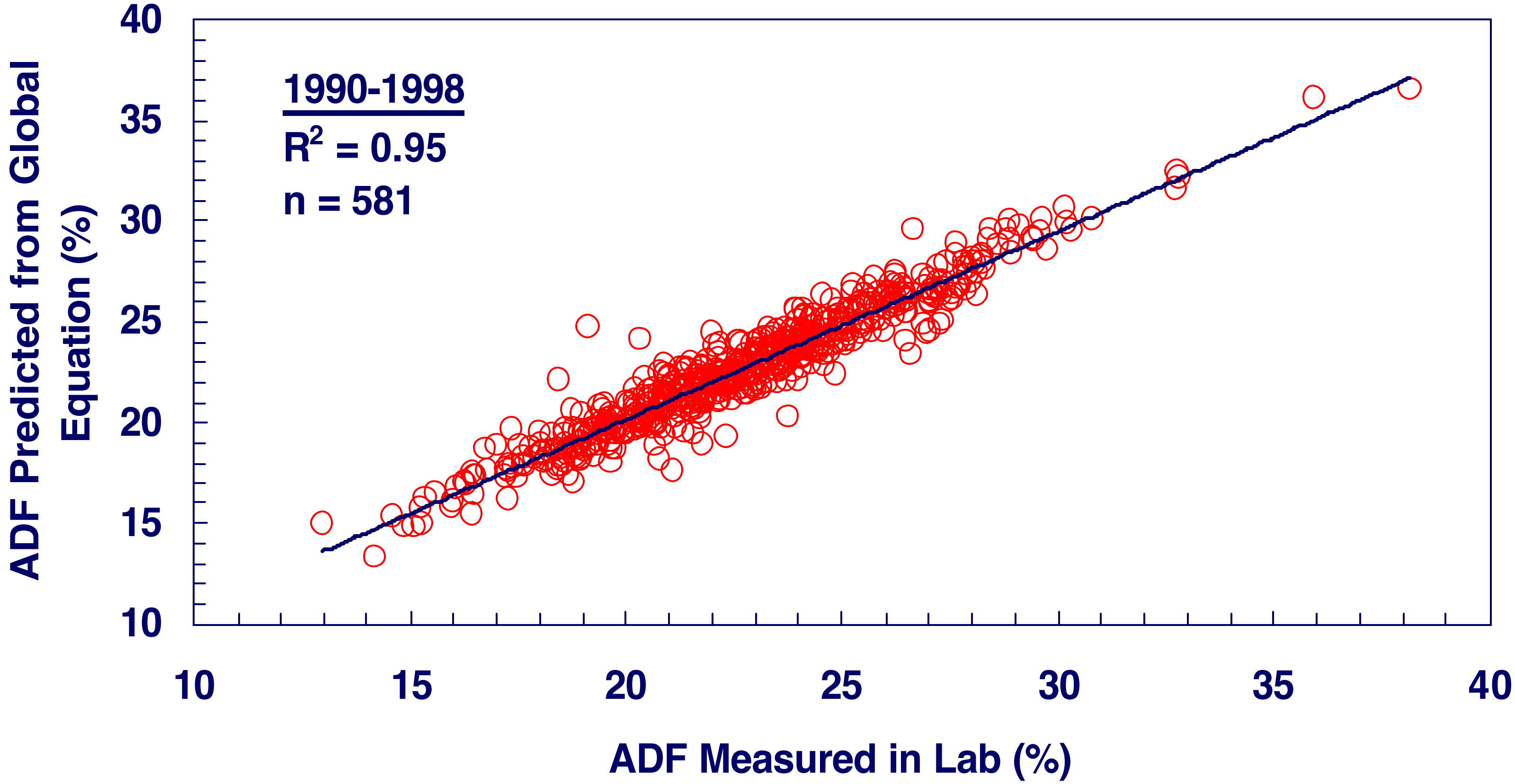

Can you do me a favor?!

NIRS Global Equation Calibration for Crude Protein (602 samples submitted)



NIRS Global Equation Calibration for ADF

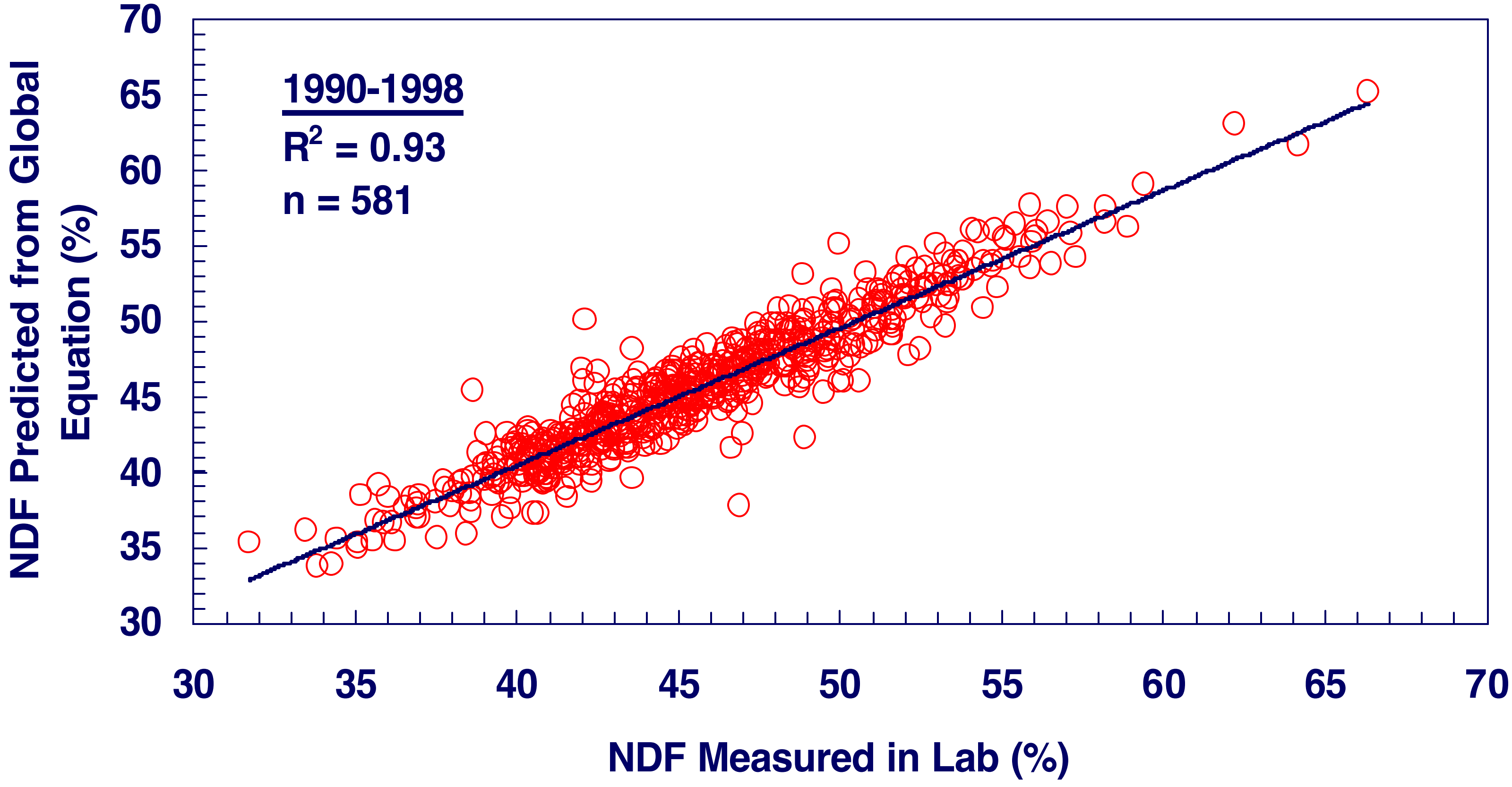
(602 samples submitted)



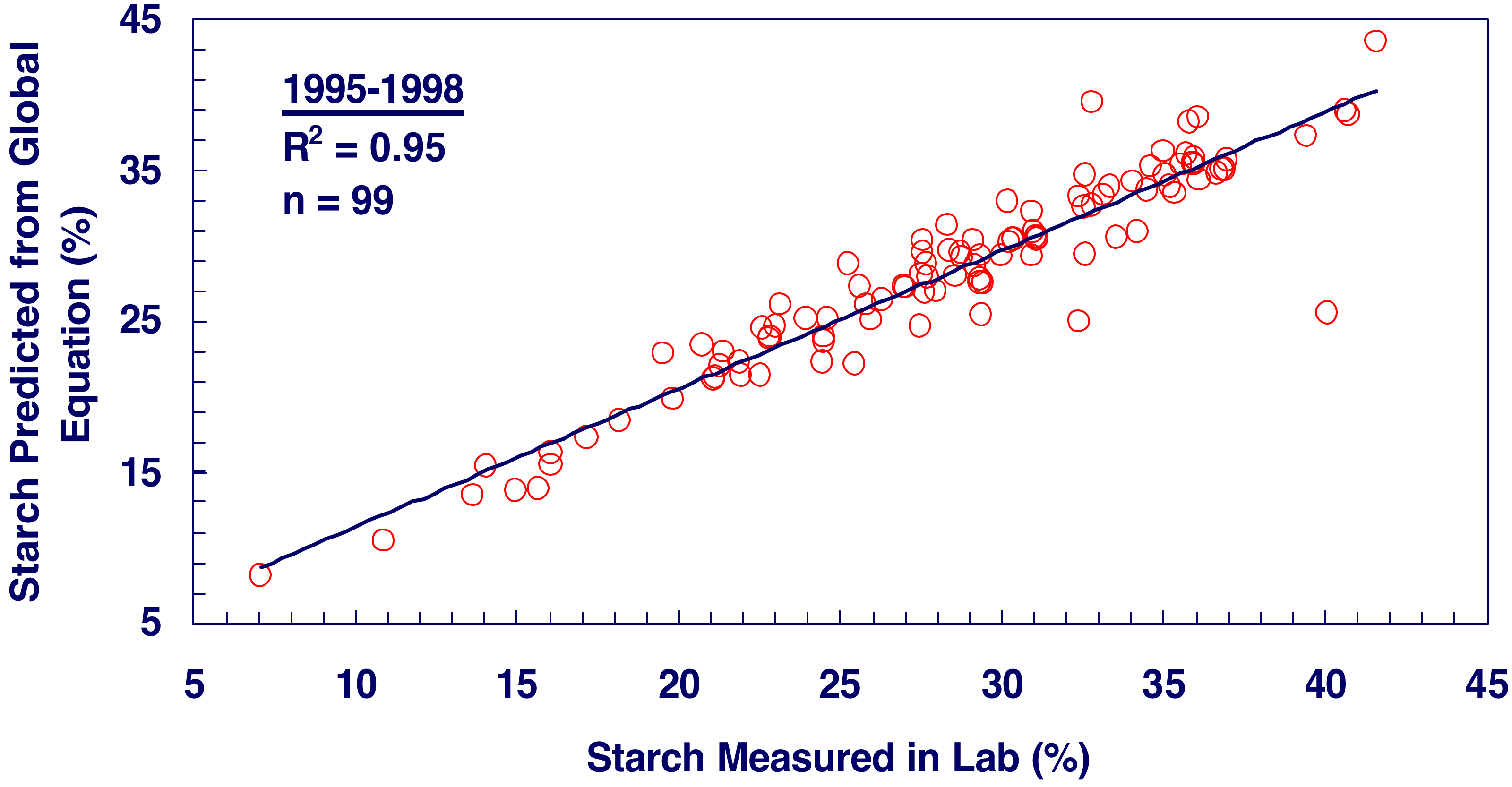
University of Wisconsin – Agronomy

NIRS Global Equation Calibration for NDF

(602 samples submitted)



NIRS Global Equation Calibration for Starch Content (104 samples submitted)




University of Wisconsin
Corn Hybrid Silage Performance Trials

2000 Wisconsin Corn Performance Trials - Silage Summary

Location	1990-1999 *N*	1990-1999 Yield	2000 *N*	2000 Yield	Percent Change
		T/A		T/A	
Arlington	388	9.3	66	9.1	- 2
Lancaster	311	7.7	66	7.8	+ 1
Fond du Lac	284	8.7	77	7.6	- 13
Galesville	284	8.0	77	8.0	+ 0
Marshfield	401	6.8	55	7.9	+ 16
Valders	328	7.1	55	7.6	+7
Ashland	109	6.7	16	5.5	- 18

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Top 10 Corn Silage Hybrids by Production Zone during 2000

Hybrid	Yield	Hybrid	Yield	Hybrid	Yield
Southern zone	**T/A**	**South Central zone**	**T/A**	**North Central zone**	**T/A**
Kaltenberg K8110LF	9.6	Kaltenberg K8108LF	9.6	Jim Coors 1	10.3
Dekalb DK611	9.5	NK Brand N48-V8	9.6	Golden Harvest H2387	9.2
Cornelius C408YG	9.5	Dahlco 2660	9.4	Jim Coors 2	9.0
Wyffels W7090	9.5	Pioneer 34G82	9.3	Garst 8640	9.0
Spangler 7558	9.3	Renk RK668	9.3	Pioneer 37R71	8.9
Pioneer 34B23	9.3	AgriPro AP9280	9.3	Dairyland Stealth 1203	8.7
Pioneer 35R58	9.2	Asgrow RX452YG	9.3	Carhart's CX1195	8.6
Renk RK775	9.2	Pioneer 35R57	9.2	Carhart's CX102R	8.6
LG Seeds LG2526SP	9.1	Carhart's CX130A	9.2	Ramy Seed PG1455	8.6
Renk RK896	8.9	Pioneer 35R60	9.2	Jim Coors 3	8.5

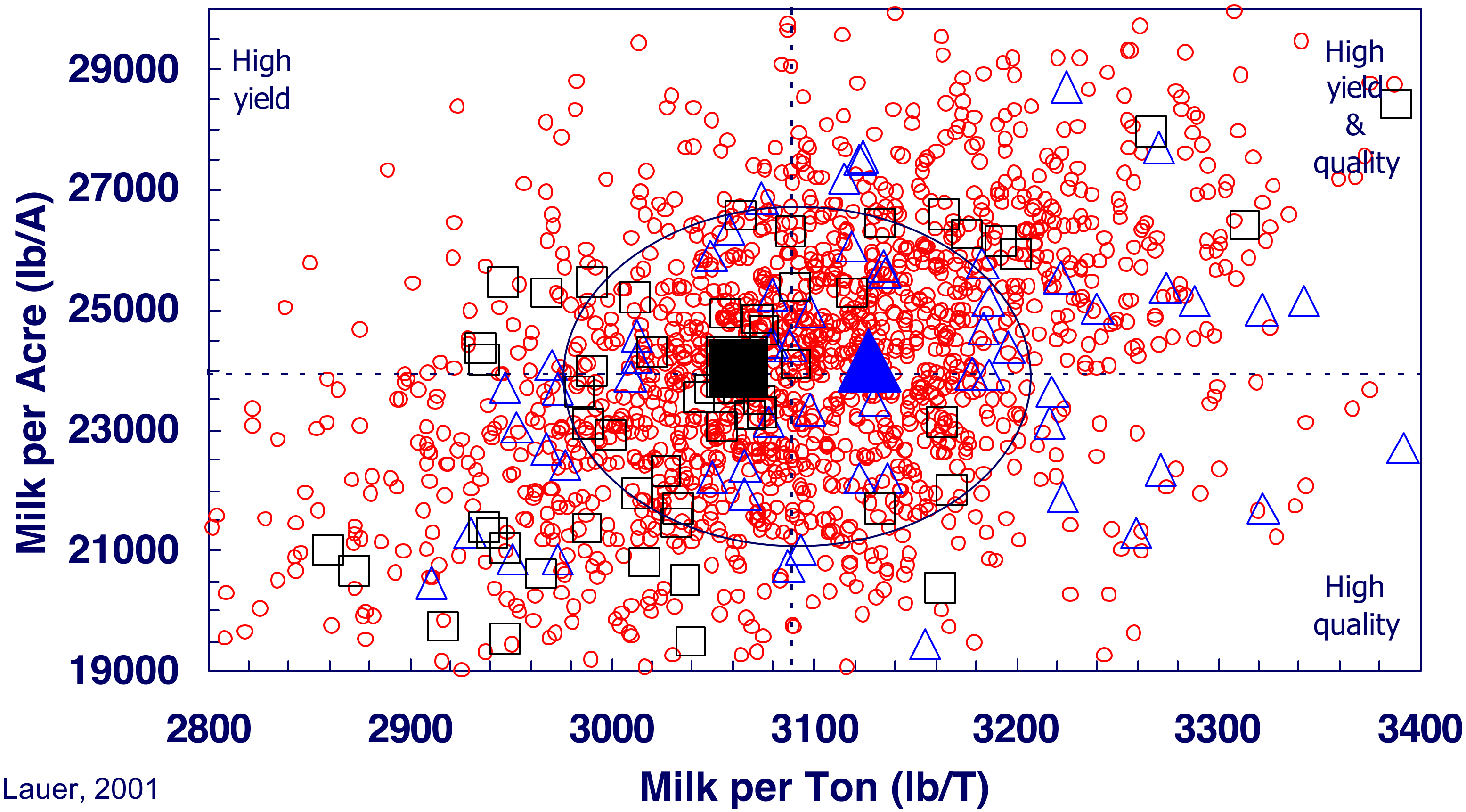
Performance of silage quality check hybrids in WI (1995-2000, n= 61 trials)

		Check hybrids for quality	
Trait	Average Hybrid	High	Low
Yield (T/A)	7.63	7.63	7.75
Moisture (%)	62.0	61.0	61.7
Kernel milk (%)	45	44	50
Crude protein (%)	7.3	7.3	7.3
ADF (%)	23.2	22.4	23.7
NDF (%)	45.7	44.4	46.5
IVD (%)	77.8	78.4	77.4
CWD (%)	51.5	51.6	51.5
Starch (%)	30.2	32.0	29.5
Milk95T (lb/T)	2020	2110	1960
Milk95A (lb/A)	15300	15800	15000
Milk00T (lb/T)	3110	3150	3090
Milk00A (lb/A)	23700	23900	23800

Corn Silage Performance in WI

1995-2000, normalized, checks ▲ = high quality, ■ = low quality

Milk2000, Oval = ± 1 std, Hybrid tests: n = 1714, Trials: n = 61



Lauer, 2001

Corn Silage Performance in WI

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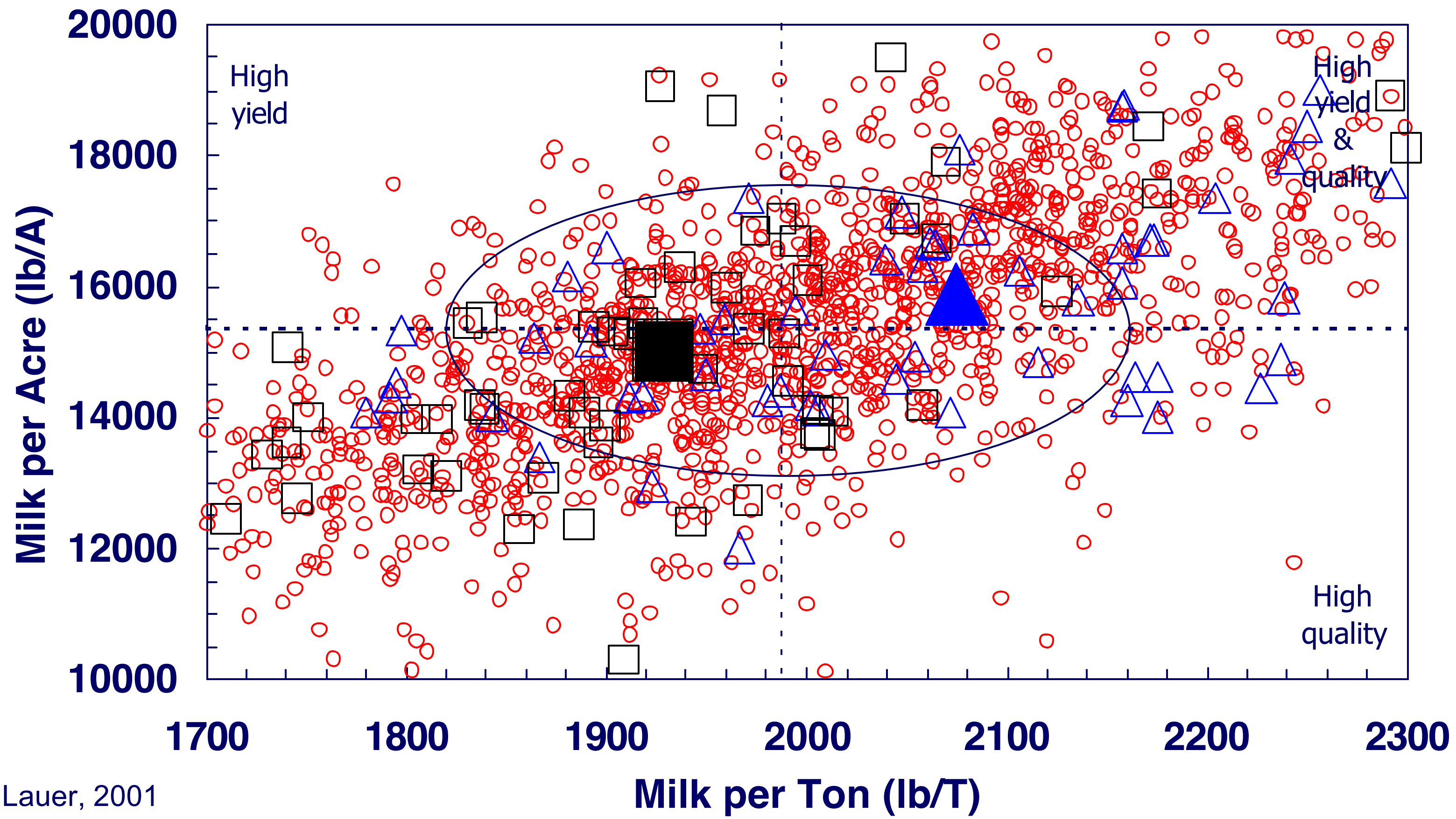


Lauer, 2001

Comparisons of high and low quality check hybrids for Milk per Ton in WI trials (1995-2000, n= 61)

- Milk95
  - ✓ Head to head comparison: 74% of trials
  - ✓ Statistical comparison: 90% of trials
- Milk2000
  - ✓ Head to head comparison: 62% of trials
  - ✓ Statistical comparison: 93% trials

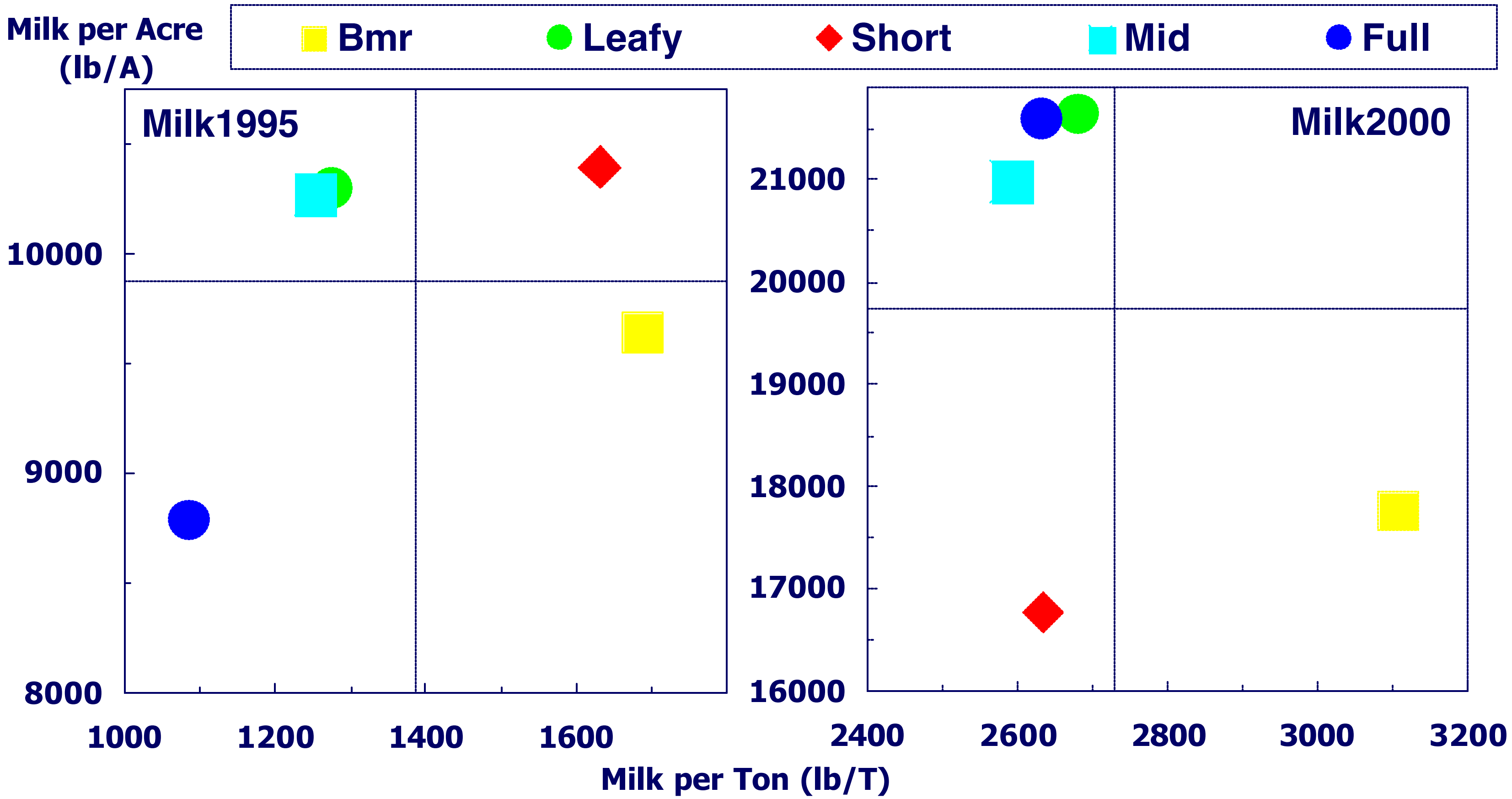
Statistical comparison = Frequency where high quality check either significantly beat the low quality check or it was not different (criteria = 1 standard deviation).


bmr
Normal

Relative Performance of Corn Hybrids Tested in Six Environments (Coors, 2000)

Hybrid	RM	YLD	MST	CP	ADF	NDF	IVD	CWD	Starch
		T/A	%	%	%	%	%	%	%
Short-season (D1297)	98	6.4	52.8	7	24	49	73	45	30
Mid-season (P35R58)	105	8.2	63.9	7	27	53	70	44	25
Leafy (NK48V8/4687)	105	8.1	64.7	7	27	53	70	44	22
Bmr (CF657)	110	5.7	67.5	7	25	50	75	50	27
Full-season (P33A14A)	113	8.1	68.6	7	29	55	69	43	20

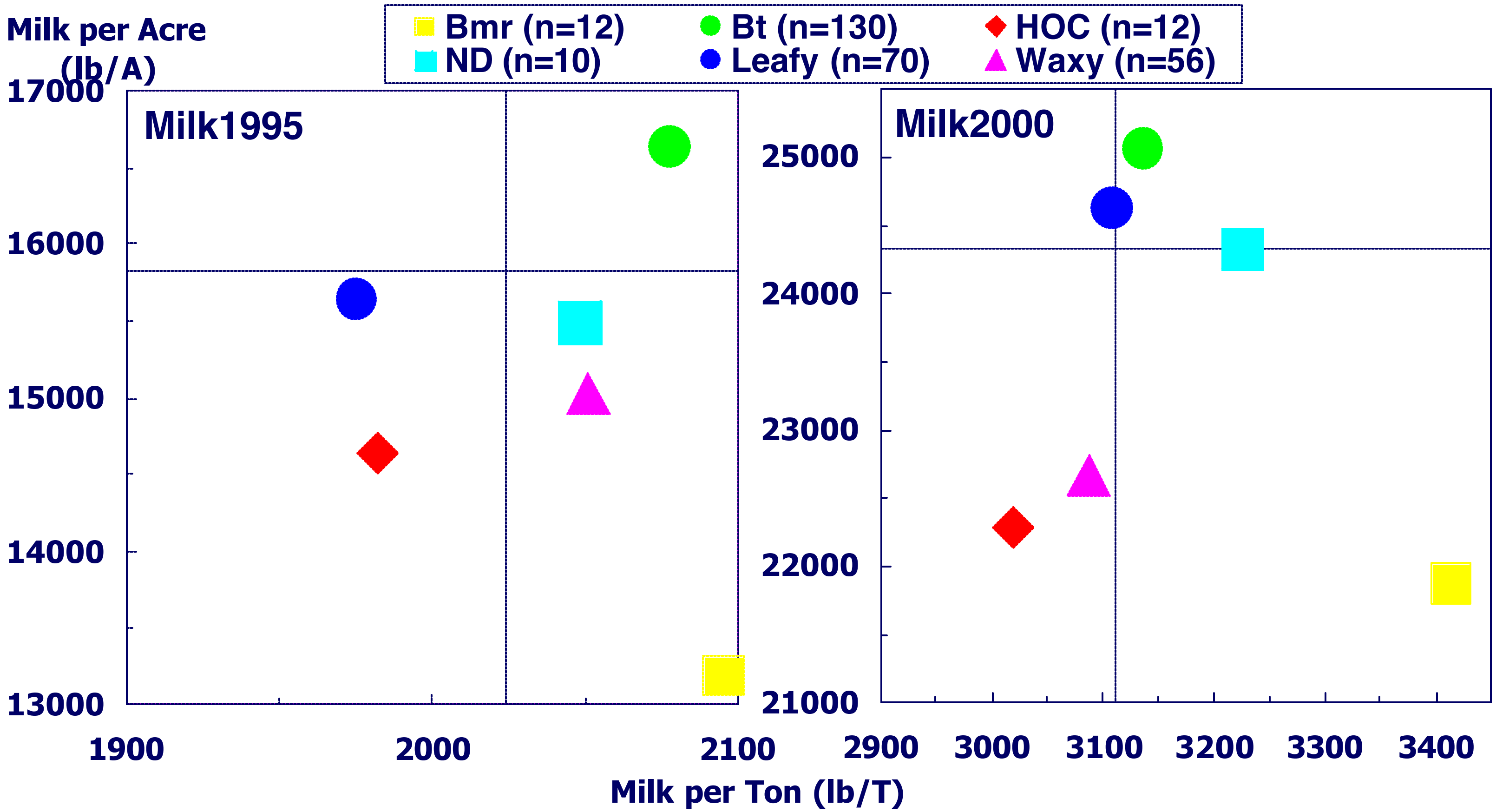
Relative Performance of Corn Hybrids Tested in Six Environments (Coors, 2000)



Relative Performance of Corn Hybrid Types Tested in the UW Silage Trials (1995-2000)

Hybrid	N	YLD	MST	CP	ADF	NDF	IVD	CWD	Starch
		T/A	%	%	%	%	%	%	%
Bmr	12	6.3	68	7.6	23	47	80	58	28
Bt	130	7.9	62	7.4	23	45	78	51	31
HOC	12	7.4	60	7.6	23	46	77	50	32
ND	10	7.4	66	8.2	23	46	78	53	31
Leafy	70	7.9	63	7.6	24	46	78	52	29
Waxy	56	7.3	62	7.7	23	45	78	51	32
All hybrids	2407	7.8	62	7.5	23	45	78	51	31

Relative Performance of Corn Hybrid Types Tested in the UW Silage Trials (1995-2000)



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."


Selecting hybrids is half the story.
The rest is management.

Silage Problems When Harvest Timing Is Off

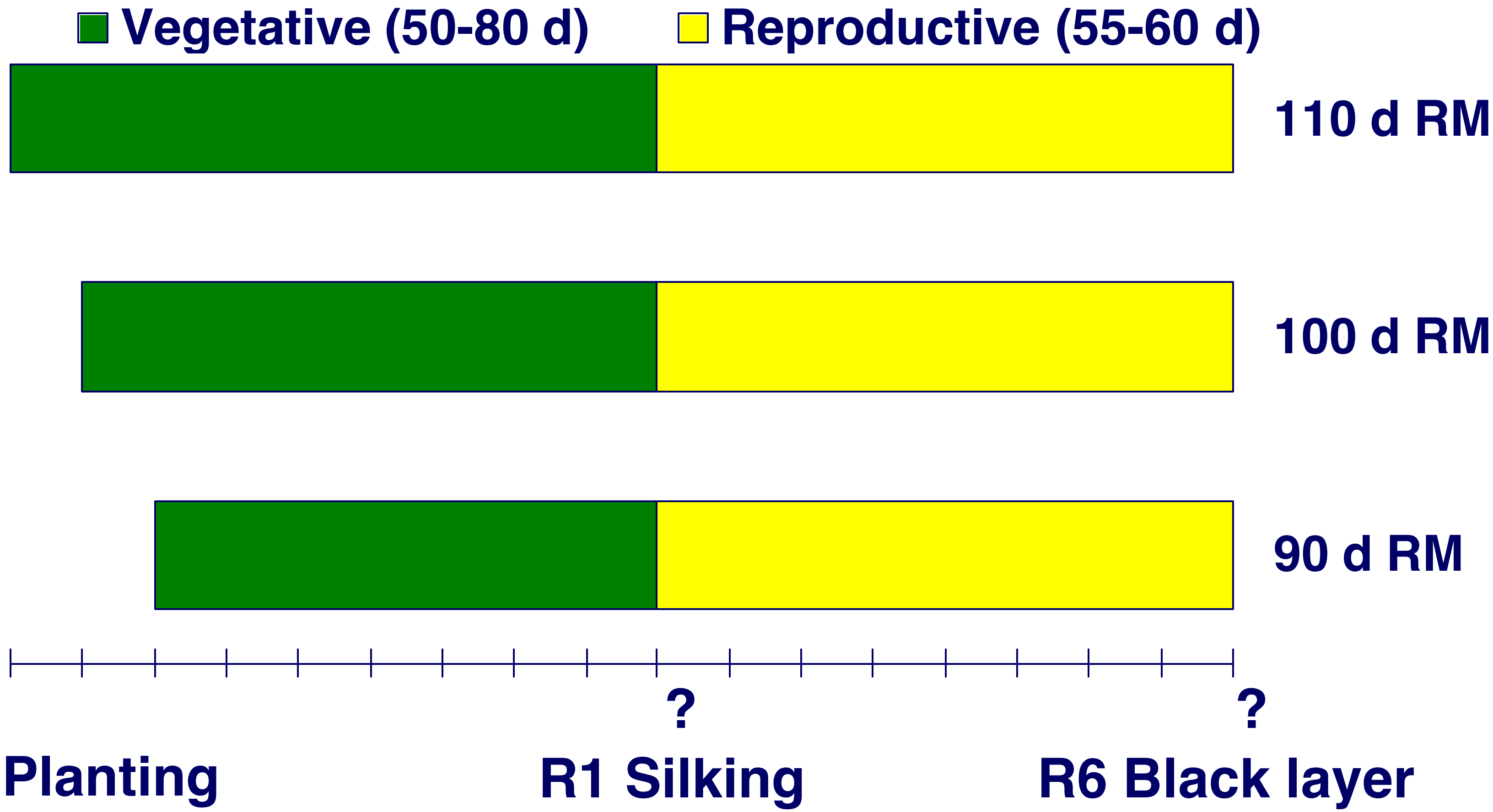
- Too wet (> 70%)
  - ✓ reduced yield
  - ✓ souring
  - ✓ seepage
  - ✓ low intake by dairy cows.
- Too dry (< 60%)
  - ✓ reduced yield
  - ✓ cause molds to develop
  - ✓ lowers digestibility, protein and vitamins A and E.

Kernel Milk Stage "Triggers" for Timing Silage Harvest

Silo structure	Ideal moisture content	Kernel milk stage "trigger"
	%	%
Horizontal bunker	70 to 65	80
Bag	70 to 60	80
Upright concrete stave	65 to 60	60
Upright oxygen limiting	60 to 50	40

"trigger": kernel milk stage to begin checking silage moisture
Silage moisture decreases at an average rate of 0.5% per day during September

Time Span of Vegetative and Reproductive Stages During the Life Cycle of Corn



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In-season Guidelines for Predicting Corn Silage Harvest Date

- Note hybrid maturity and planting date of fields intended for silage.
- Note tasseling (silking) date.
  - ✓ Kernels will be at 50% kernel milk (R5.5) about 42 to 47 days after silking.
- After milkline moves, use kernel milk triggers to time corn silage harvest.
  - ✓ Use a drydown rate of 0.5% per day to predict date when field will be ready for the storage structure.
  - ✓ See http://cf.uwex.edu/ces/ag/silagedrydown/
- Do final check prior to chopping.

Special Situations

- Drought
- Hail
- Frost
- Uneven development

UW Extension

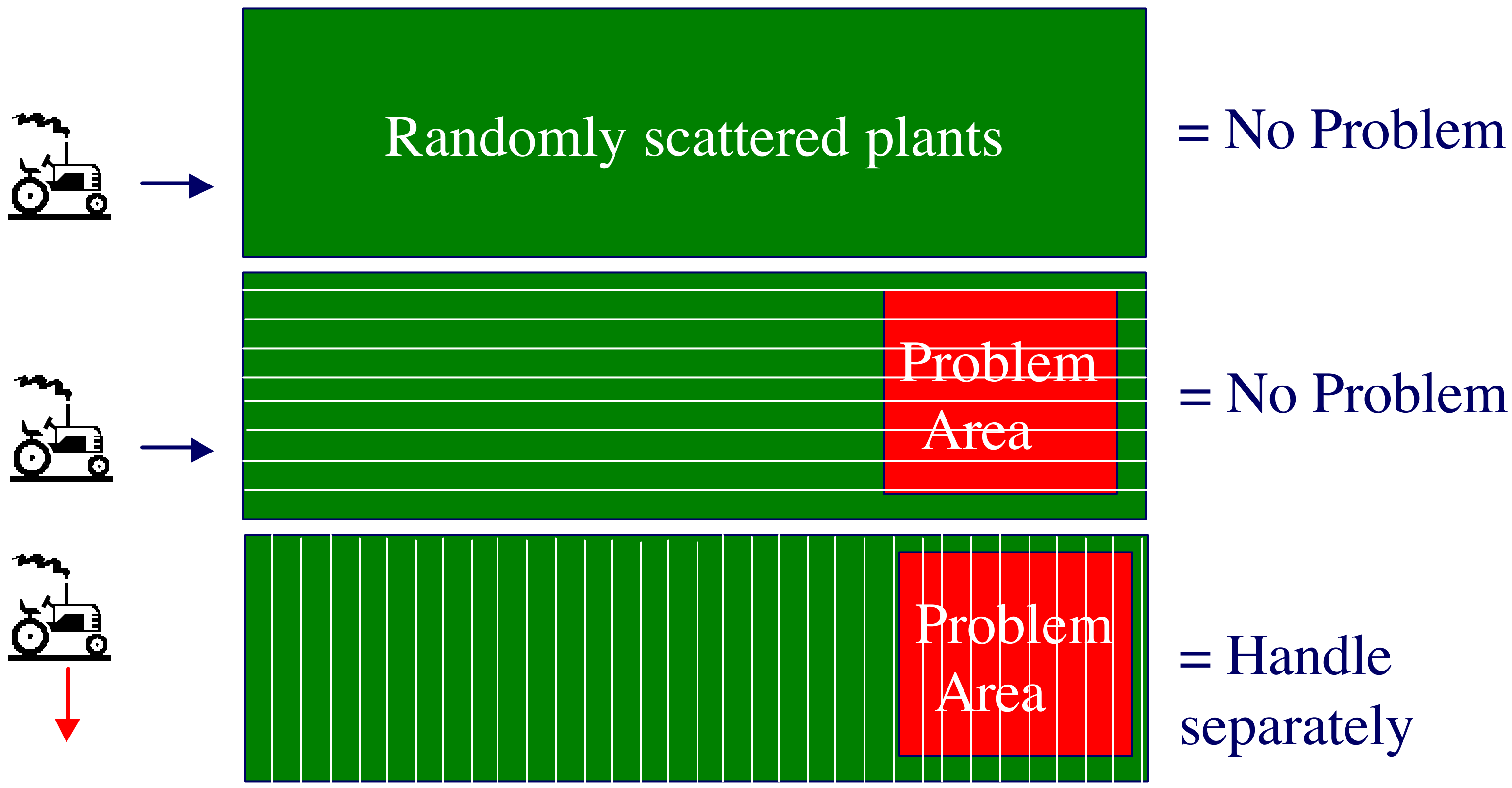
Corn Silage Response to Hail Damage during 2000 at Arlington,WI

Growth stage	Leaf removal	Yield	Moisture	Kernel milk
	(%)	(T/A)	(%)	(%)
V7	100	8.2	64	40
V10	50	8.5	64	50
	100	7.0	63	50
R1	25	7.3	69	40
	50	7.4	66	40
	100	2.8	70	20
R4	25	8.8	65	50
	50	8.1	65	40
	100	5.1	53	40
Check	0	8.9	63	50
LSD(0.10)		1.4	4	20

Harvesting Corn Silage from Fields with Uneven Development

- Avoid layering plant material differing in moisture in silo.
  - ✓ Too wet - Yield, quality and seepage losses
  - ✓ Too dry - Potential for mold development and mycotoxin problems.
- Begin chopping when majority (>50%) of the field is at the proper moisture.
- Need good mixing of plant material at chopper and silo.
  - ✓ Random uneven plants = no problem
  - ✓ Managing problem field areas depends upon row orientation
    - Each round passes through uneven problem area = no problem
    - Each round passes through uniform area = handle areas separately
  - ✓ Separately manage whole fields that differ in moisture

Harvesting Corn Silage from Fields with Uneven Development



Handling Corn Damaged By Autumn Frost

- If frost-kill occurs:
  - ✓ before ½ milkline - harvest as WP silage. Silage yield and quality trade-off exists.
  - ✓ at ½ milkline - allow field dry-down to desired moisture content for harvest as high-moisture corn.
  - ✓ at black-layer - follow usual harvest and handling procedures for high-moisture or dry grain.
- Usually must wait to chop 5 to 7 days after a frost before whole-plant moisture is at acceptable value for storage structure
  - ✓ Allow to field-dry to < 70% moisture
  - ✓ Large acreages will need to be covered quickly
  - ✓ Alternative: add 300-400 lb Wheat Mids or Corn Gluten Feed per ton silage to lower moisture content from 75% to 65% and raise energy content (Shaver).
- Store in horizontal silos (bunkers, bags, or drive-over piles) to minimize seepage losses.

Yield and Pricing of Drought Stressed Corn (grain and silage)

- Grain
  - ✓ lower yield
  - ✓ test weight (discounts may apply)
- Silage
  - ✓ 1 Ton silage per 5 bushels grain (Jorgensen and Crowly, 1972)
  - ✓ If not pollinated, expect to harvest 1 ton of 30% dry matter per ft. of height, excluding the tassel
  - ✓ Feed value is 75 to 95% of normal silage

Influence of Drought Stress on Corn Development and Yield

- Drought stress prior to pollination
  - ✓ reduced ear length
  - ✓ reduced number of potential kernels
- Drought stress after pollination
  - ✓ aborted kernels
  - ✓ poor kernel fill
  - ✓ predisposed to development of stalk rots

Management Considerations for Harvesting Drought Stressed Corn

- Development of the crop
  - ✓ if not pollinated, harvest anytime
  - ✓ if pollinated, delay harvest as long as some green leaf tissue remains and not at black layer
- Harvest at proper moisture for the storage structure
  - ✓ if too dry, need to increase packing in structure
  - ✓ Adjust theoretical length of cut: <60%= 1/2”; 60-70%= 3/4”; >70%= 3/4-7/8”
- Nitrate toxicity potential
  - ✓ Need to dilute with grain or legume hay
  - ✓ Raise cutter bar: Nitrates accumulates in bottom 10 to 12” of stalk
  - ✓ Slowly introduce drought-stressed silage during feeding
  - ✓ Watch for silo gases (nitrogen oxide gases)
- If earlier harvest, be sure all pesticides are cleared for silage (i.e. Tilt)

Putting a Value on Normal Corn Silage

- Corn silage value = relative feed value of a known market such as corn grain or baled hay
  - ✓ 1/3 to 1/2 value of hay
  - ✓ 7 to 8 X the price of a bushel of corn. If corn silage has already been harvested, then value may be 10 X the price
- Corn silage value = what it would cost to replace or substitute another feed.
  - ✓ Calculated using market prices for energy, protein, and digestibility as measured by NE_L, crude protein and NDF. Prices of corn, soybean meal, and legume hay can be used.
  - ✓ Calculated using other feed sources such as clover, alfalfa, lespedeza, ryegrass, etc.
- Corn silage value = contracted price agreed upon between grower and buyer that is above the cost of production.

OLD SLIDES

Relationship Between Kernel Milk Stage and Silage Yield and Quality

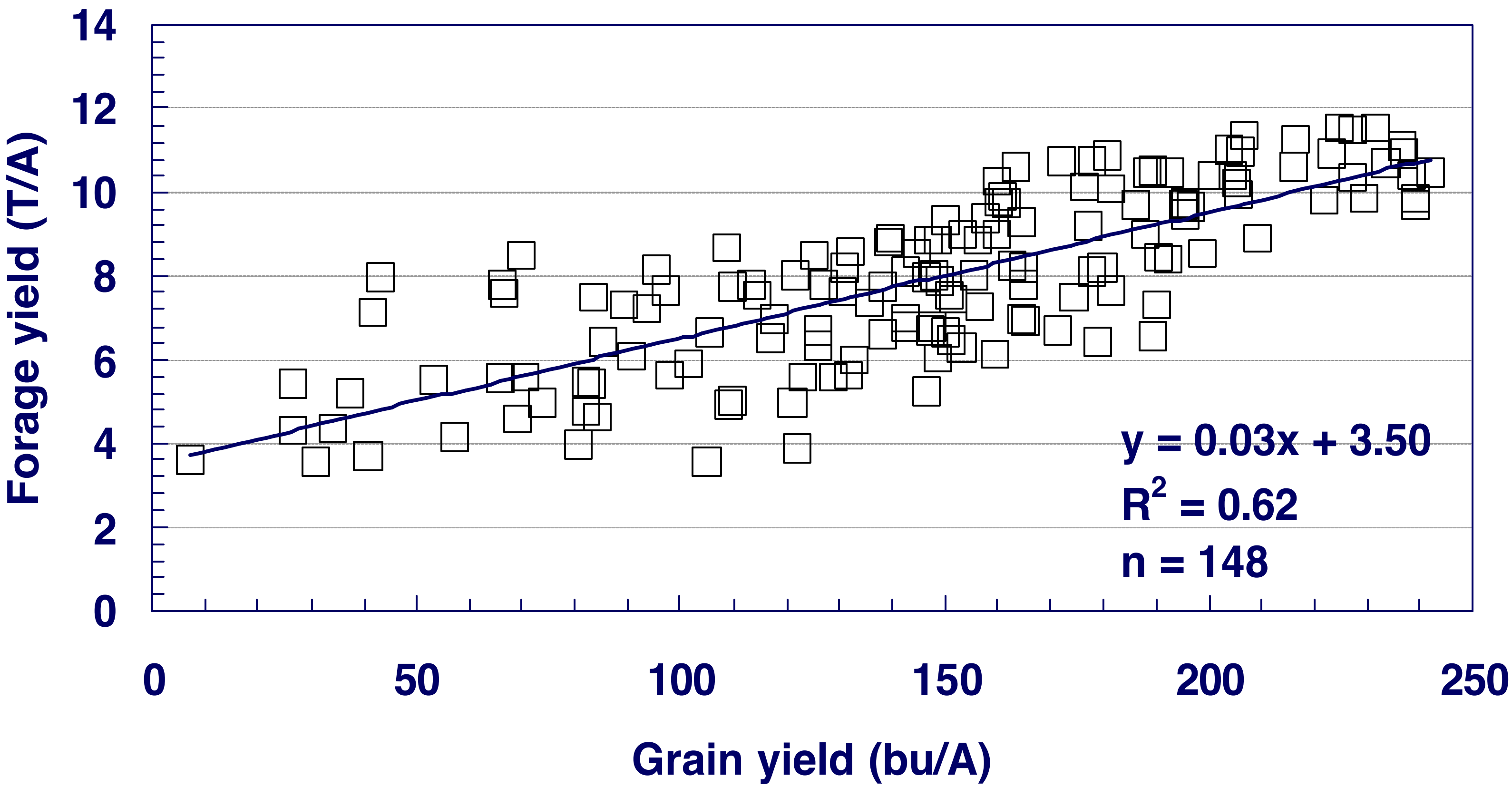
Kernel milk stage	Silage moisture	Dry matter yield	Crude protein	NDF	*In vitro* digestibility
	%	T/A	%	%	%
Soft dough	76	5.4	10.3	53	77
Early dent	73	5.6	9.9	48	79
1/2 kernel milk	66	6.3	9.2	45	80
1/4 kernel milk	63	6.4	8.9	47	80
Black layer	60	6.3	8.4	47	79

Wiersma et al., 1993

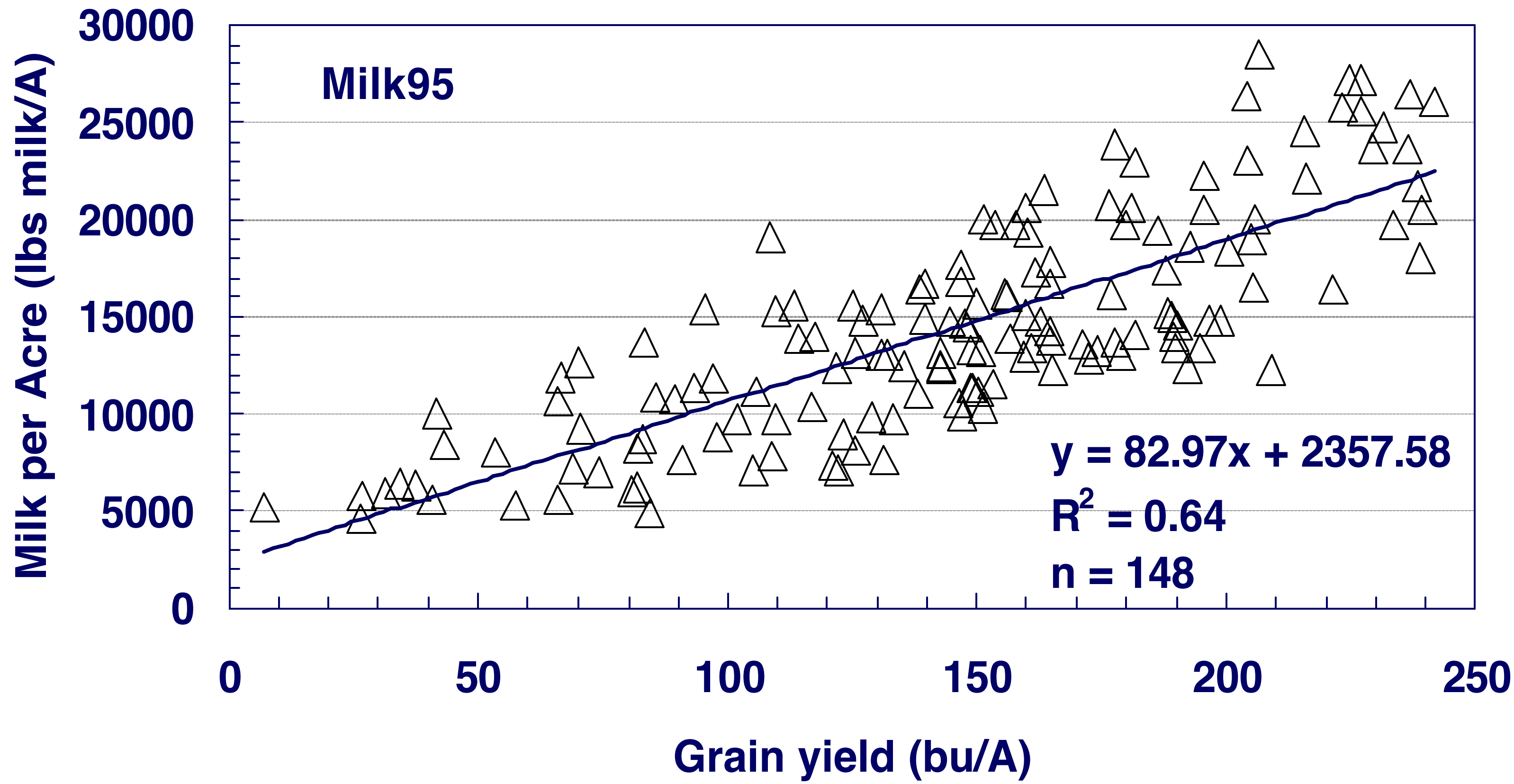
Upgrading Milk2000 from Milk95

1. Develop Milk2000 equation for predicting corn silage energy (Schwab, Shaver and Hoffman)
2. Develop starch content (%) NIRS calibration
   - ✓ Run SELECT on global samples (n= 602)
   - ✓ Wet lab chemistry on subset (n= 104)
   - ✓ Develop NIRS equation
3. Initial evaluation on calibration samples
4. Evaluate 1999 silage trial hybrids
5. Evaluate 2000 silage trial hybrids

Relationship between Forage Yield and Grain Yield for Planting Date Experiments (1997-2000)



Relationship between Milk per Acre and Grain Yield for Planting Date Experiments (1997-2000)



Feeding Guidelines – Moldy Corn or Corn Silage (Shaver)

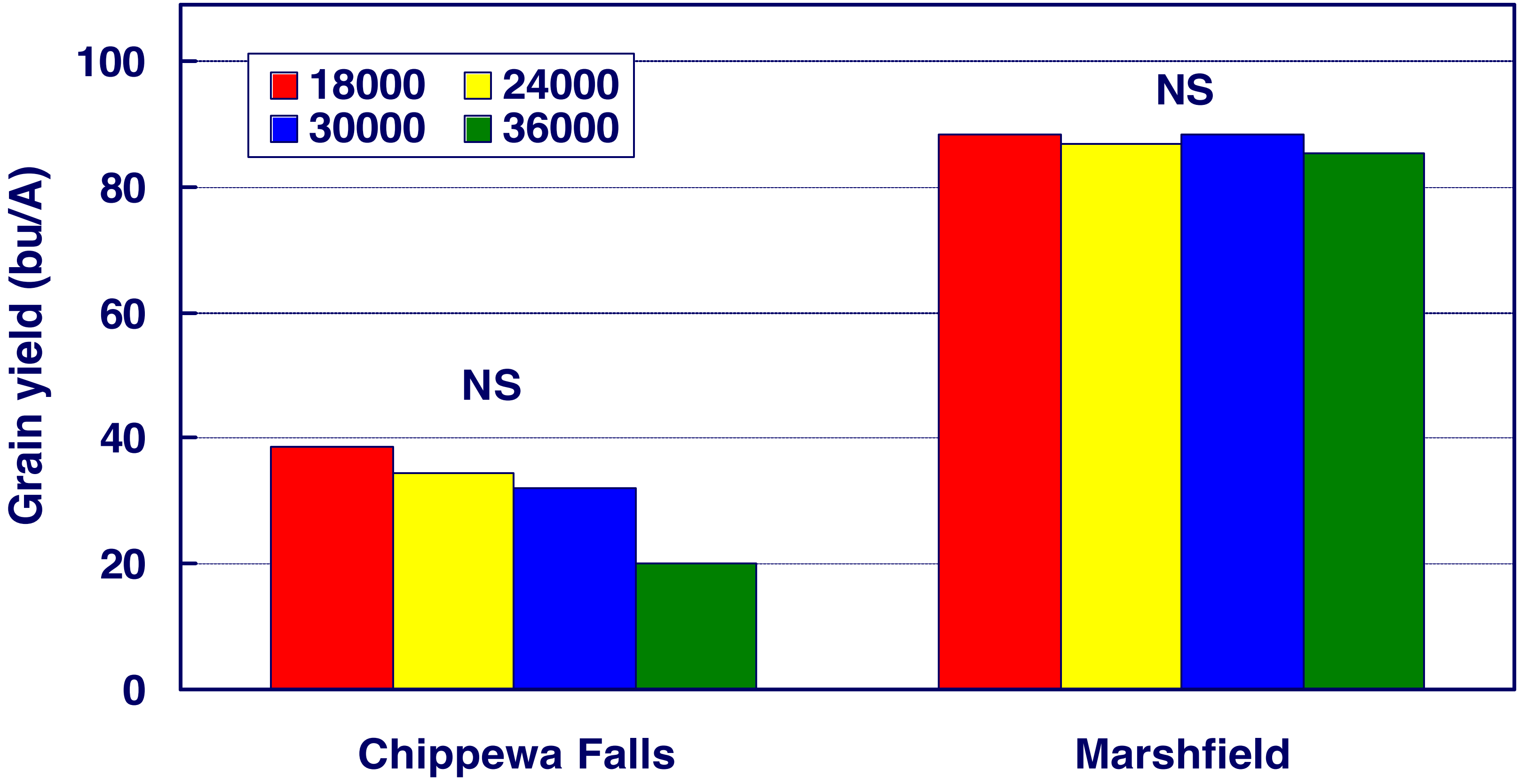
- Test for specific mycotoxins.
- What if high mycotoxin levels found?
  - ✓ Option 1: Do not feed!
  - ✓ Option 2: Target livestock groups?
  - ✓ Option 3: Dilute with “clean corn?
  - ✓ Option 4: Try feeding aluminum silicates?
  - ✓ Option 5: Dilution plus aluminum silicate?
- Feed worst corn in cold weather.
- Watch silo removal rate.
- Watch feed bunk housekeeping.
- Increase frequency of corn feeding.
- Supply adequate vitamins and trace minerals.
- Monitor intake, production, cow condition and fertility

Harvesting and Handling Non-Uniform Corn Silage Fields

Joe Lauer
UW Corn Agronomist

- Predicting silage harvest date – the influence of maturity and planting dates
- Special Harvest Situations
  - ✓ Fields with uneven development
  - ✓ Corn silage damaged by autumn frost
  - ✓ Drought damaged corn
- Putting a value on normal and immature corn silage

Response of corn to plant density during 1988



Old Relationship Between Corn Grain Yield and Forage Yield at 65% Moisture

Bu/A	Bu/T
Less than 90	5.0
90-110	5.5
110-130	6.0
130-150	6.5
Over 150	7.0

Derived from "Corn silage for Wisconsin cattle - A1178 by Jorgensen and Crowly, 1972

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

More Mileage From Corn Silage

Joe Lauer

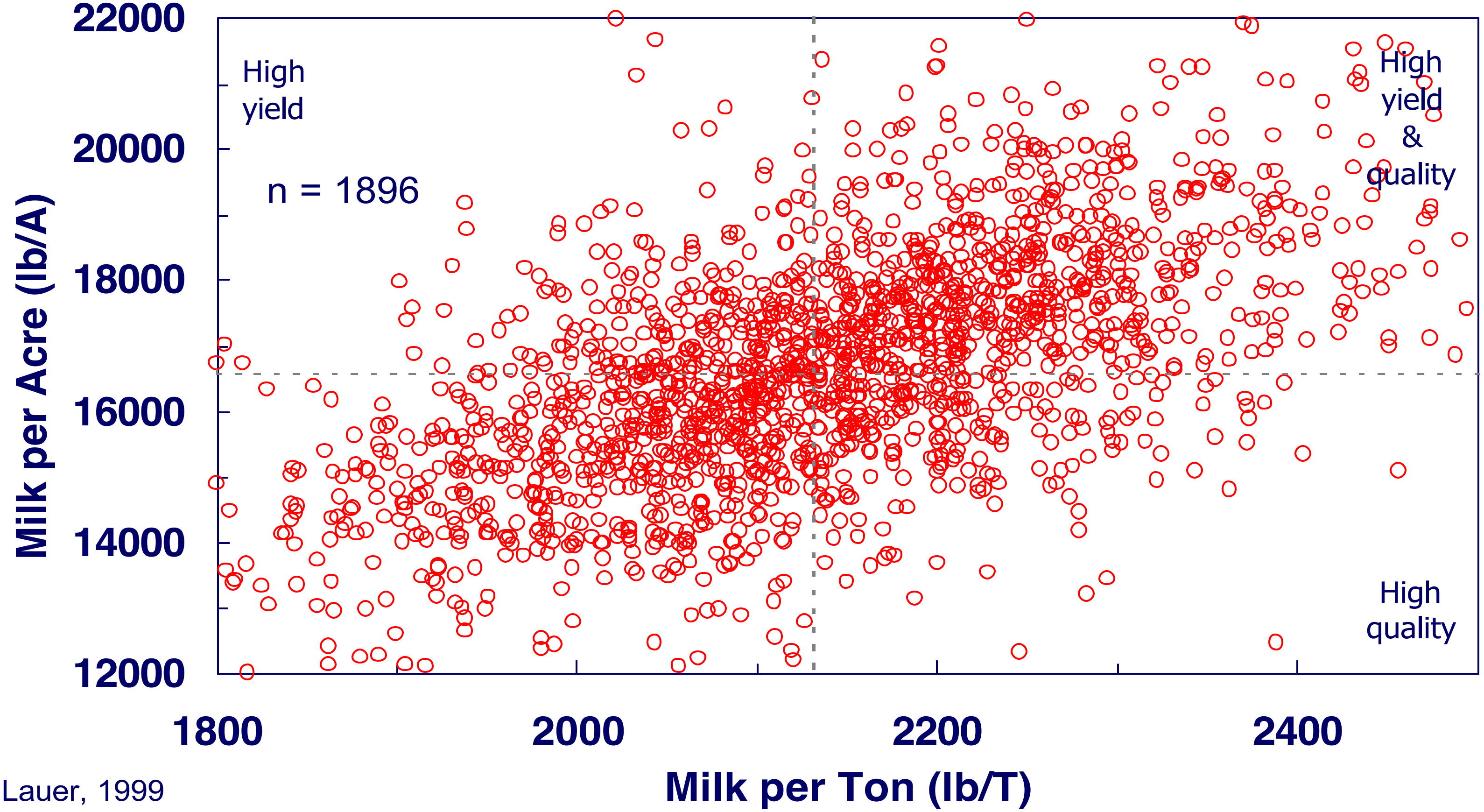
Corn Agronomist

University of Wisconsin-Extension
Cooperative Extension

UW Corn Agronomy Research Areas
"Where have we been?!"

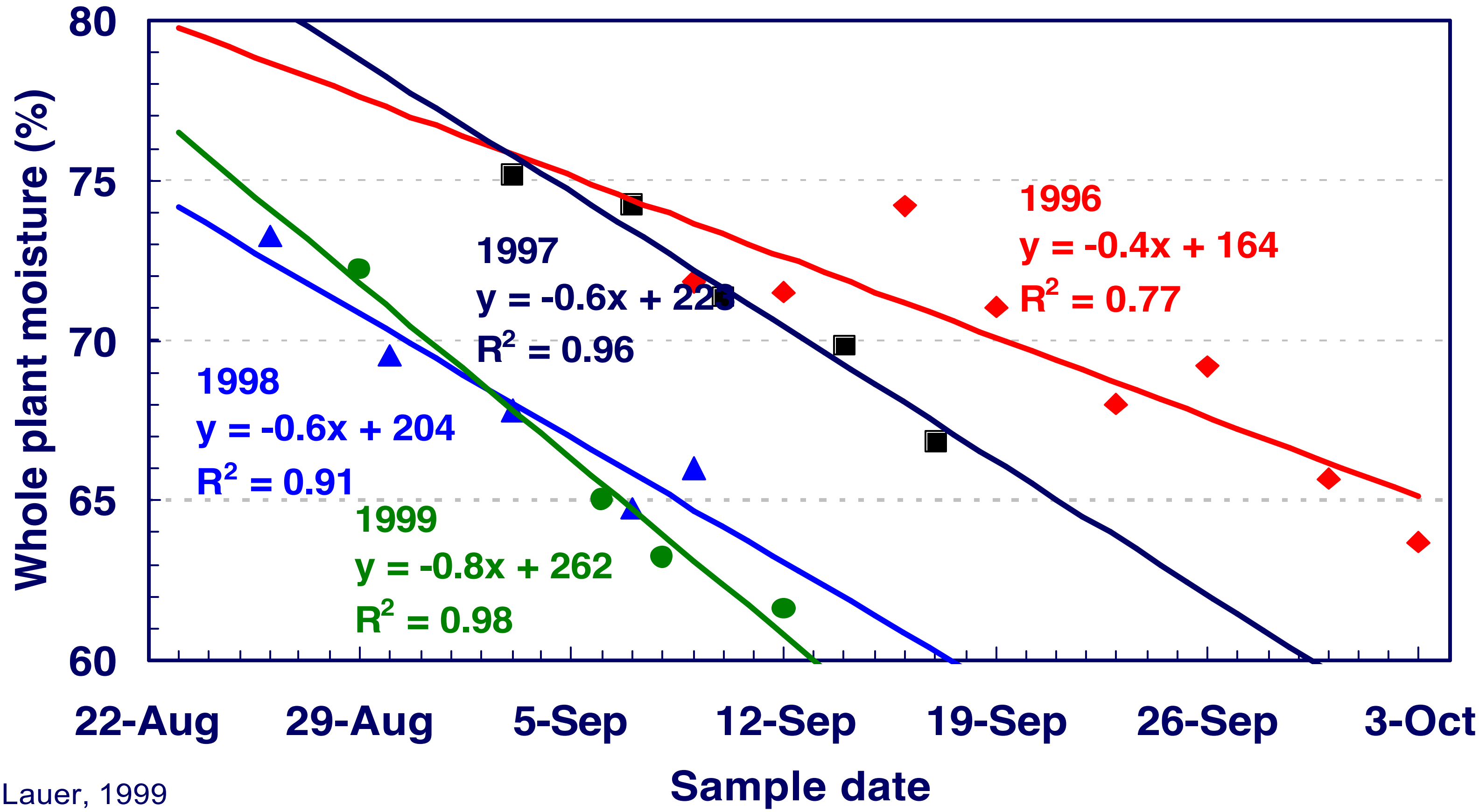
- Hybrid evaluation
  - ✓ (Coors, Shaver and Lauer)
- Management for yield AND quality
  - ✓ Population (Cusicanqui)
  - ✓ Planting date (Darby)
  - ✓ Row spacing (Lauer et al.)
  - ✓ Soil fertility (Bundy)
- Harvest
  - ✓ Timing (Darby)
  - ✓ Cutting height (Cusicanqui)
  - ✓ Special situations
    - Frost (Lauer)
    - Hail (Lauer et al.)
    - LDP (Lauer)
- Ensiling
  - ✓ Mycotoxins (Smiley)
  - ✓ Inoculants (Muck)

Corn Hybrid Silage Yield and Quality During 1990-1999 in Wisconsin (Normalized Data)



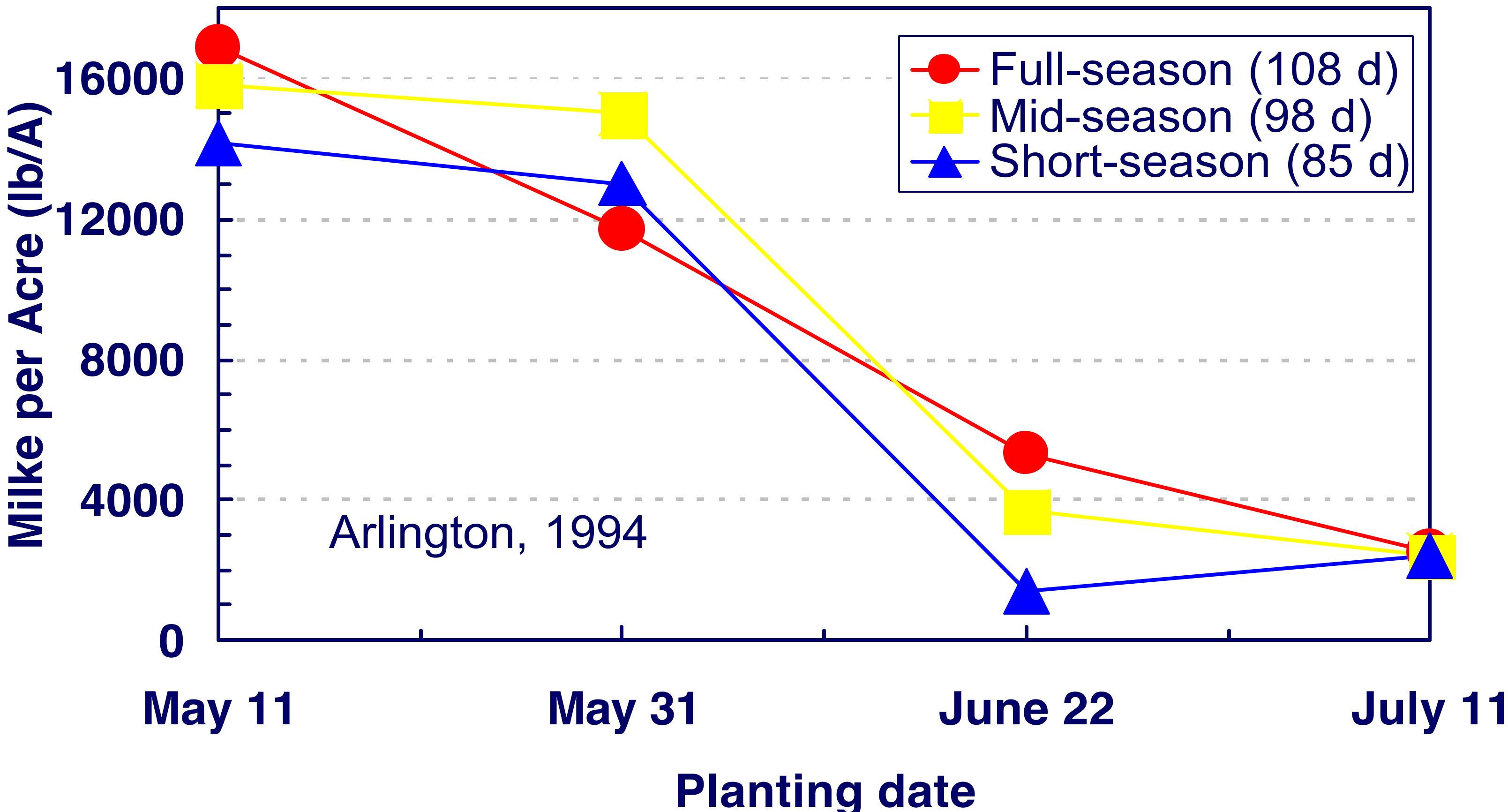
Lauer, 1999

Corn silage drydown rate in Manitowoc County, WI.



Lauer, 1999

Corn Silage Response to Planting Date

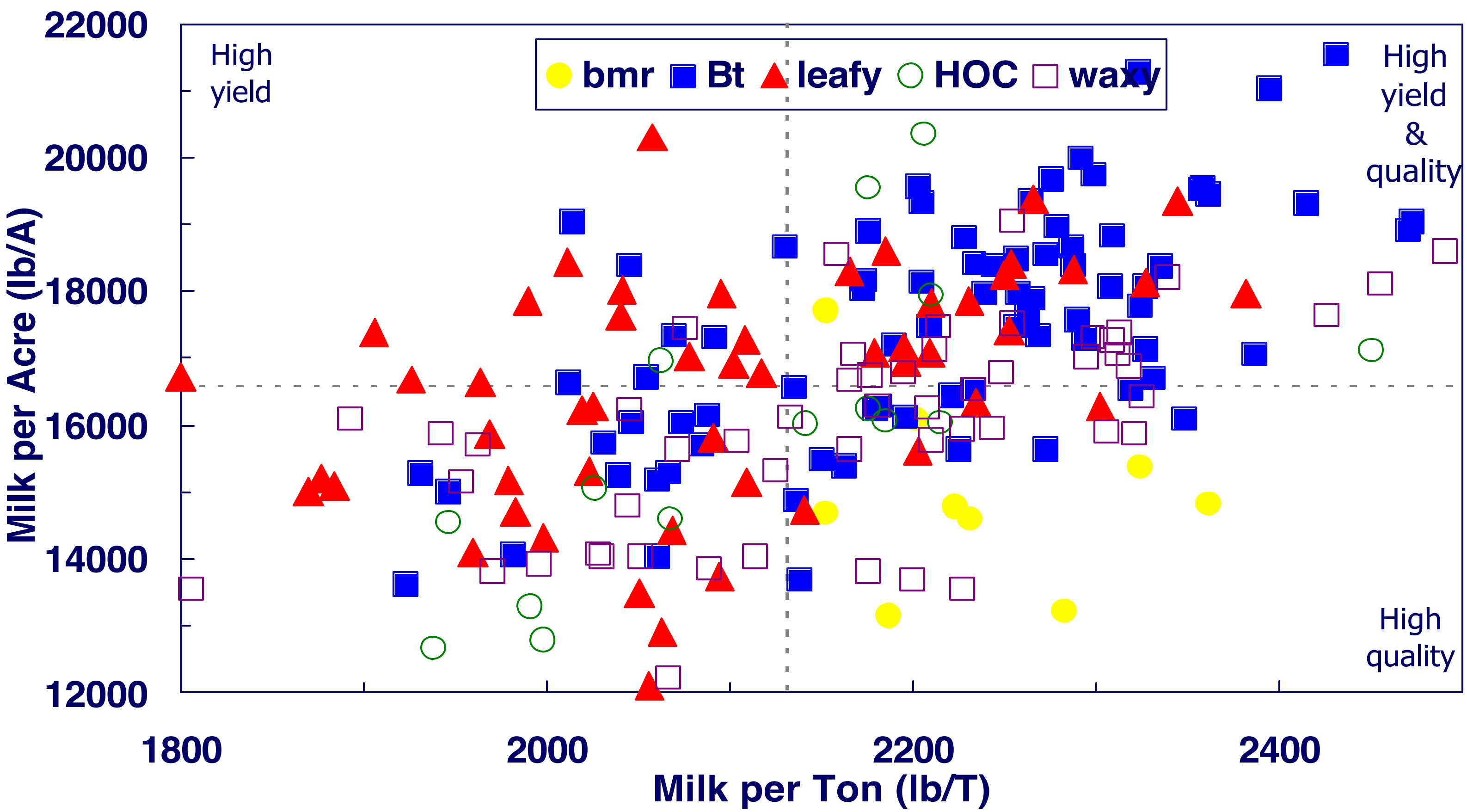


Lauer, 1994

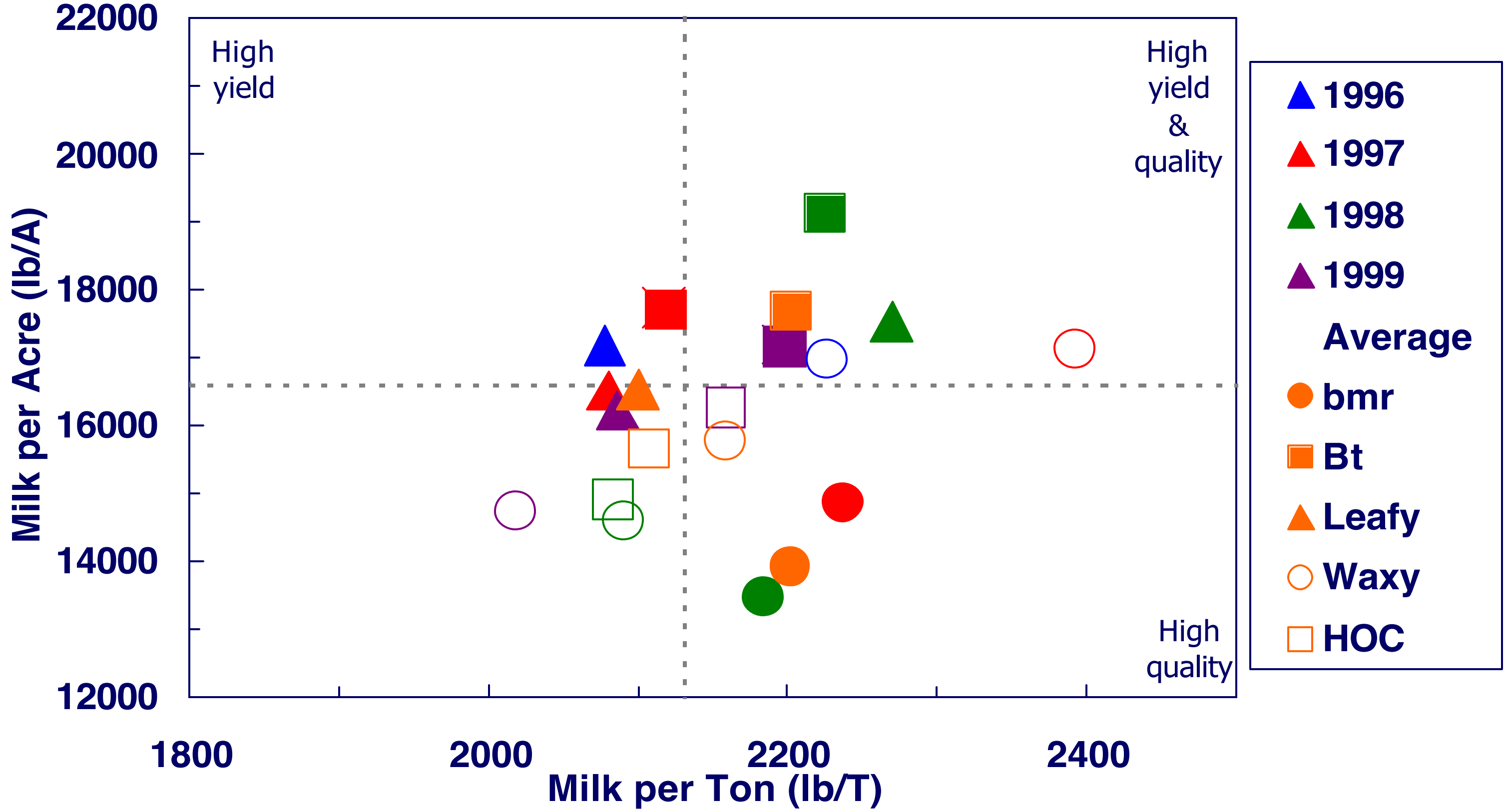
UW Corn Agronomy Research Project
"Where are we going?!"

- Hybrid evaluation
  - ✓ Within seed industry, breeding efforts are diverging
  - ✓ What is important for grain hybrids may not be important for silage hybrids
    - starch digestibility
    - "stay-green" - synchrony of drydown between ear and stover
    - stover digestibility
- Agronomic management: "Do for silage what you do for grain."
  - ✓ Decision making for changing technologies
  - ✓ Hail
- Value of corn silage

Corn Hybrid Silage Yield and Quality During 1990-1999 in Wisconsin (Normalized data)



Corn Hybrid Silage Yield and Quality During 1996-1999 in Wisconsin (Normalized data)



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

Background

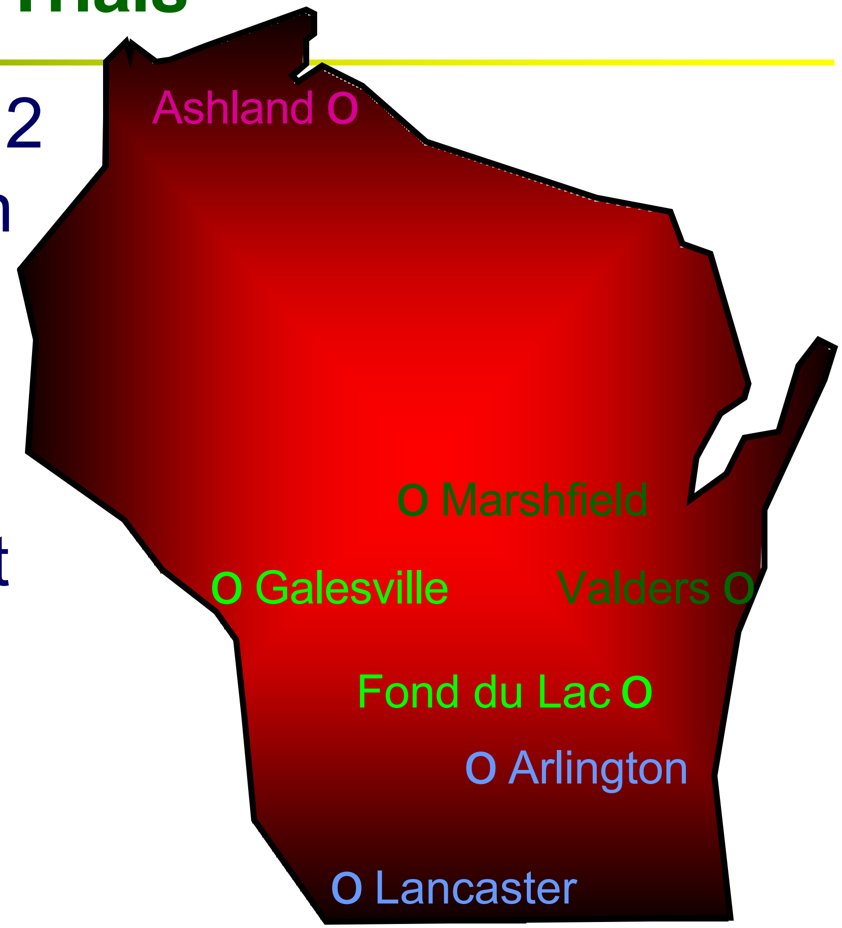
- Importance of Corn Silage to Wisconsin
  - ✓ Largest acreage and production among U.S. States
  - ✓ Used extensively in forage base for state dairy herds
- Changing Wisconsin dairy production ‘climate’
- Wisconsin Corn Silage Consortium (Coors et al.)
  - ✓ Range for NDF and digestibility among commercial hybrids sold in Wisconsin is narrow.
  - ✓ Yield and quality differences among corn hybrids are repeatable.
  - ✓ Corn silage quality can be predicted using NIR.

Developing a Corn Silage Hybrid Evaluation Program

- Fast, reliable method for predicting silage quality - NIRS.
- Development of equipment designed for harvesting a large number of plots at numerous locations.
- Results must be precise and repeatable.
  - ✓ Necessary for ranking hybrids.
  - ✓ Needed by farmers for making a hybrid selection decision.
- Development of a performance index that can be used to select hybrids.

Wisconsin Corn Hybrid Silage Performance Trials

- Each hybrid is tested at 2 locations in a production zone
- Seed companies are encouraged to enter silage hybrids in at least one grain trial




HOLLAND

Role in UW Corn Silage Program

- Extend research results and methods generated by Coors.
- Administer UW Corn Silage Evaluation Program
- Develop educational materials and programs for farmers, agents and industry.
- Monitor repeatability of hybrid rankings and implications for farm management decisions

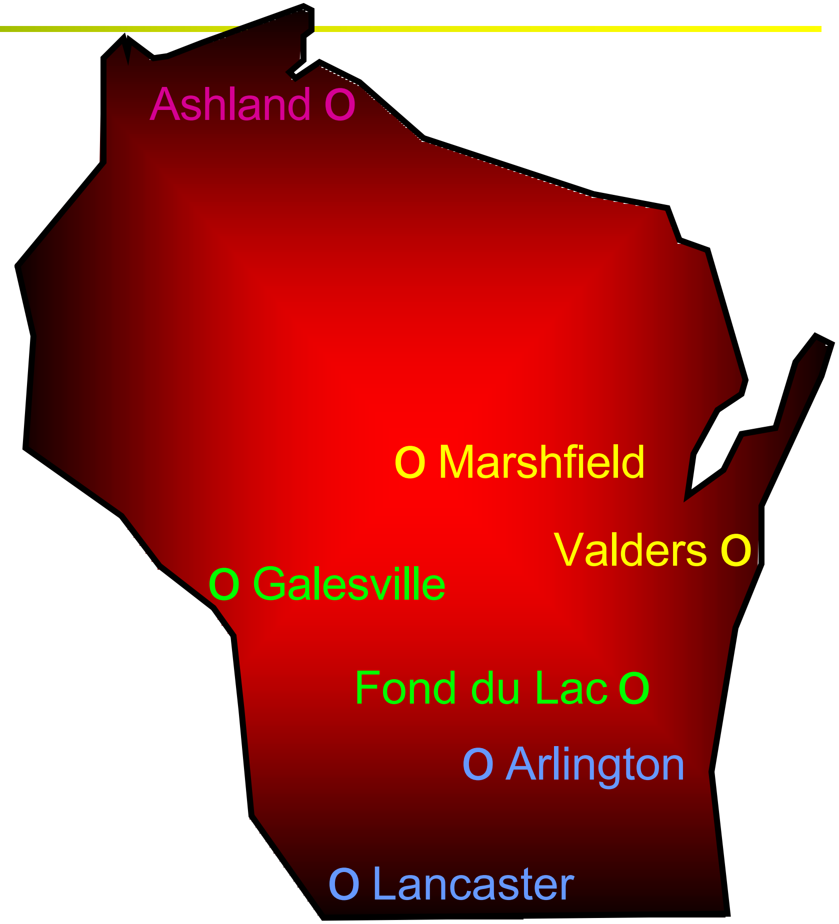
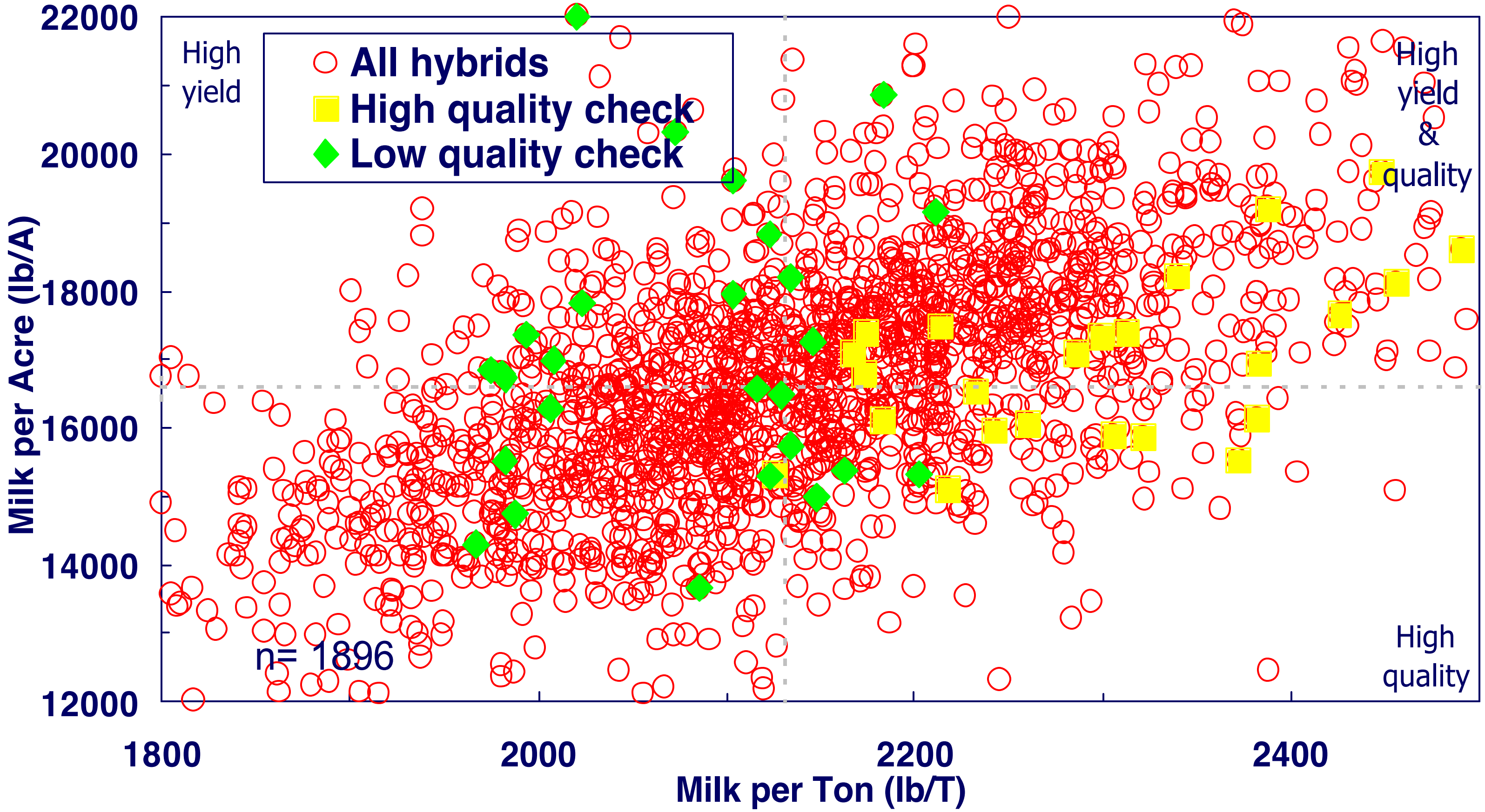


Table 11. Southern Zone - Early Maturity Silage Trial

105 DAY RELATIVE MATURITY OR EARLIER, BASED ON COMPANY RATING

		1998											
		AVERAGE											
			Kernel									ARL	LAN
		Yield	Moist	Milk	CP	ADF	NDF	IVD	CWD	MILK PER		Yield	Yield
BRAND	HYBRID	T/A	%	%	%	%	%	%	%	TON	ACRE	T/A	T/A
Dairyland	Stealth 1406	12.0 *	53.7	10	6.6	20	40	79	49	2350 *	27100 *	12.0	12.0 *
Brunner	S-5474	12.0 *	54.7	10	6.7	20	41	79	49	2320	28200 *	13.0 *	11.0 *
Carharts Blue Top	CX105A	10.0	58.8	20	7.0	19	38	80	49	2490 *	25900 *	11.0	9.6 *
Kaltenberg	K5109	10.0	61.3	30	6.8	19	40	80	50	2420 *	24700 *	12.0 *	8.2 *
Cargill	4111	9.9	61.7	20	6.9	21	41	78	48	2230	22300	11.0	8.5 *
Dekalb	DK591	12.0 *	61.8	30	7.3	22	43	79	50	2190	26500 *	13.0 *	11.0 *
105-DAY HYBRID TRIAL AVERAGE ##			61.9										
Garst	8640	10.0	62.4	10	6.8	21	41	79	48	2300	23900	12.0 *	8.5 *
Top Farm	TFsx2103	9.9	64.7	20	7.0	20	41	79	48	2300	23000	11.0	8.5 *
Cargill	F657	8.8	65.2	40	7.1	21	43	81	56	2330	20600	9.3	8.3 *
Trelay	7004	9.2	69.5	30	7.5	21	42	79	50	2280	21100	11.0	7.5
MEAN		10.0	61.4	20	7.0	20	41	79	50	2320	24300	12.0	9.3
LSD(0.10)**		1.6	8.0	10	0.4	2	2	1	2	150	4100	1.7	3.5

Yield and Quality of High and Low Quality Corn Silage Checks During 1990-1999 in Wisconsin (Normalized data)

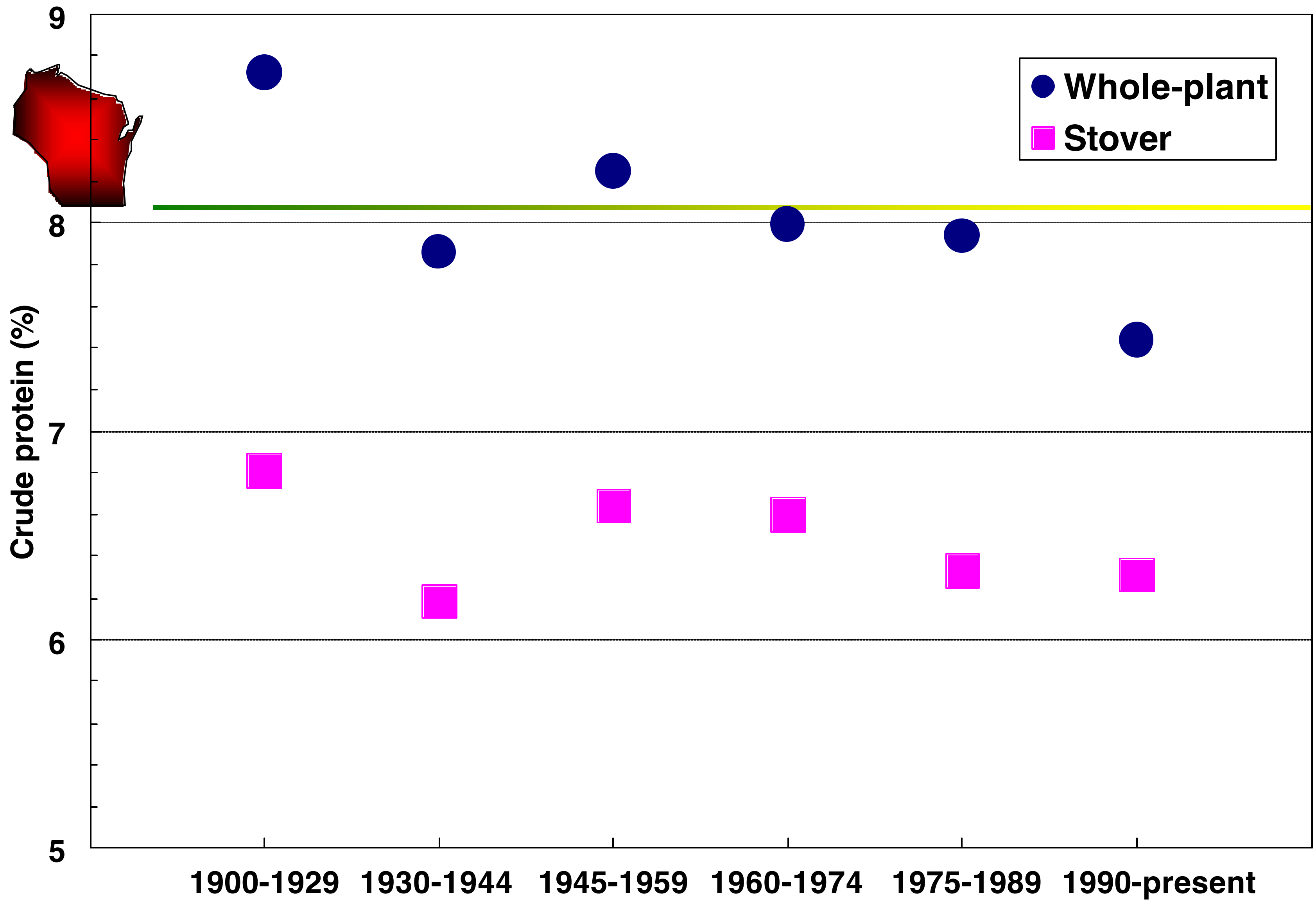


What Are the "Real World" Differences for Milk Per Acre and Milk Per Ton?

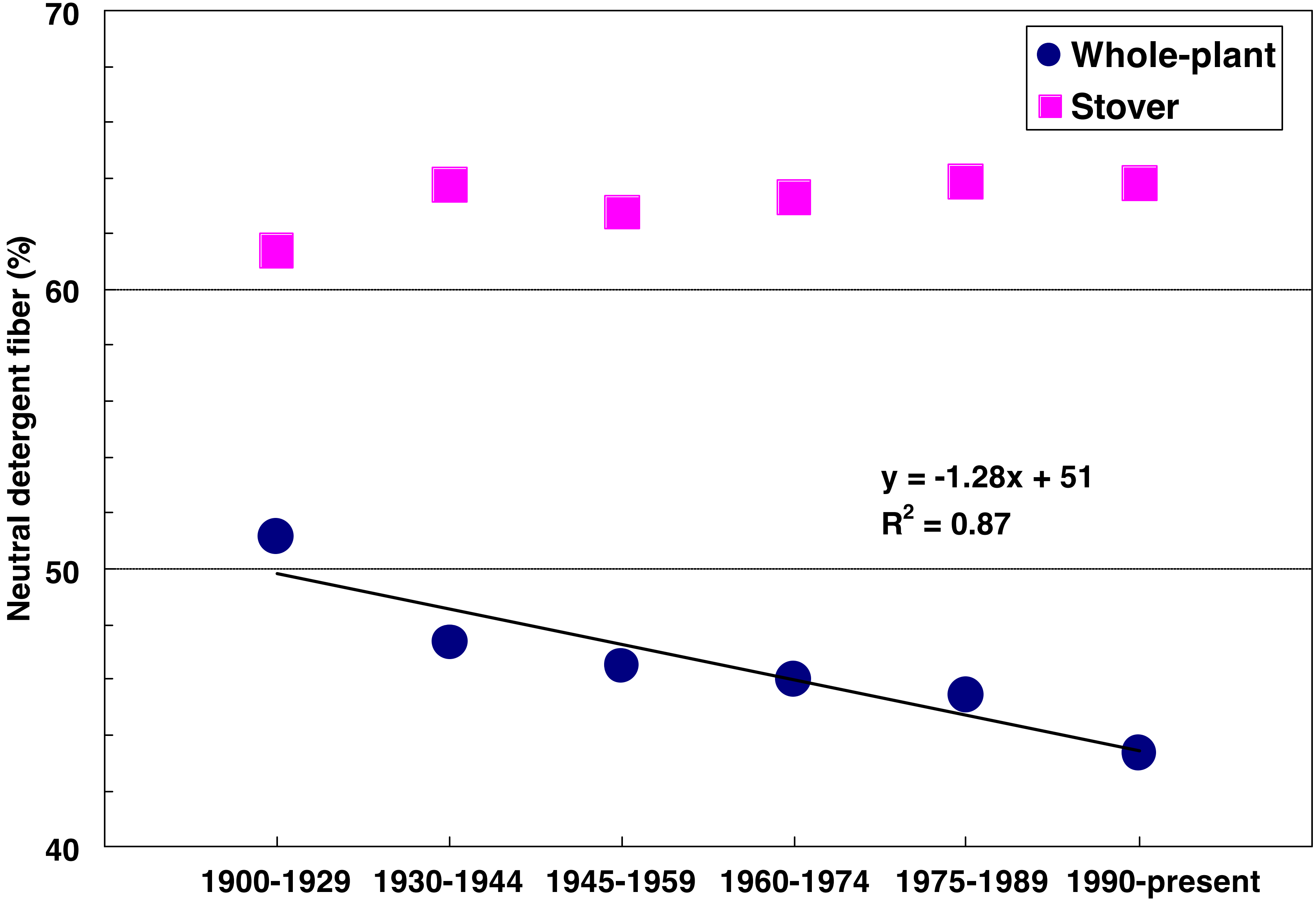
- Values measured in the UW performance trial are "potential" differences and used for hybrid ranking.
  - ✓ Ground sample removes factors like kernel hardness, TLC, harvest timing, mold development, rumen action, etc.
  - ✓ Green forage, not ensiled
  - ✓ 48 hour digestion period
- "Real world" differences are probably less due to:
  - ✓ Environment and Management --> reduces hybrid differences
  - ✓ Biological system (cow) --> compresses hybrid differences
  - ✓ Economic differences --> difficult to realize on-farm
  - ✓ Little hybrid feeding data to support estimates and measures of forage quality

Why Use Milk Per Acre and Milk Per Ton to Rank Corn Hybrid Performance?

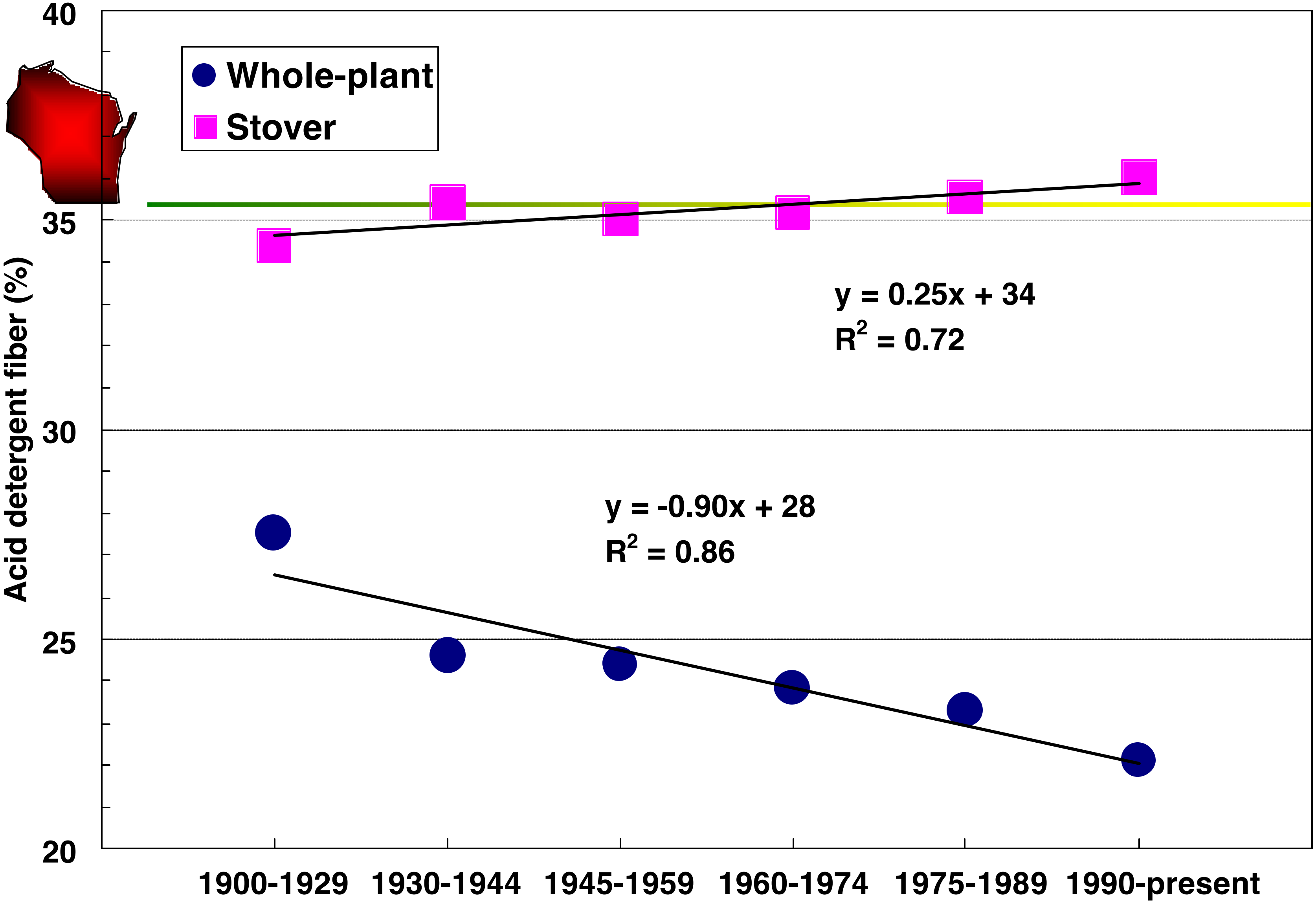
- The objective of feeding forages is to provide energy to animals. How do we estimate energy (quality)?
  - ✓ late 1800's: Proximate analysis -->TDN - overestimates energy
  - ✓ 1960's: Fiber analysis --> ADF and NDF - NE_L
  - ✓ 1970's: Digestibility, Intake --> RFV - Grasses v Legumes
  - ✓ 1990's: Digestibility, Intake, Yield --> MILK95
  - ✓ Next step: Digestibility kinetics
- Two perspectives
  - ✓ Nutritionist (ration balancing): interested in forage quality
  - ✓ Producer (farm system): interested in both yield and quality
- In most crops, there is a trade-off for yield and quality. Difficult to breed for both.



Relationship between corn forage crude protein concentration and era of release for whole-plant and stover.



Relationship between corn forage neutral detergent fiber concentration and era of release for whole-plant and stover.



Relationship between corn forage acid detergent fiber concentration and era of release for whole-plant and stover.

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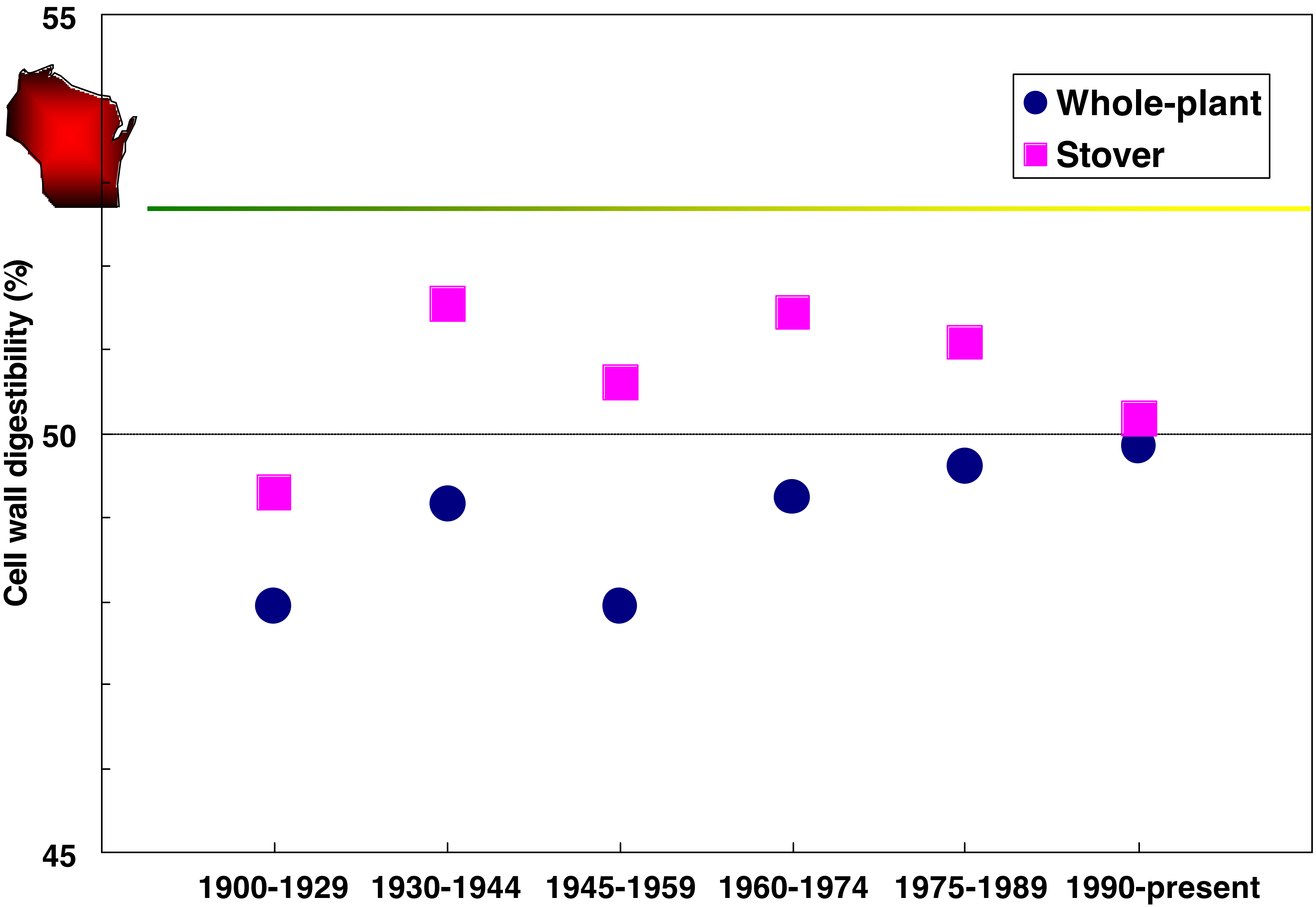
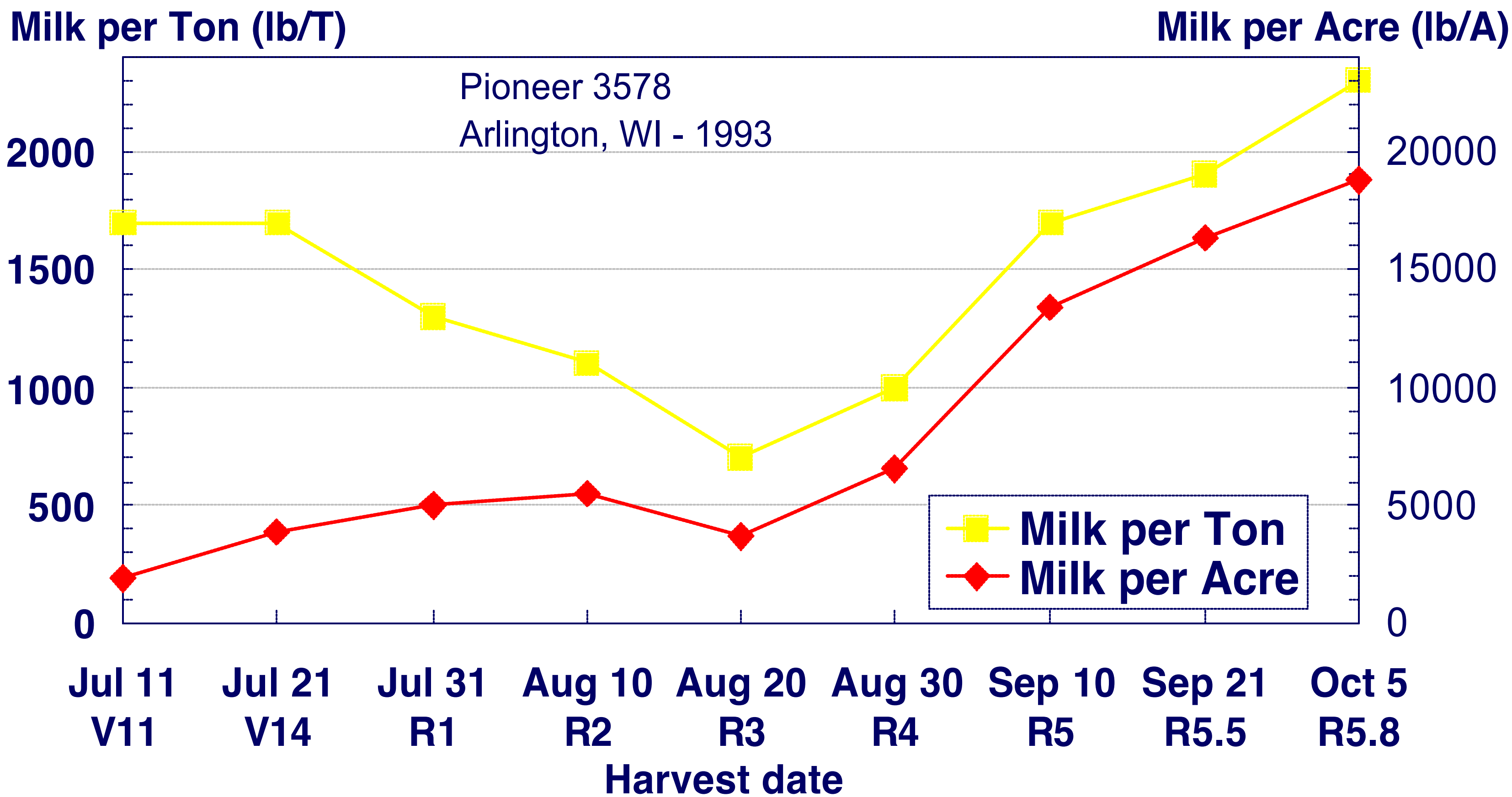


Relationship between corn forage cell wall digestibility and era of release for whole-plant and stover.

Summary

- There is a good relationship between NIRS and wet lab techniques for estimating corn silage CP, ADF NDF and IVD.
- Average range around the trial mean (n = 85) between high and low ranking hybrids is 37% for yield, 26% for Milk per Ton and 45% for Milk per Acre
- Repeatable differences among corn hybrids are observed for silage yield and quality.

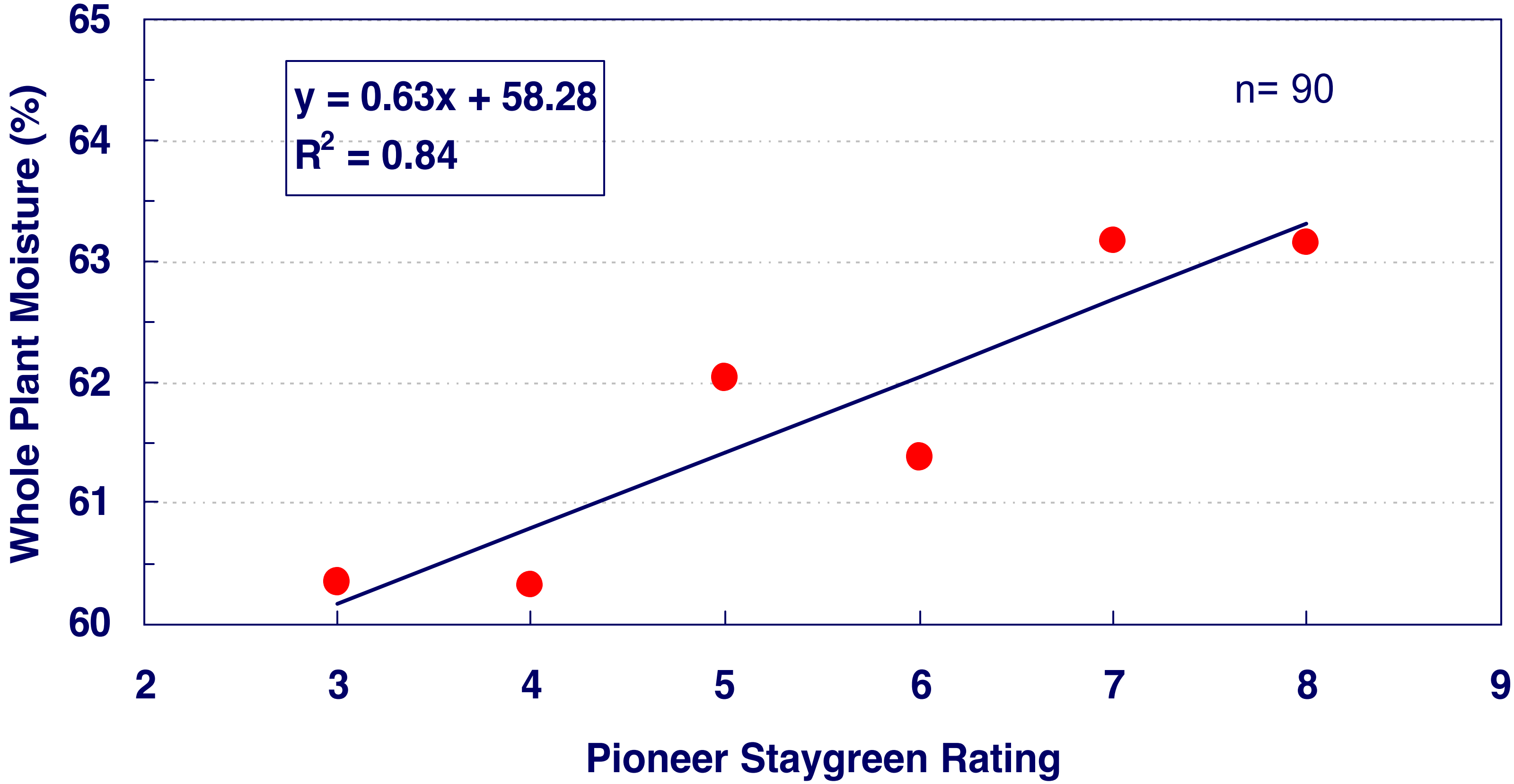
Corn Silage Yield and Quality Changes During Development



Summary

- Poor relationship between whole plant silage moisture and kernel milk stage.
- Whole plant moistures vary from 50 to 74% at 1/2 kernel milk stage.
- No obvious relationship for year, location or hybrid.
  - ✓ Of 56 hybrids with five or more testing environments, only 10 (18%) of the hybrids had $R^2 > 0.75$.
- Use kernel milk stage as a “trigger” to start checking moisture. Once moisture is known, use 0.5% drydown rate as average during September. Retest prior to chopping.

Whole Plant Moisture v. Pioneer Staygreen Rating of Pioneer Hybrids Tested UW Trials (Normalized Data)



1999 Wisconsin Corn Performance Trials
Silage Summary

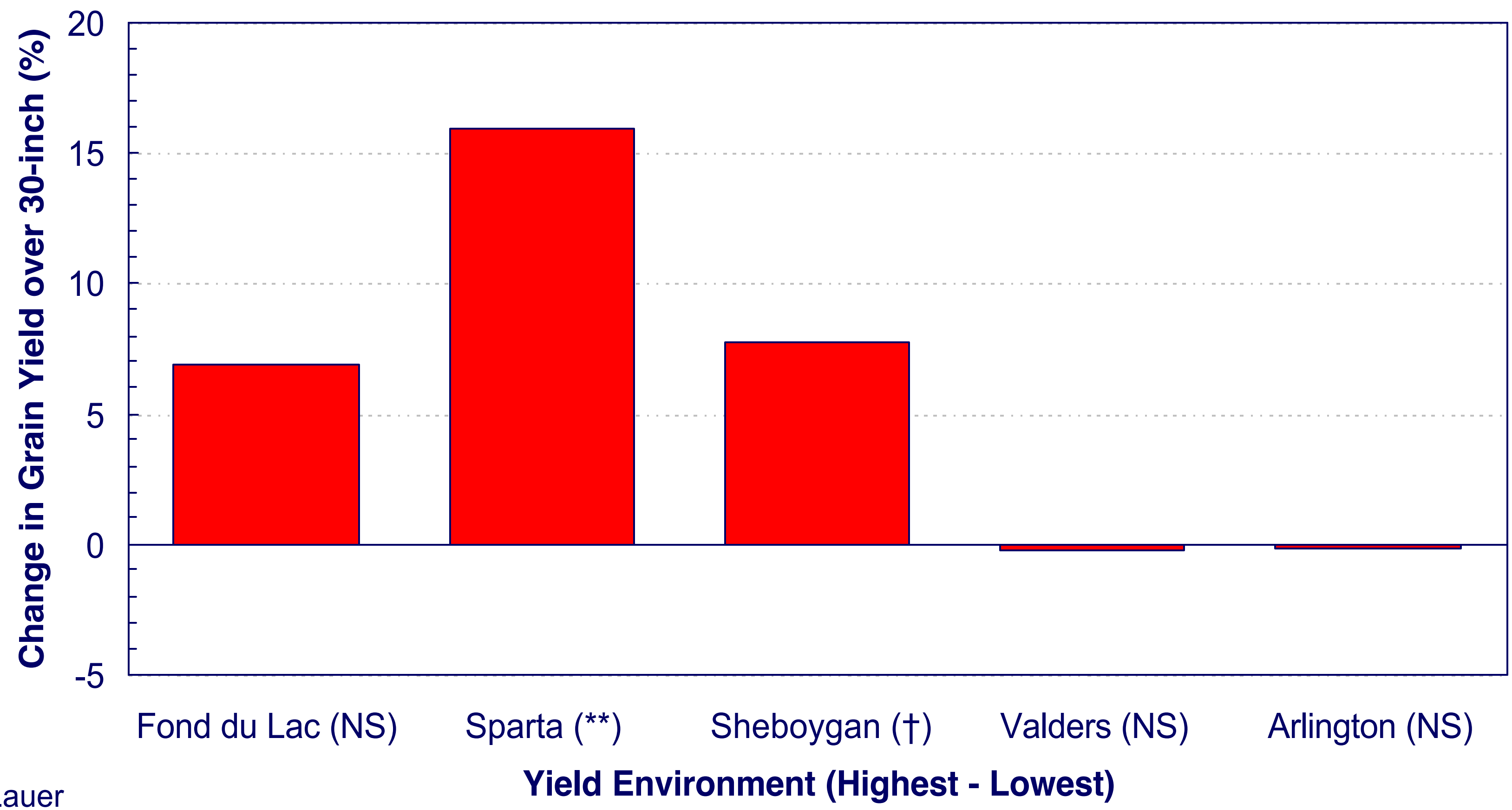
10.1
8.9

9.8
8.1

7.5
8.0

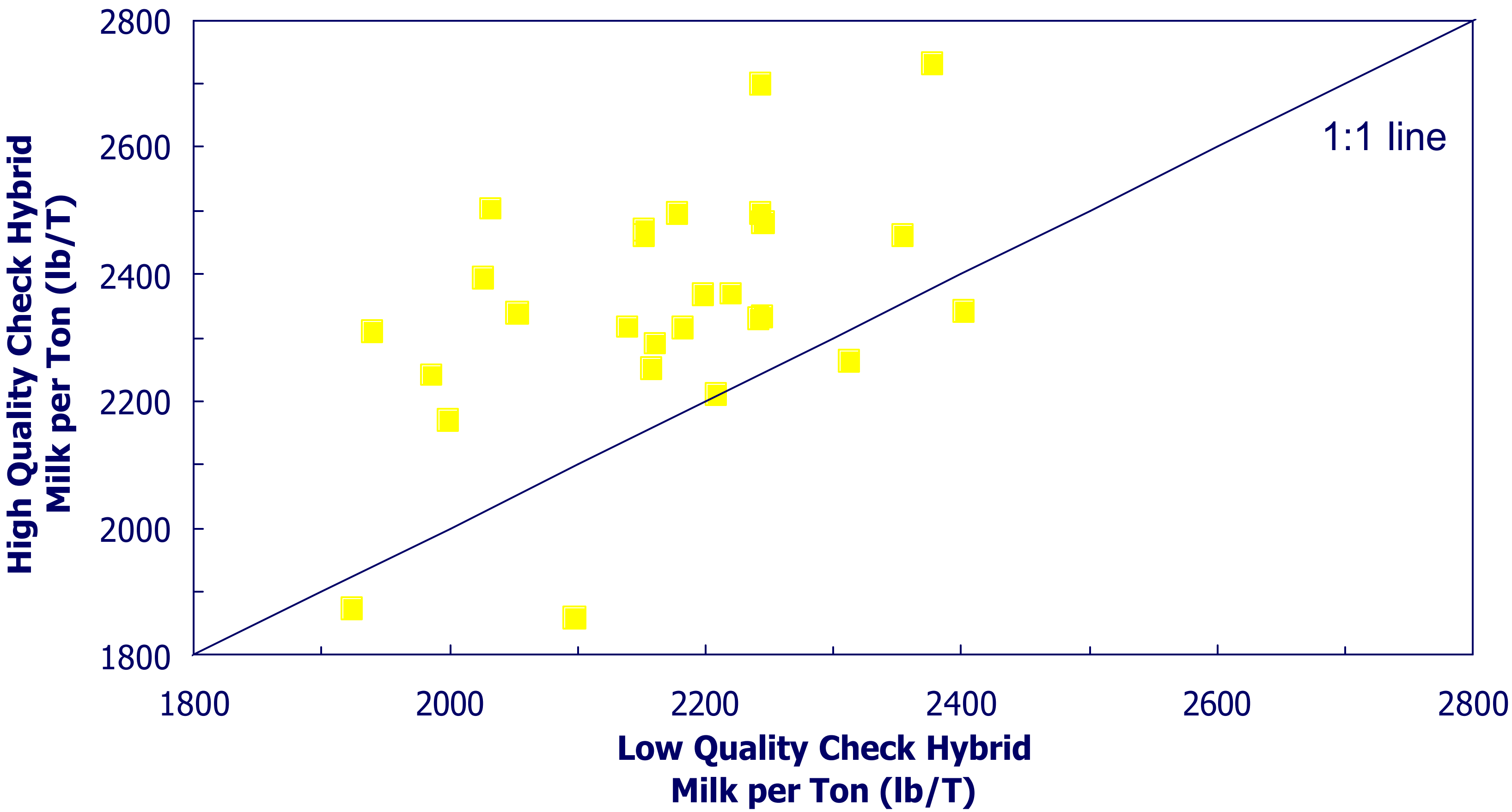
8.0

Corn Silage Yield Response to Row Spacing in Wisconsin (1997-1999)



Lauer

Rank Repeatability of High and Low Quality Corn Silage Check Hybrids in Wisconsin (1995 to 1997)

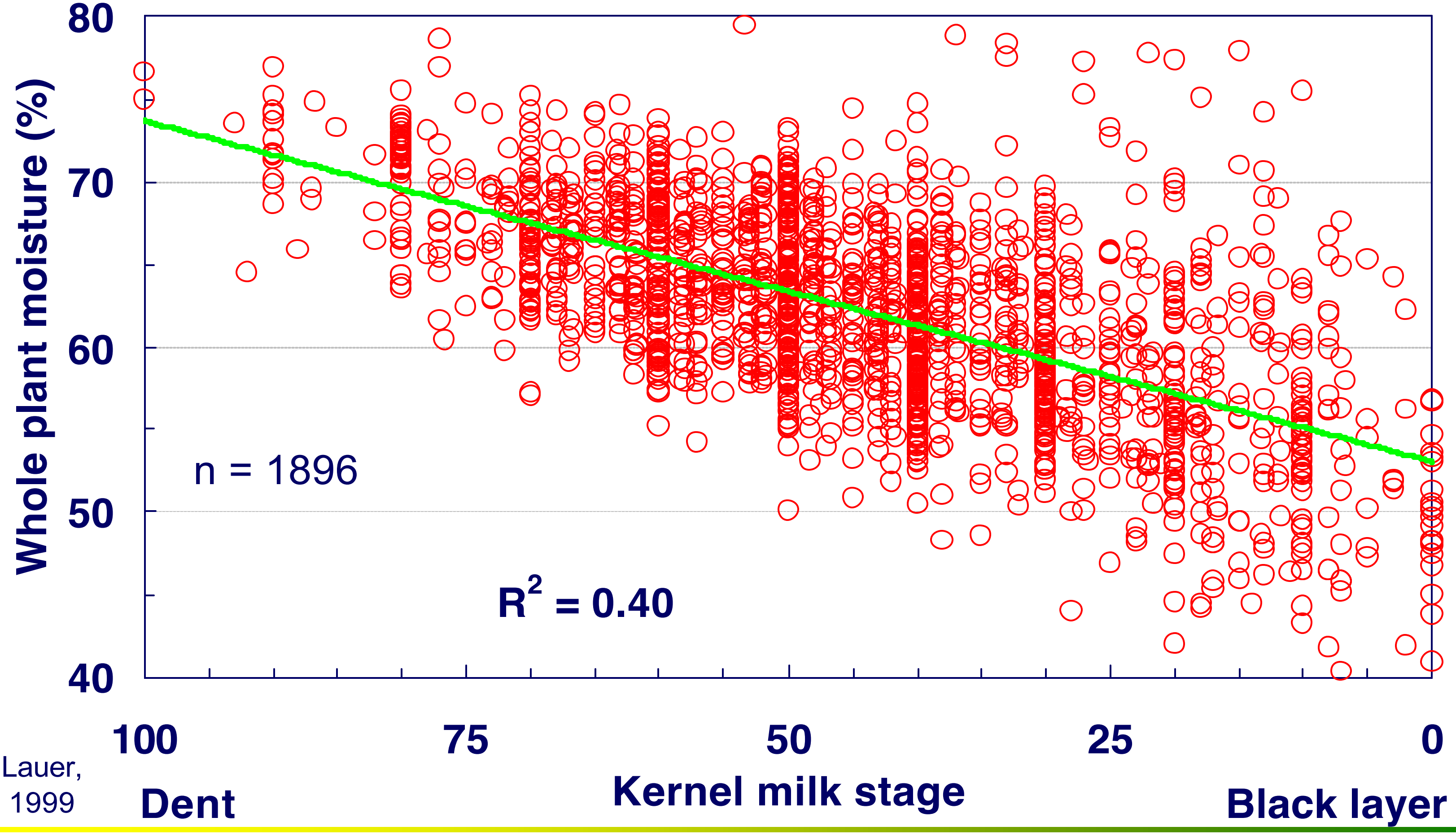


Using Wisconsin Corn Hybrid Performance Trial Results

- Use multi-environment average data
  - ✓ Begin with trials in zone(s) nearest you
  - ✓ Compare hybrids with similar maturities
  - ✓ Use many years and locations
- Evaluate consistency of performance
  - ✓ Check performance in other zones and locations
  - ✓ Check other reliable unbiased trials
  - ✓ Be wary of inconsistent performance.
- SELECT at http://corn.agronomy.wisc.edu
- *You are taking a tremendous gamble if basing your hybrid selection decisions on 1 or 2 local test plots*

1999

Relationship between forage moisture and kernel milk stage (1990 - 1999)



Lauer, 1999

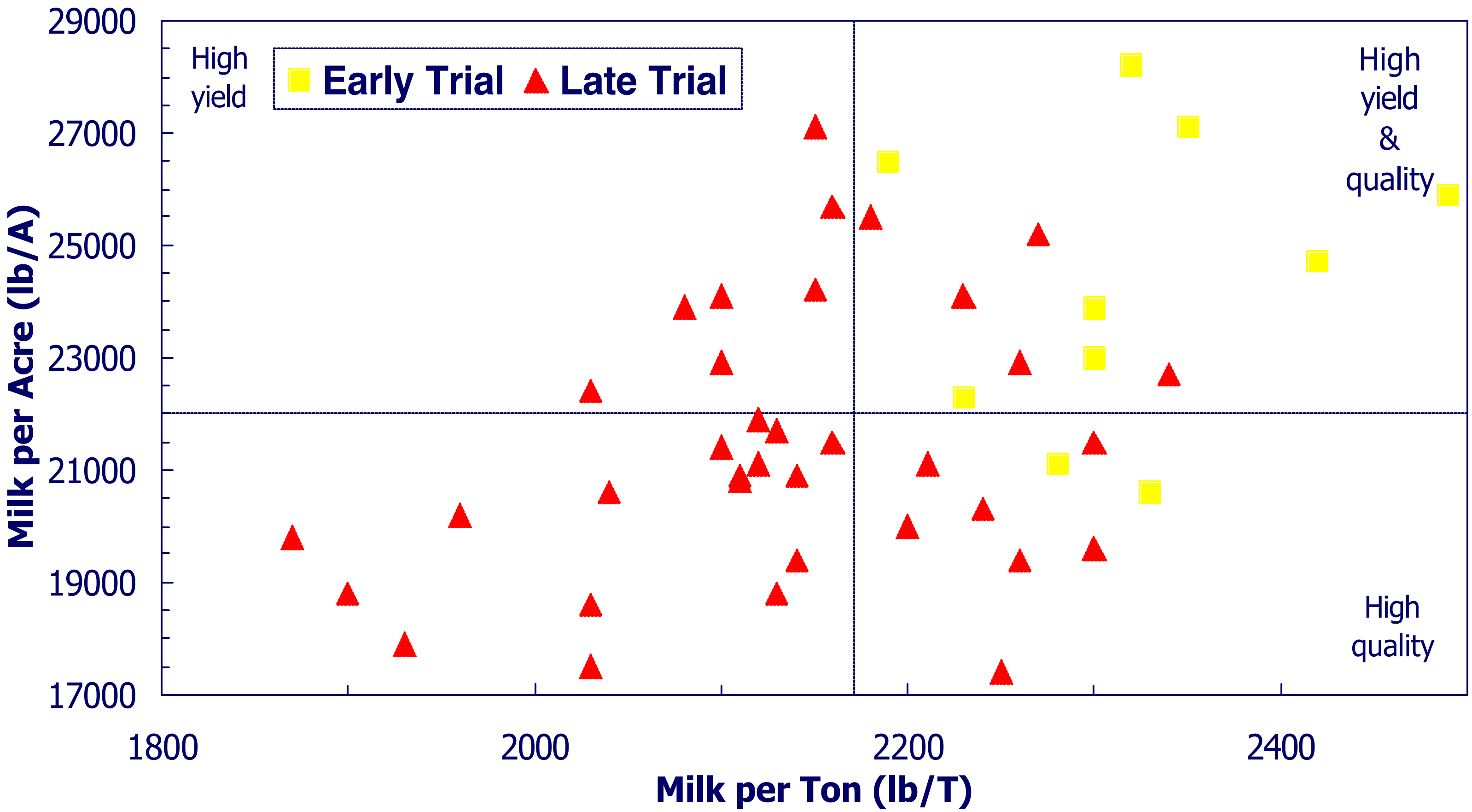
Top 10 Corn Hybrid Silage Yields in Southern Production Zones of Wisconsin during 1999

Top 10 Corn Hybrid Silage Yields in Northern Production Zones of Wisconsin during 1999

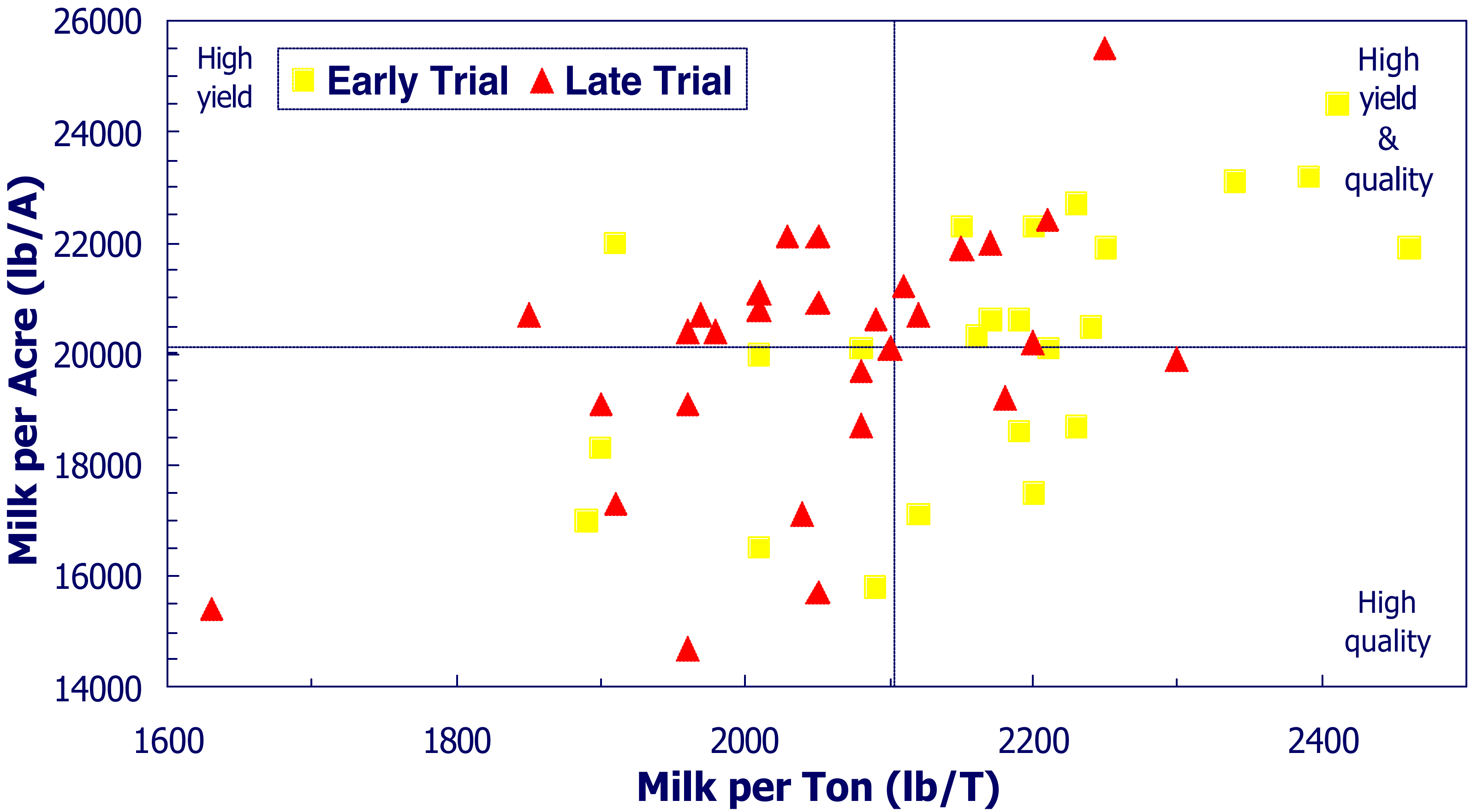
All Time Top 10 Corn Hybrid Silage Yield Performances at a Wisconsin location (1990 to 1999)

1998

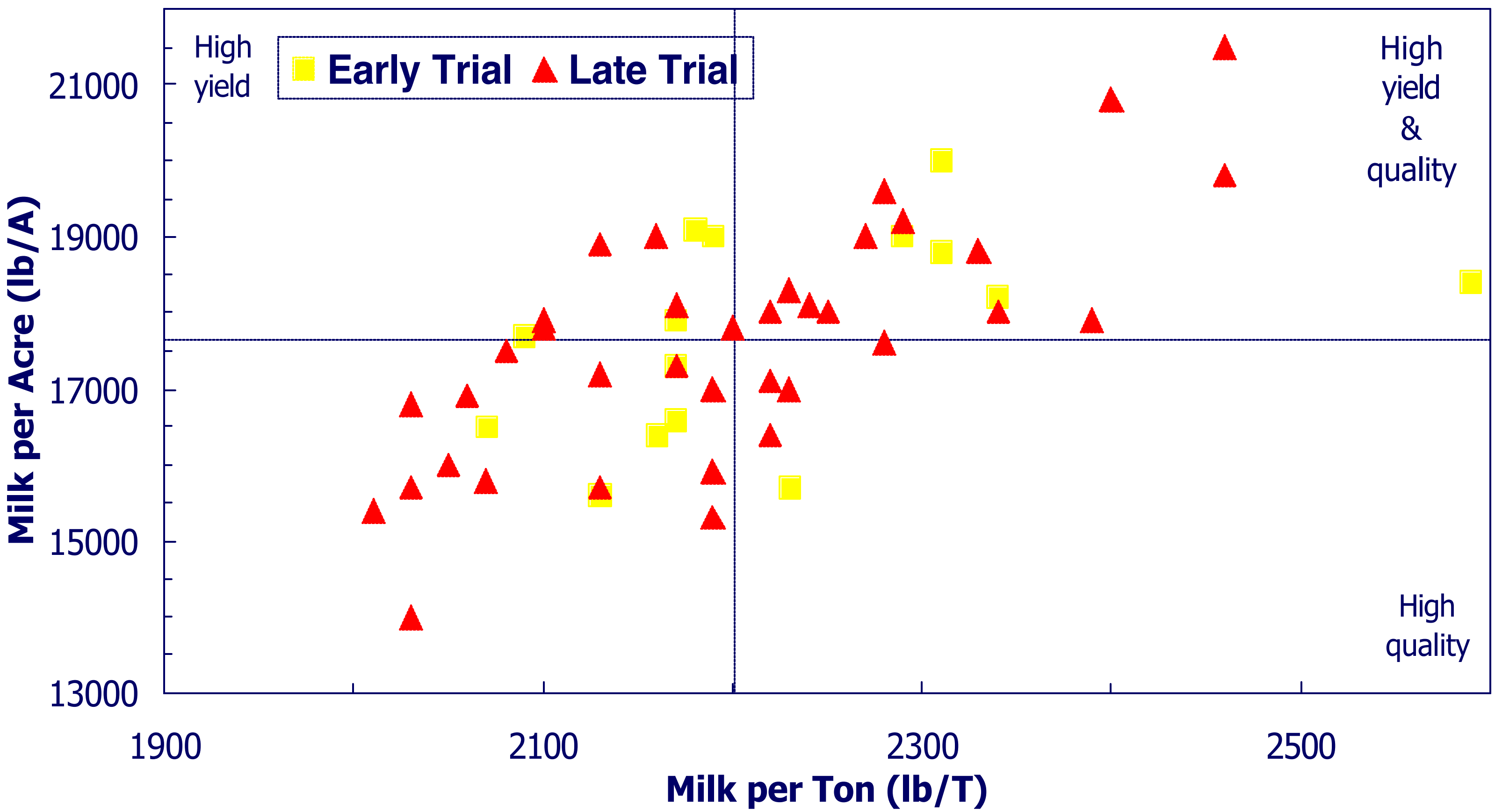
Corn Hybrid Silage Performance in the Southern Production Zone of Wisconsin During 1998



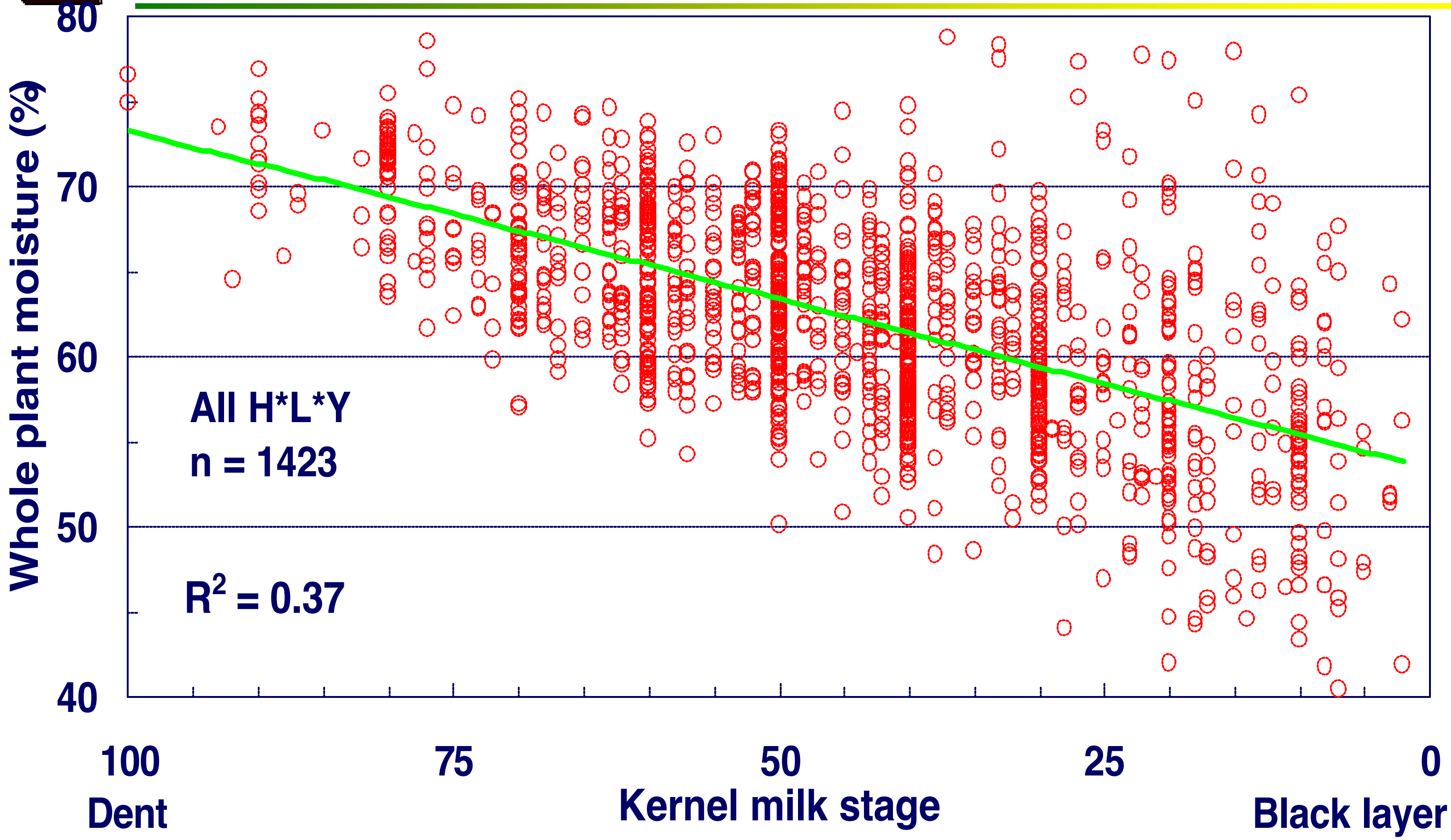
Corn Hybrid Silage Performance in the South Central Production Zone of Wisconsin During 1998



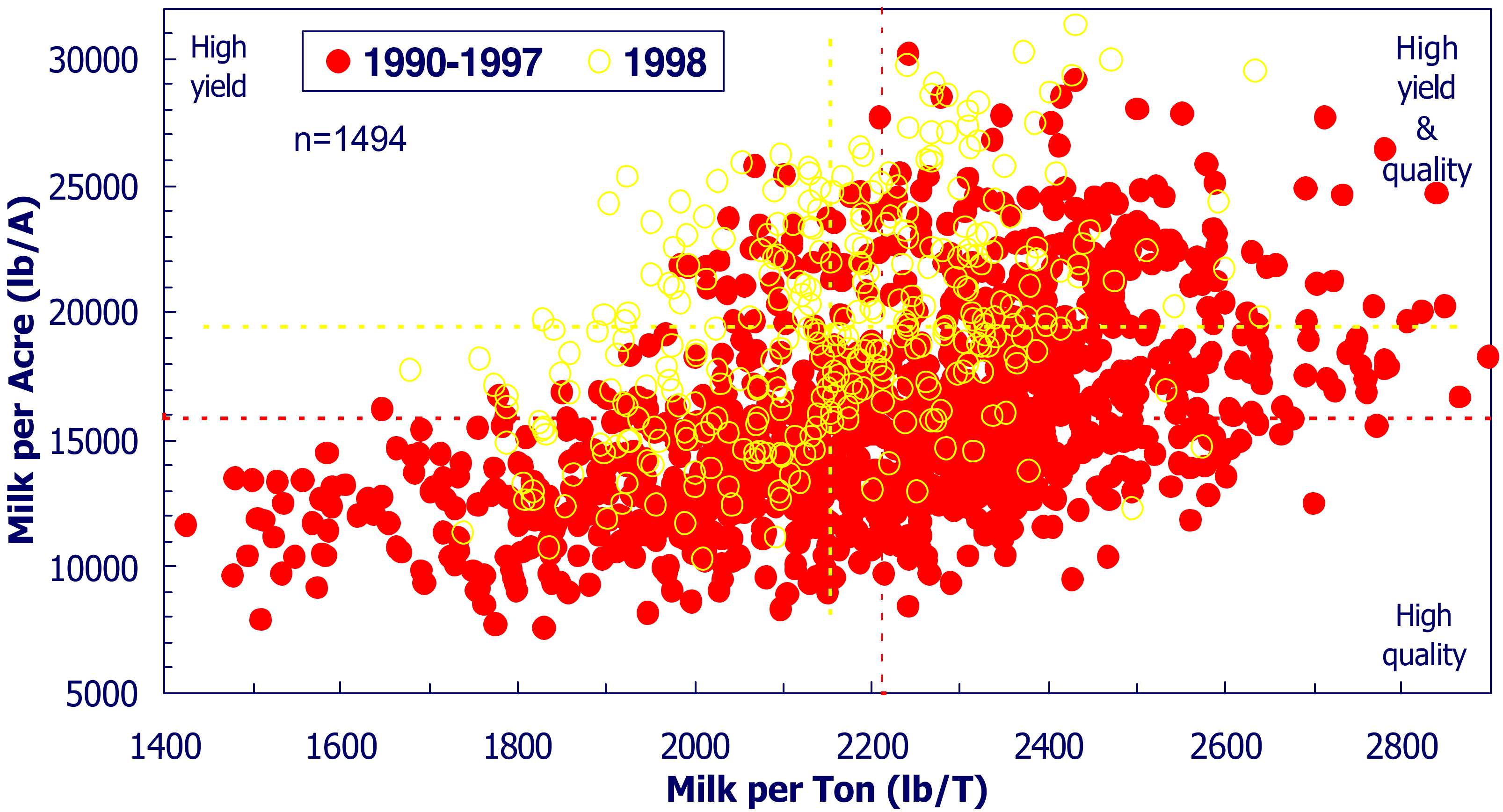
Corn Hybrid Silage Performance in the North Central Production Zone of Wisconsin During 1998



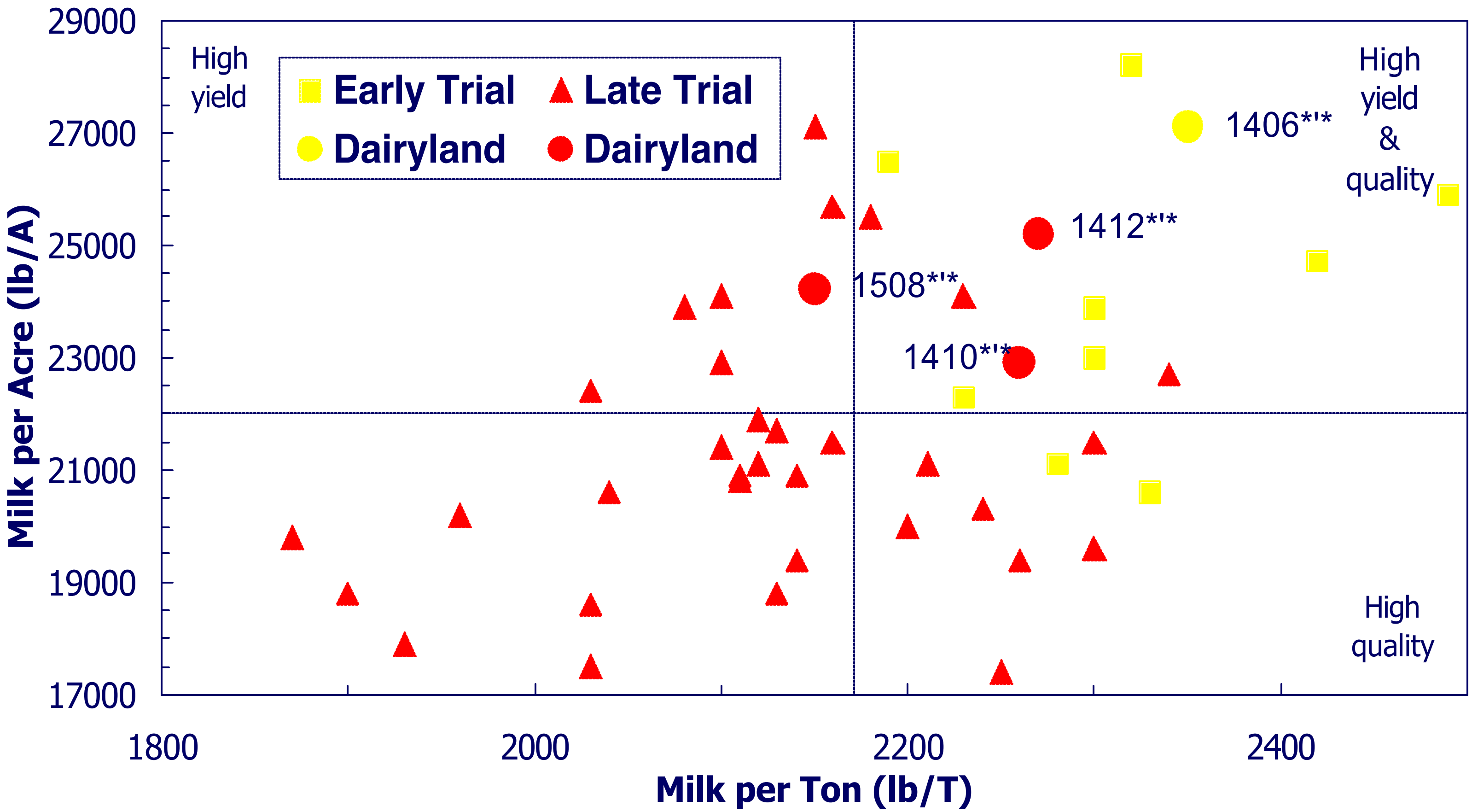
Relationship between whole plant moisture and kernel milk stage (1990 - 1998)



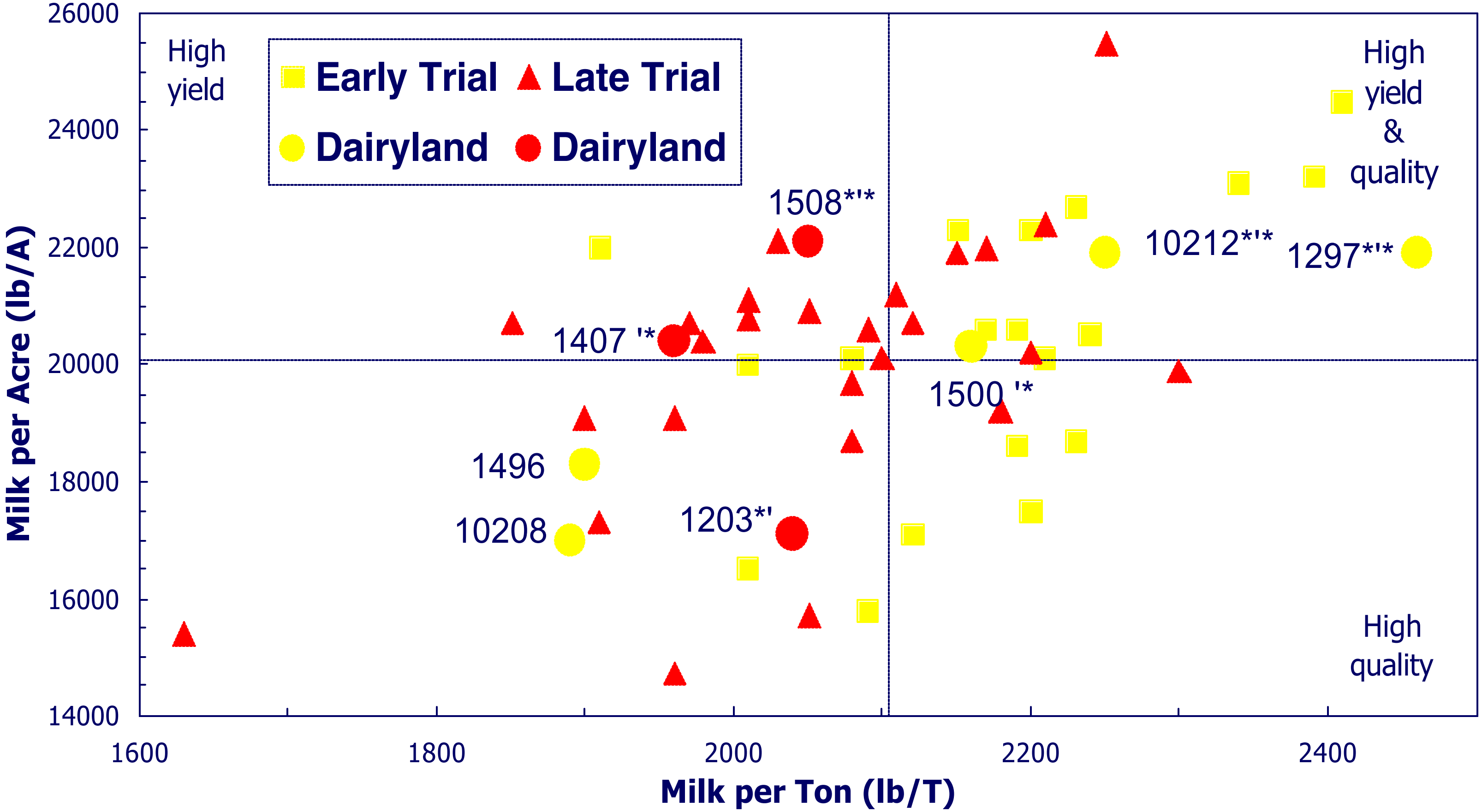
Corn Hybrid Silage Yield and Quality During 1998 Compared to 1990-1997 in Wisconsin



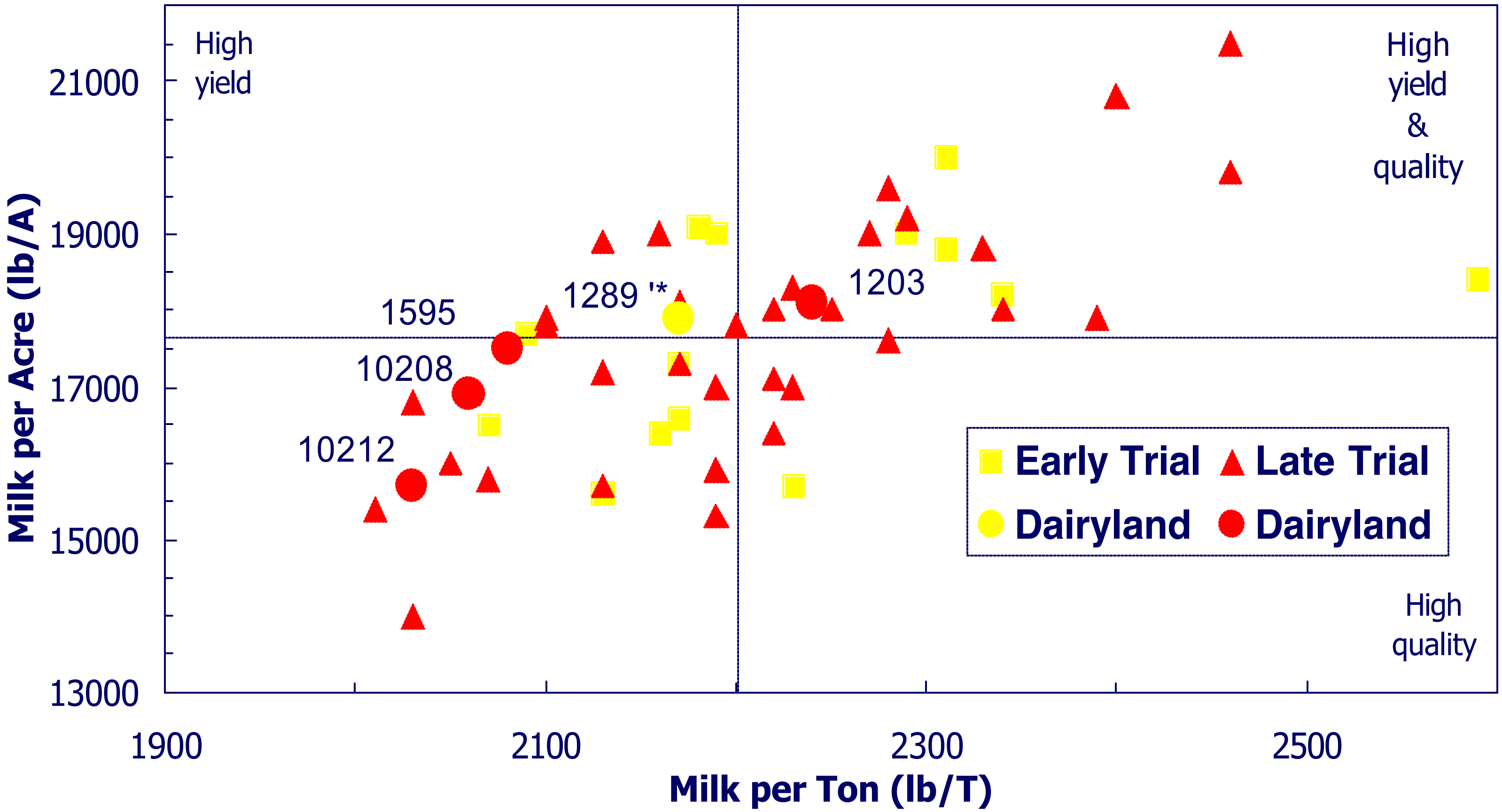
Corn Hybrid Silage Performance in the Southern Production Zone of Wisconsin During 1998



Corn Hybrid Silage Performance in the South Central Production Zone of Wisconsin During 1998



Corn Hybrid Silage Performance in the North Central Production Zone of Wisconsin During 1998



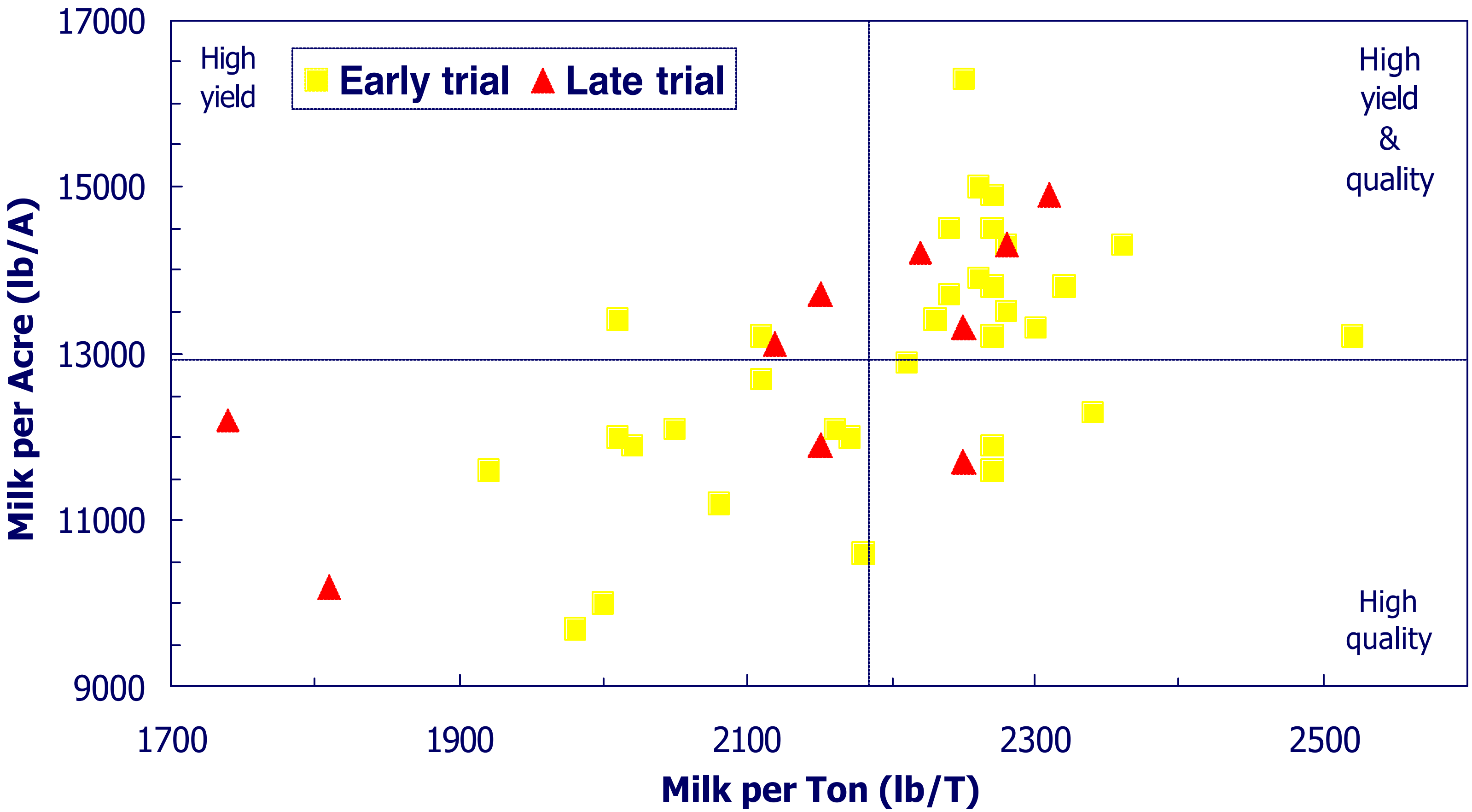
1997

TABLE 14. SOUTH CENTRAL ZONE - SILAGE LATE MATURITY TRIAL

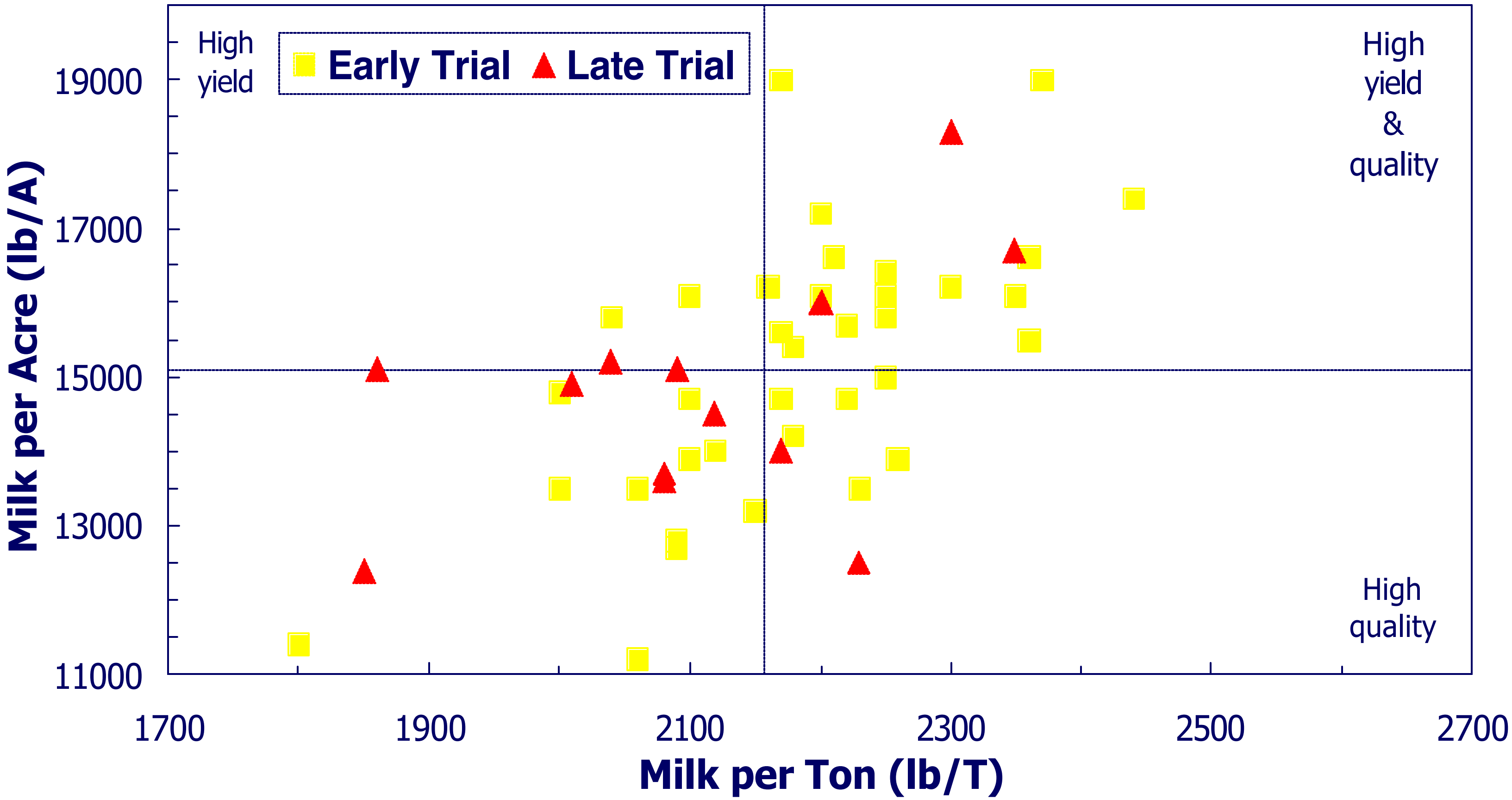
ND DU LA

AVERAGE									
Yield	Moist	Kernel Milk	CP	ADF	NDF	IVD	CWD	MILK PER	
T/A	%	%	%	%	%	%	%	TON	ACRE
7.0	66.6	60	7.4	21	41	80	52	2350 *	16700 *
6.6	67.3	60	7.4	23	46	79	55	2080	13600
6.6	68.1	60	7.3	22	45	80	56	2170 *	14000
7.3 *	68.4	60	7.2	22	44	80	54	2200 *	16000 *
7.2 *	68.9	60	7.6	23	46	79	54	2090	15100
7.5 *	69.4	70	7.1	24	47	79	55	2040	15200
6.5	69.5	70	7.4	23	46	79	53	2080	13700
8.0 *	69.7	60	7.1	22	43	81	55	2300 *	18300 *
6.7	70.1	80	7.2	23	45	79	52	2120	14500
8.1 *	70.1	80	7.3	26	49	78	55	1860	15100
7.3 *	71.2	80	7.2	24	46	78	53	2010	14900
7.2 *	71.4	70	7.9	24	45	79	53	2090	15100
6.6	73.8	80	8.2	25	48	77	53	1850	12400
5.5	75.6	70	7.7	24	47	82	63	2230 *	12500
7.0	70.0	70	7.4	23	46	79	54	2100	14800
1.0	2.2	10	0.3	2	3	2	2	210	2400

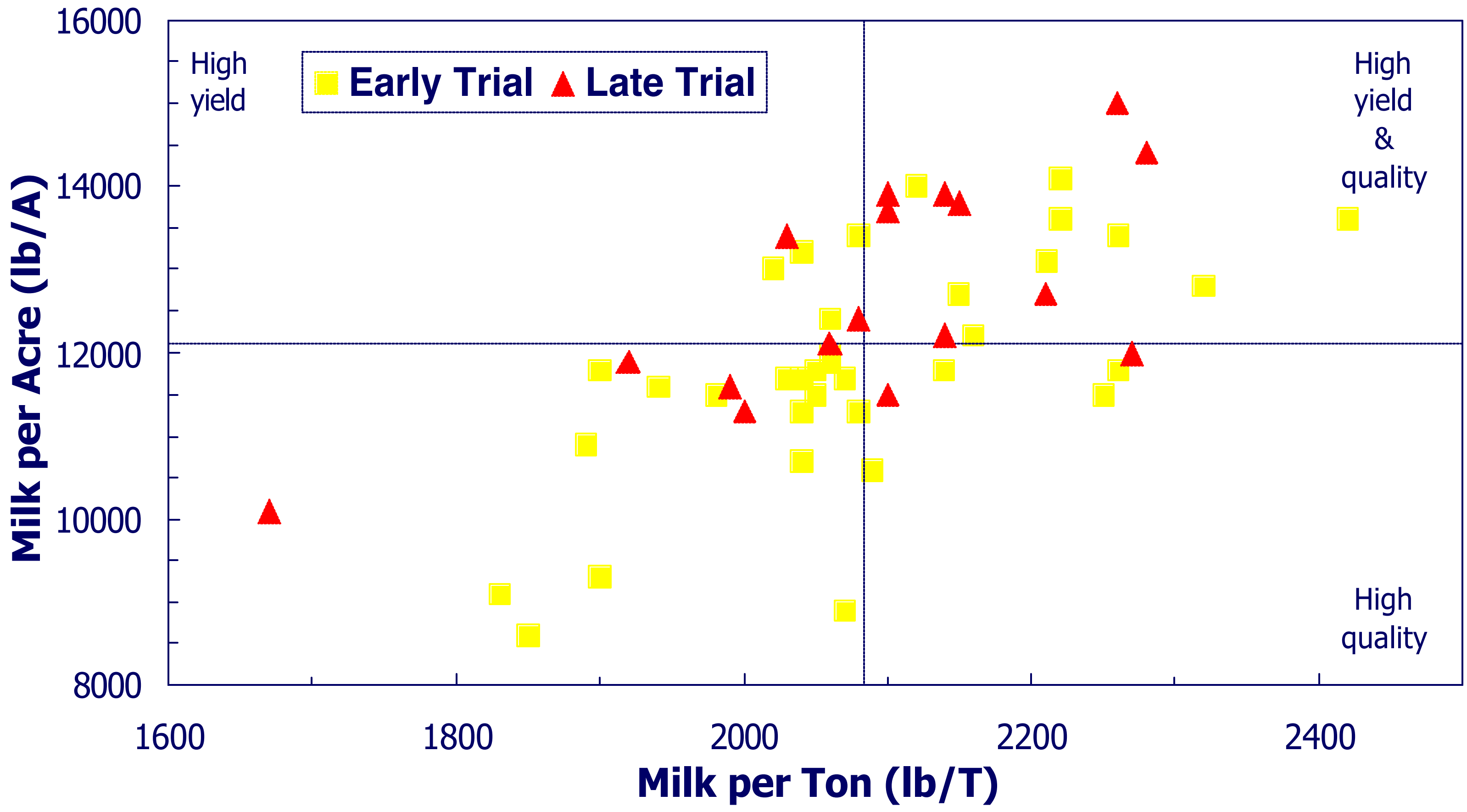
Corn hybrid silage performance in the southern production zone of Wisconsin during 1997



Corn hybrid silage performance in the south central production zone of Wisconsin during 1997



Corn hybrid silage performance in the north central production zone of Wisconsin during 1997



COORS

Repeatability of Whole Plant and Stover Silage Quality Traits (derived from Coors et al., 1995)

Conclusions from UW Corn Silage Research Consortium (Coors et al., 1995)

- Ranking among corn hybrids for silage yield and quality is repeatable.
- Range among commercial WI hybrids for silage NDF and digestibility is narrow.
- Highest grain yielding hybrids are not necessarily the highest silage yielding hybrids.
- High grain-to-stover ratios do not necessarily improve silage quality, but are desired to insure adequate fermentation and preservation

BMR

History of Brown Midrib Corn

- First discovered in dent corn at St. Paul, MN in 1924
  - ✓ bm1 (Jorgenson, 1931)
  - ✓ bm2 (Burnham and Brink, 1932)
  - ✓ bm3 (Emerson et al., 1935)
  - ✓ bm4 (Burnham, 1947)
- Corn plants exhibit a reddish-brown pigmentation of the leaf midrib at V4 to V6. Also seen in rind and pith. Coloring eventually disappears on leaves, but remains in the stalk.
- Also found in sorghum, sudangrass, and pearl millet.

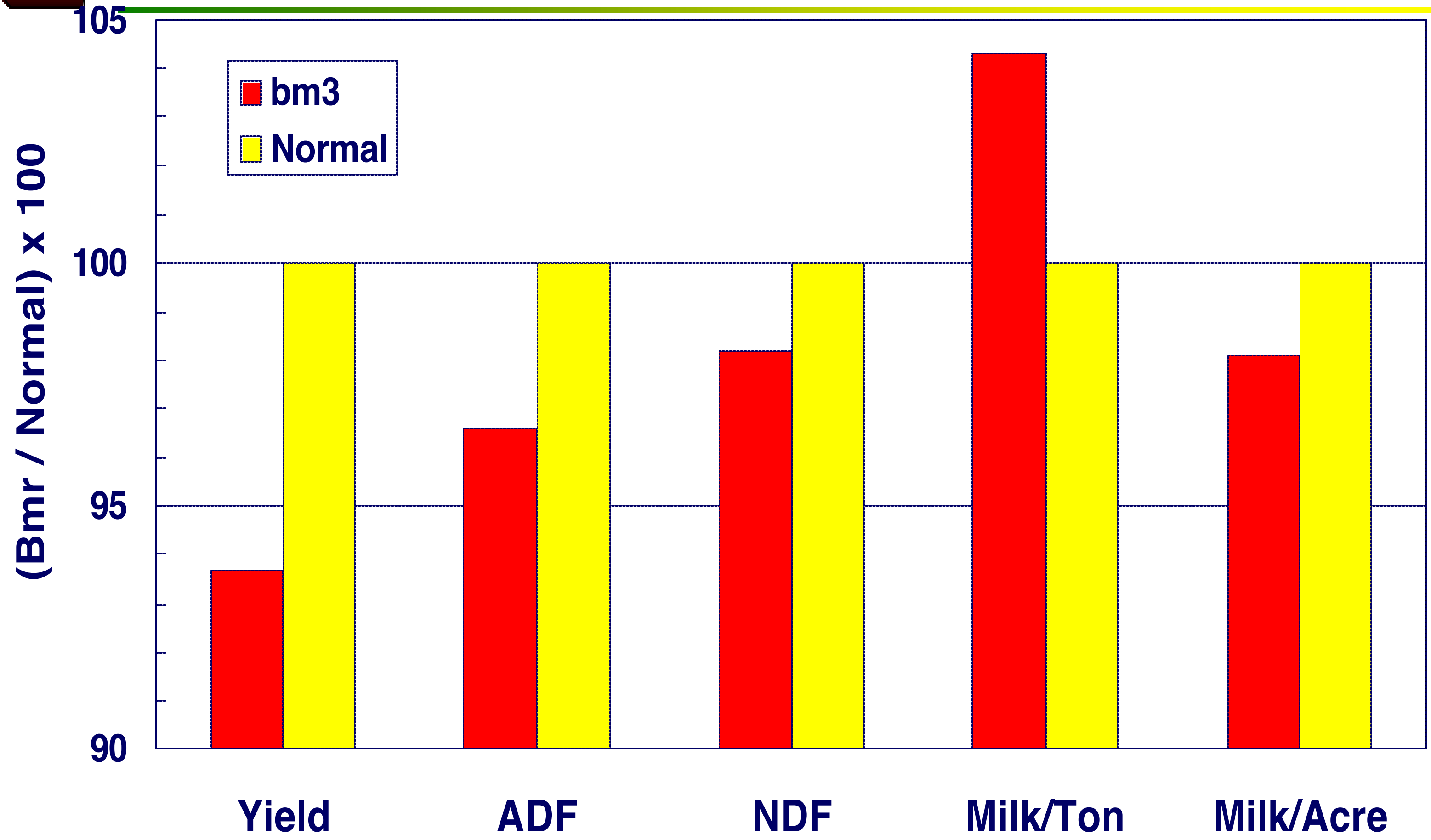
History of Brown Midrib Corn

- About 40 years after their discovery, the bmr mutations were found to have a drastic effect on lignin (Lechtenberg et al., 1972) and that digestibility was improved in ruminants:
  - ✓ sheep: Muller et al., 1972
  - ✓ goats: Gallais et al., 1980
  - ✓ heifer cattle: Colenbrander et al., 1972, 1973, 1975
  - ✓ beef cattle: Keith, 1981
  - ✓ dairy cows: Frenchick et al., 1976

History of Brown Midrib Corn

- In the U.S. results of feeding bmr corn are either inconclusive or trended slightly in favor. A significant increase in milk production was observed only once (Keith et al., 1979).
  - ✓ Increased body weight noted every time bmr was fed.
  - ✓ Energy intake was not limiting in these studies and it seems that extra nutrients digested in bmr corn are partitioned into meat or fat body tissues rather than milk.
- Feeding results from England (Weller and Phipps, 1986) and France (Hoden et al., 1985) indicate increased milk production.

Relative comparison of bm3 to normal corn



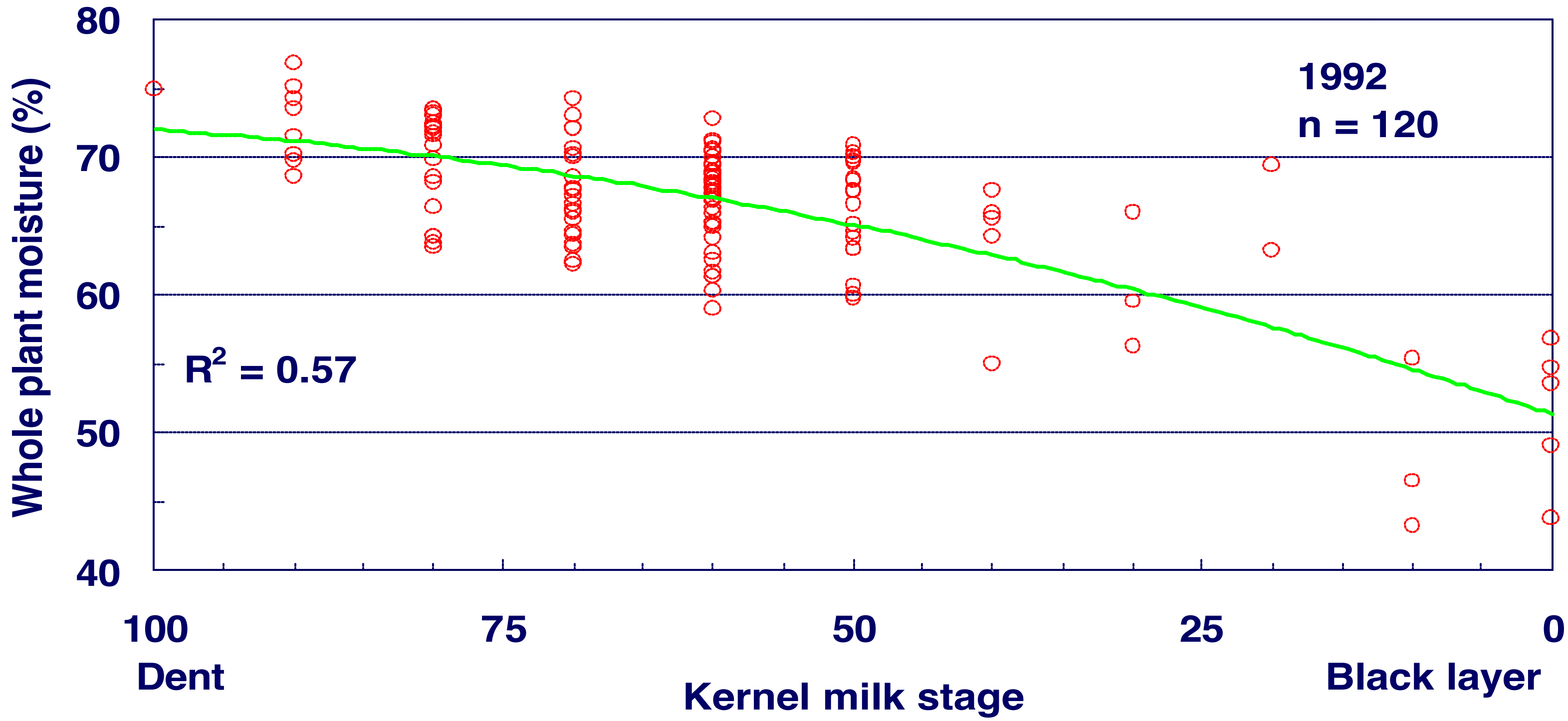
Brown Midrib compared to Dent Corn

- Advantages
  - ✓ Increased silage intake
  - ✓ Increased digestibility of stover
- Disadvantages
  - ✓ Lower yields
    - Whole plant silage
    - Grain
  - ✓ Susceptibility to lodging
  - ✓ Poor early season vigor
  - ✓ Delayed flowering
  - ✓ Slower early season growth rates

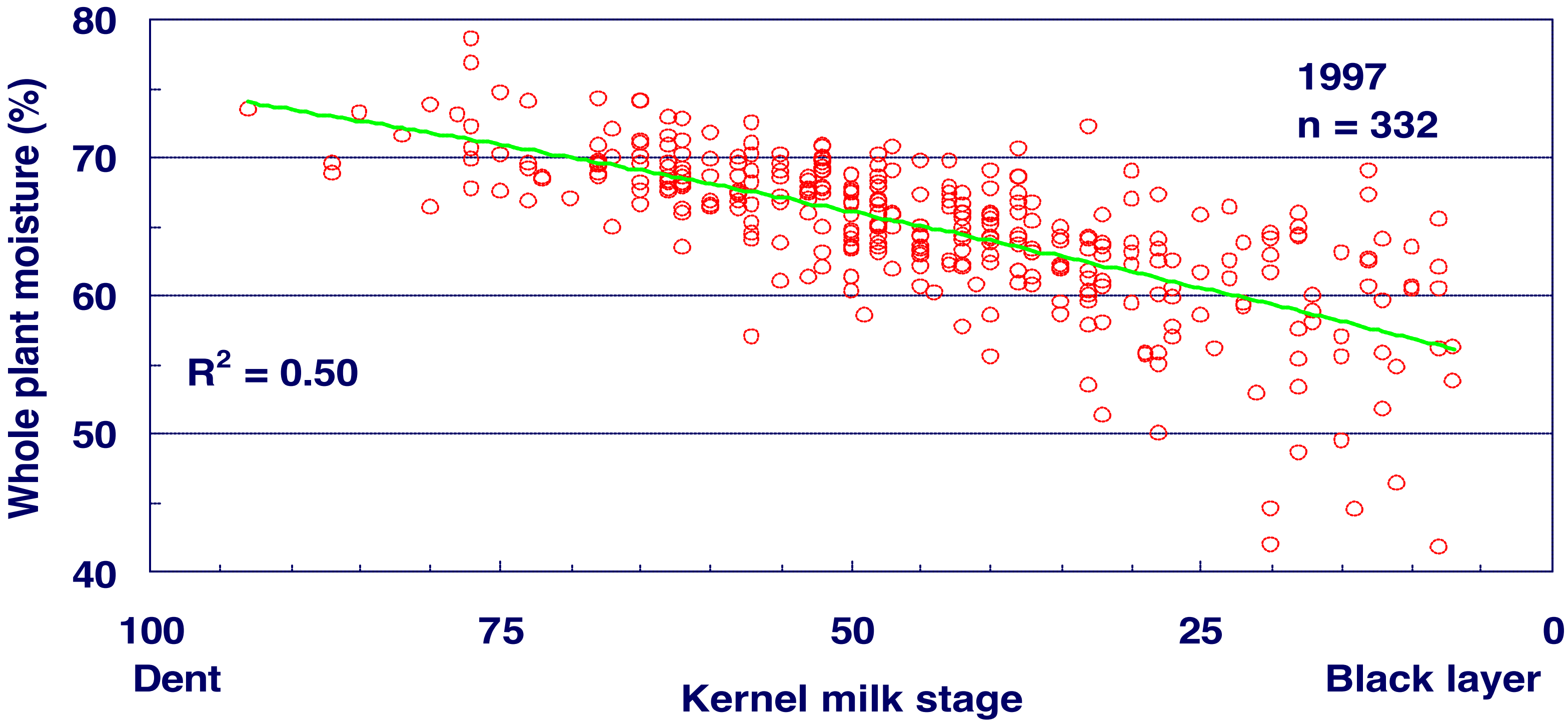
Relationship between kernel milk stage and silage yield and quality (derived from Wiersma et al., 1993)

Moisture v Milkline

Relationship between whole plant moisture and kernel milk stage



Relationship between whole plant moisture and kernel milk stage



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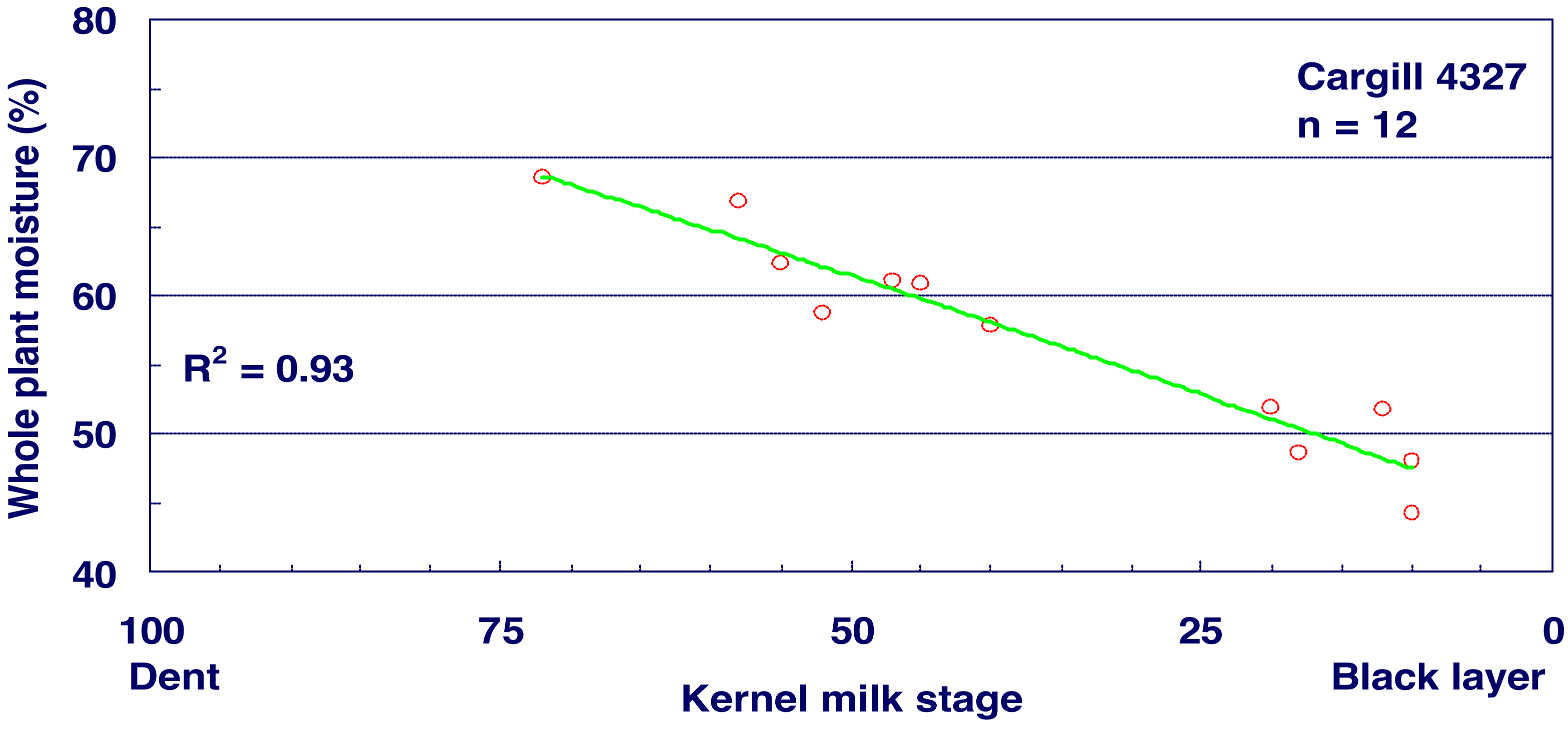
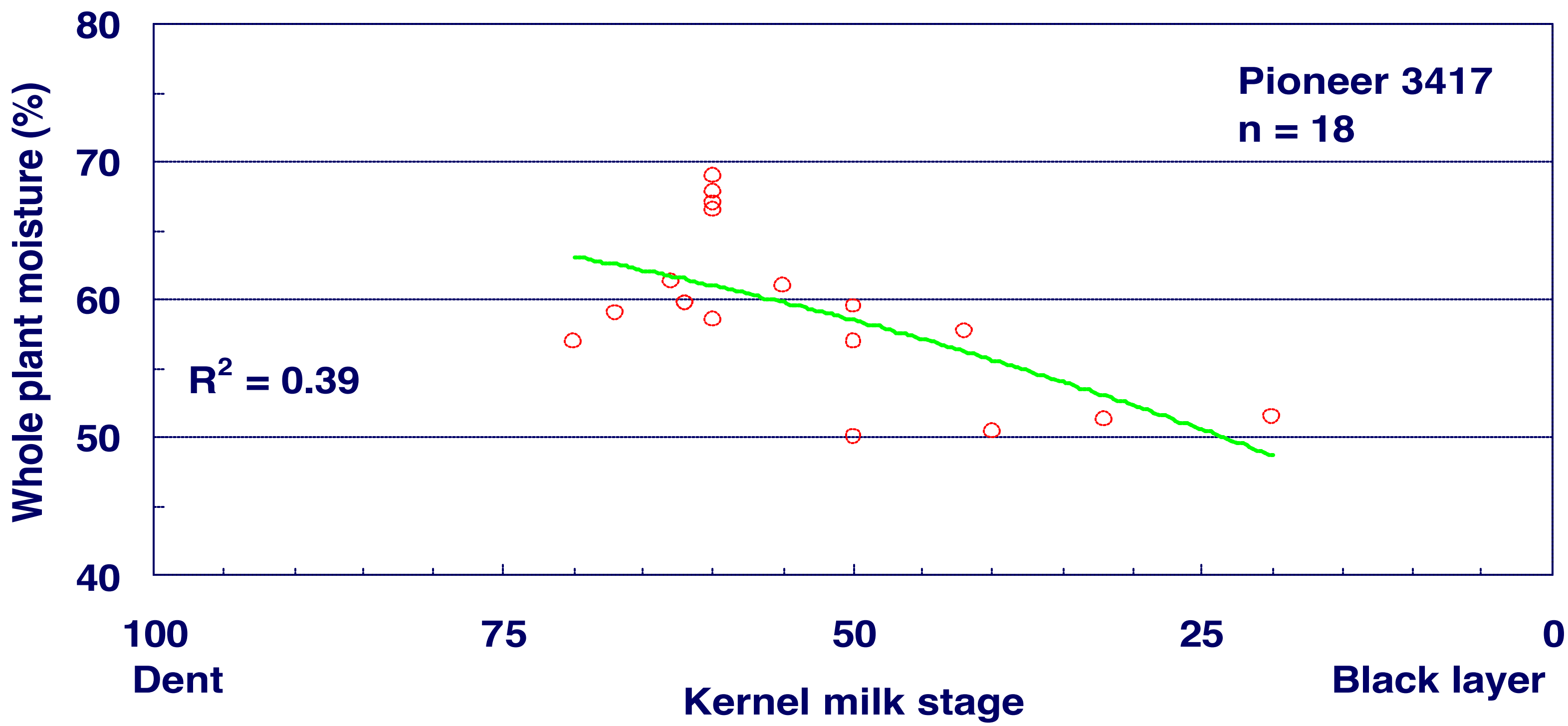
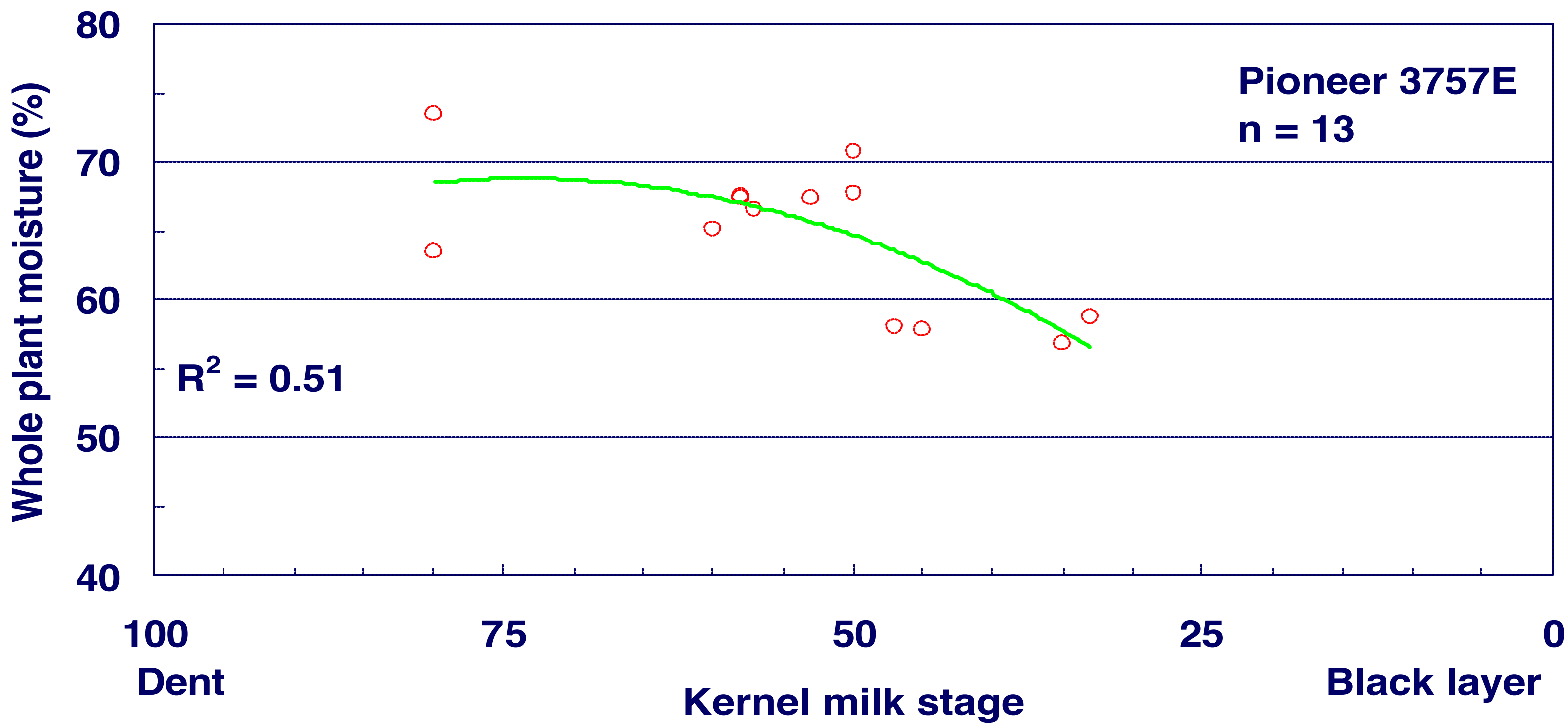


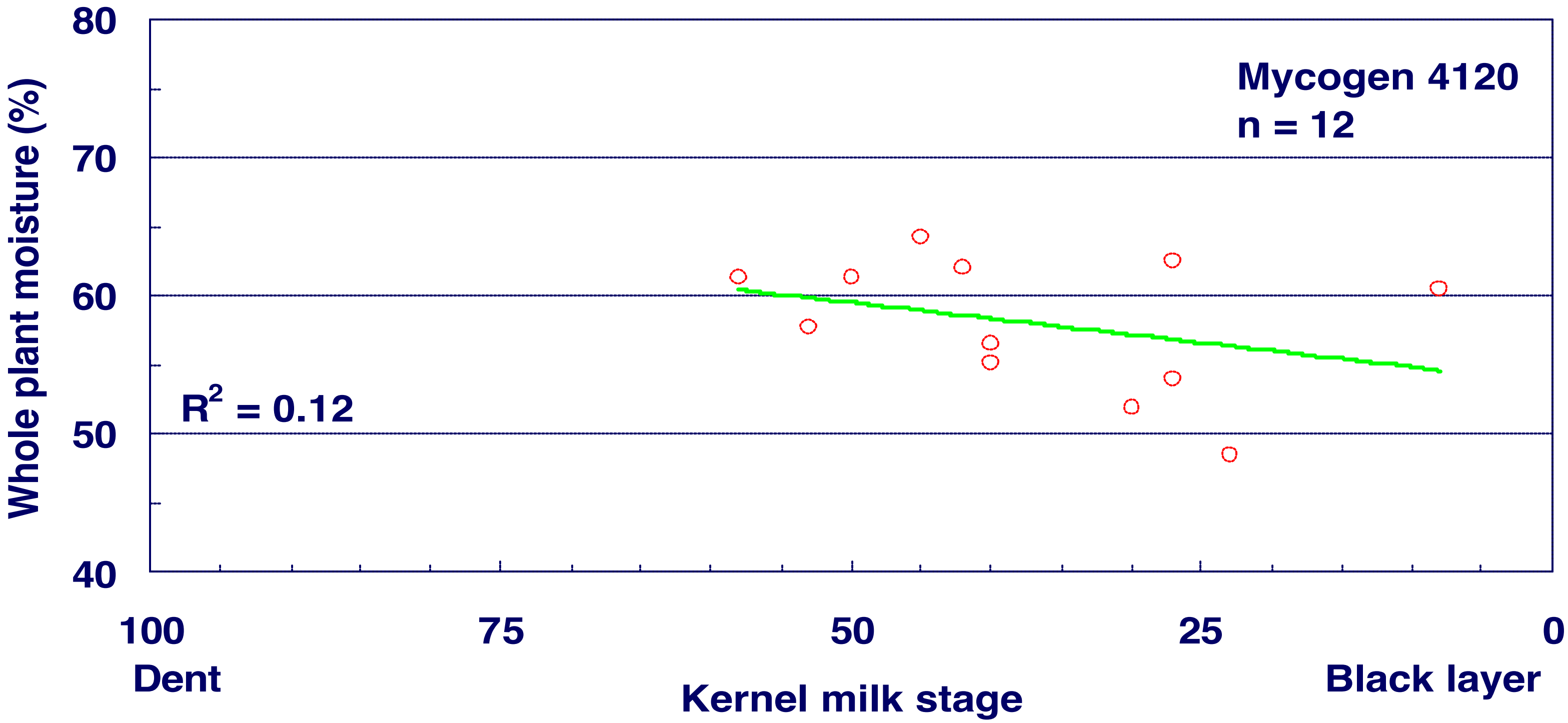
Relationship between whole plant moisture and kernel milk stage



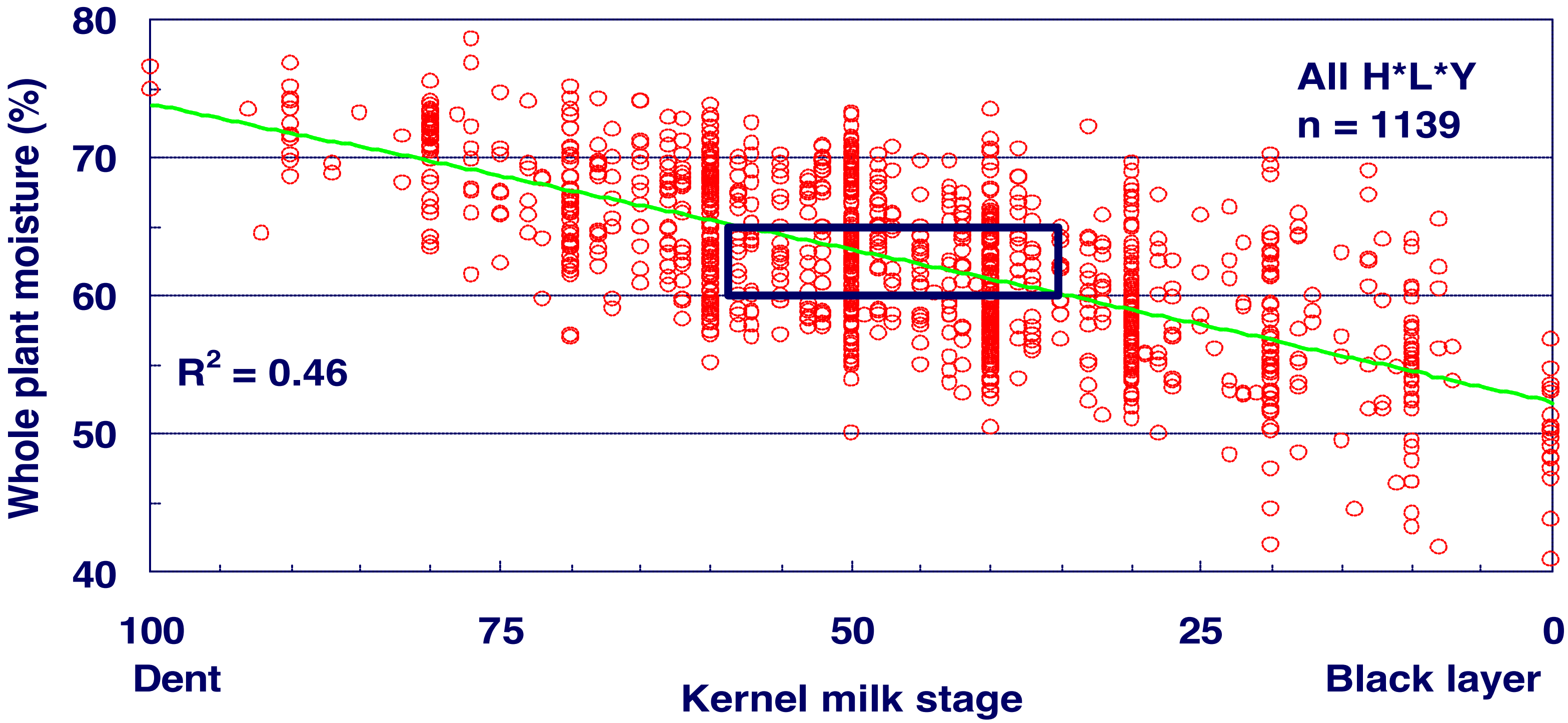
Relationship between whole plant moisture and kernel milk stage



Relationship between whole plant moisture and kernel milk stage



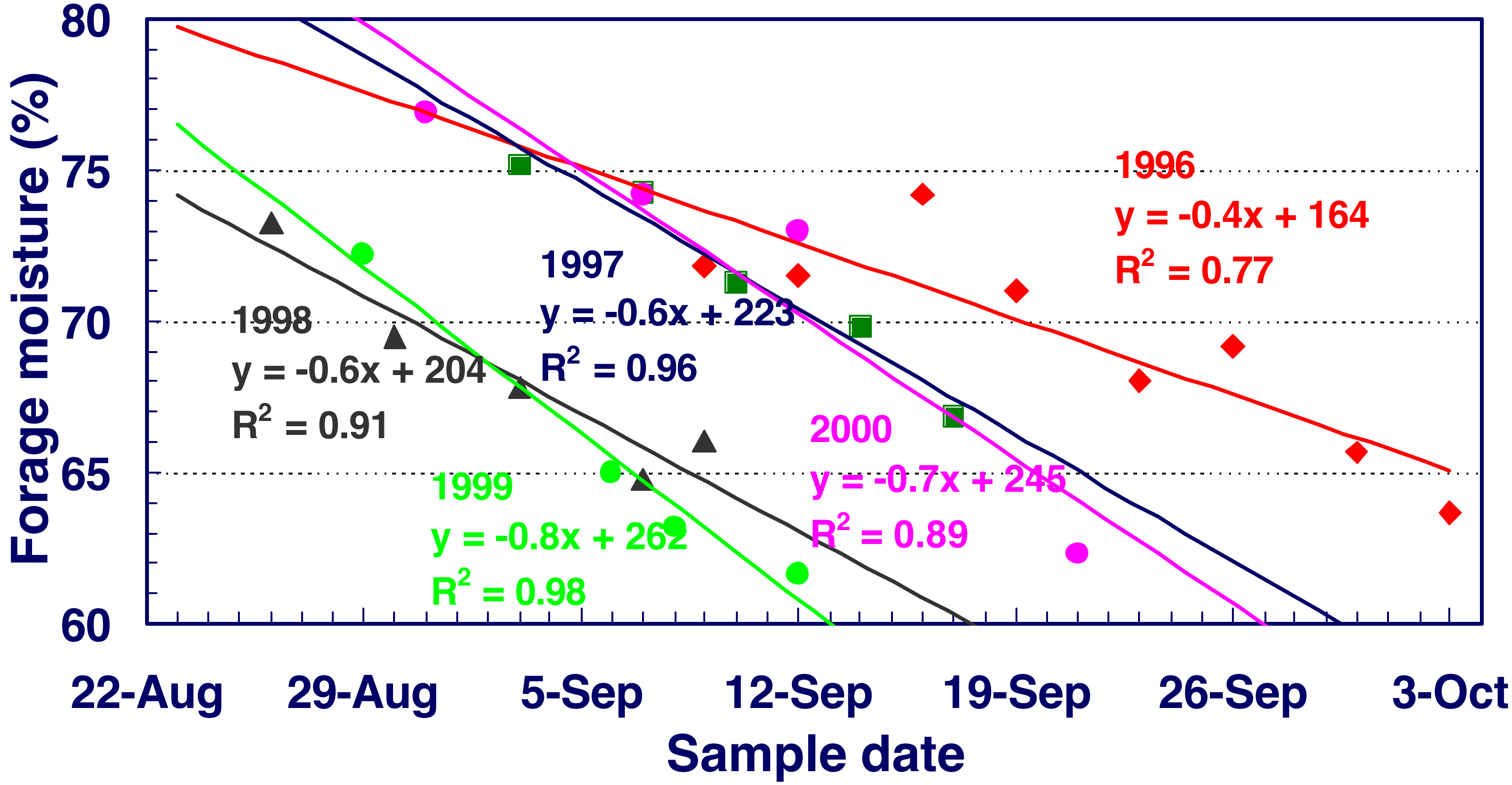
Relationship between whole plant moisture and kernel milk stage (1990 - 1997)



ERA


The Chase Is On!

Corn Silage Drydown Rate in Manitowoc County, WI.



Relationship Between Forage Moisture and Kernel Milk Stage (1990 - 2000)