The Potential and Breeding of Corn as a Cellulosic Feedstock

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Co-Authors

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Questions

- What are the component yields of corn?
- What is the composition of the components of corn?
- What role will breeding play in improving corn as an cellulosic feedstock?

Experimental design

- 50 maize genotypes
- RCBD
  - 3 replications
  - 2 years
  - 2 locations
    - 2005 trials: Ames, IA and Ankeny, IA
    - 2006 trails: Ames, IA and Belmond, IA

Germplasm

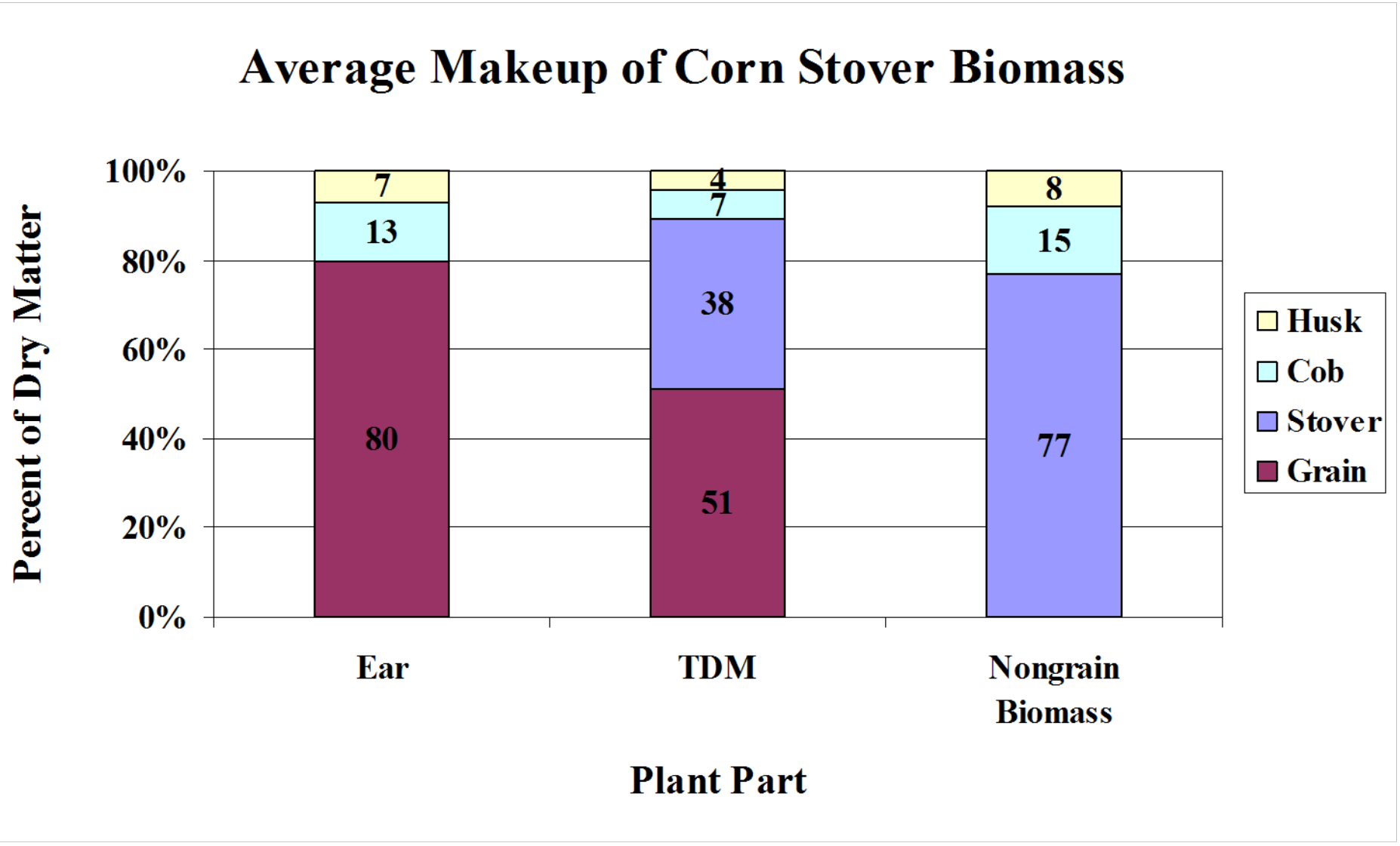
- F1 Hybrids
- Inbred x Populations
- Population x Population
- Populations
- Commercial Hybrids

- Brown midrib isogenic series
- Leafy mutation

Field Methods

- Basic Agronomic Data Collected
  - Grain yield (2005 and 2006)
  - Stover yield (2005 and 2006)
  - Cob yield (2005 and 2006)
  - Husk yield (2006 only)

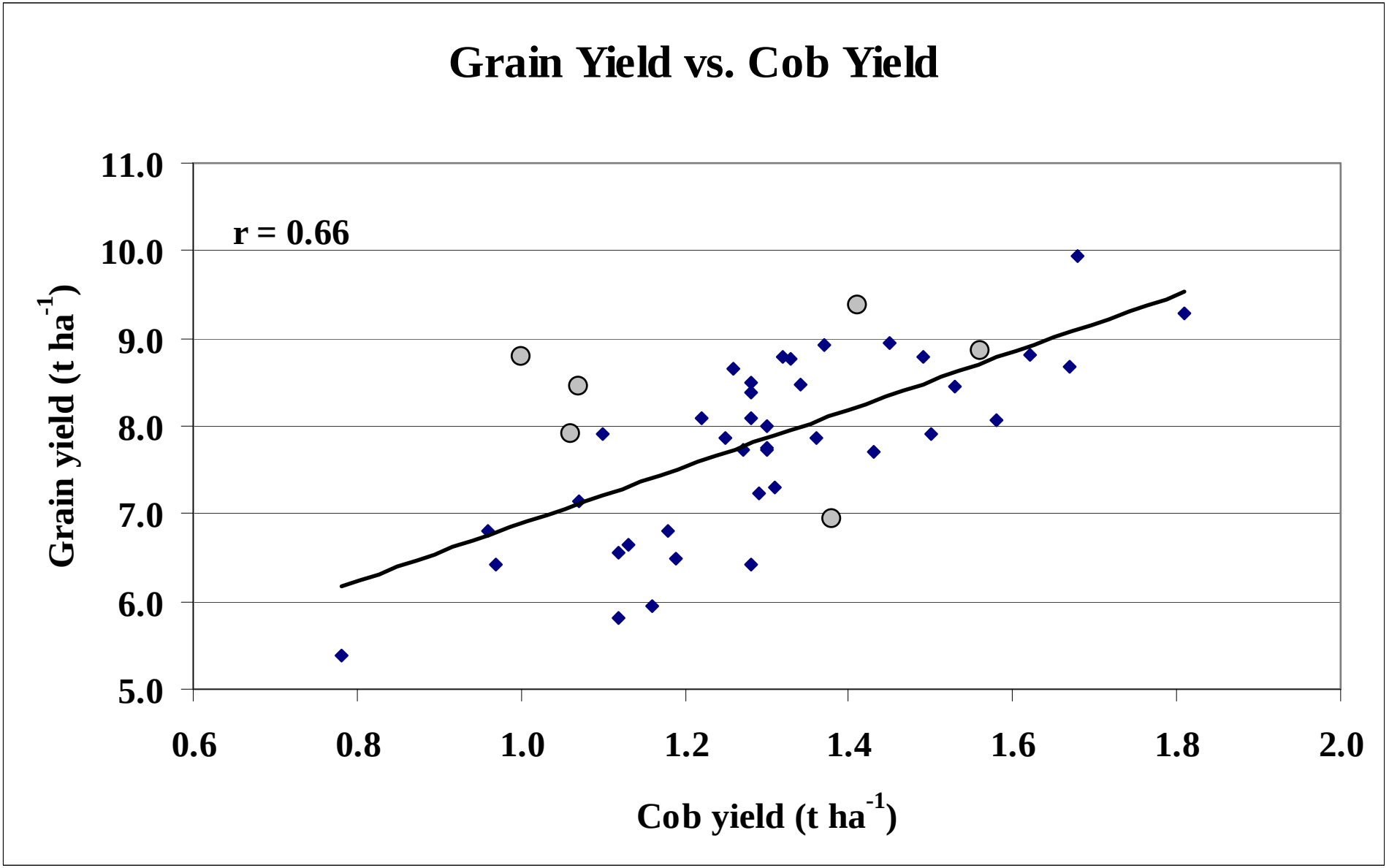
YIELD OF PLANT FRACTIONS


Average Makeup of Corn Stover Biomass
Percent of Dry Matter
100%
80%
60%
40%
20%
0%
7
13
80
4
7
38
51
8
15
77
Husk
Cob
Stover
Grain
Ear
TDM
Nongrain Biomass
Plant Part

Agronomic Results

	Cob	Husk	Grain	2006 Stover	2005 Stover	06 HI	05 HI
	----------t ha^{-1}----------						
Mean	1.3	0.71	7.9	7.3	5.9	0.51	0.49
Min	0.8	0.53	5.4	4.1	4.1	0.42	0.42
Max	1.8	1.25	10.0	10.6	8.4	0.60	0.55
LSD(0.05)	0.2	0.13	1.1	1.2	1.8	0.05	0.08

*** Cob, Husk, and Stover yield all had significant genotype and environment effects.**

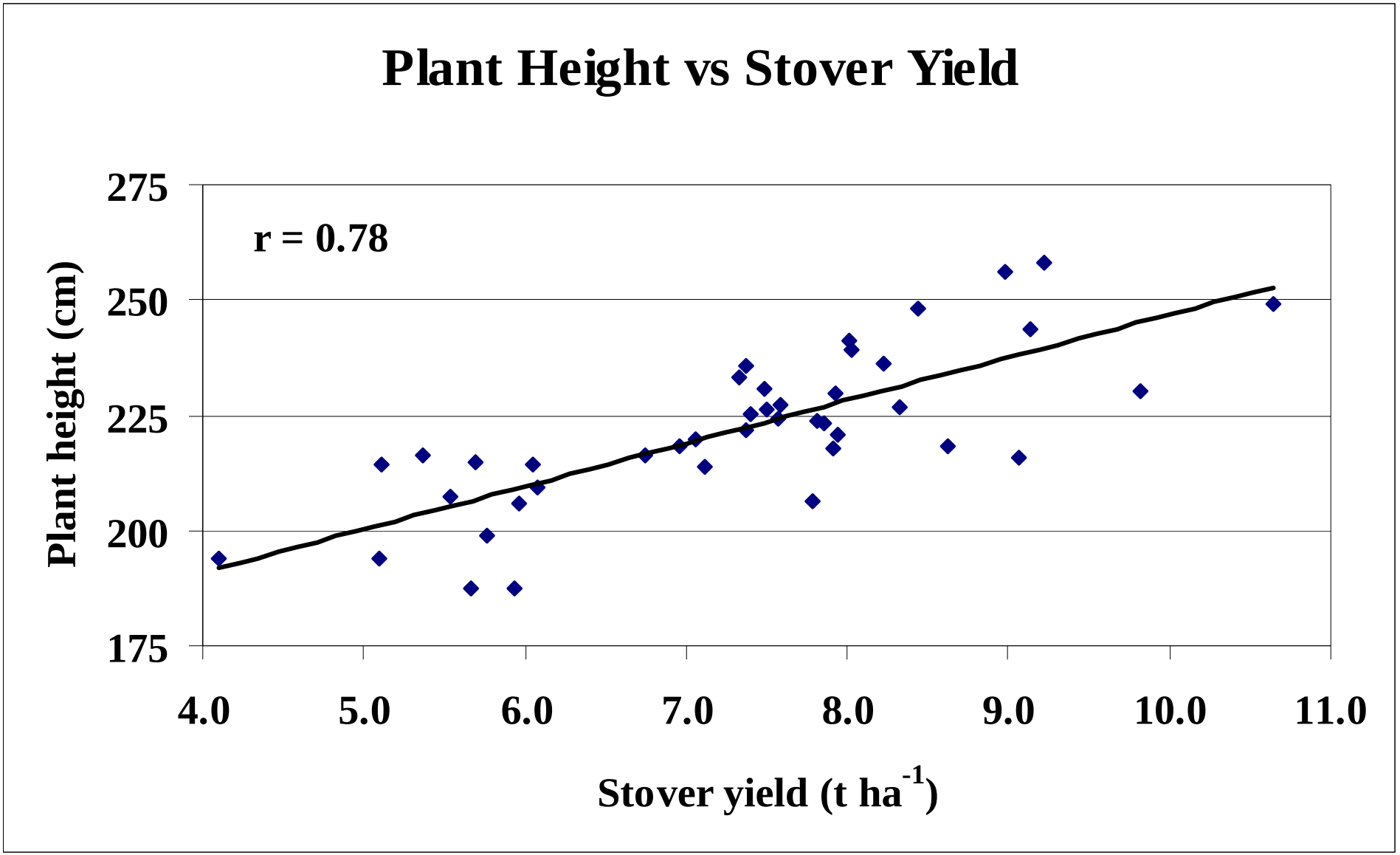

Grain Yield vs. Cob Yield
r = 0.66
11.0
10.0
9.0
8.0
7.0
6.0
5.0
Grain yield (t ha-1)
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Cob yield (t ha-1)

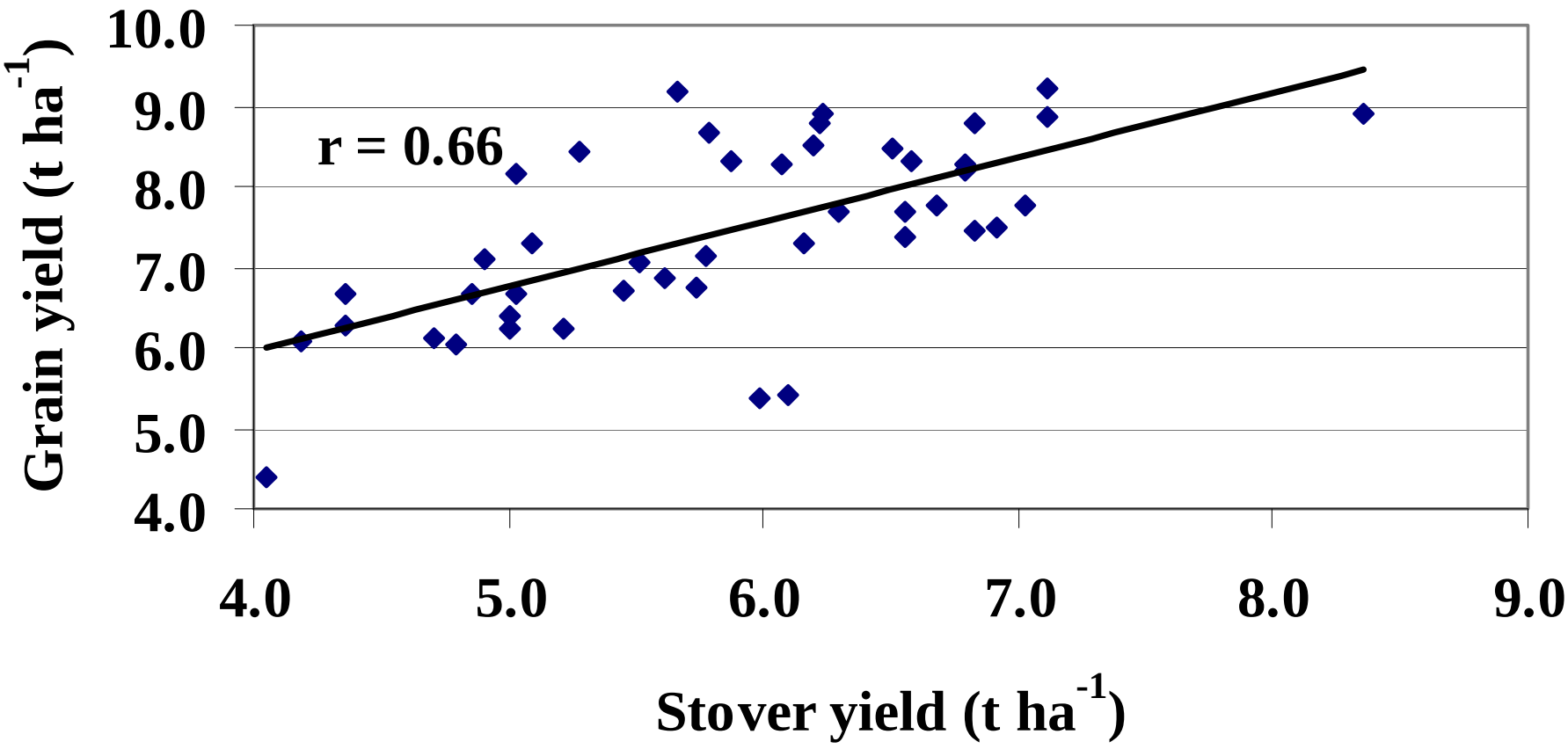
	Cob:Ear	Shelling%
Mean	14	86
Min	10	84
Max	16	90

85.5% and 85.7% for two commercial grain hybrids (Hicks et al., 1977)

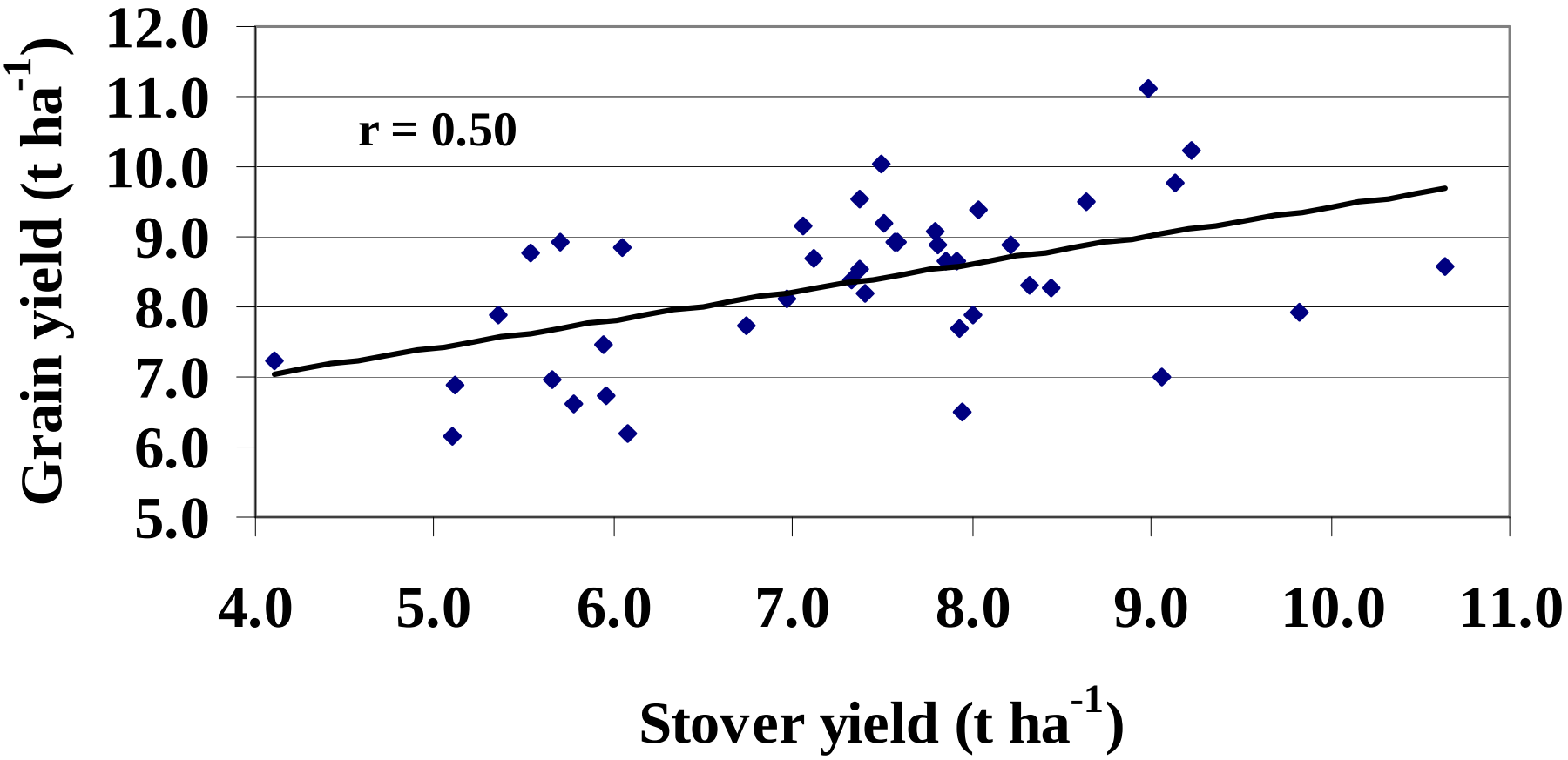
$$\frac{\text{Grain}}{\text{Grain + Cob}} = 0.86$$

Grain * 0.1628 = Cob


Plant Height vs Stover Yield
r = 0.78
Plant height (cm)
275
250
225
200
175
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
Stover yield (t ha-1)

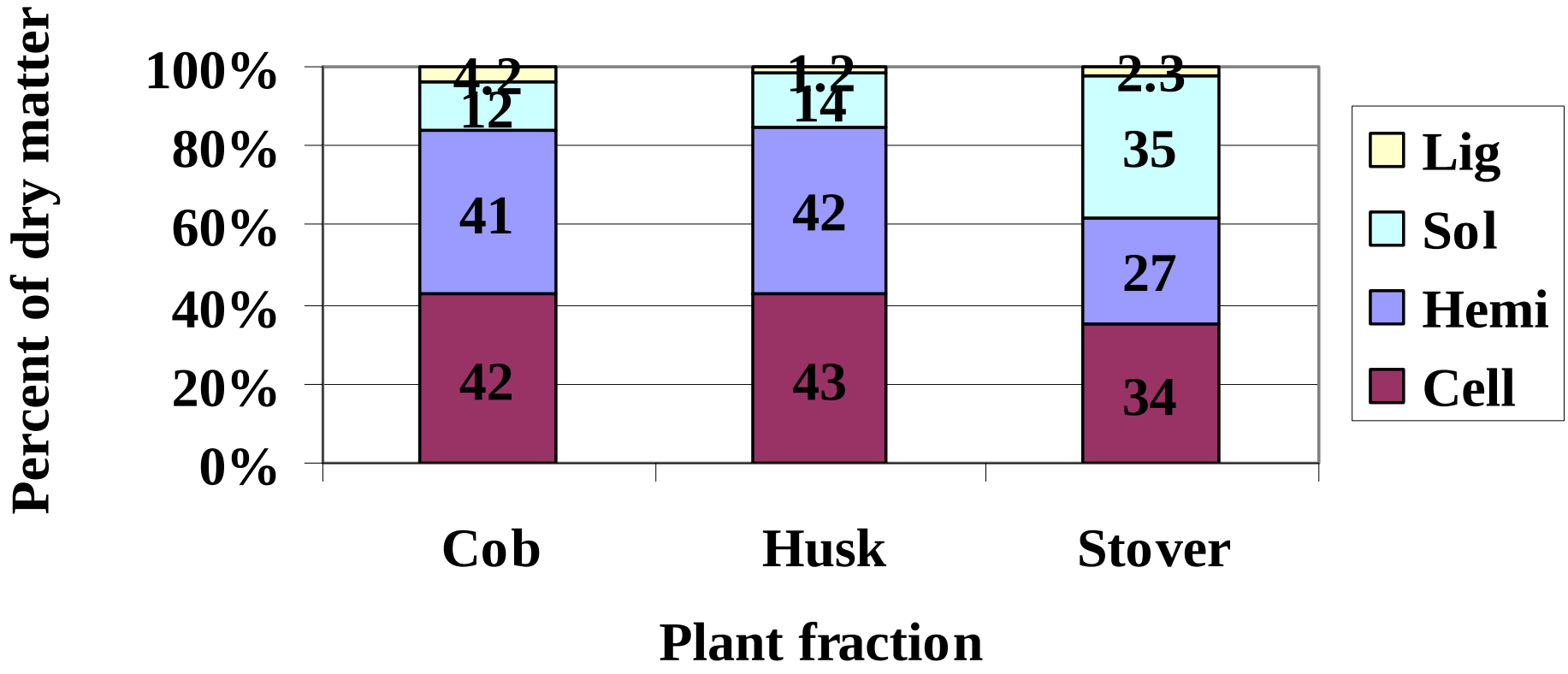

Grain Yield vs Stover Yield (2005)
Grain yield (t ha-1)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
r = 0.66
4.0
5.0
6.0
7.0
8.0
9.0
Stover yield (t ha-1)

Grain Yield vs. Stover yield (2006)

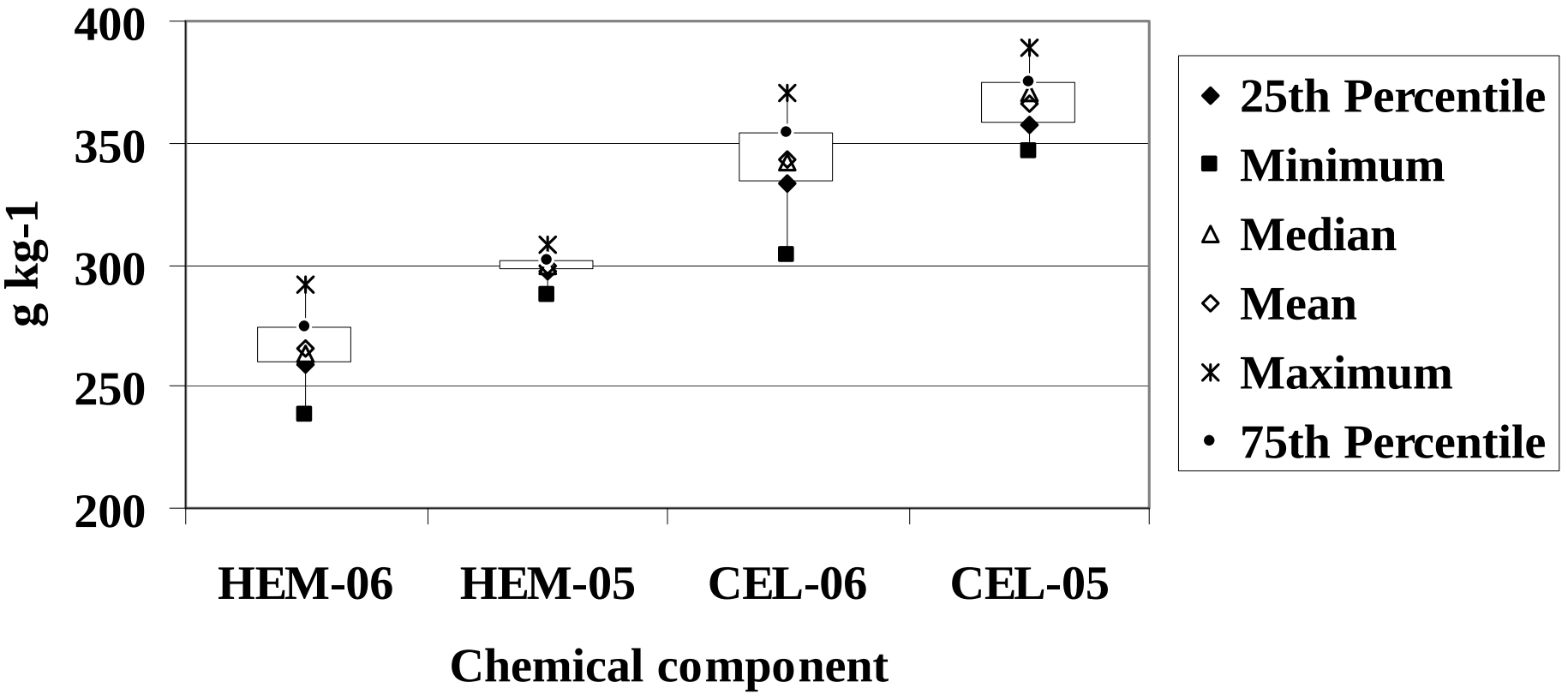


COMPOSITION OF PLANT FRACTIONS

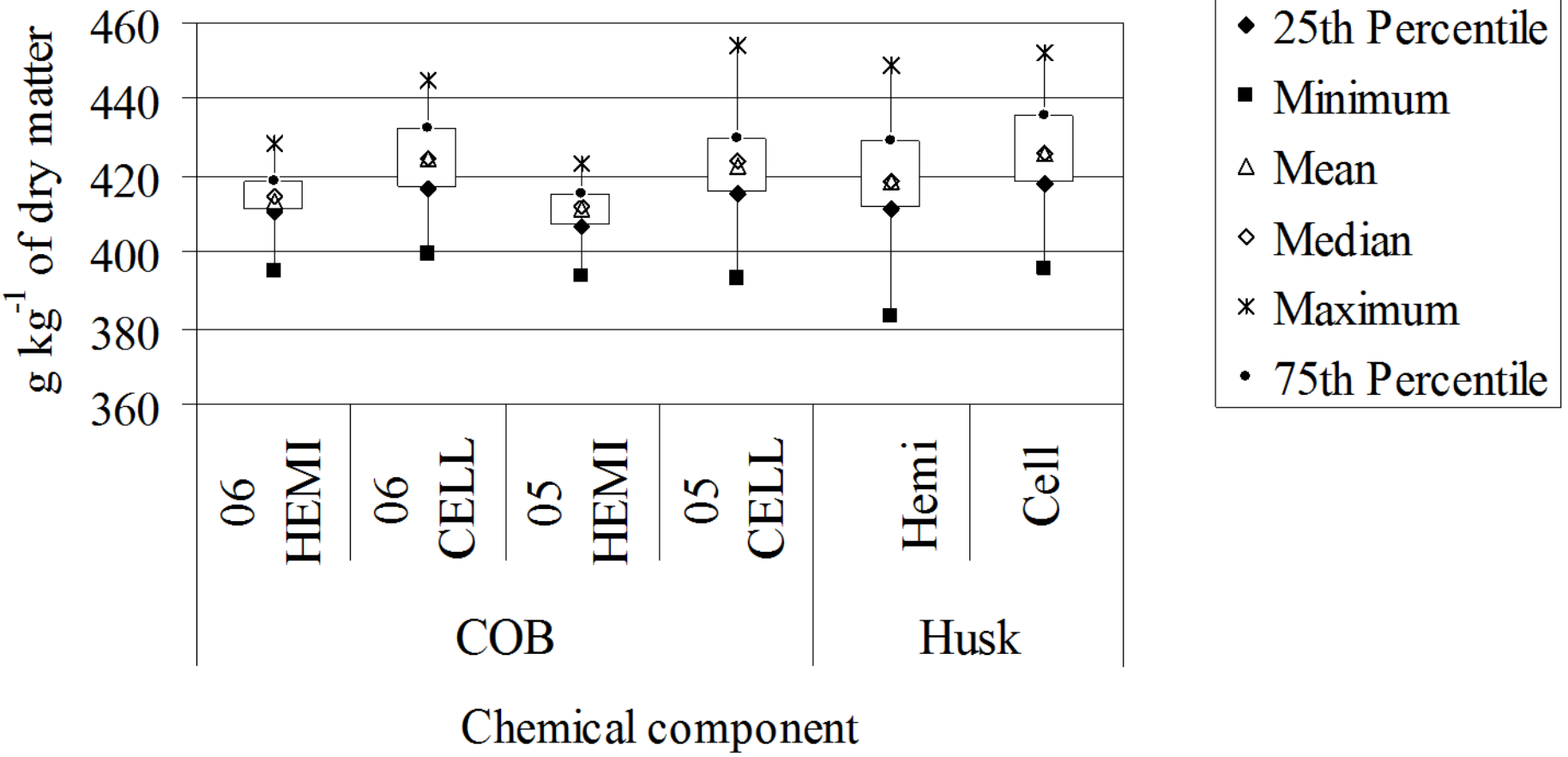
Chemical composition of cob, husk, and stover fractions



Distribution of cellulose and hemicellulose for 2005 and 2006 stover



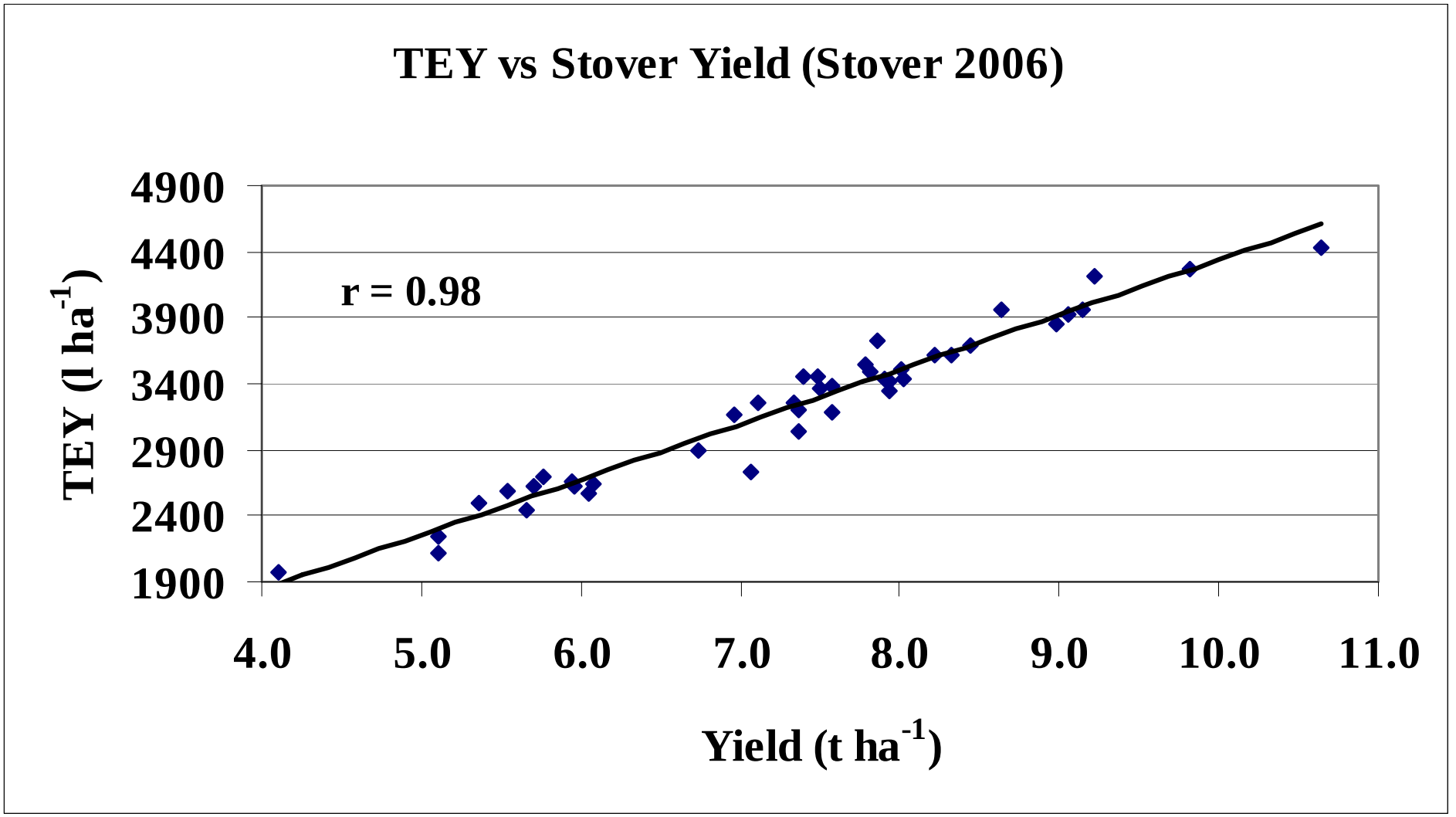
Distribution of cellulose and hemicellulose for cobs and husks



Mean Ethanol Potentials

TEP (l t^{-1})	Cob	Husk	06 Stover	05 Stover
Mean	609	616	441	485
Min	588	594	394	463
Max	627	631	481	500
LSD(0.05)	6	12	28	27

TEY (l ha^{-1})	Cob	Husk	06 Stover	05 Stover
Mean	789	438	3226	2824
Min	469	321	1966	1897
Max	1103	768	4422	4138
LSD(0.05)	102	82	551	868


TEY vs Stover Yield (Stover 2006)
r = 0.98
TEY (l ha-1)
4900
4400
3900
3400
2900
2400
1900
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
Yield (t ha-1)

ROLE OF PLANT BREEDING

Plant Breeding

- To Improve a Trait via Plant Breeding
  - Know the trait(s) we want to improve
  - Have a rapid, inexpensive, and high through-put way of measuring the trait
  - Limited understanding of the trait inheritance

Plant Breeding

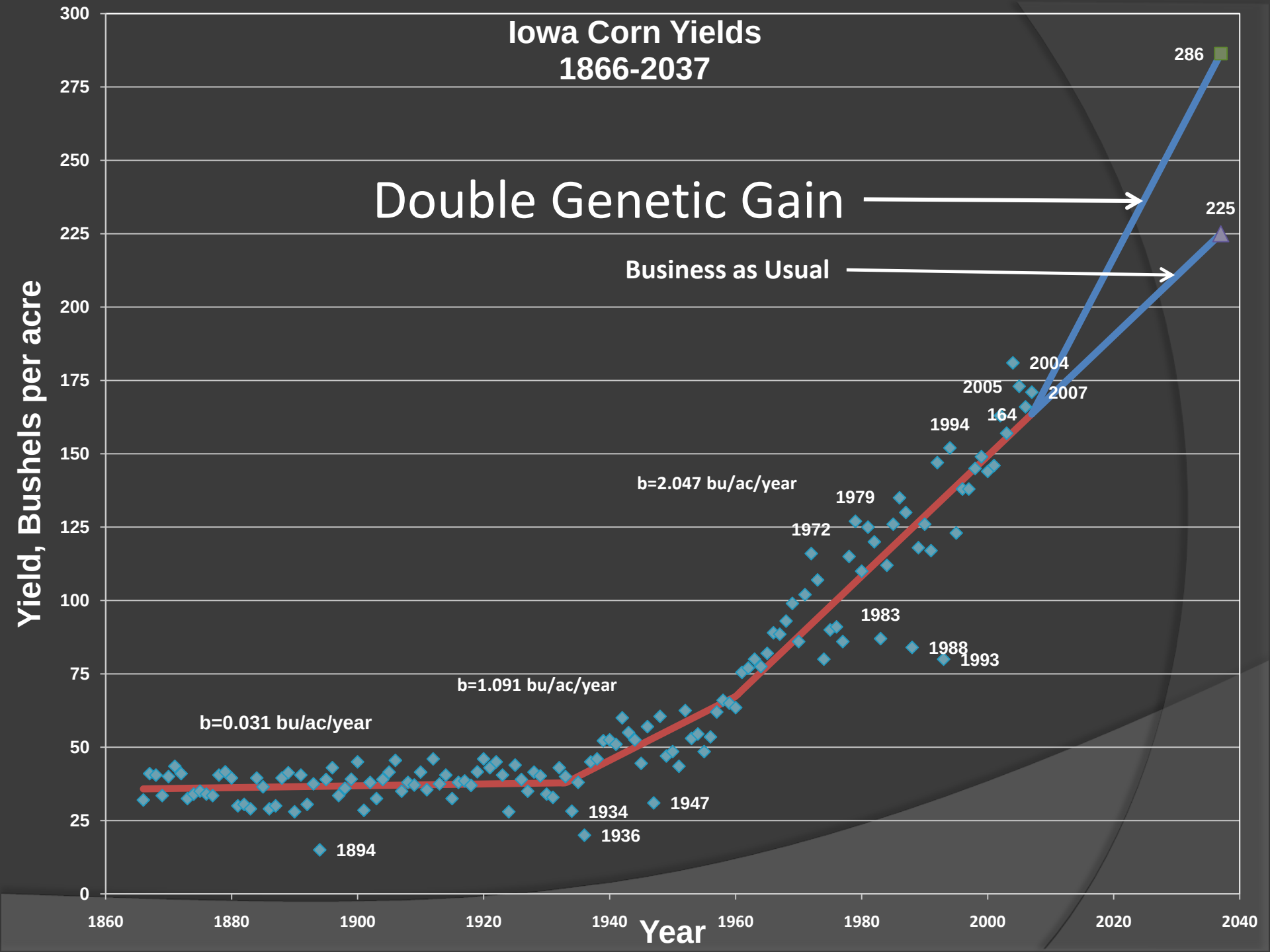
- Modify Composition
- Modify Conversion Efficiency
- Increase Biomass Yield

Cobs/Husks

- Modify Composition
  - Little Opportunity, little genetic variation
- Modify Conversion Efficiency
  - Little Opportunity – target is still unknown
- Increase Biomass Yield
  - Little Opportunity – except through further increases in grain yield

Stover

- Modify Composition
  - Great Opportunity, Good Genetic Variation,
- Modify Conversion Efficiency
  - Little Opportunity – target is still unknown
- Increase Biomass Yield
  - Great Opportunity – Caveats include developing plot harvesters that separate grain and stover and impact on grain portion is unknown


Iowa Corn Yields
1866-2037
Double Genetic Gain
Business as Usual
286
225
2004
2005
2007
164
1994
1979
1972
1983
1988
1993
1947
1934
1936
1894
b=2.047 bu/ac/year
b=1.091 bu/ac/year
b=0.031 bu/ac/year
Yield, Bushels per acre
Year
300
275
250
225
200
175
150
125
100
75
50
25
0
1860
1880
1900
1920
1940
1960
1980
2000
2020
2040