Master of Science in Agronomy Program – Plant Population Effects on Corn Yields and Ear Characteristics to Evaluate Thinning in Research Yield Trial Plots

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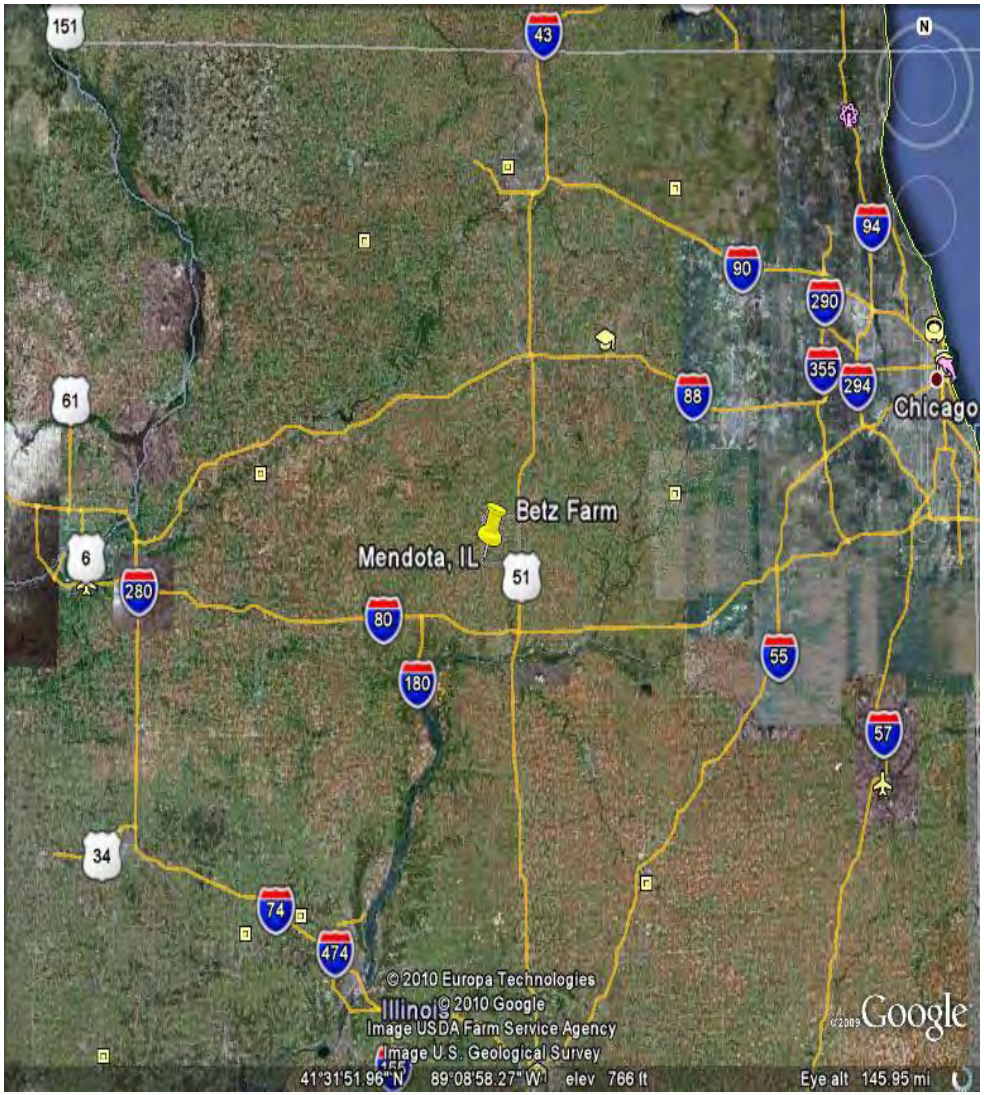
April 16th, 2010

Overview

- Introduction/Background
- Project Creation
- Plant density review
- Objectives
- Material and Methods
- Results and Discussion
- Summary

Background

- Grain and Livestock Farm
  - Mendota, IL
- Education
  - Associate of Science
    - Southwestern Community College; 1998-2000
    - Major: Agricultural Business
  - Bachelor of Science
    - Iowa State University; 2001-2003
    - Major: Agricultural Studies
    - Minor: Agronomy
  - Masters of Agronomy Program
    - Fall 2005-Current



Background

- Monsanto- Williamsburg, IA
  - 2003, Research Technician
  - 2004, Research Assistant

- Monsanto- Thomasboro, IL
  - 2008, ICB Coordinator

Project Creation

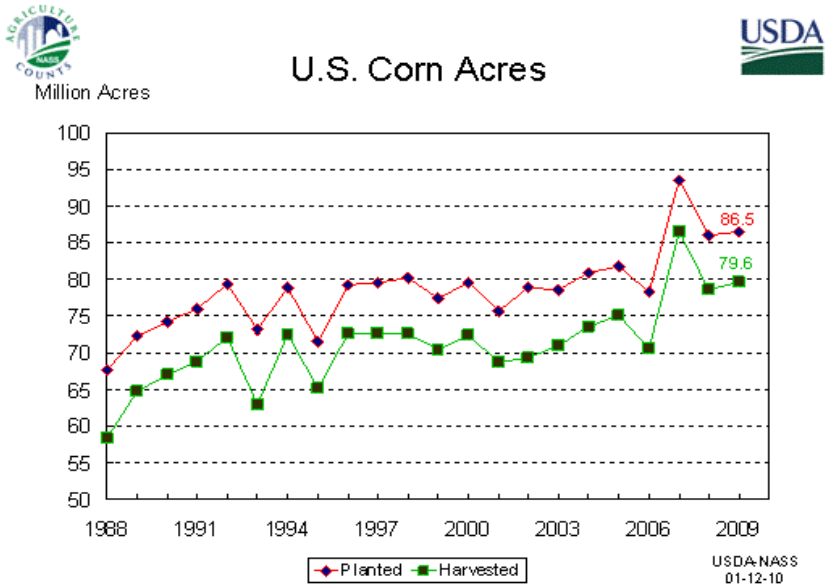
- Field research project during the 2008 growing season
- Plant density trial conducted
- Idea was to evaluate thinning of yield trial plots by looking at hybrid response to plant density

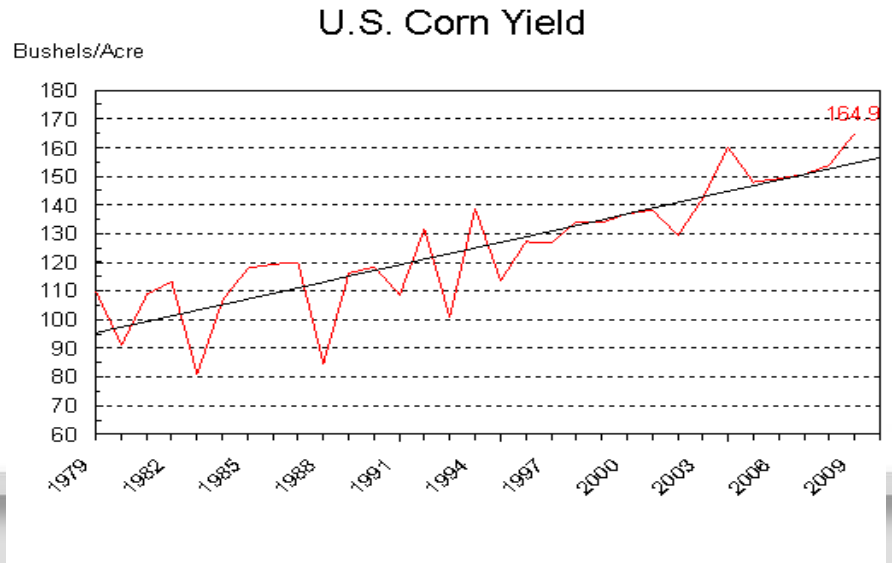
Project Creation

- Why??
  - Corn plant densities continue to rise in commercial agriculture
  - Private sector must evaluate new hybrids at higher densities
  - General interest in how hybrids respond to plant density
  - Monsanto’s commitment to double yield by 2030

Project Creation

- World population of over 9 billion by 2040
- U.S planted 86.5 million acres of corn in 2009
- A 1.5% annual increase in corn grain yield is needed
- The last 30 yrs we have had a 1.3% annual increase





Project Creation

- Plant densities are going to play a significant role in doubling grain yield by 2030
- Important to evaluate new hybrids at commercially recommended densities.
- Thinning of yield trial plots is a major job task involving many people and hours
  - Is there a chance it could be reduced?

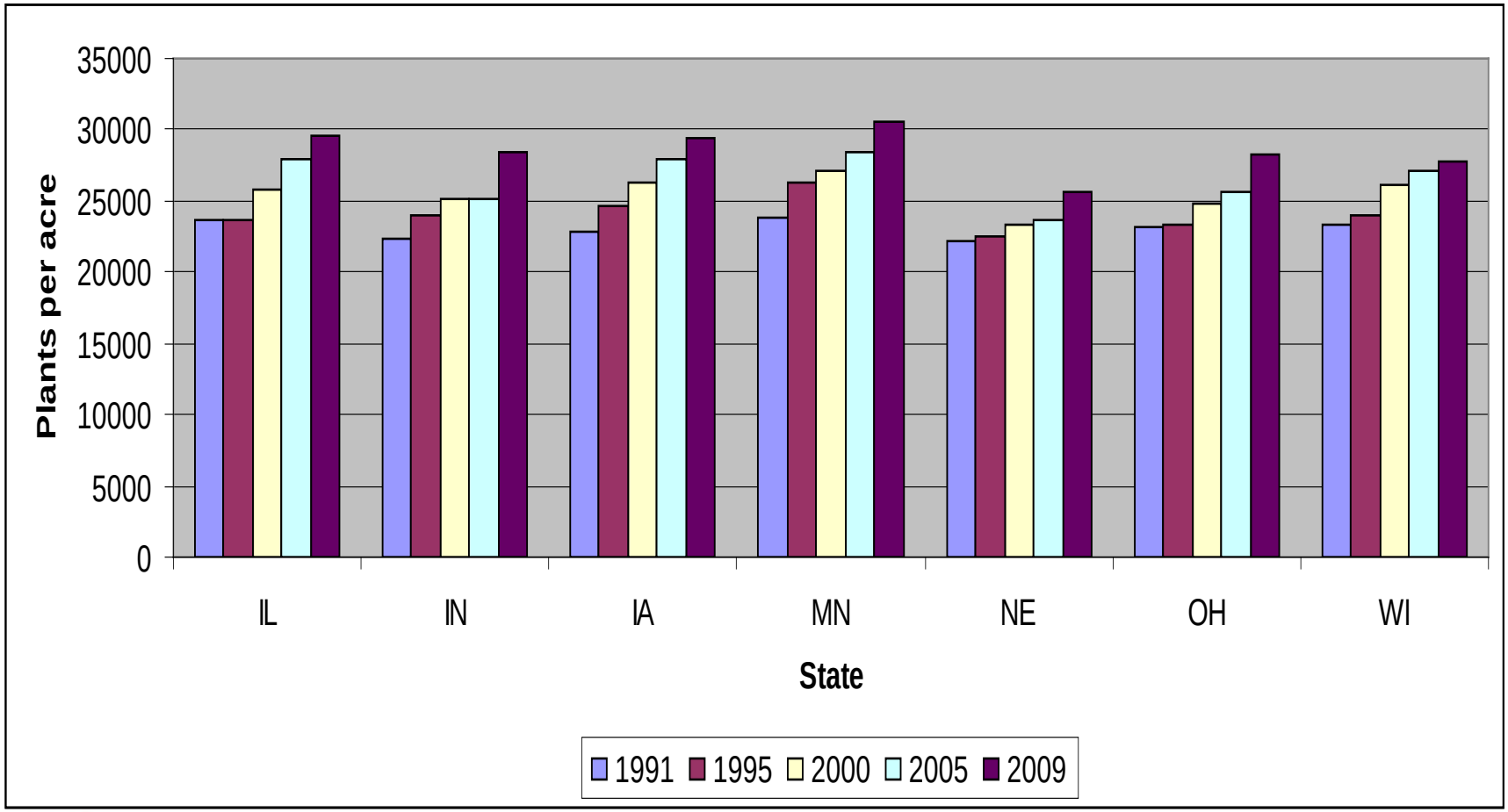
Plant Density Review

- Advancement in corn genetics has led to hybrids withstanding higher levels of stress
- Adoption of traits since the mid-90's has given farmers additional measures to protect yield
- Research has shown that hybrids with Bt have increased yields
  - Singer et. al. showed 5-8% yield increase with Bt hybrids
  - Cox et. al. (2009) showed double and triple-stack hybrids yielded 2.7% more than their base genetics

Plant Density Review

- Abundance of plant density data available
- Data from recent years has shown that the optimum plant density has increased
  - University of Minnesota recommends target planting rate of 33,000 seeds/acre
  - Purdue University recommends no less than 30,000 plants/acre for a final stand
  - Iowa State University data in 2006 showed 36,000 seed/acre
  - Monsanto data shows 33,000-38,000 seeds/acre

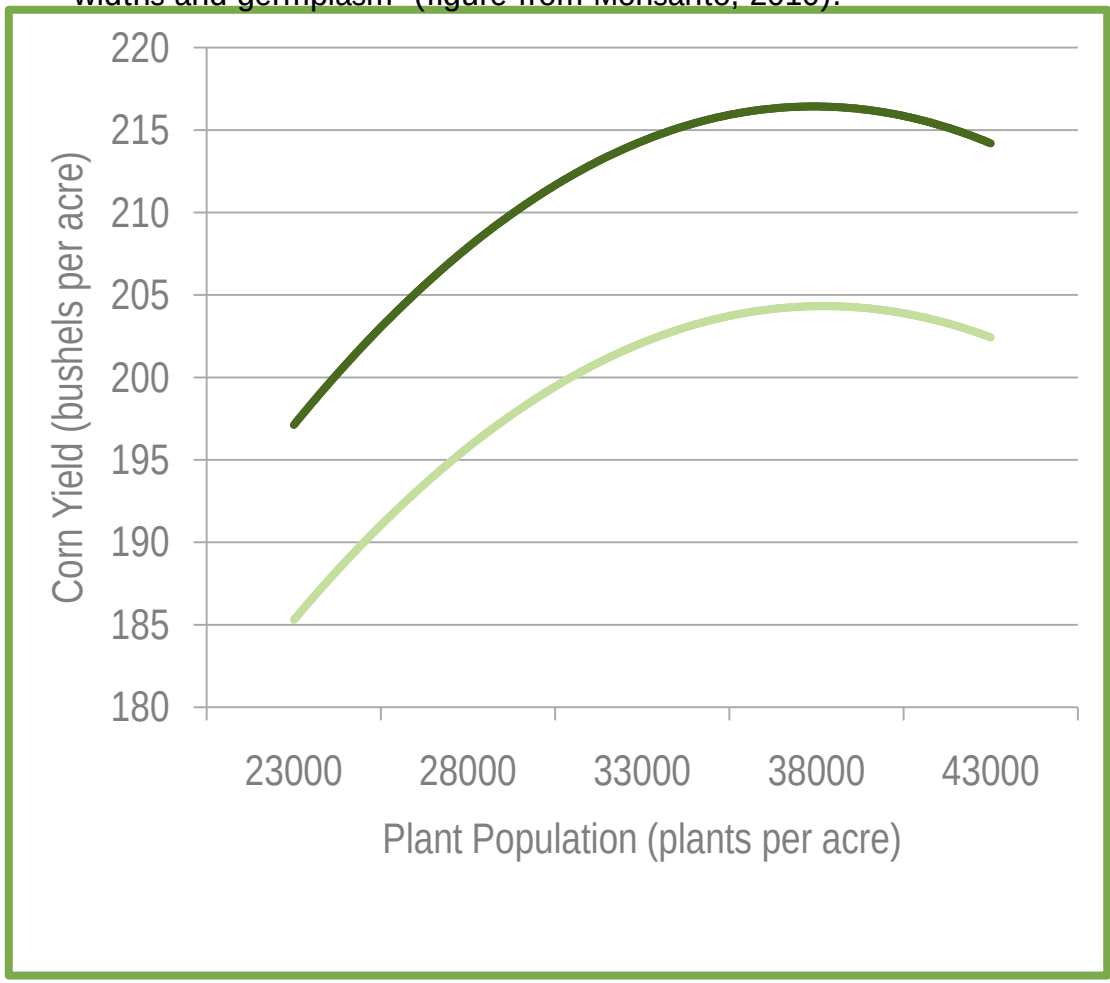
Corn crop densities for states in the Corn Belt



Plant Density Review

- Research has shown that yields have increased when plant densities are increased
- Continuing research will be vital to ensure farmers have knowledge of optimum planting densities
- Private sector must test new hybrids under higher densities to see performance

Effect of plant density by year averaged across locations, row widths and germplasm (figure from Monsanto, 2010).



Source: Monsanto. 2010. Data Review-Corn Plant Density.Marcus Jones PH.D Technology Development Manager Corn Systems_

Ear Growth Characteristics

- Companies characterize hybrids by ear type
  - Fixed (determinate)
  - Flexed (indeterminate)

- Why does ear type matter?
  - If a hybrid can truly flex then it could compensate for variations in plant density
  - Theory is as plant density is increased fixed-ear hybrids would yield better, conversely as plant density decreases flexed-ear hybrids would yield better

Ear Growth Characteristics

- Also important in the Western Corn Belt where water is limiting resource and plant densities are typically lower

- Very little scientific research comparing hybrid ear-type and their response to varying plant densities
  - Thomison and Jordan (1995) found that hybrid differences in ear growth had a small effect on yield response to density
  - Cox (1997) reported that ear type did not contribute much to hybrid variability for optimum plant density

- Interested in seeing if hybrid response to plant density varied by ear-type

Yield Components

- Four components
  - Plants per acre
  - Ears per plant
  - Kernels per ear
    - Kernels per row (KPR)
    - Kernel rows per ear (RPE)
  - Kernel weight

Kernel Rows per Ear (RPE)

- Determined between V5-V8 growth stages
- Will always be even because of the splitting of the ovules to produce two rows
- Mostly determined by genetics but early season stress can have negative impact
  - Subedi and Ma (2005) found that nitrogen deficiency before V8 caused substantial decrease in RPE as well as kernels per row
- Increasing plant density could potentially affect RPE for flexed-ear hybrids while fixed-ear hybrids would in theory continue to produce the maximum number of RPE

Kernels per Row (KPR)

- Varies much more due to environmental stresses
- Maximum KPR is determined just prior to pollination when ovule formation is complete
- Upwards of 1,000 potential ovules per ear
- Stresses leading up to V12 can reduce the KPR by reducing the number of ovules formed
- Stresses during and after silking can reduce the total number of kernels per ear
  - Select ovules are sacrificed so that the plant can supply others ovules

Kernels per Row (KPR)

- Flexed-ear hybrids in theory could compensate depending on the stress level from V5 to just prior to silking
- Fixed-ear hybrids would not be able to respond to more favorable conditions
- If fixed-ear hybrids respond to higher plant densities then it shows that they are able to set enough kernels to maximize yields under favorable conditions

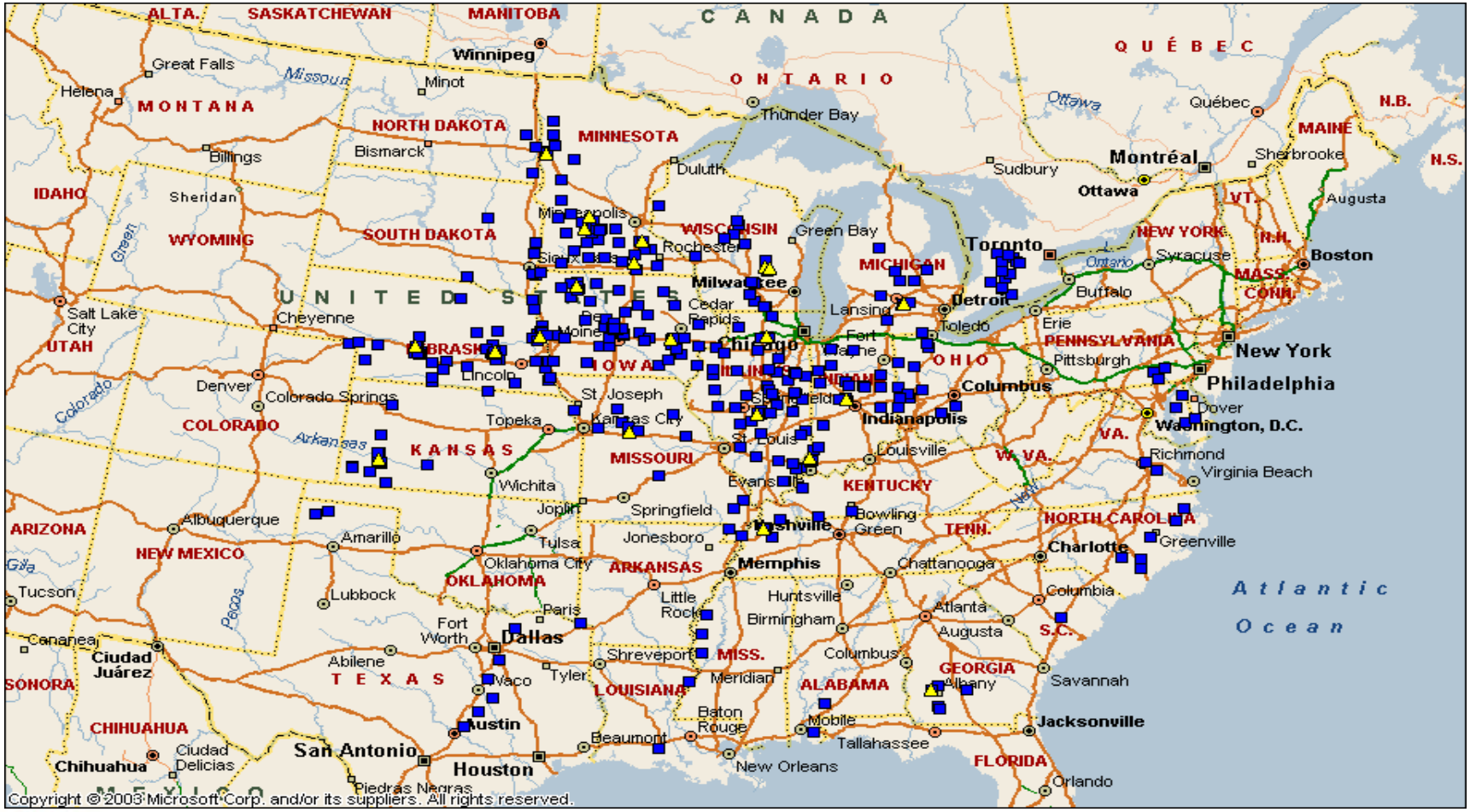
Kernel Weight

- Estimates show that 85% of the final yield is correlated with the total number of kernels and the final 15% is determined by the final kernel weight

- Late-season stress caused by drought, insect, disease or loss of leaf area can severely reduce kernel weight

- Studies have shown that as plant density is increased kernel weight is decreased
  - Lamm and Trooein (2001)
  - Cox (1996)

Monsanto testing footprint reaches hundreds of different environments



Thinning

- The removal of plants and plant competition within each plot
- Done prior to V6 growth stage
- Time consuming and costly on such a large scale

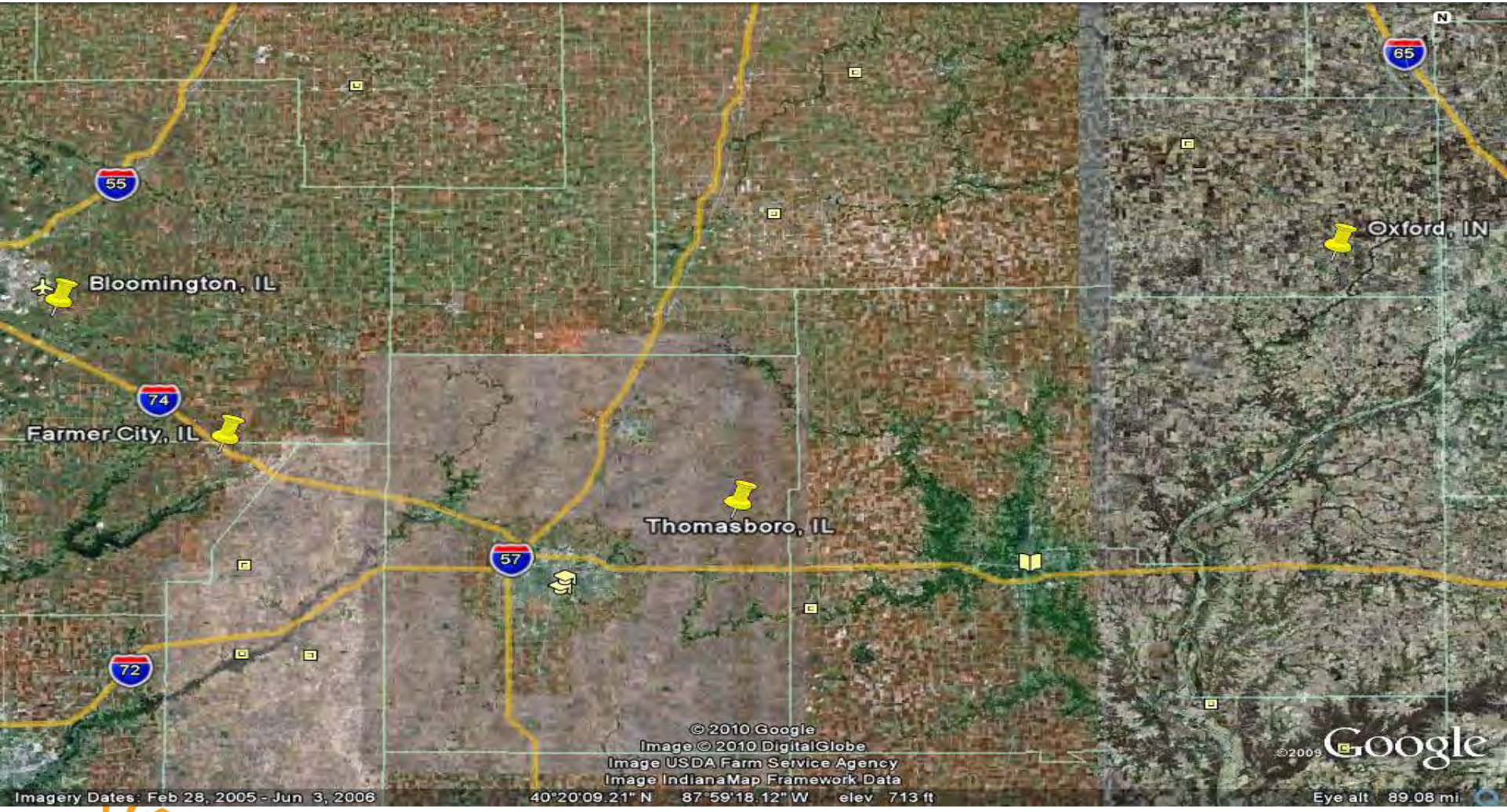
Thinning

- Research is very limited on effects of thinning
  - Hashemi et. al. showed that the greatest yield difference were when plant competition occurred between V5 and anthesis
  - Early-season competition (V5) had little effect on final grain yield
  - Nafziger showed that as thinning was delayed the ability for remaining plants to compensate decreased
- Within-row plant spacing and emergence could also affect final grain yield

Objectives

- Determine a range of plant density variability that could be tolerated without affecting yield comparison's among hybrids
- Look at effects of plant density on both fixed-ear and flexed-ear hybrids
- Determine if thinning could be reduced

Locations


55
Bloomington, IL
74
Farmer City, IL
57
Thomasboro, IL
72
65
Oxford, IN
© 2010 Google
Image © 2010 DigitalGlobe
Image USDA Farm Service Agency
Image IndianaMap Framework Data
Imagery Dates: Feb 28, 2005 - Jun 3, 2006
40°20'09.21" N 87°59'18.12" W elev 713 ft
Eye alt 89.08 mi
©2009 Google

General Site Information

Location	Soil Common Name (Taxonomic name),	Planting Date	Harvest Date	Fertilizer rates lbs/acre			Weed Control, Chemicals
				N	P	K	
Farmer City, IL	Ipava silt loam (fine, smectitic, mesic Aquic Argiudolls)	5 May	12 October	236	92	120	Bicep II, atrazine, callisto, cultivation
Bloomington, IL	Ipava silt loam (fine, smectitic, mesic Aquic Argiudolls)	5 May	17 October	170	40	120	Lumax, atrazine, callisto, cultivation
Thomasboro, IL	Drummer silty clay (fine-silty,mixed,superactive,mesic, Typic Endoaquolls)	4 May	3 October	290	NA*	NA*	Harness Xtra, atrazine, callisto, option, cultivation
Oxford, IN	Darroch silt loam (fine-loamy, mixed, superactive mesic aquic argiudolls)	6 May	8 October	147.5	52	120	Degree Xtra, laudis, aatrex, cultivation

Planting Equipment

Experimental Design

- Split plot with whole plots in a RCB with two replications
- Densities were main plots
- Hybrids were sub-plots
- Density whole plots were completely randomized within replicates at each location and within each plant density, hybrids were randomized

Experimental Design

- Four locations
- Four hybrids
  - 113-115 RM, two fixed-ear, two flexed-ear
- Nine plant densities
  - 27,404-38,038 plants per acre
- Two replications
- Seeding rate of 42,000 seeds/acre
- Four 30-inch rows
  - All four rows thinned to final stand
- Data collected only on middle two rows

Farmer City plot design

	9	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Rep 2	8	63-42		65-44		64-79		64-24		63-42		64-79		64-24		65-44		64-79		65-44		63-42		64-24	
Rep2	7	64-24		64-79		65-44		63-42		63-42		64-24		65-44		64-79		64-24		64-79		65-44		63-42	
Rep2	6	64-79		65-44		64-24		63-42		63-42		64-79		65-44		64-24		64-24		63-42		65-44		64-79	
Rep1	5	64-24		65-44		63-42		64-79		65-44		64-24		64-79		63-42		64-24		64-79		63-42		65-44	
Rep1	4	64-24		64-79		63-42		65-44		64-24		64-79		65-44		63-42		64-24		63-42		64-79		65-44	
Rep1	3	64-24		63-42		64-44		64-79		63-42		65-44		64-79		6424		64-79		64-24		65-44		63-42	
	2	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Range	1	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
	Col	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

27404 ***28631*** ***29858*** ***31085*** ***33312*** ***33539*** ***35175*** ***36402*** ***38038***

Hybrids

Hybrid	Relative maturity
DKC63-42-Med Flex	113
DKC64-79- Flex	114
DKC64-24- Fixed	114
DKC65-44- Fixed	115

- Two fixed-ear, and two flexed-ear
- All hybrids contained Yieldgard VT triple trait combination

Field Data

- Stand counts
- Plant Height
- Stalk lodging
- Root lodging
- Harvest Data
  - Grain weight (lbs.)
  - Moisture
  - Test weight

Lab Data

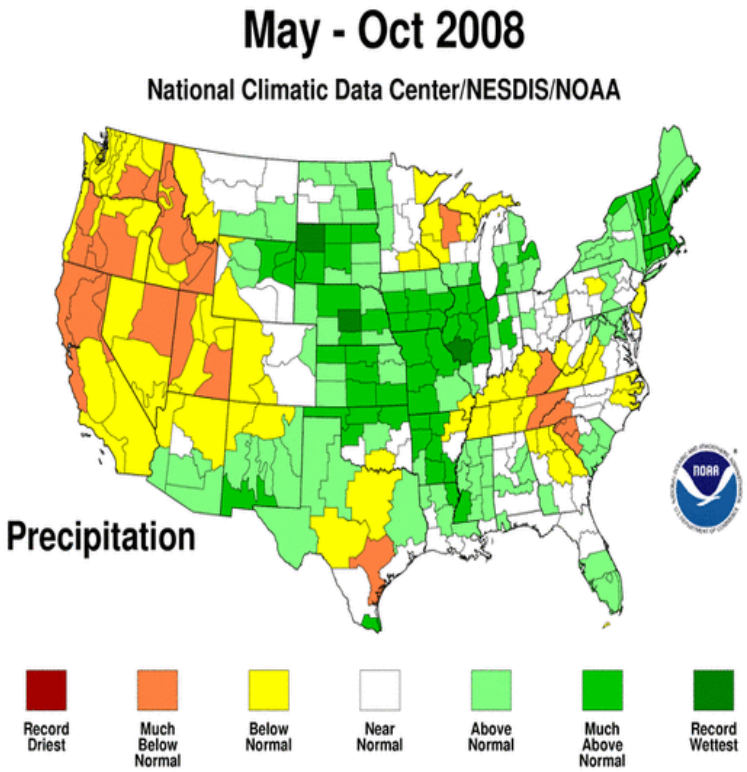
- Six ears from center two rows collected
  - Used to collect RPE, KPR and kernel weight
- Kernels per row
  - Measured from base to tip
- Kernel rows per ear
  - Measured from center of ear
- Kernel weight
  - 100 seeds counted and weighed

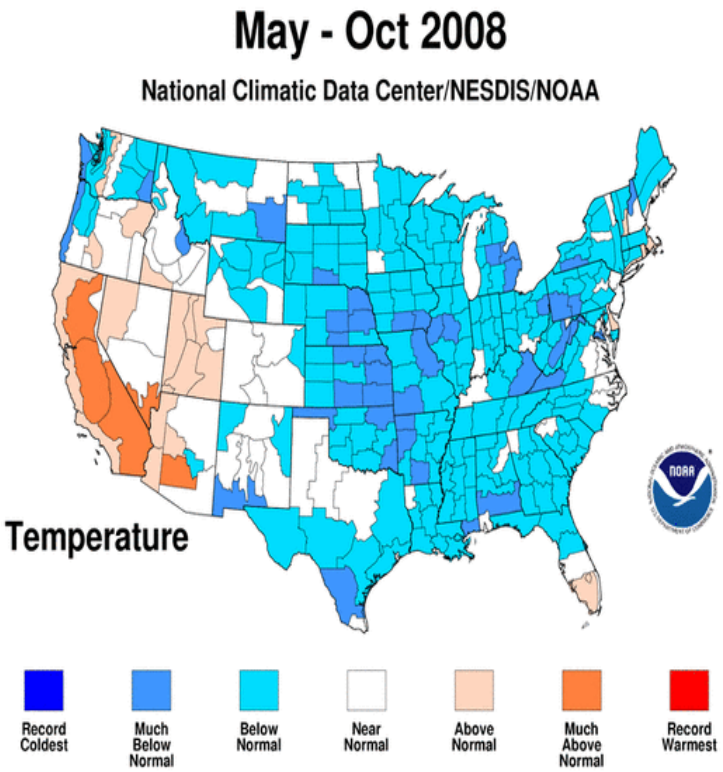
16 Kernel Rows

14 Kernel Rows

Photo courtesy of: Elmore, R, 2006. Iowa State University Extension

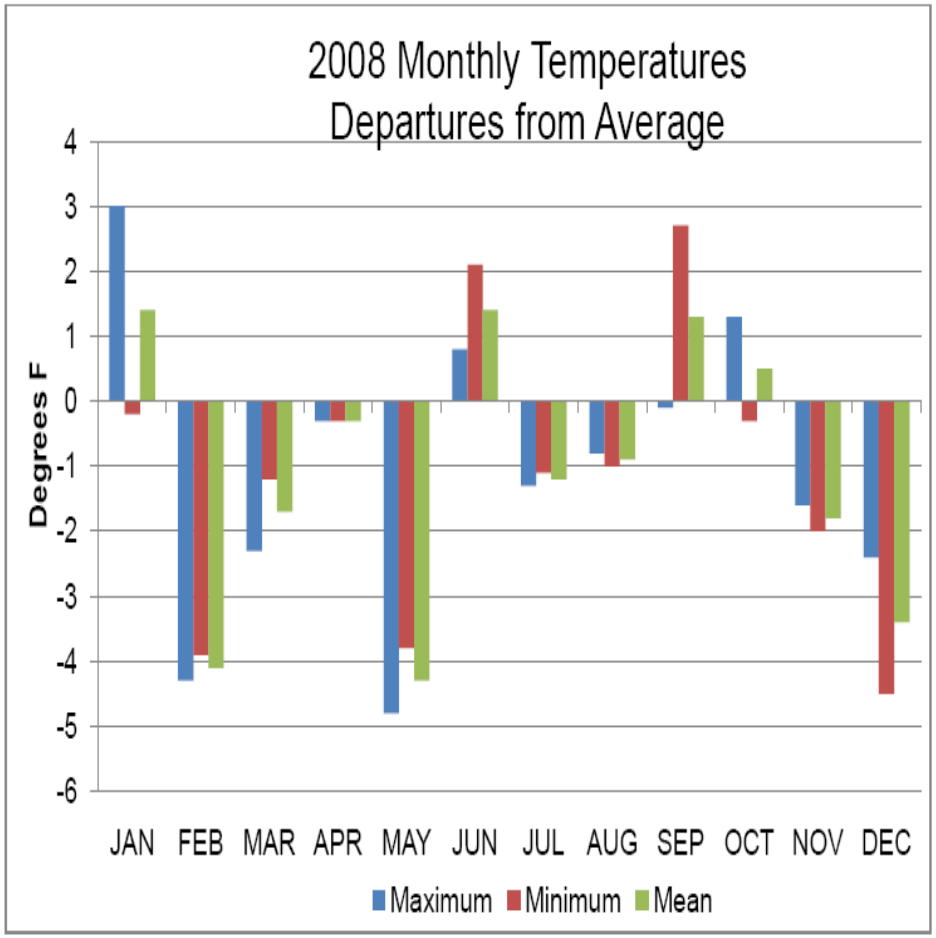
2008 Weather

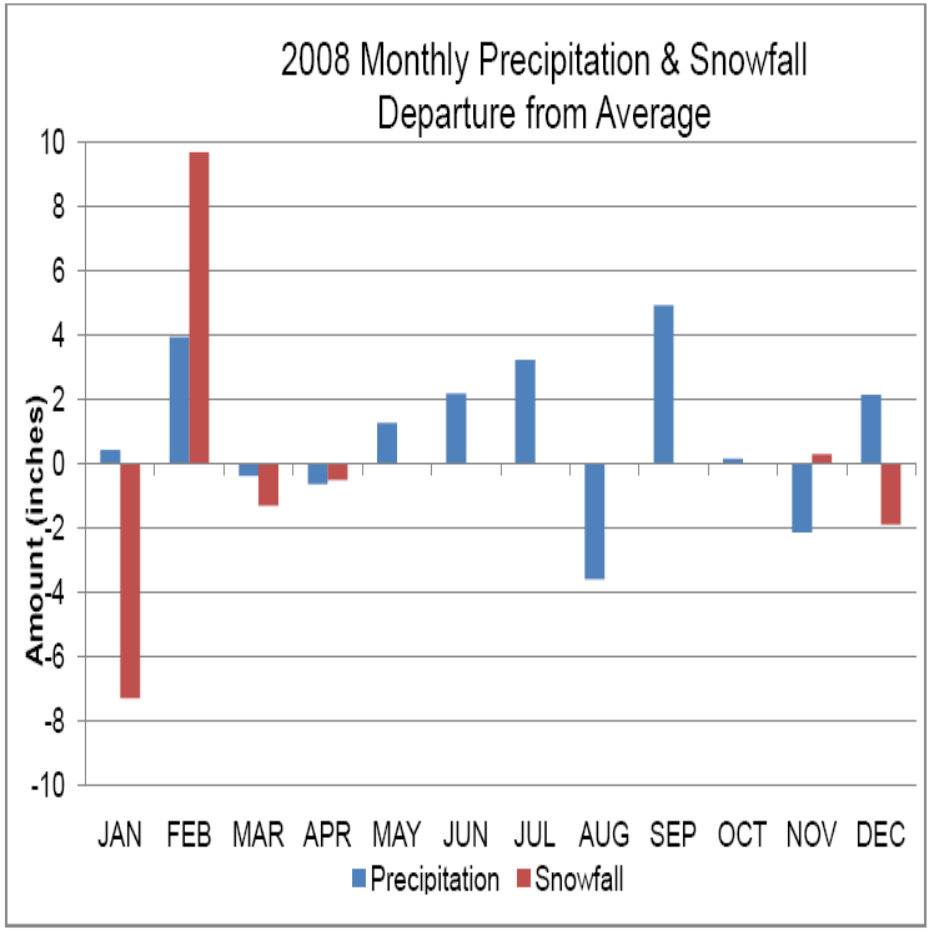




Source
http://www.ncdc.noaa.gov/oa/climate/research/2008/oct/6month.html

2008 Weather



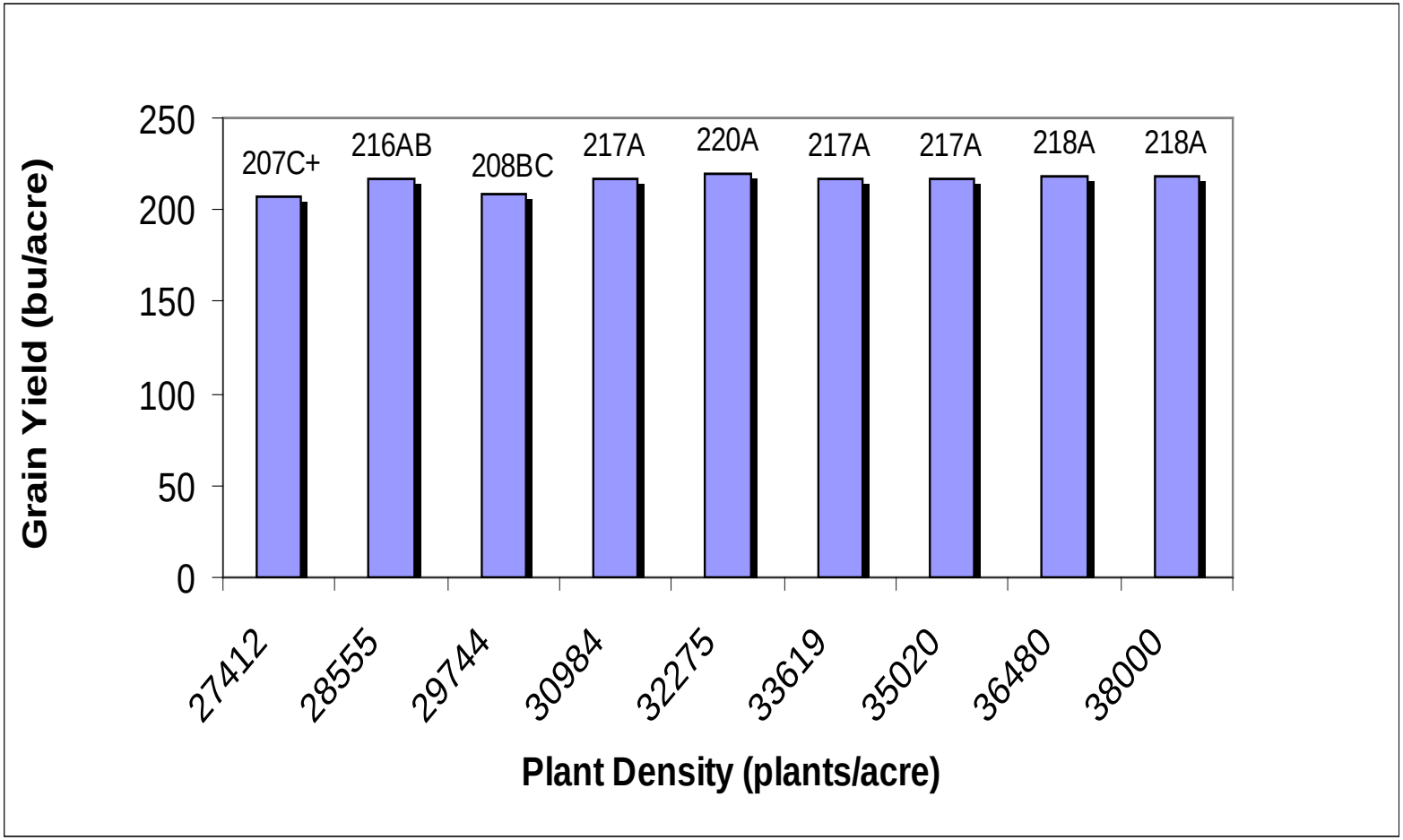


Source: http://www.isws.illinois.edu/atmos/statecli/cuweather/index.htm

Results

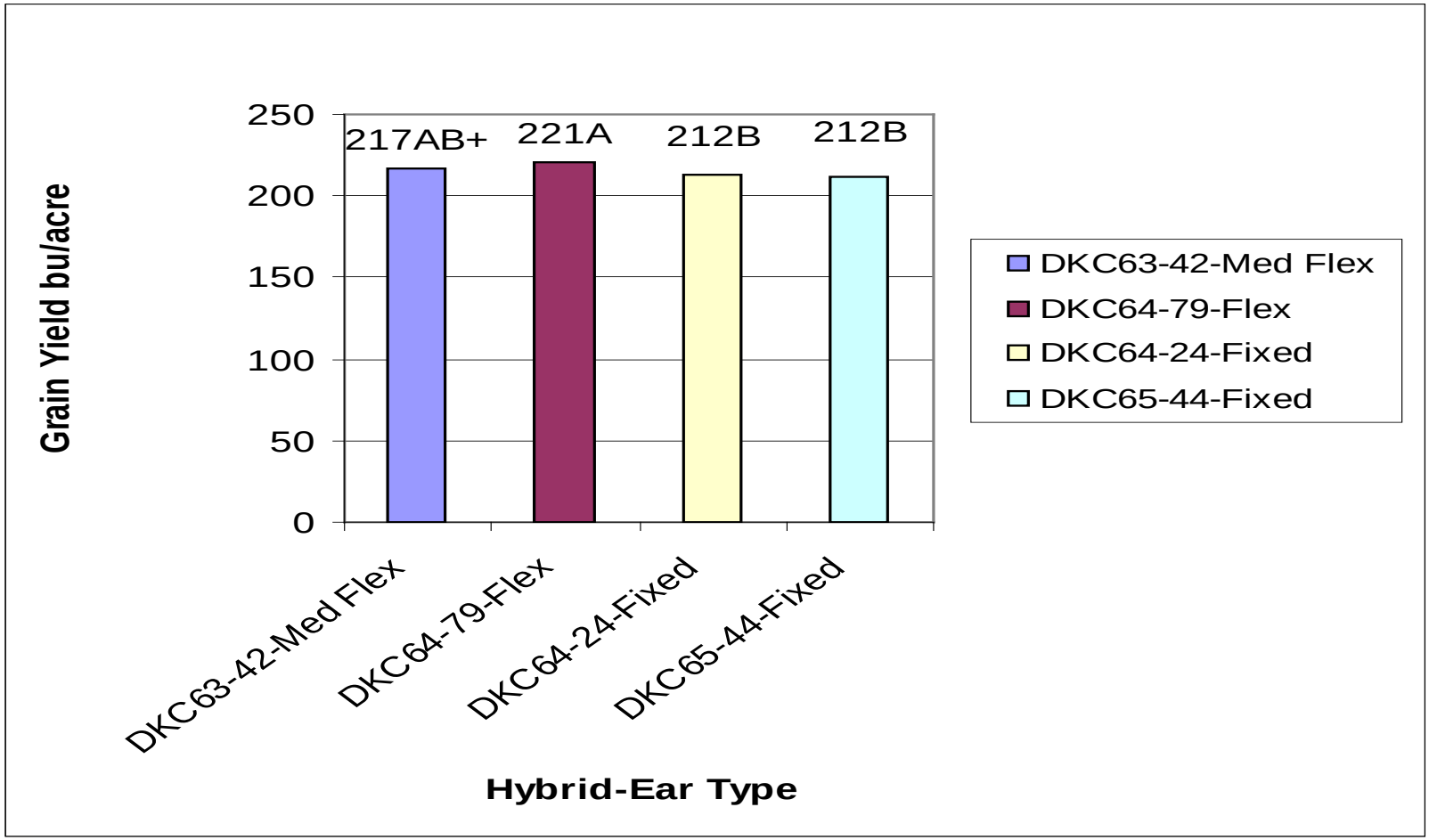
- Traits analyzed
  - Yield
  - Moisture
  - Test weight
  - Kernel rows per ear
  - Kernels per row
  - 100 kernel weight
  - Stalk lodging
  - Root lodging
  - Plant height

Yield Results



† Means followed by same letter are not different

Yield Results



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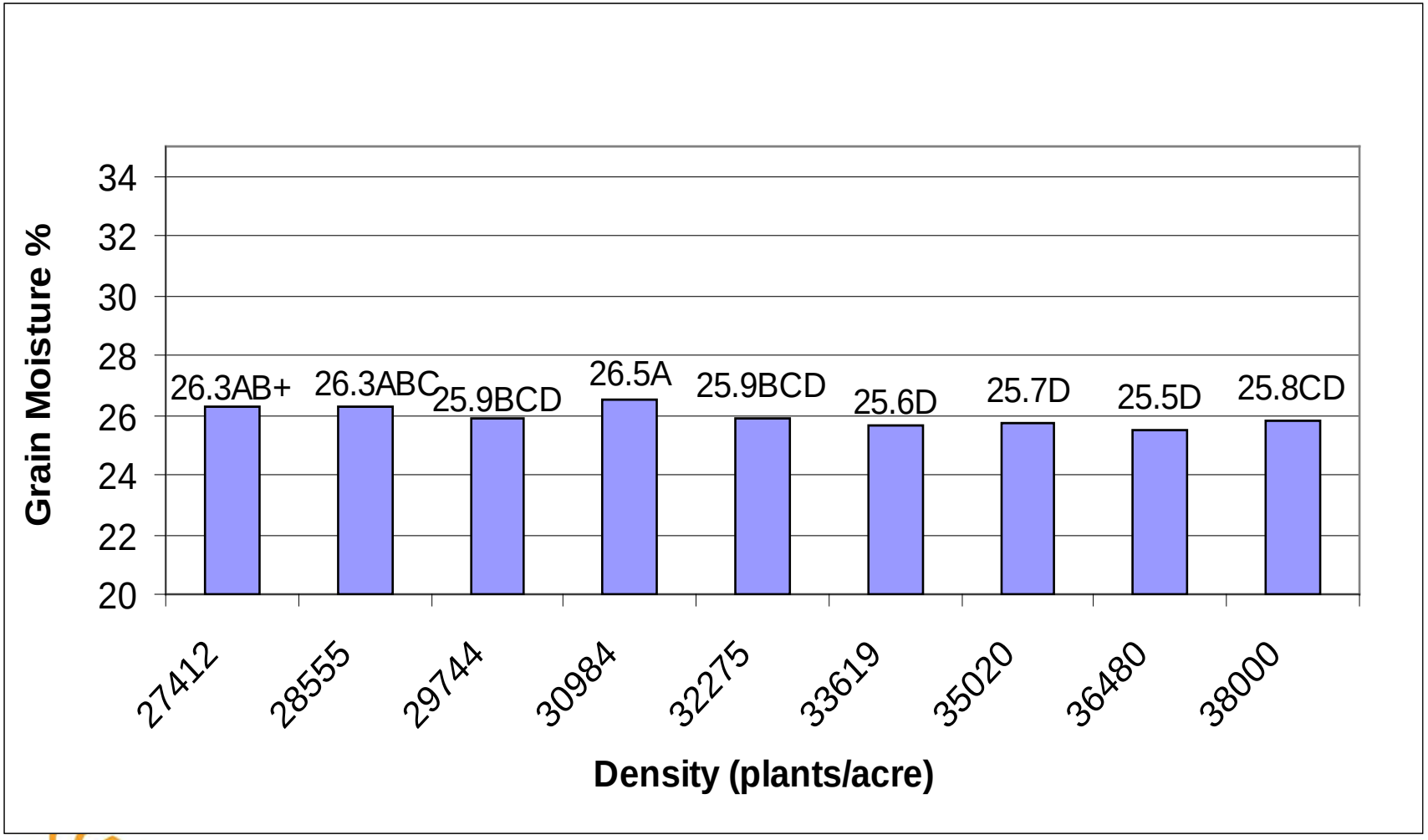
Grain Moisture Results



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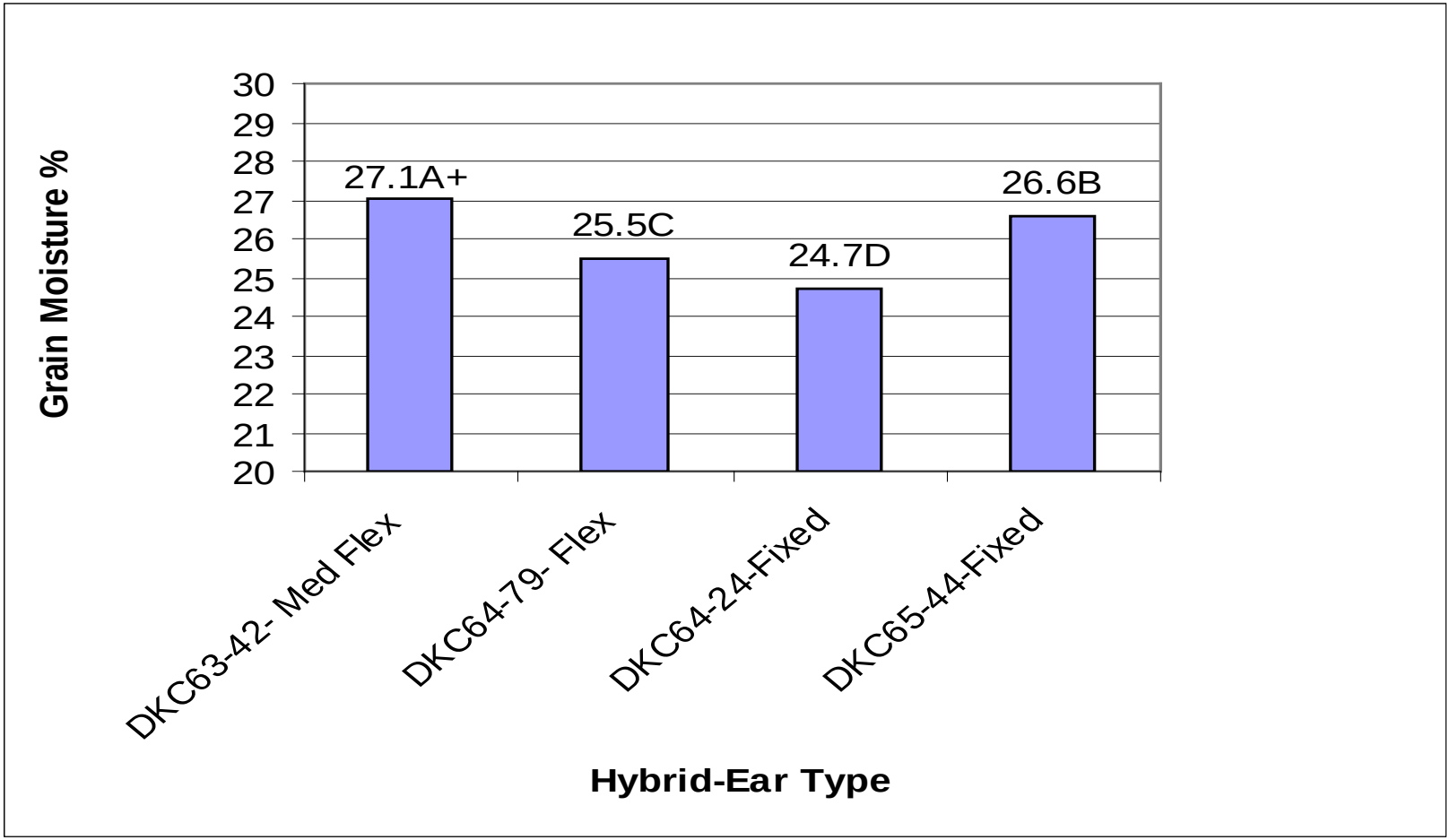
Grain Moisture Results



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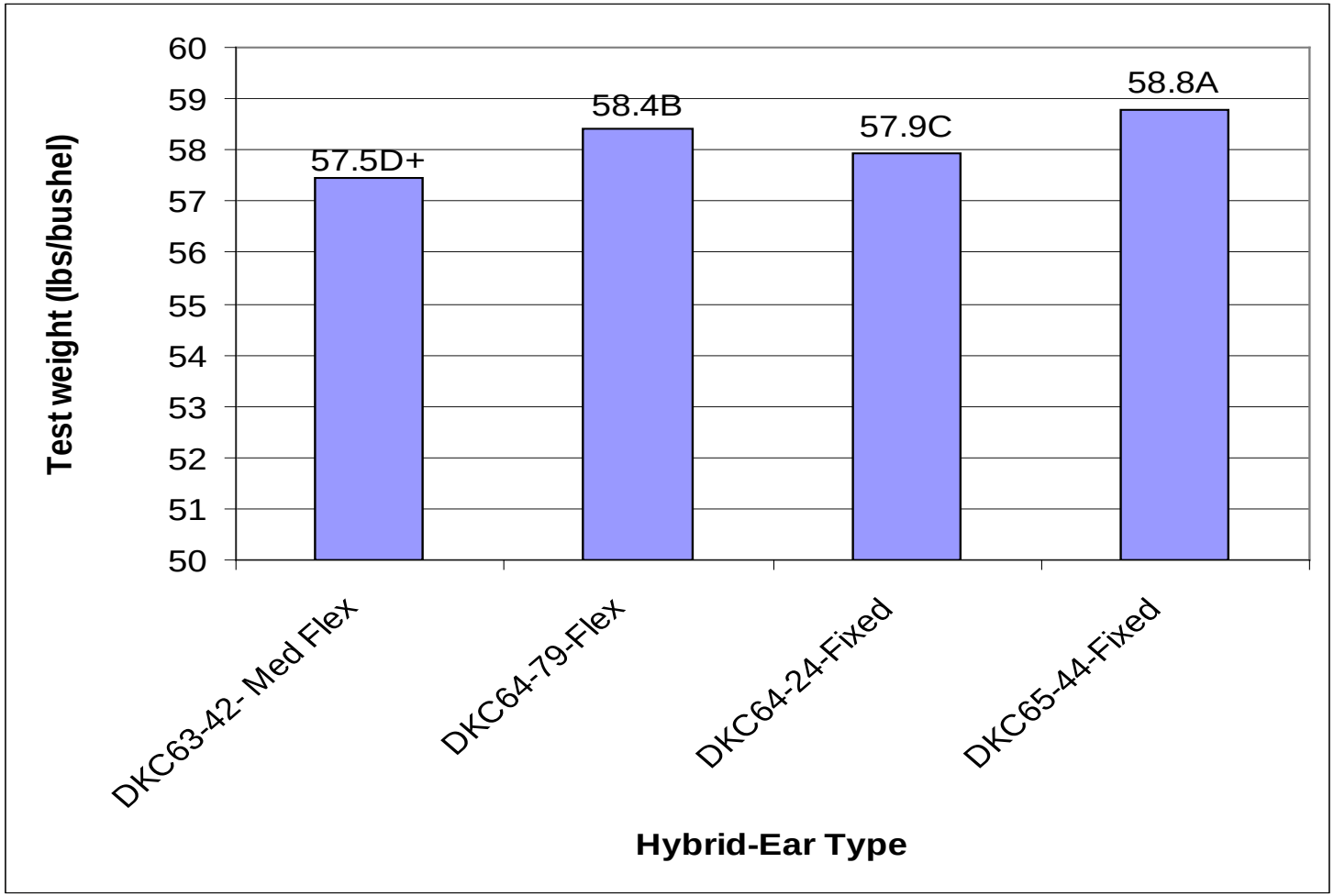
Test Weight Results



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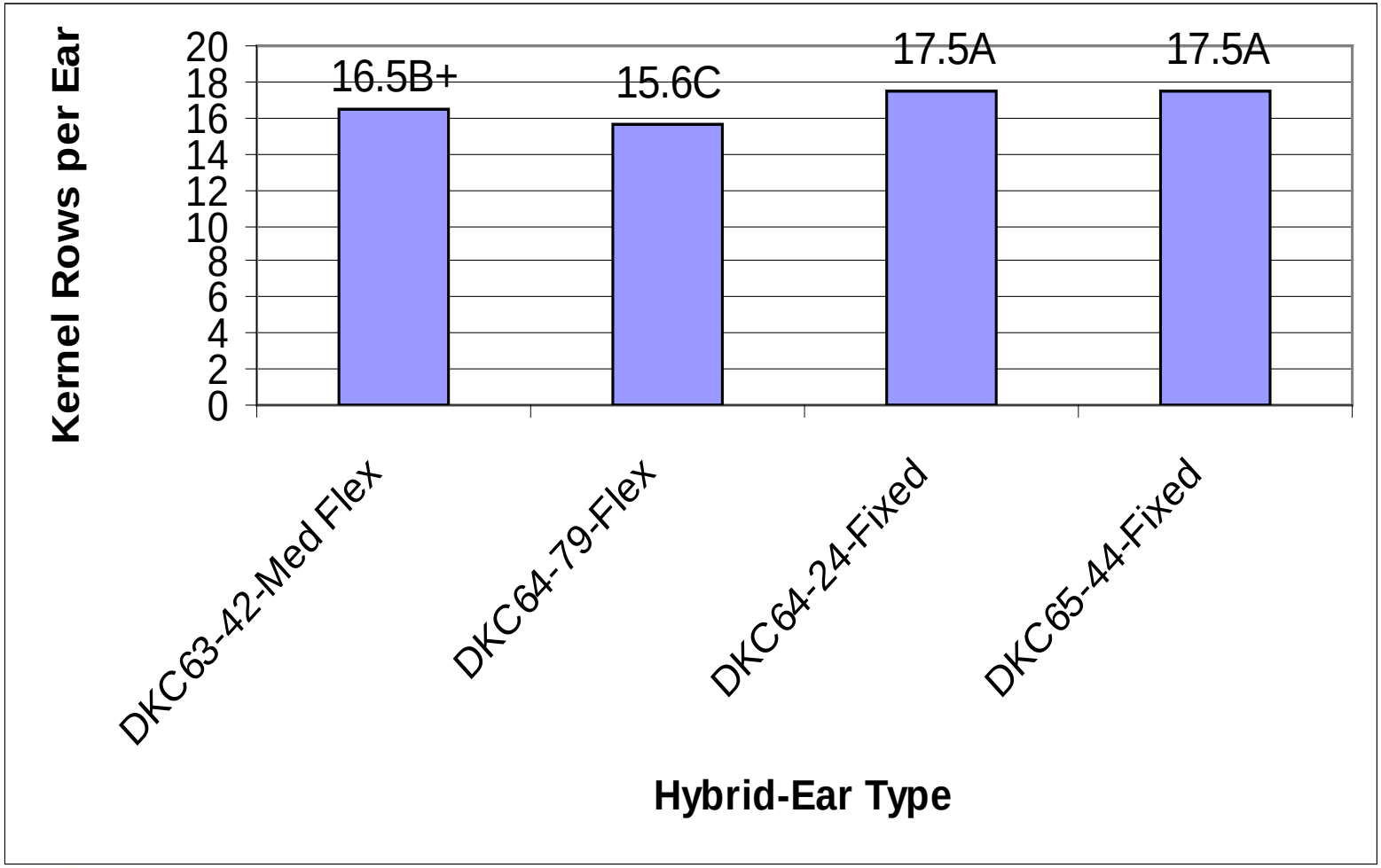
Kernel Rows per Ear



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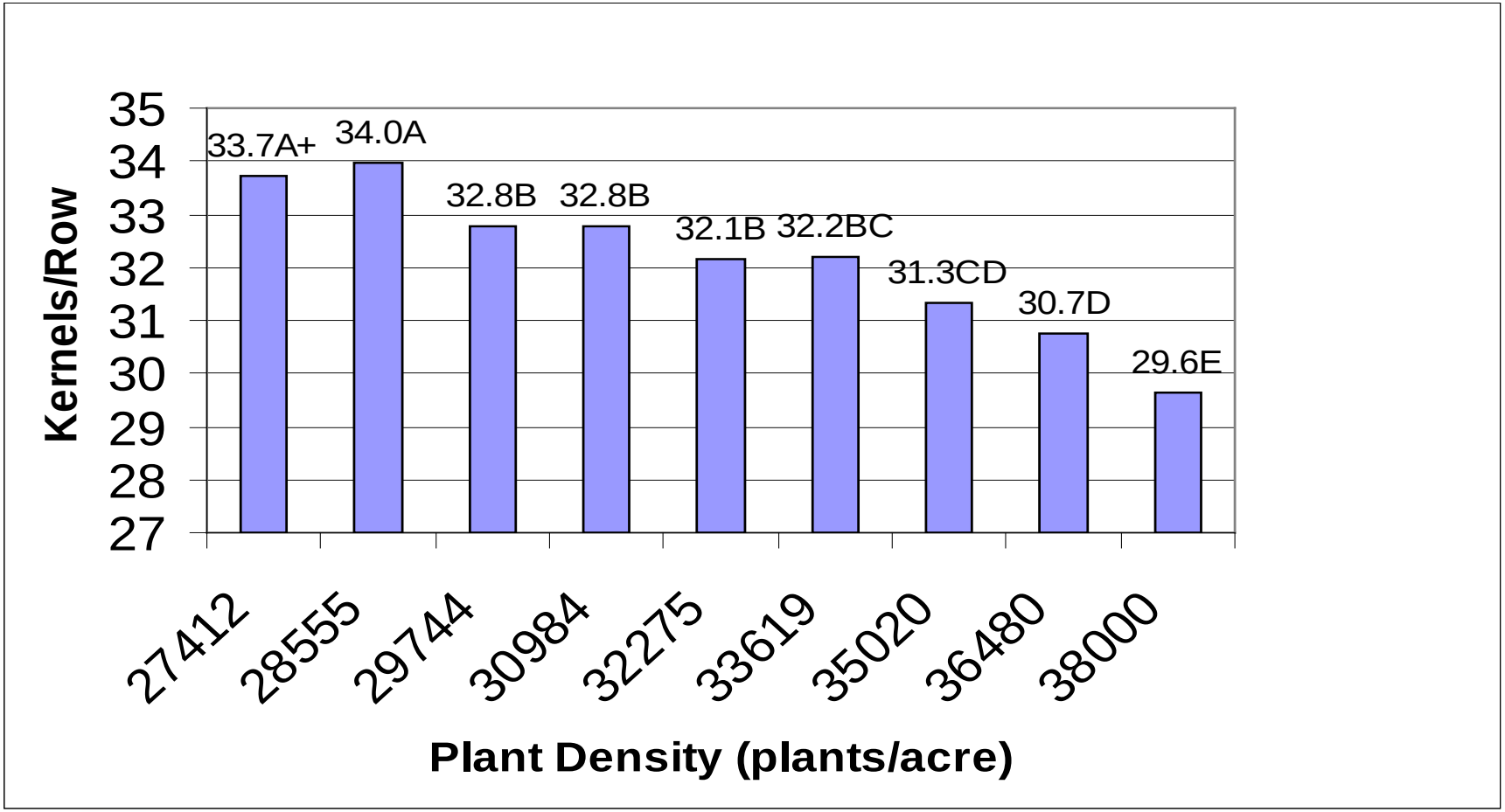
Kernels per Row



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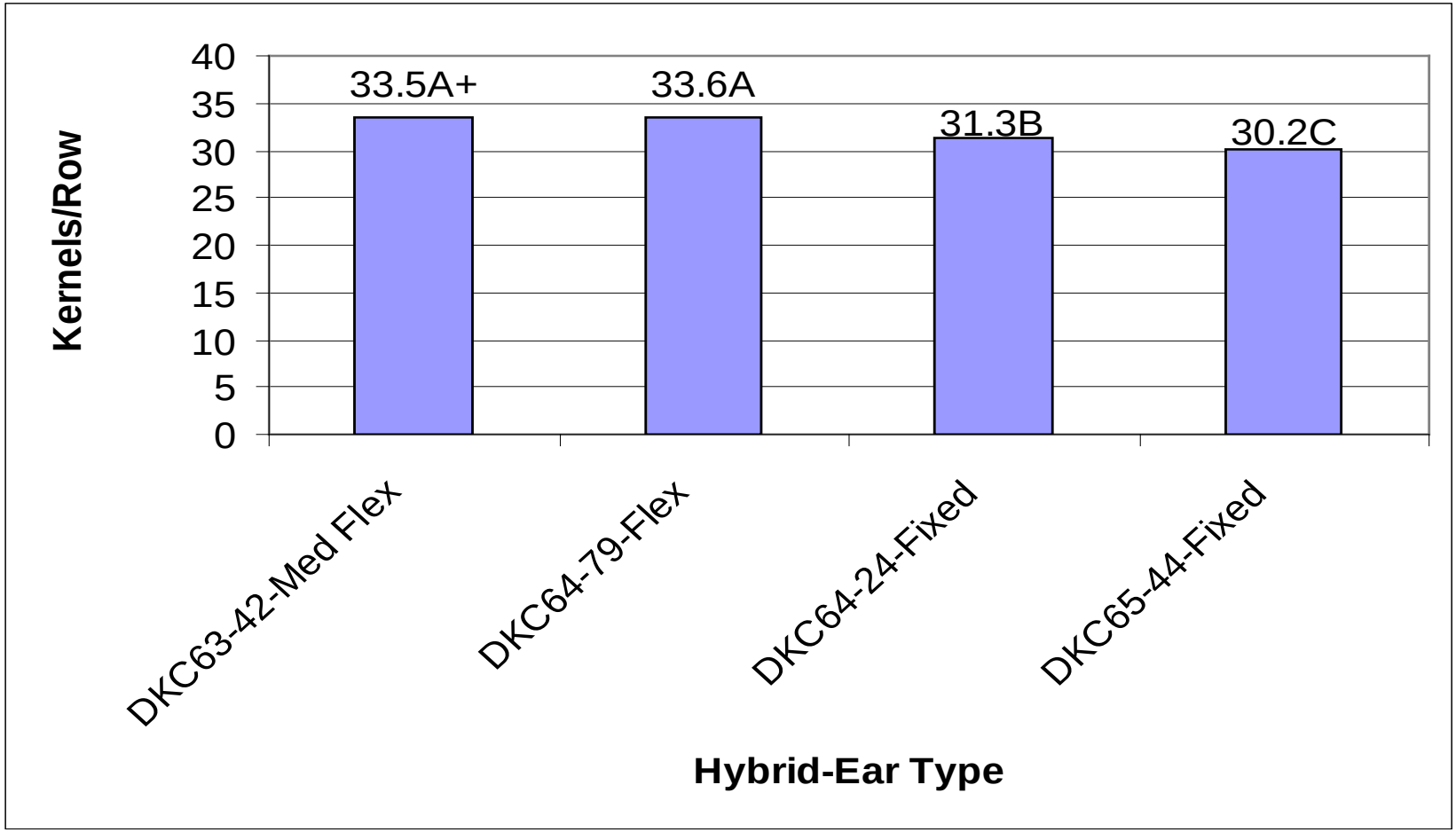
Kernels per Row

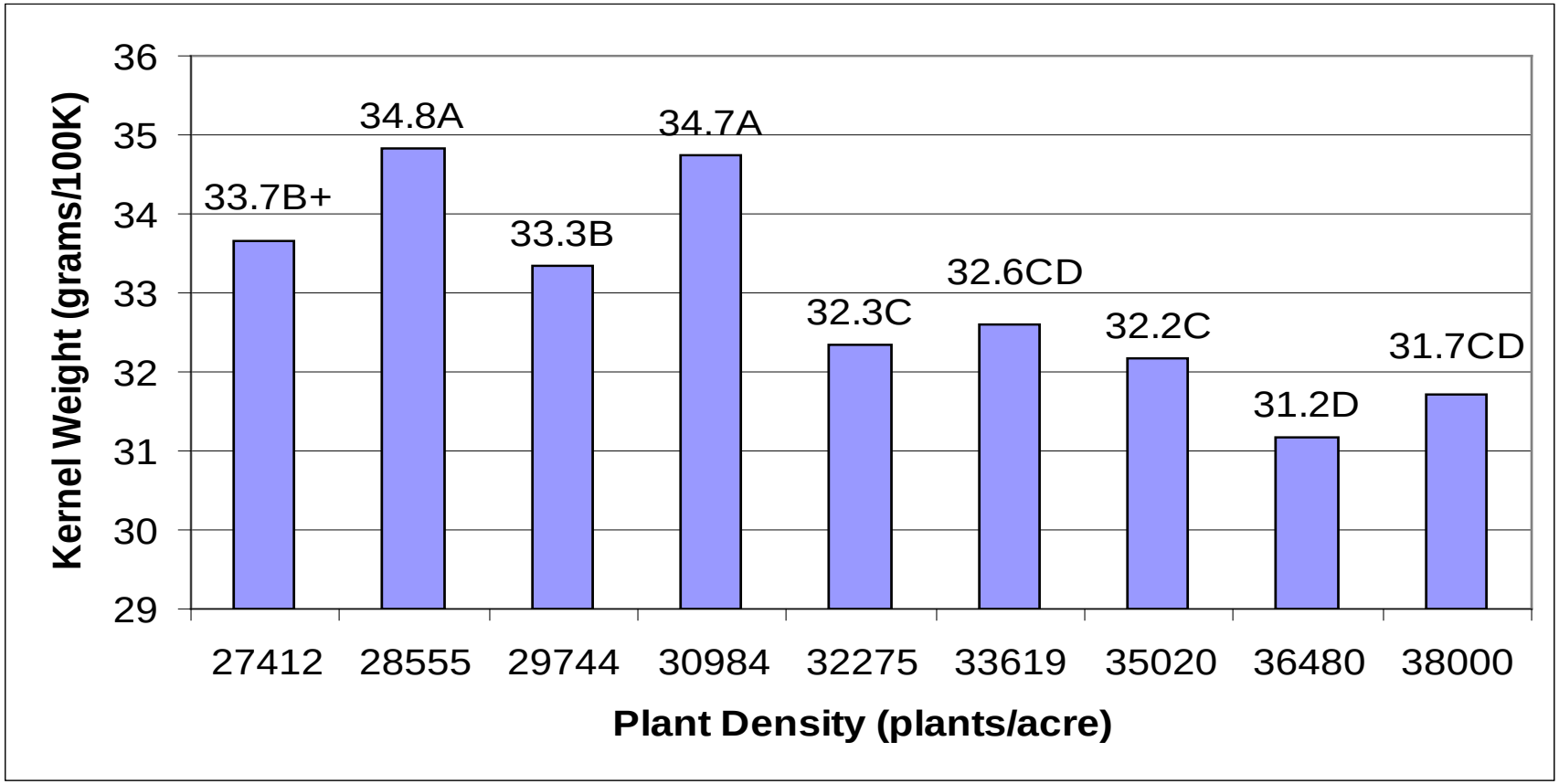


† Means followed by same letter are not different


DKC64-79-Flex
Density: 27,412
DKC64-79-Flex
Density: 38,000


DKC65-44-Fixed
Density: 27,412
DKC65-44-Fixed
Density: 38,000

100 Kernel Weight



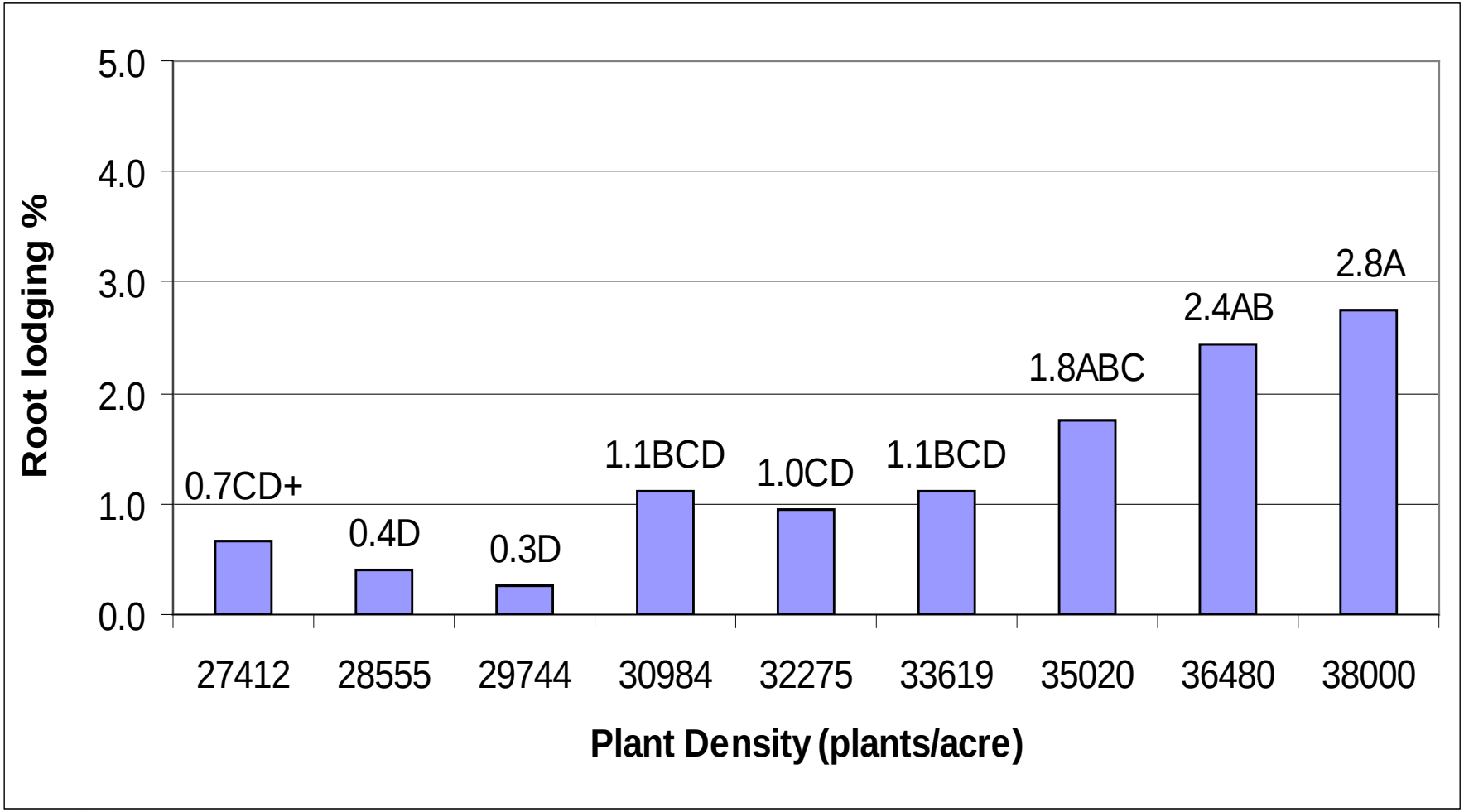
† Means followed by same letter are not different

100 Kernel Weight

Hybrid	Grams/100K
DKC64-24-Fixed	33.5A
DKC65-44-Fixed	33.3A
DKC64-79-Flex	33.0A
DKC63-42-Med Flex	31.8B

† Means followed by same letter are not different

Root Lodging



† Means followed by same letter are not different

Root Lodging

Hybrid	Root Lodging Percent
DKC64-79-Flex	2.1A
DKC63-42-Med Flex	1.9A
DKC64-24-Fixed	0.85B
DKC65-44-Fixed	0.22B

Conclusions

- No hybrid response to increasing density for:
  - Yield
  - Grain moisture
  - Test weight
  - Kernel row numbers
  - Kernels per ear
  - Kernel weight
  - Stalk lodging
  - Root lodging
  - Plant height

Conclusions

- The number of kernel rows per ear was less affected by density then was the number of kernels per row and kernel weights
- Difficult to conclude that a reduction in thinning could be warranted based on one year of data
- Could be worthwhile to continue to investigate if thinning could be reduced
  - If the range of plant densities can be increased without causing negative impact on yield comparisons

Conclusions

- This study showed that the two lowest densities limited the hybrids ability to yield and should be considered on the low end of what should be used to evaluate new hybrid performance

- Fixed-ear hybrids are not being given an advantage based on this data set

- Increasing density does not seem to favor either a fixed-ear or flexed-ear hybrid

Acknowledgements

- Iowa State University
- Drs. Elmore, Moore and Loynachan
- Dr. Mowers
- All of my colleagues at Monsanto
- Wife and family


Questions?