Evaluation of Plant Density and Row Spacing to Optimize Hybrid Performance

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In current hybrid corn production, plant population density and row spacing are two variables, among many, which can impact the performance of the corn crop. Density trends in North American corn production have shown a steady increase in seeding rates of greater than 300 plants / acre / year over the last two decades. This steady increase in plant density has triggered debate over row spacing optimization; however, row spacing trends are not clear. What is apparent is that plant population density can have a profound effect on individual plant characteristics such as stalk thickness and field level variables such as canopy closure. These changing characteristics have prompted questions about how to optimize commercial hybrid management for density and row spacing. As this debate continues more will be asked of corn researchers to properly characterize individual hybrid performance under these highly influential GxExMxT interactions. A portion of this work can be done by leveraging the technologies available today, which were not available only a few years ago, such as the integration of precision management practices. Ultimately, the need for characterization will impact the corn breeder, who must determine the selection criteria for which they are advancing lines. Selection and characterization across the depth and breadth of corn production practices will be important for developing successful commercial corn products in the coming years.

Evaluation of Plant Density and Row Spacing to Optimize Hybrid Performance

Illinois Corn Breeders School

March 04 – 05, 2013

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Agenda

- Production Trends
- Historical Density Trends
- Row Spacing Questions
- What does this mean to breeding?
- A couple minutes on Corn Stover

Corn Production Trends

- More Informed Management
- Assessment of G x E x M x T
- Better Characterized Hybrid Choices
- Investment in Equipment & Improvements
- Fertility & Chemistry
- Speed & Timing
- Technology
- Large Demand for #2 Yellow

- For researchers: keeping up with the extraordinary pace and ever increasing operation complexity is a challenge

- For farmers: what changes can be made to make this operation more profitable

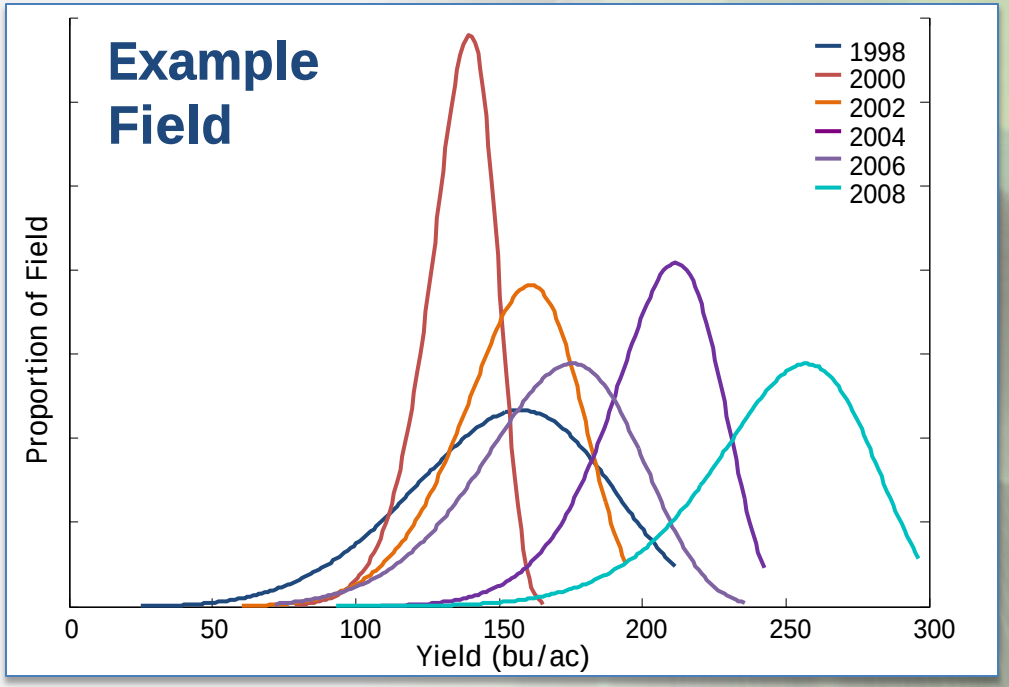
So Many Considerations…….

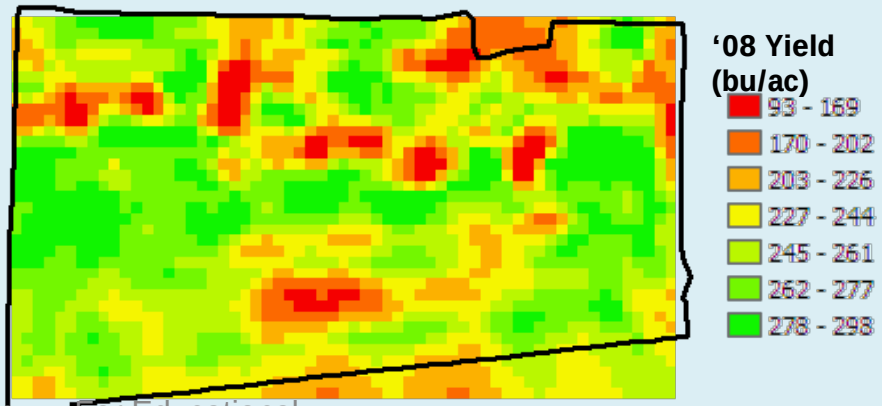
- Genetics
  - Which Hybrid(s), what trait package, seed treatment, etc
- Environment
  - Hybrid by field decisions, soil type, rotation, fertility, disease load.
- Management
  - Yield Target and subsequent input decisions.
- Technology
  - Not only newest seeds and traits, but utilizing data to make the most profitable decision.

More integrated management systems will allow for many variables to be evaluated and considered for the establishment of the corn crop.

A Key Concept: The Yield Distribution

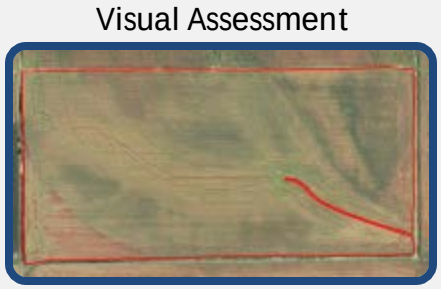
- The mean yield of a hybrid, field, or county provides little information about its characteristics
- Plants have biological and environmental constraints that limit the maximum yield
- Environmental factors (e.g., weather, pest damages, management) often affect output so low yields are frequently observed
- Yield is NOT just one number; it is a distribution

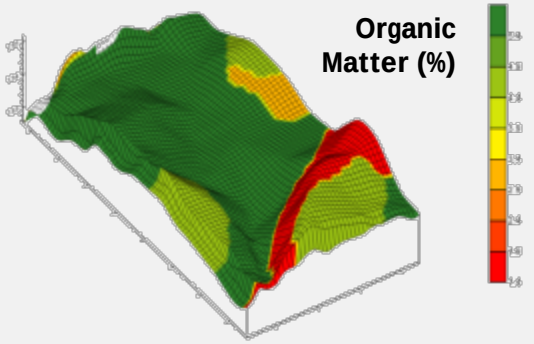


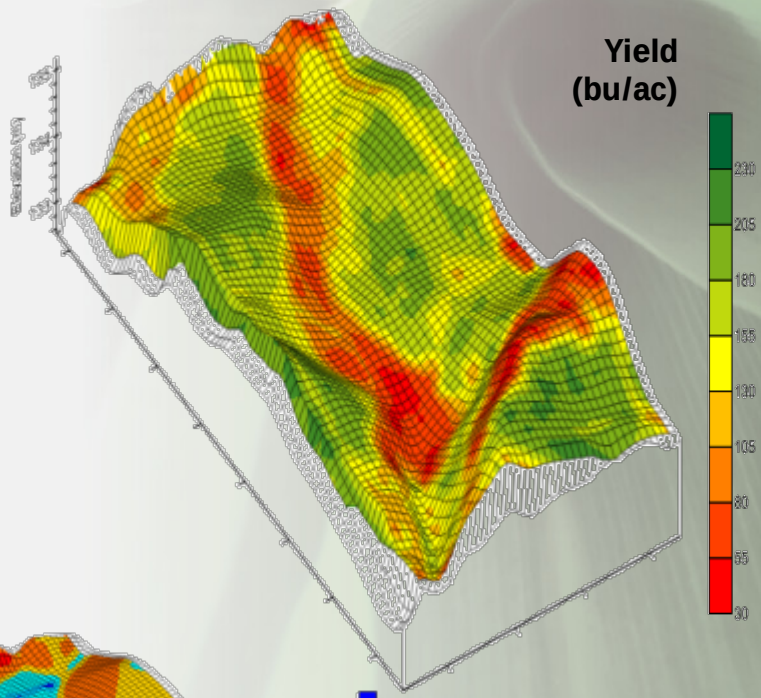


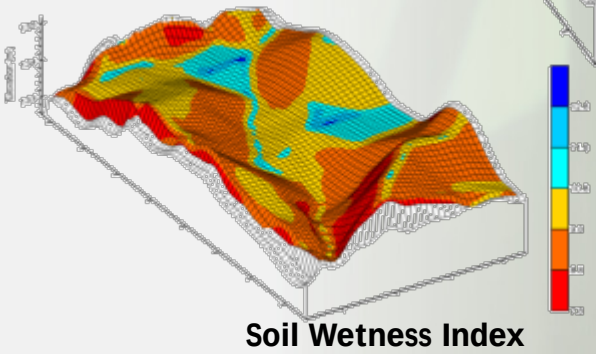
How To Impact Yield?

- Look at Probable Variables
- Incorporate Useful Data
- Develop Plan
- Gain Feedback
- Amend Hypotheses
- Utilize new tools









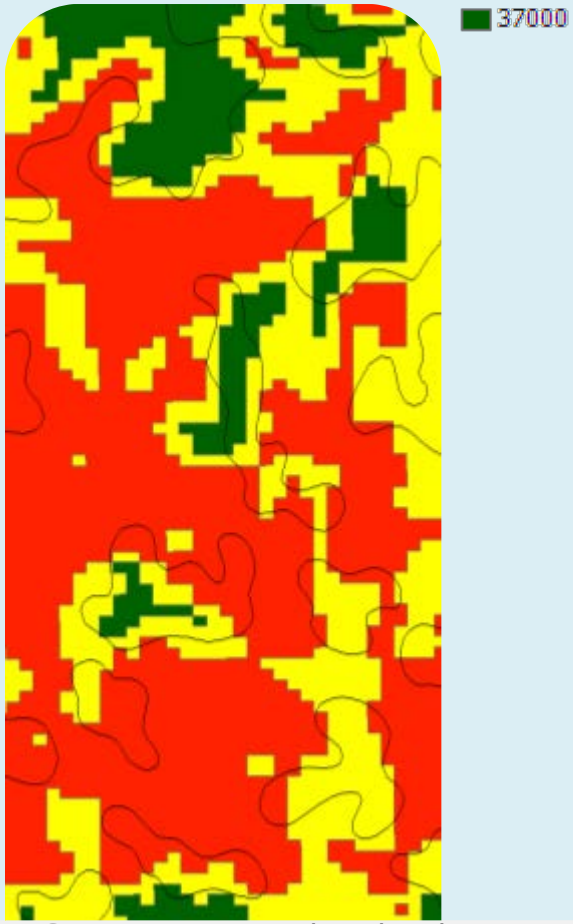
Application of Variable Rate Technology

Soil Type

Target Density

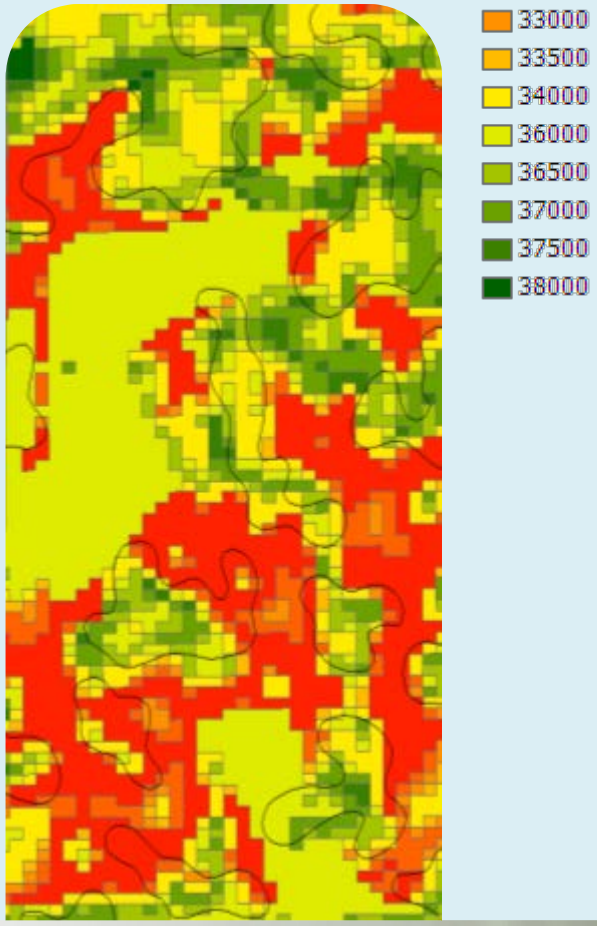
Normalized Yield

Target Density



FieldScripts℠

Target Density



Plant Density

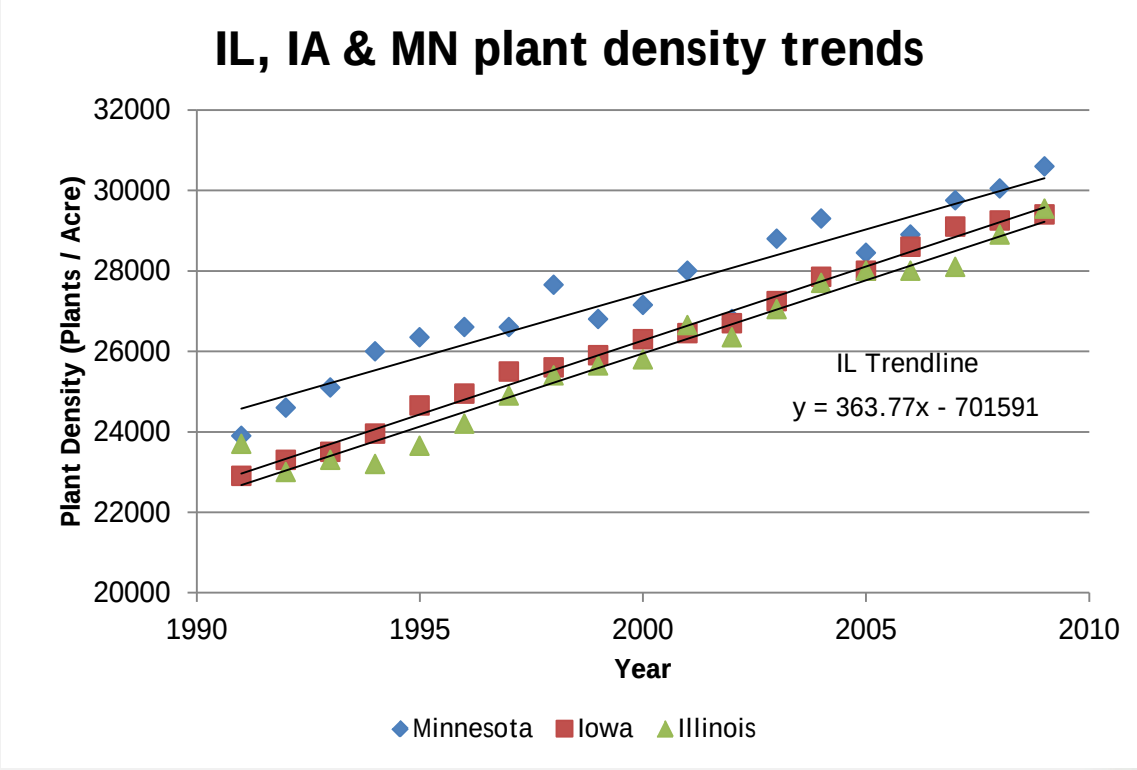
- Many management decisions interact to determine final yield, some variables are highly influential.
- Plant Density is one of these variables.
- What are the trends?
- What must plant breeders to do ensure hybrids are prepared for changing management variables?

Plant Density Trends:

A Steady Increase In Plants Per Acre

The improvements that allow for increased plant population have increased yield
The yield component most correlated with genetic gain is ears or kernels / unit area.

Average Plants Per Acre

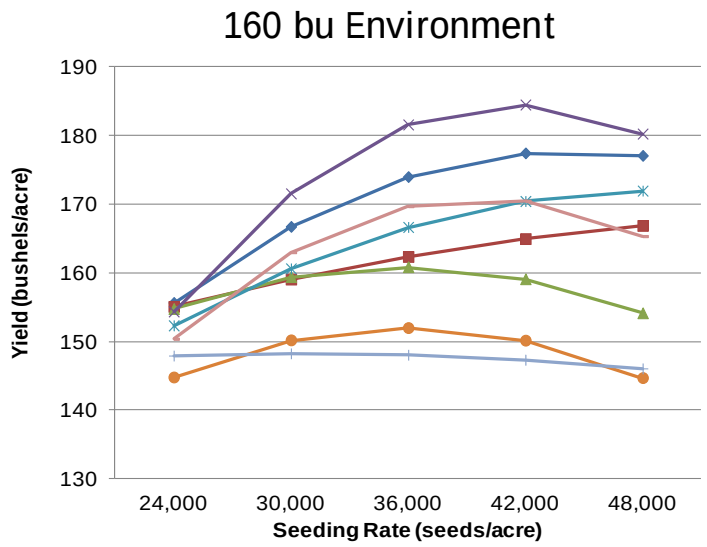


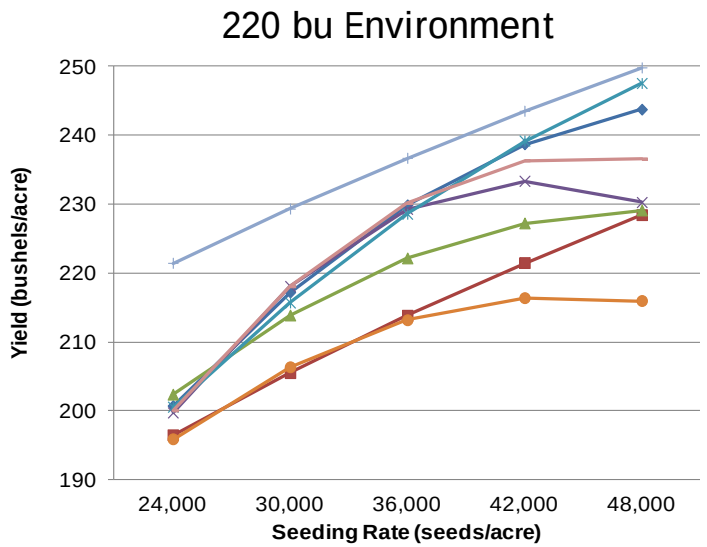
- Plants per acre in IL have increased at ~ 350 PPA / yr (R2 = 0.96) over the last 20 yrs... deceleration coming after a dry year?
- Expect NASS planting densities of >33,000 ppa by 2020
- Reports of corn planting densities exceeding 50,000 ppa.
- Movement toward multiple seeding densities.
  - Source: (USDA/NASS) & messengernews.net

Trends: Higher populations to achieve maximum yields

- It depends on the environment…and the environment depends on inputs
  - more cost implications at high yield levels

- Can we continue to develop corn which exhibits yield gain at higher and higher density?





Each line depicts the yield response to density for an individual hybrid under two yield environments.

Plant Density Effects on Corn Plant Mass

- As density increases the resource limitations have a dramatic impact on the average per plant biomass.

Target Density	Average of Total Stover (g/plant)	% decrease per 5000 plants	Average of Total Grain (g/plant)	% decrease per 5000 plants	Average Harvest Index	Average of Bushels / A (15% mst)
23000	149.9		187.7		0.56	196.4
28000	128.3	14%	167.5	11%	0.57	212.6
33000	114.8	10%	147.7	12%	0.56	218.6
38000	101.9	11%	131.4	11%	0.56	219.8
43000	101.3	1%	123.6	6%	0.55	221.4

~ Data from 2008 & 2009 Stover Plots: 26 hybrids at 20 site*yr locations
~Data collected at harvest not R6

Stalk Characterization

- Linear Decrease in Stalk Diameter and Thickness with relation to increased density
- While Rind Thickness and Internode Diameter don't correlate completely with stalk lodging it is a measureable trait that correlates with the force it takes to crush a stalk.
- Note the asymptotic response of Internode length (Plant Height) to Density

Density (Plants/A)	Stalk: Max Force to Crush (lbf)	Percent Change	Stalk Diameter (mm)	Percent Change	Stalk Rind Thickness (mm)	Percent Change	Average Internode Length (mm)	Percent Change
23000	37.82		17.84		1.15		165.73	
28000	31.26	-17.4%	16.54	-7.3%	1.08	-6.1%	169.11	2.0%
33000	26.19	-16.2%	15.87	-4.1%	1.00	-6.9%	174.21	3.0%
38000	23.10	-11.8%	15.04	-5.2%	0.96	-3.9%	173.81	-0.2%
43000	20.70	-10.4%	14.31	-4.9%	0.92	-4.4%	173.26	-0.3%

n=780 corn stalks characterized across 8 site-years.

Two stalk segments from the same commercial hybrid, one grown at 23,000 ppa, the other at 43,000 ppa.

Twice the population empirically means half of the resources on a per plant basis.

This adds to the complexity when evaluating hybrids for line selection and advancement.

Summary Thoughts on Density

- NASS shows a significant trend for increasing plant density in North America corn production
- USDA / NASS data below some other industry information.
- The coming years will see a trend toward variable rate seeding density as a more integrated farming model develops
- Hybrid performance and response to plant density is an important trait for characterization
- Selection of integrated variables within a breeding program will increase the complexity and challenge of line selection and hybrid development

Narrow Row Introduction

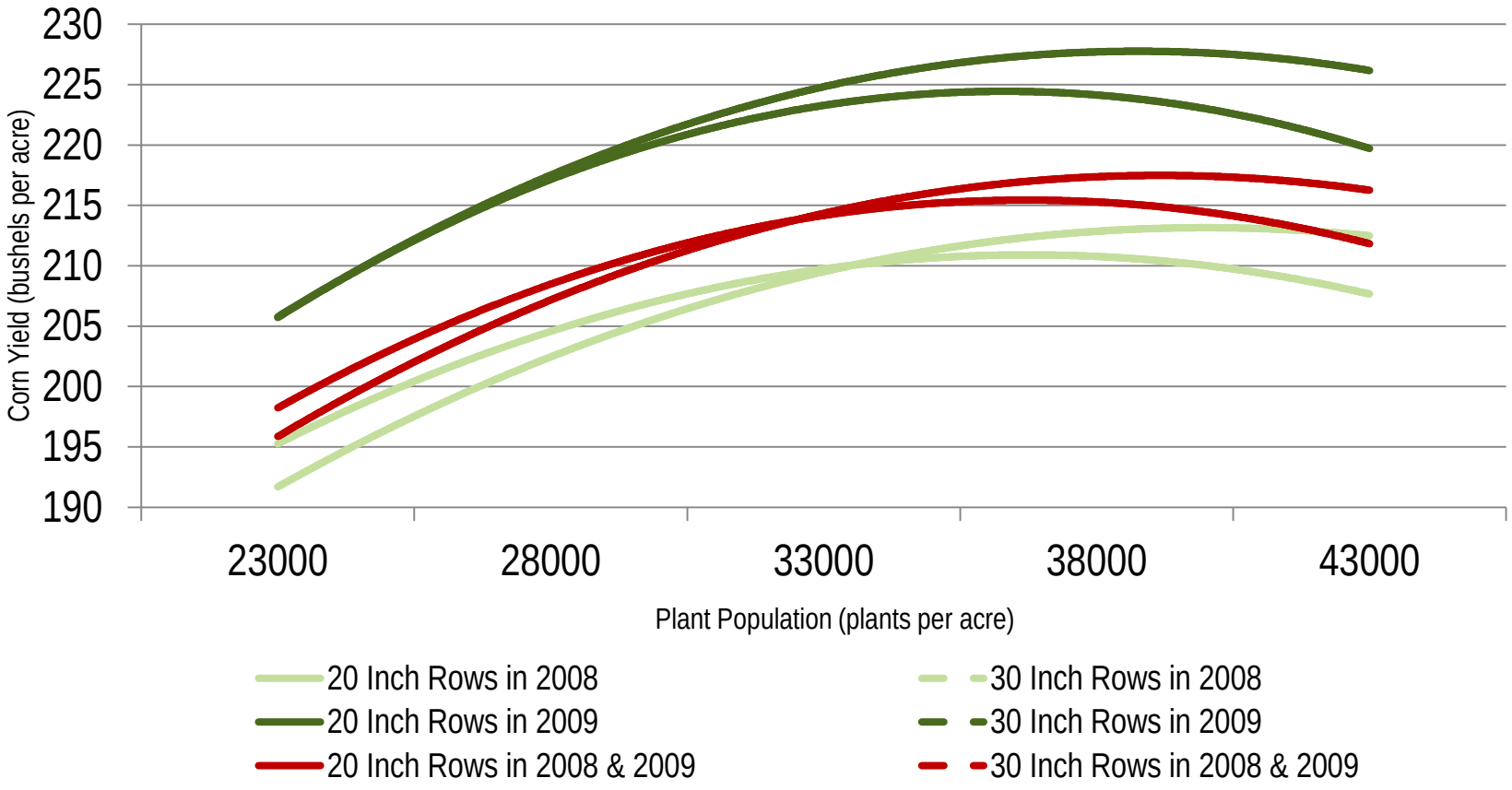
- What are the issues?
- Why move narrower?
- 30's, Twins, 20's, 15's, 12's?
- A few considerations
  - Equipment
    - (Converting and Trading)
  - Targeted Density & Yield Potential
  - Other world areas
  - Industry seems to be caught in a chicken or egg argument.

Artwork: Purdue University – Agron. Dept
by permission: Dr. RL (Bob) Nielsen

Yield Response to Row Spacing

Highly dependent on other variables. Generally in high yielding conditions where high density is important, 20”rows show some advantage.

Effect of population, row spacing, and year on yield potential. *Source: Monsanto data 2008 and 2009.*



Light Interception

Average of Licor LAI reading taken ~V8 (LAI-est)	**Planting Density (PPA)**				
Row Spacing	**23000**	**28000**	**33000**	**38000**	**43000**
20”	1.44	1.61	1.78*	1.83*	2.28**
30”	1.42	1.62	1.62	1.70	1.88

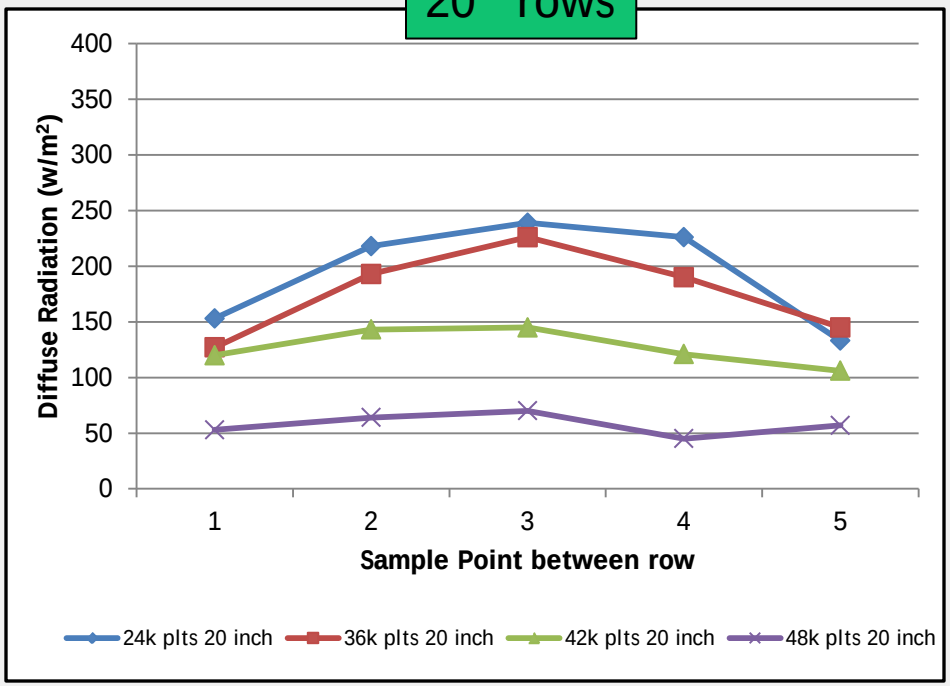
- Benefits of Narrow Rows include better light interception, more equidistant plant and root orientation, canopy closure for weed control, etc.
- Measurements taken at 4 spots between rows and above canopy in each plot.
- A clear row spacing by plant density interaction is observed at higher plant densities

Mid-Season Solar Data

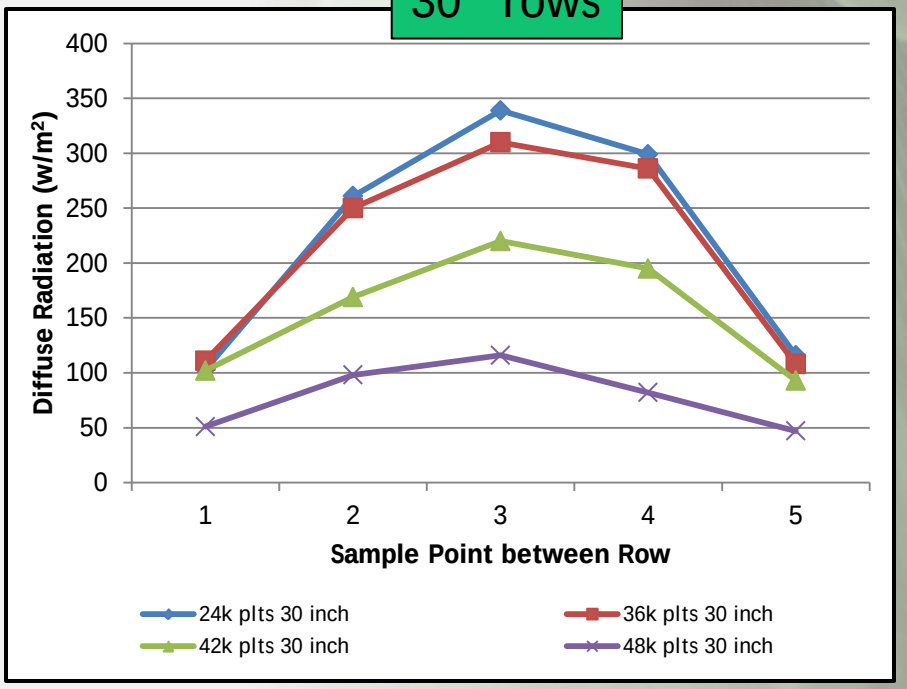
- Solar data from density trials
- Collected with LiCor LAI-2000
- Raw Diffuse Solar Radiation Values between rows
- Two – 5 reading reps per row space*density plot
- One hybrid – One week after flowering

- Same relationship as seen in previous study: Row Spacing * Density Interaction

20” rows



30” rows



Row Spacing Summary

- Row spacing data is highly variable across published research
- In a corn system, Row Spacing is probably a variable driven by the optimum plant density determined from other management variables.
- It can be hypothesized that narrower rows can improve plant canopy characteristics – more so at higher planting density
- Row Spacing is definitely a variable currently driven by other non-corn production variables
  - Synergistic opportunities:
    - Beet production in the North
    - Seed production
  - Yield Potential
  - Equipment Trade-In; Lease program

Breeding considerations for a changing production landscape

- Many plant characteristics are dependent upon Environmental and Management variables.
- How these variables impact different hybrids across treatment variables is an important consideration for hybrid characterization.
- As characterization variables gain value it will be important for corn breeders to be aware of the range of these variables as they determine their testing selection criteria.
- Density is one of the most important management variables affecting hybrid performance.
- At high density, row spacing may also be an important variable.

Corn Stover Co-Product

Options for increased corn demand

One pass with Cornrower: 8 rows of grain harvested, stalks chopped and windrowed

- Monsanto, along with other industry partners, has participated in an ongoing project to find sustainable utility in corn stover as a feedstock and / or grain co-product

- The objective is to provide guidance and resources to stover end users for economical and sustainable stover collection.

- Our most recent work has been with ADM, Deere, ISU, UNL, Purdue, the SunGrant initiative, and numerous cattle feeders toward the utility of Stover as an portion of a economical ruminant ration.

- Results show that corn stover can be sustainably removed from many production scenarios.

- The stover can be upgraded with Calcium Oxide to improve digestibility

- The stover can then displace a large portion of the grain from the cattle ration when combined with distillers grains.

- This can be done with minimal impact on rate of gain and becomes a very economical model from a feeding perspective.
  - Farmgate economic models being developed.

Questions