Thoughts on Row Spacing & Plant Population

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It’s all about capturing sunlight!

Building a crop canopy

- Every agronomic decision you make potentially influences crop canopy development and the capacity to intercept sunlight. Hybrid | Seeding rate | Row width | Irrigation
- Soil fertility | Weed control | Planting date | Foliar fungicide
- Not to mention the influences of weather, soils, and pests during canopy developmt.
Bottom line on seeding rates...

- Current data suggest that many growers should be targeting **economic FINAL stands** no less than ~ 30,000 ppa; equal to a seeding rate of ~ 33,000 spa.
- Exceptions being...
  - Lower yielding environments (e.g., 130 bpa or less) where growers should target final populations between ~ 24 to 30,000 ppa.
  - More northern areas where final stands may need to be 33,000 ppa or greater.

Balancing act for corn...

- More plants per unit area equals more ears per unit area. (that’s good)
- But, ear size per plant decreases with increasing plant density. (that’s not good)
- The optimum final stand is that which best balances the decrease in ear size per plant with the gain in ears per unit area.
- Furthermore, stalk health & integrity at higher populations sometimes falters.

Harvest populations - Illinois

Average harvest populations reported by Illinois corn growers have been steadily increasing by about 370 plts/ac/yr over the past 20 years.
Average harvest populations reported by Indiana corn growers have been steadily increasing by about 310 plts/ac/yr over the past 20 years.

Since 2005, a decrease in the lowest populations and an increase in higher populations.

Since 2007, a decrease in the middle populations and an increase in higher populations.

Source: USDA-NASS Crop Production Reports
Grain Yield vs Final Stand
2007-2009 NCGA Winners

Very little relationship between grain yield and harvest plant population among the top winners.

Identifying optimum seeding rates

- Seeding rates represent a quantitative input, so ought to develop a yield response curve to estimate optimum rate.
  - Similar to how we evaluate N rates.
- Simply comparing one rate vs. another may answer which is superior, but does not offer best estimate of optimum rate.

My rate vs. your rate

6 Combinations of High vs. Low populations
High 33k to 42k
Low 28k to 35k
33 replicated strip trials (18 counties)
Avg yield difference = -0.2 bpa

What do you learn from this effort?

Identities of the researchers have been removed to protect the guilty.
Yield response to seeding rates

- It is not feasible to evaluate yield response to every possible seeding rate alternative.
- So, we evaluate yield response to four to six seeding rates that represent the range of possible seeding rates and then develop a yield response curve.
  - E.g., 29k, 34k, 39k, and 44k seeding rates.

Yield response to seeding rates...

- Lower and higher than optimum seeding rates included to capture full range of yield response.

Choice of response curves

- To describe yield response to plant density, there are alternative “shapes” of response curves to choose from.
  - Statistically, one or two or all of them may offer good “fits” to the data set.
  - It is a certain amount of responsibility on the researcher’s part to choose the model that visually reflects the yield response to the actual data.
Simple linear
Simple quadratic
Linear plateau
Quadratic plateau

Common choices

Yield response example

- Quadratic response model;
- Easy to create w/ Excel™;
- Offers good “fit” to the data

R² = 0.9467

Yield response example

- Quadratic-plateau response model;
- Requires more robust stats program;
- Also offers good “fit” to the data
Why does this matter?

- Choice of model can influence estimation of optimum plant population.

![Graph showing quadratic and quadratic plateau models with R² = 0.9467.]

With seed corn ~ $3 per thousand........

More “curve balls”

- Sometimes, you have no business trying to fit a yield response curve to the data.
- In other words, sometimes there is no yield response.

![Graph showing percent of max. yield against harvest population.]

An example...

- Recent public data suggested an agronomic yield plateau occurred close to 36,000 seeding rate.
- Supporting data points not shown.

![Graph showing corn grain yield at varying seeding rates.]

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Follow-up to that data...

Suggested optimum plant population ranging from 36k to 38k plts/acre, though confusing because previous response curve was for SEEDING rate.

Data behind the curve...

If these were your data, would you stand behind a quadratic model or any model?

Yield response by yield level

Figure 3. Corn grain yield response to plant population by location yield level. 2004 to 2007 (n is the number of observations within a yield range.)
Whoa...let’s take another look

- Those data were analyzed by fitting quadratic curves to the yield response data.
- What if a quadratic-plateau model were used instead?

Yield response by yield level

Est’s of optimum population based on a QP model were 2k to 4k lower than those based on quadratic model.

Monsanto summary...

Figure 1. Effect of population and year on yield potential. Source: Monsanto data 2008 and 2009.
Seeding rates & yield levels

Estimated optimum seeding rates for 113 RM hybrids grown in 3 yield environments.

Figure 5. Effect of population on seed yield. Source: Monsanto data from Phar 6 RY Yield Estimator National 113 RM Hybrid. 2008 and 2009. – 2011 Purdue University.

Recent university data...

- Iowa: Suggests optimum final stands level out around 30,000 ppa.
- Southern IL: Suggests optimum final stands closer to 24,000 ppa (more challenging soils).
- Northern IL: Suggests optimum final stands near 35,000 ppa.
- Central/southern MI: Suggests optimum final stands near 36,000 ppa.

2001 - 2004 Large plot trials...

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2008 - 2010 Seeding Rate Trials

- On-farm, replicated trials to evaluate corn yield response to plant populations.
  - Farmer cooperators using their own farm equipment to plant and harvest.
- Contact your local Extension educator or Certified Crop Adviser if you would like to participate in 2011.

2008 - 2010 OFR trials...

- Percent of max. yield vs. seeding rate
- Note similar response to older data with older hybrids

Seeding rate decisions...

- Are influenced by actual yield response to plant population and the cost of seed.
  - Agronomic optimum seeding rates
    - Maximum yield regardless of cost.
  - Economic optimum seeding rates
    - Maximum $ return to seed inputs.
Today’s elite hybrids?

- Some claim that today’s elite multiple biotech trait hybrids respond better to higher seeding rates than today’s elite non-biotech or simply RR hybrids.
  - However, there is little, if any, independent data to support the claim.
  - Today’s hybrids are simply more stress tolerant across the board than those of 20 years ago.

Bt vs. non-Bt response, WI

- “It was concluded that Bt corn hybrids require higher plant populations for maximizing yield potential…”
  - 42.3k vs. 40k plants per acre, but economically equal at 34k
Bt vs. near isoline hybrids

- Non-Bt vs. Bt-RW or Bt-RW-ECB
- Six site-yrs for corn / soy
  Two site-yrs for corn / corn
- Yield responses to plant density equal
  - Economic maximum plant density across all hybrids ranged from 32k in IL to 37k in IA.

Data source: Coulter et al. (2010)

Seeding rate decisions...

- Are not influenced very much by hybrid.
- Today's hybrids in general have much better population tolerance than their predecessors.
  - Improved ability to maintain ear size at higher plant densities.
  - Less tendency to remobilize stored stalk carbohydrate reserves during stressful grain fill; thus less tendency for stalk lodging at higher plant densities.

Stalk health concern...

- Remains an issue for hybrids with moderate or worse stalk strength or stalk rot resistance.
- Such hybrids should be planted at more moderate seeding rates to minimize the risk of severe stalk lodging prior to harvest.
Current data suggest that many growers should be targeting economic FINAL stands no less than ~30,000 ppa; equal to a seeding rate of ~33,000 spa.

Exceptions being…
- Lower yielding environments (e.g., 130 bpa or less) where growers should target final populations between ~24 to 30,000 ppa.
- More northern areas where final stands may need to be 33,000 ppa or greater.

What about “fixed” and “flex” ear hybrids?
- Surely their optimum plant populations differ?

Hybrids are thought to differ for their ear size response to plant densities.
- Commonly used terminology includes “flex”, “semi-flex”, or “fixed” ears.
- “Flex” hybrids are thought to change ear size (kernel number) more dramatically in response to low or high plant density than that of “fixed” hybrids.
Ear flex: Not well documented

Interestingly, there is very little scientific literature that documents hybrid ear size response to plant density.

- What little there is suggests that “fixed” and “flex” hybrids share common plant densities for achieving optimum grain yields.
- Occasionally, I evaluate such hybrids in plant density demos at our crop diagnostic training center facility.

2005 Comparisons...

- Two hybrids rated by a seed company as strongly “fixed” or “flex” were planted at 15, 30, 40, & 50k seeds per acre.
- Random ears were sampled from each plot.
  - Numbers of kernel rows & kernels per row were counted for each individual ear.
  - Total kernels per ear were calculated and expressed as a percent of mean kernel number for 30k seeding rate.

- “Flex” hybrid indeed flexed at both low and high plant densities.
- “Fixed” hybrid flexed more than “flex” hybrid???
2006: Different pair of hybrids

- More “flex” at low pops
- Less “flex” at high pops

2008: Yet another pair of hybrids

- More “flex” at low and high pops

Bottom line...

- Essentially, all hybrids flex ear size in response to changes in plant density.
- Some flex more than others, but apparently not as consistently as some seed companies claim they do.
Bottom line on seeding rates…

- Current data suggest that many growers should be targeting economic **final** stands no less than ~ 30,000 ppa; equal to a seeding rate of ~ 33,000 spa.
- Exceptions being…
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My opinion on row spacing…

- Traditional 30-inch rows are not a primary limiting factor for corn grain yield today in the heart of the Corn Belt.

The move to 30-inch rows…

- Was accompanied by a good consensus by public researchers throughout the Corn Belt that 30-inch rows would yield 6 to 7 percent better than 36- or 38-inch rows.
- But, what about a move from 30-inch rows to narrower rows today?
  - Has garnered farm press attention for years.
Some folks say…

- "I’m gonna switch to 20-inch rows because I hear the “big boys” are doing it and are harvesting 20 to 40 more bu/acre!"
- "I’ve heard that narrow rows don’t work until you push populations to 45,000."
- “There’s been a rapid adoption of narrower rows in recent years.”
Row spacing decisions are...
- Influenced by machinery issues:
  - Equipment tire size
  - Post-planting operations
  - Planters & seed meters
  - Combine headers
  - Row irrigation
  - Compatibility with other crops

Row spacing decisions...
- Are also influenced by the crop's yield response to narrower rows...
  - Primarily related to plant-to-plant competition for available water, nutrients, and light.
  - If more than enough water, nutrients, & light; then NOT likely to see a significant response to narrower rows.

Response to row spacing...
- Is also related to whether the crop canopy is “capturing” at least 95% of the available sunlight during flowering or beyond.
  - Barbieri et al. (2000), Maddoni et al. (2006)
Light capture in wide vs narrow rows

Up to ~95% light capture, narrow rows usually capture more light than wider rows.

![Graph showing fPAR vs. Maximum IPARNR]

**fPAR** = Fraction of Photosynthetically Active Radiation intercepted by crop canopy

![Graph showing Yield response vs. light capture]

- Possible ½ to ¾ percent yield increase for each percentage point increase in sunlight capture up to about 95% capture.
  - Andrade et al. (2002)

Consequently...

- Narrow rows may be most beneficial where canopy development & yield are challenged by marginal soils or climates.
  - Northern climates (cooler, less growth).
  - Nutrient deficient soils (esp. nitrogen).
  - Sandy, non-irrigated, often droughty soils.
  - Shorter-season hybrids.
  - Smaller, shorter, less leafy hybrids.
Use your eyes…

- Estimate % light capture by estimating % shade beneath the crop canopy shortly after noon on a sunny day in early July.
  - If less than ~ 95% shade, then likely not at maximum yield potential.

Most public research…

- Indicates that yield response to row spacing narrower than 30 inches is generally positive, but very inconsistent.
  - Averaging 1.5 to 2.5% advantage.
  - Most have found that optimum seeding rates are similar for different row widths.

Reported Responses to Narrow Rows (15- or 20-inch) 1984-95

- Average response = + 1.5%
- % Difference to narrow rows
Reported Responses to Narrow Rows (15- or 20-inch) Since 1996

Average response = +2.6%

Source: scientific literature

Purdue twin row data 2009

Westcentral Indiana 2009
Four seeding rates (28 – 43 spa)
[no interaction among seeding rates]
Average yield for trial = 232 bpa

Source: T. Vyn, Purdue Agronomy

Purdue twin row data 2010

Westcentral Indiana 2010
Four seeding rates (28 – 43 spa)
Average yield for trial = 192 bpa

Source: T. Vyn, Purdue Agronomy
Purdue OFR data, 2010

Data from industry sources...
- Varies, but tends to show similar relatively low percent yield responses for narrow rows; including twin-row configurations.

Grain Yield Response to 22.5-inch Rows
(Pioneer Hi-Bred Intl', 1991-95)
- Statistically significant response to 22.5-inch rows at 5 of 16 trials.
- Across all 16 trials, average response to 22.5-inch rows = + 4.1%
Averaged over 2 years, 10 locations, 21 hybrids, 5 seeding rates, & 3 replicates per ecozone.

Source: Monsanto Technology Development. 2009 National Research Summary, "Evaluation of Corn Plant Density & Row Spacing"

Significant row spacing effect only in eastern Iowa (+ 5.5%).

Source: Monsanto Technology Development. 2009 National Research Summary, "Evaluation of Corn Plant Density & Row Spacing"

Averaged over 80 sites, 40 hybrids, 10 locations, & 3 replicates per year.

Source: Monsanto Technology Development. 2009 National Research Summary, "Evaluation of Corn Plant Density & Row Spacing"

Monsanto Twin Row Data 2009

Twenty locations across 10 states
Twins vs. 30-inch rows
Four seeding rates (28 to 43k) [slight interaction among seeding rates]

Source: Monsanto Technology Development. 2009 National Research Summary, "Evaluation of Corn Plant Density & Row Spacing"
Row Spacing & Seeding Rates for Corn

2009 DEKALB Twin Row Trials (Illinois)

Average advantage to twins ~ 2.3%

Plants per acre


Other reports of higher yields...

- Are more difficult to assess because details of the comparisons are not clear.

Other reports of higher yields…

- Not uncommon for on-farm trials to compare 30-inch rows planted at one seeding rate with a narrow row spacing at a higher seeding rate.
  - 30-inch rows @ 28k
  - 20-inch rows @ 35k

- In some cases, I suspect that documented yield increases to narrow rows may be related to slower seed metering and more uniform stand establishment when planting at aggressively high seeding rates and fast planting speeds.

Bottom line on row spacing…

- Traditional 30-inch rows are not a primary limiting factor for corn grain yield today in the heart of the Corn Belt.
- Profitability depends on costs to change, acreage, potential yield, & grain price.