Yield Response of Corn to Plant Population in Indiana 1

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Summary:
Results from 67 field-scale trials around Indiana since 2008 suggest that optimum plant populations for 30-inch row corn grown under minimal to moderate stress conditions average about 32,100 PLANTS per acre (ppa) or seeding rates of about 34,000 SEEDS per acre (spa). The results further suggest that corn grown under extremely challenging conditions (e.g., severe drought stress) may perform best at PLANT populations no higher than 24,400 ppa and perhaps as low as 21,000 ppa under truly severe growing conditions (actual drought, non-irrigated center pivot corners, non-irrigated sandy fields with minimal rainfall, etc.).

One of the reasons that plant population is a popular topic in coffee shops, Internet chat rooms, the farm press, and crop seminars is that variable rate seeding technology is rapidly becoming a standard accessory on corn planters. Another factor that spurs the interest in plant populations is the not uncommon belief that today’s hybrids will respond dramatically to aggressively high plant populations. The harvest populations often associated with national corn yield contest winning entries, coffee shop scuttlebutt, and encouragement from seed company marketing efforts fuel this belief.

Corn plant populations have steadily increased in Indiana for the past 25 years at approximately 300 plants per acre per year (Nielsen, 2013). In 2014, the estimated average plant population statewide (USDA-NASS, 2014) was approximately 30,850 PLANTS per acre (ppa). Considering stand establishment success typically ranges from 90% to 95%, this means that the average statewide seeding rate is probably between 32,500 and 34,300 seeds per acre (spa).

Statewide increases in plant population have occurred as growers have shifted from quite low seeding rates to intermediate and higher seeding rates. In 1998, nearly 46% of Indiana's corn acres were estimated to have final stands less than 25,000 ppa and only 5% with final stands greater than 30,000 ppa (Nielsen, 2013). Whereas in 2012, only 14% of Indiana’s acres were reported to be less than 25,000 ppa and 50% of the acres were reported to be greater than 30,000 ppa. Among the changes that have allowed growers to steadily increase plant populations has been the genetic improvement in overall stress

1 Also available in HTML format on the Web at http://www.kingcorn.org/news/timeless/SeedingRateGuidelines.html
tolerance that has resulted in a) ear size and kernel weight becoming less sensitive to the stress of thicker stands of corn and b) improved late-season stalk health.

Field-Scale Seeding Rate Trials

Background on the trials

We began a more focused effort several years ago to evaluate yield response to plant population in field-scale trials at Purdue Ag. Research Centers and with growers around the state. Since 2008, 67 such field-scale trials have been conducted.

The trials range in size from about 30 acres to 100 acres. Individual plots are typically length of field by twice the width of the combine header. All of our trials to date have been on 30-inch rows, with the exception of a couple of twin-row trials. Most of our trials are planted using variable rate technologies and “prescription” seeding rate files that we develop prior to planting with our GIS software. Commercial field equipment is used for all field operations. Grain yields at harvest are typically estimated with GPS-enabled yield monitors and the subsequent spatial yield data are processed after harvest with GIS software to eliminate any obvious non-treatment field variability (e.g., wet holes, gullies, planter skips, etc.). The statistical quality of the data from these field-scale trials is typically better than we could achieve with small-plot trials in the past and thus yield response to plant population can be more accurately quantified.

A random assortment of hybrids has been used in the trials, but 23 trials were split-planter comparisons using pairs of hybrids purposely chosen for their advertised differences in response to population. Most of the trials were conducted at the farmer’s normal nitrogen (N) fertilizer rate. However, 8 trials evaluated yield response to plant population at normal and higher than normal N rates.

General yield levels of the trials have ranged from less than 100 bushels per acre (bpa) to nearly 250 bpa. Twelve of the 67 trials can be characterized as “severely stressed”, most of which occurred during the severe drought conditions of 2012. The results of these trials offer an interesting insight into the relative risk of higher seeding rates for crops under severe stress. Consequently, the results are presented separately for the bulk of the trials that were characterized as “normal” productivity (moderate or less stress) and the 12 trials characterized as “severely” stressed (mostly drought).

Final stand or harvest population is rarely equal to the number of seeds that were planted because germination and/or emergence are rarely perfect plus plant mortality often occurs throughout the season. Percent stand (final population divided by seeding rate) in our 67 trials averages 96%, but ranges from as low as 79% to as high as 100%. Therefore, yield response to seeding rates is more appropriately analyzed and presented in terms of yield response to PLANT populations.

Growers should routinely calibrate the seed drop of their planters, count established plants no earlier than V6 (six visible leaf collars), and calculate percent stand in all their fields every year to determine whether there is room for improvement. With today’s planter technologies and seed quality, aiming for a percent stand of no less than 95% is certainly achievable. Equally important is that the knowledge of your historical percent stand allows you to convert recommended final PLANT populations to SEEDING rates.
Example: If the recommended PLANT population is 30,000 and your historical percent stand is 95%, then the targeted SEEDING rate would be 30,000 divided by 0.95 or 31,579 SEEDS per acre.

Results of the trials

“Normal” Growing Conditions. For the 55 trials characterized as experiencing a “normal” range of growing conditions (moderate to low stress), maximum grain yield occurred at an average PLANT population of 32,100 ppa. Using an average percent stand of 95%, that would translate to a SEEDING rate of about 34,000 spa.

Optimum PLANT populations for the 55 individual trials ranged from just over 24,000 to just under 44,000 ppa (Fig. 1). However, optimum PLANT populations for 68% of the trials ranged from 27,000 to 35,000 ppa.

There was no relationship between yield level and optimum plant population even though optimum yields among the 55 trials varied from 140 to nearly 250 bpa (Fig. 1). This result suggests that, if spatial variability for productivity within a specific field was similar to this range, there may be minimal value to variable rate seeding.

Severe Stress Conditions. The average optimum PLANT population for the 12 severely stressed (mostly drought) trials was 24,400 ppa or about 7,000 fewer ppa than those trials that experienced more “typical” growing conditions. At 95% stand establishment rate, the 24,400 PLANT population would equal a SEEDING rate of about 25,700 spa. Among the individual trials, optimum PLANT populations ranged from 20,400 to 33,000 ppa and optimum yields ranged from 71 to 168 bpa (Fig. 2).

Hybrid Comparisons. Twenty-three of the 67 trials included targeted comparisons of paired hybrids characterized by the seed companies as “less” or “more” responsive to plant populations with the objective to document whether or not such advertised hybrid population “ratings” resulted in significantly different optimum plant populations. Of the 23 such trials, only 9 trials resulted in any significant differences between the paired hybrids for yield response to plant population (Fig. 3). Of those 9 trials, different pairs of hybrids were used in 6 trials (Trials 1 – 6 in Fig. 3), while Trials 7 – 9 involved the same pair of hybrids. In four of the first six trials, the hybrid rated as “more responsive” indeed had a higher optimum plant population, but for two of those six trials, the hybrid rated as “less responsive” had a slightly higher optimum population than the “more responsive” hybrid (opposite of what the ratings would suggest). For the three trials that evaluated the same pair of hybrids, the optimum plant population for the “more responsive” hybrid was higher that that of the “less responsive” hybrid in 2 trials, but lower in the third trial. Furthermore, the same two hybrids used in Trials 7 – 9 were evaluated in 5 other trials in which they responded identically to plant population. Confused? The “take home” message from these 23 paired hybrid trials is that hybrid ratings for yield response to plant population are apparently not “black and white”.

Effect of Nitrogen (N) Fertilizer Rate. Eight of the 67 trials included both the farmer’s normal N rate and a rate from 50 to 75 lbs higher than his normal rate with the objective of determining whether yield response to plant population might be influenced by N availability. However, yield response to plant population was not influenced by N rate in any of these eight field trials (data not shown).
Economics. “Agronomic” optimum populations are those that result in maximum grain yield, regardless of cost. Clearly, your market price for grain and the cost of seed influence the estimation of economical optimum seeding rates. Recognize that percent stand establishment also influences the calculation of economic optimum seeding rates. Table 1 provides estimates of economically optimum PLANT populations calculated for a range of grain prices and seed costs, using the average grain yield response in the 55 trials that represent “typical” growing conditions.

The estimates also factor in the extra seed cost associated with a 95% stand establishment rate. If percent stand in your fields is historically lower than that, then you either need to figure out how to improve the success of stand establishment or you need to use a higher seeding rate just to achieve the desired economically optimum final stand and, therefore, incur even more seeding cost.

Summary

Results from 67 field-scale trials around Indiana suggest that optimum plant population for corn grown under typical yield levels and growing conditions is approximately 32,100 ppa or seeding rates of about 34,000 spa at 95% stand. The results further suggest that corn grown under severely stressful conditions may perform best at plant populations no higher than 24,400 ppa and perhaps as low as 21,000 ppa under truly severe growing conditions (actual drought, non-irrigated center pivot corners, non-irrigated sandy fields with minimal rainfall, etc.). Economic optimum plant populations are several thousand ppa less than agronomic optimum plant populations, the magnitude of the difference being dependent on grain price and seed cost.

There is little evidence from these trials that hybrids characterized as “more” responsive to population respond consistently differently to plant population than hybrids characterized as being “less” responsive. There is also no evidence from these trials that higher than normal N fertilizer rates influence yield response to plant population.

On-Farm Field-Scale Seeding Rate Trials: We Need Your Help!

The 67 field-scale trials summarized in this report were scattered throughout the state and represent a wide range of growing conditions. However, more such trials are needed to better identify the possible effects of different growing conditions, hybrids, and N fertilization levels on yield responses to plant population. Field-scale on-farm seeding rate trials are simple to conduct if your planter is equipped with GPS-enabled variable rate controls because we can create a “prescription” file for the trial that “tells” the VR controller where to automatically change seeding rates during planting. With a bit more effort, on-farm seeding rate trials can also be conducted without variable rate controls.

We encourage you to consider collaborating with us to conduct field-scale seeding rate trials on your farm. These trials can be customized to include two or more nitrogen fertilizer rates or multiple hybrids. Such trials will help you better identify the “ballpark” optimum plant populations for your conditions and can also be used to evaluate yield response to plant population in different areas or “zones” within fields to help address the question about the relative merits of variable rate seeding.
If you would like to participate in one or more on-farm seeding rate trials with corn, please download the protocol for this at the following URL and contact Bob Nielsen (rnielsen@purdue.edu) for additional information.

http://www.agry.purdue.edu/ext/ofr/protocols/PurdueCornSeedingRateProtocol.pdf

**Acknowledgements**

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**Cited references**


Figures & Table on following pages…
Fig. 1. Optimum PLANT populations versus optimum grain yield for each of 55 field-scale trials across Indiana characterized as experiencing a normal range of growing conditions (moderate to low stress), 2008 – 2014. The average optimum PLANT population was 32,100 ppa and 68% of the individual trial optimum PLANT populations were between 27,000 and 35,000 ppa (indicated by dark lines on graph).

Fig. 2. Optimum PLANT population versus optimum grain yield for each of 12 field-scale trials across Indiana characterized as being severely stressed, 2011-2014. The average optimum PLANT population for these severely stressed trials was 24,400 ppa and ranged from 20,400 to 33,000 ppa.
Fig. 3. Nine trials documented significant differences between paired hybrids characterized by seed companies as being less responsive (less resp) and more responsive (more resp) to plant population. None of the other 14 paired-hybrid trials exhibited any hybrid difference for optimum plant population. *Each trial represents a different pair of hybrids, except for Trials 7 - 9. The calculated optimum plant population is shown above each bar.

Table 1. PLANT populations that maximize marginal return to seed calculated with market grain price (per bu.) and seed cost (per 80,000 seed unit), based on average yield response to population in 55 Indiana trials that represent a common range of growing conditions (not severe stress conditions).

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NOTE: To calculate seeding rates from the values of this table, divide by your expected percent stand. For example, 29000 plants per acre divided by 95% stand = 30526 seeds per acre.