Variable-Rate Seeding for Corn and Soybean: Technological Capability vs. Agronomic Reality?

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Because many producers are getting planters that are capable of changing planted populations accurately as they plant across a field, there is a great deal of interest in ways to fine-tune seeding rates within fields in order to maximize yields and increase efficiency of the seed used. In order to have variable-rate seeding "work," different parts of a field need to have different responses to plant population. We have to be able to predict these responses at planting time, and the economic benefit of knowing the responses and acting on them needs to exceed the cost of implementing the practice.

To date, while a number of producers are using variable-rate planting for corn, it remains unclear whether or not this practice provides much economic return. Bullock et al. (1998) did some of the early work on this question, and concluded that it would be too costly to gather the information needed to make this approach provide much return. They also pointed out that more-variable fields are more likely to provide a return, but that even in those cases the return would likely be modest. At the same time, the cost of actually doing variable-rate seeding is not very great; those who buy planters equipped with hydraulic drives for better performance have almost no cost for implementing variable-rate seeding. That means that the gross return doesn't have to be very high in order for the practice to provide a return.

The tolerance to stress from high populations bred into modern corn hybrids means greater tolerance to weather-related stress as well. While older hybrids tend to go barren as populations increase, newer hybrids have the ability to produce silks and to successfully produce high seed numbers per acre even at high levels of competition between plants. This has important implications for the question of variable-rate seeding; it tends to mean that yields level off rather than drop off as populations rise above the population needed to maximize yields in a certain field, or part of a field, in a given year.

Testing the response to variable rate seeding also requires that we use the cost of seed and the price of the crop produced in order to find the point on the response curve where the cost of the last seeds planted is just covered by the additional grain produced. The goal is not to maximize yield in each part of the field, but rather to establish a plant stand that is economically optimized for each part of the field. In other words, if seed had no cost, then we could simply make sure we had somewhat higher stands than needed in each part of the field in order to maximize returns.

Trials

We have conducted a series of corn plant population studies at six different locations in Illinois—three in the northern half of the state and three in the southern half—over the past several years. Many of the corn trials used the same hybrid, so hybrid is a minor factor. In most of the trials, harvest populations were established by hand-thinning, and ranged from 20,000 to 40,000 or 45,000 plants per acre.

The soybean population studies consisted of planting 50, 100, 150, and 200 thousand seeds per acre in small plot studies at 33 site-years in Illinois. We did not routinely count actual stands in these trials, but in the large majority of the trials, stand establishment was very good, and actual stands were within a few percentage points of planted stands.

Population Responses and Optimum Plant Population

Responses to plant population for corn averaged across all site-years in northern and southern Illinois are shown in Figure 1. On average, corn yield responded to plant populations up to about 37,400 plants per acre in northern Illinois and 31,100 plants per acre in southern Illinois. The optimum plant population using a seed price of $3.50 per thousand seeds ($280 per unit) and a corn price of $3.50 per bushel was about 33,500 plants per acre in northern Illinois and 27,300 plants per acre in southern Illinois. In both cases, optimum populations were some 3,800 lower than the populations needed to maximize yields.

Figure 2 shows soybean seeding rate responses averaged over site-years in the three regions of Illinois. Yields were maximized at seeding rates of about 164, 158, and 175 thousand seeds per acre in northern, central, and southern Illinois. Optimum seeding rates calculated using a seed cost of $40 per 150,000 seeds (3,000 seeds per lb in a 50-lb unit) and $9.00 per bushel as the soybean price were 140, 128, and 138 thousand seeds per acre for northern, central, and southern Illinois.

Variable-Rate Population?

The findings shown in Figures 3 and 4 speak to the question of whether or not variable-rate planting "works" in corn. The fact that there is some correlation between yield and the population it takes to reach that yield is not especially strong—there are a lot of points well off the "average" line—but the fact that there is a correlation at all means that having more plants in higher-yielding parts of the field and fewer in lower-yielding parts might be reasonable. According to the equations shown in the two figures, each 10-bushel increase in yield takes about 830 more plants in northern Illinois, starting at about 27,000 plants for a 125-bushel yield and going to about 39,400 plants at a yield of 275 bushels.

In southern Illinois, about one-fourth of the trials showed negative or no response to increasing population and some required high populations to reach modest yields. Using all of the data (Figure 4) indicates that each 10-bushel increase in yield required about 760 more plants per acre. A yield of 100 bushels requires about 23,200 plants, and a 250-bushel yield requires about 34,600 plants. If we delete the data from the very dry site-years where there was no (or negative) response to increasing the population above 20,000 per acre, the 100-bushel yields need about 27,400 plants and 250-bushel yields need about 34,200 plants.

If we could know before the season what population to put where in a variable field, how much would it pay? We can answer this by pretending that each trial is a section in a field, then calculating return (gross minus seed cost) at both a fixed population and at the optimum rate for each region. For northern Illinois, using the optimum for each section produces a net return (to seed) of $8.81 more per acre than using 33,500 plants per acre over the entire field. In southern Illinois, using "variable-rate" plant population returns $34.52 per acre more than using a uniform, fixed population of 27,300 per acre. The return in southern Illinois came from avoiding high populations in areas where high populations decreased yields, and from accommodating some high populations needed to optimize yields in 2008.

While variable-population planting seems to make sense, we are seeing the same problem with population that we see with nitrogen: those parts of the field that seem to be the highest-yielding and so the most logical for higher rates may not reach high yields in some cases. More problematic is that areas of lower average yields might have very good yields in good years, in which case planted populations will often be too low.

Hybrids

A great deal of effort is spent matching plant population to specific corn hybrids, either to maximize benefits from having high populations for those hybrids that do well under higher populations, or by avoiding problems such as lower yields and lodging that come from having populations too high for the hybrid or field. One way hybrids are described for purposes of such matching is by “ear flex.” A hybrid with more ear flex can increase its ear size at lower populations or if the growing conditions are good, but presumably will reduce ear size as populations get higher or conditions are poor. On the other end of the scale are “fixed-ear” hybrids, which are presumed to suffer at low populations due to their inability to increase ear size, while doing well at higher populations, where they maintain ear size well.

It is at present best to heed the advice of seed companies in setting populations for hybrids, though hybrids suggested to be grown at lower populations—common for “flex ear” hybrids—might mean that standability is an issue or that the hybrid tends to be more tolerant of stress, so might be best on less-productive fields. For more productive fields, it is usually best to choose hybrids suggested for high populations. As with other issues related to hybrid responses, we do not have enough data to suggest whether or not different hybrids might respond differently to variable-rate populations.

Soybeans

The small differences in plant population response in different parts of Illinois (Figure 2) suggest that there may be limited advantage to using different seeding rates in different parts of variable fields. While individual sites did show a range of different responses to seeding rate (Figure 5) most of the responses and yield levels were similar enough to suggest that it would be difficult to find a good indicator for what seed rate to use in different parts of variable fields. Two of the 33 sites showed a yield decrease with increasing seeding rates above the lowest rate (50,000 per acre), and about 10 sites showed little response, while most of the remaining two-thirds of the sites showed optimum seeding rates between 100 and 150 thousand per acre.

Adding to these relatively small differences among sites is that fact that soybean stands as a percentage of planted seed tend to be more variable in soybean than in corn. This would add a considerable degree of uncertainty to any decision to cut seed rates, even if one had reason to believe that seeding rate could be cut in part of the field.

Reference

Bullock, D.G., D.S. Bullock, E.D. Nafziger, T. Doerge, S. Paszkiewicz, P. Carter, and T.A. Peterson. 1998. “Does variable rate seeding of corn pay?” *Agron. J.* 90:830-836.

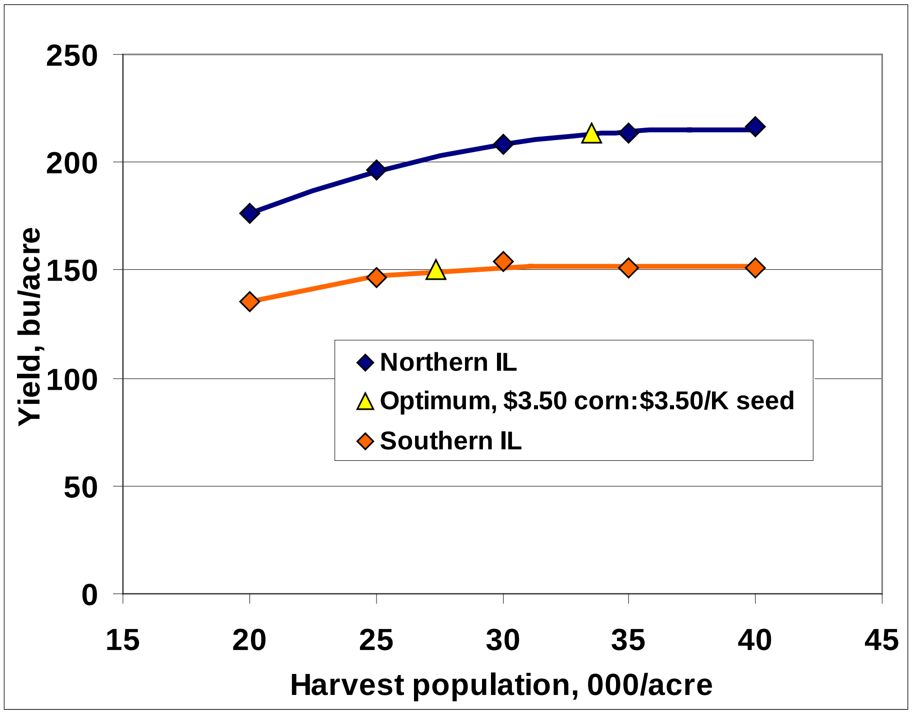

Figure 1. Corn yield responses to plant population (final stand) averaged over 35 trials in northern Illinois and 36 trials in southern Illinois. Optima are calculated on the basis of corn at $3.50 per bushel and seed at $3.50 per thousand, or $280 per unit of seed.

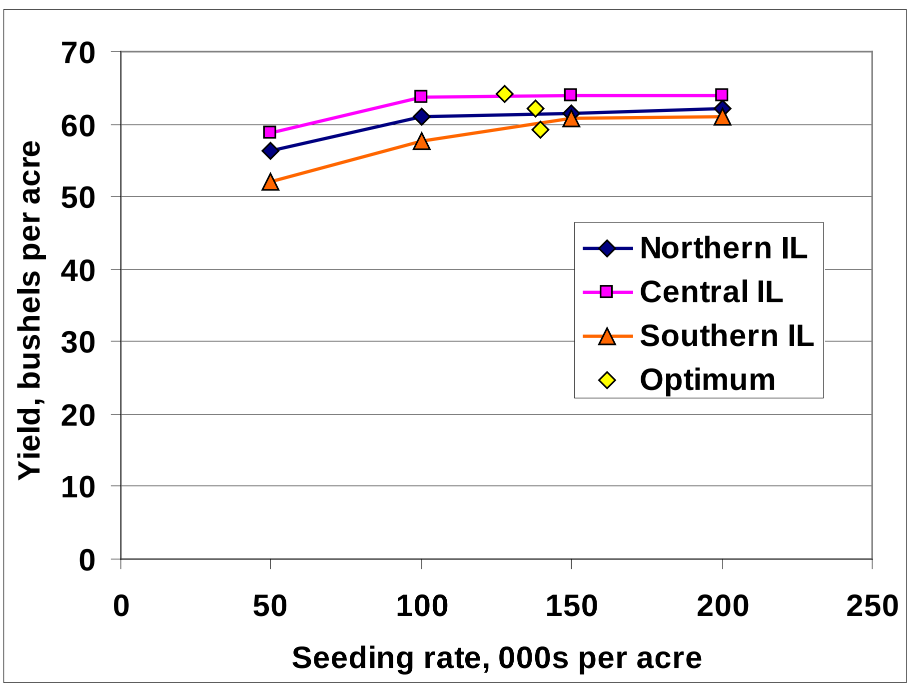

Figure 2. Soybean response to seeding rate averaged over 10 southern, 13 central, and 10 northern Illinois trials, 2005-2008. Optima are calculated at a seed cost of $40 for 180,000 seeds and a soybean price of $9.00 per bushel.

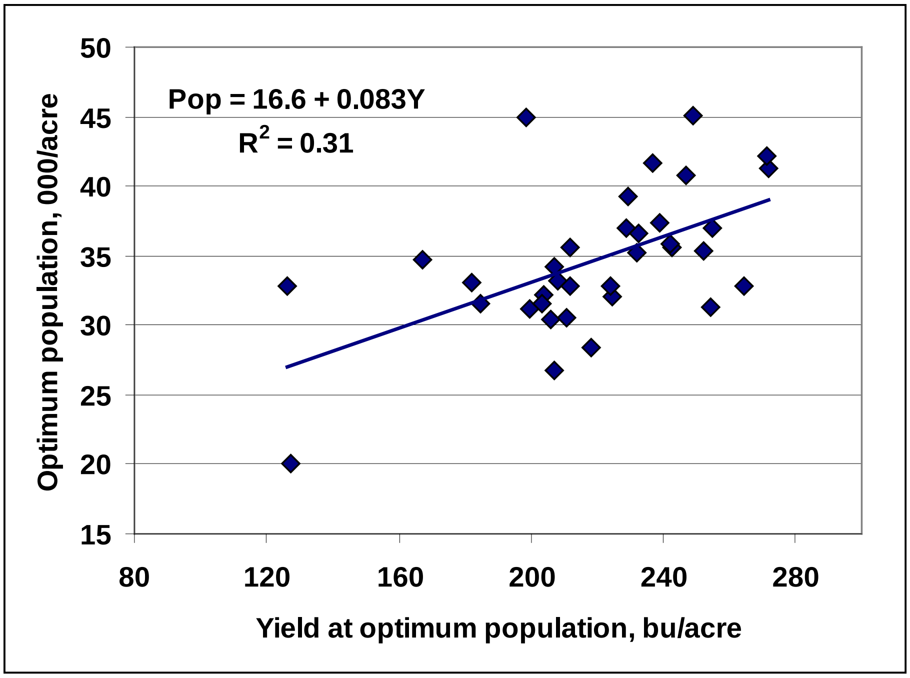

Figure 3. Yield and final plant stand needed to reach that yield over 36 trials in northern Illinois. Optimum plant populations are calculated at a seed cost:corn price ratio of 1: that is, the cost of 1,000 seeds equals to the price of one bushel of corn.

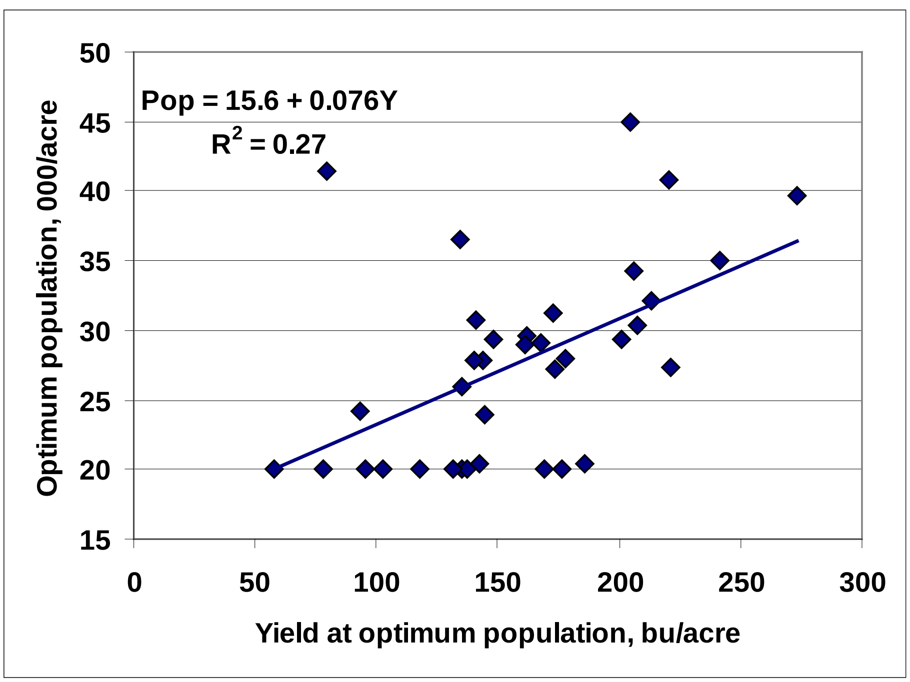

Figure 4. Yield and final plant stand needed to reach that yield over 36 trials in southern Illinois. Optimum plant populations are calculated at a seed cost:corn price ratio of 1: that is, the cost of 1,000 seeds equals to the price of one bushel of corn.

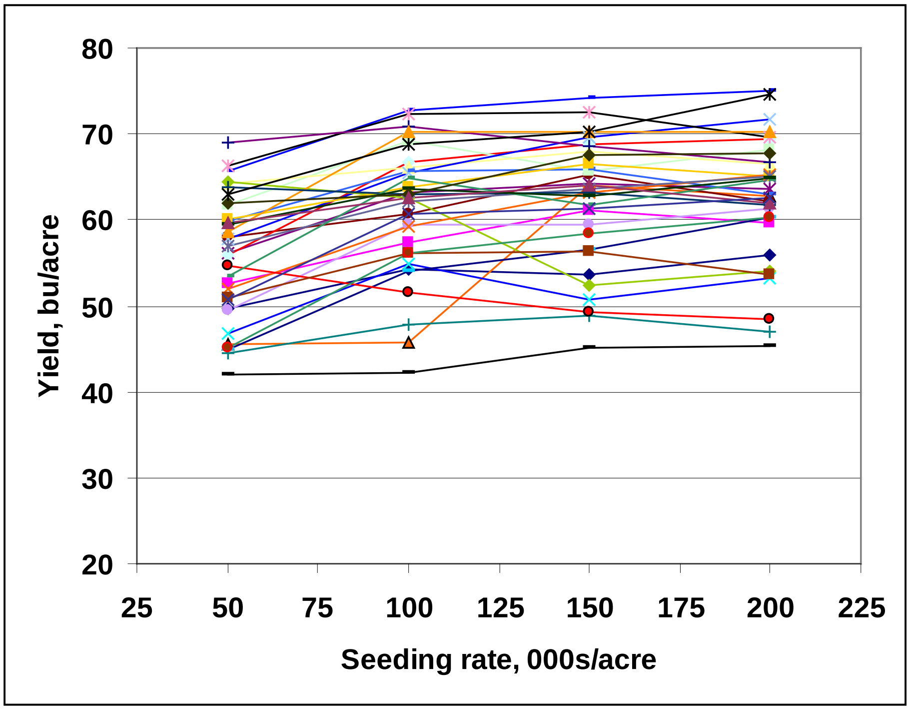

Figure 5. Soybean yield response to seeding rate for each of the trials averaged in Figure 4.