HYBRID, PLANT POPULATION, AND NITROGEN INTERACTIONS IN CORN

Emerson D. Nafziger and Robert Clark
Crop Sciences, University of Illinois, Urbana, Illinois

Abstract

Characterizing hybrids by their response to both plant population and N response will be needed to help make variable-rate population and N rate work. We planted four corn hybrids at three sites in Illinois over two years, using combinations of 18,000, 34,000, and 50,000 plants per acre 0, 80, 160, and 240 lb N/acre. Across three environments where shortage of water reduced yields, 50,000 plants/acre yielded less than the two lower populations, both of which yields about the same. There was little response to N rates greater than 80 lb N/acre in the lowest and highest populations, but at 34,000 plants/acre, yield responded to N up to 160 lb N/acre. Across three environments with low stress, the lowest density yielded the least, and did not respond to N rates above 80 lb N/acre, while the two higher densities both yielded the same responded the same to N rate, with yield increasing up to 160 lb N/acre then leveling off. Hybrids responded slightly differently to plant population, somewhat in line with their ear (fixed versus flex) characteristics in both environments, but did not respond differently to N rate. These results indicate that it may be difficult to distinguish clear enough differences among hybrids in their responsiveness to population and N rate to enable a more informed application of variable rates of population and N for different hybrids, within or among fields.

Introduction

With the possible commercialization of “nitrogen-use-efficient” corn hybrids within the next few years, the hybrid x nitrogen rate question is going to take on more importance. Nitrogen nutrition of NUE hybrids will presumably need to be managed differently than with “normal” hybrids, whether that means using the same rates of N with the expectation of higher yields, or the use of less N with expectation of similar yields. The improvement of NUE continues to evolve as hybrids develop and cultural strategies progress, raising questions of suitable nitrogen management (Bundy et al., 2011).

The question about differential responses of corn hybrids to plant density is also an important one, and one that has been relevant for a long time. Hybrids have long been characterized as to their position along the scale from “fixed-ear” (determinate) to “flex-ear” (indeterminate) types, with the former better able to maintain ear size as plant density is increased, and the latter better able to expand ear size if conditions are very good or plant density is low. Most high-performing hybrids tend to be characterized as “fixed-ear”, and with higher densities recommended for high yields.

While a physiological link between ear flex characteristics and N responsiveness has not been well-established, simultaneous measurement of responses to N rate and plant density might prove to be of value in terms of characterizing corn hybrids. Modern hybrids have shown tendencies to withstand higher levels of stress (i.e.- low N, high plant densities), which allow

them to better sustain suitable photosynthetic rates, appropriate assimilate supplies, and maintain plant growth rates attributable to enhanced nitrogen and water use efficiency (O'Neill et al., 2004). Responses to density are easier to see with greater consistency than are responses to N rate, which are subject to considerable variation over fields and years (Miao et al., 2006).
Results of a prior study in Illinois showed that corn at two lower plant densities (20,000 and 26,700 plants/acre) had higher optimum N rates than did plant densities of 33,300 or 40,000 plants/acre (Nafziger, unpublished). In contrast, in a recent Indiana study, Boomsma et al. (2009), using a wide range of plant densities (22,000 to 44,000 plants/acre) and N rates (0 to 300 lb N/acre), showed that higher densities required more N than did lower densities. This makes sense, given that without fertilizer N, fewer plants means more soil-supplied N per plant and so higher yields than at high densities, and that higher yield potential from higher plant densities can only be realized by adding fertilizer N. At the same time, both high density and high N rates often lead to greater total vegetative growth, which in turn requires more water through mid-season. If water supply becomes limiting thereafter, both high density and high N could lower yields.

While the concept that different hybrids respond differently to both plant density and N rate seems intuitive, it remains unclear whether hybrids have up to now been characterized well enough to clearly distinguish which need more or less of these inputs, either among fields or within fields. Due to unpredictable supplies of N and water from the soil, doing such characterization is difficult, but unless it can be done, it is unclear how well individual hybrids will be able to be matched to the "correct" density and N rate for a specific part of a field.

By better understanding N rate and plant density interactions, it might be possible to develop a system to more easily characterize hybrids – perhaps a "flexibility index" that would have elements of responsiveness to both N rate and plant density. The objectives of this study are to see whether different commercial corn hybrids respond differently to both N rate and plant density, and how consistent such responses might be across sites. We also wanted to see whether or not nitrogen and plant density responses among hybrids are related to one another.

Materials and Methods

A small-plot study was conducted at three Illinois locations in 2011 and 2012: on a Flanagan silt loam soil at DeKalb, a Muscatune silt loam at Monmouth, and on a Drummer silty clay loam soil at Urbana. Trials were planted following corn, and all fields were tilled. Planting was delayed by wet weather in 2011, with all trials planted between May 3 and May 15. In 2012, all sites were planted in mid- to late April.

Main plots in the study were N rate, with rates of 0, 80, 160, and 240 lb N/acre applied as sidedress UAN (28%) at about growth stage V3. Plant densities of 18,000, 34,000, and 50,000 per acre were assigned to subplots, and the four Pioneer® hybrids used in the study were assigned to sub-subplots. Final stands as a percentage of dropped seed numbers ranged from 96 to 99% at all sites except DeKalb in 2011, where stand establishment was 91%. Each sub-subplot was 4 rows (10 ft.) wide by 23 ft long. Yields were taken by machine-harvest of the center two rows of each sub-subplot, and were converted to 15% moisture.

The Pioneer® hybrids used, and their characterization (provided by M. Rupert of DuPont Pioneer) with regard to N and population responsiveness, were: 33D49 (flex-ear, more responsive to N); 33K44 (flex, less responsive to N); 33W84 (fixed, more N responsive); and 34F07 (fixed, less N-responsive).

Both 2011 and 2012 were stressful in parts of Illinois, including in some of these trials. Because yield levels differed so much due to different levels of stress among sites, we elected to divide the sites into three "high-stress" sites – Urbana in 2011 and 2012, and DeKalb in 2012 – and three "low-stress sites" – Monmouth in 2011 and 2012, and DeKalb in 2011.

Results and Discussion

Responses to plant population and N rate averaged across all four hybrids showed that, in the high-stress environments, corn at the high plant population (50,000 plants per acre) yielded less than the other two densities (Figure 1). There was no response to N rates above 80 lb N/acre at in either the low or high density, but at the middle density (34,000), the maximum yield was produced with 160 lb N/acre. Thus yield loss from very high density was not reversed by adding more N. There was no interaction between hybrid and N rate, but there was a small interaction between hybrid and population, with the "flex-ear" hybrids (33D49 and 33K44) yielding more at the low density than the fixed-ear hybrids, but losing more yield than the fixed-ear hybrids as population increased from the low to middle density.

In the low-stress environments, the lowest density (18,000) yielded the least, with the middle and high densities producing similar yields (Figure 2). Yields at the lowest density responded little to N rates above 80 lb N/acre, presumably because at low density ear and kernel size were maximized, and per-plant N was no longer limiting. At both higher densities, yields responded to up to 160 lb N/acre, with no additional increase to 240 lb N. Again in these environments, flex-ear hybrids yielded a little more than fixed-ear hybrids at the low density, and their yields increased a little less from the low to the middle density than did yields of fixed-ear hybrids. One of the flex-ear hybrids lost more yield from the middle to the high density than did the other hybrids (data not shown).

Our results do not support the commonly-held idea that high plant populations require more N. In both high-stress and low-stress sites, yields were maximized at 34,000 plants and 160 lb N, both of which represent typical producer rates in much of the Corn Belt. Raising both, to 50,000 plants and 240 lb N, dropped yields by 42 bu/acre in the high-stress environments, and had virtually no effect on yield in the low-stress environments. Among the combinations of population and N levels used in this study, with corn priced at $5.00/bushel, N at $0.50 per lb, and seed at $3.50 per thousand seeds, the highest return to seed and N in the high-stress environments ($524/acre) was at 18,000 plants and 80 lb N/acre, while in the low-stress environments, the highest return ($869/acre) was at 34,000 plants and 160 lb N/acre.

While hybrids responded slightly differently to population, somewhat in line with their ear (fixed versus flex) characteristics, under both sets of environments, this was not the case for N rate; there were no consistently different hybrid responses to N in either set of environments. The lack of a hybrid x N rate x population interaction under either environment indicates that hybrids did not respond consistently differently enough to both N and population to allow us to separate out hybrid by "type", at least based on results of this study.

While we may eventually find a way to identify hybrids genetically as to their responsiveness to population and N rate, the fact that we found few consistently different responses to either input under either high or low stress is not encouraging. We can expect even more variability when we combine these responses in the field. This will make it difficult to find hybrid differences that are consistent enough to use.

References

Boomsma, C.R., J.B. Santini, M. Tollenaar, T.J. Vyn. 2009. Maize morphophysiological responses to intense crowding and low nitrogen availability: An analysis and review. Agron.J.. 101:6:1426-1448.

Bundy, L.G., T.W. Andraski, M.D. Ruark and A.E. Peterson. 2011. Long-term continuous corn and nitrogen fertilizer effects on productivity and soil properties. Agron.J. 103:5:1346-1351.

Miao, Y.X., D.J. Mulla, P.C. Robert, and J.A. Hernandez. 2006. Within-field variation in corn yield and grain quality responses to nitrogen rate. Agron. J. 98:129-140.

O'Neill, P.M., J.F. Shanahan, J.S. Schepers, and B. Caldwell. 2004. Agronomic responses of corn hybrids from different eras to deficit and adequate levels of water and nitrogen. Agron. J. 96:6:1660-1667.

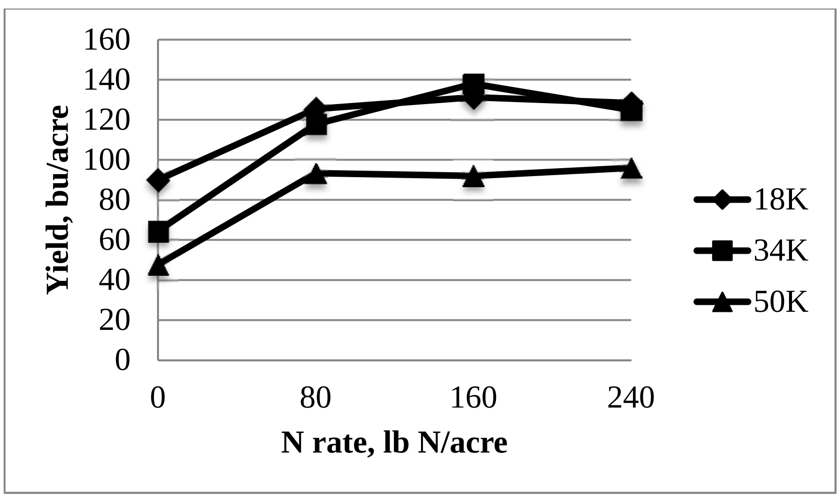

Figure 1. Response of corn grain yields to N rate at three different plant densities, averaged over three high-stress sites (Urbana 2011 and 2012, DeKalb 2012) and four hybrids.

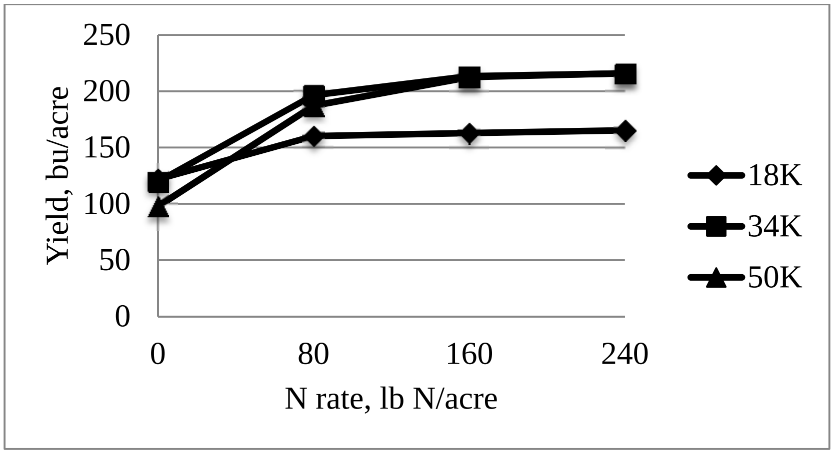

Figure 2. Response of corn grain yields to N rate at three different plant densities, averaged over three low-stress sites (Monmouth 2011 and 2012, DeKalb) and four hybrids.

PROCEEDINGS OF THE

43^{rd}

NORTH CENTRAL
EXTENSION-INDUSTRY
SOIL FERTILITY CONFERENCE

Volume 29

November 20-21, 2013
Holiday Inn Airport
Des Moines, IA

PROGRAM CHAIR:
Carrie Laboski
University of Wisconsin
1525 Observatory Dr.
Madison, WI 53706-1207
(608) 263-2795
laboski@wisc.edu

PUBLISHED BY:
International Plant Nutrition Institute
2301 Research Park Way, Suite 126
Brookings, SD 57006
(605) 692-6280
Web page**: www.IPNI.net**

ON-LINE PROCEEDINGS:
http://extension.agron.iastate.edu/NCE/