Fertilizer Bands and Dual Effects of Nitrogen on Young Corn Plants

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Applications of N fertilizer that relieve temporary deficiencies of N in young corn plants can advance plant growth stage as well as accelerate rate of growth within growth stages. This article summarizes main points of the manuscript recently published in *Communications in Soil Science and Plant Analysis* and describes how fertilizer bands applied prior to planting can advance growth stage of corn plants. Further discussion is focused on the practical importance of this effect.

Recent studies show that early season applications of N that relieve temporary deficiencies of N in corn seedlings can accelerate plant growth stage as well as result in taller and greener plants (Zhang et al., 2007, 2008a, 2010). In a recent review, Nafziger (2006) referenced studies showing that differences in plant age and size reduced corn yield because of interplant competition.

Whereas the apparent effect of N fertilization on plant height and leaf color has been widely recognized, the potential effect of N fertilization on accelerating growth stage has not been recognized and makes it difficult to diagnose deficiencies of N. These effects have been commonly observed when bands of fertilizer N are applied diagonally to corn rows before fields are planted (Blackmer, 2001).

We report observations showing that pre-plant applications of fertilizer N in bands diagonal to corn rows can advance growth stages of the plants near the bands and discuss the importance of these effects. The primary point addressed is that the practical importance and basic significance of the effect has not been recognized.

Study Area and Plant Grouping

The observations were made in a field in a corn-soybean rotation and managed by a producer using his normal practices. A week before planting corn in late April, anhydrous ammonia was injected at a rate of 106 kg N/ha (95 lb N/A) in bands about 15° diagonal to corn rows. An additional 112 kg N/ha (100 lb N/A) was injected as a urea-ammonium-nitrate solution between corn rows on June 10. Four categories were formed according to heights and positions of corn plants relative to the tracks of the pre-plant fertilization. Representative plants were categorized as Group 1 including the tallest plants directly over the fertilizer bands, Group 2 including taller plants on the transitional portion but not directly over the bands, Group 3 including shorter plants between the bands, and Group 4 including the shortest plants far from the bands.

Height Measurement

Starting from June 14, corn heights were measured from the soil surface to the height of the uppermost collars on individual plants at 5-day intervals until the topmost leaf collar reached its terminal height. Permanent records of key events were made by taking photographs of the relevant part of the plants with a measuring tape in the background to indicate height above ground. Approximately 2,500 digital photographs were taken.

Abbreviations and notes for this article: N = nitrogen; CMR = chlorophyll meter reading.

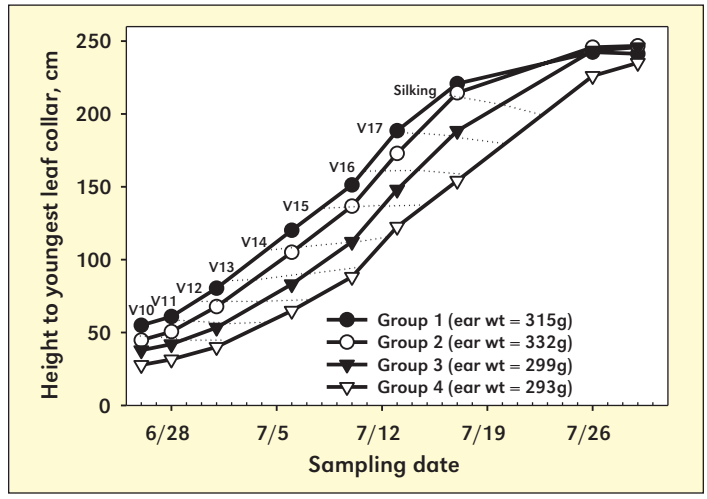

Figure 1. Temporal pattern of corn heights in four groups formed to present their relative position to the fertilizer bands. Groups 1 and 2 represent the tall plants directly over the fertilizer bands and on the transitional portion, respectively. Groups 3 and 4 represent the short plants between and far from the fertilizer bands, respectively.

Chlorophyll Measurement

Chlorophyll contents were measured by using a Minolta SPAD-502 meter and recorded as chlorophyll meter readings (CMRs) from June 26 through July 28 (corresponding to the growth stages V8 through R2 as described by Ritchie et al., 1986) at approximately 5-day intervals. The youngest fully expanded leaf was used for measurements until the tassels emerged; thereafter the ear-leaf was measured. All readings were taken halfway between the stalk and leaf tip and along the leaf margin. The mean of four individual CMRs on each leaf was calculated.

Data Analyses

The baseline measurement of corn heights on June 26 and the relative positions of those plants to fertilizer bands were used to group plants into four categories. The same approach of averaging was applied to leaf CMR measurements. The four categories clearly showed effects of anhydrous bands on plants in the test area.

Results

1. Plant heights clearly indicated the location of fertilizer bands and the differentiation of growth stages.

The plants in each of the four groups followed the same pattern of growth as normally expected, i.e., relatively slow in the seedling stage, relatively rapid during the period of "grand

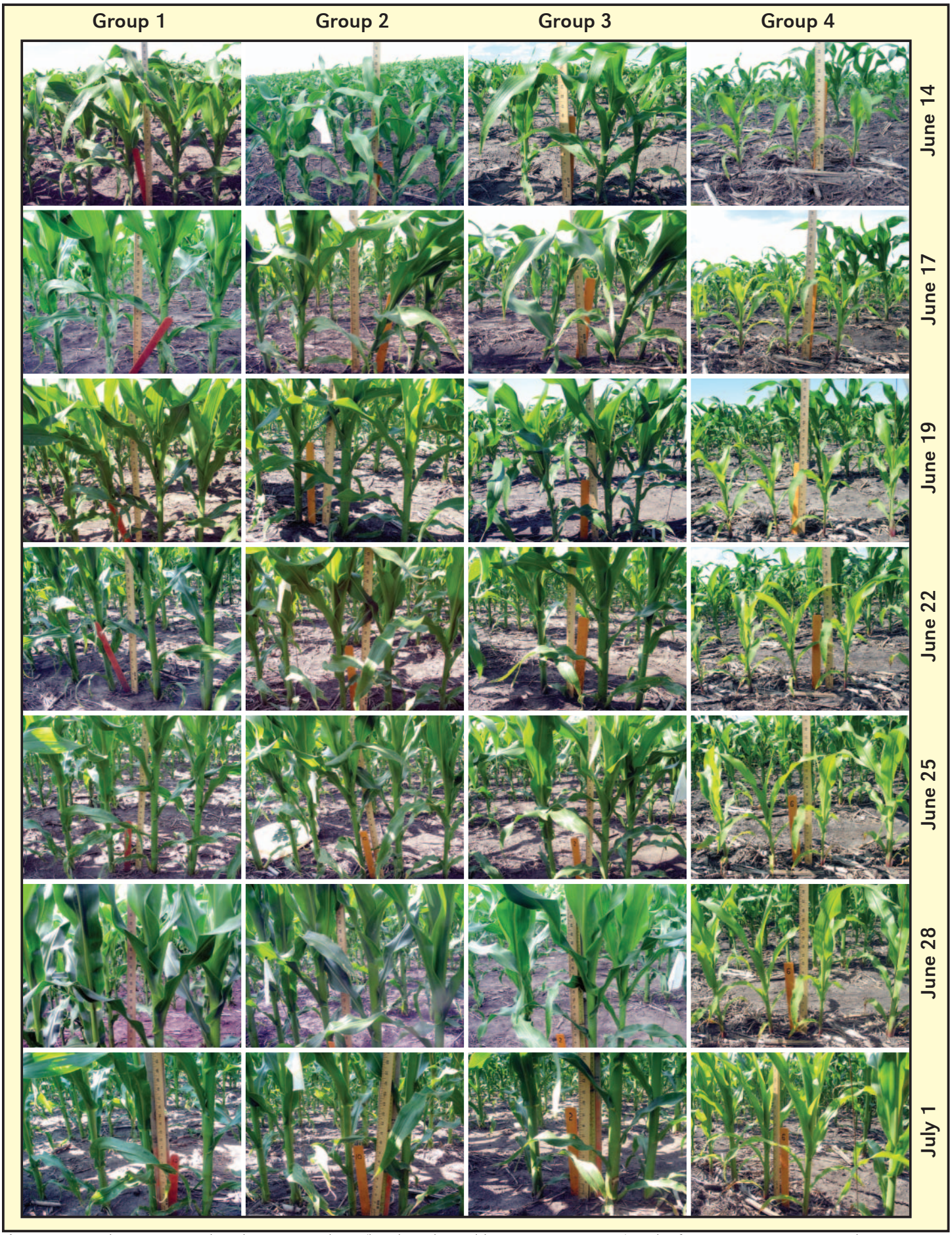

Figure 2. Corn plants as viewed aside on seven dates (height indicated by a measuring tape) in the four groups representing the range in initial heights observed from first measurement.

Corn plants show when their roots first reach bands created by injection of anhydrous ammonia.

growth," and a slow down as plants ended the vegetative stages of growth and entered the reproductive stages (Ritchie et al., 1986; Zhang et al., 2008b, 2009).

The initial plant heights measured on June 26 showed significant differences among the four groups **(Figure 1)**. The difference gradually increased as plants further developed and showed a maximum lag of 66.5 cm (26 in.) of height between Group 1 and Group 4 on July 17. The R1 stage as indicated by the emergence of silk started earlier on the plants over fertilizer bands than on the plants between fertilizer bands. This stage also started earlier on taller plants than on shorter plants. The emergence of silks seemed very sensitive to the plant heights as defined in this study. Most plants entered the R1 stage at an approximate height of 200 cm (79 in.) in this study.

Plant heights corresponding to different landscape positions across fertilizer bands were related to growth stages within each date **(Figure 2)**. These relationships suggest that much of the variability in corn height with respect to the position of fertilizer bands could be linked to differences in growth stage. Regression analysis showed that the initial corn heights had great effect ($p < 0.01$) on plant heights throughout the growing season until all plants approached their terminal heights by July 28. Analysis of variance showed that the overall effects of fertilizer bands on plant heights were statistically significant ($p < 0.05$) during this period. Toward the end of the season, differences in plant heights among the four groups were minimized, likely due to all plant roots eventually reaching the fertilizer bands, making earlier season growth and development differences less apparent on final ear weight **(Figure 1)**.

2. The greenness of corn leaves varied due to leaf position prior to silk emergence; thereafter it was linearly related to plant growth stages.

Leaf greenness as indicated by CMRs was solely measured on the uppermost developed leaves on June 26 and July 6 **(Figure 3)**. The statistically insignificant relationship ($p > 0.05$) between CMRs and growth stages measured at these dates suggests that CMRs measured on the uppermost developed leaves were greatly influenced by the change of leaves as plants advanced in growth. Thereafter, CMRs taken on the ear-leaf provided a reliable indication of growth stages.

3. Linear association of plant height and leaf greenness varied by growth stages.

The observed corn heights and leaf CMRs on July 6 and July 28 were poorly correlated ($p > 0.05$) **(Figure 4)**. Coefficients of variation for plant heights were about 3 to 4 times greater than for CMRs (data not shown). Almost all plants approached their maximum heights by July 28 and the coefficient of variation subsequently reduced to 3%.

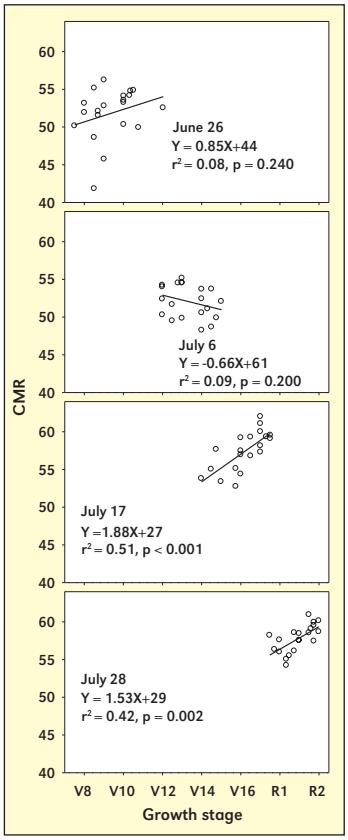

Figure 3. Relationships between CMR and growth stages on four different dates.

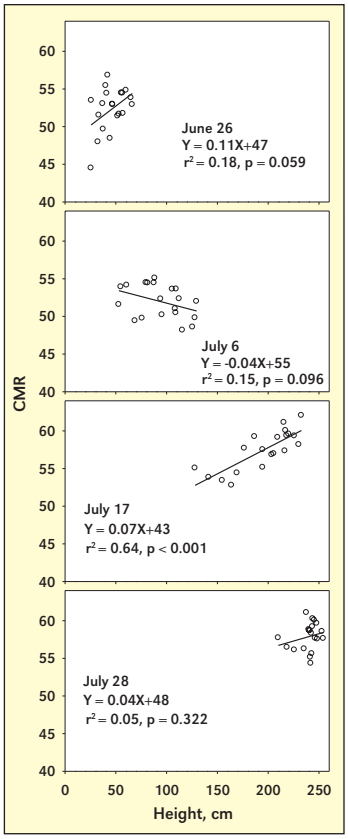

Figure 4. Relationships between corn heights and CMR measured on four different dates.

Summary

When bands of pre-plant fertilizer are applied diagonally to rows of plants, variation in the amount of time for roots to grow enough to reach the bands results in a situation where adjacent plants within each row show effects that vary in a predictable sinusoidal pattern. Plants farther from the bands may have delayed development early in the season. This delayed development carries through much of the season. BC

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References

Blackmer, A.M. 2001. Integrated Crop Management Newsletter IC-486. 25 Jun. 2001. Available at: http://www.ipm.iastate.edu/ipm/icm/2001/6-25-2001/reachanhy.html

Nafziger, E.D. 2006. 28 Feb. Crop Management doi: 10.1094/CM-2006-0227-05-RY.

Ritchie, S.W., et al. 1986. Spec. Rep. 48. Rev. ed. Iowa State Coop. Ext. Serv., Ames, IA. Available online at: http://www.extension.iastate.edu/hancock/info/corn.html

Zhang, J., et al. 2007. Agron. Sustain. Dev. 27: 313-319.

Zhang, J., et al. 2008a. Pedosphere 18:60–68.

Zhang, J., et al. 2008b. Pedosphere 18:545-553.

Zhang, J., et al. 2009. Comm. Soil Sci. Plant Anal. 40:2087–2093.

Zhang, J., et al. 2010. Comm. Soil Sci. Plant Anal. 41:1306–1314.