EFFECT OF CORN PLANT SPACING AND EMERGENCE VARIATION ON YIELD

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There is much recent interest in the grain yield response of corn (*Zea mays* L.) to plant spacing deviation and plant emergence variation. More is known about plant spacing deviation than plant emergence variation. Key planting factors influencing corn stand establishment include spacing of seed, uniform seed depth, seed quality, planter speed, insects, diseases, desired seed population, and optimum soil environment for rapid germination and uniform emergence (including soil moisture and temperature), No single factor is responsible for differences among fields for stand establishment, rather fields with uneven plant spacing have unique problems and often a combination of factors during the planting operation leads to inconsistent stands.

Previous results are mixed regarding corn grain yield response to deviation of within row plant spacing. Early research on plant spacing deviation indicated little response to yield even when planted in hills (Kiesselbach et al., 1935 as reported by Dungan et al., 1958). In Iowa, no significant yield impacts were observed in stands with up to 6 inches standard deviation (Erbach et al., 1986). Similar results were observed in Ontario (Muldoon and Daynard, 1981), Illinois (Johnson and Mulvaney, 1980)and Indiana (Nielsen, 1995). However, Nielsen (web) later stated that grain yield decreases 2.5 bu/A for each 1 inch standard deviation greater than 2 inches. Other results indicate plant spacing significantly reduces grain yield. In Kansas, researchers found a 3.4 bu/A decrease for each 1 inch increase in standard deviation (Krall et al., 1977) and, others found that grain yield decreased when standard deviation values were greater than 2.4 inches (Vanderlip et al., 1988).

Most farmers and agronomists agree that uniform stand establishment is ideal and can only be achieved by a well-calibrated planter and sound agronomic practices. It is unclear whether corn yield responds to uniform spacing, and if it does how badly it has to get before the grain yield impact pays for the expense of "tuning" the planter. Our objective was to measure the response of corn to plant spacing deviation, and, if a response was significant, to determine the critical point where plant spacing deviation influenced grain yield.

Studies were conducted at 24 site-years between 1999 and 2001. In all years, the adapted hybrids used were 'Pioneer 35R57' planted at Arlington, Janesville, and Lancaster, 'Cargill 4111' planted at Fond du Lac, Galesville, and Hancock, and 'Novartis NK Brand 3030Bt' planted at Chippewa Falls, Marshfield, Seymour, and Valders. Management practices were typical of those utilized commercially in many dry land fields in the Corn Belt of the Midwestern United States. Plots were harvested in mid- to late-October with a two row Kincaid plot combine.

The experimental design at each site-year was a randomized complete block with three replications. Plant spacing deviation treatments were established by over seeding at 90,000 seeds/A and thinning back at V5-6 (Ritchie et al., 1993) to desired plant spacing deviations. Plant spacing deviation treatments of 2, 4, 8, and 12 inches in 2-, 4- and 8-plant patterns involving neighboring plants were established (Fig. 1). The control treatment was a plant spacing deviation of 0 inches.

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It was difficult to establish a control treatment with a target plant spacing deviation of 0 inches. In this study the control treatments ranged from 1.6 to 3.3 inches plant spacing deviation. Many reasons can be attributed to this including slight deviation from the mark at thinning, change in plant size between thinning and when spacing measurements were taken at harvest, and measurement error all could affect target plant spacing deviation.

A common observation in corn is increasing plant density increases grain yield. Care was taken to ensure that plant densities among plant spacing deviation treatments within an environment were equal.

In 1999, plant spacing deviation treatments did not affect grain yield at 18 of 20 sites. Linear and quadratic relationships between grain yield and plant spacing deviation were observed at 4 of 20 sites. In 3 of 4 significant locations grain yield increased with increasing plant spacing deviation, while in the fourth site grain yield decreased with increasing plant spacing deviation. Grain moisture was not affected by plant spacing deviation in 19 of 20 sites (Table 1). No trend was observed in the single environment where plant spacing deviation significantly affected grain moisture. Plant lodging and grain test weight were not affected by the plant spacing deviation treatments. Thus, there was little evidence to support the hypothesis that plant spacing deviation affects grain yield or other agronomic measures in a 2-plant pattern as long as adequate population is present.

The amount of plant spacing deviation is related to plant density. Low plant density has more space between two neighboring plants and thus more potential for greater plant spacing deviation. As plant density increases there is less space between neighboring plants. The only way to increase plant spacing deviation in a plant community and not affect plant density is to arrange plants into hill patterns of 4-, and 8-plant patterns (Fig. 1).

In 2000 and 2001, 2-, 4-, and 8-plant patterns increased the number of sites where grain yield was significantly reduced. However, the other agronomic measures of grain moisture, plant lodging and grain test weight were not affected by increasing plant spacing deviation. Plant density was affected by plant spacing deviation treatments in 6 of 14 environments. Most significant relationships between grain yield and plant spacing deviation were observed in 8-plant patterns. Also, significant plant death was occurring in 4- and 8-plant ‘hills’ thereby affecting final harvest plant density. For the 2-plant pattern treatments, none of the 14 site-years had a significant relationship between grain yield and plant spacing deviation. As plant spacing deviation increased with 4- and 8-plant arrangements more site-years exhibited significant relationships with 2 of 14 site-years with 4-plant patterns and 11 of 14 sites-years with 8-plant patterns. In all cases where a significant relationship was measured, grain yield decreased with increasing plant spacing deviation. Plant spacing deviation did not affect grain moisture, plant lodging or grain test weight in any environment.

When combining data from all site-years, no significant relationship was measured between relative grain yield and plant spacing deviation for 2-plant patterns. For both the 4- and 8-plant patterns a significant quadratic term was often observed. The overall relationship between relative grain yield and plant spacing deviation is shown in Fig. 2. The critical value for the overall relationship was 4.7 inches and the 95% confidence interval was 3.9 to 5.6 inches.
Grain yield was not affected from that of the control when all plant patterns had plant spacing deviation less than 4.7 inches, but grain yield was reduced between 5 and 18% when plant spacing deviation was greater than 4.7 inches (Fig. 2). In most commercial corn fields yield differences observed in this study were more likely due to plant density differences between treatments rather than plant spacing deviation. Averaged across all environments, no significant

relationship was measured between grain yield and plant spacing deviation where plant densities were similar, except when obvious gaps where present in the stand and plants were arranged in 4- and 8-plant patterns.

Other studies determined the impact of plant emergence timing on grain yield. When plants were "set back" by clipping all emerged leaves, grain yield was reduced on a plot basis by 2%, 17%, and 13% when applied at V2, V4 and V6, respectively (Figure 3). Research conducted by Deen et al. in Ontario found that later emerging plants in a stand yielded 35% and 72% less than the average of neighboring plants when emergence was delayed 2- and 4-leaves. Expressed on a plot basis grain yield decreased 4.0% and 8.3% when 17% of the plants in a plot had delayed emergence by 2- and 4-leaves (Figure 4).

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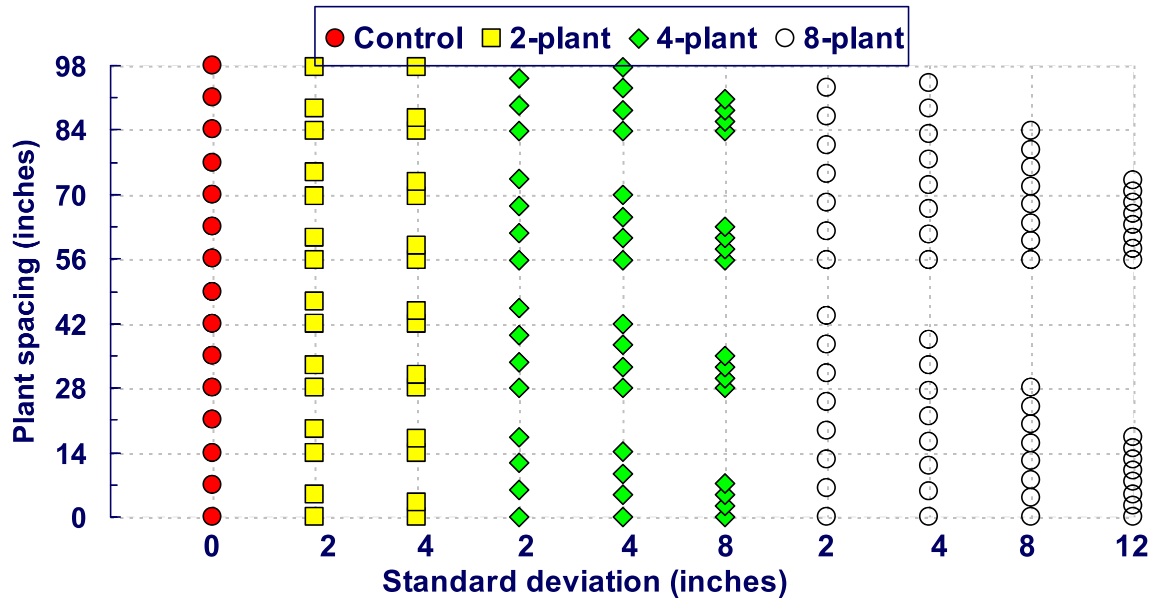

Fig. 1. Target plant spacing deviation treatments for 2-, 4- and 8-plant patterns for plant densities of 30,000 plants/A. The control is zero standard deviation.

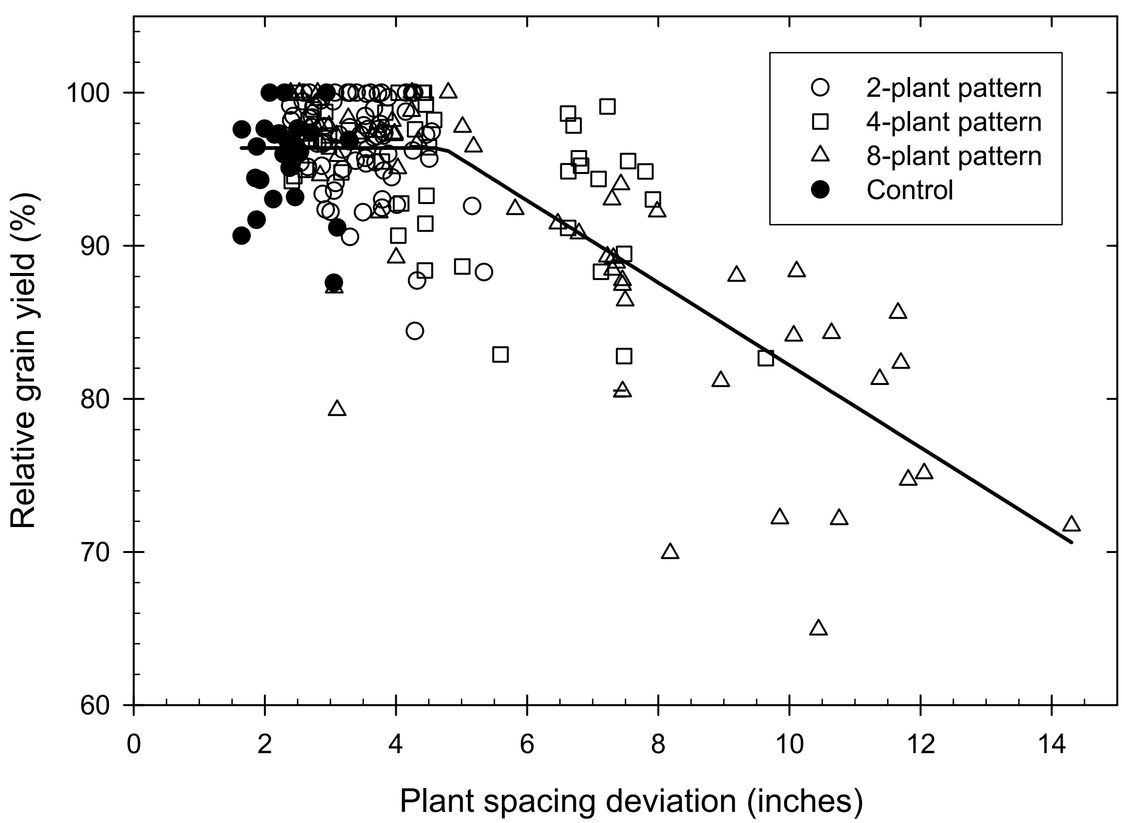

Fig. 2. Relationship between relative grain yield and plant spacing standard deviation for 2-, 4-, and 8-plant patterns at 30,000 plants/A (Y = 96.4, if X < 4.7 and Y = 109.1 – 0.42 X, if X > 4.7; R^2 = 0.57). Relative grain yield was determined for each plot as yield divided by the average yield from the greatest yielding plant spacing variation treatment for each site-year.

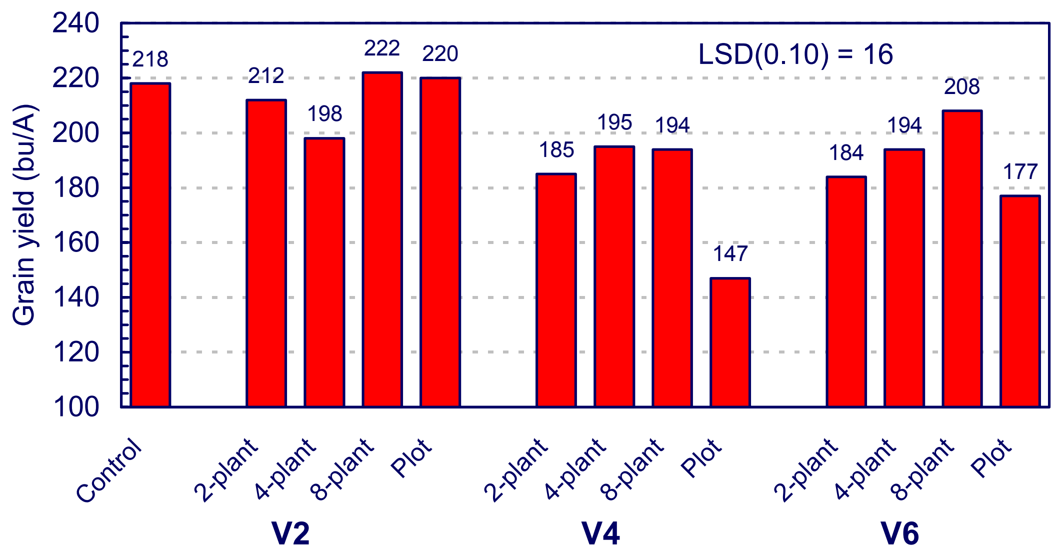

Fig. 3. Corn grain yield response to clipping plants in various plant patterns and growth stages at Arlington, WI during 2003.

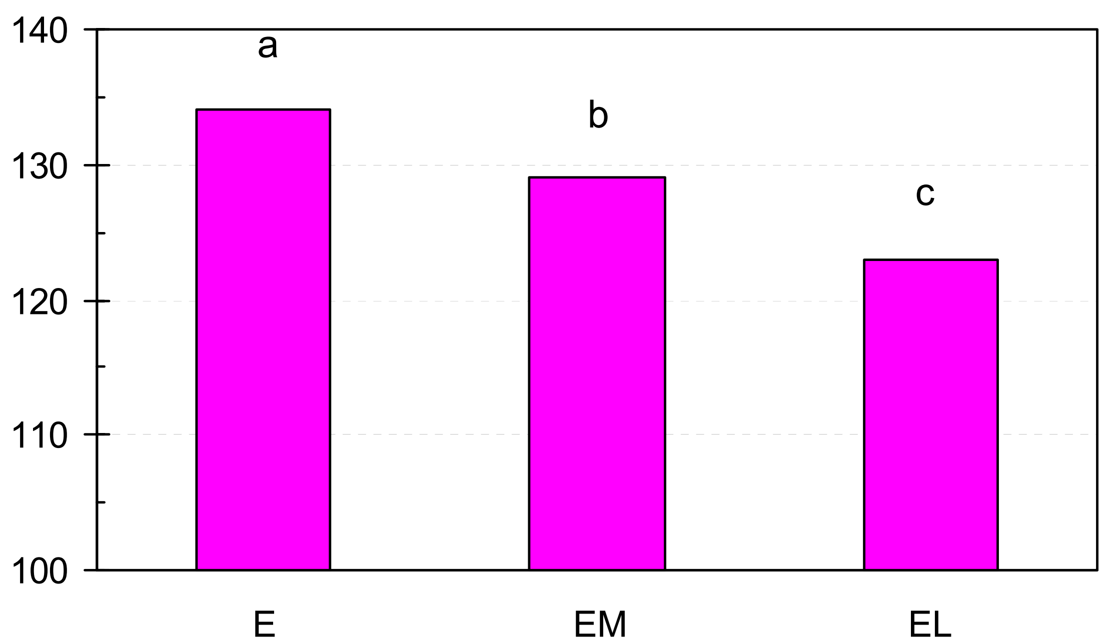

Fig. 4. Corn Grain Yield Response to Plant Emergence in Ontario (derived from Deen et al., 2003)