In-Row Spacing Effect on Yield of Individual Corn Plants

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Introduction

Non-uniform spacing of corn plants in the row is typically associated with variability in spacing of seeds by the planter and with incomplete germination or plant establishment from planted seeds. Such variability in plant spacing has been identified as a possible source of yield loss in this crop (Nielsen, 2004). Nafziger (1996) reported, however, that skips and doubles affected yield almost entirely though their effect on stand density, not through their effect on plant spacing variability as influenced by missing or extra plants. Other have also reported little or no influence of plant spacing variability on corn grain yield (Lauer and Rankin, 2004; Liu et al., 2004).

Corn plants grown in rows compete with their neighboring plants for water, sunlight, and nutrients, with plants at high density experiencing more intense competition. At a given plant density, increasing plant spacing variability would negatively affect yield only if plants with less than average amounts of space in the row suffered yield losses greater than the additional yields produced by plants with more than average amounts of space available in the row.

We undertook this study to see if such yield compensation among more- and less-crowded plants results in a net loss of yield in stands with more than normal amounts of plant spacing variability.

Methodology

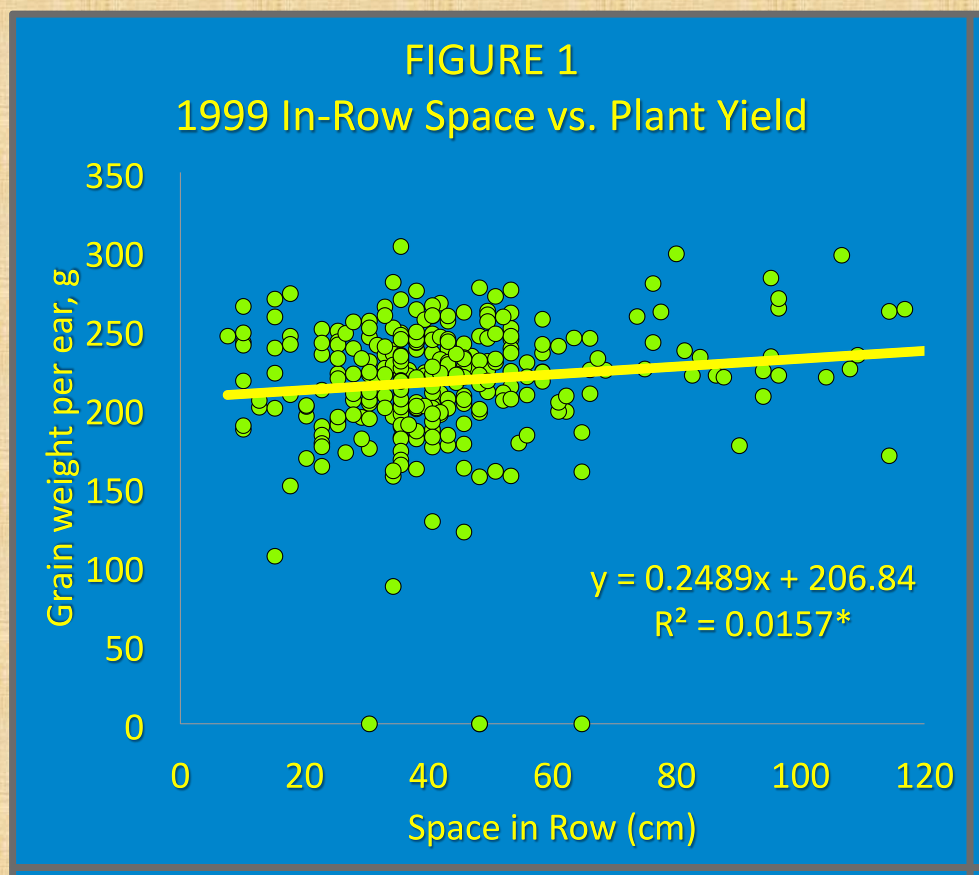
Studies were conducted at the University of Illinois Crop Sciences Research and Education Center located near Urbana, Illinois. The corn crop followed soybean each year, and studies were conducted on highly productive silt loam or silty clay loam soils. In each case, very high plant densities of 150,000 to 200,000 plants ha^{-1} were established with a commercial corn planter with rows 76.2 cm apart. After emergence and before growth stage V5, plants were removed by hand on a random pattern, leaving fixed target densities with plants spaced unevenly down the row. Established densities were: 60,300 ha^{-1} in 1999; 64,600 and 81,800 ha^{-1} in 2000; 60,800 and 75,600 ha^{-1} in 2002; and 77,300 ha^{-1} in 2011. In the 2011 trial, plants to be removed were identified using a randomization procedure, while in previous years plants were removed "by eye" to leave the correct number of plants but with uneven spacing.

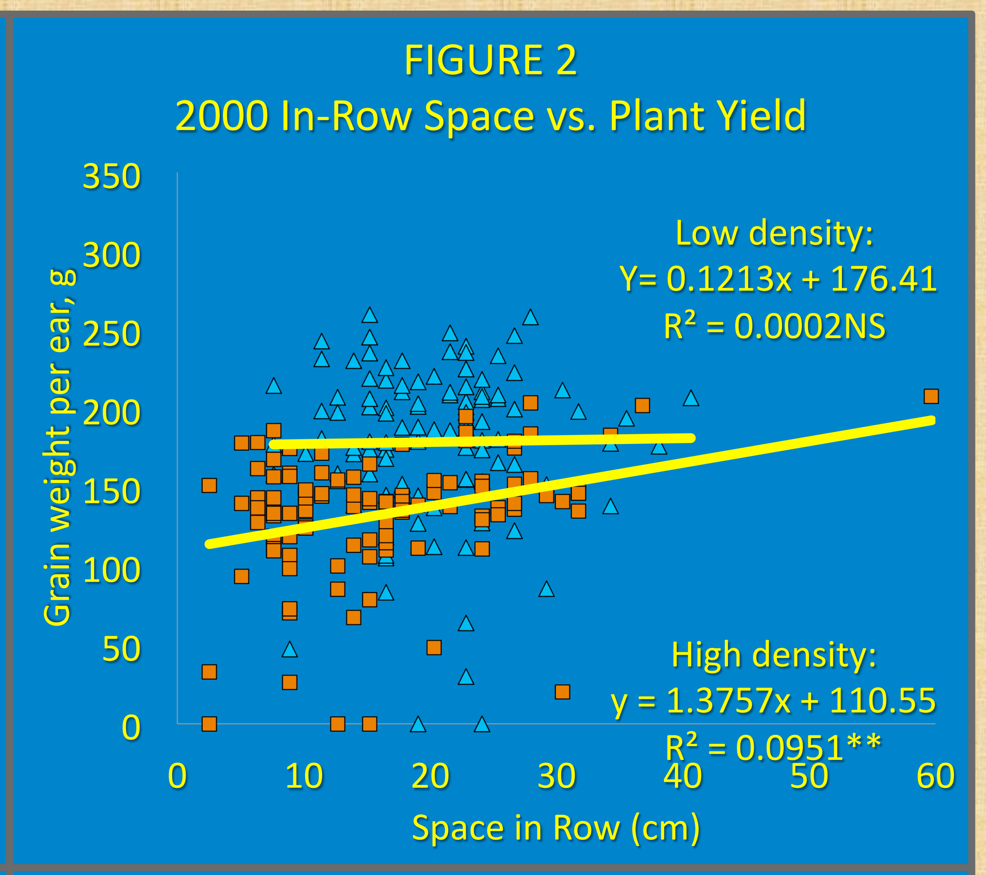
At maturity, the distance to each plant from the end of the row was recorded and the ear from each plant was identified and removed by hand. Ears were dried and shelled, with grain weight recorded for each ear and corrected to 850 g kg^{-1} dry matter. Regression analysis was used to determine if yield per plant was influenced by the amount of space occupied by that plant.

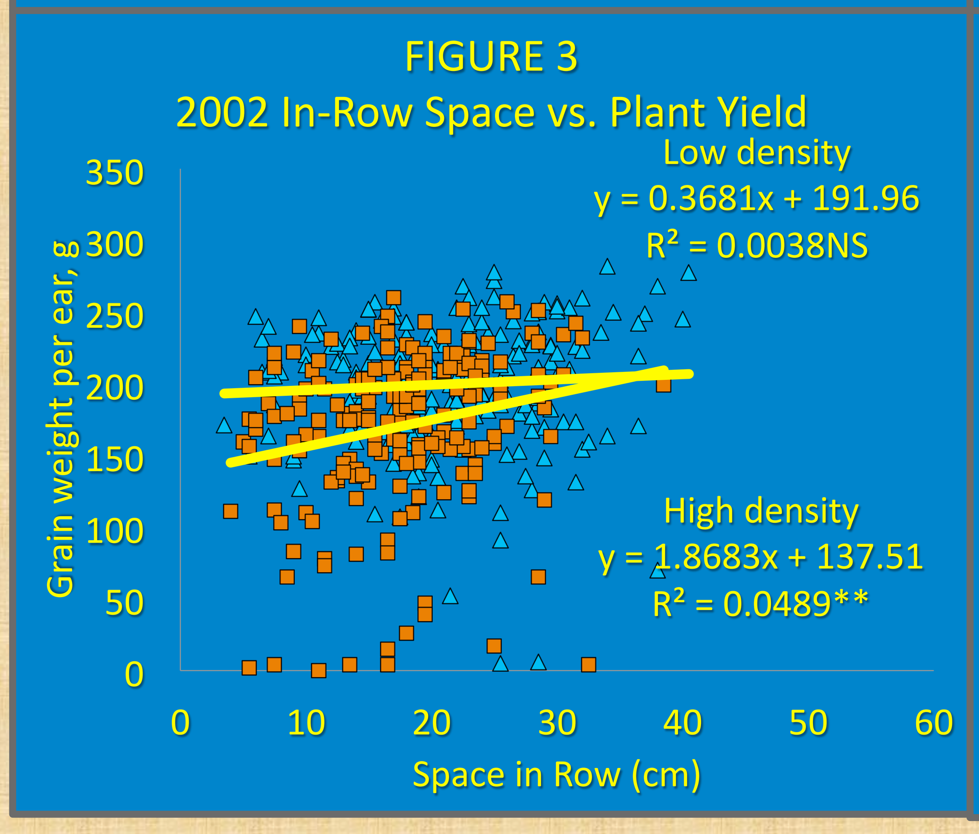
Results

Growing conditions were good in 1999, with average yield of harvested ears equivalent to 13.1 Mg ha^{-1}. There was more stress in 2000, and the average yield at 64,600 plants ha^{-1} was 11.6 Mg ha^{-1}, and at the higher density of 81,800 plants ha^{-1}, yield per plant dropped proportionately more than density increased, and the overall yield was only 10.8 Mg ha^{-1}. In 2002, the lower and higher densities produced yields of 12.1 and 12.7 Mg ha^{-1}, respectively. In 2011, the overall yield was 14.2 Mg ha^{-1}.

In 1999, plants at a density of 60,300 ha^{-1} showed a small but significant correlation (r=0.125) between each plant's space in the row (SiR) and grain weight per plant (GWP), with the slope of the line indicating that yield per plant increased about 0.25 g for each additional cm of space the plant had in the row (Fig. 1). In 2000 and 2002, we found no correlation between SiR and GWP at lower plant densities (64,600 and 60,800 plants ha^{-1}, respectively) but at higher densities (81,800 and 74,600 plants ha^{-1}) we found significant correlations between SiR and GWP; correlation coefficients were r=0.308 and r=0.221, and GWP increased at 1.38 and 1.87 g per cm of increase in SiR in 2000 and 2002, respectively (Figs. 2 and 3). In 2011, with 77,300 plants ha^{-1}, we found no correlation between SiR and GWP (r = -0.020) (Fig. 4).







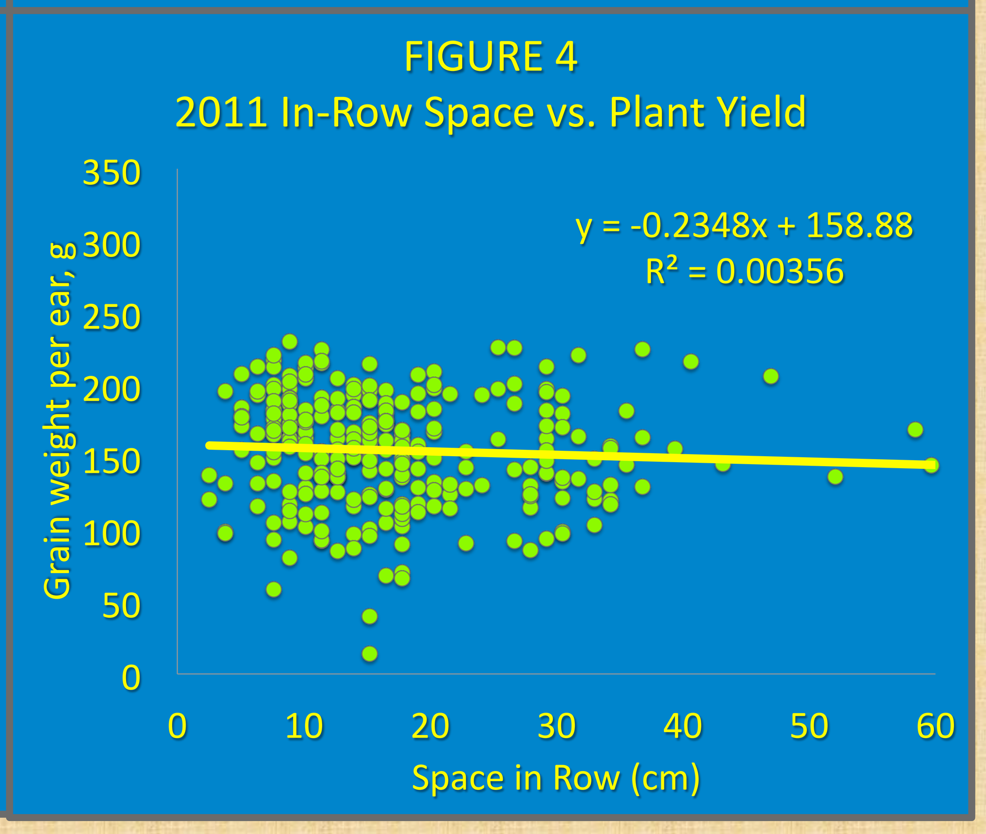


Figure 2: Low Density = 64,600 plants ha^{-1}; High Density = 81,800 plants ha^{-1}

Figure 3: Low Density = 60,800 plants ha^{-1}; High Density = 74,600 plants ha^{-1}

Summary and Conclusions

Under relatively low final plant densities of 60,000 to 65,000 plants ha^{-1} in 1999, 2000, and 2002, the amount of space occupied by individual plants had no effect on the amount of grain each plant produced (Figs. 1, 2, and 3). This suggests that ear size, at least as constrained by the overall density, was not able to increase very much even if space available in the row increased, and was maintained as space in the row decreased. Hence the level of competition experienced by a plant and that influences its yield is not closely related to the nearness of its two neighboring plants, but may be influenced by a larger group of plants including across the row, or may simply be random in nature.

Under higher densities in 2000 and 2002, plants with more space in the row did produce larger amounts of grain (Figs. 2 and 3). It's possible that plants at higher densities were simply under more stress and so the effect of nearness of neighboring plants on increasing or decreasing stress was more distinct. This idea is supported by the fact that in 2011, with higher yields and so (presumably) less stress, individual plant yield was not affected by the amount of space that plant had in the row (Fig. 4).

Despite the presence of small effects of plant spacing on yield of individual plants, it is not clear that such an effect would likely man lower yields with more variability in plant spacing, providing that plant densities are optimal and conditions are favorable. Even with some stress resulting in lower yield at the higher density in 2000, space available to each plant explained less than 10% of the variability is per-plant yield, and under minimal stress at a similar density in 2011, this percentage was zero.

References

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