Can Narrow Row Spacing Be Used to Manage Higher Planting Densities of Corn?

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Crop Physiology

Question: ***Are corn plants at increased planting densities more productive when planted in a narrower row spacing?***

Objective: ***Identify physiological factors that are associated with the yield responses to planting density and row spacing.***

Introduction:

- Corn (*Zea mays L.*) grain yields have increased significantly since the 1930s largely due to genetic improvement and better crop management, especially row spacing and fertilization.
- The average U.S. corn planting density has increased 988 plants ha^{-1} year^{-1} since the 1960s.
- Narrower row configurations provide more spacing between plants within a row at a given planting density (Figure 1).

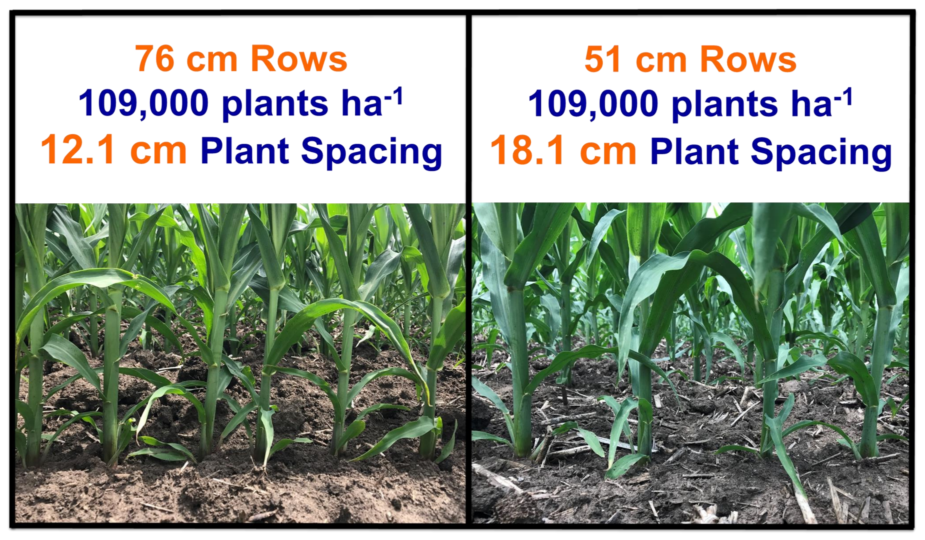


Figure 1. Spacing among plants within a row widens from 76 cm rows to 51 cm rows at 109,000 plants ha^{-1}.

Research Approach:

Field plots were planted 18 May 2016 at Champaign, Illinois on a Drummer-Flanagan silty clay loam. Treatments were arranged in a split plot design with row spacing as the main plots and hybrid and planting density randomized with 8 replications.

Eight commercial Dekalb hybrids were planted at 79,000, 94,000, and 109,000 plants ha^{-1} in a 76 cm row spacing and 94,000, 109,000 and 124,000 plants ha^{-1} in a 51 cm row spacing (Table 1).

Urea ammonium nitrate (UAN; 32-0-0) was applied pre-plant across all treatments at a rate of 314 kg N ha^{-1}.

Table 1. The spacing between each plant within a row at each planting density and row spacing treatment combination.

	Row Spacing	
Planting Density	76	51
plants ha^{-1}	cm	
79,000	16.6	-
94,000	14.0	21.0
109,000	12.1	18.1
124,000	-	15.9

Measurements

- The number of plants with tillers were counted at the V8 growth stage.
- Fractional Green Canopy Coverage was measured at the V8 growth stage using the Canopeo App (Patrignani and Ochsner, Agron. J. 107:2312–2320 (2015)).
- At the kernel blister growth stage (R2), leaf area index was determined by measuring the length and maximum width of the 8th leaf from the top of the plant. (Pearce et al., Crop Science 15:691-694 (1975)).
- At physiological maturity (R6), total above-ground biomass was calculated by excising six plants plot^{-1} at the soil surface, drying and weighing them, then extrapolating the weights to the planting density.
- Grain yield was acquired by mechanically harvesting each plot on 8 October 2016.
- Post- harvest root sampling was conducted to measure the size of the plant root system. Six plant roots plot^{-1} were excavated, cleaned of any soil, dried, and weighed to obtain the average root weight plant^{-1}, and then extrapolated to the planting density for total below-ground biomass.

Photosynthetic Potential:

- **At the V8 growth stage, the canopy coverage indicating photosynthetic potential of 51 cm rows was 7% greater ($P \leq 0.10$) than the wider row spacing across all planting densities. (Figure 2). Maximizing light interception by achieving complete ground cover as quickly as possible is an important crop production strategy.**
- **Later in the growing season, light interception and photosynthetic capacity increased as planting density increased (Table 2). The greatest leaf area index was achieved at the highest planting density (Table 2). There was no effect of row spacing on leaf area index (Table 2).**

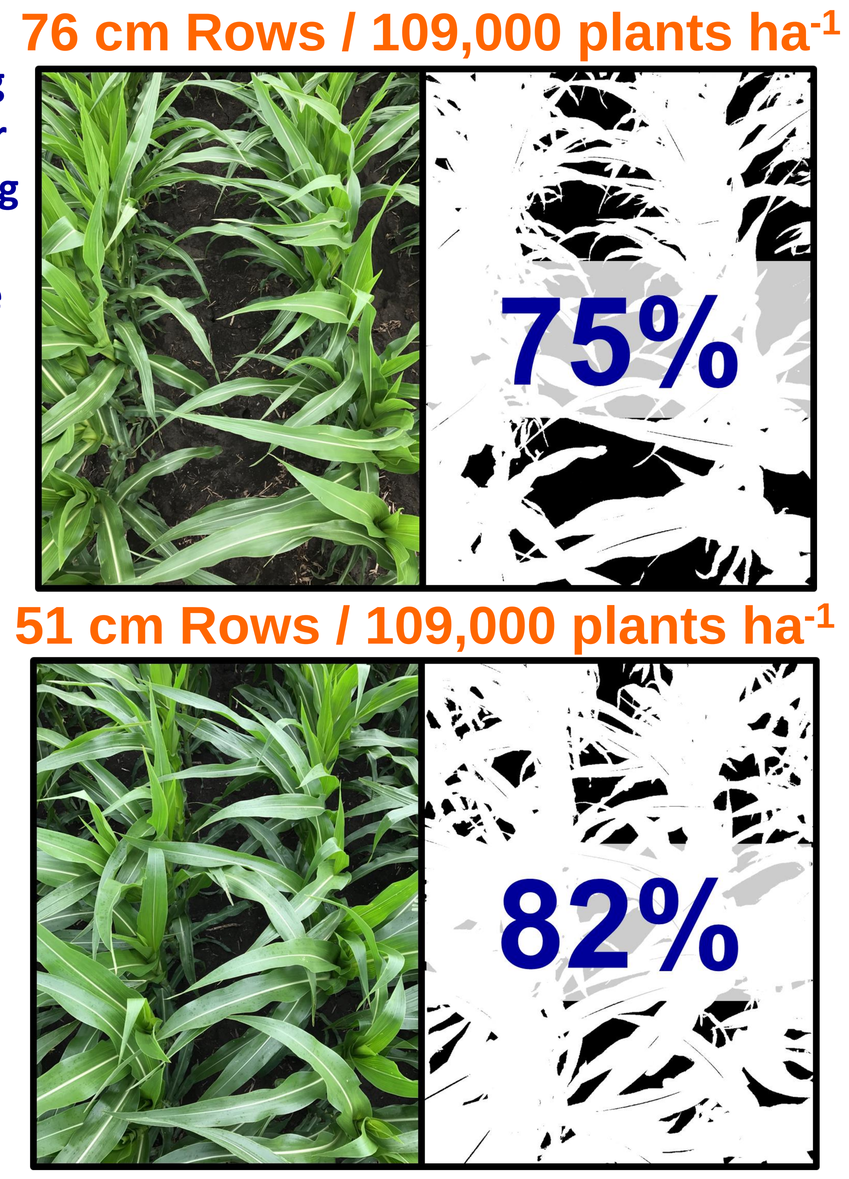


Figure 2. Effect of row spacing on Fractional Green Canopy Coverage at 109,000 plants ha^{-1} for the same hybrid. The difference shown between row spacings is similar to that found at other planting densities, when averaged over all hybrids.

Table 2. Leaf area index at the R2 growth stage as affected by row spacing and planting density at Champaign, IL in 2016. Values are averaged across 8 hybrids.

Row Spacing	Planting Density (plants ha^{-1}) 79,000	94,000	109,000	124,000
76 cm	4.6 d†	5.2 c	5.7 b	-
51 cm	-	5.2 c	5.7 b	6.4 a

† Mean separation tests were conducted using an LSD calculation with Tukey adjustment. Letters compare each row spacing and planting density treatment combination. Similar letters are not significantly different at $P \leq 0.10$.

Physiological Changes:

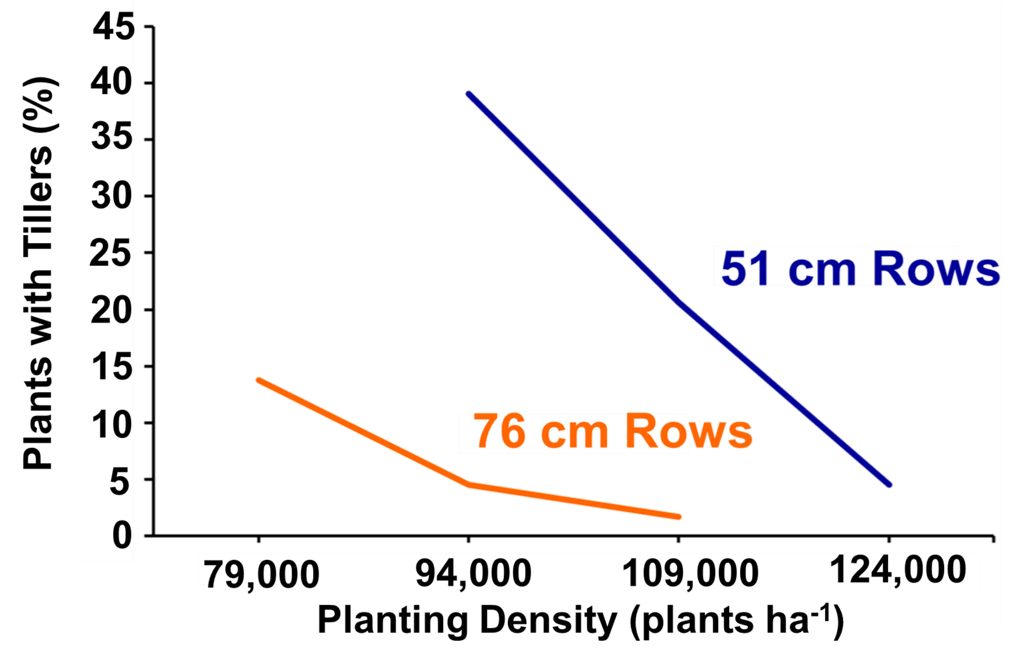
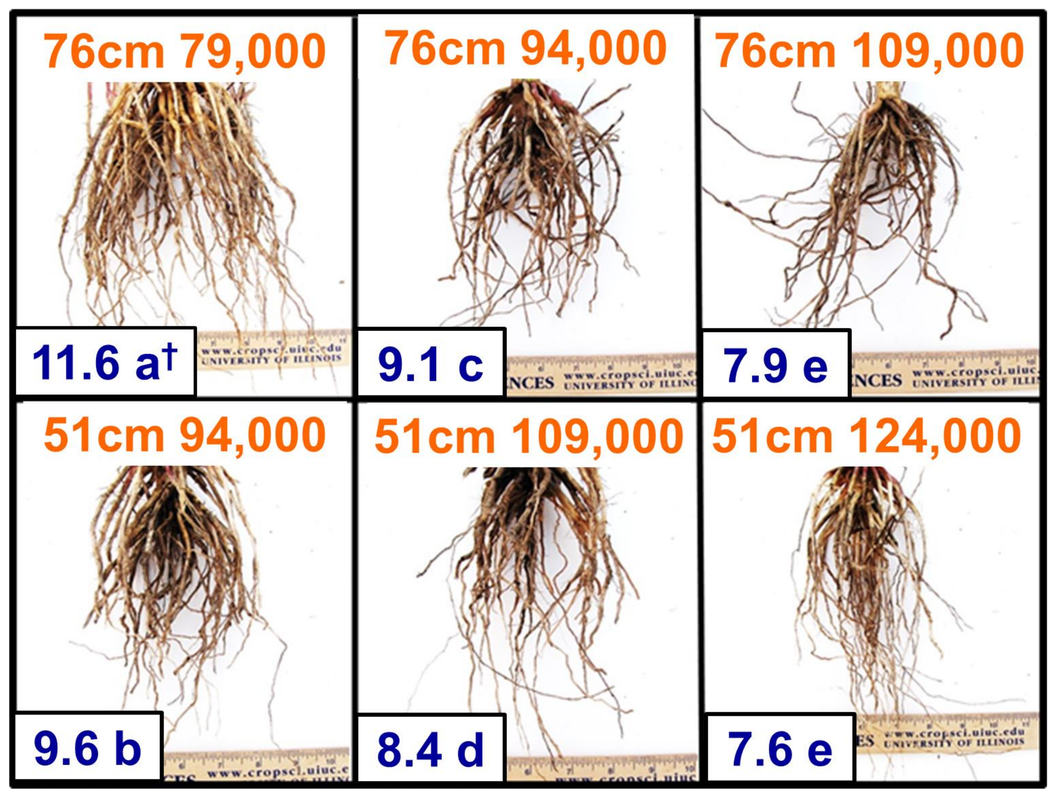


Figure 3. Effect of row spacing and planting density on the number of plants with tillers at the V8 growth stage.

Figure 4. Average per-plant root mass at post-harvest due to planting density and row spacing changes at Champaign, IL in 2016. Values represent the average of 8 hybrids, expressed in grams root^{-1} on a dry weight (0% moisture) basis.



† Mean separation tests were conducted using an LSD calculation with Tukey adjustment. Letters compare each row spacing and planting density treatment combination. Similar letters are not significantly different a $P \leq 0.10$

- **As planting density and/or row spacing increased, the amount of plants with tillers decreased (Figure 3). Planting 94,000 plants ha^{-1} in a 51 cm row resulted in 39% of the plants having tillers (Figure 3), indicating that the plant density at that row spacing was not high enough to maximize grain yield.**
- **Within a row spacing, as planting density increased the size of each individual root system was significantly smaller (Figure 4). Interestingly, 79,000 plants ha^{-1} in a 76 cm row and 124,000 plants ha^{-1} in 51 cm spacing have similar plant-to-plant spacing within the row, but the root system of the lower density and wider row spacing was 66% larger (Figure 4).**
- **When expressed on per area basis, total above-ground biomass increased by greater planting density and narrower row spacing (Table 3). Below-ground biomass, however, was much less affected by planting density and row spacing, and at the density extremes (e.g. 79,000 plants ha^{-1} in 76 cm row spacing and 124,000 plants ha^{-1} in a 51 cm row spacing) the below-ground biomass in the same (Table 3). This physiological effect suggests that the increased density of 124,000 plants ha^{-1} creates a competitive environment where the plants are concentrating most of their energy into producing above-ground biomass and not below-ground biomass.**

Table 3. Total above-ground and below-ground biomass as affected by planting density and row spacing changes at Champaign, IL in 2016. Values represent the average of 8 hybrids, expressed on a dry weight (0% moisture) basis.

Row Spacing	Planting Density (plants ha^{-1}) 79,000	94,000	109,000	124,000
	kg ha^{-1}			
Above-Ground Biomass				
76 cm	23,795 e†	24,603 d	25,217 cd	-
51 cm	-	25,540 c	26,513 b	27,556 a
Below-Ground Biomass				
76 cm	964 a	874 b	846 b	-
51 cm	-	945 a	935 a	959 a

† Mean separation tests were conducted using an LSD calculation with Tukey adjustment. Letters compare each row spacing and planting density treatment combination within a biomass parameter. Similar letters are not significantly different a $P \leq 0.10$.

Grain Yield:

Table 4. Final grain yield as affected by planting density and row spacing at Champaign, IL in 2016. Values represent the average of 8 hybrids, expressed on a dry weight (0% moisture) basis.

Row Spacing	Planting Density (plants ha^{-1}) 79,000	94,000	109,000	124,000
	Mg ha^{-1}			
76 cm	13.7 e†	14.3 d	14.5 c	-
51 cm	-	14.5 c	14.8 b	15.4 a

† Mean separation tests were conducted using an LSD calculation with Tukey adjustment. Letters compare each row spacing and planting density treatment combination. Similar letters are not significantly different at $P \leq 0.10$.

- **When averaged across 8 hybrids, as planting density increased grain yield increased at both row spacings (Table 4). The highest yield (15.4 Mg ha^{-1}) was achieved by planting 124,000 plants ha^{-1} in a 51 cm row (Table 4).**
- **The same yield of 14.5 Mg ha^{-1} at 109,000 plants ha^{-1} in a 76 cm row spacing can be achieved by planting 15,000 less plants ha^{-1} and narrowing the row spacing (Table 4).**
- **Narrowing the row configuration increased yields by 0.2 and 0.3 Mg ha^{-1} at 94,000 and 109,000 plants ha^{-1}, respectively (Table 4).**

Conclusions:

1. **Can narrower row configurations be used as a management tool to increase corn productivity at higher planting densities?**
   Yes, narrower row spacings result in more rapid canopy coverage, provide better plant-to-plant spacing within a row, and significantly increased grain yield when compared to wider rows at a given planting density.
2. **Which physiological factors are associated with the yield responses to planting density and row spacing?**
   Above-ground, photosynthetic potential and biomass production were greatest at high plant densities and in the narrower row spacing, leading to the greatest yield. Conversely, below-ground biomass per area was relatively unaffected by plant density, because individual root mass decreased as the planting density increased.