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

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

Objectives: 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).

Physiological Changes:
- 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.

Research Approach:
- Field plots were planted 18 May 2016 at Champaign, Illinois on a Drummer-Flanagan silt loam 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.

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 Canopee 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 ≤ 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).

Grain Yield:
- 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.