Response of Corn to Plant Density

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Plant density has been recognized as a major factor determining the degree of competition between plants. Yield per plant decreases as the density per unit area increases. Reduction in grain yield may be the result of lower number of ears (barrenness), lower kernel weight or a combination of these components. In dense populations, many grains may not develop. This occurs in some genotypes due to poor pollination resulting from delayed silking compared to tassel emergence and/or due to limitation in assimilate supply that causes kernel and ear abortion.

Grain yield per unit area is the product of grain yield per plant and number of plants per unit area. At low densities, grain yield is limited by the number of plants, whereas at higher densities it declines due to increase in number of aborted kernels and barren stalks. Therefore, finding the optimum densities that produce the maximum yield per unit area under different environmental conditions and/or genotypes has been the major concern in many investigations. The timing of competitive stress may also be important. Many studies indicate that competition after flowering has more detrimental effects on grain yield compared to competitive pressure during vegetative growth. Radioactive labeling studies also have shown that less than 10% of grain yield is attributable to assimilates formed by photosynthesis before silking. However, carbohydrate level in plants before silking may establish sink capacity (capacity of the plant to form yield), and thus may be quite important in determining the final yield. Plant stress after silking also increases the contribution of pre-silking assimilates to yield.

The research described in this study used isolated plants as a model, to provide a quantitative estimate of the extent of competition taking place on any measured variable in the crop community. The effect of time of reduction in competition pressure at different stages of corn development on kernel development and final grain yield were also investigated.

The design of the experiment was a split plot with 3 replications. The main plots were corn hybrid cultivars and five-row sub-plots were used with rows 36 inch apart and 24 ft long. Sub-plots were 5 plant densities; 3, 4.5, 6, 9, and 12 plants m^{-2} (12,000 to 48,600 plants per acre) combined with 4 removal treatments where alternate plants were cut at the soil surface at 3 critical stages of growth. These were, no removal (R_0), removal during vegetative growth (R_1), removal at 50% tassel emergence (R_2), and removal at early grain filling time (R_3). One larger sub-plot for each hybrid in each replication was allocated to widely spaced or "isolated plants", which were separated by 6.5 ft between plants (0.25 plants m^{-2}). Multiple hybrids were planted over several years.

In general total grain yield for non removal plots reached a maximum grain yield at 24,300 to 36,400 plants per acre (6 to 9 plants $m^{-2)}$. Plants grown in "isolated" densities were used to determine the relative level of competition for each yield component. The yield of the plant in isolation represents the full yield potential of the genotype at this location in these years. Yield components were analyzed to determine how the yield per plant adjusted to increasing competitive pressure as density increased.

The relative impact of density on each yield component was determined by comparing the position and slopes of regression lines. The reduction in total grain yield was mostly due to the reduction in number of productive ears per plant. Number of kernels per row also decreased significantly as the density increased. Rows of kernels per ear and weight per kernel were less affected.

A comparison between unthinned and thinned plants having the same density as unthinned plants after thinning, showed plants remaining after early thinning (R_1) had a similar yield at harvest as unthinned plants. This indicates that early competition (from seedling emergence to R_1) had no significant effect on final yield. Plant competition between the periods of R_1 (vegetative stage) and R_2 (anthesis) had the greatest effect. Reduction in yield between these two periods was 13 to 30%, and the yield loss was greater in high densities than low densities. When compared to their initial densities, the amount of yield compensation through removal of alternate plants, was greatest with earlier removal. The average increase in grain yield compared to plants grown at the initial non thinned density (R_0) was 59-65%, 29-37% and 16-19% for R_1 , R_2 and R_3, respectively.

Yield components showed different responses to increasing assimilate supply through thinning. The component affected most was the number of kernels per row. Plants thinned at anthesis (R_2) had about 10% fewer kernels per row than those in unthinned plots. Plant removal did not increase the number of ears per plant in single-eared less-prolific hybrids, except in high density and only when plant removal was done early (R_1). In a semi-prolific hybrid only the number of ears per plant was different to those in unthinned plots at equivalent harvest densities; none of the other yield components differed from unthinned plots. This indicates that kernel number per row and weight per kernel which decreased at high densities in unthinned plots responded to thinning even at the later stages of growth.