COMPETITION AMONG EQUALLY-SPACED COTTON PLANTS GROWN AT FOUR PLANT POPULATION DENSITIES

S.J. Maas
USDA-ARS
Shafter Research Station
Shafter, CA

Abstract

A study was conducted in 1996 to investigate the dynamics of interplant competition among equally-spaced cotton plants grown at four plant population densities (15.50, 3.88, 1.72, and 0.97 plants/m^2). Plant growth was monitored weekly to determine when competition among neighboring plants began. Results indicated that interplant competition commenced shortly after adjacent plants made physical contact within and across the row. Results of this study may be used to test physiological cotton growth simulation models.

Introduction

Like most field crops, cotton (*Gossypium* spp.) is commercially grown in field stands characterized by significant interplant competition. While many studies have shown effects of plant population density on cotton yield, few have investigated the dynamics of competition within the plant community. Such studies have been carried out for other agricultural crops (Hozumi et al., 1955; Donald, 1963; Black, 1966; Soetono and Puckridge, 1982; Maas, 1985). They emphasize the importance of individual plant size and spacing in the development of competition among neighboring plants.

The objective of this presentation is to report preliminary results of a study conducted in 1996 to investigate the dynamics of interplant competition in cotton. This study involved cotton plants grown in a square pattern which equalizes the contributions of within- and across-row interaction to competition. Results from this study will be used to validate the principles for calculating competition effects in cotton growth simulation models.

Materials and Methods

Field Data

The study was conducted during the 1996 growing season at Shafter, CA. The Acala cotton variety 'MAXXA' was hand-planted at four plant population densities (15.50, 3.88, 1.72, and 0.97 plants/m^2). Each plant was equally spaced from its neighbors within and across the row. The resulting plant spacings for the four treatments were 25.4, 50.8, 76.2, and 101.6 cm (10, 20, 30, and 40 in, respectively). The 25.4-cm treatment was replicated 12 times. All other treatments were replicated 16 times. Each replication of the 25.4-cm treatment contained 16 plants. Each replication of the other treatments contained 15 plants.

The experiment was planted on May 17, 1996 (Day 138). All replications were sprinkler irrigated weekly during the experiment to avoid water stress. The plots were hand-weeded to avoid the possibility of competition between cotton and weed plants. Starting on Day 156 (June 4), measurements were made on one replication from each treatment per week. The replication was selected randomly from those available within the treatment at the time of the measurement. Measurements of plant height and width were made on each plant in the replication using a meter stick. Plant height was measured from the soil level to the top of the plant leaf canopy. Plant width was measured as the greatest horizontal distance across the plant leaf canopy. The plants were then cut at the soil level and taken to the laboratory. There, the leaves were removed and put through an electronic leaf area meter (LI-COR Model 3100) to determine the leaf area of each plant. The leaves and remaining portions of the plant were later dried in a ventilated oven and weighed to determine the above-ground dry mass of each plant in the replication.

The last remaining replication in each treatment was allowed to grow to maturity so that a yield sample could be obtained from it. Defoliants were applied on Days 269 and 279 (September 25 and October 5). On Day 289, all bolls were removed from each plant in the remaining replications. In the laboratory, the number of green (immature) and mature (open) bolls from each plant were counted. The seed cotton was removed from the mature bolls and run through a micro-gin to separate the lint and seeds. The dry weights of lint and seeds obtained from each plant were then recorded.

Statistical Analysis

The sample mean and standard deviation (SD) were calculated for each measured quantity (plant height, width, leaf area, dry mass, boll number, and yield). "Students" t statistic (Panofsky and Brier, 1968, p. 63) was used to determine the significance of the difference between sample means for the various treatments.

Results and Discussion

Plants in all treatments appeared to grow normally over the course of the experiment. The effects of interplant competition, as indicated by relatively smaller plant sizes as compared to the other treatments, were first noticed in the 25.4-cm treatment. Competition effects were noted for the other treatments at successively later dates.

Sample mean and SD values for plant width are plotted versus time in Figure 1. Prior to the onset of interplant competition, plant size increased approximately

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1485-1487 (1997)
National Cotton Council, Memphis TN

exponentially with time, as indicated by the curve in the figure fit to the mean values of plant width from the 101.6-cm treatment prior to Day 210. Data from a particular treatment tended to depart from this curve following the onset of competition. This departure tended to occur for each treatment at or shortly after the point when leaves from adjacent plants first began to touch. As indicated by the horizontal lines in Figure 1, this first contact between neighboring plants occurred approximately on Days 170, 187, 196, and 203 for the 25.4, 50.8, 76.2, and 101.8-cm treatments, respectively. Following the onset of competition within a treatment, the rate of increase in plant width dropped off sharply, resulting in a relatively constant plant width for the remainder of the measurement period. This response was also observed in the measurements of plant leaf area, above-ground dry mass, and height (Figures 2, 3, and 4, respectively).

Leaf area index (LAI), calculated by dividing the leaf area per plant by the square of the plant spacing, is plotted for the four treatments versus time in Figure 5. LAI values for all treatments approached approximately 1 following Day 220. A cotton canopy with LAI = 1, planophile leaf display, and no leaf overlap would intercept all the solar radiation falling upon the crop. It appears that, following the onset of interplant competition, the plants in this study maintained sufficient leaf area to efficiently intercept the maximum amount of available solar irradiance.

Observed boll numbers and lint yields are summarized on a per-plant and per-land area basis in Tables 1 and 2. As indicated in Table 1, the mean number of bolls per plant and the lint yield per plant consistently increased with increasing plant spacing. Results in Table 2 indicate that, on a land-area basis, the four treatments produced about the same number of bolls. However, there was a significant difference in the number of open (mature) bolls between the two upper and two lower plant spacings. As indicated in Table 2, this difference carried through to lint yield per unit land area. Thus, it appears that the greater plant spacings increased the ability of plants to mature bolls.

Acknowledgements

I wish to thank R.J. Thullen, USDA-ARS plant physiologist, and L. Vera and M.P. Rodriguez, USDA-ARS biological science technicians, for their efforts in this study.

Disclaimer

Mention of trade names in this manuscript does not imply endorsement by the United States Department of Agriculture.

References

Black, J.N. 1966. Competition within grass and cerial communities. In: Milthorpe, F.L., and J.D. Ivins (eds), *The Growth of Cereals and Grasses*. Butterworths, London. pp. 167-177.

Donald, C.M. 1963. Competition among crop and pasture plants. In: Norman, A.G. (ed), *Advances in Agronomy, Vol. 15*. Academic Press, New York. pp. 1-118.

Hozumi, K., H. Koyama, and T. Kira. 1955. Intraspecific competition among higher plants. IV. A preliminary account of the interaction between adjacent individuals. *J. Inst. Polytech. Osaka City Univ., Series D*: 121-130.

Maas, S.J. 1985. Modeling the competitive environment of field crops. Dissertation, Texas A&M Univ., College Station, TX. 189 pp.

Panofsky, H.A., and G.W. Brier. 1968. *Some applications of statistics to meteorology.* Pennsylvania State University, University Park, Pennsylvania. 224 pp.

Soetono and D.W. Puckridge. 1982. The effect of density and plant arrangement on the performance of individual plants in barley and wheat crops. *Aust. J. Agric. Res.*, 33: 171-177.

Table 1. Lint yield and boll numbers on a per-plant basis.

Plant Spacing	Total Bolls per plant	Open Bolls per plant	Yield g per plant
25.4 cm (10 in)	1.9 (a)	1.2 (a)	1.7 (a)
50.8 cm (20 in)	6.0 (b)	5.0 (b)	7.0 (b)
76.2 cm (30 in)	23.8 (c)	21.1 (c)	43.2 (c)
101.6 cm (40 in)	42.2 (d)	30.2 (d)	60.0 (c)

Note: Values in a column with the same letter in parentheses are not significantly different at the 5 percent level.

Table 2. Lint yield and boll numbers on a per-land area basis.

Plant Spacing	Total Bolls/m^2	Open Bolls/m^2	Yield g/m^2
25.4 cm (10 in)	30.1 (a)	18.5 (a)	25.6 (a)
50.8 cm (20 in)	23.3 (b)	19.4 (a)	27.2 (a)
76.2 cm (30 in)	40.9 (a)	36.2 (b)	74.3 (b)
101.6 cm (40 in)	40.9 (a)	29.3 (b)	58.2 (b)

Note: Values in a column with the same letter in parentheses are not significantly different at the 5 percent level.

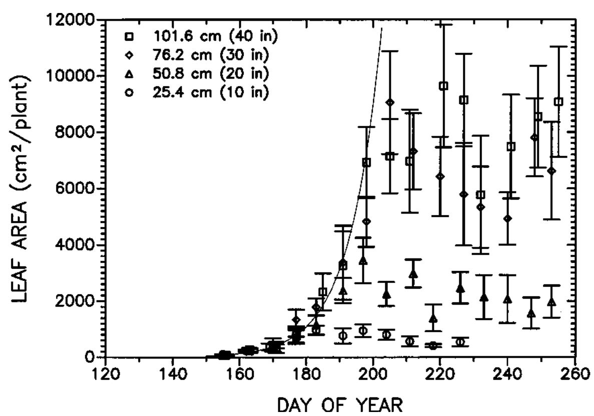

Fig. 2. Observed plant leaf area versus time for the four plant spacings. Veritcal bars around each symbol represent $\pm$1 standard deviation about the mean. Solid curve is an exponential fit to the data from the 101.6-cm treatment prior to Day 210.

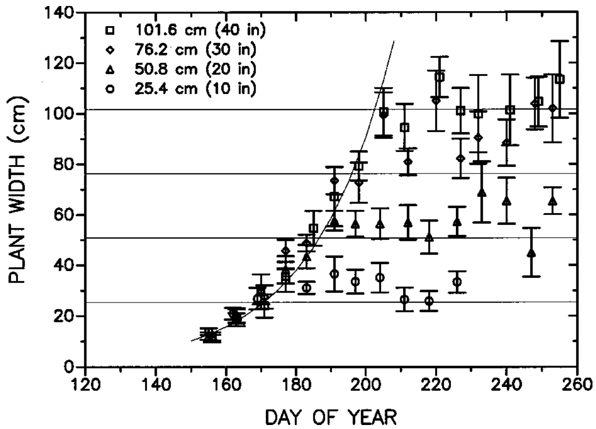

Fig. 1. Observed plant width versus time for the four plant spacings. Veritcal bars around each symbol represent ± 1 standard deviation about the mean. Solid curve is an exponential fit to the data from the 101.6-cm treatment prior to Day 210. Solid horizontal lines indicate where plant width equals plant spacing for the four treatments.

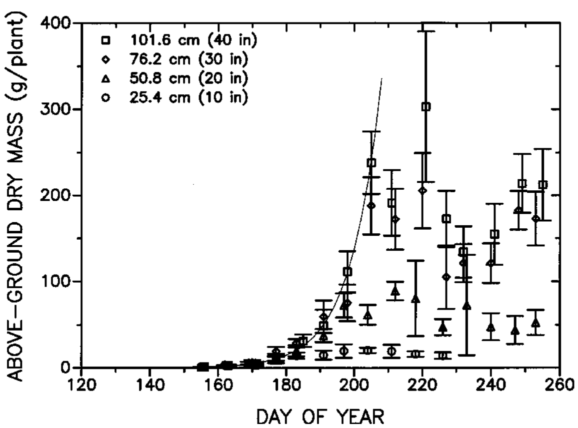

Fig. 3. Observed plant dry mass versus time for the four plant spacings. Veritcal bars around each symbol represent ± 1 standard deviation about the mean. Solid curve is an exponential fit to the data from the 101.6-cm treatment prior to Day 210.

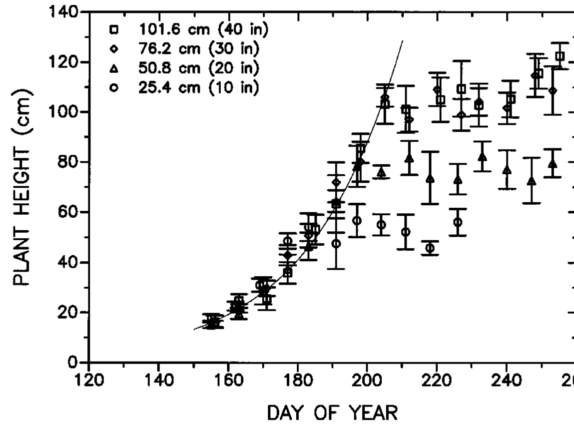

Fig. 4. Observed plant height versus time for the four plant spacings. Veritcal bars around each symbol represent ± 1 standard deviation about the mean. Solid curve is an exponential fit to the data from the 101.6-cm treatment prior to Day 210.

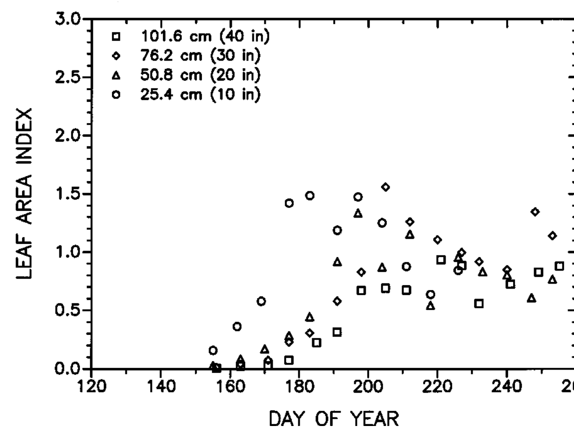

Fig. 5. Observed leaf area index versus time for the four plant spacings.