PLANT POPULATION LEVELS AND EARLINESS IN AMERICAN UPLAND COTTON

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Introduction

Earliness in American upland cotton (*Gossypium hirsutum, L.*) is a difficult attribute to define, since the cotton plant flowers and develops fruiting forms over a long period of time under potentially diverse environmental conditions (Mauney, 1986). Bennett (1908) reported the development of early rapid-fruiting types of cotton to escape boll-weevil damage. Ewing (1918) studied varietal differences and environmental factors which influence the fruiting of cotton. He showed that earliness is influenced by when the cotton plant initiates fruiting, the rate of flowering and the length of the boll period and that these factors varied with different varieties as well as with the environmental conditions under which the plants were grown. Hintz and Green (1954) demonstrated, in a study of Oklahoma varieties, that Stormproof 1 was later than Oklahoma Special because of a delayed appearance of squares and blooms and a slower rate of squaring and blooming. Lankart 57 was later than Oklahoma Special because of a slower rate of squaring and flowering and a longer boll period. Inheritance of the boll period was reported by these workers to be controlled by genes having additive effects.

Review of 1999 Official Variety Trial Reports from several State Experiment Stations revealed that differences in levels of earliness among cotton varieties is currently defined as the percent open bolls at first harvest (for example, see Caldwell et al., 1999). The date of first harvest seems to be determined by practical considerations, such as weather conditions and availability of equipment and personnel. A second definition of degrees of earliness, or maturity, among cotton varieties appears to be a determination made by the breeder or company submitting the variety for test as early, medium or late maturity. In recent years, most varieties appear to be classified as either early or medium maturity, the late maturity classification occurs rarely, if at all. These findings suggest that earliness is loosely and rather poorly defined. This important crop attribute deserves, and is currently receiving, more definitive treatment (Bourland et al., 2000).

The purpose of the present study is to attempt to characterize the influence of in-row plant spacing on the developmental factors reported to influence earliness in three commercial upland cotton varieties generally thought to be early, medium and late in maturity.

Experimental Procedure

Deltapine 50 (Delta & Pine Land Co.), HS 46 (Agripro Seeds, Inc.) and MD51ne (USDA Public Variety) were selected as reasonable representatives of early, medium and late maturing varieties, respectively. These varieties were planted in 38 inch rows on 6 May, 1995 in replicated plots at a high seeding rate and hand thinned to the appropriate in-row spacing at the 1st - 2nd true leaf stage. Plant mapping was initiated at approximate 1st flower on the 10th of July and continued at about 5 day intervals and was discontinued on the 8th of September when the plots were approaching 50 percent open. The node of the 1st fruiting branch was recorded at each mapping. At least 10 plants were mapped at each population level on each mapping date. Four, 10 Ft. sections of row of each variety were harvested by hand by fruiting zone at open boll maturity for determinations of yield and quality. Fruiting zones were defined according to the "Cotton Fruiting Zones" table below.

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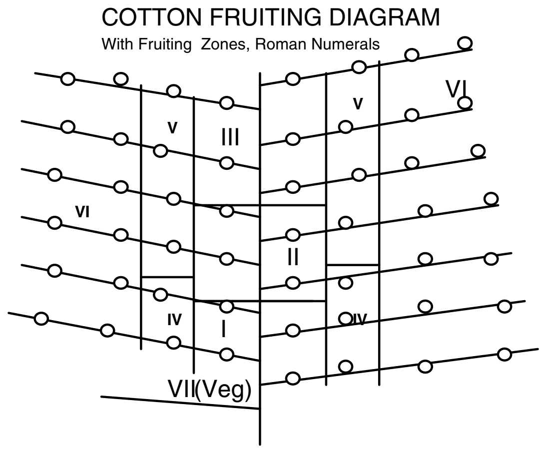

Results and Discussion

Node of 1st Fruiting Branch

The first question addressed was as suggested by Ewing (1918), when, or where, do these varieties initiate fruiting? Figure 1 shows how the node of the first fruiting branch varied by variety and plants per Ft. of row. DP 50 initiated fruiting at a lower node than HS 46 and MD51ne at all four in-row plant spacing levels. HS 46 had the highest node of first fruiting branch of the three varieties. Based on these data, DP 50 appears to be the earliest of the three varieties, confirming the conventional wisdom that it is an early maturing variety. Using this same criterion, HS 46 would be classified as the latest of the three varieties, however, it does not appear to be significantly different from MD51ne in this regard.

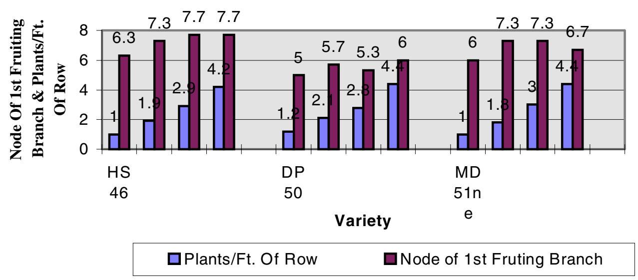

Figure 1. HS 46, DP 50 and MD51ne: Node of First Fruiting Branch and Plants per ft. of Row, N.E. AR, 1995.

Figure 2 shows the linear least squares regression analyses of the change in the node of the 1st fruiting branch with change in the in-row plant spacing level for all three varieties. These data reveal that HS 46 responded linearly to changes in plant spacing at a rate of about 0.5 of a node of the 1st fruiting branch per plant per Ft. (R squared = 0.81). DP 50 also responded to changes in plants per Ft. of row in a linear fashion at a lower rate of approximately 0.25 of a node of the 1st fruiting branch per plant per Ft. (R squared = 0.58). The node of the 1st fruiting branch for MD51ne did not respond to changes in plant spacing in a linear mode (R squared = 0.19) rather, as shown by Figure 2, responded in a polynomial mode yielding a quadratic function (R squared = 0.98). Figure 3 shows the rate analysis, based on the 1st derivative of the quadratic equation, for the change in the node of the 1st fruiting branch at different in-row plant spacings for MD51ne. These data indicate that the node of the 1st fruiting branch for MD51ne changed at a continuously variable rate decreasing from about +1.5 nodes per plant per Ft. of row at 1 plant per Ft. to approximately -1.5 nodes per plant per Ft. of row at 4 plants per Ft. These findings clearly demonstrate that the node of the 1st fruiting branch is influenced by both variety and in-row plant spacing, and that in-row plant spacing is, at least, as influential as variety.

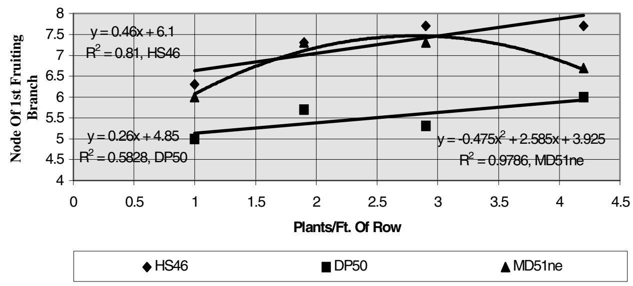

Figure 2. HS 46, DP 50 and MD51ne: Change in Node of First Fruiting Branch with Change in Plants per ft. of Row, N.E. AR, 1995.

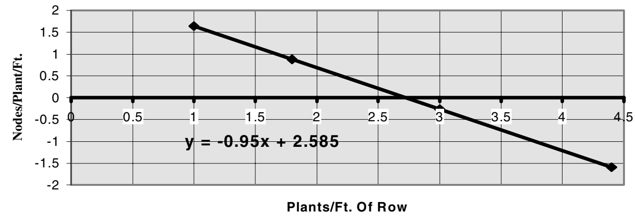

Figure 3. Rate Analysis, MD51ne: Change in Node of First Fruiting Branch per Plant per ft. of Row.

Fruiting Rates

All three of the earlier investigators referenced above indicated that earliness in American upland cotton was influenced by the rate of formation of fruiting forms. As a results of these reports, efforts were made to determine the fruiting rates of the three varieties included in this study at different plants per Ft. of row levels. These data were developed by calculating the best fit quadratic equations for the developmental curves of total and 1st and 2nd position fruiting forms produced at approximate 5-day intervals from July 10 through September 8, 1995. Fruiting rates were then estimated from the 1st derivatives of the quadratic equations described above. Maximum fruiting rates occurred on the earliest observation date, 7/10/95.

Figure 4 summarizes the results of these studies for total fruiting forms per plant per Ft. on July 10, 1995 at 1 and 3 plants per Ft. of row. At 1 plant per Ft. of row, there were distinct varietal differences, i.e., 0.89 total fruiting forms per plant per day for DP 50, 2.36 total fruiting forms per plant per day for HS 46 and 3.1 total fruiting forms per plant per day for MD51ne. At 3 plants per Ft. of row, these differences were greatly reduced, i.e., 0.62 total fruiting forms per plant per day for DP 50, 0.75 total fruiting forms per plant per day for HS 46 and 1.01 total fruiting forms per plant per day for MD51ne.

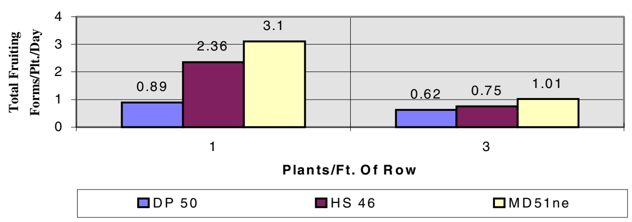

Figure 4. DP 50, HS 46 and MD51ne, Fruiting Rates: Total Fruiting Forms per Plant per Day at 1 and 3 Plants per Ft. of Row.

Recognizing that commercial cotton production is not done by the plant but by unit of land surface, Figure 5 summarizes the results obtained for total fruiting forms per acre per day an the same date, 7/10/95.

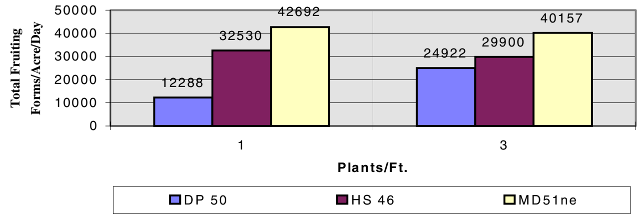

Figure 5. DP 50, HS 46 and MD51ne, Fruiting Rates: Total Fruiting Forms per Acre per Day at 1 and 3 Plants per ft. of Row on July 10, 1995.

Jenkins et al., (1990) reported that a large percentage (>70%) of cotton yield is derived from the central portion of the plant. Based on this report, it seemed appropriate to ask if plant population levels influenced the location of fruiting forms on the plant? Figure 6 summarizes the results of a study to determine the effect of in-row plant spacings on "effective" fruiting rates, i.e., 1st and 2nd position fruiting forms per plant per day. At 1 plant per Ft. of row, DP 50 produced 0.22 1st and 2nd position fruiting forms per plant per day, whereas both HS 46 and MD51ne produced 0.78 1st and 2nd position fruiting forms per plant per day. This finding represents a more than 3.54 fold difference between DP 50 and the other two varieties, i.e., reportedly early and late maturing types, with respect to the "effective fruiting rates. At 3 plants per Ft. of row, this large difference between reportedly early and late maturing types disappeared, with all three varieties approaching about 0.5 1st and 2nd position fruiting forms per plant per day. Figure 7 shows these results in terms of 1st and 2nd position fruiting forms per acre per day at 1 and 3 plants per Ft. of Row.

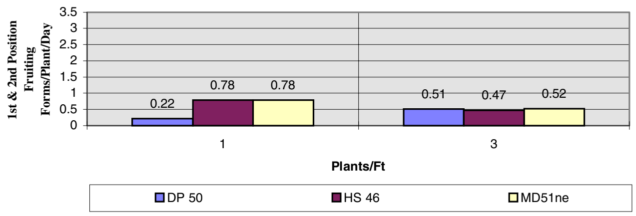

Figure 6. DP 50, HS 46 and MD51ne, Fruiting Rates: 1st and 2nd Position Fruiting Forms per Plant per Day at 1 and 3 Plants per ft. of Row on July 10, 1995.

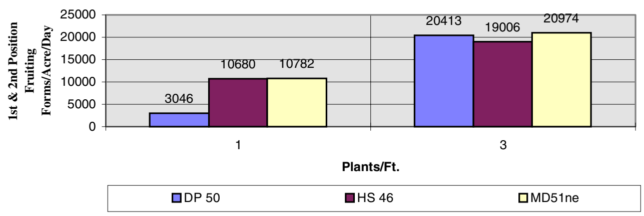

Figure 7. DP 50, HS 46 and MD51ne, Fruiting Rates: 1st and 2nd Position Fruiting Forms per Acre per Day at 1 and 3 Plants per ft. of Row on July 10, 1995.

Percent Open Bolls

The ultimate test of earliness is whether or not cotton bolls are opened and can be harvested. Figure 8 shows the percent open bolls on 9/8/95 for the three varieties in the study at 1 and 3 plants per Ft. At 1 plant per Ft., DP 50 was 43 percent open, HS 46 was 34 percent open and MD51ne was 15 percent open. These findings are consistent with the proposition that DP 50 is early maturing, HS 46 is medium maturing and MD51ne is late. At 3 plants per Ft., DP 50 was 63 percent open; HS 46 and MD51ne were both 50 percent open. Thus, at 3 plants per Ft., DP 50 still appeared to be the earliest but HS 46 and MD51ne were the same. These data clearly illustrate that in-row plant spacing have a significant effect on earliness, indeed, the maximum genetic difference in percent open on 9/8/95 was between DP 50 and MD51ne at 1 plant per Ft., a difference of 27 percent. On the other hand, MD51ne showed a 34 percent difference in percent open between 1 and 3 plants per Ft. Therefore, the maximum plant spacing difference was 7 percent larger than the maximum genetic difference.

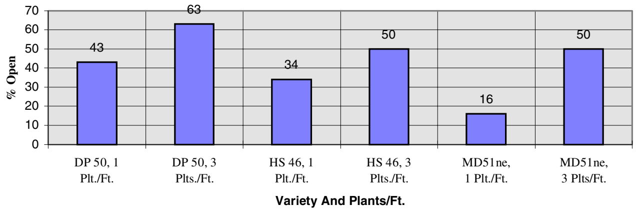

Figure 8. DP 50, HS 46 and MD51ne: Percent Open at 1 and 3 Plants per ft. of Row on 9/8/95.

Boll Opening Rates

Figure 9 shows the effect of in-row plant spacing on the rate of boll opening, a dynamic indicator of earliness. At 1 plant per Ft. MD51ne had the lowest rate of boll opening of all three varieties at 2556 open bolls per acre per day. DP 50 and HS 46 were very similar at 1 plant per Ft., having boll opening rates of 6053 and 6403 open bolls per acre per day, respectively. MD 51ne, at 3 plants per Ft. of row, gave the greatest increase in boll opening rate over the 1 plant per Ft. rate at 9488 open bolls per acre per day, a 3.7 fold increase. DP 50 had the second highest level of improvement at 11921 open bolls per acre per day, a 1.97 fold increase. HS 46 had a boll opening rate of 9935 open bolls per acre per day at 3 plants per Ft., a 1.55 fold increase over the rate a 1 plant per Ft. These results constitute very strong evidence that in-row plant spacings have a truly quantitative impact on earliness.

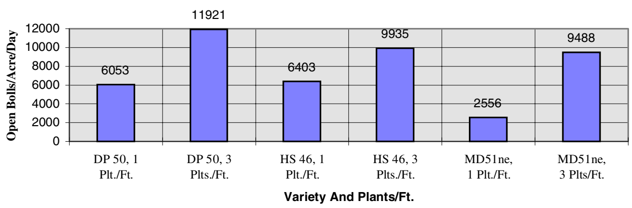

Figure 9. DP 50, HS 46 and MD51ne: Rate of Boll Opening (Open Bolls per Acre per Day) at 1 and 3 Plants per ft. of Row, 8/17 - 9/7, 1995.

Location of Yield

Common sense dictates that earliness in American upland cotton must ultimately be determined by the location of the mature bolls on the plant. Bolls located in 1st and 2nd positions on fruiting branches near the bottom of the plant must be the earliest. Figures 10, 11 and 12 show the percent of total lint yield derived from the 1st eight 1st position bolls for DP 50, HS 46 and MD51ne at 1, 2, 3 and 4 plants per Ft. of row. This is a very stringent measure of earliness. All three varieties benefited in earliness from an increase in the in-row plant spacing level. MD51ne had the greatest improvement in the percent of yield in the 1st eight 1st position bolls of 52.1 percent from 1 to 4 plants per Ft. DP 50 had the second best improvement in this measure of earliness of 33.2 percent from 1 to 3 plants per Ft. HS 46 showed the poorest improvement in the percent of total yield in the 1st eight 1st position bolls of 21.8 percent from 2 to 3 plants per Ft. of row. These findings indicate that diverse genetic types of cotton may benefit in terms of earliness, yield and quality by optimum plant spacing management.

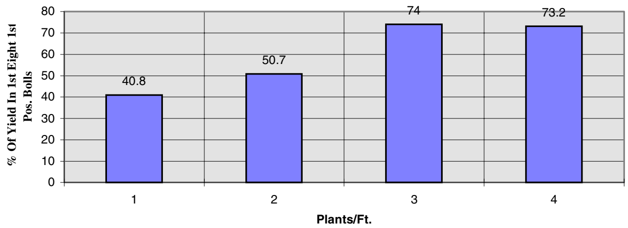

Figure 10. DP 50: Percent of Total Yield in 1st Eight 1st Position bolls at 1, 2, 3 and 4 Plants per ft. or Row.

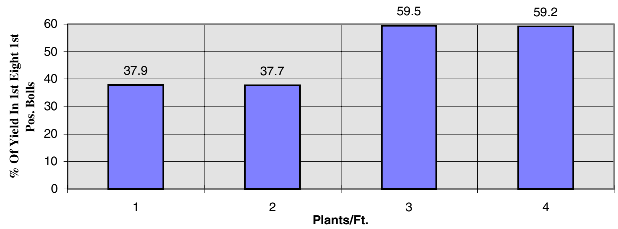

Figure 11. HS 46: Percent of Total Yield in 1st Eight 1st Position Bolls at 1, 2, 3 and 4 Plants per ft. or Row.

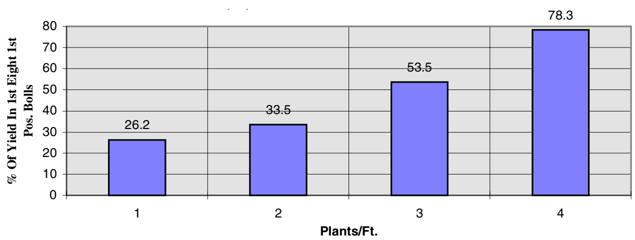

Figure 12. MD51ne: Percent of Total Yield in 1st Eight 1st Position Bolls at 1, 2, 3 and 4 Plants per ft. or Row.

Yield and Quality

Early maturity in cotton has many advantages (see Poehlman, 1959). In addition to crop management and yield advantages, Lewis (1996) reported that the most pernicious source of variability in cotton fiber quality is the environmental conditions under which the fibers develop. Fruiting forms are produced on cotton plants in a sequential manner, starting with the first fruiting branch at the bottom of the plant and progressing upward and outward in an arithmetic progression. The developmental sequence is commonly defined as about three days difference in age for first position bolls from one fruiting branch to the next, the vertical fruiting interval, and approximately six days difference in age for fruiting forms produced in second positions and further out the same fruiting branch, the lateral fruiting interval. This indeterminate fruiting habit provides for significant sources of variation in cotton fibers simply because the fibers from bolls produced in different positions on the plant may have different fiber properties because they were formed and grew at different times under quite different conditions of temperature, moisture, etc. Managing in-row plant spacing to concentrate the lint yield into bolls developed under more similar environmental conditions could significantly reduce the variability in important cotton fiber properties such as genetic short fiber content (Lewis, 1998). Efficient, High speed yarn forming devices, such as Murata Vortex Spinning, and the competitiveness of U.S. textile mills could benefit enormously from reduced variability in cotton fiber properties.

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