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THE RELATIVE CONTRIBUTION OF INDIVIDUAL FRUITING SITES TO COTTON YIELD AND QUALITY

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Abstract

The indeterminate growth habit and the production of multiple fruiting sites on axillary branches allows the cotton plant, *Gossypium hirsutum* L, to initiate more fruiting sites than it ever matures as harvestable bolls. Work across the Cotton Belt indicates that fruit retention represents less than 30% of the total fruiting sites produced. First position sites on fruiting branches contribute 50-80% of the harvested yield and second position sites contribute 20-25%. An understanding of the contribution of individual fruiting sites to yield and quality of lint and seed is essential to development of management strategies to optimize inputs and reduce cost of production by trying to protect fruiting sites that have very low probabilities of producing harvestable fruit. Due to the relative shortness of the growing season in West Texas, it is even more important to understand the role of various yield components to final harvestable yield and the quality of the fiber at each fruiting site. Overall yield is dependant on the number of bolls per unit land area and the amount of lint boll^{-1}. Boll number is dependent on the number of plants acre^{-1} as well as the number of bolls plant^{-1}. Plants acre^{-1} can be controlled to a certain extent at planting time by choosing the right seeding rate. The bolls plant^{-1} component is strongly associated with the environmental resources available to each plant and inversely related to plant density. Boll size is a function of the number of seed boll^{-1} and the amount of lint that each seed produces. The objective of this research was to determine the relative importance of each fruiting site to final yield and quality. First position bolls accounted for 70 to 75% of the total yield. Second positions made up 20 to 25% and third and fourth positions contributed less than 5% to the overall yield of the crop. The bulk of the yield (>75%) was produced from mainstem nodes 8 through 12 This makes first position fruit on these nodes very important to total lint produced. Lint boll^{-1} increased as the number of seed boll^{-1} increased. Lint seed^{-1} appeared to be more closely coupled to the environment than did the number of seed boll^{-1}. Lint seed^{-1} is a weight measurement and is made up of fiber length and micronaire. Under severe environmental stress, the fibers will not elongate or they will not build as dense a secondary wall, depending on what growth stage the boll is in at the time of the stress. The results of these analyses provide valuable information as to the value of individual fruiting sites to final yield and quality.

Introduction

The indeterminate growth habit of cotton results in production of fruiting sites and the growth and development of individual fruit over an extended period of time as opposed to a very short flowering period for some of the more determinate crop species such as the cereal grains. This fruiting habit reduces the risk of complete crop failure due to excessive environmental stress at any one time during the growing season, but also causes each fruit to be exposed to different weather conditions during development. On the Texas High Plains, flowers produced in July develop fruit under favorable temperatures in August. However, August flowers develop fruit under declining temperatures in September. This can result in tremendous variability in size and lint quality among fruit on the same plant. In the San Joaquin Valley of California, Kerby et. al. (1987) found that on average 58, 21, and 6 percent of the final yield was produced at the first, second, and other fruiting sites on individual fruiting branches. Jenkins et. al. (1990a) in the Mississippi Delta reported total yield was distributed as 70, 20, and 3 percent across fruiting positions 1, 2, and 3. This study also indicated that nodes 9 through 14 produced the majority of the lint in all cultivars. Jenkins et. al. (1990b) also found that across cultivars, the percentage of the plants with a harvestable boll at fruiting position 1 on a sympodial branch increased from 9.6% at node 6 to 48.7% at node 12, decreasing after that. Less than 1% of the plants had a boll at the second fruiting site on the sixth node and only 21.2% had a boll at the second position on node 12. Fewer than 5% of the plants matured a boll at the corresponding third fruiting positions. Also, bolls at the first fruiting site were 14% larger than those at second position and 21% larger than those at the third.

By understanding the relative contribution of each individual fruiting site to the total yield and quality of the harvested crop, better management decisions can be made to maximize the production and retention of the most valuable sites and to minimize the cost of protecting the less valuable sites.

Materials and Methods

In order to generate a large database, this study was conducted over a two year period (2000 & 2001) under contrasting environmental conditions. Data were collected from our own research farm, variety tests of various seed companies, and individual producer fields. This approach offered an opportunity for differences in weather patterns, management strategies, varieties, and many different growing environments resulting in a wide range of yields.

Immediately prior to harvest at each site, a box-mapping approach was used to determine the relative contribution of each fruiting site to yield and quality. Plants were removed from a $10m^2$ area at random in each field and hand harvested by position. The total bolls from each fruiting position were then ginned using a ten-saw gin. Fiber quality analyses were conducted by the International Textile Center in Lubbock Texas.

Results and Discussion

Yields ranged from about 200 pounds acre^{-1} to over 2000 pounds acre^{-1} across the 120 environments evaluated.
Multiple regression analysis for the two-year means of total yield revealed a partial R^2 of 0.854 for the number of bolls acre^{-1} and 0.097 for the grams of lint boll^{-1} (Table 1). Analyses of the boll number component revealed that a strong interaction existed between plants acre^{-1} and bolls plant^{-1} , as expected. The number of fruit plant^{-1} is dependent upon the number of fruiting sites plant^{-1}, and the retention of fruit. Both of these components are highly sensitive to environmental stress. Lint boll^{-1} accounts for approximately 10% of final yield variability and has both a genetic and environmental component. The size of individual fruit is related to the number of seed boll^{-1} and the amount of lint seed^{-1}. Lint seed^{-1} is a function of the number of fibers seed^{-1} and fiber weight, which is due to the overall length and micronaire of the fiber. At this point it is unclear as to whether it is the length or the micronaire of the fiber that account for more of the fiber weight. However, it is clear that it is not the number of fibers seed^{-1} since this factor makes up less than 3% of the variability in lint seed^{-1}.

Boll Distribution

Across all yield levels, 90 to 95% of the yield was produced in the middle of the plant, from five or six nodes (Table 2). First position fruit accounted for 70 to 75% of the total lint and second position 20 to 25%. Third and fourth position fruit accounted for less than 5% of the total yield, in most cases (Fig. 1). The percent of plants with a boll at any given position had the greatest influence on yield. At yields of 250 pounds acre^{-1} only one node had a harvestable first position boll on more than 50% of the plants. As yield increased to 600 pounds acre^{-1}, there were 4 nodes with a first position boll on over 50% of the plants. At 1,100 and 1,600 pounds acre^{-1} yields, there were 6 to7 nodes with a boll on more than 50% of the plants (Table 2).

Boll Size

Lint boll^{-1} is a function of the number of seed boll^{-1} and the amount of lint seed^{-1}. Lint boll^{-1} increased as yield increased up to 500 pounds acre^{-1}, then leveled off around 1.5 grams boll^{-1} (Table 2). The slight decrease in lint weight observed at the 1,600 pound yield was due to more third position fruit making up the average. Lint seed^{-1} is a function of the number of fibers seed^{-1}, fiber length, and micronaire. Current analysis indicates that lint seed^{-1} is more strongly influenced by length and micronaire, than by fibers seed^{-1}.

Fiber Quality

The cotton fiber elongates for the first 20 to 25 days after the white flower is visible. Fiber length and strength are highly linked to the genetics of the cultivar. Both years revealed that fibers from second position fruit were just as long as those from first positions and in any one cultivar varied less than 3/32nds across all fruiting positions. Strength followed this same pattern varying less than 8 g tex^{-1} due to boll position. Part of the variability in strength is probably due to micronaire because of the way the HVI machine measures bundle strength and not individual fiber strength. Micronaire was highest for the lower fruiting positions and declined up the plant and out on sympodial branches as expected due to temperature differences during cellulose deposition.

Conclusions

In the past it has been accepted that the nodes that produce the most yield have been on the bottom of the plant, when in fact they are in the middle of the plant. First position bolls account for 70 to 75% of the total lint and second position for 20 to 25%. Third and fourth position fruit add very little to total yield accounting for less than 5% in most cases. The number of bolls acre^{-1} account for 85% of the yield and the size of the bolls account for only about 10%. Fiber maturity is typically measured in terms of micronaire. Prolonged water stress, root restrictions, nutrient deficiencies, low temperatures, and insect pressure can delay maturity. All of these except temperature and, in some cases, water stress can be avoided with proper management. Environmental effects are not the same for all cultivars. Cultivars with genetic potentials for better quality cotton will react the same to adverse weather conditions as those with poorer traits. However, it was noted that some cultivars held to a one to one regression line closer than others. By knowing that up to 95% of the yield is produced on nodes 6-12, and that first position bolls account for 70 to 75% of the yield, better management decisions can be made to save these key bolls and possibly increase yield and fiber quality.

References

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Table 1. Multiple regression analyses of total lint yield vs. bolls acre^{-1} and lint boll^{-1}.

MULTIPLE REGRESSION ANALYSES of COTTON LINT YIELD

Source	Component	Parameter Estimate	Partial R^2 % Variability
Lint Yield	Intercept	0.00	– – –
	Boll acre^{-1}	16.77	0.854
	Lint boll^{-1}	38.42	0.097
		Total R^2	0.951
Boll Acre^{-1}	Intercept	0.00	– – –
	Boll plant^{-1}	6.43	0.374
	Plants acre^{-1}	1.51	0.376
		Total R^2	0.750

Table 2. Component Contribution to Harvestable Yield

Yield (lbs. acre^{-1})	Main Stem Node Number Contributing to 95% of Total Yield	Number of Nodes with a Boll on More Than 50% of the Plants	Avg. Lint Boll^{-1} (grams)	Number of Seed Boll^{-1}	Avg. Lint Seed^{-1} (milligrams)
250	4-7	1	1.04	23	43.32
650	6-12	4	1.49	25	59.00
1,100	6-13	6	1.50	30	49.44
1,600	6-13	7	1.28	28	53.28

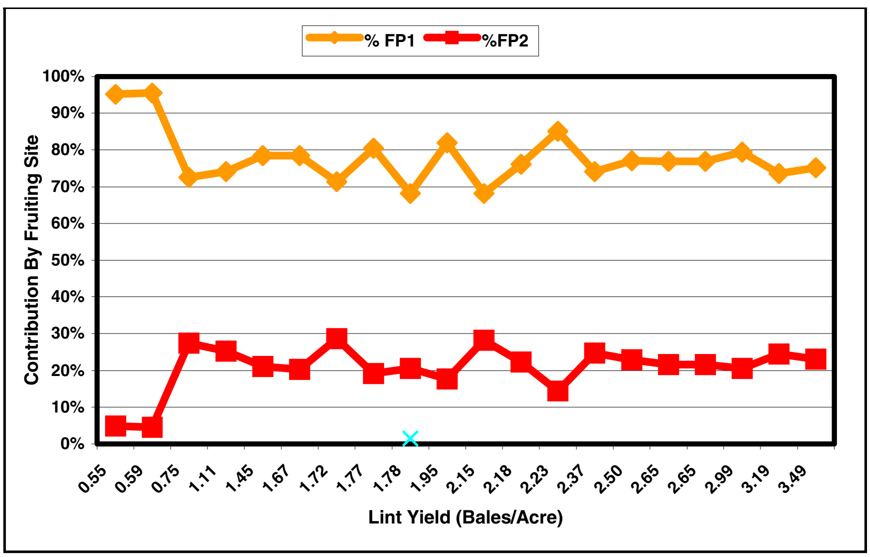

Figure 1. Contribution by fruiting site to total lint yield.