STUDIES ON OBJECTIVE COTTON YIELD FORECASTS
BY THE RESEARCH AND DEVELOPMENT STAFF

- Introduction -

During the 1954 growing season a scientifically selected sample of [illegible] cotton fields in [illegible] Southern States was visited as of August 1 and [illegible] to obtain [illegible] observations and fruit counts that might be useful in forecasting yields. The same fields were visited after harvest for [illegible] to determine the amount of open cotton left behind in harvesting and the number of bolls that failed to make cotton. These counts, [illegible] represents that [illegible] desirable from experience in 1954, were repeated in 1955 on a sample of [illegible] fields. Data for 1954 and such data as are already available for 1955 show some interesting relationships which [illegible] particularly noteworthy because the two growing seasons were so widely different: 1954 was a very dry season while 1955 has up to now been exceptionally favorable. These studies lead one to believe that reliable forecasts of cotton yields can be made from fruit counts as early as August 1.

- The 1954 Fruit Counts -

The 1954 fruit counts as of August 1, September 1, and end of season are summarized below. Bloom counts are combined with small boll counts in this report to give the "small boll" figures. Figures on "large bolls" represent combined separate counts of unopened bolls one inch or more in diameter, open bolls, and burrs. The end of season count represents all bolls from which cotton was picked, also open cotton still in the field, plus bolls which failed to open or reach full size. This last figure was not actually a "count." Because many burrs were missing after farmers harvested their fields, it was necessary to compute the number of open bolls from which cotton was harvested by working back from the known average yield for the sample (derived from [illegible]) and the amount of cotton per boll. [illegible] open bolls still remaining in the field after harvest were added to [illegible] to derive a total boll "count." All figures are expressed in terms of fruit per 10 feet of row.

Table 1
1954 Fruit Counts per 10 Feet of Row

	August 1	September 1	End of Season
Squares	73.5	-	-
Small Bolls	2[illegible].7	13.1	-
Large Bolls	22.6	55.5	62.8

Of the total "count" of 62.8 bolls at the end of the season, 91 percent represents cotton picked by the farmer, 4.5 percent represents open bolls which were left in the field or which opened after the farmer harvested his crop and another 4.5 percent represents bolls that failed to reach maturity for various reasons.

The first point to strike the eye in looking at these figures is that the number of bolls for which we can account at the end of the season is almost exactly equal to the total number (68.7) counted as of September 1. This suggests that the total number of bolls present on September 1 is a good index of final yield — the only additional information needed on that date is the weight of cotton per boll, and the only uncertainty is the fraction of bolls that will fail to reach maturity or will be ruined in harvesting. The weight of cotton per boll can be determined by picking and weighing open cotton on sample plants as was actually done in this survey. It is also likely that harvesting losses tend to be a rather constant fraction of total yield from one year to another. This reduces the area of uncertainty on September 1 to a forecast of the number of bolls that will fail to reach maturity because of shedding, frost, weevils, or other damage. But further experience should shed considerable light on these matters, and, in any event, the extent to which judgment needs to be exercised is even now quite small.

This reduces the forecasting problem as of August 1 to forecasting the number of bolls present by September 1. On August 1 only 51.3 bolls were present, as compared with 68.7 on September 1. The increase of 17.4 between the two dates represents 22.2 percent of the squares counted as of August 1. To forecast the yield on August 1 it would seem that it is necessary only to take 22.2 percent of the squares counted and to add that figure to the number of bolls counted. Using an estimate of 1 pound of seed cotton per [illegible] bolls, 37 pounds of lint per 100 pounds of seed cotton, and the average row spacing for all fields studied, gives a factor of 4.67 which can be applied to the estimated total bolls in 10 feet of row to derive a *potential* yield in terms of pounds of lint per acre. Experience in 1954 suggests that the actual *harvested* yield is 9 percent less than that forecast because of normal harvesting losses and failure of some bolls to reach maturity. By September 1 the total observed boll count alone seems to be a reliable indication of the final boll count.

- The 1955 Fruit Counts -

Counts this season are being made as of August 1, September 1, October 1, and after harvest. The season is not yet over and the actual yield per acre has not been determined. But the season is advanced enough to give some indication of the reliability of fruit counts as yield indicators. Only August 1 and September 1 counts are available at this writing.

Table 2
1955 Fruit Counts Per 10 Feet of Row

	August 1	September 1
Squares	54.9	-
Small bolls	23.5	24.7
Large bolls	20.4	58.5

The August 1 total fruit count was almost identical with that found in 1954 — [illegible] as compared with [illegible]. But a slightly higher fraction was in the square stage. But the most striking feature of the September 1

counts is that 83.2 bolls were present, as compared with only 69.7 on the same date the previous year. It is believed that the September 1 count, together with the observed weight of cotton per boll, pretty well tell the story of what the final yield will be this year -- the major unknowns are the extent to which bolls present on this date may be shed or damaged during the rest of the season and the extent of possible harvesting losses. The point that seems to need most attention in the forecasting situation as of August 1. Data show the boll count increased from 43.9 to 63.2 between August 1 and September 1 -- an increase of 37.3 bolls as compared with only 17.1 the previous year. This increase represents 66.3 percent of the August 1 squares instead of only 32.2 percent as in 1954.

This indicates pretty clearly that a fruit count alone as of August 1 is not a reliable indicator of the number of bolls that will be present by September 1. This raises the question of whether the more rapid fruiting rate between August 1 and September 1 in 1955 was a consequent of more favorable growing conditions between these two dates, or whether a higher fruiting capacity was already built into the plants by August 1 of this year. Growers' high reported cotton condition and appraisals of prospective yields on August 1 of this year do vest that the general appearance and vigor of the plants on that date pointed to a high yield. This, in turn, gives weight to the hypothesis that the heavy fruiting between August 1 and September 1 resulted from plant characteristics that were already in evidence on August 1 even though the crop was in a later stage of maturity and many plants had no large bolls.

- Rate of Fruiting as a Forecasting Device -

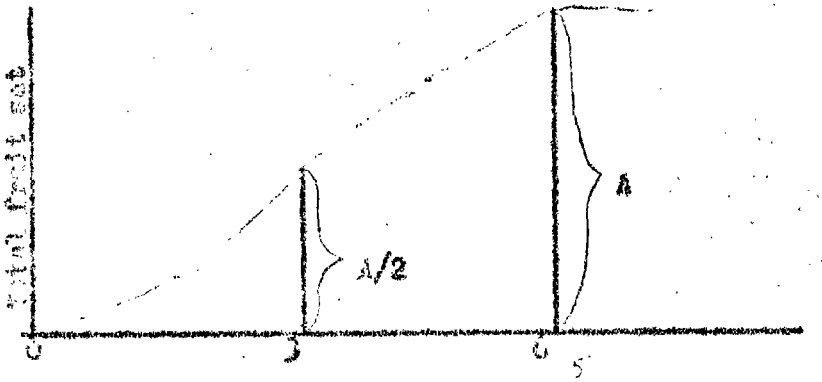
A re-examination of the 1954 and 1955 data reveals some relationships that account for the difference in rate at which new bolls were set on the plants between August 1 and September 1 in the two years. The pertinent factor seems to be the stage of development of the plants as of August 1. The percentages of plants falling in various categories on August 1 are shown below for the two years.

Table 3
Classification of Plants by Stage of Maturity on August 1

	1954 Percent	1955 Percent
Plants with squares only	6.5	24.9
Plants with squares and small bolls	18.4	21.3
Plants with squares, small bolls, and large bolls	75.1	53.8
Total	100.0	100.0

In 1954, 75.1 percent of the plants were in the large-boll stage by August 1 and had stopped adding fruit, while in 1955 only 53.8 percent fell in this category by August 1. This means that a higher percentage of plants were still adding fruit on August 1, 1955 than on August 1, 1954. The situation is as follows:

The total amount of fruit set on the cotton plant, by any date after squaring begins, follows an S-shaped growth curve as shown in the chart.



About 3 weeks after squaring starts, small bolls begin to appear. At that time the plant has about one-half its total fruit load and is in its most active fruiting stage. About 6 weeks after the first squares are formed, large bolls begin to appear; from that time on, the total amount of fruit on the plant remains fairly constant because the plant is carrying its full fruit load.

When fruit counts are made throughout the Cotton Belt as of August 1, plants on which only squares are present can range anywhere from those on which squaring is just beginning to those on which many squares are ready to burst into bloom. This means that the average plant on which squares are counted should be about midway on the zero to 3-week fruiting range shown on the chart and should have about 1/4 of its full fruit load. For the same token, plants with small bolls but no large bolls could be anywhere on the 3 to 6-week fruiting range shown on the chart, with the average plant being near the middle of the range and carrying 3/4 of its full load. All plants with large bolls already are carrying their full load.

Using the percentages shown in Table 3, the average fruit load for all plants in the sample on August 1, 1954 is $0.065(A/4) + 0.435(3A/4) + 0.750(A) = 0.905A$, in which A is the full potential. The total fruit actually counted (squares + all bolls) on August 1, 1954 was 130. Hence, $A = 130/0.905 = 144$. This means simply that if all plants had been at their full potential on August 1, 1954, we would have found 144 units of fruit per 10 feet of row instead of the 130 that were actually there.

But, the most interesting feature of these relationships is the estimate of rate of fruiting that can be derived from them. Plants in the square stage are setting fruit at an average rate of approximately A/6 units per week. Plants in the small-boll stage are setting fruit at about the same average rate. Plants in the large-boll stage have stopped setting fruit. As 25.0 percent of the plants fell in the first two categories on August 1, 1954, the average rate at which fruit was setting at that date is $0.250(A/6) + 0.750(0) = 0.042A$ or 6.0 units per week.

On August 1, 1955 the total fruit counted was almost identical with the August 1, 1954 total -- 127 as compared with 130. But, because of higher proportions of plants in the actively fruiting stages, the fruit [illegible] potential in 1955 is 2.172, as compared with 2.02, the previous year. The average rate at which fruit was [illegible] on August 1, 1955 is found to be 0.4394 or 13.1 units of fruit per week. This means that on August 1, 1955 fruit was being added to the average plant 13.1/6.0 or 2.18 times as fast as on August 1, 1954.

In 1954, 17.4 bolls were added to 10 feet of row between August 1 and September 1. The above computations indicate that in 1955 the increase should be (2.18)(17.4) or 37.9 bolls. As shown earlier in Table 2, the increase that actually took place between August 1 and September 1, 1955 was 37.5 bolls. Apparently data available as of August 1 can be used to forecast the number of bolls that will be found a month later, by bringing rate of fruiting into the picture. That rate of fruiting can be deducted from the August 1 fruit counts and the distribution of plants by classes representing pertinent stages of plant development as of that date. That forecast in turn should lead to a fairly reliable forecast of the crop for the season. Periodic plant observations during the remainder of the growing season would enable the crop reporting board to keep abreast of changes in prospects as the season advances.