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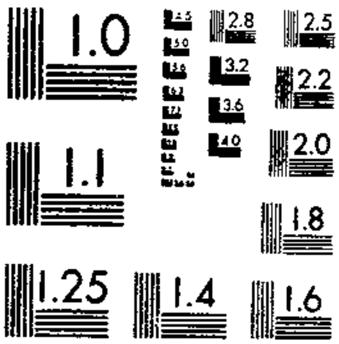

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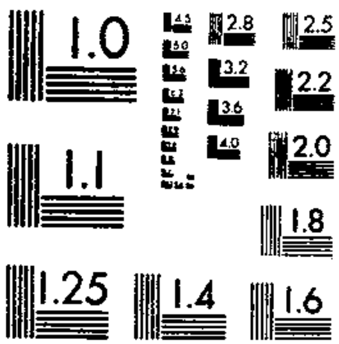

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ANALYSIS OF FACTORS INFLUENCING COTTON YIELDS AND THEIR VARIABILITY

With special reference to the Upper Piedmont and West Texas Rolling Plains [1]

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CONTENTS

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CONTENTS—Continued

Cotton yields vary widely between farms in any year, and between years on the individual farm. In any area—over time—there are also wide differences among the average yields for individual farms. This report is concerned with the reasons behind the last two of these three sources of variation in yield. Anything that will increase a farmer's yield level should tend to increase his average net income and his level of living. Likewise, the attainment of more stability in yields from year to year will tend to make cotton farming less risky. An extremely low yield in a particular year may deplete a farmer's resources and shrink his credit base to such an extent that his production capacity will be greatly curtailed. The impact of such an event extends to and often affects first of all, the living standard and financial security of his family. Therefore, anything that can be done to help stabilize the yields of cotton should tend to make cotton farming a less precarious occupation.

In this bulletin certain basic characteristics of farms and operators, along with other production factors that are subject to management are examined in an attempt to learn the reasons for differences in variations between farms, with respect both to the general level of cotton yields and to yearly yields. The results of the analysis of yearly yields by regression methods are applied in determining crop-insurance premium rates.

SUMMARY

Sample data for two contrasting areas—the Upper Piedmont of South Carolina and Georgia and the Rolling Plains of West Texas—were used in the study. Additionally, data from the Crop Reporting Board on county yields by years, and the results from experimental plots at experiment stations were analyzed in order to supplement the findings from the sample study. The phases of the study were: (1) Analysis of sample characteristics, (2) tabular analysis by cross-classification methods of the relationships of operator and farm characteristics to average farm yield and the coefficient of variation in yield, (3) correlation analysis of location and production factors against average yield and the coefficient of variation in yield, (4) correlation of production practices and of either periodic tendencies in yield or rainfall factors against farm yearly yield, and (5) application of the regression equations of yearly yields and their standard errors of estimate, to forecasts of yearly yields and computation of premium rates required in order to insure specified percentages of the forecasted yields.

Analysis of the sample characteristics disclosed a U-shaped distribution of yearly yields of farms as the time interval of the yield history varied from 1 to 9 years. The array of yearly yields of farms with yield histories of 3 years or more by yield groups gave a moderately positively skewed distribution which approached the normal curve more closely as the crop year became more favorable. The frequency distribution of farm average yields closely approximated the normal curve, whereas that of the coefficient of variation was quite different from it. A comparative tabulation of operator and farm characteristics, and production practices for all farms in the sample, with yield histories of 3 years or more, disclosed that the following factors were associated with increased level of yield in the Upper Piedmont: Lower erosion, less steep topography, more favorable practices in obtaining seed from breeder and treating them before they were planted, higher applications of fertilizer per acre, and a higher percentage of cropland in cotton. There was some tendency for the operators to be younger and to have more education where yields were high. Loss from hail varied inversely with average yield.

In the West Texas Rolling Plains the factors associated with the size of average yield were more limited and less regular, presumably because of the high importance of variations in weather. But the tabular comparisons disclosed that the following factors are associated with increased yield level: Less erosion, less steep topography, increased years of experience of the farmer, high percentage of cropland in cotton, more years in school by the farmer, less off-farm work, lower loss by hail, and a lower percentage of cotton acreage abandoned.

From an analysis of scattered experiment station data other factors which might be hypothecated to have an effect particularly in the humid areas are: pH of soil, fertilizer analysis, quantity of barnyard manure used, and placement of the fertilizer relative to the seed.

The data on production and yield risk obtained on farms that had been inherited were most important. In both sample areas the operators who inherited their farms had significantly lower yields, and somewhat higher relative yield variability than operators who had bought their farms, although the inheritors were not greatly below

the others in production inputs. The explanation of why this relationship existed is involved; but the one who inherits a farm may fail to show competent managerial ability or to develop such ability because he is dominated by the older generation.

Another major finding was that tractor farms showed higher yields and materially lower relative yield variability than nontractor farms of comparable size. Although tractor farmers tended to be superior also in certain production inputs, the differences are probably more than could be accounted for by these factors. It appears, therefore, that the greater timeliness and power afforded by tractors must have been part of the reason.

Kind of labor proved to be one of the most decisive and reliable analytical factors in the West Texas Rolling Plains; and kind of manager in the Upper Piedmont. In West Texas, the farmers who employed hired labor had materially higher yields, lower relative yield variability, and fewer crop failures. In the Upper Piedmont, white owner-operators (men) who bought appeared to be the more efficient operators in obtaining higher average yields and lower yield risk with hired labor. On the other hand, other white operators and Negro operators obtained highest yields with family labor, which may have indicated an inability to manage outside labor efficiently.

In the analysis of average yields and yield variability against factors which are subject to differential variation, methods of correlation analysis were applied to a group of homogeneous farms in each sample area. In the Upper Piedmont the analysis was confined to the white owner-operators (men) who bought their 1946 farms, and in the West Texas Rolling Plains to owner-operators (who bought) and to share-renters, both classes of whom employed hired labor and hired labor in combination with other types of labor. In applying correlation methods to these data, it was assumed that the frequency distribution of average yields conformed sufficiently close to the normal curve for the purposes of the study. Although the distribution of the coefficients of variation was not normal, the analysis was performed in order to explore possible relationships.

The multiple correlation analyses for the farms in the Upper Piedmont with only the factors subject to differential variation, along with factors pertaining to time and location differences, disclosed that the rate of fertilizer application, percentage of cropland in legumes, number of years in yield history, and county yield, and the functions of these four factors, explained 42 percent of the variation in average yield between farms. In West Texas the number of years in the yield history, percentage of cotton acreage not harvested, percentage of cropland in cotton acreage harvested, yearly trend in yield, and county average yield, and the functions of these five factors, explained 38 percent of the differences in yields between farms.

No fertilizer was reported as being used to produce cotton in the West Texas Rolling Plains. In the Upper Piedmont, the differential response of average yield and the location of the point of maximum average yield from fertilizer applications varied directly with the relative level of yield of the county. The size of the coefficient of variation in yields declined with increased fertilizer applications up to 700 pounds per acre, after which there was a rise in relative yield variability. At any given rate of fertilizer application the coefficient of variation varied directly, although not strongly, with the county coefficient of variation.

The factor having the strongest and most consistent effect on yield risk was the average yield level for the farm. In general, as the farm yield level rose the yield risk declined. In the Upper Piedmont a rise in farm yield level of 100 pounds was associated with a decline in the coefficient of variation of 5.9 percentage points; 9.3 in West Texas. Agronomic results, particularly of Miller and Bauer (*20, 21, 22*) in Illinois, tended to confirm this finding.[2] The consequences for the individual farmer should not be minimized. As various studies show that costs of production per unit decline with increases in the level of yields, it follows that the cost of risk also declines. Farmers who make capital expenditures on land—for increased use of fertilizer and manures, planting of increased quantities of legumes, and following better practices otherwise—in order to raise yields also have lower risk costs. A greater capital accumulation over time should result.

This factor—average yield level for the farm—and certain other factors that are subject to differential variation were correlated against the coefficient of variation in yield. However, the results in explaining differences in variability of yields between individual farms were not so satisfactory as those obtained in a correlation of these factors with farm average yields. In the Upper Piedmont, average farm yield, acres of cotton harvested, rate of fertilizer application, years in yield average, percentage of cropland in cotton acreage harvested, yearly trend in yield, and county coefficient of variation, and the functions of these seven factors, explained 28 percent of the farm differences in variability of yields. In the West Texas Rolling Plains, average farm yield, percentage of cotton acreage not harvested, percentage of cropland in cotton acreage harvested, yearly trend in yield, and county coefficient of variation in yield, and the functions of these six factors, explained 37 percent of the differences in the coefficient of variation between farms. In both areas the coefficient of determination was comparatively low. The analysis was extended to develop regression equations for forecasting yearly yields and errors of estimate for such forecasts.

In the correlation analyses with yearly yields, the same group of homogeneous farms used in the correlation analysis of average yields were used, with one exception. In the Upper Piedmont the group of white owner-operators (men) who purchased was further refined to exclude those not growing cotton in each of the 3 years from 1944 to 1946. The yearly analysis was thus limited in the Upper Piedmont in order to obtain observations on yield and fertilizer reports, for a recent period and of a certain accuracy. In contrast, the yield interval for the West Texas group of farms was of varying length—3 to 9 years. For both samples two correlation analyses were made. In one case, certain technical factors were combined with previously proved periodic elements in yearly yields; and in the other, the procedure was the same except that certain rainfall factors were substituted for the periodic factors.

In the correlation analyses with technical factors and the *periodic*

[2] Numbers in italics refer to Literature Cited.

elements against yearly yields, the following factors and their functions proved statistically significant in the Upper Piedmont: Rate of fertilizer application, average farm yield 1944–46, percentage that annual cotton acreage harvested was of average cotton acreage harvested, and county yield the previous year as a percentage of the preceding 6 years' average yield. The index of determination was 0.58. The factors and their functions that proved statistically significant in the West Texas Rolling Plains were: Percentage of seeded cotton acreage abandoned, farm average yield in 1938-46, acreage of cotton seeded as a percentage of the 1938–46 average, county average yield the second preceding year, and county average yield the ninth preceding year. Here the index of determination was 0.44.

A 1-percent change in acreage of cotton from average was associated inversely with an 0.28-pound change in yearly yield, in the Upper Piedmont, and with an 0.81-pound change in West Texas.

The factors representing periodic changes in yearly yields had the following regression effects: In the Upp · Piedmont, the change in county yield the preceding year as a percentage of the 6-year average with fertilizer in a joint function was associated with yearly yield inversely. In the West Texas sample, a pound of change in county yield the second preceding year was associated inversely with an 0.2-pound change in the individual farm yearly yield; on the other hand, a pound change in county yield the ninth preceding year was associated directly with an 0.4-pound change in the individual farm yearly yield.

In the correlation analyses with technical and *rainfall factors* against yearly yield the following factors were included in the analysis for the Upper Piedmont: Rate of fertilizer application, average farm yield in 1944–46, June plus July rainfall, August rainfall, and the percentage that the annual cotton acreage was of average acreage. These factors and their functions accounted for 60 percent of the yearly variations in yield. In the West Texas Rolling Plains the factors included were: Percentage of seeded cotton acreage abandoned, average farm yield in 1938–46, and April, May, July, and August rainfall. These factors and their functions explained 50 percent of the yearly variation in yields. A 1-percent increase in the percentage of cotton acreage abandoned was associated with a decrease in yearly farm yield of 1.7 pounds. An increase of 1 inch in April rainfall was associated with 17.1 pounds of increase in yearly yield, of May rainfall with 6.0 pounds, of July rainfall with 6.5 pounds, and a 1-inch increase in August rainfall was associated with a 5.7-pound increase in annual yield.

Tests of the reliability of the regression equations in predicting yearly yields, and of the dependability of the respective standard errors of estimate, indicate varying degrees of success in estimating actual yields and the losses that would be incurred in a crop-insurance program under which a coverage equal to 75 percent of the forecasted yield is insured. In both areas, the regression equations appeared to provide reliable yield forecasts and bases for crop-insurance premium rates in the case of farms representative of 3-year yields in the Upper Piedmont and 9-year yields in West Texas. But more accurate figures, both in yearly yield forecasts and their corresponding premium rates, were obtained for the farms and for the years that were analogous to those used in the correlation analysis. Use of the regression method of forecasting yearly yields (from production practices and other conditions) was less successful for the farms that had records of yield covering 1 or 2 years.

In conclusion, this report deals with the degree of association between certain basic operator characteristics, farm characteristics, and production practices subject to managerial decision, on the one hand, and farm average yields and variability in annual yields, on the other. As there tends to be an inverse relationship between average yields and variability in yields, a farmer who spends money to increase his annual yield, thereby gaining in the short run, also tends to increase his average yield—and level of living—in the long run. Whether or not he recognizes it, such a policy pays a profit because it makes for less variability in annual yields, reduces the risk of a low annual yield and increases the farmer's chances of staying in business. The farmer will be interested in this report because it deals with the degree of response in output that is associated with alternative choices in management. Moreover, it is hoped that the measures of association between the operator characteristics and farm characteristics, on the one hand, and level of yield and variability of yields, on the other, will be of value to credit and insuring agencies in extending their services to cotton farmers.

INTRODUCTION

One obstacle to effective planning of agricultural production is the variability of output from given inputs. Ordinarily, a producer is not able to estimate the effects of a certain amount of input; he can only guess the limits within which the response may occur. When a wide range in response is connected with a given practice in farming, an operator may be affected in several ways. He may refuse to adopt the practice, or he may undertake it with extreme caution, making small trials or experiments at first, then gradually expanding its scope as his confidence increases. His use of capital will almost surely be affected. If he has sufficient capital and if his source of additional capital is reliable and adequate, he will be more confident and therefore more ready to adopt the practice and to carry it on. The adequacy of his supply of capital will also influence his allocation of resources between new and old techniques. In general, the more restricted his working capital, for the current year and for the long run, the less likely will he be to venture into the new and untried. The consequences are important to the breadth and rapidity of progress in agriculture.

Many agricultural problems are closely related to the fact that yields are highly variable. Careful estimates of probable variations in yield are essential to the successful operation of crop insurance. Before deciding upon a loan program for a farm enterprise one must make an appraisal of the farm yield prospects. The chances of low yields or crop failure must be taken into account. Any planning that concerns the investment of resources in farm production must recognize the problem of variability of yields on the individual farm.

Two major assumptions are made with respect to variability in yields: (1) That the yearly distribution of yields during a period in the past, in a group of farms that constitutes a proper sample, will adequately represent the yearly distribution of yields for a similar group of farms in the future, under similar conditions as to geographic location and length of yield history and (2) that variations in yields from year to year over time are made up of three major elements—random, man-made, and periodic, or perhaps systematic.

Many investigators have assumed that variations in yields over time are entirely, or almost entirely, of a random nature. If this assumption were true, most of the reasons for this study would disappear. Furthermore, if the validity of the assumption were unchallenged, much of the work of the experiment stations on the most efficient rate of fertilizer applications and other differential factors would become useless, as year-to-year changes in policy of a differential sort by farmers could have no bearing upon yearly response in yields. That is, the assumption of randomness in yearly variations in yield is inconsistent with that part of farm management which has to do with input-output response; for if the assumption were true, the basis for rational behavior of farmers in these respects would cease to exist.

The second or man-made element in the variability of yields has been implied, in part, in this discussion so far. When the farm operator increases the quantity of fertilizer he uses, he expects to obtain an increase in yield in the same crop-year. Obviously, there are residual and long-run benefits to be obtained also, but the initial basis of the farmer's action regarding inputs may be traced to his expectations in the immediate crop-year. Almost all factors that are subject to differential action would be applied by the farmer with the same thought in mind. For example, certain practices, such as variety of seed used, treatment of seed, and method of planting, are expected to affect the yield in the first year and to affect the yield level and variability in yields if repeated over time.

The third element in yield variations is the periodic component, or perhaps the cyclical changes in yield, over time. It is less established than any other. A few years ago it was shown that a cycle of 5 to 6 years and of multiples of this time period existed in yields of cotton, apples, wheat, and perhaps of certain other crops (*8*). Although not accepted as a final explanation, variations in solar radiation during June, July, and August (particularly in August) were established as the apparent or immediate cause of the cycle.[3] Since this article appeared in 1942, peaks in yields occurred in 1942 and in 1948; with another in 1944 as a phase of the regular 11-year cycle (1911, 1933, 1944). Each of these three peaks has been followed (as in the cycles before 1942) by a characteristically sharp drop in yield the year following the peak. If a periodic element in yearly yield variations can be satisfactorily established, the fact will be of value in forecasting yields in the immediate crop year, and perhaps even for some time in the future.[4]

These are the assumptions that concern us now, although later in the manuscript other assumptions are made regarding the normality of the distribution of annual yields and the functional nature of the input-output relationships involved.

This study was undertaken in order to increase our basic knowledge of how individual farm yields vary over time in relation to a multitude of farm and operator characteristics and to farm-production practices. Although the scope and other limitations of the study do not permit detailed applications of the results to problems of farm credit or to regional agricultural planning, the utility of the results is demonstrated later in the forecasting of yields and premium rates for possible use in a crop-insurance program for cotton.

The data for the analysis have been drawn from three major sources: (1) Estimates of yearly county yields prepared by the Crop Reporting Board; (2) published results and data otherwise available from experiment stations, covering fertilizer experiments and other results from various practices with cotton; and (3) basic data on characteristics of farm, operator, and production of individual farms, selected as random samples from two areas in the Cotton Belt—the Upper Piedmont and the Rolling Plains of western Texas. In the Upper Piedmont, samples of farm operating units were drawn from Greenville and

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[3] Solar and sky radiation during these months at Washington, D. C., and New Orleans, La. (particularly in August), varied inversely with national yields.

[4] A factor to represent the periodic element in county yields is employed in later sections of this bulletin to increase the accuracy of forecasted yields. However, looking ahead, it should be pointed out that the periodic elements in county yields are not the same as for national yields because of the disturbing and perhaps modifying effects of such factors as woods, bodies of water, mountains, prevailing winds, and other geographic and topographic factors.

Pickens Counties, S. C., and from Carroll, Clarke, Cobb, Douglas, Haralson, Jackson, and Madison Counties, Ga. In the Rolling Plains of western Texas, samples were obtained from Cottle, Fisher, Howard,[5] Haskell, Knox, Mitchell, Nolan, Runnels, Scurry, and Taylor Counties.

The two sample areas represent the extremes in the agriculture of the Cotton Belt.[6] The Upper Piedmont has long been one of the chief cotton-growing areas in the South. Since the middle 1920's, however, acreage has declined and although yields have tended to rise, because of the selection of better land, use of more fertilizer, and more systematic rotation of crops, the trend in production is downward. Farms are small, tenancy is high, and mechanization has only recently become considerable. The soils are derived basically from granites, gneiss, and schist, and are rederiths and yelloweriths, with the Cecil-Appling series predominating. Erosion takes a heavy toll but the soils recover fairly rapidly even after heavy erosion damage if proper emphasis is given to fertilization, crop rotation, use of farm manures, and contour farming. Rainfall averages between 50 and 60 inches annually and is generally fairly adequately distributed during the critical months of June, July, and August. Consequently, the area has among the surest and most stable yields of any of the cotton areas.

From practically all points of view, the West Texas Rolling Plains is at an opposite extreme from the Upper Piedmont. Its farms are large, although tenancy is high. Cotton-production operations are almost completely mechanized except for hoeing and harvesting, which is done chiefly by hand and mainly by migrant Mexican laborers. Some erosion has occurred but the area is not so seriously affected by it as the Upper Piedmont. The soils are reddish Chestnuts, reddish Browns, and Blacks, and do not require fertilization. Rainfall ranges between 20 and 25 inches and is seldom distributed by months in a way that is favorable for the production of cotton. Therefore, yields in this area are more uncertain and variable than in the other main cotton area. It was thought, therefore, that this study of the factors associated with yield level and yield variability would be most revealing if based on records obtained from these two contrasting areas.

A significant characteristic of the figures of yearly yields employed in this study is their accuracy; especially is this true of yields from 1938 to 1942, figures for which came from forms of the Agricultural Adjustment Administration that were prepared initially from ginning certificates. It should be pointed out that although the years 1938 to 1946 constituted the period of time for the study, figures for the full 9 years were obtained for only a few farms in each area. Cotton farmers are highly mobile and in some years no cotton at all was grown on some of the farms. As a major objective of the study was to associate the characteristics of the operator and of the farm with

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[5] Only that part of Howard County was included in the sampling area which fell in the West Texas Rolling Plains proper.

[6] The inclusion of irrigated farms from West Texas was avoided in order to eliminate the effects of bad management of irrigation water and inability to time it properly in relation to the rainfall of the area. This poor timing is known to have unfavorable effects on cotton growth. In order to avoid broadening the scope of the study by another third, farms from the irrigated areas of New Mexico, Arizona, and California were also excluded from the study.

yearly yields over time, the time interval used depended upon the duration of the operator's occupancy.

In each case, yields were obtained by years from 1946 back to 1938 in accordance with the length of time the 1946 operator had lived on the farm. If the 1946 operator was not on the farm and could not readily be interviewed in the neighborhood, the farm was omitted. If the operator could be located, the field enumerator obtained data as to acreage and production of cotton from 1946 and previously, although in no case earlier than 1943. All other farm and operator data also came from the 1946 operators. Acreage and yield of cotton from 1938 to 1942, and, when available, other years later than 1942 (1943, 1944, etc.) were obtained from AAA office forms.

CHARACTERISTICS OF SAMPLE SUMMARIZED

In this section of the bulletin some of the more important characteristics of the sample data are summarized.

(1) Of 968 farms surveyed in the Upper Piedmont, 624 reported three or more years of cotton yields between 1938 and 1946. The average yield for these 624 farms was 314 pounds and the average coefficient of variation of individual farm yields was 28 percent. The remaining 364 farms reported 1 or 2 years of yields, primarily in 1946, and had an average yield of 307 pounds.

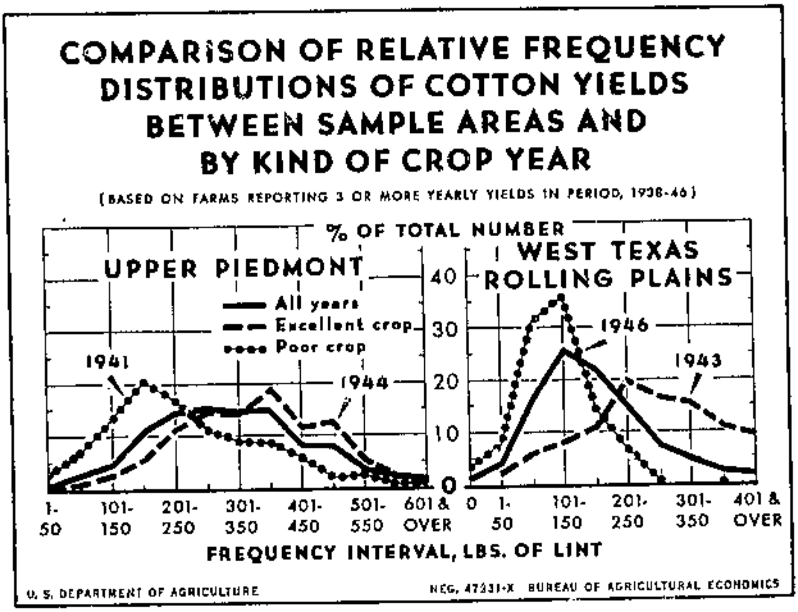

FIGURE 1.—The frequency distributions of yearly yields for all years had a greater positive skewness and a much higher peakedness in the West Texas Rolling Plains than in the Upper Piedmont. In both sample areas, an *excellent* crop-year raised all measures of central tendency and reduced the skewness to a small negative value, whereas a *poor* crop-year increased the peakedness of the distribution (sharply in the Texas sample), increasing its positive skewness in the Upper Piedmont but lowering it in the West Texas Rolling Plains (table 22, p. 130).

Of 662 farms surveyed in the West Texas Rolling Plains, 411 were farms for which three or more years of yields were reported during the period 1938–46. Only 1 or 2 years of yields on the other 251 farms were reported, usually in the last year or two of the period. The average yield for the larger and longer-period group of farms was 165 pounds. The average for the smaller group was 109 pounds. The 411 farms for which three or more years of yields were reported during the period had an average farm coefficient of variation of 46 percent.

Thus the farms for which three or more years of yields were reported had average yields that averaged about 90 percent higher and coefficients of variation in yields that averaged 39 percent lower in the Upper Piedmont than in the Rolling Plains of western Texas.

(2) The distribution of farms according to the number of years cotton was grown during the 9-year period 1938–46, formed a U-shaped curve, with farms most heavily concentrated at the extremes of the time interval.

(3) The frequency distributions of yearly yields considered compositely are shown, by areas, in figure 1.[7] The greater skewness and peakedness in the West Texas Rolling Plains is accounted for by the greater differential effect of weather variations on a lower general level of yields (47 percent lower) in the area than in the Upper Piedmont.

One final comment is in order regarding the frequency distribution of yearly yields. As expected, the measure of absolute dispersion of all yields together was much larger than the dispersions of the yield histories of separate farms when averaged. In the Upper Piedmont, the standard deviation of the composite distribution was 122; in the Texas sample, 88. The corresponding averages of the standard deviations of individual farm yields was 89 and 75 respectively. Thus the standard deviation of the composite yield distribution in the Upper Piedmont was 1.4 times that of the standard deviations of the individual farm-yield histories averaged, and 1.2 times the standard deviation of those in the Texas Rolling Plains (Appendix table 22, p. 130).

(4) In the Upper Piedmont, the farm coefficient of variation in yields tended to increase with increases in the time interval above 3 years. However, in the West Texas Rolling Plains, no significant connection was noted between the length of the time interval over which yields were accumulated beyond 3 years, and the coefficient of variation.

(5) Trends in yields increased the coefficient of variation of farm average yields when the time duration of the yield history was long (8 or 9 years), provided also that the rate of change in yield was strong. The gain from removing trend from yield variation in the shorter periods was lost by the relatively high loss in degrees of freedom. Of 624 farms in the Upper Piedmont, the coefficient of variation was corrected for 281 farms reporting 8 or 9 years of yields; of 411 farms in the West Texas Rolling Plains, 179 with 8 or 9 years of yields were similarly corrected. The result was a drop in the average coefficient of variation from 29 to 27 in the former sample area but no change in the latter. The differences in results obtained from these simple corrections imply stronger trends in yields in the Upper Piedmont than in the Texas sample, which is a reflection of the greater response the operators obtain from factors that are subject to differential variation in the former region.

(6) No method of grouping farms and calculating measures of central tendency gave nearly so high an average yearly trend value, standard deviation, or coefficient of variation, as was obtained by averaging the individual farm values for these three measures. Average trend was somewhat less in error in either area than the standard deviation and coefficient of variation which were too low, when based

[7] The frequency analysis was based on farms reporting three or more years in the period 1938–46. From the standpoint of the analysis, however, the departure of the distributions from normal in both areas was not considered large enough to warrant the use of other forms of distributions. In retaining the theory of the normal curve, it was assumed that the actual distributions approached the normal curve closely enough for the purposes of this analysis, especially within the range of the curve for which the results are most applicable.

on county data, by 50 to 100 percent. These findings suggest that no one of the ordinary measures of central tendency is efficient in correcting for skewness in annual yields; but, more important, they suggest the significance of diverse movements in yield in a sample of farms and the extent to which yield aggregates or composites provide an inadequate estimate of the three measures of relative variability in yields on individual farms (table 25, p. 133).

(7) As the yearly yields extend over a period of 9 years, there were several time-interval choices for computing the coefficient of variation. But because of statistical limitations, it was obvious that farms reporting less than 3 years of yields during the period could not be employed if a measure of yield variability were to be obtained that would have some stability and reliability.[8] Between 1938 and 1942, as marketing quotas were in effect on cotton, the reports on yield were probably as accurate as it is possible to obtain them. Actual gin returns were used by the county agricultural personnel as a basis for calculating the yields of individual farms. An alternative was to use only the farms for which 8 or 9 years of yields were reported. This would have given a longer period over which the random elements of yield variability that are attributable to weather could have operated, and would have given a better idea of how trends in yields affected the variability of yields. The objection to this was that the working sample of farms would have been greatly reduced. A third alternative was to use all farms having records of three or more years of yields. This would have given a maximum working group of farms but the shorter time intervals (3 and 4 years) raised questions as to their effect on both average yield and the coefficient of variation in yields.

In order to decide upon the best choice, the effects of all three periods on average yields and the coefficients of variation in yields by yield groups were compared, for the Upper Piedmont sample. The tabular comparisons indicated virtually no difference between three groups of farms representing different time intervals. As the "three or more years" group afforded the largest number of farms, the exploratory cross-tabulation analyses were based almost entirely upon this grouping, but supplementary tabulations were made for other important factors, using those farms that qualified under the other two time periods (table 26, p. 134).

(8) The inclusion of zero yields (complete crop failure) increased the coefficients of variation in yields of the sample farms from the West Texas Rolling Plains. In both sample areas, the normal curve was a poor fit to the frequency distributions of the individual farm coefficients of variation but was somewhat less so for the Texas farms because of the greater range (4 to 245 percent as compared with 5 to 83 percent in the Upper Piedmont) in the farm coefficients of variation from zero yields.

(9) In both areas, the frequency distributions of farm-average yields for three or more years during the 9-year period 1938–46, conformed sufficiently to the normal curve to make its theory applicable. How-

[8] A 2-year period was not selected as the shortest time interval because only one degree of freedom would have been left for computing the unbiased standard deviation.

ever, the normality of the distribution of average yields for sample farms in the Upper Piedmont was better than that for the sample farms from the Texas Rolling Plains. The distribution of average yields for the latter farms was in fact quite peaked.

PERIODIC VARIATIONS IN YIELDS

United States Average Yields

The prevailing idea among agriculturists with respect to variations in crop yields is that they are mainly the result of changes in weather and that no particular pattern exists in the sequence of yearly yields, these being in the nature of random variations.[9] Considerable evidence in support of periodic variations in the yields of a few crops was presented several years ago in an analysis of the influence of solar radiation on yields of apples, cotton, and winter wheat (*8*). The nature of the variations in yield of cotton for the United States is indicated in table 27 (p. 135) which shows first differences in yields since 1909. The 40-year period very definitely shows certain types and combinations of periodic variations, although investigation of the period from 1867 to 1908 shows that many of them are obscured.[10]

The most obvious periodic variation that can be selected from the table is the sharp decline in yield which occurred every 6 years. Although the data do not show it in every phase, a study of unadjusted yield data discloses that a maximum in yield was repeated at intervals of 5 or 6 years—recently periods of 5 and 6 years alternating—which gives a longer phase of 11 years. Another 11-year cycle is present; it occurs out of phase with the more regular one above, which may be noted in the following time intervals and their multiples in number of years: 1911 (1922 missing because of the boll weevil), 1933, and 1944. Note the 11-year interval, and the further fact that these years, particularly the latter two, gave a double peak with the recent 5-year systematic movements (1933 after 1931, and 1944 after 1942; 1922 also would have given it with 1920 following a 6-year movement).

Further evidence on the periodic (nearly systematic) behavior of cotton yields is presented in figure 2, which includes correlation coefficients that were calculated by methods described by Kendall (*16*). In brief, a second-degree parabola was fitted to yields from 1909 to 1948 and the deviations of the actual yields from this line were calculated.[11] These residuals were repeated, once as X_1 and again as X_2.

[9] There are noteworthy exceptions, for important evidence has been presented by several investigators in this field in support of periodic movements in certain weather factors, or in specific crops, or both; most notable among these would be A. E. Douglass' cycles of various lengths in the thickness of yearly tree growth (rings which he relates to rainfall and the 11-year sunspot cycle).

[10] It is probable that much of the earlier data on yields, particularly for the years before 1920, contained many inaccuracies. Even with present techniques, there is a possibility that regression methods employed in connection with condition reports plus various corrections, remove a part of the sharpest variations in yields over time.

[11] This was done to remove a very noticeable systematic movement in yields of this character. Beginning about 1915 there is a sharp dip in yields until 1930, after which reduced acreage, coupled with rapid advances in production technology, caused a sharp upward trend.

Then a series of coefficients of serial correlations was computed with the pairs, increasing the lag between the duplicated values by 1 year in each case. The coefficients obtained are plotted in figure 2. From an examination of this figure one is forced to conclude that the evidence of a periodic movement in cotton yields cannot be ignored with safety. The maximum positive correlation coefficients (r's) were obtained with 1, 6, 11, and 18 years lagged, and maximum negative r's at 4, 10, and 16 years lagged.

Counting the years from peak to peak and from trough to trough, or by other standard methods, gives time intervals of 5 or 6 years, which are consistent with the findings in table 27. As, according to Kendall (*16*), the tests of significance of correlograms are not avail-

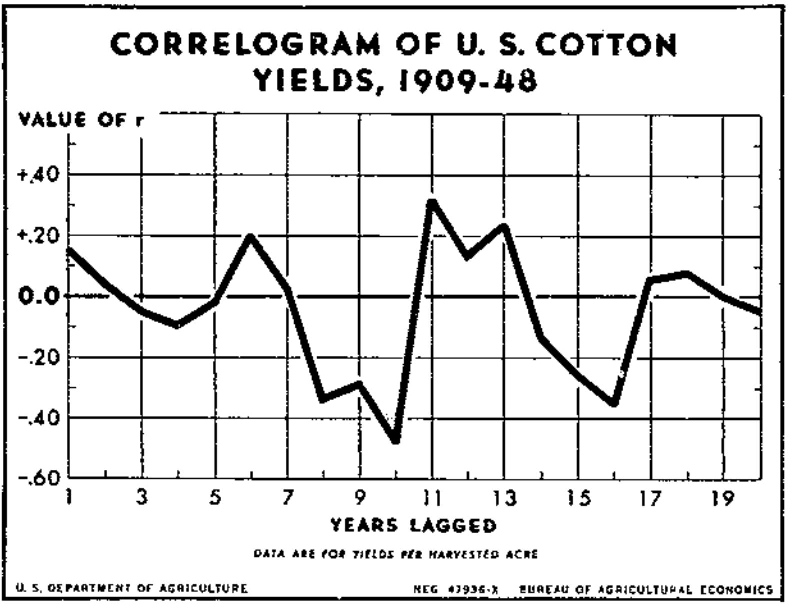

FIGURE 2.—The number of years between peaks and between troughs varies from 5 to 6. Intuitively, this strengthens the case for periodic movements in cotton yields.

able, one must form an intuitive judgment from the general significance of the over-all oscillatory character of the movements in the correlogram as a whole. Obviously, the undulations in figure 2 are not random, but are periodic to a considerable degree.

At the present time, the best known explanation of the systematic movements that occur in cotton yields is that given in the study by Fulmer (*8*) previously mentioned. In that work, an apparent tie-in with variations in solar radiation was established as a first approximation to the ultimate cause, or causes. Radiation data for Washington and New Orleans for May through August were examined in relation to cotton yields. It was found that solar radiation in the years of highest cotton yields tended to be at a minimum in June, July, and August, considered as a simple average. The relation to other crop-years was not so clear, probably because of interference from strictly local weather factors. Subsequent work has demonstrated that August is probably the key month—solar radiation being at a minimum for the phase in that month when maximum cotton yields occurred.

The hypothesis offered in explanation of the relationship, deduced from several studies on the effect of light quality on plant growth, was that years of high solar radiation in August and also in the preceding months of June and July caused an abnormal vegetative growth of the plant, to the detriment of the growth of bolls and hence later of lint cotton. The converse occurred in years of low radiation in August, which often was preceded by some reduced intensity in radiation during June and July. In the former, gigantism in plants occurred; in the latter there was a tendency toward dwarfing of plants. This may help to explain why the early-month crop estimates made some years ago were generally too high in years of low yields and too low in years of high yields.

In other words, the condition of the crop as shown by weed growth is an unreliable indicator of final harvest. In further explanation of the effects of radiation, it was hypothecated that as plant growth tended, according to studies of the effect of light on plants, to be normal in size and shape only in a regular light spectrum and tended to be abnormal, tall, and spindly (deceivingly large), in the long end of the spectrum, the ultimate cause of the periodic variations in yields was the variations in quality and intensity of light, which may be associated in some way with the recorded variations in solar radiation over time in the months specified.

Sample County Average Yields

During the 9-year period 1938–46, the nine counties in the Upper Piedmont which were included in the sample had an average annual yield of 280 pounds, an average coefficient of variation in yields of 17 percent, and an average yearly upward trend in yield of 5.1 pounds.[12] This compares with 155 pounds, 36 percent coefficient of variation, and an average yearly downward trend of 2.7 pounds for the 10 Texas Rolling Plains counties in the sample. Consequently, the nine Upper Piedmont counties compared with the 10 West Texas counties had 81 percent higher yields; but only 47 percent as much variation in yields and a positive in contrast with a negative trend in yields. However, the yields of neither area have as well-defined cyclical tendencies as do the United States yields (fig. 3). This is because county yields are more subject to local weather factors—such as mountains, lakes, prevailing winds, and large areas of timber—and are not so greatly influenced by over-all factors, such as solar radiation, as is the national average.

But these yields have other characteristics which are worth noting from the standpoint of future analyses of individual farm data. A 1-year lag gave the highest r (over 0.6) with the Upper Piedmont 9-county composite yearly average; whereas 2- and 9-year lags gave

[12] All averages given in this section were computed as a simple average derived from adding the respective county figures and dividing by the number of counties in each sample area.

the highest r's for the 10 West Texas Rolling Plains counties, the 2-year lag being negative and the 9-year lag positive. Moreover, the range of values of r obtained with a 1-year lag in the Upper Piedmont and a 2-year lag in the Texas Rolling Plains closely coincided with the limits obtained from further lags in time, until a 7-year lag was reached in the former and a 9-year lag in the latter sample area. This indicates that a time length of about 3 years may be expected to cover a considerable part of the range in yields in the near term in both sample areas, although yield observations to 7 years and beyond would add to the range of the Upper Piedmont counties. A range to 9 years would add a good deal to that of the 10 counties from the West Texas Rolling Plains.

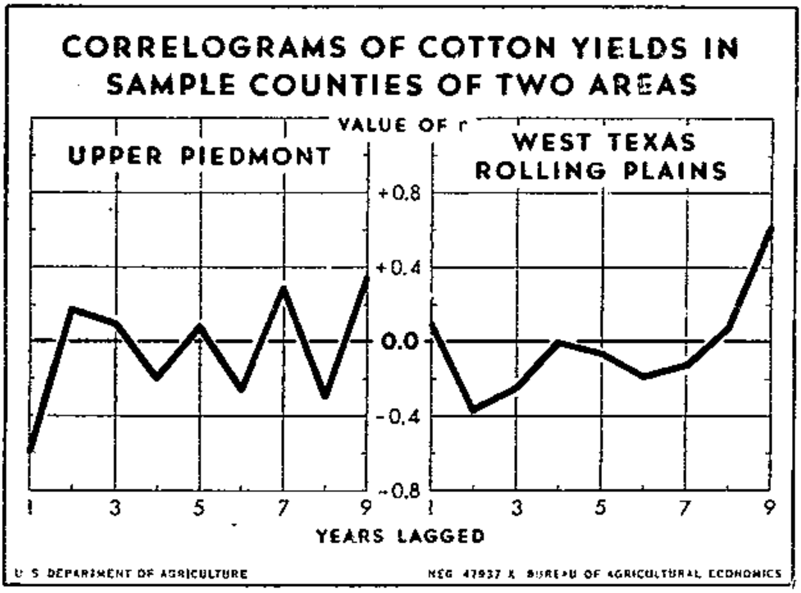

FIGURE 3.—The highest correlation was obtained with a 1-year lag in the composite-yield series for the 9 Upper Piedmont counties and with a 9-year lag in the case of the 10 counties from the West Texas Rolling Plains—the former being negative, the latter positive.

The correlation coefficients in figure 3 indicate that the apparent periodic movements in average yields of the two sample areas are inversely related. This evidence was investigated further by putting the two yield series together in a lag correlation. Results indicate that the residuals from trend in each area are most highly correlated when 10 counties from the West Texas Rolling Plains are in a leading relationship to the 9 Upper Piedmont counties by from 5 to 7 years, the 5- and 7-year r's being positive and the r of the 6-year being negative.

There is no way to test the general significance of these results. As it is around 0.4 with each of the three different period-lags, our tentative judgment is that some sort of nonsimultaneous, periodic fluctuations are present. If this proves to be true, the consequence for forecasts of yield between the different regions of the country might be important. For instance, in recent years, a downward trend in yields of the sample counties from the West Texas Rolling Plains has prevailed, in contrast to an upward trend in the Upper Piedmont counties. Does the relationship forecast a downward trend in the next few years in yield of the eastern counties and an upward trend in that of the counties of the Texas Rolling Plains, because of a shift in some phase of the weather cycle? The answer to this question cannot be given now but a sufficiently long yield series might permit it to be answered satisfactorily.

GEOGRAPHIC VARIATIONS IN COUNTY YIELDS AND THEIR VARIABILITY

Yield averages for a period of years vary from county to county because of fundamental differences in soil fertility and climate. As certain physical conditions—climate, plant cover, type of rock, age and weathering of rocks, and relief—determine in a general way the kind of soils to be found in geographic regions, counties of certain characteristics of yield tend to cluster. For instance, the average yields in counties in the Coastal Plain differ from those in the Piedmont, and average yields for the Delta counties from those for counties in the West Texas Rolling Plains.

A great part of the yield differentials are accounted for by the fundamental soil differences and by variations in rainfall and other climatic factors. The effect of soil is influential but its complexity forbids detailed and adequate treatment here. Climate is influential and more is said about it later. But another set of geographic factors can be measured and treated. These are: Elevation above sea level, degrees of latitude North, and distance from the ocean. These three factors do, in effect, measure some parts of soil and climatic differences both compositely and complexly. For example, a figure for the distance from the ocean reflects rainfall, humidity, variability in rainfall, and other weather conditions. Latitude and elevation operate jointly to move the plants up to a point at which they are affected by lower humidity, differences in frost conditions, and by a different quality of light. These influences are referred to as "bioclimatic" forces. They were summarized as follows in the 1941 Yearbook of Agriculture, p. 293: "For each degree of latitude north or south of the Equator, and also for each 400-foot increase in altitude, the date of flowering of plants of the same species is retarded 4 calendar days; for each 5 degrees of longitude from east to west on land areas it is advanced 4 calendar days."

To test the effect of the three location factors (elevation, latitude, and distance from ocean) on average yields by county, a group of selected counties from each of the working subdivisions was subjected to multiple curvilinear correlation analysis.[13] Elevation and latitude

[13] Selected on the basis of availability of satisfactory data on elevation for the county. These were taken from meteorological reports. Data from near the center of the county were given preference. Most of the information on latitude was similarly derived. Distances from the ocean were scaled, as was the measure of latitude in certain cases. In all, data from 240 counties were obtained by these methods.

were treated as jointly influencing yield, and in certain areas elevation was treated as a curvilinear function also. The correlation analysis gave a significant correlation for each area, the index being highly significant; the coefficients of regression were also generally highly significant (by the *F*-ratio method); a few functions of the main factors were not significant at the 5-percent point, but were retained because of their influence on the other coefficients.[14] The results of the application of the regression equations, given in footnote 14, to the general range of conditions in the States are given in table 1.

The data in the table answer certain questions with respect to the influence of geographic factors on yield of cotton. The only factor to show a uniform tendency, in general, was latitude. In all areas except Oklahoma and Texas, an increase in latitude, at uniform conditions with respect to elevation and distance from the sea, was accompanied by an increase in county average yield. In Texas and Oklahoma, the relationship was more complex. At moderate ranges in elevation—100 to 1,000 feet—the yield dropped off with latitude at first, until around 32°; then it rose with increases in latitude. Somewhere above 1,000 feet in elevation, however, increased latitude was accompanied by a decline in county average yield.

Generally, elevation has a negative effect on yield although there are exceptions. In the eastern cotton States, increases in elevation at 36° of latitude tended to be associated with increases in county average yield. However, at 34° the average county yield declined with increases in elevation above 500 feet, and at 32° it decreased directly with elevation from the lowest points. In Texas and Oklahoma, latitude likewise tended to increase county yield between 2,000 and 3,000 feet elevation, with latitudes around 30° and 32°. (This statement is qualified by the fewness of counties in these limits.)

County average yield tended to increase directly with distance from the ocean—the third factor affecting yield—in all areas except in the Delta States. Here, Mississippi Delta counties with very high yields upset the expected relationship of heavy rainfall and high humidity at low latitudes, particularly along the ocean, to yields. The effect on county yield in the eastern cotton States was generally small but was comparatively large in Oklahoma and Texas.

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[14] Where X_1 equals yield, X_2 elevation in feet, X_3 latitude, and X_4 distance from the ocean in miles, the regression equations follow:

Eastern cotton States: $X_1 = -376.8 - 1.12869X_2 - .00002(X_2)^2 + 18.90819X_3 + .03369X_2X_3 + .00904X_4$; ($\bar{P}^2 = .5764^{**}$; $\bar{S} = 40.3$)

Delta: $X_1 = -2429.63 - .52823X_2 + .00016(X_2)^2 + 89.36479X_3 + .00374X_2X_3 - .86388X_4$; ($\bar{P}^2 = .3411^{**}$; $\bar{S} = 67.3$)

Oklahoma and Texas: $X_1 = 112.4 + .41688X_2 + .00002(X_2)^2 + 3.55024X_3 - .02409(X_3)^2 - .01598X_2X_3 - .36379X_4 + .00128(X_4)^2$; ($\bar{P}^2 = .4504^{**}$; $\bar{S} = 26.2$)

($\bar{P}^2$=Index of determination; $\bar{S}$=Standard error of estimate.)

**Significant at the 1-percent point.

TABLE 1.—*Average yield per acre of cotton as affected by elevation, latitude, and distance from ocean, 3 specified regions, period 1938–46*[1]

Region, latitude, and distance from ocean	Yield per acre when elevation above sea level is—						
	100 feet	300 feet	500 feet	700 feet	1,000 feet	2,000 feet	3,000 feet
	Pound	*Pound*	*Pound*	*Pound*	*Pound*	*Pound*	*Pound*
Eastern:							
32°:							
50 miles	224	212	198				
150 miles	224	212	199				
34°:							
100 miles	268	270	270				
300 miles	270	272	272	269	263		
400 miles	271	273	272	270	264		
36°:							
100 miles	313	328	341				
300 miles	315	330	343	354	368		
500 miles	317	332	345	356	370		
Delta:							
32°:							
50 miles	348	278					
150 miles	261	192					
34°:							
200 miles	398	330	274	231			
300 miles	311	243	188	145			
36°:							
300 miles	491	424	370	329	290	362	
400 miles	404	338	284	242	204	276	
Oklahoma-Texas:							
30°:							
100 miles	167	156	147	140	134		
300 miles	196	186	177	170	163	171	225
32°:							
200 miles	170	153	138	124	108	83	105
300 miles	197	180	165	152	135	111	133
34°:							
300 miles		174	153	134	107		
400 miles		227	206	186	160	104	
36°:							
400 miles			193	167	132		
500 miles			272	246	210	122	

[1] Based on correlation analysis of data for counties for which meteorological records showed elevation and latitude at the approximate center of the county.

COEFFICIENT OF VARIATION IN COUNTY YIELDS

The coefficient of variation in county yields over the 9-year period was computed for each of the 240 counties.[15] The measure of relative variability thus obtained was subjected to correlation analysis against the three factors mentioned, and the additional factor of county average yield. The index of correlation was statistically significant at the 1-percent point except in Oklahoma and Texas, where it was

[15] The standard error of the regression line of trend was expressed as a percentage of the mean. That part of the variation in annual yields accounted for by trend was thus removed as a source of variation. See table 42, in Appendix, for data by counties.

significant at the 5-percent point. The regression coefficients, although they were not all significant at the 1-percent point, or even at the 5-percent point, add valuable information concerning the coefficient of variation geographically and hence they are shown.[16]

The combined effect of elevation and latitude, when distances from the ocean and the respective average yields were held constant at their mean values, is shown in table 2. The contrasting effects produced on

TABLE 2.—*Coefficient of variation, as affected by elevation and latitude, 3 specified regions, period 1938–46*

Region and elevation	Coefficient of variation with north latitude—				
	28°	30°	32°	34°	36°
Eastern:					
200 feet	-------	25.8	25.7	25.6	-------
400 feet	-------	27.6	26.1	24.6	23.1
600 feet	-------	-------	26.4	23.5	20.6
800 feet	-------	-------	26.8	22.5	18.2
Delta:					
100 feet	-------	-------	29.1	29.0	-------
200 feet	-------	-------	28.4	29.8	-------
300 feet	-------	-------	27.6	30.6	33.6
500 feet	-------	-------	26.1	32.2	38.3
1,000 feet	-------	-------	-------	36.2	-------
1,500 feet	-------	-------	-------	44.0	-------
2,000 feet	-------	-------	-------	-------	-------
Oklahoma-Texas:					
100 feet	-------	15.6	25.3	-------	-------
300 feet	11.8	19.8	27.6	35.0	-------
500 feet	17.8	24.0	29.9	35.4	40.8
1,000 feet	-------	33.5	34.8	35.7	36.3
2,000 feet	-------	-------	42.2	33.7	25.0
3,000 feet	-------	-------	-------	28.3	-------

the coefficient of variation are significant. In the eastern cotton States, as elevation and latitude increased together, the coefficients of variation declined more than proportionately. In the Delta States the coefficients increased more than proportionately, except at 32° latitude, where a decrease occurred with increased elevation. In Oklahoma and Texas, the combined effect of elevation and latitude on the coefficient of variation is much more complex. The two factors combined

[16] Where X_1 equals the coefficient of variation, X_2 county average yield, X_3 elevation, X_4 latitude, and X_5 distance from the ocean in miles, the results follow:

Eastern cotton States: $X_1 = 15.27 - .02132X_2 + .11492X_3 + .66100X_4 - .00353X_3X_4 - .03711X_5$; ($\bar{P}^2 = .4580$**; $\bar{S} = 6.1$)

Delta: $X_1 = 88.79 - .04796X_2 - .25330X_3 - .80135X_4 + .00768X_3X_4 - .09402X_5$; ($\bar{P}^2 = .7114$**; $\bar{S} = 6.7$)

Oklahoma-Texas: $X_1 = -132.83 - .09155X_2 + .16201X_3 - .0000017(X_3)^2 + 7{,}6779X_4 - .03868(X_4)^2 - .00467X_3X_4 - .28461X_5 + .00045(X_5)^2$; ($\bar{P}^2 = .1209$*; $\bar{S} = 9.4$)

(P^2 = Index of determination; S = Standard error of estimate.)

**Significant at the 1-percent point. *Significant at the 5-percent point.

to increase the coefficient of variation until an elevation of 1,000 feet and 34° latitude were reached; after that, except at 32°, the coefficient declined with increases in elevation. The rise in variability around 32° can be associated with the movement into the High Plains of Texas where good yields of cotton from the land are less certain, although yields average somewhat higher than in the Low Rolling Plains. The decline after 1,000 feet and 34° latitude shows the influence of the better cotton lands in middle Texas which produce higher and more stable yields. The drop in the coefficient of variation at 36°, with increases in elevation after 500 feet, reflects conditions in the east-central part of Texas where some counties had only moderate variability in yields.

Referring back to the other two areas, the decline in relative yield variability with increases in latitude and elevation in the eastern States is associated with movement into the Piedmont where soils are better and there is seldom an excess of rainfall. It is well-established that the Piedmont is about the surest cotton area in the East. In the Delta, the drop in variability at 32° latitude with increases in elevation shows the effect of moving from the low-lying lands of Louisiana and Mississippi to higher lands where drainage is better and rainfall not so excessive. The sharp increase in the coefficient of variation at greater latitudes, and after 1,000 feet, is caused by the highlands of Arkansas.

Although not so significant statistically with respect to their regression coefficients or their association with the county coefficients of variation as were elevation and latitude, the other two factors included in each correlation analysis (distance from the ocean in miles and county average yield) showed well-defined relationships. Both were strongly negative; that is, the size of the coefficient of variation in county yields declined in all areas as distance from the ocean increased; also, the same negative relationship existed, and more sharply in all three areas, as county average yields increased.

The highest regression of distance from the ocean on the coefficient of variation was found for counties in Oklahoma and Texas, with the Mississippi Delta and the eastern cotton States following next in that order (footnote 16). However, despite the sizes of the regression coefficients which were based on a sample of counties in each area, a study of figure 4 discloses that the effect of distance from the ocean on the county coefficient of variation was very irregular in Oklahoma and Texas. Except in the Corpus Christi area and south to the Rio Grande, the county coefficient of variation tended to decline as distance from the ocean increased, until interior Texas was reached; after that the coefficient of variation rose with further increases in distance, particularly in the direction of the Texas panhandle and western Oklahoma.

In this connection, the low variability in county yields of the irrigated areas should be noted, as it reflects better control of the water supply (fig. 4). The heavy rainfall near the coast of Texas and the high humidity apparently affect cotton adversely. Movement inland leaves these conditions behind. At some distance, presumably around 300 miles, the optimum for the area is reached. Further increases in distance beyond this point bring the continental type of climate—low and very uncertain rainfall, but also lower humidity, which is a counteracting favorable factor.

From the correlation analysis of the three location factors and the county average yield, the effect of county yield on the county coefficient has been calculated. The following tabulation shows the results when the other three factors—elevation, latitude, and distance from the ocean—were held constant at their mean values in the regression analysis.

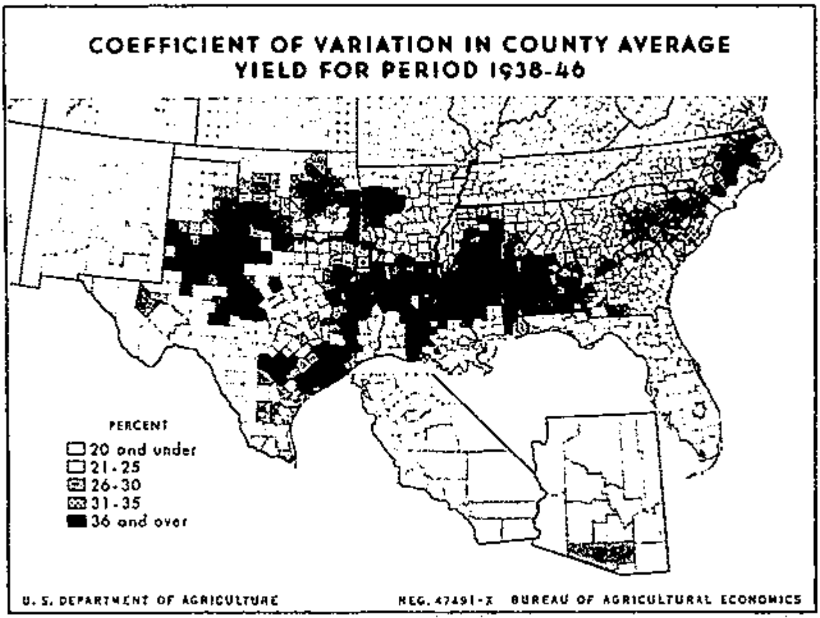

FIGURE 4.—The smallest county coefficients of variation in yield occur in the irrigated areas, in central Texas, the Delta, and the Upper Piedmont. The highest county coefficients of variation are in western Texas, Louisiana, the eastern hilly area (northwestern Alabama, eastern Mississippi, and western Tennessee), and the middle Coastal Plain. With the exception of the middle Coastal Plain and central Texas, the counties that are high in average yield tend to be low in relative variation of yields. Data, by counties, are given in table 42, in Appendix.

	Coefficient of variation estimated from regression coefficient		
County average yield:	*Eastern*	*Delta*	*Oklahoma and Texas*
100	27.8	39.0	36.8
200	25.7	34.2	27.7
300	23.6	29.4	18.5
400	21.5	24.6	...

The relationship was negative. A unit of increase in average yield was associated with the greatest reduction in relative yield variability in Oklahoma and Texas and the smallest in the eastern cotton States. The ratios for Oklahoma and Texas to the Delta States were 2 to 1 and to the eastern cotton States about 5 to 1. This is probably not a significant comparison, as the regression coefficient for Oklahoma and Texas fell short of significance at the 5-percent point.

In recognition of the marked association found between level of yield and variability of yield and the relation this factor is expected to have to future work in this field, the county average yield for 1938–46, and the coefficient of variation in county annual yields during this period were computed for each county in the Cotton Belt for which there was a continuous record of yields for 8 or 9 years. The results are shown by counties in figures 4 and 5. Because of the detail involved in presenting these data for 707 counties, only a few gen-

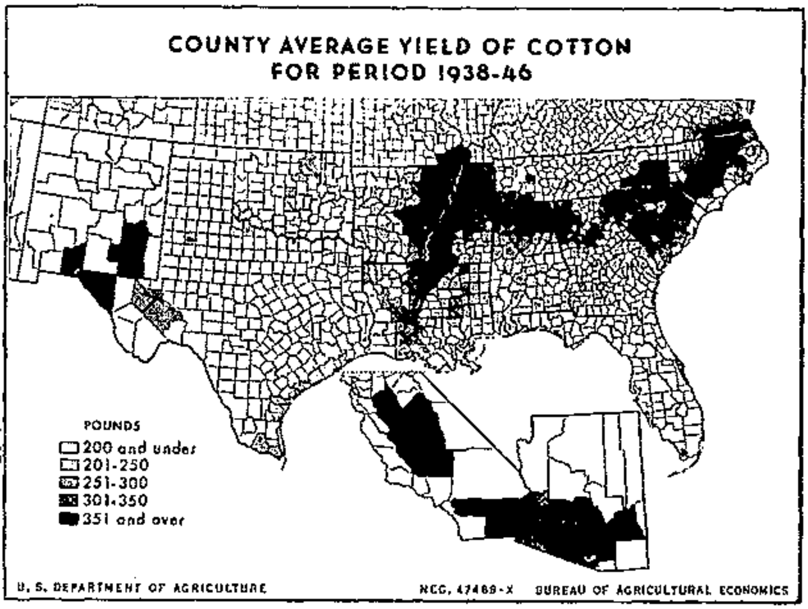

FIGURE 5.—The higher yielding counties are in the irrigated areas, and in the Delta, Upper Piedmont, and middle Coastal Plain. The lower-yielding counties comprise all of Oklahoma and Texas, as well as western Arkansas and Louisiana, and the eastern hilly area (northwestern Alabama, eastern Mississippi, and western Tennessee). Data, by counties, are given in table 42, Appendix.

eral comparisons are possible. The higher-yielding counties are in the irrigated areas, and in the Delta, Upper Piedmont, and middle Coastal Plain counties, while the lower-yielding counties comprise all of Oklahoma and Texas, western Arkansas and Louisiana, and the eastern hilly section (northwestern Alabama, eastern Mississippi, and western Tennessee).

A comparison of the data shown on figures 4 and 5 with respect to the counties in these areas indicates an inverse relationship between yield level and yield variability—although comparatively low. The counties most difficult to place in this relationship are those in the middle Coastal Plain and central Texas. High yields are typical of the counties of the former but the coefficient of variation is moderately high. The reverse is true of central Texas, where medium to low yields are associated with moderately low coefficients of variation.

The data in figures 4 and 5 were paired by counties in a correlation analysis, employing a double frequency table. The result was that an r of -0.4250 was found, which is significant at the 1-percent point. The regression equation is: $Y=39.1-4.726X$, where Y is the coefficient of variation, X the county average yield in hundreds of pounds. Thus, for the Cotton Belt as a whole, a 100-pound increase in county average yield during the period reduced the county coefficient of variation by 4.7 percentage points.

Returning to the multiple correlation analysis above (pp. 22 to 26) in which three location factors were included, along with the county-average yield, as independent variables, it was found that this approach when applied to counties by subregions of the Cotton Belt reflected somewhat more accurately the influence of level of yield on variability of yields. For example, the net regression of county average yield on the county coefficient of variation per 100 pounds of increase in yield was as follows:

	Effect of 100-pound increase in county yield
Eastern cotton States....	2.1 percentage points decrease in the county coefficient of variation
Delta	4.8 percentage points decrease in the county coefficient of variation
Oklahoma and Texas...	9.2 percentage points decrease in the county coefficient of variation

The regression referred to above is "net" because the influence of elevation, latitude, and distance from the ocean have been taken into account by the correlation analysis.

Although it appears that level of yield more sharply influences yield variability in Oklahoma and Texas, this must be conditioned by the fact that estimates are not expected to coincide as regularly or as closely as in the eastern or Delta States, because the regression coefficient for Oklahoma and Texas lacked signifiance at the 5-percent point.

FACTORS AFFECTING INDIVIDUAL FARM AVERAGE YIELDS AND THEIR VARIABILITY

Frequency Distributions of Average Yields and of the Coefficients of Variation

The typical feature of the distributions of average yields and the coefficients of variation was their positive skewness. But the distributions of the coefficients of variation had by far the largest skew, 0.28 and 0.38 in the Upper Piedmont and the West Texas Rolling Plains respectively, compared with only 0.09 and 0.08 for the respective distributions of average yields. A characteristic of the distributions was their difference in peakedness. In the Texas sample, the average yield distribution showed a very large peakedness but the coefficient of variation was only a moderately peaked distribution.[17]

Opposite conclusions are true for the Upper Piedmont sample. Here average yields were distributed in nearly a normal pattern while the coefficients of variation formed a more peaked distribution. The χ^2 test indicated that the normal curve may be a reasonably close approximation to the distributions of average yields for both samples but that, as one would expect, this was not the case with the distributions of the coefficients of variation.

The coefficient of variation as a measure is comparable to the standard deviation. In the Upper Piedmont, a well-distributed and adequate rainfall, coupled with more effective soil-management practices, keeps the upper limits of the range in coefficients of variation much lower. In the Texas Rolling Plains, in contrast, the greater variability in weather conditions, the effects of which can be modified only a little by management practices, causes yields to vary through a wide range—from zero to many times the mean. The corresponding coefficients of variation were therefore widely dispersed. Irrigation brings noteworthy exceptions. Attention is called to the fact that the coefficients of variation of county yields in the irrigated areas are lower by far than in other western counties and compare favorably with those for eastern counties. This was due partly to the higher average yields that prevailed in the irrigated areas (fig. 5). However, when water is available through some irrigation system it is usually due to public policy and not to superior management on the part of the farmers.

Basic Operator Characteristics

The more basic characteristics of operators of cotton farms in the South considered in this study are tenure status, color, sex, age, origin of operator, years of schooling, years of experience in growing cotton, and method by which owner-operated farms were acquired. In one form or another each of these characteristics reflects the degree of control of the resources necessary for production, the conditions under which competition is met, and the skill, alertness, and progressiveness with which the operator carries on the production and marketing processes.

TENURE STATUS

Tenure status is an indication not only of present control of resources but of current progress in their accumulation. An owner obviously has a tremendous advantage over a tenant in control over the factors needed in production and in ability to acquire the additional resources needed from credit agencies. Because he has assets, he is not subjected to the same discount for moral risk as the tenant, and

[17] In this and future discussions of yield, it will be understood that yield is computed on a harvested-acreage basis in the Upper Piedmont and on a planted-acreage basis in the West Texas Rolling Plains. As the percentage of cotton acreage abandoned was low (0.2) in the Upper Piedmont, the yield on a harvested basis is so near the yield on a planted-acreage basis that it is sufficiently comparable to yield as computed for the Texas sample.

capital rationing, as a rule, operates less forcefully on him than on the tenant.

In table 28 (p. 136) comparative data are given for the major classes of operators for the two sample areas in which three or more years of yields were reported between 1938 and 1946. According to the definitions of operators used in this study, the dominant types of operators in the Upper Piedmont apparently were owners and cropper-tenants;[18] and in the West Texas Rolling Plains, owners, share-renters, and standing renters. Both owners and cropper-tenants in the Upper Piedmont sample had higher average yields than the other two tenure groups (estate-operated farms and other tenants) during the three periods for which comparisons of yield are made. In fact, except for the averages based on three or more years, cropper-tenants have a small edge in both size of average yield and in smallness of the coefficient of variation. (See pp. 14-15 for a discussion of the statistical aspects of this measure of yield dispersion of the individual farm.) In the West Texas Rolling Plains the two major tenure classes—owners and share-renters—also had the edge in average yield but were excelled by the standing renters in smallness of the coefficient of variation. Owners and share-renters in this area also had more favorable yearly trends in yields, as indicated by the fact that the farms among each class that reported 8 or 9 years of yields during the period 1938–46 had a less rapid rate of down-trend in yields than did standing renters of "other" operators.

Perhaps the comparatively favorable showing made by cropper-tenants in the Upper Piedmont should be explained. Because of their greater control over resources and greater independence in farm operations, it was to be expected that owners would show up better with respect to both production functions. But it was somewhat of a surprise to find a group of sharecroppers on a par with owners with respect to yield level and yield variability. Even though the group name (cropper-tenants) is descriptive, their status is not that of the typical sharecropper. By definition, such operators are operating tenants. As a general rule they live at some distance from the landlord, and exercise all the major decisions of an entrepreneur. Their tenure is of considerable duration; they do not move every year or so, as do many sharecroppers. As the landlord lives apart from the cropper-tenant and usually has considerable capital, the cropper-tenant generally is provided with all he needs in the way of fertilizer, seed, and other supplies. As may be seen from table 28, the typical cropper-tenant used only 20 pounds less fertilizer per acre, on the average, than did the typical owner-operator. Typically, landlords lived in cities or towns. They were lawyers, doctors, or other professional men who had few hesitations about supplying the needs of the farm.

Table 28 shows that the 8- or 9-year farms in the Upper Piedmont had an upward trend in yields, whereas in the West Texas Rolling Plains they had an equally large downward trend. This was a definite distinction between the two sample areas for the period.

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[18] Cropper-tenants are operators who own no workstock or equipment but who live apart from the landlord and exercise most of the decisions of the entrepreneur. They are therefore considered as bona fide managing tenants.

Two additional distinctions between the two sample areas have to do with the differences in acreage planted to cotton and the corresponding yield. Acreages per farm in the West Texas Rolling Plains average about five times more than in the Upper Piedmont, whereas yields averaged about half as much. The percentage of planted acreage not harvested was higher in the Texas Rolling Plains but loss from hail averaged higher in the Upper Piedmont, although in neither sample area did losses from hail loom large during the period under study.

COLOR OF OPERATOR

A second basic characteristic of farm operators studied in the Cotton Belt is the color of the operator. Negro farmers appear as an important group only in the Upper Piedmont. Of 411 farms reporting three or more years of yields, 1938–46, in the Texas sample only 2 were designated as other than white. They were probably Mexicans. In the Upper Piedmont, however, 11 percent were Negro operators. The status of Negro farmers in the Southeast is more precarious as regards tenure than that of white operators under corresponding conditions. White operators have more choice in selecting land and, in some instances, they may even take less discount on loans than do Negro operators. Apparently, white operators control proportionately more of the needed resources of production and can gain additional needs more readily and under more favorable circumstances than can Negro operators. Moreover, the higher educational level of the white operators makes them more alert to the adoption of the latest and more improved techniques of production. The effects of these and other factors on their average yields and yield variability are shown in table 29 (p. 137).

The data reveal that, depending upon the period, white operators, both owners and tenants, were from 20 to 60 percent higher in average yield and from 15 to 40 percent lower in yield variability.[10] As between white owners and tenants, there is little difference in either average yield or coefficient of variation, although both tend to favor the white owner-operator group. But in the case of the Negro operators, the owners had both a lower average yield and a higher coefficient of variation than tenants—from 4 to 16 percent lower average yields and from minus 5 to plus 30 percent higher coefficients of variation. These differences were accounted for by the smaller farms the owners operated (8.2 acres of cotton compared with 12.1 acres) and the smaller quantity of fertilizer used per acre on cotton—50 pounds less. A selectivity factor probably also existed in the kind of land use. As the average Negro owner probably begins with a smaller capital than the average white owner, he is more likely to settle in a submarginal farming locality.

It is to be noted that the 8- or 9-year farms of both white and Negro owners had a more rapid upward trend in yields than those of corresponding groups of tenants. It is suggested that the longer tenure of owners in both groups accounted for the difference. The ability to

[10] A subdivision from the Texas sample was not included because the number of farms other than white are too few.

improve a farm and reap its benefits is related to tenure and to the prospects for continued occupancy. Obviously, owners are more advantageously placed in regard to all these considerations.

SEX OF OPERATOR

A third difference between farm operators that may be taken into account is sex. In order to hold constant the influence of racial differences, comparisons according to sex of the operator are given only for white operators (table 30, page 138). Apparently, only a small proportion of the operators in the Texas sample were women. Although in the Upper Piedmont, women constituted 7 percent of the total white operators reporting three or more years of yields between 1938 and 1946, in the Texas sample, they made up only 1 percent. It appears that on both production counts (average yield and coefficient of variation) irrespective of the period taken for comparison, the men were better farm operators than the women.

Farms operated by women were from 11 to 18 percent lower in average yield in the Upper Piedmont and from 3 to 5 percent lower in West Texas. Although there was one exception in each of the three periods compared, women owners showed somewhat higher variability in yields than men. As the women operators in the Upper Piedmont applied an average of only 20 pounds less fertilizer per acre than the men, these differences, in this area at least, cannot be accounted for by differences in quantity of fertilizer used.

A woman is particularly disadvantaged in operating a farm in comparison with a man who can withstand the heavy work and the routine of supervising labor with less strain. Moreover, a woman operator's ability to pay is investigated by credit agencies more carefully than a man's ability to pay and this is to her disadvantage in obtaining and using credit. As a woman operator is probably unable to spend as much time in the field with the farm labor, her farm-labor efficiency may be lower. In the Upper Piedmont, 51 percent of the women operators employed sharecroppers as compared with 25 percent for all operators. This is an easy way to avoid responsibility for supervision of labor. The technical knowledge of agriculture and understanding of new techniques on the part of the women may be less thorough than that of men and women may lack experience and technical agricultural training. This may lead to a lessened ability to visualize and understand the more complex agricultural processes. This tendency is reflected in part in reports of enumerators that 46 percent of the farms operated by women in the Upper Piedmont were severely eroded as compared with 29 percent for all farms.

In 1946, in both samples, women operators had been growing cotton 3 to 4 years longer, on the average, than their male counterparts. They operated somewhat larger cotton acreages in the Upper Piedmont on an average; but in the West Texas Rolling Plains the average cotton acreage on farms operated by women was hardly two-thirds of that for the farms operated by men.[20] Both factors (longer period of occupancy and larger acreages) in the Upper Piedmont reflect the

[20] In these comparisons only the Upper Piedmont sample had enough white women operators (37) to render the differences conclusive.

fact that farm property has been inherited, or that possession was gained by other parallel methods. (Fifty-eight percent of the farms operated by white women in the Upper Piedmont were acquired by inheritance as compared with 16 percent for the white male-operated farms.)

HOW FARM WAS ACQUIRED

As the amount of capital available to the operator in farming decidedly influences his success, the inheritance of farms should provide an initial advantage. That it does, from the standpoint of available capital, cannot be denied; but according to comparisons between owners who bought and owners who inherited, the inheritors covered by this study made a less favorable showing in average yield and yield variability than did the purchasers. This means that certain counterbalancing unfavorable factors connected with inheritance tend to overcome the initial advantage of a gratuitous capital investment. Comparisons between these two operator groups as to yield and yield variability, and certain operator characteristics are shown by sample areas in table 31, page 139.

The data show that the operators who bought their farms averaged 9 to 12 percent higher yields in the Upper Piedmont and 4 to 6 percent higher in the West Texas Rolling Plains.[21] Stability of yields also tended to favor the purchasers, particularly in Texas. Also, the West Texas Rolling Plains data on yield risk, showed that there was a greater abandonment of cotton acreage among inheritors (2.3 percent as compared with 1.9). It was found that yields for the longer-period farms (those with 8 or 9 years of yields) had a more rapid upward trend in the Upper Piedmont and a less rapid downward trend in the Texas sample.[22] On the part of the purchasers, this may indicate a more rapid adoption and exploitation of the new techniques of production and the cumulative effect of soil-improvement practices.

Further examination of the data shows wherein operators of purchased farms were superior and inferior, so far as operating practices are concerned, to those inheriting farms. It is apparent that they were not greatly superior in production factors, certainly not enough so to explain the differentials in yields. Although a higher percentage of inheritors occupied more severely eroded farms, the differences were not large otherwise. In the Upper Piedmont, purchasers used 30 pounds more fertilizer per acre and had a somewhat better record as regards the treating and cleaning of planting seed. But all these differences, even taking into account the existence of somewhat less erosion, prob-

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[21] A study in Illinois of the factors affecting success of farm loans (*1*) tends to confirm these results. The authors (Ackerman and Norton) found that, although inherited farms were more valuable, loans made on purchased farms were more successful than those on farms acquired by inheritance or gift despite the fact that the soils of inherited farms were considered superior to those on farms purchased. No indication was given as to why the loans on these farms were more successful.

[22] Beginning with table 31, the 5-year averages have been omitted primarily because nothing new is added. This period was included in the last three tables referred to in order to demonstrate to the reader that the other two period averages (3 or more years and 8 or 9 years) show the relationship about as efficiently as the 5-year period averages (1938–42) based on ginning records. For this reason, no further reference in this study is made to the 5-year period.

ably are not enough to account for the higher average yield of those farmers who bought their farms, especially when the greater education and younger average age of the inheritors are taken into account. Some of the difference may be due to managerial ability and the conditions under which the two classes of farms are operated.

For analytical purposes, the conditions under which farms are acquired by inheritance may be divided into two major categories—those left in the natural course of events to the nonresident child, and those left as consideration for the child's having remained on the farm.

Farms may pass by inheritance to city relatives, or to farmer relatives who live in the community or on an adjoining farm. In the former case, the inherited farm would, as a rule, be operated as a tenant farm, and the effects on yields and yield risk would be those of typical tenant-operated farms with uncertain tenure. But if the heir lives in the community, or on an adjoining farm, he would be likely to have the familiarity with and interest in farming to capitalize on his inheritance. Farms of this kind would be expected to show up more favorably with respect to average yield and yield variability than other groups of farms.

When a farm is bequeathed as a reward for the child's remaining on it, although the factor of interest can be reasonably assumed, the operator may be of somewhat lower inherent managerial ability and less maturely developed than the typical owner-operator who bought his farm with money saved or raised through some financial institution. Although the purchased farm usually reflects the owner-operator's likes and judgment in its selection, the inherited farm does not necessarily show either. Those who inherit farms might be expected to be somewhat less bold and energetic than their brothers who acquired land by other means, or who left the business of farming altogether to find city employment. Furthermore, their managerial development might be hindered by the domination of the older generation, which could prevent them from reflecting the alertness and progressiveness in farm operation that their age might warrant. On these farms this may mean that by the time the father retires or dies, the younger man has passed his physical prime and has become set in the ways and methods of an older generation.

In order to test the possible effect of parental influence on the development of managerial ability, the 59 inherited farms in the Upper Piedmont were examined for the degree of experience that the operators had obtained on the farm before they assumed active operation. (Owing to tabulation limitations it was not possible to analyze similarly the 33 inherited farms in the Texas sample.) It was found that only 18 of the operators had acquired considerable experience on the farm before becoming its operator. Furthermore, the inheritors with experience before inheritance appeared to be less able than the other inheritors in several ways. Although they planted more acres to cotton (17.6 acres compared with 14.7), their average years of schooling were fewer; they used about 50 pounds less fertilizer per acre on the average, and they tended to use inferior practices in the acquisition and treatment of planting seed. On the other hand, they had some favorable production factors, as compared with those inheritors who had had no previous experience; that is, they were younger, more experienced, engaged relatively less in off-farm work, and planted a higher ratio of legumes to cotton acreage harvested.

But despite these apparent counteracting influences, inheritors with previous experience averaged 40 pounds of lint cotton less than inheritors without previous experience, and 56 pounds less than purchasers. This amounts to 13 and 17 percent lower average yields, respectively. The bases of comparison are the averages computed from three or more years of yields reported during 1938 to 1946.

There was no significant difference in yield risk. When the comparisons were made on the basis of 8 or 9 years of yields, however, it was found that although the differentials in average yields were somewhat narrowed, the differences in yield risk became more noticeable. The risk was 4 percentage points higher than for inheritors without experience and 12 percentage points higher than for purchasers. Furthermore, the trends in yield showed significant differences. The inheritors with experience had a downward trend of 4 pounds yearly; those without experience on the farm before inheriting it had an upward trend of 6 pounds annually, which equaled the annual improvement in yield for the operators of purchased farms.

Therefore, these data indicate that if the length of previous experience on the inherited farm were held constant, the difference between the operators of purchased farms and the operators of inherited farms would be narrowed considerably, especially with respect to average yield. Although the number of operators with previous farming experience who inherited farms is somewhat small for the significance desired, the results give some support to the opinion that the son who remains on the farm with his father may have less inherent managerial ability and less chance for its development than the son who strikes out on his own.

Further study will be required, however, before definite conclusions can be drawn regarding some of the points raised here. The father-son farm operating agreements, which have received much attention recently, are an attempt to formalize the division of managerial responsibilities between a father who wishes to retire or begin "taking it easy" and a son who has the opportunity to, or must, remain on the home farm. Within the framework of a businesslike agreement, the son (or son-in-law) who remains would have a better idea of the boundaries within which he can make his own decisions. Such agreements should make farming on the home farm more attractive to all home-staying heirs.

YEARS OF SCHOOLING

Numerous farm-management studies have shown a positive relationship between years of schooling and type of education on the one hand and success in farm business on the other. They have demonstrated fairly conclusively that although labor income tends to increase greatly as a result of years spent in school, an agricultural training contributes much to the influence of education on profits from farming. Factors associated with the increase in education and in labor income in a more ultimate sense were size of business, efficiency in production, and efficiency in marketing. The directness of causation, or association, is not clear as these are, to a considerable extent, a function of education and ability, or both. Level of education may or may not be analogous with managerial ability.

The data obtained from this study by cross-classification against years of schooling showed that a relationship existed between years of schooling and average yield but that any relationship that existed between years of schooling and variability in yields was too irregular and complex to mean much. In the Upper Piedmont, according to the figures, the average yield increased with education through the 9-to-11-year group, then dropped off, and variability of yields declined. In the West Texas Rolling Plains, average yield was apparently not affected by years of schooling but the coefficient of variation increased with the number of years. Thus education appears to have had an opposite effect on stability of yields in the two regions. These contradictory findings in the two areas suggest that years of schooling may not be as closely related to the size of an operator's average yield and the variability in his annual yields as some of the other factors.

Agricultural education of farm operators favorably affected average yield in both regions but, according to the data, had an irregularly unfavorable relationship with relative yield variability. As agricultural training of operators increased from high school and beyond, average yields (although on a higher level than that of the nonagriculturally trained) declined in the Upper Piedmont but rose slightly in the Texas sample; yield variability showed a tendency to decline as agricultural training increased beyond high school, but remained on a higher level than was true for nonagricultural groups in the Upper Piedmont. Lower average yields for the group of farmers beyond high school were apparently due to the greater emphasis on size of the cotton enterprise at the expense of land quality.

Although in the Upper Piedmont, cotton acreage of the high-schooled operator group exceeded that of the fourth-to-seventh grade group by 20 to 31 percent, the group trained beyond high school had cotton acreages that exceeded by 79 to 118 percent that of the fourth-to-seventh grade group. In the Texas Rolling Plains the differentials were roughly analogous—10 to 17 and 84 to 103 percent respectively (table 32, p. 141). Evidently the better schooled group of operators found it more economic to sacrifice average yield to some extent for the greater advantages realized from larger acreage and greater total production. Economies realized from pushing machinery and managerial ability to near-capacity use would be the chief consideration, especially in the Texas sample.

The reason why the agriculturally trained operators tended to have higher uncertainty of yields, it is suggested, is because of the greater interest and alertness of this group of farmers in introducing progressive changes. The more rapidly new techniques are introduced, the less time is left for long trial, and consequently more errors are made in both selection and use. This supposition is partially supported by the more rapid upward trend in yields found among the 8- or 9-year farms of this group of operators in the Upper Piedmont; and it is partially disproved by the larger downward trend in yield for the agriculturally trained than for the nonagriculturally trained operators in the Texas sample.

A discrepancy also arises from the differences in relative abandonment of acreage. In the Upper Piedmont, comparatively speaking, the agriculturally trained operators had the highest abandonment of acreage of any group of operators, whereas in the Texas Rolling Plains they had the lowest. In the former area, the higher rate is probably a reflection of speed and alertness on the part of the operators in using the land for other purposes, while the lower rate in the West Texas Rolling Plains is perhaps an indication of lack of suitable alternative enterprises, considering the time left to replace the acreage of cotton that shows prospects of poor yield. Where it is possible, as in the Upper Piedmont, to plant a subsequent crop on land planted to cotton that has been abandoned, there is an incentive to do so in order to make use of the fertilizer already applied on the cotton. In the West Texas Rolling Plains, on the other hand, as the rather scarce harvest labor is paid at piece rates, little is lost by continuing to harvest poor crops. In this area, whether cotton was picked or left (as a failure or near failure) the effect of abandonment on average yield and the coefficient of yield variability were the same for the purposes of this study, as both yield measures were computed on the basis of planted acreage in the Texas sample.

YEARS OF EXPERIENCE

As no two farms are exactly alike, each time an operator moves he must learn the characteristics and behavior of the new farm by trial and error, which requires time. Moreover, any scheme of land management of any degree of complexity, such as a rotation system, fertilization and liming, and drainage and terracing, may not return full benefits until several years have elapsed. Therefore, the duration of the operator's occupancy has a bearing on his yields and on other measures of his success on the farm. Low-quality management may show either poor yields or a decline in yields, whereas management of high quality would be expected to reflect gains.

In figure 6 are shown the average yield and the coefficient of variation for varying time intervals of experience and according to major groups of operators. The data indicate that maximum average yields were obtained by operators who had had around 11 years of experience growing cotton on the 1946 farm in the Upper Piedmont and around 20 years of experience in the Texas Rolling Plains. The "miscellaneous" operators, who averaged highest yield at around 28 years of experience, formed an exception that was not particularly significant, as it was based on only a few cases.[23]

An additional effect of experience was that the minimum coefficient of variation in farm yields tended to occur simultaneously with the maximum in yield; one group of operators in each region ("other white" operators in the Upper Piedmont and share-renters in the Texas Rolling Plains) showed rather large differentials between the extremes

[23] The definition of "farm" varies somewhat from that used heretofore. In order to eliminate differences in the averages, due to varying numbers of years upon which they are based (particularly the effects of the 3-year farms), records for all farms not reporting 5 years of yields during 1938–42 were omitted. This reduced the number of records and tended to assure reasonably constant time intervals as bases for the averages.

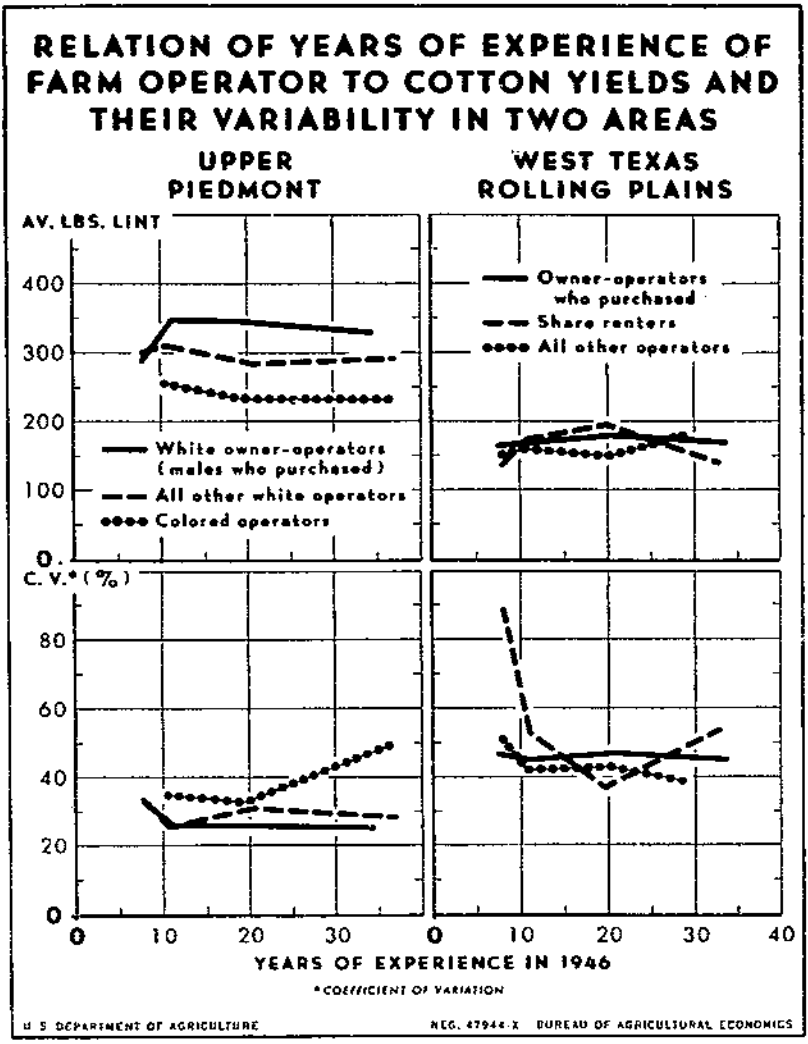

Figure 6.—The optimum effect of experience on yield and relative variability of yield appears to have been reached at approximately 11 years in the Upper Piedmont and at about 20 years in the Texas Rolling Plains, except for the miscellaneous class of operators which reached it at around 28 years. In both areas, the minimum in yield variability agreed closely with the maximum average yield, or departed from it to only a minor extent.

and a strong inverse correlation with the curves of average yield. The managers with the best records in the two samples were white owner-operators (men who bought their farms) in the Upper Piedmont and share-renters in Texas. The lines for each in the chart strikingly confirm their superiority, for each had a sharper and more distinct increase to the maximum in average yield, and contrariwise a sharper decline to the minimum in the coefficient of variation, than any of the other groups of operators in each area.

With reference to all groups, the rise in yield with years of experience to a maximum reflects the period required for operators to learn the soils of the farm and crop-weather relationships, and to work out a thoroughly satisfactory system of land management for the farm; whereas the decline from maximum yield with further increases in the duration of occupancy indicates the influence of the aging of the operator and his declining interest and alertness in agricultural progress.

AGE OF OPERATOR

The age of the operator may be expected to affect the yield function, as it is related to other factors that have a more direct connection—such as physical stamina, educational level, progressiveness, and capital accumulation. When the operator performs most or all of the farm work, the effect of age on physical stamina will affect the results. Much farm work in connection with the production of cotton, especially in areas in which mechanization is not common, is heavy. In these areas, younger men would have an edge over the older farmers. In the case of educational level, other things being equal, the younger farmers are likely to be in better position.

Obviously, educational facilities and scholastic content differ today from those of 25 years ago, and both are expected to continue to improve. Therefore, the younger farmers might be expected to excel the older farmers in educational level and in progressiveness.

Even if educational levels are equal, the older farmers may be less openminded toward new developments in agriculture. Age brings in its wake increased caution and conservatism. One aspect of age that favors the older farmers is the matter of accumulation of capital. If a farmer has been moderately successful and thrifty, he usually has more capital accumulated, either in real estate or other investments, than the younger farmers. But the latter may have a credit advantage in being able to present their business plans in a more favorable light and more optimistically.

In the West Texas Rolling Plains area, it was found that age of operator was not closely related to average yield. In the Upper Piedmont, however, average yields for white owner-operators (men) who purchased were highest in the age group under 31; for other white operators, in the age group 31 to 40, and for Negro operators, in the age group 41 to 50. Thus the maximum in average yield increased one age group of 10 years with each change in operator's group.

In the Upper Piedmont, the difference in average yield from highest to lowest was 113 pounds, or 28 percent (with a secondary peak difference of 50 pounds, or 15 percent) for white owner-operators (men) who purchased; 46 pounds, or 14 percent, for other white operators; and 112 pounds, or 35 percent, for Negro operators. Therefore, the sharpest differential was indicated for Negro operators. As a matter of fact, it appears that as the efficiency of the managerial group improved, the effect of age became less marked. For instance, the effect of age is apparently more pronounced for "other white" operators than for white owner-operators (men) who bought their 1946 farms—the highest quality of managers of the three groups (fig. 7).

In the Upper Piedmont, the increase in effect of age as the quality of management declined is directly associated with the degree of physi-

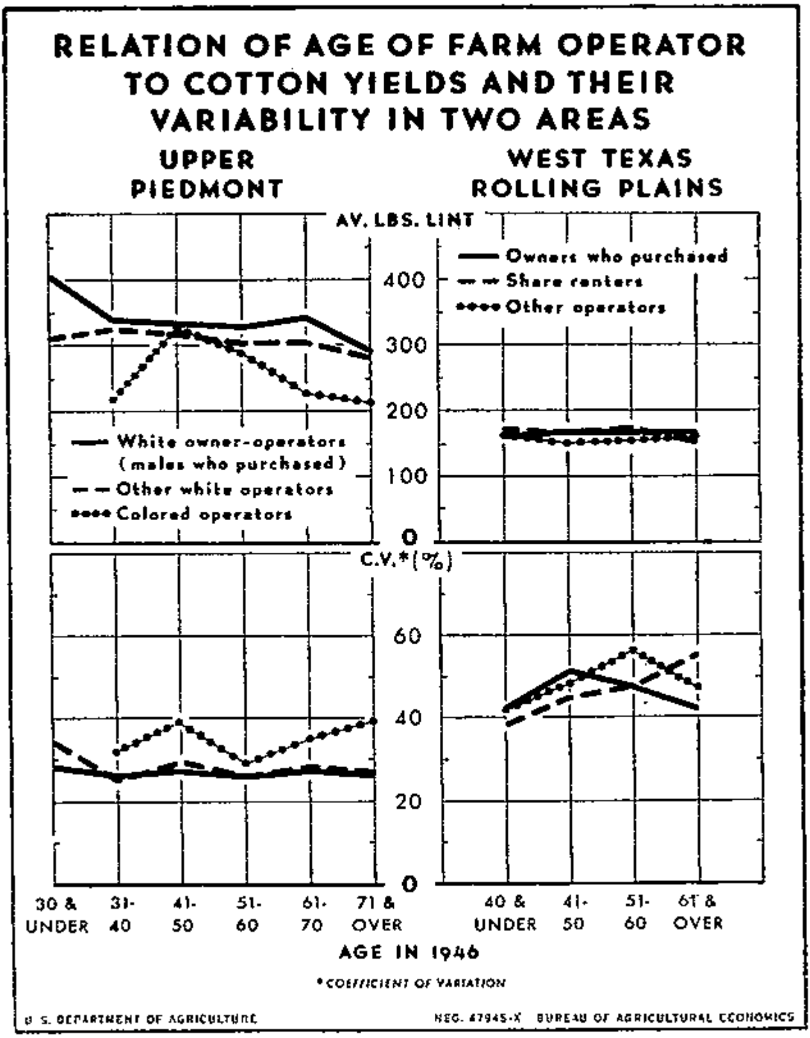

FIGURE 7.—Maximum average yields were obtained by the groups of operators at different age levels, although the differential due to age was rather small in the West Texas Rolling Plains. There was no strong relationship between age and the coefficient of variation in yields. In the Upper Piedmont, no relation could be detected; but in the West Texas Rolling Plains variability of yield tended to increase with age, with two operator groups showing definite maxima —"owner operators" in the 41 to 50 age group, and "other operators" in the 51 to 60 age group.

cal participation in production of cotton. Negro operators participated a great deal more than did white owner-operators. This was borne out by the fact that 92 percent of the Negro operators used family labor, whereas only 52 percent of the white owner-operators did so. In other words, the operators who got the superior results apparently spent a higher percentage of their time in managing labor and in looking after other business matters of the farm. Consequently, physical stamina was related less closely to success in producing cotton than in the case of the operators who did the work themselves. But the better educated and better informed groups of operators were able apparently to manage their hired help about as well at any age.

Age of operator apparently affected very little the size of the coefficient of variation in the Upper Piedmont. But in the West Texas Rolling Plains the coefficient of variation tended to rise strongly as age increased. However, the groups of farms operated by owners who purchased and those operated by other groups of operators showed peaks in variability of yields, followed by considerable decline in the coefficients, the peaks occurring at the age groups 41 to 50 and 51 to 60 respectively. It is suggested that the unfavorable effect of age on stability of yields in the Texas sample was because of the slowing effect of age on decisions, and on their execution. In an area subject to great vicissitudes of weather, timing is important.

ORIGIN OF OPERATOR

In his analysis of the lending operations of the Federal Land Bank of Springfield, Hill (*15*) found that both operator's origin and previous experience had a significant bearing on the success of loans. Borrowers from the same farming region (the Northeast) who had had previous farming experience had about half the foreclosure rate of borrowers from the same region who were without previous farming experience. Borrowers who came from other regions and who had no previous farming experience in the Northeast had a foreclosure rate about four times that of the former and about double that of the latter. Hill attributed the very high foreclosure rate among borrowers from other farming regions to mistakes in choosing farms rather than to lack of experience. Either they lacked judgment in selecting a good farm, or they were sold one at a price in excess of its actual worth. This failing is indirectly the result of lack of experience in judging the performance of different soil types and the importance of such factors as drainage, topography, and nearness to market.

The majority of the operators who reported three or more years of yields came from local farms—80 percent in the Upper Piedmont and 57 percent in the West Texas Rolling Plains. Next were those from farms elsewhere in the Cotton Belt—17 percent were thus classified in the Upper Piedmont and 37 percent in the Texas sample. Only a very minor percentage came from local towns or cities. But some fundamental differences in yields and in production factors are found among these groups of operators, as shown in table 33 (p. 142). The data show that operators from local towns and cities had the highest yields but also the highest relative variability in yields. This group also had by far the highest percentage of abandonment of acreage in both samples—1 percent in the Upper Piedmont and 4.3 percent in the West Texas Rolling Plains.

In the case of the other two groups of operators, the relation to yield was not consistent. In the Upper Piedmont, operators from local farms had a higher average yield than those from farms elsewhere in the Cotton Belt and a somewhat lower variability of yields. But in the Texas sample, the opposite relationship existed between the two groups. Operators from elsewhere, now farming in the Texas Rolling Plains, in addition to having higher yields and lower coefficients of variation than operators whose origin was local, planted an average of almost 10 acres more cotton, but planted a somewhat lesser percentage of it on the contour (a practice highly recommended for conservation of both soil and water in the Rolling Plains of Texas) with no higher percentage of abandonment than operators from local farms.

Because of the contradictory relationships to the yield factors of the two groups of farm operators with farm backgrounds, conclusions are possible concerning only operators from local towns. Although their number in each area was comparatively small, the extent to which they differ from the other two groups was striking. They obtained higher average yields; but from two standpoints they were poorer risks in regard to yields because they had higher variability of yields and a higher percentage of acreage abandonment. The greater yield risk of these operators indicates two operator characteristics—more experimentation with new techniques of production and quicker acceptance of losses as shown by the higher percentage of abandonment of planted cotton acreage. (This is partially affirmed by the fact that those farms among them whose records of yields covered 8 or 9 years had a more rapid upward trend in yield or a less rapid downward trend.) Apparently the operators were more ready to plow up lands that showed poor prospects for profitable yield or they did not bother to hire labor to pick over such fields. The other groups of operators might have had them picked anyway, thereby reducing the ratios of abandonment but with no material effect on yield.

As the other two groups of operators (those from local farms and from farms elsewhere in the Cotton Belt) in both sample areas showed a different relationship to yield and yield variability, no adequate explanation can be made of their effects. It is suggested that in the Upper Piedmont the more unfavorable showing of the operators from farms elsewhere in the Cotton Belt may be attributed to shorter experience on the 1946 farm (average of 4 years) and to the use of less fertilizer (80 pounds less on the average). They may also be handicapped in some cases because of lack of long-standing acquaintance with the local sources of capital. But in the Texas Rolling Plains, as shown previously, share tenants show up as favorably as owners. They probably invest most of their funds in farm machinery which requires a comparatively large amount of capital. Consequently, in an area in which weather conditions are unfavorable for high and stable yields, greater flexibility in choice of cotton farms afforded by a capital set-up in breadth and not depth is apparently significant in explaining the differences. Such operators can keep trying out farms until they obtain the best possible advantage from the standpoint of the contingencies involved.

ILLNESS OF OPERATOR

The effect of illness on yearly yields was investigated, but no analysis was made of the relation between degree of illness and average yields or the size of the coefficient of variation. All farms that reported illness during any of the 9 years were brought into one group and those reporting no illness were brought into another group. Then a comparison was made of the average of the yearly farm yields for the two groups. In tabulating the yields for the group for which illness was reported, all years were included irrespective of whether illness was reported for the entire period. No analysis was tried with the other method which suggests itself—that is, averaging for comparison only the yields that coincided with a year of illness. This would have necessitated splitting the yields of some farms but the results might have shown an even greater difference.

Despite the shortcomings of the method employed, the results do indicate that illness of the operator on farms in the Upper Piedmont

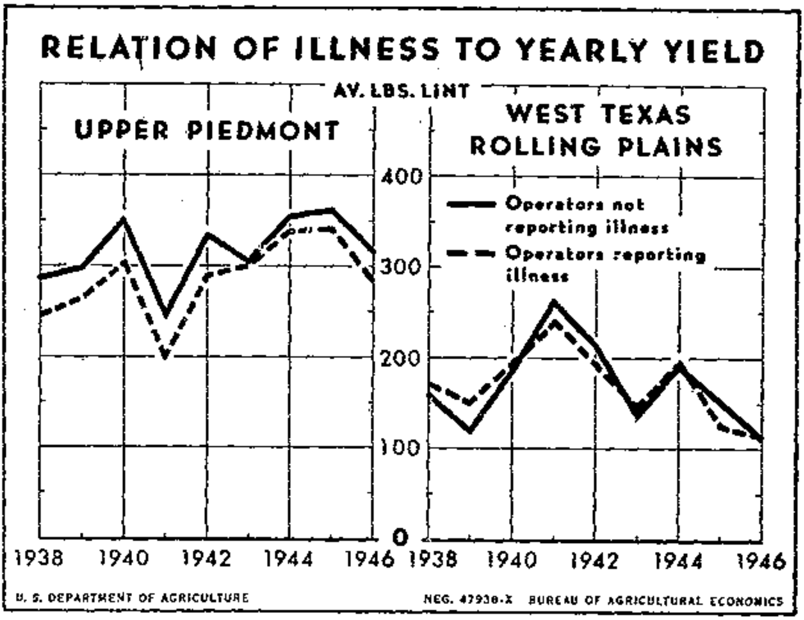

FIGURE 8.—Illness apparently had a striking and significant effect on yearly yield in the Upper Piedmont but in the West Texas Rolling Plains there was no definite relationship. The extent to which hired labor and tractor-drawn machinery are employed in the West Texas Rolling Plains reduces the significance of operator's health and stamina to cotton production and helps to explain the lack of connection between illness and yearly yields in this area.

reporting three or more years of yields was associated with a strikingly lower yield compared with the operators who reported no illness. Illness of the operator would affect his ability to work and, if sufficiently serious, his ability to supervise his farming operations. But in the West Texas Rolling Plains there is no regular relationship (fig. 8). The average yields in the Upper Piedmont for farms on which operators reported illness but for which less than 3 years of yields were available, also showed lower average yields than occurred on the "no illness" farms. In the sample from the Plains 56 percent of the operators employed hired labor as the only source, compared with 6 percent in the Upper Piedmont.

The percentages of farms using sharecropper labor as the sole source of labor were 4 and 20 percent respectively. Therefore, the typical operator apparently depended less on his and his family's labor in the Texas Rolling Plains than in the Upper Piedmont. Consequently, sickness would have a less direct bearing on the ability of the average operator to cultivate his cotton in the Texas Rolling Plains. Furthermore, the fact that operations were completely mechanized reduced the effect of illness in at least two ways: By providing a source of power subject to higher rates of operation for longer duration in a critical period and by reducing the arduousness of the work.

The conclusion is that illness affects yearly yields unfavorably in the Upper Piedmont through the inability of the operator to get the necessary operations done; but that in the Texas Rolling Plains there may be little or no over-all effect because of greater dependence: (1) On hired labor, (2) on mechanization, and (3) on neighbors who often help out in such an emergency. Cotton is generally picked by migrant labor in the Plains so the operator in this area would not be as much concerned in this regard as the grower in the Upper Piedmont who, along with his family, often harvests much of the cotton produced himself.

Professor Bonnen of Texas Agricultural and Mechanical College adds another reason why illness may be less of a limitation in the Texas Rolling Plains. He states that "moisture conditions control time of planting and usually the optimum period for planting is quite short. If it is missed there may not be another opportunity. In the Plains country it is not uncommon for neighbors to move in with large numbers of tractors and prepare and plant or cultivate a sick person's crop." (From a letter dated July 20, 1950.)

Basic Farm Characteristics

The basic farm characteristics which are examined here in relation to average yield and yield variability are topography, soil erosion, soil texture, and soil color. These four fundamental natural traits of the individual farm have a vital bearing on fertilizer requirements, maintenance of fertility and prevention of soil erosion, and the possibilities and economics of use of farm machinery.

TOPOGRAPHY

Topography is of material importance in erosion control and in the economics of farm-machinery use. Topographical ratings given individual farms by the enumerators indicate (table 34, p. 143) that in both samples, steepness of topography influenced average yield and variability in yields. As the relative steepness of topography increased, average yields declined, whereas the coefficient of variation of yields tended to increase. Topography influences average yield because erosion and leaching are likely to increase with steepness of the land. Limitations on the use of modern labor-saving machinery increase as the roughness of the topography increases. Although the increased effectiveness of machinery on level land may not be a factor in higher yields, indirect effects from improved soil tilth and greater timeliness of operation would be expected to have a bearing on average yield and its relative variability.

The results of several other researchers tend to confirm these general findings. In an investigation of the effect of land quality on farm organization and yields in Tennessee, for crop-years 1938 and 1939, Bonsor (*3*) and others concluded that "as the slope increased in steepness there was a decrease in corn yield, even within the same soil series." In a study of factors affecting success of farm loans in 7 counties in Illinois, covering the loan experience of 827 farm loans between March 1917, and May 1933, Ackerman and Norton (*1*) found that "the percentage of foreclosures was higher among farms with a rolling topography . . . than among those on level land." This indicates a topographic disadvantage in either yields or other factors for financial success.

DEGREE OF EROSION

The degree of erosion found on a farm reflects the extent of good land management and the cropping system in use; it also indicates for the future the extent of soil building needed, the character of the land management required, and the yields that may be expected. Obviously, other things being equal, yields may be expected to be considerably lower on eroded soils than on uneroded soils of the same type.

Latham (*17*), in experiments at Moores, S. C., on mixed A-, B-, and C-horizons collected from exposed horizons at different locations in the area of the South Tyger River Project, demonstrated that over the 4-year period 1936–39, with similar fertilizer treatments, the A-horizon was more than three times more productive than the B, and 11 times more productive than the C-horizon. He found that, as the C-horizon was so low in the scale of productivity to begin with, additions of organic matter gave relatively the greatest increase in yields on this kind of soil. This experiment was conducted on the Cecil soils which predominate in the Upper Piedmont sample.

But experiments on more deeply eroded soils in the Western States show that similar conclusions are valid there also. Bennett (*2*) cites an experiment at Tyler, Tex., which showed that the fertilized subsoil of Kirvin fine sandy loam gave yields 43 percent below those on the unfertilized topsoil. He explained the lower yields on subsoils by the deficiency in organic matter, impaired structural efficiency, and reduced availability of moisture and plant nutrients.

In order to test further the effect of these factors on yield and yield variability, enumerators were instructed to grade the degree of erosion of each farm visited, both by observation and in consultation with the operator.[24] This method was crude but under the circumstances it was probably the best approach. In figure 9 are shown the effects of degree of erosion on yield and its coefficient of variation by important operator categories in the Upper Piedmont and by types of labor used

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[24] From the standpoint of degree of erosion, there were seven possible ratings—none, scarcely none, light sheet erosion, heavy sheet erosion, all topsoil gone, occasional small gullies, and numerous gullies. Enumerators were mostly employees of the Agricultural Adjustment Administration office and were familiar with erosion and with its effect and problems.

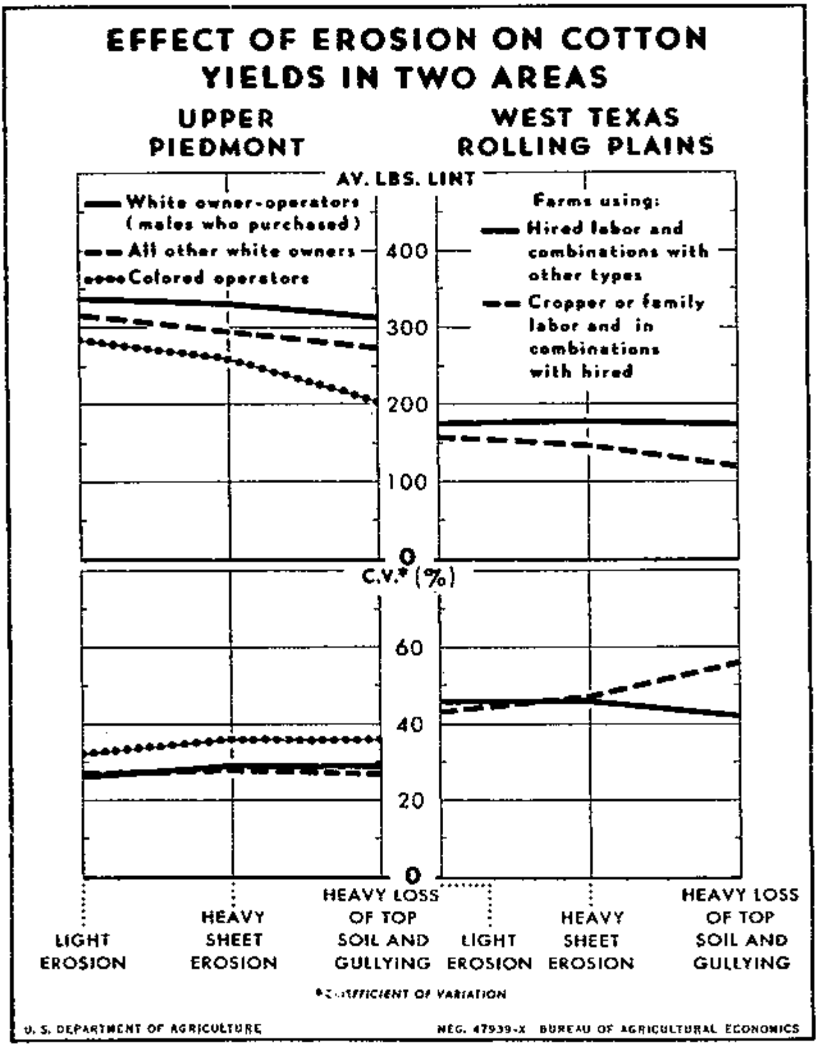

FIGURE 9.—Although the level of yields varied with the managerial or labor group, increased erosion lowered the average yield of all groups. In the Upper Piedmont, where erosion was more clearly identified, its effects were proportionately greater as the efficiency of the managerial group declined, presumably because of the greater premium which heavily eroded soils placed on good land management. Yield variability tended to increase with degree of erosion in the case of all operator groups in the Upper Piedmont and one of the two labor groups in West Texas.

in the West Texas Rolling Plains. In both samples, yields declined with the degree of erosion but the decline in the Upper Piedmont sample was sharper. In this sample, the differential in average yield associated with degree of erosion also increased as the efficiency of the group of operators declined. The groups of operators given in the chart reflect managerial ability to obtain and utilize the factors of production. The differential in average yield from light to heavy erosion was 25 pounds, in the case of the white, male owner-operators who bought their farms; 43 pounds for other white operators; and 80 pounds for all Negro operators.

In the West Texas Rolling Plains, a similar tendency for the average yield differential to widen with decline in the quality of the labor employed[25] was also apparent. It was especially marked in the low-efficiency labor groups—croppers and family labor. On those farms that used hired labor and combinations of it with other types, the grades of erosion set up by enumerators affected average yield very little. However, in the case of farms using cropper or family labor and combinations with hired labor, the decline in average yield from light to severe erosion was 37 pounds. This amounts to 24 percent and is quite significant for Texas.

As there is comparatively little severe erosion in Texas, the term, "severe erosion," may not have meant the same thing to enumerators there that it did to enumerators in the Upper Piedmont, where a great deal of severe erosion and extensive gullying is found.[26] Furthermore, because of differences in the fundamental processes of soil formation (downward percolation in the Southeastern area and upward percolation in western Texas), fertility is not greatly affected by soil erosion in the West Texas Rolling Plains but is seriously affected by it in the Upper Piedmont. The greatest influence of erosion in this area on average yields would appear to be through the effect of soil loss on soil structure and organic matter.

In both sample areas, the increased differential in average yield from soil loss, associated with kind of operator or type of labor, reflects the premium on good soil management that the more severely eroded soils require. Operators with sufficient capital and necessary knowledge are able to move more quickly, effectively, and surely, to minimize the effects of a heavily eroded soil.

In the Upper Piedmont, yield variability showed an irregular tendency to increase with erosion. There appeared also to be a differential increase in variability of yields as between owner-operators and Negro operators; that is, not only did variability of yields rise with soil erosion but it rose more rapidly in the case of Negro operators. In the West Texas Rolling Plains, only those farms using cropper or family labor and combinations with hired labor showed a strong tendency for variability of yields to rise with degree of erosion. However, both classes of farms showed a strong tendency to abandon

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[25] Type of operator appears to be considerably less important as an analytical factor in the Texas sample than the kind of labor employed, which reflects managerial ability not only to discriminate in hiring capable help, but in other managerial functions as well.

[26] Professor Bonnen of the Texas Agricultural and Mechanical College questions the existence of "heavy" erosion in the Texas Rolling Plains on the basis of the Soil Conservation Service mapping of 32,584 acres which showed only 8.8 percent moderate erosion and 0.7 percent severe erosion. The results indicated are not to be considered as analogous to Soil Conservation Service concepts of erosion—except as those which coincide with the concepts of degree of erosion of agricultural workers who had had much experience with farmers in the area. Appearance has perhaps played a large part in all of these ratings but the results indicate that an objective basis has been determined by which valuable information as to yield and yield risk for individual farms may be inferred.

cotton acreage as the degree of erosion increased. The effects of erosion on the percentage of abandonment rose sharply as the efficiency of labor employed declined. This is shown in the following tabulation:

	Percentage of cotton acreage abandoned	
	Hired labor and combinations with other types	*Cropper or family labor and combinations with hired labor*
Light erosion	0.9	1.7
Heavy sheet erosion	.7	3.0
Heavy loss of topsoil and gullying	2.7	21.0

SOIL COLOR

Rice and Alexander (*27*) rank the different soils, classified according to color, in the following order of productivity: Dark-brown to black, red or reddish-brown, yellow, gray, and white. They caution that color in itself is not important but that it often serves to indicate other soil conditions that are. The dark-brown and black in soils are often caused by a higher content of humus, which is associated with a favorable soil structure and adequate supplies of nutrients such as calcium and nitrogen. When these colors are due to a high content of some mineral or to poor drainage, the soils are likely to be of low quality.

Red soils owe their color mainly to compounds of iron, that is, unhydrated iron oxides, which do not exist in poorly drained soils; therefore, such soils have good drainage and aeration and are very favorable to crops. The yellow in soils is believed to be caused by hydrated iron oxides. Many yellow soils are imperfectly drained; others appear to have acquired their yellow color because of previous poor drainage. Consequently, these soils are inherently of low productivity. The gray color in soils may be due to lack of sufficient oxygen or to low content of organic matter and iron. Soils with reduced compounds of iron are commonly gray or bluish gray and may be mottled with yellow or rusty brown if the water table fluctuates. Normally, they support a very specialized or stunted vegetation.

As with topography, erosion, and soil texture, the enumerators rated each farm with respect to its soil color in order that the possible bearing of color on the yield factors under investigation might be learned. That the very rough descriptive terms for soil color arrived at by the enumerators are related to the problems being analyzed is indicated in table 35, p. 144. The data there shown indicate that both average yield and the coefficient of variation in yield varied in both samples rather significantly with the soil-color characterizations of the farms. The ranking from high to low in average yield, of the soil colors in the Upper Piedmont sample, was dark-red, gray to gray-yellow, red to gray-red, and other colors; in the Texas sample, the rankings were dark-red, red, and gray-red, dark-brown to black, gray to gray-yellow, and other colors. With one exception the rankings in relative variability of yields were the same.

The difference in average yield from highest to lowest was 51 pounds, or 16 percent, in the Upper Piedmont, and 18 pounds, or 10 percent, in the West Texas Rolling Plains. Differences in the coefficients of variation were 33 and 12 percent respectively. Apparently, the productivity differentials between soil colors were less distinct in the Texas Rolling Plains. Further, the order of productivity as determined differs from that reported by Rice and Alexander (*27*). The differences are probably due to the influence of erosion on soil color, which is especially important in the Upper Piedmont where loss of a gray topsoil gives a red subsoil in whole or in part, depending upon whether part of the gray A-horizon remains as a sheet or in islands.

Some phases of the highly productive Cecil soils of the Upper Piedmont have a gray A-horizon. When eroded, they might very well fall into the third color-group for the area. If uneroded, or not greatly eroded, they would fall into the second color-group. On the other hand, the dark-red color-group, the first and the highest yielding of the four classes shown, would include the reddish Cecil soils, which are quite productive and widespread, and the Davidson series which is the best of all.

A few other points may be made from the data in table 35. Fertilizer applications apparently did not account for the differentials in yield and yield variability. Except for the last soil class, which included only 6 farms, the quantity of fertilizer applied was nearly the same for all soil-color groups. Only 20 pounds more were applied on the average in the first group than in the second and third groups. But in both samples, with only one exception, the percentage of cotton acreage abandoned was highest on the soil colors that rank lowest.

The conclusion is that rankings of soils according to color showed a fair degree of differentiation between average yields and uncertainty of yield.

SOIL TEXTURE

The texture of soils is of great economic importance. The coarser textured soils are often devoted to crops that require much hand labor. These are light soils, generally of low fertility, and quick to warm up in the spring. This last-named quality gives them an advantage of earliness which is important in moving truck crops to market at a profitable price. On the other hand, the finer textured soils—the clays in particular—are likely to be heavy and stiff. Usually, they require heavy machinery for tillage and the systems of agriculture used on them tend to be more extensive.

Certain other aspects of soils which have a bearing on crop growth are also indicated by texture. Texture indicates drainage; it has a bearing on structure; and it is related to the readiness with which certain minerals become available. The sandy soils, particularly the coarser and deeper sands, often lose moisture too quickly and are low in natural fertility. Clay soils, although they are a great deal more fertile, may be too compact and have poor aeration.

Texture was judged by the enumerators in the way explained in connection with other physical characteristics. The relation of texture to yields and their variation is given in table 36, page 145. In both samples, the sandy soil had by far the highest yields and in the West Texas Rolling Plains they also had the lowest coefficients of variation in yield. In both areas, the clays made a rather poor showing in average yield—the lowest in the Upper Piedmont and the next lowest in the West Texas Rolling Plains—and they were associated with the highest yield variability.

The poor showing of this class of soils is undoubtedly a reflection of soil erosion, especially in the Upper Piedmont where, after some years of erosion, the very desirable sandy clay loams become clays. Also, in both samples, this soil group had the highest abandonment of cotton acreage. In the West Texas Rolling Plains, the alluvial soils were the lowest of the three soil groups in average yield. The greater availability of moisture in these soils, which are low-lying, was reflected, not in a high average yield as was expected, but in comparatively low variability of yields (next to the lowest of the three soil groups) and in the lowest percentage of acreage abandonment of the three texture groups studied.

Factors Subject to Management

Most of the factors examined heretofore are basic or long-run; that is, they are either fixed for the operator's life (as with sex, race, or education) or are subject to change over a long period (such as soil erosion). In contrast, the short-run practices to be considered next may be changed at will or in a comparatively short period, by the operator. Therefore, his ability to manage or to influence yield variability favorably is more closely related to such factors as kind of seed, seed treatment, kind and rate of fertilizer applied, crop rotation, etc. Differences with respect to these practices pose all of the problems of uncertainty as to yield discussed above.

SOME EXPERIMENTAL RESULTS

As only a few crop-and land-management practices could be included in the questionnaire, some comparable fertilizer results and additional results from practices based on experimental data, are presented in the Appendix, which begins on page 107. The effects of such factors as winter cover crops, liming, pH value of soil, and crop rotation, and of these practices in various combinations on the average yield, variability of yields, and trend of yields are shown. Additional information is presented as to the effects of fertilizer practices—rates, elements, and placement—and the tonnage of barnyard manure used. Many interesting relationships are presented but the main conclusion is that—irrespective of soil type, location, and other conditions—good land-management practices influenced favorably the average yield, yield risk, and the trend in yields.

EFFECT OF TRACTORS

Tractors have increased very rapidly on American farms since 1940. The increase has been relatively more rapid on the farms in the Southeast.[27] One source (*4*) estimates that about 38 percent of the land

[27] From January 1, 1940, to January 1, 1945, the total increase in tractors on farms in the United States was 57 percent; from January 1, 1945, to May 1, 1948, another 34-percent increase occurred. This should be compared with increases of 114 and 55 percent respectively for the Southeastern States. See D. O. Mesick (*19*) and A. P. Brodell and J. A. Ewing (*4*).

breaking was done by tractor power in the Southeast and 35 percent in the Delta, in 1946, although much lower percentages of the cultivation were done by tractor power in these areas. Perhaps their greatest influence on cotton farming in the Southeast, and particularly in the eastern part of the Cotton Belt, has been through the reduction in number of cotton farms and the increase in a more extensive system of agriculture (7).

Tractors possess tremendous advantages for agriculture in the South not only because they increase efficiency in operation and save feed, but also because of various technical effects produced by them. They provide greater flexibility in farming operations and greater timeliness in doing critical jobs which tend to produce a better soil tilth. Both factors, and especially soil tilth, could have a bearing on crop yields.

Green and others (*10*) in a study of tractor power on farms in North Carolina found that yields were higher on tractor than on nontractor farms. However, no explanation was offered as to why this was true. Tractor farms were larger than nontractor farms and it is not unlikely that they were inherently more productive and their operators more progressive in applying the latest techniques of production.

Tractors were used in cotton growing on all farms in the Texas sample. In the sample from the Upper Piedmont, 42 percent of the farms with three or more years of yields reported tractors used (either as owned tractors or hired) sometime in the period; and 25 percent of the farms with 1- and 2-year yields.

A comparison of tractor and nontractor farms in the Upper Piedmont according to various operator and farm characteristics and production factors, by tenure class, for farms reporting three or more years of yields is given in table 37, p. 146. No similar comparison can be given for the farms from the West Texas Rolling Plains because tractors were used on all sample farms in that area. As tractor farms tend to be larger, the nontractor farms in the comparison have been limited to those reporting 10 or more acres of cotton harvested during the period. The data show that, irrespective of the tenure class, tractor farms showed higher average yields and lower coefficients of variation than nontractor farms.[28]

On owner-operated farms the advantage in yield from the use of tractors varied from 14 to 20 percent and they showed 11 percent less yield variability than farms without tractors. On the tenant-operated farms the advantage when tractors were used was 10 to 26 percent in yield level and 14 to 23 percent in yield risk. Study of the comparisons in the table reveals that almost without exception the tractor farmers were superior to the nontractor farmers in both

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[28] Only farms reporting tractors used in cotton production more than 50 percent of the time during the period were used in the comparisons, in order to assure that the practice was firmly established. However, a cursory examination of tractor farmers who employed them less than 50 percent of the time during the period revealed that the relationships discussed below were sustained, although with less of a differential in yield over the nontractor farms. There was also more irregularity in the supporting farm and operator characteristics. Examination of similar data for farms reporting 1 and 2 years of yields also confirmed the advantages of tractor farms over nontractor farms and showed that operator and farm characteristics had a distinct bearing on production results.

land factors and production practices.[20] They reported a less steep topography and less erosion; they applied more fertilizer, had a higher legume ratio, used better practices in acquisition and treatment of seed; they had a higher level of schooling, and were from 2 to 3 years younger. The extent to which the more favorable showing of these farmers was due to superior land and to the production practices enumerated cannot be assessed, although certainly it made up some and perhaps a major part, of the difference. This means that the tractor as such is probably not the chief reason for the yield and yield-risk differentials shown. Even if the tractor is not a major factor in the higher yields of such farms, for the purposes of this study it provides a means of identifying farms with advantages in average yield and with respect to uncertainty in yields.

KIND OF LABOR

It has been shown (*25*) that hired labor is less expensive, considering the work accomplished, than either sharecropper or family labor. When help is hired for contract wages, there is more incentive to plan the work program so that the maximum amount of work will be obtained for the wages paid. In the case of either family or sharecropper labor these motives do not exist, as in these cases the wage rate is determined by the quantity produced. When the operator wishes to do little supervision or planning of his work program he depends upon the sharecropper system. Family labor originates on small farms and is usually low in managerial ability.

The type of labor reflects not only the efficiency of the labor but also the progressiveness of the operator. A recent study (*7*) of Southern agriculture has demonstrated that sharecropper labor is uneconomic under customary sharing arrangements on farms that have high yields and on farms in the Eastern part of the Cotton Belt, particularly, which have become mechanized or are in transition to a high degree of mechanization. Hired labor works much better with mechanization because the operator gains the benefits of savings in labor.

The growing emphasis on crop rotations with leguminous crops, liming, and strip cropping, is not compatible with the old sharecropper system, because the duration of occupancy usually is not long enough for the laborer to gain much of the benefit. Since 1930, the number of sharecroppers on southern farms has decreased (*7*), chiefly for the reasons cited. The move toward larger farms with hired labor is in line with the general trend toward commercial farming. The investments in machinery and land that are required for the operation of larger cotton acreages with hired labor are made possible only by the reduced cost per pound resulting from concurrent gains in efficiency.

In figure 10 is shown the relationship of the different kinds of labor used on three groups of cotton farms in each area to yield and to yield variability. The labor groups were determined according to the specialized type of labor in use. When one or more types of labor

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[20] Among the owner-operated farms one exception appears; the operators of tractor farms had fewer years of experience growing cotton on the 1946 farm. There are two exceptions in the case of the tenant-operated tractor farms: Their operators had fewer years of experience also and lower regularity in poisoning for control of the boll weevil.

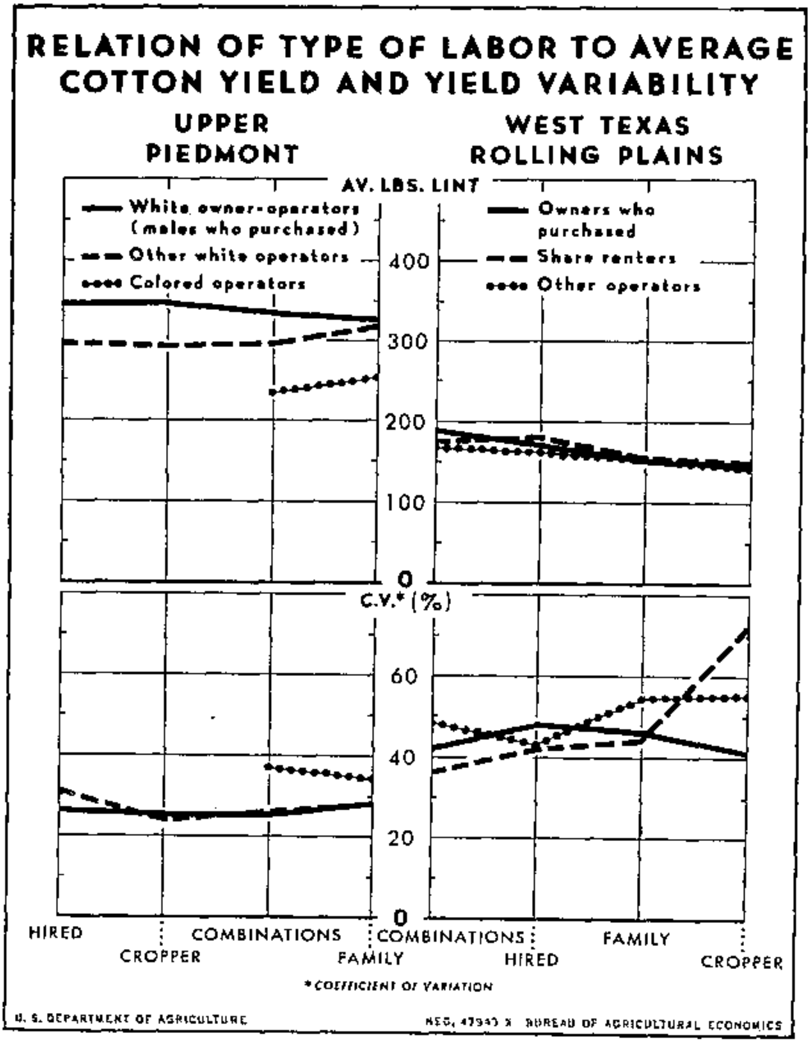

FIGURE 10.—In the Upper Piedmont, the highest yields on white owner-operated farms (men who bought their farms) were obtained with cropper and hired labor, while other white operators and Negro operators were more successful with family labor. In the West Texas Rolling Plains, highest average yields were obtained with other types combined with hired labor, or with hired labor alone. In neither sample, however, were there consistent effects of type of labor on yield variability, although in the Texas Rolling Plains variability tended irregularly to increase as the quality of labor declined.

were used in combination or when one type of an earlier period was displaced by another type at a later period, some combination of labor types was considered the type in use. It is seen that the type of labor associated with the most favorable average yield and yield stability varied with the area and by groups of farms. In the Upper Piedmont, highest average yields were associated either with sharecroppers or with hired hands on white owner-operated farms which were bought and operated by males; whereas the highest average yields for the other two groups of operators (other white operators and Negro) were associated with family labor. The better yields obtained by these last two groups with family labor is a further reflection of their lesser managerial ability.[30] Apparently they can neither select the highest type of sharecroppers or hired hands nor can they manage either type effectively. However, they do obtain a comparatively higher response from self-help and from family members.

In the West Texas Rolling Plains, either hired labor or combinations of this type of labor with other types gave highest yields to all three groups of operators. Farmers who employed sharecroppers as their sole source of labor obtained lower average yields than with any other group—from 26 to 44 pounds—or 16 to 23 percent lower than those employing the most efficient type of labor (combinations or hired labor). Family labor showed up but little better than sharecropper labor insofar as average yields were concerned—from 6 to 12 pounds higher. Therefore, the proper type of labor in the West Texas Rolling Plains was associated either with much higher yields over "other" types of labor, or the higher average yields were brought about by some other combination of factors such as land quality and farming practices, which in turn were due to better managerial ability.

No regular association between variability of yields and type of labor was apparent in the Upper Piedmont but there tended to be a direct relationship between yield stability and efficiency of labor in the West Texas Rolling Plains. An important factor in the higher yield risk in the Texas sample was the percentage of cotton acreage abandoned, which increased as the quality of labor declined.

	Percentage of cotton acreage not harvested		
Type of labor:	*Owners who purchased*	*Share renters*	*Other operators*
Combination of types of labor......	0.4	—	0.5
Hired labor	1.1	1.0	.8
Family labor	3.7	.7	2.5
Sharecropper labor	3.8	[1]11.0	4.5

[1] One farm.

The effect of type of labor on percentage of abandonment, a significant factor in high variability of yields, reflects the quality of labor, poor work habits, and other factors that contributed to the inefficiency of labor. A managerial factor appears also. Apparently those operators who make mistakes in their choice of labor and its management might be expected also to err in selection of land most suitable for cotton.

YEARS SINCE SEED WERE OBTAINED FROM BREEDER

Cotton producers must renew their seed stock at fairly frequent intervals in order to preserve the purity of the strain and thereby to assure yields of a certain level and a product of desirable quality. Information was obtained to test the effect of seed-stock renewal under

[30] Less than that of white owner-operators (men) who bought their farms, as indicated by the approximately 20-pound differential in average yield when either sharecropper or hired labor was the type.

field conditions. The data indicated that the effect of age of planting seed on average yield and yield variability was not uniform as between the two areas. In the Upper Piedmont, both average yield and variability of yields were affected favorably by the recentness of the seed received from the breeder, but in the Texas sample no consistent relationships could be detected. Apparently other major factors so dominated yield and yield risk in the West Texas Rolling Plains that they obscured this measure of seed quality.

In the Upper Piedmont, the highest yields were obtained with seed planted either directly or 1 year from the breeder. Where seed is planted "1 year from the breeder," direct plantings have already occurred and the plantings made were for the second-crop year. Yield differentials with this seed practice in that area were large, ranging about 50 to 60 pounds. Except for the owner-operator group, variability of yields tended to increase strongly with the number of years that had elapsed since the seed were bought from the breeder. In the case of owner-operators, the highest yields were not obtained with seed planted directly from the breeder but from seed planted one year from the breeder. This relation was not unexpected. It has been shown (*18*) that seed must become acclimated to the latitude, the growing season, and other local factors, especially if it is produced some distance from where it is used. The effect of this factor, however, did not appear in connection with the other groups of operators in this area, both of whom had much lower yields than owner-operators, although it may be that other factors operated to obscure its influence.

EFFECT OF SEED TREATMENT

Seed treatment includes the cleaning of seed to remove foreign matter, trash, and black seed, and its treatment against "damping off" by the use of a mercurial powder (some form of Ceresan).[31]

The data indicate that the effects of seed treatment as between the two areas were about the same as those associated with quality of seed. However, the relationships between seed treatment on the one hand and level and variability of yields on the other were stronger in the Upper Piedmont, with the exception of average yield for the owner-operator group. The decrease in average yield as the regularity of seed treatments declined varied between 50 and 60 pounds, whereas the coefficient of variation in yield increased about 35 percent. Consequently, the effect of this practice on both average yield and yield risk must be regarded as marked and significant.

In the West Texas Rolling Plains, there appeared to be no connection between seed treatment and either yield level or yield variability. Yet the relation to relative acreage of cotton abandoned was marked, as shown below:

	Percentage of cotton acreage not harvested	
Regularity of seed treatment:	Operators employing hired labor	Operators employing family and cropper labor
Always	0.7	1.7
Sometimes	.7	2.3
Never	1.6	5.6

[31] Rotten shank is one such disease; it causes young plants to die and produce a poor stand. Treatment of seed with a mercury dust before planting is a recommended remedy.

This tabulation apparently indicates that regularity of seed treatment was rather closely associated with abandonment of cotton acreage, which also increased as the efficiency of the employed farm labor declined. In conclusion, although frequency of treatment of seed was not closely associated with size of average yield in the Texas sample, it had a close connection with the relative abandonment of cotton acreage planted. Therefore, it must be taken into account in calculations of yield risk and it might also be considered in setting premium rates in crop insurance.

Management Factors Subject to Differential Variation

Farmers may vary several production factors within wide limits, both qualitatively and quantitatively. Chief of these inputs that are subject to differential variation are fertilizer applications, crop rotations with legumes, quantity of labor used, and quantity of seed planted per acre. All are subject to qualitative and quantitative manipulation. Both kinds of adjustments are especially applicable to fertilizer, for the operator not only has a choice of analysis and rate per acre but he may also make his selection according to sources of the different plant-food elements. Data were obtained in the questionnaire only on fertilizer applications and growth of leguminous crops.

The effect of labor in a qualitative sense has already been treated. (See p. 51). Only the farms in the Upper Piedmont sample reported use of fertilizer and production of legumes. However, several other factors are considered in this section, such as percentage of cropland in cotton acreage harvested, percentage of cotton acreage not harvested, size of cotton farms as measured by cotton acreage, average yield, and certain other factors indirectly related, as age of operator and years of experience growing cotton. None of the latter factors is as subject to managerial adjustment as are fertilizer and legumes. But any of them may represent managerial choice, as in the case of percentage of cropland in cotton harvested and percentage of cotton acreage not harvested; or managerial growth and capacity, as indicated by total acreage of cotton harvested; or the operator's general production efficiency, as in the case of average yield.

Percentage of cropland in cotton acreage harvested indicates the quality of the land, as the more cotton that can be grown in competition with other crops, the more suitable apparently the land is for cotton up to a certain point. This limit would appear to be set by differential cotton yields and the erosive characteristics of the soil. The percentage of cotton acreage not harvested is apparently due to managerial venturing onto lands that are marginal for cotton and to managerial choice in taking losses quickly and moving promptly to use the land for some other purpose. Increased size of farm, as measured by acres in cotton, shows the manager's ability to grow larger cotton acreages either by accumulation of capital or by a combination of capital and credit.

"Growth" of the operator in this respect is perhaps a reflection of progressiveness in other ways, as in the introduction of the latest methods and practices, etc. There is a close association between average yield and the relative progressiveness of the farm operator in adopting current practices, and the degree to which these practices are continued over several years. In general, the higher the average yield, especially if it is for several years, the more likely it is that the operator has adopted the latest techniques and that he is farming a good soil well. On the other hand, an operator with low average yields would be expected to be at the opposite extreme in all of these factors.

APPLICATION OF CORRELATION METHODS TO ASCERTAIN PRODUCTION FUNCTIONS

Regression methods were used to ascertain the degree of association between some of the factors mentioned above and farm average yields, and between these factors and the coefficients of variation in annual farm yields. Such methods are particularly adapted to a study of these relationships, because of the varying lengths of the periods of yields and for other reasons. In the Upper Piedmont, the analysis was based upon records for 272 white owner-operators (men) who had bought their farms; and in West Texas, upon the records for 203 owner-operators and share-tenants.

The procedure employed in the correlation analysis was one of trial and error in the choice and combination of factors. To the basic factors of time duration of yearly yields, trend in yields, and county or location, was added in turn each of the factors discussed above. Those that proved to be significant were combined into an over-all multiple curvilinear regression analysis. All regression coefficients that did not prove to be significant in this second stage, or were otherwise deemed unnecessary to any of the functional relationships, were dropped, and a re-solution was made. The results were then studied for each factor in turn to gain some idea of its functional nature and behavior. The general procedure used in this sort of analysis was to hold all other factors in the regression analysis constant at their mean values, and to calculate the net effect on average yield and the coefficient of variation of the factor left at its appropriate values.

Table 3 summarizes by areas the factors included in this phase of the correlation analysis. This table includes a list of all the quantitative factors and the respective types of functions that were correlated against either average yield or the coefficient of variation. The inclusion of any factor as an independent variable in relation to either dependent variable in the two areas is indicated by "yes"; its exclusion by "no"; its significance, when included, by the asterisk. The form of the function used—linear, simple parabola (footnote 4 in table 3) or a joint function—is also similarly designated. Consequently, this table catalogues in tabular form the factors studied by correlation methods against average yield and its coefficient of variation, how they functioned in influencing either dependent variable, and whether a statistically significant relationship was obtained.

These points may be illustrated with the factor "percentage of crop acreage harvested." It may be seen that it was employed in a parabolic function in both sample areas against average yield, and also as a joint function with application of fertilizer in the Upper Piedmont. Only as a parabolic function, however, did it prove to be of statistical significance in one area—the West Texas Rolling Plains. This factor was also related to the coefficient of variation in both areas, as a linear function in the Upper Piedmont, and as a parabolic function in the Texas sample. Both relationships proved to be significant at the 1-percent point. Other factors may be traced out similarly in table 3.

From a study of table 3 it is possible to learn the functional nature of the factors that proved statistically significant in explaining average farm yields and the coefficients of variation in annual yields; but only the mechanics of the relationships are apparent, not their nature and possible causal connections. This more detailed treatment remains to be given in the following pages.

An additional comment may be made concerning the correlation coefficients in table 3. They are based on the composite of all factors listed in the table which proved statistically connected in a significant way (or otherwise necessary), either as linear, parabolic, or joint functions, or some combinations of these, with the dependent factors.

It may be seen that the highest index of correlation was obtained from the analysis with average yields of farms selected from the Upper Piedmont sample, whereas the lowest was obtained in connection with the coefficient of variation of the same farms.[32] The latter was rather low for the Upper Piedmont farms, primarily because of peakedness of the distribution of the coefficients of variation, so that tests of significance are of doubtful value. (If they could be accepted with full validity, the *F*-ratio test indicates significance at the 1-percent point.)

With regard to the *basic* factors, all independent variables except farm average yields in the Upper Piedmont, years in yield history, trend, and county average yield (measure of location), proved to be highly important in the regression analysis. In the Upper Piedmont, the analysis showed, however, that neither (1) trend nor (2) number of years in yield history had a significant connection with average yields. But number of years was considered necessary in the analysis because of its highly significant joint effect with legumes. Detailed consideration follows of the factors subject to differential variation by the operator.

APPLICATIONS OF FERTILIZERS

Fertilizer practices used on the sample farms in the Upper Piedmont varied a great deal among the nine sample counties. Heaviest rates and highest analyses were applied in Greenville and Pickens Counties. This may have been true because of the higher response obtained from a higher and better distributed rainfall, and from soils which naturally have a higher capacity for fertilizer. In most of the Georgia counties, neither the rainfall nor the soil conditions are as favorable to maximum exploitation of fertilizer as in the two South Carolina counties. Therefore, fertilizer is applied at lower rates. The differences in these counties are recognized in other ways.

The Georgia counties are not considered from various points of view to be as favorable for cotton as are the South Carolina counties. Inherent differences are reflected in the differences in levels of yield, whereas the relative certainty of the crop is indicated by the differ-

[32] The farms selected from each sample for analysis by correlation methods of factors against farm average yields and farm coefficients of variation have been previously described. (See page 56.) Both average yield and the coefficient of variation of the individual farms were based on the yield history, 1938-46, but for 3 or more years' duration.

TABLE 3.—*Summary of correlation results obtained with specified factors against average yield and the coefficients of variation of selected sample farms, by areas*[1]

Independent factor	Kind of function	Upper Piedmont		West Texas Rolling Plains	
		Average yield	Coefficient of variation	Average yield	Coefficient of variation
Factor included or not in analysis:					
Basic factors:					
Yield:					
Years represented	Linear	[2] Yes	[3] Yes	**Yes	*Yes
Trend	Parabola [4]	Yes	**Yes	**Yes	**Yes
	Jointly with years	Yes	**Yes	**Yes	**Yes
County location	Linear	**Yes	*Yes	**Yes	Yes
	Jointly with fertilizer	**Yes	No	No	No
Management factors:					
Rate of fertilizer application	Parabola [4]	**Yes	**Yes	No	No
Percentage of cropland					
Legumes	Parabola [4]	**Yes	Yes	No	No
	Jointly with fertilizer	**Yes	Yes	No	No
Cotton acreage harvested	Linear	No	**Yes	No	No
	Parabola [4]	Yes	No	**Yes	**Yes
	Jointly with fertilizer	[5] Yes	**Yes	No	No
Percentage of cotton acreage not harvested	Linear	No	No	**Yes	**Yes
Correlation results [6]					
$\overline{P}$		**0.6630	**0.3999	**0.6387	**0.5992
$\overline{P}^2$		.4202	.1311	.3836	.3327
$\overline{S}$		64.6000	10.5000	38.6000	15.6000

[1] Based on farms as rigidly defined previously. See p. 56.

[2] Not significant, but retained because, jointly with legumes, it is significant at the 1-percent point.

[3] Significant at 1-percent point jointly with trend.

[4] Simple type, or of the form $Y=a+bX+cX^2$.

[5] When this factor and its functions were included, the joint effect with fertilizer was highly significant but percentage of cropland and its functions were dropped since $\overline{P}^2=.4164$, a ratio somewhat lower than with them omitted.

[6] Obtained from multiple correlation analysis with all factors in above tabulation which proved significant plus other factors which were included for reasons noted.

** Significant at the 1-percent point. Tests were derived according to the *F*-ratio method. In order to apply this method, it must be assumed that the deviations from the correlation surface occur in an approximately random manner, which it is believed the data in this study do sufficiently for the purpose of the study. The *F*-ratio for *R*, *P*, or r is the ratio of the mean variance associated with the regression equation to the mean square of the error of estimate. The *F*-ratio for individual regression coefficients was computed similarly, that is, the mean square of the variation associated with each regression coefficient was expressed as a ratio to the mean square of the error of estimate. The *F*-tables found in many standard statistical texts indicate ences in size of the coefficients of variation. Greenville and Pickens Counties had county yields each averaging close to 350 pounds, whereas yields in each of four of the Georgia counties averaged nearly 250 pounds and in each of three others nearly 275 pounds. In the case of the county coefficients of variation, the story is somewhat different. Practically all of the counties had coefficients of nearly 15 percent but Clarke and Madison had coefficients of 25 and 20 percent respectively.

The analysis by cross-classification showed that the specified sample farms had different responses from fertilizer applications in the different counties. Farms in Georgia counties had the lowest response and had lower limits to its use. The combined effect of fertilizer and location on farm average yields and upon the coefficients of variation in annual farm yields is shown in figure 11. As previously mentioned, all other factors included in the correlation analysis were held constant at their mean values in arriving at the relationships shown in figure 11. It may be seen that the effects of quantity of fertilizer on farm average yields were affected by the county's inherent ability to produce cotton, measured by county average yields; and, also, that the quantity of fertilizer used and the farm coefficients of variation in yield were closely related to the county coefficients of variation in yield.

Both farm average yield and coefficient of variation varied directly, but less than proportionately, with their respective county average yields and coefficients of variation in yield. The individual farm coefficients of variation, although they varied directly and less than proportionately with the county coefficient of variation, tended to reach their smallest values (lowest yield variability) with applications of about 700 pounds of fertilizer. The effect of applications of fertilizer in the different locations on the individual farm's average yield was much more complex. Farm average yields rose as applications increased to a certain point, but the maximum yield varied with the county average yield; the higher the county average yield (or inherent ability to produce cotton) the higher the rate of application possible before the limit in yield response was reached.

The county location also influenced the differential rate of response (that is, the rapidity with which farm yields rose with additional applications of fertilizer), the rate of increase in yields from additional units of fertilizer being more rapid in the counties of highest average yields.

As shown in figure 11, 350 pounds of lint cotton is the approximate county average yield of Greenville and Pickens Counties, S. C., whereas 250 pounds is the approximate yield for most of the Georgia counties, although Carroll, Haralson, and Madison Counties had average yields of about 275 pounds. In the case of the county coefficients of variation, 15 percent is a reasonable approximation to all counties except Madison and Clark Counties which had 20 and 25 percent

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whether the ratio is significantly larger than unity—at the 1-percent point, 5-percent point, or of no significance; and the conclusion that any particular coefficient of correlation or regression coefficient has one chance, five chances, or more than five chances in 100 of having occurred by accident. Significance at the 5-percent point at least, but preferably at the 1-percent point, is required in order to reject the Null hypothesis, that is, that the relationship occurred by chance. Below and in succeeding pages highly significant means significance at the 1-percent point, whereas significant means significance at the 5-percent point. * Significant at the 5-percent point.

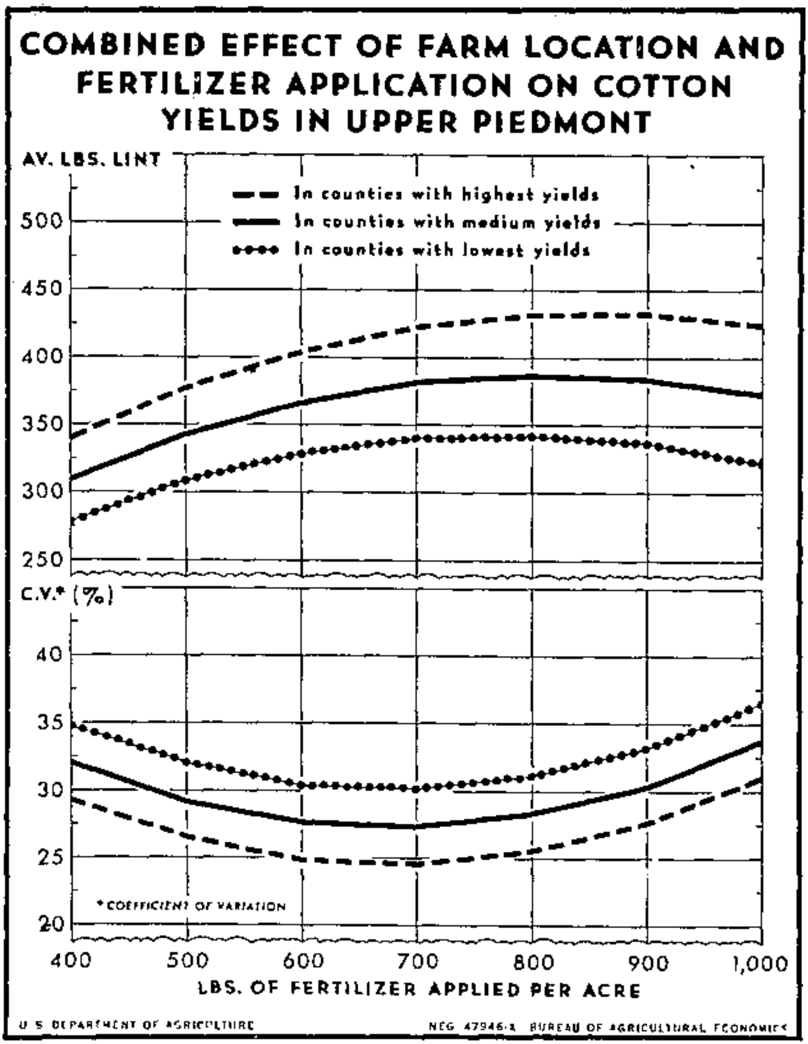

FIGURE 11.—The differential response of farm average yield and the point of maximum yield to fertilizer applications varied directly with the relative yield level of the county. In general, the higher the productivity of the county, as measured by county average yield, the greater was the differential response of farm average yield from fertilizer and the farther to the right was the point of maximum yield. In the case of the farm coefficients of variation in cotton yield, an application of 700 pounds of fertilizer gave the minimum point of variability. At any given rate of fertilizer application, the farm coefficient of variation varied directly with the county coefficient of variation.

respectively. In making up the two sections of the chart, average yields and the coefficients of variation by location were paired; that is, the high county average yields were plotted with the low county coefficients of variation, and vice versa, in accordance with the tendency for the county relationships to be associated in this way. (See pp. 26-27.)

PERCENTAGE OF CROPLAND IN LEGUMES

Until the AAA program was instituted, cotton farmers were more careless in their treatment of the soil and were rather haphazard in related production practices. The growing of legumes was the exception rather than the rule. Few farmers followed any systematic crop rotation. In the Upper Piedmont at least, the more fertile upland soils were selected for cotton. Corn received second choice—bottom lands and worn-out low-yielding upland soils. The general practice was to plant cotton until the land had to be used for less important crops because of erosion or, if the erosion were severe, turned back to trees. When the Soil Conservation and Domestic Allotment Act went into effect, the cotton-acreage reduction program was tied in systemically with a soil conservation program which required the growing of legumes, the acreages of which were in some way related to the acreage of cotton and other soil-exploiting crops. With a much reduced acreage of cotton and a considerable acreage of legumes, the average cotton farmer had to rotate his cotton land and adopt a system of agriculture which favored this practice.[33] But the higher the percentage of cropland in legumes the more probable it is that cotton was produced in some sort of sequence with these other crops; also the higher the percentage of cropland in legumes the more frequently would cotton follow legumes in reasonably close sequence. Hence it would derive some of the benefits of the legumes—increased nitrogen and humus, and increased protection of the soil from erosion and leaching.

In table 3 it was shown that the percentage of cropland in legumes did not significantly affect the farm coefficients of variation; but that its relationship to farm average yield was highly significant during the period of the study. Therefore, no further reference to the effect of legumes on the farm coefficient of variation is made here. However, a more thorough study of the effects of legume intensity on farm average yield follows. The net effect of percentage of cropland in legumes on yield considered in connection with county location, and rate of fertilizer application is given in table 4. The data show that farm average yield was a joint function of legume intensity, fertilizer application, and county location. All three factors were statistically significant (table 3).

These expected farm average yields were calculated on the basis of the respective regression coefficients. They indicate that rate of application of fertilizer was the chief factor in the response of yield to relative legume intensity. At an application of 400 pounds of fertilizer there was little response of farm average yields from legumes; and after 20 percent of the cropland in legumes there was a downturn in average yield. But with a fertilizer rate of 1,000 pounds per acre, the response of farm average yield to increases in percentage of cropland in legumes was strong throughout the limits of legume intensity.

The data do not provide direct answers to these differences but it is suggested that differences in soil capacity for fertilizer, brought about by erosion and in other ways, was probably a factor. This may

[33] There was no way by which information on specific rotations could be included in the questionnaire without increasing greatly the complexity of the analysis.

also mean low rates of fertilizer use, thin soils, inadequate management, and other unfavorable farm conditions. The poor response of farm yields from various intensities of legumes with low rates of fertilizer applications reflects these indirect influences. Also, the point of maximum average yield from percentage of cropland occupied by legumes varied with the rate of fertilizer application. With an application of 400 pounds, this point was in the vicinity of 20 percent of the cropland in legumes; with 700 pounds, 40 percent; and with an application of 1,000 pounds the maximum percentage of cropland in legumes was beyond the limits of the calculated yields.

TABLE 4.—*Expected farm average yield of cotton as affected by fertilizer application, percentage of cropland in legumes and county average yield, Upper Piedmont*

Rate of fertilizer application and percentage of cropland in legumes	Expected farm average yield of cotton when county average yield is—		
	250 pounds	300 pounds	350 pounds
	Pounds	*Pounds*	*Pounds*
400 pounds of fertilizer and percentage of cropland in legumes, percent:			
10	279	310	341
20	282	312	343
30	279	310	340
40	272	302	333
50	259	290	320
700 pounds of fertilizer and percentage of cropland in legumes, percent:			
10	333	374	415
20	343	384	425
30	349	390	431
40	349	390	431
50	345	386	427
1,000 pounds of fertilizer and percentage of cropland in legumes, percent:			
10	306	357	408
20	325	376	427
30	338	389	441
40	347	398	449
50	350	402	453

A significant relationship shown by the table is the influence of fertilizer on the county differentials in farm average yield. Other things being equal, locality differences in average yields reflect to a considerable extent the inherent ability of the respective soils or soil groups to produce cotton. It appears that increasing the rate of fertilizer application widens these differences. This indicates that the better-producing localities gain more, relatively, from high fertilizer application than do the low-producing localities. That is, the low-producing localities lack the capacity to use efficiently a high rate of fertilizer application, and this apparently indicates that a first step for these localities might be an improvement in management practices, such as planting legumes, adopting crop rotations and erosion-control measures, using barnyard manure, improving the preparation of seedbeds and improving other cultural practices.

EFFECT OF TIME DURATION OF LEGUME PRODUCTION ON AVERAGE YIELD IN THE UPPER PIEDMONT

A problem in crop rotation with legumes is the effect of the time duration of the practice on farm average yields. Obviously, the longer any given rotation with legumes persists, the greater the accumulation of soil humus and the more the soils are otherwise improved. Thus it may be expected that the cumulative effects of crop rotation will be a function of time.

The length of the rotation cycle is an aspect of the effect of legume production on crop yields. The shorter the cycle, other things being equal, the more quickly are results to be expected and the greater will be the effect on average yield of a given time duration of the practice. As mentioned earlier, it was not possible to obtain from the farmers in the sample accurate estimates of their percentages of cropland devoted to legumes for the earlier years of the period 1938–46.[34]

But irrespective of whether confirmation of a connection between production of cotton and production of legumes can be established directly, it may be reasonably assumed that when the two crops were grown on a given farm, some sort of rotation or exchange of land probably existed between them. Furthermore, the higher percentage of cropland in legumes, the more frequently and directly was this exchange likely to have occurred. When the acreage of legumes occupied a third of the land and cotton close to a third, the chances are good that some sort of 3-year rotation existed. But when the percentage of legumes was very low, say 10 percent, the chances that there was a rotation are poor. If an exchange occurred at all, it is likely to have been unsystematic and irregular.

In figure 12 the combined effect of time, fertilizer, and percentage of cropland in legumes on farm average yields is given.[35] The data show that fertilizer had an important effect on the influence of the other two factors. Although it was the time duration of the practice at a given percentage of cropland in legumes and a given rate of fertilizer that raised the level of farm yields, the rate of fertilizer application determined the differential in rate of response in farm average yield to additional percentages of cropland in legumes.

As between different rates of fertilizer application, the general average of the farm yields appears to be near the optimum at 700 pounds.

[34] Evidently, the estimate obtained was subject to considerable memory bias as time retrogressed. The figures are good for recent years but poor for earlier years of the period. Actually, the differentiation established for the last 3 years, which tended to be the level given for all years, may be regarded as a fair approximation of the differentiation for all years for two reasons: (1) The big change in crop practices occurred in 1938, the new system in effect beginning then; (2) farmers are given to habits and are likely to follow a pattern in cropping practices once it is established.

[35] The factor for location has been assumed constant at its mean value. All regression coefficients were highly significant except the one for time; but time, jointly with legumes, gave a joint function which was very significant.

This is in line with previous findings when the location factor was held constant. (See p. 60.)

As the time interval decreased with all three rates of fertilizer application, but especially with 400 and 700 pounds, the percentage of cropland in legumes appears to exert a negative influence on yields. Actually it is the quality of the land that was reflected. If soils were in such condition that they required a high percentage of legumes (say 50 percent), much suitable land for cotton must not have existed. If this condition arose as a result of soil erosion, it is to be expected that the rebuilding process required great emphasis on legumes and grasses, with such soil-depleting crops as cotton kept in a relatively minor position. Consequently, in a short period these soils would not

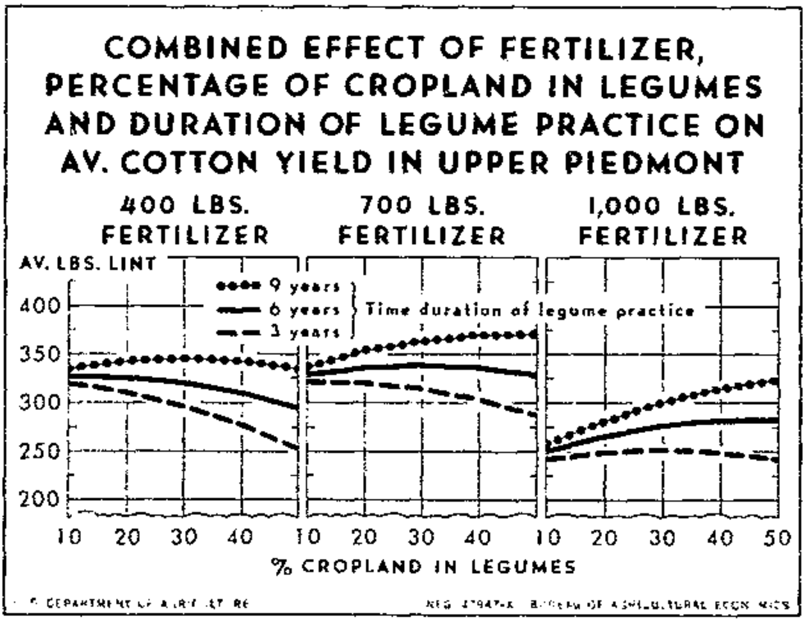

FIGURE 12.—The association between percentages of cropland in legumes and average yield depended on rate of fertilizer application and the time over which legumes had been planted. In general, the longer the time interval and the higher the rate of fertilizer application, the greater the difference in average yield resulting from additional percentages of cropland planted to legumes.

show up favorably in average yields even though a high percentage of the cropland was planted to legumes. But as the time interval increased, the effects would tend to accumulate and the yields would rise more rapidly than those on soils that initially were higher in productivity but on which a smaller percentage of cropland was in legumes. This would indicate a very long cycle in the rotation or no rotation at all.

The greater response of yields to intensive use of legumes and high rates of fertilizer applications is in line with agronomic results. Soils thus treated, especially if they have depth, have a greater capacity for utilizing fertilizer. The greater quantity of humus and the more favorable structure of these soils enable them to absorb the high rates with less chance of damage to the crops from residues of fertilizer during periods of unfavorable moisture conditions.

PERCENTAGE OF CROPLAND IN COTTON ACREAGE HARVESTED

The percentage of cropland devoted to a crop over a period of years reflects, for many farms, the equilibrium point of the particular crop relative to the other crops grown in combination with it. In general, the percentage of cropland a crop is able to hold in competition with other crops indicates the relative favorableness of natural and economic conditions for this particular crop. Consequently, when cropping systems have been worked out, the production response is expected to vary directly with the relative proportion of the cropland given to the enterprise in any given area with reasonably homogeneous conditions as regards the natural factors of crop growth.[36]

In the correlation analysis, the relation of percentage of cropland in cotton to farm average yield was not statistically significant in the case of the farms selected from the Upper Piedmont sample. But against the coefficient of variation of these farms this factor was significant. In the West Texas sample, the percentage of cropland in cotton showed a statistically significant relation to both farm average yields and coefficients of variation. The reasons the relative percentage of cropland in cotton was not related to farm average yield in the Upper Piedmont, as outlined, must be sought in the factors subject to differential management, which are more numerous in the Upper Piedmont than in the West Texas Rolling Plains. Two of these, rate of fertilizer application and percentage of cropland in legumes, could overcome the differential effects on average yield of land quality (percentage of cropland in cotton). The fact that a study (*9*) of this relationship based on census data for South Carolina for 1929 gave results in accordance with the theory indicates that the large increases in fertilizer and legumes accompanying the AAA limitations on acreage in the later period may have obscured the relationship.

The relation of percentage of cropland in cotton to the farm coefficients of variation in the Upper Piedmont was highly significant and inverse, however. The net effect is shown by the following tabulation:

Percentage of cropland in cotton acreage harvested:	*Coefficient of variation*
10	29.3
20	28.0
30	26.8
40	25.5
50	24.2

[36] The comparative importance of cotton in the cropland organization in the period 1938–46, appears on first thought not to reflect a free enterprise economy because of AAA operations. But on second consideration it must be regarded as the dominant fact, as the Agricultural Adjustment Administration began with an economy which had reached a competitive adjustment, from which in general it made proportionate reductions in acreage. The resulting differential variations, which 1938–46 represents, therefore reflect the original competitive equilibria more than other forces. The differential effects on yields will differ in the West Texas Rolling Plains from those in the Upper Piedmont because the natural conditions for growth of cotton are quite different.

The reason yield variability tended to decline with increases in the percentage of cropland in cotton is not clear, as there was no significant relation with average yield.

Below are shown for the West Texas Rolling Plains the relationships between percentage of cropland in cotton (acreage harvested), on the one hand, and farm average yield and the coefficient of variation in farm yields on the other. The data indicate that the percentage of cropland in acreage of cotton harvested was positively related to farm average yields and negatively related to farm coefficients of variation.

Percentage of cropland in cotton acreage harvested:	*Average yield* [1]	*Coefficient of variation* [2]
10	136	68
20	152	57
30	166	49
40	178	43
50	188	38
60	196	36

[1] Factors included in regression analysis: Years in yield, county average yield, trend in yield, percentage of cropland in cotton acreage harvested, and percentage of cotton not harvested. Results: $\bar{P}^2=.38365$; $P=.6387$ (highly significant); $\bar{S}=38.6$; all b's were highly significant. In obtaining values of the dependent, all factors, except the independent factor above, were held constant at their mean values.

[2] Factors included in regression analysis: Years in yield, trend in yield, county coefficient of variation, percentage of cropland in cotton, and percentage of cropland not harvested. Results: $\bar{P}^2=.3327$; $P=.5992$ (highly significant); $\bar{S}=15.6$. All regression coefficients were highly significant except years in yield (over 5 percent) and county coefficient of variation which fell short of the 5-percent point by a small margin. All independents were held constant at their mean values except percentage of cropland in cotton.

It is apparent that, although both relationships were strongly inclined, the response of each dependent variable to percentage of cropland in cotton was less than proportionate; that is, the rates of change dropped off at the higher percentages. The percentage of cropland in cotton was inversely related to variability in yields primarily because of the direct association between size of the cotton enterprise on the farm and the percentage that the cotton acreage was of the total acreage in cropland. It is generally recognized that as crop acreages increase, yield variability declines. This fact is recognized by the Federal Crop Insurance Corporation by granting of reductions in rates based on size of crop acreage insured.

In the West Texas Rolling Plains, these relationships are markedly significant in estimating farm average yield and yield risk, because a factor external to the manager's yearly production adjustments is provided for gauging the relative yield level of individual farms. It is of decided significance also for farm-management theory as the results help to explain the relation of both enterprise specialization and size to profits in farming over the short run.

The greater relative showing of the Texas Rolling Plains in the net regression effects implies that differentials in quality of land are probably more important in that area in explaining differentials in farm average yield than in the Upper Piedmont, where specific management factors (fertilizer, legumes, etc.) have a greater bearing on yields and thus tend to obscure the effect of land quality.

PERCENTAGE OF COTTON ACREAGE NOT HARVESTED

In the West Texas Rolling Plains, the percentage of cotton acreage abandoned looms large in some years and on some farms, particularly on those on which a large percentage of the labor is either family or sharecropper. (See p. 53.) Also, that abandonment declines with increased frequency of seed cleaning and/or seed treatment before planting. (See p. 54.) Crop failure is largely a result of weather conditions—the nearer rainfall is to the limit for crop survival and the more unreliable it is, the higher the probability of crop failure. But the differences in relative crop failure between farms in an area of given weather characteristics depends, in addition to the two management factors discussed, upon many other management factors not enumerated.

If, as demonstrated, the percentage of cropland harvested of some specific crop represents its competitive equilibrium in competition with other crops, the acreage of that crop not harvested reflects errors in judgment of the various operators in adjusting to the respective farm equilibria which vary from farm to farm, depending upon the relative adaptability of land resources to the production requirements of the enterprise in question, compared with competing crop enterprises. The adjustments must determine the proper relationship of cotton to other crops, discounting the vagaries of weather.

The correlation analyses (table 3) of the effect of percentage of cropland in cotton acreage harvested on average yield and yield variability in the West Texas Rolling Plains also included the percentage of cotton acreage not harvested as a variable factor. Thus, there was opportunity to explore the relationship between relative abandonment on the one hand and farm average yield and coefficient of variation on the other.

The results were as follows:

Percentage of cotton acreage not harvested:	*Average yield* [1]	*Coefficient of variation in yield* [1]
0	177	44
1	175	46
5	164	53
10	152	61
15	139	70
20	126	79
25	113	88

[1] The same factors were included in the regression analysis as discussed above. See page 66, footnotes 1 and 2; and all other variables (except percentage of cotton not harvested) were held constant at their respective mean values in preparing the estimates.

The net regression values show the extent of the inverse correlation between relative abandonment and average yield, and of the direct relation between abandonment and yield variability. (On the basis of the correlation analyses, the regression coefficients in both cases are significant at the 1-percent point.) In each case, the change in average yield or the coefficient of variation which accompanied a given percentage change in relative abandonment was more than proportionate. Quality of land, as a production function, was obviously lower on farms that had the higher percentages of abandonment.

Effect of Size of Cotton Enterprise and Average Yield

Size of cotton enterprise and average yield are more in the nature of general and catch-all variables. They do not indicate the differential manipulation of production factors. Rather, they reflect the success the operator has achieved because of his judgment in managing inputs skillfully. The size of the cotton enterprise in the Cotton Belt is a good measure of size of business. Ownership of a farm indicates relative success in obtaining profits from the farming operations and then pyramiding them. In the case of a rented farm, it indicates the operator's ability to maintain a large-scale going concern under a more inflexible but also more compelling cost structure. Average yield likewise reflects the operator's success in obtaining profits and pyramiding them, but less strongly so than size of cotton enterprise.

SIZE OF COTTON ENTERPRISE

In the cross-classification analysis with size (acres) of the cotton enterprise against the coefficient of variation, a strong inverse relationship was found for the Upper Piedmont sample but only an irregular one for the Texas sample. In neither sample was a connection found between *acreage in cotton and average yield on individual farms.*

Inclusion of size of the cotton enterprise and average yield in the correlation employed in the study of factors that are subject to differential variation through management, discloses that only in the Upper Piedmont was there a significant association between acreage of cotton and coefficient of variation. The net regression effect of acres of cotton harvested on the coefficient of variation in the Upper Piedmont works out as follows:

Acres:	*Coefficient of variation* [1]
10	28
50	25
100	22
150	18
200	15

[1] The net regression coefficient as determined was significant at the 1-percent point. $P = .4965$ and was likewise significant at the 1-percent point. The following factors were held constant at their mean values: Yearly trend in yield, location, and average farm yield.

The inverse connection is probably due to the fact that, other things being equal, the percentage of total costs represented by cash costs tends to rise as size of farm increases.[37] This would tend to make larger farms more vulnerable to fluctuations in yields and would force

[37] This is based in general on the idea that the managers of large farms must hire more labor relatively (or else advance rations to sharecroppers) than the operators of small farms who would have primarily family labor with which to reckon.

their operators to give greater attention to risk-reducing practices in connection with yield.

The lack of a relation between acres of cotton and the coefficient of variation in the West Texas Rolling Plains is partly explained by the greater homogeneity of the farms selected from the sample and by the connection between cotton acreage and some more direct production factors which may obscure the effect of size.[38] In the Texas sample, there were fewer Negro and also fewer women farmers, fewer small farms, more tractor operation (100 percent), and a higher percentage of hired labor. The last factor, incidentally, was one of the major criteria employed in choosing the farms from the Texas sample for use in the correlation analysis. The connection between acreage of cotton, on the one hand, and yield level and yield variability on the other was obscured by some of the more direct production factors. A study of the cross-classification data indicates that both years of schooling of the operator and the percentage of cropland in cotton acreage harvested, were related to size of the cotton enterprise.

EFFECT OF AVERAGE YIELD ON VARIABILITY OF YIELDS

It is an accepted agronomic principle that good land management improves the fertility of the land and the physical structure of the soil in the course of time. As already shown, soils that have a high humus content have a greater capacity for fertilizer, and are therefore less subject to yield variability. As the humus content is raised and the physical structure of the soil becomes more granular and otherwise more favorable, its water-holding capacity is improved and crops grown on it do not suffer so much from irregularities in rainfall. In general, the level of yields that a farmer maintains is a good measure not only of his soil's fertility and physical structure but also of his management of the factors that help to create these and other desirable soil characteristics.

In a previous section, the percentage of cropland in cotton acreage harvested, as a measure of land quality, was analyzed. Apparently there is a conflict between these two measures of land quality (percentage of cropland in cotton and average yield); however, the net effects of each were ascertained by correlation analysis. The net effect of average yield on the coefficient of variation, obtained by holding other factors in the respective regression equations constant at their mean values, was as follows:[39]

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[38] The cross-classification analysis of size with coefficient of variation was based on all farms. As this analysis group included various tenure classes and kinds of labor, removal of these differences by sorting affected quality of management by removing certain low-efficiency operators. (See the analysis on kind of labor, pp. 51-53.) Thus the improved homogeneity with respect to operators removed the effects of more direct production factors; hence the disappearance of size of cotton enterprise as a factor influencing the relative variability in yields.

[39] In the Upper Piedmont, $P = .5552$ (highly significant) and $\bar{P}^2 = .27895$; in the West Texas Rolling Plains, $P = .6317$ (highly significant) and $\bar{P}^2 = .3680$. Factors held constant at their mean values: Upper Piedmont—years cotton grown, trend in yield, location, rate of fertilizer application, percentage of cropland in cotton harvested, and average acres of cotton harvested; in the West Texas Rolling Plains—years cotton grown, trend in yield, location, percentage of cropland in cotton harvested, percentage of cropland in cotton not harvested, and average cotton acreage planted.

	Coefficient of variation[1]
Upper Piedmont:	
100 pounds average yield[1]	41
200 pounds average yield	35
300 pounds average yield	29
400 pounds average yield	24
500 pounds average yield	18
West Texas Rolling Plains:	
100 pounds average yield[1]	52
200 pounds average yield	43
300 pounds average yield	34

[1] Net regression coefficient of average yield on the dependent variable (coefficient of variation in yield) was significant at the 1-percent point.

In both sample areas the net relationship was strongly inverse, and the respective regression coefficients were significant at the 1-percent point. For each 100-pound increase in farm average yield, the coefficient of variation declined an average of about 6 percentage points in the Upper Piedmont and 9 percentage points in the West Texas Rolling Plains.[40] At intermediate yields in the Upper Piedmont, this means that a 33-percent increase in farm average yield was accompanied by a 17-percent decrease in yield variability; whereas in the West Texas Rolling Plains, a 50-percent increase in farm average yield was associated with a 26-percent decrease in yield variability. Thus in neither area was the yield increase proportionate to the decline in yield variability, the ratio at intermediate yields being about 2 to 1.

Investigations at the Illinois Agricultural Experiment Station by Miller and Bauer (*20, 21, 22*) into the effect of land fertility, soil treatment, and rotations, on yield variability of corn, wheat, and other crops in the rotation, support these conclusions. Using 10 plots at 17 locations in their State, they tested the effect of manure with lime, and with lime and rock phosphate; also crop residues with lime, rock phosphate, and potash in the various experimental combinations, on the yield and the stability of yield of corn and wheat, for 15 years. They show that the most effective treatment or combination of treatments reduced *average variation* of corn yield by about 30 to 50 percent below the *average variation* on untreated plots, and that of wheat yields by 30 to 40 percent; although in the case of three major soil groups the reduction in *average variation* of wheat yields during the 15-year period was nearer 60 percent. Also, in similar experiments during a more recent period on *all crops* in the rotation, they show that the most effective treatment reduced the *average yield variation* of all crops compositely 25 to 50 percent.

Their main conclusions are that: (1) Fertile soils produced the highest yields and with the greatest regularity, from year to year; (2) untreated infertile soils were very irregular in yields; (3) except

[40] The geographic analysis of county coefficients of variation (cf. p. 27) for the counties from Oklahoma and Texas gave an almost identical net regression effect as farm average yields (9.2 percentage points compared with 9.3 per 100 pounds of increase in yield). On the other hand, the geographic analysis for the Eastern States was much less successful in obtaining the relationship between farm average yields and their coefficients of variation (2.1 percentage points compared with 5.9 per 100 pounds of increase in average yield).

for sandy and hilly soils, all poor and medium fertile soils showed a large increase in yield stability with soil treatment, which also raised the level of yield; (4) good farming methods were rewarded by increased crop yields which at the same time reduced yield variability and made the crop more predictable.

These findings are of the utmost significance for the individual farmer. According to cost-of-production studies it follows, from the relation between yield risk and yield level, that variability in cost of production per unit for individual farms over a period of years should also decline as yield increases. This apparently indicates that risk-bearing cost is an inverse function of yield level. Therefore, there is a strong incentive for farmers to make the necessary expenditures of capital and effort to raise the yield level of land as a method of reducing both average unit cost and average risk cost. This would result in a greater *surplus, over time,* and therefore more rapid accumulation of capital and economic progress.

The tendency of relative yield variability to decline with increases in average yield, although less than proportionately, means that the corresponding standard deviation tended to increase with average yield, even though less than proportionately. The significance of this relationship to premium rates for crop insurance may not be fully appreciated because the effect on premium rates is not readily apparent. When the standard deviations of annual yields increase less rapidly than the corresponding average yields, the premiums per acre will be less on high-yielding farms than on low-yielding farms, under a system of crop insurance which insures for a fixed percentage of the farm's average yield. This is clearly shown by the premium rates calculated below for two yield levels, with two assumptions as regards the yield risk:

Assumed average yield	Coefficient of variation in yields	Standard deviation of yields	Insured yield (75 percent coverage)	Premium per acre [1]	Premium as percentage of average yield
Constant yield risk:	*Percent*	*Pounds*	*Pounds*	*Pounds*	*Percent*
200	30.0	60	150	6.8	3.4
400	30.0	120	300	13.6	3.4
Declining yield risk:					
200	35.0	70	150	9.8	4.9
400	22.5	90	300	6.1	1.5

[1] For methods used in calculating crop-insurance premium rates, see Appendix, pp. 117-119.

With a constant yield risk, the absolute premium increased with average yield but the proportion of average yield required to meet the premium payments remained constant. With a declining yield risk, as average yield increased the premium decreased both absolutely and relatively.[41] That the high-yielding farms would have lower crop-insurance costs, as a general rule, than the low-yielding farms is in accordance with the realities of the situation, and is due to the constant percentage coverage, coupled with the tendency of relative yield risk to vary inversely with the size of average yields.

FACTORS INFLUENCING AVERAGE YIELD

Because of the marked influence of average yield on yield variability it is desirable to examine in greater detail the reasons for the variation in level of yield. Obviously these variations are due mainly to land quality, production practices, and managerial efficiency. But from the standpoint of this study, it is desirable to learn the actual details under each of these headings.

No measure of land quality was obtained in the study but certain factors that have a bearing on soil fertility were obtained. Two of these (soil erosion and topography), along with certain indices of production practices, are given in table 38, p. 148, by yield levels for each of the two sample areas. These comparative data throw considerable light on the factors that are related to level of yield. In the Upper Piedmont, high yields occurred concomitantly with lower erosion, less steep topography, more off-farm work, more favorable practices in obtaining seed from breeder and in treating them before planting, higher fertilizer applications per acre, and a higher percentage of cropland in cotton.[42]

When farm yields were high it was usually found that the farm operators were in the younger age groups and in the groups that had had a fair amount of schooling. Hail loss also varied inversely with average yield. In the West Texas Rolling Plains, on the other hand, the factors associated with level of yield were more limited and less regular, presumably because of the greater influence of weather and the more rigid definition of the group of farms under examination.[43]

In the Upper Piedmont, both erosion and topography showed an inverse relationship with level of yield. As they increased, average yields declined. There was a slight tendency for the increase in operator's age to be associated with average yield; but it is suspected that this apparent connection was due to the influence of experience, which is also directly and more strongly related to level of yield. It should be noted that the 1946 age of operators in the West Texas Rolling Plains averaged around 48 years, or from 5 to 8 years younger than the average in the Upper Piedmont. Consequently, the age factor was nearer the optimum (32) for farming operations in the Texas

[41] This result is in accordance with the relationship of yield risk to average yield found in the study.

[42] Based on 317 white owner-operators (men) who bought the farms occupied by them in 1946. The farms included in this section are thus the same group that was analyzed above by correlation methods.

[43] Based on owner-operators (those who bought their farms) and share-renters, both groups of whom employed only hired labor. In an earlier section, the connection between type of labor and average yield was shown to be strong. Consequently, much of the differentiation in average yield for the sample has been eliminated by thus rigidly defining the farms under study.

sample than in the Upper Piedmont.[44] High yields were also associated with a high percentage of cropland in cotton.

Other factors associated with level of yield in the West Texas Rolling Plains were years of schooling, off-farm work, loss by hail, and percentage of cotton acreage abandoned. Operators with high yields also had spent more years in school. Presumably yields were affected by the greater alertness and progressiveness which education had given these operators. Off-farm work of the operators tended to be negatively correlated with average yield in the Texas sample, in contrast with a positive relation in the Upper Piedmont. In the West Texas Rolling Plains, the vicissitudes of weather and the extent to which farmers there employ hired labor demand more supervision by the manager. In the Upper Piedmont, weather is not so critical and the sharecropper system of labor calls for little attention. Hail loss per acre in the West Texas Rolling Plains was also inversely related to average yield and this was likewise true of the Upper Piedmont.

The percentage of cotton acreage abandoned is the final but not the least important factor to be discussed in this connection. Its influence on average yield and production risks in the West Texas Rolling Plains has been investigated in previous sections. It was found to have a negative relationship to average yield with this group of farms, as with all others. One effect of abandonment on average yield is obvious—it spreads less production over a given acreage. (In the Texas sample, yield is on a planted, or seeded, acreage basis.) Other effects might arise indirectly through weakened financial resources that would have a bearing on the ability of the operator to hire adequate labor and to buy other production inputs in the most desirable quantities.

Estimating Equations

In order to provide maximum efficiency in forecasting either average yield or the coefficient of variation, the significant or otherwise highly important factors from the last several sections have been combined into over-all regression equations for each area. The results are given in tables 5 and 6. In these tables, a description of the independent variables and their respective statistical functions, the units of measure used for the independents, the regression coefficients, the F-ratios of the regression coefficients and the Beta coefficients, are shown for each independent factor in both sample areas. Also included are the indexes of correlation, the coefficients of determination, the standard errors of estimate, and the values of the constant "a." Thus all data necessary to the formulation of a complete regression equation, the interpretation of each regression coefficient, the determination of the relative importance of each such coefficient, and an estimate of the error that might be expected to attend the application of the respective equations, are listed in convenient form.

For illustration, the equation for estimating average yield for similar farms in the Upper Piedmont is given. When X_1 equals average yield in pounds, X_3 rate of fertilizer application in 100 pounds, X_4

[44] This may be explained partially by the differences in the sample component between the two areas. The group of farms under investigation for the West Texas Rolling Plains are operated by owners and share-renters (about one-third of the latter) while in the Upper Piedmont the operators are all owners.

years in average yield, X_5 percentage of cropland in legumes, and X_{11} the county average yield (in units of 100 pounds) for the period 1938–46, the equation is written as follows, with "a"=4.4, and other values from the first section of table 5.

$$X_1=4.4+46.7791X_3-4.4478(X_3)^2-.1840X_4-2.1022X_5-.0248(X_5)^2+.2817X_4X_5+.2705X_3X_5+33.6517X_{11}+6.8883X_3X_{11}.$$

TABLE 5.—*Summary of correlation results for analysis of specified factors against farm average yields as reported by farmers for three or more years during period 1938–46, in two sample areas*

Factor	Unit	Regression coefficient	F-ratio of regression coefficient	Beta coefficient
Upper Piedmont: [1]				
fX_3, Rate of fertilizer application:				
X_3	100 pounds	46.7791	**154.9	0.716
X_a	$(X_3)^2$	−4.4478	**161.0	−.814
X_4, Years in yield average	1 year	−.1840	.4	−.004
fX_5, Percentage cropland in legumes:				
X_5	1 percent	−2.1022	**30.3	−.343
X_k	$(X_5)^2$	−.0248	**14.2	−.247
$f(4,5)$—X_q	(X_4) (X_5)	.2817	**44.2	.395
$f(3,5)$—X_u	(X_3) (X_5)	.2705	**37.9	.267
X_{11}, County average yield, 1938–46	100 pounds	33.6517	**50.0	.219
$f(3,11)$—X_w	(X_3) (X_{11})	6.8883	**124.1	.442

a=4.4

$P^2_{1.3\ldots11}$=.43950; $P_{1.3\ldots11}$=.66295**; $\bar{P}^2_{1.3\ldots11}$=.42025; $\bar{S}_{1.3\ldots11}$=64.62

($\bar{P}^2$=Index of determination; $\bar{S}$=standard error of estimate.)

Factor	Unit	Regression coefficient	F-ratio of regression coefficient	Beta coefficient
West Texas Rolling Plains: [2]				
X_4, Years in yield average	1 year	18.3466	**84.7	0.800
X_5, Percentage cotton acreage not harvested	1 percent	−2.5761	**16.2	−.216
fX_6, Percentage cropland in cotton acreage harvested:				
X_6	1 percent	1.8548	**51.1	.397
X_m	$(X_6)^2$	−.0092	**18.3	−.171
fX_7, Yearly trend in yield:				
X_7	(Add 150) ÷ 10	−20.6178	**37.5	−.965
X_p	$(X_7)^2$	.8276	**34.2	.951
$f(4,7)$—X_r	(X_4) (X_7)	−.7484	**42.2	−.536
X_{11}, County average yield, 1938–46	100 pounds	76.6692	**39.6	.268

a=66.3

$P^2_{1.4\ldots11}$=.4079; $P_{1.4\ldots11}$=.6387**; $\bar{P}^2_{1.4\ldots11}$=.3836; $\bar{S}_{1.4\ldots11}$=38.56

($\bar{P}^2$=Index of determination; $\bar{S}$=standard error of estimate.)

[1] Based on 272 white (male) owner-operated farms which were purchased.

[2] Based on owner-operated farms, which were purchased, and on share-rented farms, both classes of which were operated with either hired labor or hired labor in combination with other types of labor during the period. There was a total of 203 farms involved.

** Significant at the 1-percent point.

TABLE 6.—*Summary of correlation results from analysis of specified factors against coefficient of variation in yields reported by farmers for three or more years during period 1938–46, in two sample areas*

Factor	Unit	Regression coefficient	F-ratio of regression coefficient	Beta coefficient
Upper Piedmont: [1]				
X_2, Farm average yield, 1938–46 [2]	100 pounds	−5.8661	**63.7	−0.439
X_1, Acres of cotton harvested	1 acre	−.0682	**7.7	−.137
fX_4, Rate of fertilizer application:				
X_4	100 pounds	−5.9700	**21.8	−.691
X_m	$(X_4)^2$	.3554	**8.2	.492
X_5, Years in yield average	1 year	−.2485	.1	−.044
X_7, Percentage of cropland in cotton acreage harvested	1 percent	−.5876	**26.2	−.466
$f(4,7)$—X_w	$(X_4)\ (X_7)$	.0950	**30.5	.558
fX_8, Yearly trend in yield:				
X_8	(Add 150) ÷ 10	−6.3300	**68.7	−1.415
X_r	$(X_8)^2$	.2094	**94.1	1.426
$f(5,8)$—X_s	$(X_5)\ (X_8)$	.0938	*6.4	.285
X_{10}, County average coefficient of variation, 1938–46	1 percent	.3289	3.4	.078

$a=104.9$

$P^2_{1.2\ \ldots\ 10}=.3082$; $P_{1.2\ \ldots\ 10}=.5552$; $\overline{P}^2_{1.2\ \ldots\ 10}=.2790$; $\overline{S}_{1.2\ \ldots\ 10}=9.54$
($\overline{P}^2$=Index of determination; $\overline{S}$=standard error of estimate.)

Factor	Unit	Regression coefficient	F-ratio of regression coefficient	Beta coefficient
West Texas Rolling Plains: [3]				
X_2, Average farm yield, 1938–46 [2]	100 pounds	−9.4236	**20.2	−0.222
X_5, Years in yield average	1 year	11.3698	*6.3	1.270
X_6, Percentage cotton acreage not harvested	1 percent	1.5088	**47.5	.324
fX_7, Percentage cropland in cotton acreage harvested:				
X_7	1 percent	−1.1375	**54.2	−.623
X_l	$(X_7)^2$	.0092	**30.1	.439
fX_8, Yearly trend in yield:				
X_8	(Add 150) ÷ 10	−6.1011	**58.5	−.732
X_r	$(X_8)^2$	.2448	**51.5	.721
$f(5,8)$—X_s	$(X_5)\ (X_8)$	−.6212	**19.5	−1.140
X_{10}, County average coefficient of variation, 1938–46	1 percent	.6486	3.3	.127

$a=83.6$

$P^2_{1.2\ \ldots\ 10}=.3974$; $P_{1.2\ \ldots\ 10}=.6304$**; $\overline{P}^2_{1.2\ \ldots\ 10}=.3695$; $\overline{S}_{1.2\ \ldots\ 10}=15.21$
($\overline{P}^2$=Index of determination; $\overline{S}$=standard error of estimate.)

[1] Based on 272 white (male) owner-operated farms which were bought and not inherited.
[2] Farms reporting 3 or more years of yields during the period.
[3] Based on owner-operated farms which were purchased, and share-rented farms, both classes of which were operated with either hired labor or hired labor in combination with other types of labor during the period. The total number of farms involved was 203.
** Significant at the 1-percent point.
* Significant at the 5-percent point.

The index of determination is 0.4202 while the error of estimate equals 64.62 pounds. The *F*-ratio for each regression coefficient is also shown. It may be seen that all were statistically significant at the 1-percent point except number of years in yield average, which was not significant. However, this factor is jointly related to percentage of cropland in legumes, the regression coefficient of which was highly significant. In the last column of this section of the table are given also the Beta coefficients which, by comparison between the different independent factors, make possible the determination of the relative importance to the analysis of the different independent factors. For example, quantity of fertilizer applied has a larger Beta coefficient, by far, in both functions, than any other factor or its function. This indicates that it makes a relatively larger contribution (per standard deviation) to average yield than do any of the other three independents, or their functions, which were included in the regression equation.

Tables of this sort give in compact form all the quantitative information it is necessary to know concerning a correlation analysis. In tables 5-10 data of this sort are given. Their use in formulating regression equations and in deducing other useful information about the correlation analysis is exactly as given above.

AVERAGE YIELD

In table 5 are given for each area the factors (with their respective functions) which were found to be important in explaining average yield. The chief factors in the Upper Piedmont, based on size of Beta coefficients, are as follows: (1) Rate of fertilizer application; (2) rate of fertilizer application jointly with county average yield; (3) percentage of cropland in legumes jointly with time interval of yield; (4) percentage of cropland in legumes; (5) rate of fertilizer and percentage of cropland in legumes jointly; (6) county average yield; and (7) time interval of yield.[45]

Thus only four factors, together with their functions, explained 42 percent of the differences among farm average yields during the period. (Averages are for farms in this group which reported three or more years of yields during the period.) The remainder of the variability was accounted for by soil type, topography, and other basic factors which also caused farm average yields to vary. Nevertheless, the 42-percent explanation of variations in farm average yields was highly significant. The importance of quantity of fertilizer applied and legume practices used, in this percentage, is indicated by their respective coefficients of regression and joint functions with other factors. The regression equation for estimating average yield from these factors is given above. (See p. 74.)

In the West Texas Rolling Plains, the following factors proved to be influential in explaining the differences among farms in average yield (in order of relative importance): (1) Yearly trend in yield; (2) time interval of yield; (3) trend and time jointly; (4) percentage of cropland in cotton acreage harvested; (5) county average yield; (6) percentage of cotton acreage not harvested.

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[45] Not significant but included because of the high significance of this factor when considered jointly with legumes.

These five factors and their functions explained 38 percent of the variation in average yields among farms. With two exceptions the factors differ from those found to be important in the Upper Piedmont area. Furthermore, they are mostly uncontrollable by the manager, although there would appear to be some exception in the case of percentage of cropland in cotton acreage harvested, and percentage of acreage not harvested. These two factors are subject to a considerable measure of control by proper selection of land and use of keen judgment in production. The relatively large influence of trend in yield emphasizes the importance of weather, particularly cycles in weather, which override most actions and decisions that the manager might otherwise take.[46]

Although fertilizer is not adaptable to the area, and crop rotation with legumes does not have the place of importance that it has in the Upper Piedmont, an operator in this area is not wholly without techniques to influence favorably the trend of his yields. Both large terraces and contour cultivation help to conserve moisture. A rotation with fallow land prior to the planting of cotton is also helpful. Avoiding the planting of cotton after a moisture-depleting crop, such as cotton or grain sorghums, has been found to be helpful. An effective way to increase trend is by selection of land, particularly when this is coupled with shrinkage in relative acreage planted to cotton over a period of years, as during the AAA period, and hence during many of the years from 1938 to 1942.

Although the general trend of yields of the 10 counties and also of the sample farms in Texas was downward during the period of the study 1938–46, it appears that, had the acreage retrenchment program not been in effect, the yearly rate of decline in yields would have been even greater. From this it may be concluded that weather conditions, which were more unfavorable than usual, were of great importance during the period of the study.

COEFFICIENT OF VARIATION

In table 6 is given all the information necessary to formulate an estimating equation for predicting variability of yields in each area.[47] But certain deficiencies may seriously limit their use. In the first place, the distribution of coefficients of variation was too peaked, especially in the Upper Piedmont, to give sufficient validity to tests of significance based on normal distribution theory.

Second, two factors—size of the cotton enterprise and average yield—reflect in part some of the more direct production functions that are included; so there is a tendency, through allocation between the factors in the correlation analysis, to reduce the relative importance of the more direct production factors while the more remote ones acquire some of this importance. Consequently, although the index of

[46] In the sense of a series of years of low rainfall followed by a series of years of relatively high rainfall, and vice versa.

[47] Although they are given here for study and for other possible uses, it is not believed that crop-insurance premium rates should be determined in this way. The abnormality of the distribution of the individual values of the coefficient of variation makes the chance for error too great, especially in the Upper Piedmont and similar areas. A more desirable procedure would be to base them on the errors of forecast of individual farm yearly yields over time. See pp. 97-99 and 117-119.

correlation is enlarged, the nature of the net effect of the "closer" production factors on the coefficient of variation tends to become obscured. For these reasons, it is doubtful whether the regression equations have much value for estimating the coefficient of variation, especially for the Upper Piedmont and similar areas where the distribution of the individual observations of the coefficient of variation departs rather seriously from normal. Despite these shortcomings, it is believed that considerable light is thrown on some of the causes of relative yield variability, and that an examination of the data in table 6 in further detail, from this point of view, is justified.

The factors that were uniform for both samples in explaining yield risk were average yield, trends in yields, time interval of yields, percentage of cropland in cotton acreage harvested, and county coefficient of variation (although in neither area was the coefficient quite significant at the 5-percent point). Two other factors were important in the Upper Piedmont—acres of cotton harvested and rate of fertilizer applications. One additional factor was important in the West Texas Rolling Plains—percentage of cotton acreage not harvested.

The factors that ranked highest in importance in the Upper Piedmont, according to the Beta coefficients, were yearly trend in yield, amount of fertilizer used, fertilizer applied and percentage of cropland in cotton (jointly), percentage of cropland in cotton acreage harvested, and farm average yield. In the Texas Rolling Plains, the ranking of the factors was: Time interval of yield, time and trend jointly, yearly trend in yield, percentage of cropland in cotton acreage harvested, percentage of cotton acreage not harvested, farm average yield, and county coefficient of variation. The seven independent factors and their functions explained 28 percent of the individual farm differences in yield risk in the Upper Piedmont, whereas six independent factors and their functions accounted for 37 percent in the West Texas Rolling Plains. Therefore, the correlation analysis with the coefficient of variation was somewhat more effective in the Texas sample than in the Upper Piedmont sample

FORECASTING YEARLY FARM YIELDS BY CORRELATION METHODS

So far the factors that have a bearing on average yield and variability of yields have been explored. It has been demonstrated that those more closely associated with the level of average yields conform reasonably well with agronomic principles and that the results were statistically significant. In the case of the coefficient of variation the results have not been so conclusive. Although certain factors have been established as important in relative yield variability, the relationships cannot be regarded as highly dependable for the distribution departed too greatly from normality for the dependable application of tests of significance to the correlation results. Furthermore, even though the factors were demonstrated as statistically significant, the low index of determination suggests that a crop-insurance program based on the coefficient of variation might be unduly risky.

Exceptions may be made to these points in the case of the West Texas Rolling Plains but not strongly so, as a better alternative appears. This alternative for premium rates for crop insurance is the estimation of yearly yields from a regression equation for a homogeneous group of farms with the crop-insurance premium rates based on the errors of forecast. Such a procedure would give a flexible rate structure and would also provide a reasonable degree of security for the insurer, as the probabilities in the situation would be subject to measurement.

This section of the bulletin was designed primarily to explore the possibility of forecasting annual farm yields, and only incidentally to establish the functional character of certain management factors subject to differential (year-to-year) variation. From this viewpoint, it was thought that the inclusion of the average yield as an independent factor was desirable as it reflected the best available estimate of the expectation of annual yield. Its inclusion provided the only way in which between-farm differences in productivity, due to soil fertility, topography, and other natural conditions, could be included. The average yield was repeated for every year in the yield series.

Estimating Yearly Yields in the Upper Piedmont

FARMS INCLUDED IN THE ANALYSIS

The farms included in this analysis were those operated by white owner-operators (men) who bought the farms on which they were living in 1946 and who grew cotton during the 3 years from 1944 to 1946. The 198 farms that met these requirements provided a good-sized homogeneous sample, with 594 yearly yield observations. The study in the Upper Piedmont was confined to this 3-year period in order to obtain yield observations, paired with fertilizer applications, which were as accurate as practicable. From the questionnaires, it was found that farmers reported very little increase in their rates of fertilizer usage between 1938 and 1946. This indicates that the farmers were likely to report to enumerators the same quantity of fertilizer for the earlier years that they did for the more recent years.

Examination of USDA Crop Reporting Board estimates of fertilizer used per acre in producing cotton by farmers in South Carolina and Georgia during 1944, 1945, and 1946, reveals that there was practically no variation during this period in the State averages. Consequently, the above-mentioned bias in farmers' estimates of rate of fertilizer applied to cotton was avoided approximately by confining the analysis to the period 1944-46. No farms with less than 3 years of cotton yields were used as it was believed that the recentness of experience on the farm might affect the results. A use was found for the yield records for less than 3 years, however, in testing the applicability of the regression estimates of yields and crop-insurance premium rates.

FACTORS INFLUENCING YEARLY FARM YIELDS

Relation of Technical Coefficients of Production and Average Yield to Yearly Farm Yields.—In table 7 are summarized the factors that proved most important in the correlation analysis in estimating yearly farm yields. Only three factors are involved, although one other (percentage of county yield the previous year as percentage of the 6-year county average yield) proved statistically significant in a joint function with rate of fertilizer applications.[48]

For the most part the factors included are those that might be expected to be most highly associated with variations in yearly farm yields. These are fertilizer and changes in quality of land. The rela-

TABLE 7.—*Summary of correlation results from analysis of specified factors against yearly farm yields in the Upper Piedmont, 1944–46*[1]

Factor	Unit	Regression coefficient	F-ratio of regression coefficient	Beta coefficient
fX_2, Rate of fertilizer application (including ammonia):				
X_2	100 pounds	10.4721	**72.8	0.419
X_4	$(X_2)^2$	−.0815	**58.7	−.354
X_5, 1944–46 farm average yield [2]	Pound	.8858	[3]** 750.5	1.772
$f(2,5)$—X_6	$(X_2)(X_5)$	.0136	**103.4	.355
$f(2,8)$—X_6	$(X_2)(X_8)$ [4]	−.0466	**31.8	−.067
X_9, Percentage annual acreage harvested was of average acreage harvested	Percent	−.2797	*3.9	− .157

$a = 28.8$
$P^2_{1.2 \ldots 9} = .5887$; $P_{1.2 \ldots 9} = .7672$**; $\bar{P}^2_{1.2 \ldots 9} = .5845$; $\bar{S}_{1.2 \ldots 9} = 74.2$
($\bar{P}^2$ = Index of determination; $\bar{S}$ = standard error of estimate.)

[1] Based on 198 white owner-operators (male) who bought the farms which they were operating in 1946, and who also reported 3 years of yields between 1944 and 1946.

[2] The average was repeated for each year in the period as a means of removing differences in yield level between farms.

[3] The F-test is of questionable validity because of difficulties in determining degrees of freedom with this factor. See footnote 2 above.

[4] County yield previous year as percentage of average of county yields for 6 preceding years. This factor proved statistically significant only with fertilizer in a joint function.

** Significant at the 1-percent point.

* Significant at the 5-percent point.

tion of rate of fertilizer application to *yearly* yields is obvious; an increase would be expected to increase yearly yield, other things being equal, and vice versa.[49] The quantity of fertilizer applied was treated in the analysis as a parabolic function. The negative second-degree part of its equation indicates that when fertilizer rates were very high

[48] Two additional factors (age of the operator and years of experience on the 1946 farm) and their functions were tested for their significance or contribution to the correlation analysis. Only age and its second-degree function seemed statistically significant by the F-ratio method, but it reduced the value of some of the net regression coefficients without increasing the coefficient of determination, reducing it, in fact, because the loss in degrees of freedom from the increased constants more than made up for the gain in the correlation index. Consequently, detailed study and analysis of both age and experience have been omitted.

[49] The regression analysis was designed to measure the year-to-year changes of the factors on yearly yield. In the case of fertilizer, there are also residual or long-run effects, which are reflected in yield level. As a given fertilizer practice of some duration affects soil character—tilth, structure, etc.—they are best reflected as long-run influences.

the influence of fertilizer on yearly yield prospects was negative. However, its net effect cannot be so simply deduced as two other functions of this factor are joint with other factors—farm yield level, and the preceding year's county yield relative to the 6-year county average. To get the true effect of rate of fertilizer use on yearly variations and cotton yield, all of these interrelationships must be examined simultaneously. This has been done in figure 13.

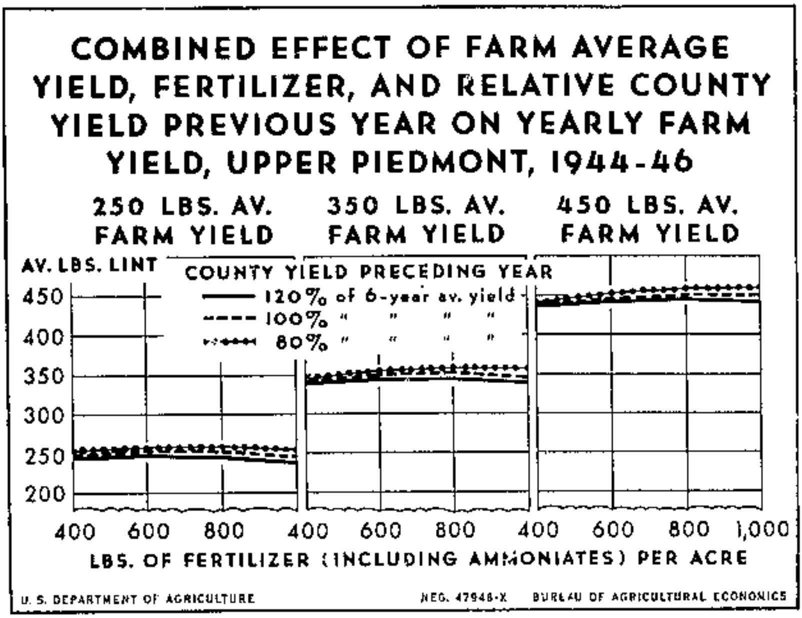

FIGURE 13.—Yearly yield response from applications of fertilizer was a function of farm average yield and the percentage that the county yield the preceding year was of the 6-year average (periodic influence). The point of maximum yearly yield from fertilizer applications increased directly with average farm yield. With an application of 600 pounds of fertilizer the farm average yield was 250 pounds and with 800-1,000 pounds of fertilizer the farm average yield was 450 pounds. The relative lowness of county yield the preceding year, as a percentage of the 6-year average county yield, also affected the location of the point of optimum yearly yield from fertilizer. As the percentage which the county yield was of the 6-year average declined, this point moved to the left when farm average yields were 350 or 450 pounds.

A factor which measures changes in quality of land from year to year has been reflected in the analysis indirectly, as no direct measure of land quality was obtained in the field enumeration. It has been indicated by expressing cotton acreage harvested in a particular year as a percentage of the average acreage harvested during 1944 to 1946.[50] The regression, as expected, was negative. For each 1-percent increase in acreage harvested above average, yearly yield declined 0.28 pounds on the average.

[50] A low percentage of cotton acreage relative to average acreage indicates an improvement in land quality because the smaller relative acreage permits the farmer more latitude in selecting the most favorable fields for cotton. The converse is true of a high percentage of cotton acreage relative to average acreage.

In the joint function with fertilizer, a measure of the preceding year's county yield has been included. This was done in order to measure any tendency for high yields to be followed by low yields, and vice versa. County yield the previous year as a percentage of the 6-year average in an independent role failed to show statistical significance, and it appears that there may not be much direct periodic effect. But indirectly, through its influence on fertilizer response, a definite and significant connection with yearly yields was shown. As the regression coefficient was negative, the indication is that the higher the county yield in any given year relative to the 6-year average, the more the effects from fertilizer applications on individual farm yearly yields are reduced the following year.

A final factor indicated in table 7 remains to be discussed. This is the farm average yield for 1944–46 which influences yearly yields by establishing their base, or the level about which they fluctuate. This factor was important to the correlation analysis as it tended to reflect differences in productivity between farms. There was no other way to do it in the analysis with the data available. As a measure, average yield—in addition to reflecting productivity—probably reflects some production practices which are due to management, such as fertilizer applications in a long-run sense; but it is believed that both inherent productivity and productivity that has been established by crop rotation, the planting of legumes, etc., over a long period are its primary determinants. The importance of average yield in the analysis is shown by the fact that 1 pound of increase in it accounted for an 0.88-pound increase in yearly yield. The Beta coefficient of this factor is 1.77, the largest by far of any of the other factors included in the analysis. Measuring each factor's importance by its Beta coefficient, gives the following ranking for the factors influencing yearly yield in the Upper Piedmont: (1) Average farm yield; (2) rate of fertilizer application; (3) rate of fertilizer and average yield jointly; (4) percentage annual acreage harvested was of average acreage harvested; and (5) rate of fertilizer and the percentage that the county yield the previous year was of the 6-year average, in a joint relationship.

The relationships outlined above are more emphatically portrayed in figure 13. The joint relationships of farm productivity, change in quality of land, and change in county yield the preceding year from the 6-year average are shown in this chart. Although all the factors were closely associated with changes in yearly yields from their respective averages, the greatest changes were associated with rate of fertilizer application and the percentage that the county yield the previous year was of the 6-year average. In general, the lower the county yield the year preceding, compared with the 6-year average, the lower the cotton acreage harvested was relative to average; and the higher the rate of fertilizer application, the more yearly yields tended to exceed the farm average. This relationship arises because the prospects for the succeeding crop, land quality (land selection), and quantity of fertilizer are combined in such a way as mutually to reinforce the influence of each other. That is, the kind of response from fertilizer in any given year is related to the sort of crop-year and the quality of land on which cotton is planted.

The figure also shows that the differential response in yearly yield from rate of fertilizer applications was related to level of yield (measure of soil capacity) of the farm and the relative favorableness of the crop year. In general, the higher the farm average yield and the lower the percentage that the county yield the previous year was of the 6-year average (and the more favorable the prospects of the current crop year relative to the preceding), the greater was the differential response from different rates of fertilizer application. It is seen from the regression equation that at any level of yield, a greater fertilizer response was obtained when there had been a comparatively low county yield the previous year relative to average; and conversely, when the county yield the previous year had been high relative to average. That is, the joint effect of fertilizer and favorableness of the crop year were the dominant forces in determining the differential effect of fertilizer on *yearly* yields.

It appears that the point of maximum yearly yields from applications of fertilizer when the county yield the previous year had been 80 percent of average approximated 800 pounds in cases where the farm average yield was either 250 or 350 pounds; but that it was about 1,000 pounds if the farm average yield approximated 450 pounds. But with county yield the previous year 20 percent above average, the maximum occurred with 200 pounds less of fertilizer at each of the three levels of farm yield shown—occurring at 600 pounds of fertilizer when average farm yields were either 250 or 350 pounds and at 800 pounds if average farm yield was 450 pounds. It is apparent also that the differential response from fertilizer was less when the county yield the previous year had been 20 percent above average than when it had been 20 percent below average.

Relation of Technical Coefficients of Production, Farm Average Yields, and Rainfall Factors to Yearly Yields.—In the preceding section, a measure of the tendency toward sequence in yearly cotton yields was employed in the correlation analysis in order to include in the yearly yield forecasts, roughly the influence of weather conditions as they might vary, periodically or cyclically. The independent factor which was introduced for this purpose was county yield the previous year expressed as a percentage of the county 6-year average yield. In this section, rainfall during certain months was substituted for it. The monthly rainfall data were June-plus-July rainfall and August rainfall.[51]

The factor for June-plus-July rainfall was included as a second-degree parabola under the assumption that in a humid region such as the Upper Piedmont, an optimum rainfall for growth of cotton is probable. In the case of August rainfall, a linear relationship was used because the preliminary analysis indicated that a constant negative relationship existed. All other factors are as included in table 7 above, with a few exceptions. Fertilizer was included also as a joint function with June and July rainfall as it is during these months that the largest vegetative growth of the plant takes place. Also the factor for June-plus-July rainfall is entered jointly with August rain-

[51] In exploratory analyses with various rainfall factors against county average yields, the factors selected here were established as those most important relative to yield.

fall under the assumption that deficiencies or excesses in one period or month might be made up by excesses or deficiencies in the other.

The results of the analysis are shown in table 8. It is seen that the regression coefficients were highly significant except for the first-degree function of June-plus-July rainfall and the percentage that the annual acreage of cotton harvested was of average acreage harvested. Both were significant at the 5-percent point by F-ratio tests. Substitution of the two rainfall factors and their several functions

TABLE 8.—*Summary of correlation results from analysis of technical, rainfall, and other specified factors against yearly farm yields in the Upper Piedmont, 1944–46*[1]

Factor	Unit	Regression coefficient	F-ratio of regression coefficient	Beta coefficient
fX_2, Rate of fertilizer application (including ammonia):				
X_2	100 pounds	3.8592	**27.7	0.154
X_k	$(X_2)^2$	−1.1169	**99.3	−.581
X_5, 1944–46 average yield [2]	Pound	.8329	[3]**728.2	1.666
$f(2,5)$—X_s	$(X_2)(X_5)$	.0203	**158.6	.527
fX_6, June plus July rainfall: [4]				
X_6	1 inch	−28.7249	*5.5	−1.436
X_n	$(X_6)^2$	2.4787	**7.7	1.958
$f(2,6)$—X_t	$(X_2)(X_6)$	.8367	**47.5	.356
X_7, August rainfall [4]	1 inch	27.3016	**74.1	1.092
$f(6,7)$—X_v	$(X_6)(X_7)$	−3.7380	**65.2	−1.383
X_9, Percentage annual acreage of cotton harvested was of average acreage harvested	Percent	−.3365	*4.9	−.188

$a = 97.8$

$P^2_{1.2 \ldots 9} = .6042$; $P_{1.2 \ldots 9} = .7773^{**}$; $\bar{P}^2_{1.2 \ldots 9} = .5974$; $\bar{S}_{1.2 \ldots 9} = 73.1$

($\bar{P}^2$ = Index of determination; $\bar{S}$ = standard error of estimate.)

[1] Based on 198 white owner-operators (male) who purchased the farms operated by them in 1946 and who also reported 3 years of yields between 1944 and 1946.

[2] See footnote 2 to table 7.

[3] See footnote 3 to table 7.

[4] For the following weather stations in or near the sample counties: Greenville, Clemson College, Athens I, Gillsville, Carlton Bridge, Atlanta Airport, Tallapoosa, and Newman.

**Significant at the 1-percent point.

*Significant at the 5-percent point.

for the percentage change in the county yield from the 6-year average increased the adjusted coefficient of determination only slightly (from 0.5845 to 0.5974). This indicates that the regression equation based on the technical coefficients with the periodic factor in county yields are almost as effective as with the two rainfall factors.

A study of table 8 discloses that the signs of all factors previously analyzed in this section (table 7) remained unchanged but that the size of all regression coefficients was lower, with two exceptions. The regression coefficient for fertilizer and average yield jointly was almost double the previous value, whereas the regression coefficient for change in cotton acreage was enlarged from 0.28 to 0.34 pounds for each percentage point change in acreage of cotton from average. As the index of determination was somewhat larger, the presumption is that a part of the effect of the factors shown in the previous analysis was affected by the rainfall factors. On first consideration, it appears that the regression coefficients for the two rainfall factors, June-plus-July rainfall and August rainfall (in the sign of the coefficient) are opposite to those expected, the former factor being negative and the latter positive. But on closer examination, it is seen that the joint function of the two factors is of great significance. Consequently, as once before, it becomes necessary to study together all factors that operate jointly with the rainfall factors. This is done graphically in figure 14.

Ignoring the differential effect of fertilizer the lines in this chart show that yearly yields declined relative to farm average yield as June-plus-July rainfall increased, assuming an August rainfall of either 8 or 12 inches. On the other hand, under an assumption of 4 inches of August rainfall, yearly yield was less, with 10 inches of June-plus-July rainfall, than with 5 inches, but greatly increased if June-plus-July rainfall was 15 inches. This shows, in general, that yearly yields declined relative to farm average yields as total rainfall increased in these three critical months, but that if June-plus-July rainfall was 10 inches or more the yield rose as August rainfall dropped toward 4 inches, and perhaps below. This indicates that an excess of rainfall in June and July may *partially* compensate for a later low rainfall in August; it also shows that a high relative rainfall in August more than compensates for low rainfall in June and July. The conclusion is that a low August rainfall was more important to high yields than high rainfall in June and July.

The graph also shows that a low June-plus-July rainfall was associated with yearly yields that were comparatively stable relative to their respective averages, but that their instability increased as June-plus-July rainfall increased. Furthermore, it appeared that the amount of June-plus-July rainfall, up to at least 15 inches, was the strategic factor in the differential response of yearly yields from applications of fertilizer. The differential response from fertilizer also appeared to be influenced by the average yield for the farm, and increased directly with increases in average farm yields. For example, at three levels of yield—250, 350, and 450 pounds—it was noted that with a June-plus-July rainfall of 5 inches, the point of maximum returns in yearly yields was reached with an application of 600 pounds of fertilizer; with 10 inches of rainfall the maximum was reached at 800 pounds; and with 15 inches of rainfall in June and July, it was reached when 1,000 pounds of fertilizer were applied.

In every case, the point of the maximum in yearly yields from applications of fertilizer increased as the level of farm yield increased. For each 5 inches of increase in June and July rainfall, the quantity of fertilizer required to give maximum yearly yields was increased by 200 pounds. Therefore, the conclusion might be that not only a high soil capacity but also a high amount of rainfall in June and July is required for a high rate of fertilizer application to give high yearly yields in the Upper Piedmont.

A further conclusion from this section is that high June-plus-July rainfall, combined with low August rainfall, influenced yearly yields

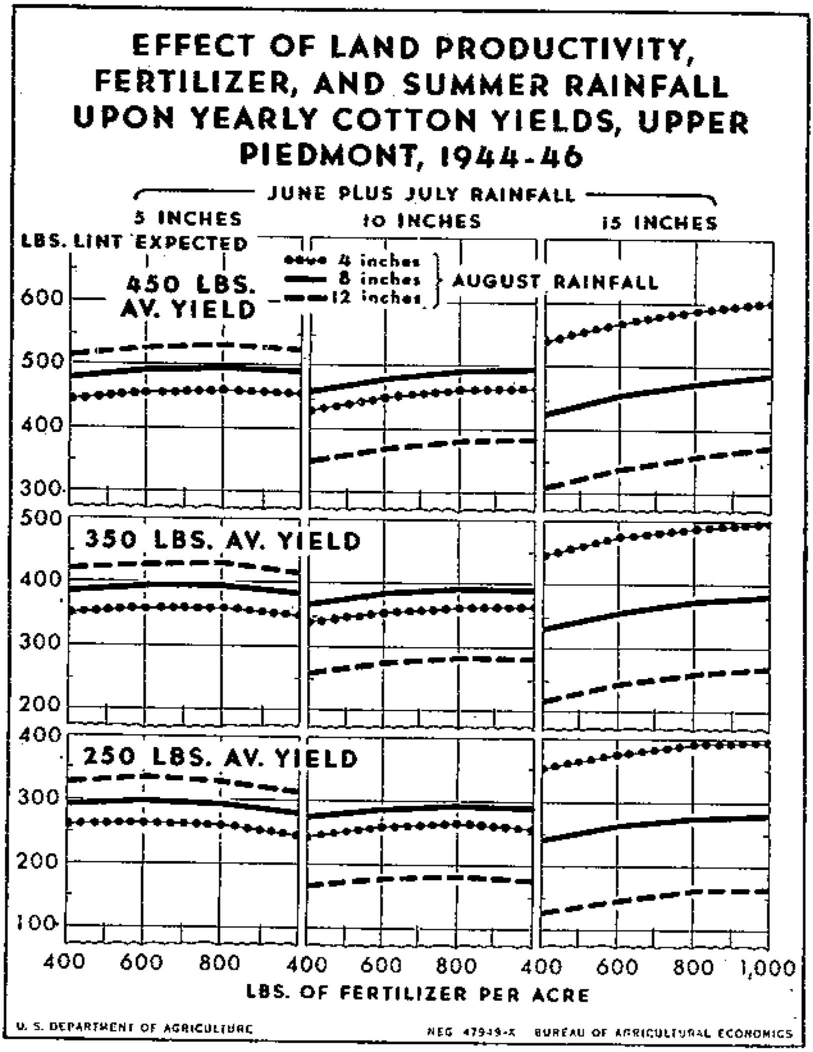

FIGURE 14.—The greatest stability in yearly yields with respect to farm average yield was associated with low June-plus-July rainfall, while conversely the greatest instability was associated with high June-plus-July rainfall. The lowest yearly yields relative to the farm average were associated with high June-plus-July rainfall combined with high August rainfall, whereas the highest yields were related to high June-plus-July rainfall coupled with low August rainfall. The highest differential response in yearly yields from increased fertilizer applications came when June-plus-July rainfall was high. On the basis of the results, it appears that high yearly yields relative to farm averages may be expected either from low June-plus-July rainfall coupled with high August rainfall or from high June-plus-July rainfall combined with low August rainfall, but more so from the latter combination.

directly by a certain increment, while from the favorable effect of high June-plus-July rainfall on fertilizer effect, yearly yields received an additional increment. A low June-plus-July rainfall combined with a high August rainfall gave high yearly yields also but apparently with very little or no stimulus from applications of fertilizer. As the first rainfall combination (or sequence) appeared to give higher yearly yields than the second sequence, the difference was apparently due to the fertilizer increment. Also the greatest variability from the average of yearly yields, was associated with the first rainfall combination, with fertilizer likewise responsible because a very favorable response in yearly yield was obtained with a rate of fertilizer application considerably in excess of the quantity required for the optimum (700 pounds) in yield variability.

Estimating Yearly Yields in the West Texas Rolling Plains

FARMS INCLUDED IN THE ANALYSIS

In this analysis with yearly yields, two major classes of operators were included: Owner-operators who bought the farms occupied by them in 1946, and share-renters. As indicated previously, these two categories of farms have many similarities in utilization of cropland, level of yield, and variability of yields. For purposes of the analysis they were rendered even more homogeneous by a rigid specification as regards the kind of labor employed. The requirement in this respect was that both classes of operators employ only hired labor, or hired labor in combination with other types.

Contrary to the procedure in the Upper Piedmont (where limitations on the time interval had to be made in order to obtain fertilizer data of maximum usefulness) varying time intervals in the yield record, 1938 to 1946, were used; but in no case was a yield duration of less than 3 years used. Consequently, this procedure gave for the analysis of Texas data an assortment of farms with yield intervals varying from 3 to 9 years. When all farms with missing values in any year were eliminated, 203 were left. In connection with these farms there were 1,374 yearly yield observations. Although varying time intervals in annual yields introduce certain difficulties in regard to comparability over time of some of the independent factors, it does give the sort of cross-sectional sample which a crop-insurance program would face.

FACTORS INFLUENCING YEARLY FARM YIELDS

The correlation approach used in connection with the Texas sample was similar to that employed for the Upper Piedmont, except that no strictly technical factors of production were available (technical in the sense that they are subject to differential variation by the manager). First, certain factors of land quality and a measure of abandonment of cotton acreage were combined with county yields in two time-lags to reflect certain periodic movements in yields which appeared to be present.[52] Next, the county-yield factors were replaced by monthly rainfall factors during the growing season.

[52] In the analysis with aggregates, the correlation of yearly county yields gave highest correlation coefficients for the second and ninth preceding years.

The results from the first analysis are given in table 9. Five independent variables were included: Percentage of seeded cotton acreage abandoned, 1938–46 average farm yield (for periods varying in duration from 3 to 9 years), acreage of cotton seeded as a percentage of the 1938–46 average, and county yield lagged 2 and 9 years respectively. All were significant statistically at the 1-percent point. These five factors compositely accounted for about 44 percent of the yearly variations in yields of these Texas farms during the period.[53] Farm average yield appeared to be the chief factor in explaining individual differences in yearly farm yields. The second most important factor,

TABLE 9.—*Summary of correlation results from analysis of specified factors against yearly farm yields in the West Texas Rolling Plains, 1938–46*[1]

Factor	Unit	Regression coefficient	F-ratio of regression coefficient	Beta coefficient
X_2, Percentage of seeded cotton acreage abandoned	1 percent	−1.7636	**67.4	−0.159
X_6, 1938–46 farm average yield[2]	Pound	.9596	[3] **592.2	.480
fX_9, Acreage of cotton seeded as a percentage of 1938–46 average:[4]				
X_9	1 percent	−.8158	**121.9	−.212
X_w	(X_2) (X_9)	.0048	**17.9	.049
X_{12}, County yield 2d preceding year	Pound	−.2049	**41.2	−.135
X_{13}, County yield 9th preceding year	Pound	.4254	**280.3	.311

$a = 67.1$

$P^2_{1.2 \ldots 13} = .4425$; $P_{1.2 \ldots 13} = .6652$**; $\bar{P}^2_{1.2 \ldots 13} = .4401$; $\bar{S}_{1.2 \ldots 13} = 68.7$

($\bar{P}^2$ = Index of determination; $\bar{S}$ = standard error of estimate.)

[1] Based on owner-operators who purchased the farms operated by them in 1946, and share-renters, both classes of whom employed hired labor or hired labor in combination with other types. A total of 203 farms involving 1,374 yearly yield observations.

[2] Averages based on 3 or more yearly yield reports during the period. The average yield was repeated for each year in the period as a means of removing differences in yield level between farms.

[3] F-ratio tests are of questionable validity because of difficulty of determining degrees of freedom.

[4] Acreage of cotton seeded in any year expressed as a percentage of the average seeded acreage for the farm's time interval (3 or more years) during period 1938–46.

** Significant at the 1-percent point.

[53] The analysis with the five factors in table 9 was also extended to include age and years of experience with parabolic functions. Only years of experience and its function gave a statistically significant regression coefficient (at the 5-percent point); however, the index of determination was not raised by this factor. In fact, the corrected index of determination was somewhat lower than that obtained with the five factors in table 9. The conclusion is that in the West Texas Rolling Plains neither age nor experience had a significant bearing on yearly yields when the farms were owner-operated (by owners who had purchased) or share-rented, and where hired labor or hired labor and some combination of other types of labor was used. These factors might have been more closely associated with the size of yearly yields if they were the farms and their operators had been less rigidly defined in this analysis.

as measured by the Beta coefficient, was the county yield the ninth preceding year. The relationship was positive, and for each pound of increase in county yield the ninth preceding year, the expectation on the average was for an increase of 0.43 pounds in the current annual yield.

The percentage that the annual acreage of cotton seeded was of the average acreage seeded appeared to be a third main factor. For each 1 percent of increase in acreage seeded above average for the farm,

TABLE 10.—*Summary of correlation results from analysis of technical, rainfall, and other specified factors against yearly farm yields in the West Texas Rolling Plains, 1938–46*[1]

Factor	Unit	Regression coefficient	F-ratio of regression coefficient	Beta coefficient
X_2, Percentage of seeded cotton acreage abandoned	1 percent	−1.7438	**74.4	−0.162
X_5, 1938–46 farm average yield [2]	Pound	.9757	[3] **672.2	.488
X_6, April rainfall [4]	1 inch	17.1046	**337.4	.291
X_7, May rainfall [4]	do	5.9981	**81.2	.150
X_8, July rainfall [4]	do	6.475	**41.2	.142
fX_9, Acreage of cotton seeded as a percentage of 1938–46 average: [5]				
X_9	1 percent	−.6776	**113.1	−.175
X_{10}	$(X_2)\ (X_9)$	.0066	**27.8	.069
X_{11}, August rainfall [4]	1 inch	5.6624	**80.8	.113

$a = -4.6$

$P^2_{1.2 \ldots 11} = .5014$; $P_{1.2 \ldots 11} = .7081$**; $\bar{P}^2_{1.2 \ldots 11} = .4984$; $\bar{S}_{1.2 \ldots 11} = 65.0$

($\bar{P}^2$ = Index of determination; $\bar{S}$ = standard error of estimate.)

[1] Based on owner-operators who purchased the farms occupied by them in 1946, and share-renters, both classes of whom employed hired labor or hired labor in combination with other types. The 203 farms thus defined had 1,374 yearly yields.

[2] Averages based on 3 or more yearly reports during the period. The average yield was repeated for each year in the period as a means of removing differences in yield level and between farms.

[3] See footnote 3 of table 9.

[4] For the following weather stations in or near the sample counties: Abilene, Ballinger, Big Spring, Haskell, Knox City, Munday, Paducah, Snyder, Roscoe, and Rotan.

[5] Averages based on 3 or more yearly reports of cotton acreage seeded.

** Significant at the 1-percent point.

yearly yield declined 0.82 pounds, on the average. The association between this factor and the yearly variations in cotton yield was more than twice as great as in the Upper Piedmont, where a 1-percent increase in acreage harvested above the farm's average caused a decline of 0.28 pounds on the average.

The other factors ranked in order of their importance were as follows: Percentage of cotton acreage abandoned and county yield the second preceding year.

Both factors showed a negative relationship with yearly yield in the West Texas Rolling Plains. For each 1-percent increase in acreage abandoned, yearly yield decreased 1.76 pounds. In the case of county yield the second preceding year, each pound of increase was associated with an average decrease of 0.20 pounds in yearly yield.

The results obtained from a second phase of the correlation analysis with yearly yield in this sample area are given in table 10. The difference between the methods used to obtain the results shown in this table and in table 9 is that rainfall data were substituted for the county-yield data that were used in the two lagged relationships. Four rainfall factors, April, May, July, and August rainfall, replaced the two county-yield factors; all other factors remained as in table 9. (These factors were selected on the basis of relative importance established by correlation analysis of various monthly rainfall data against county average yields.)

The over-all result was favorable in that the index of determination was increased from 0.44 to 0.50, representing an increase of 14 percent in the explained variability. Again, as above, farm average yield was the main factor explaining differences in yearly yield. Next was April rainfall. Other factors ranked in order of importance, based on size of the Beta coefficients, were percentage of seeded acreage of cotton abandoned, annual seeded acreage as percentage of the farm average seeded acreage, and May, July, and August rainfall.

The net effect of a 1-percent increase in cotton acreage abandoned was a reduction of about 1.7 pounds in yearly yield—a value close to that shown in table 9. On the other hand, the regression effect of changes in acreage seeded from the farm average acreage seeded was considerably reduced in importance—a 1-percent increase was associated with a 0.68-pound decrease in yearly yield. This may be compared with the 0.82-pound decrease mentioned above (table 9). The difference may be attributed to the inclusion of the four rainfall factors, some of which, particularly April and May rainfall, had a direct bearing on relative abandonment of cotton acreage. The regression effects of 1 inch of rainfall on yearly farm yields in the Texas sample were as follows:

Rainfall:	Pounds increase
April	17.1
May	6.0
July	6.5
August	5.7

Thus, an inch of April rainfall had almost three times as much effect on yearly yields as any of the other three monthly rainfall factors. The great importance of rainfall in this month may be due to its bearing on stands of cotton. As the area is subhumid or semiarid, enough moisture to "get the crop up" is often of critical importance in the production of any crop, for without an adequate stand the effectiveness of later work on the crop and of rainfall in later months are greatly reduced.

The fact that rainfall in 4 of the 5 months during which the cotton crop matures failed to be more closely associated with yearly yields in our calculations is unexpected. But this failure to establish greater importance probably can be explained by the inability of reports from the weather stations to reflect accurately the rainfall received on the farms in the sample. Observations from only 10 stations were employed for the sample of 10 counties. This is about one set of observations for each county in the sample. In an agricultural area as dry as the West Texas Rolling Plains, it is apparent that a vastly greater number of weather observations should be used if the range of variability in rainfall is to be reflected, thus making it possible to establish more accurately the association between rainfall and yearly yields. In a humid area in which rainfall seldom goes below, or even approaches, the critical limit, a large number of separate observations would not appear to be so important. Despite the deficiencies in the data regarding Texas rainfall, the four rainfall factors, correlated against yearly yields in the Texas Rolling Plains, accounted for a higher proportion of the variance in yearly yields than did the two rainfall factors in the Upper Piedmont.

As abandonment of cotton acreage is so important to the success or failure of a crop-insurance program in this area, certain factors thought to have a bearing on it were analyzed by correlation methods. The factors included were age of operator, years of experience of operator, and the four monthly rainfall factors mentioned. The index of correlation which resulted was very small and not statistically significant. Furthermore, only the regression coefficient for years of experience was significant at the 5-percent point. Other trials, which included percentage change in acreage of cotton seeded, produced no better results.

The poor showing in the correlation analysis with abandonment of cotton acreage may be explained by the fact that the group of farms under investigation had very low abandonment as a whole. As previously shown, at least one of the factors, type of labor, which caused a high rate of abandonment of acreage, was eliminated by definition.[54] The second factor, seed cleaning or treatment, or both, was shown also to have affected significantly the abandonment of acreage. Although not specifically eliminated by definition as in the case of type of labor, this second factor may be of little importance because superior management by the group of operators under consideration may imply superiority in this respect also.

CROP-INSURANCE PROGRAM BASED ON REGRESSION EQUATION OF YEARLY YIELDS

In the analysis so far factors that influence farm average yield, variability in annual yields and trends in yields have been studied. The factors that influence average yield and yield variability are regarded as useful in setting up productivity and risk categories of farms. It is believed, however, that premium rates in crop insurance could not be calculated from the coefficient of variation of the yield series for the individual farm. When groups of farms are thus treated the frequency distribution of the coefficients of variation is too abnormally skewed for normal curve theory to be applied.

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[54] Farms with hired labor showed a very low abandonment of cotton acreage; those with family and sharecropper labor, a very high rate. See p. 53.

A further difficulty of such an approach is that the yearly yield forecast, which such a procedure implies, would be based on the respective farm average yields. By this method, the average yield would be assumed as the most probable expected yield for any given year, and all years in the future would be assigned the same prospective yield. The results uncovered in this study indicate that this assumption regarding future yields on any given farm is too unrealistic and too inflexible to meet the realities of the situation, or to attract the better farmers into an insurance program. Obviously future yield expectations for a particular farm are dominated by dynamic rather than static forces. These dynamic forces include both processes of growth and processes of decay. The processes of growth are influenced by the introduction of new techniques, increased experience in production, changes in characteristics of operators (such as age to a certain point), which influence yields favorably, a favorable cycle in weather conditions, etc. The processes of decay are soil erosion, the loss in physical strength that comes from the aging of the operator, an unfavorable cycle in weather, etc.

Sometimes the processes that raise yields compete with those that lower them. For example, an alert youthful operator, who is introducing new techniques as rapidly as possible, may still find that his crop is subjected to an unfavorable weather cycle. Contrariwise, the forces that lower the yield may be in conflict with a favorable weather cycle and other factors associated with high-yield farms. The opposite influences of the weather cycle on trends in farm yields are illustrated by the two sample areas for 1938–46. The trend in yields was upward in the Upper Piedmont but downward in the West Texas Rolling Plains, because of opposite effects of the weather during the selected period.

Some factors that introduce changes in the general character of the farm's yield over time are subject to the volition of the operator. The factors of production that he may manipulate in changing the course of his yields are rate of fertilizer application, crop rotation, shift in farm organization, kind of labor, treatment of seed, use of tractor power, and many others. In the correlation analyses, the regression coefficients of some of the factors that determine yearly yields of farms were calculated, as well as those of other yield factors external to the farm which might be used successfully in preparing forecasts of the yearly yield. (The external factors were: Previous yearly yield of the county expressed as a percentage of the 6-year average county yield in the Upper Piedmont, and county yields the second and ninth preceding years in the West Texas Rolling Plains.) Consequently, by employing the regression equations, it is possible to forecast, with known error, the yield of individual farms for the year ahead—once production plans are known for that year.

The forecast would not be expected to give any farm's yearly yield exactly but a series of such yield forecasts should average out. Each farm forecast, however, would be within the error limits of the respective regression equations. This method would enable realistic and flexible yield forecasts for groups of farms, and would reduce the cost of guaranteeing any percentage of the respective farm-yield forecasts depending upon the reduction in the variance of the original yield observations that is accounted for by the causal factors included in the regression equation. The results would be a radical departure from yield forecasts based on yield histories of individual farms, or some area normal yield.[55]

Some idea of the success with which yields could be forecasted, and of the possible saving to farmers in premiums from this increased ability of the insurer to look ahead in estimating yearly yields, is indicated by the results obtained from the correlation analysis. (See tables 7-10.) The results from both areas indicate that the size of the coefficient of determination was increased materially by including the farm average yield as one of the presumed causal factors associated with variations in yearly yields.

In the Upper Piedmont, average yield and three other factors explained 58 percent of the variation in annual yields. In the West Texas Rolling Plains the average farm yield and four other factors explained 44 percent of the variation in yearly yields. It is believed that insurance coverages and rates based on regression-forecasted yields and their corresponding errors of estimate would be more equitable and adequate than can be obtained by any other method.

Tests of Adequacy of Regression Equations in Preparing Forecasts of Yearly Yields and Crop-Insurance Premium Rates

Table 11 gives the results of testing these regression equations and their standard errors for both sample areas, under four sets of conditions as regards type of farm and time intervals. Test I is based on a sample of farms taken from those used in the correlation analysis. Test III is analogous with test I as to characteristics of both farm and operator, but differs from it in that no farm in this group was used in the correlation analysis because the time interval (1- and 2-year farms) was considered too short. Test II in each area is similar to test I with respect to length of history of yields; however, farms in this group were not used in the correlation analysis, and their characteristics contrasted sharply with the farms included in test I.

In test II, for the Upper Piedmont, another condition was imposed by excluding all farms operated by Negro operators, both owners and tenants. These farms differed drastically from the others in average yield and size of the coefficient of variation in yields. Test IV was closely analogous to test II in the respective areas, differing in that the time duration of yields for these farms was only 1 and 2 years. In all tests, yearly yields were forecasted, premium rates were computed for 75-percent yield coverages, and loss-costs were calculated.[56] The forecasted yields may be compared with the actual yields and estimated loss-costs may be compared with the computed premium

[55] The mapping of counties into productivity areas does not remove the necessity for a yield forecast for farmers who participate in a crop insurance program based thereon. As the insurance guarantee of necessity specifies some yield or yield group, it must be determined by some yield average or normal yield for the area. Consequently, yield expectations for crop insurance become assumptions based on these norms, and are subject to most of the criticisms of farm average yields based upon yield histories.

[56] For methods of computation, see Appendix, pages 117-119.

TABLE 11.—*Tests of reliability of regression equations of yearly and average yield, and the dependability of error of estimate of yearly yields in estimating crop insurance premium rates for groups of farms of varying relationships to those in the correlation analysis*

Item	Unit	Farms with 3 or more years of yields		Farms with 1 or 2 years of yields	
		Test I [1]	Test II [2]	Test III [3]	Test IV [4]
Upper Piedmont:					
Yields:					
Yearly	Number	100.0	100.0	64.0	60.0
Average					
Forecast	Pound	368.0	338.0	298.0	293.0
Actual	do	365.0	334.0	[5] 335.0	[5] 301.0
Difference	do	−3.0	−4.0	37.0	8.0
Percentage difference	Percent	−1.0	−1.0	12.0	3.0
Data for 75-percent crop insurance:					
Average for all farms:					
Loss-cost	Pound	3.0	4.6	5.8	7.2
Computed premium rates [6]	do	4.4	5.5	6.7	6.7
Loss-cost margin	do	1.4	.9	.9	−.5
Percentage margin on loss	Percent	47.0	20.0	16.0	−7.0
Federal crop insurance rate, 1945	Pound	11.0	10.3	[7] 11.0	[7] 10.9
West Texas Rolling Plains:					
Yields:					
Yearly	Number	138.0	126.0	60.0	60.0
Average					
Forecast	Pound	144.0	142.0	134.0	145.0
Actual	do	178.0	163.0	[5] 116.0	[5] 101.0
Difference	do	34.0	21.0	−18.0	−44.0
Percentage difference	Percent	24.0	15.0	−13.0	−30.0

Data for 75-percent crop insurance:					
Average for all farms:					
Loss-cost	Pound	7.0	9.1	16.0	23.0
Computed premium rates [6]	do	13.6	13.6	14.0	13.4
Loss-cost margin	do	6.6	4.5	−2.0	−9.6
Percentage margin on loss	Percent	94.0	49.0	−12.0	−42.0
Federal crop insurance rate, 1945	Pound	14.0	12.0	[7] 13.0	[7] 13.0

[1] In the Upper Piedmont, the correlation analysis was based on 198 white owner-operators (male) who bought the farms occupied by them in 1946 and who also met the further condition of having produced cotton in all 3 years from 1944 to 1946. Of the 594 yearly yields thus employed in the correlation analysis, 100, or a 17-percent sample, were selected at random by year and farm to test the equation and method of computing premium rates.

In the West Texas Rolling Plains, the correlation analysis was confined to owner-operators who bought their 1946 farms, and share-renters, both classes of whom used hired labor or hired labor in combination with other types. The yield interval varied from 3 to 9 years. As there were 203 farms without missing values in any of the cells, the total yearly yields represented were 1,374. Of this number, 138, or a 10-percent sample, were selected at random by year and farm for use in the test.

[2] Based on all farms in sample outside the correlation group (317 in Upper Piedmont and 206 in the West Texas Rolling Plains) which reported 3 or more years of yields. In addition, all Negro operators were omitted in the Upper Piedmont, which left 237 farms in the group. In the West Texas Rolling Plains there were 204 farms outside the correlation group. A random selection of 14 percent of the yearly yields in the period 1944–46 for the Upper Piedmont and a 10-percent random selection of the yearly yields in the period 1938–46 for the West Texas Rolling Plains were made in order to perform test II.

[3] Test III was based on all farms similar in characteristics to those in the correlation analysis except time duration of yields. However, only the 1946 actual yield was used in the comparison with estimated yield for each farm. In each sample, a 100-percent sample on 1946 yields was selected.

[4] Test IV was based on farms dissimilar in characteristics (as in test II) to those farms in the correlation analysis. In the Upper Piedmont the 1- and 2-year farms, excluding those in test III, were further refined by dropping all Negro operators. In both areas, the analysis pertains to the 1946 yields and the sample selected on this year was 33 percent of the total cases in the Upper Piedmont and 50 percent of those in the West Texas Rolling Plains.

[5] 1946 actual yield.

[6] Computed according to methods set forth in the Appendix, pp. 117-119.

[7] Basis of FCIC 1946 premium rates.

rates and with the 1945 FCIC premium rates (or the 1946 rate in the case of the 1- and 2-year farms).

The results indicate that the regression equations might be successfully applied to the longer-period farms, either with characteristics like those included in the correlation analysis or without closely analogous characteristics, to forecast yearly yields and premium rates in connection with a specified yield coverage. Furthermore, the average loss-cost for the sample of yearly yields, for farms over the years included in the correlation analysis, was lower than the average premium rate, indicating favorable experience in crop insurance. (The yield period was 1944–46 in the Upper Piedmont and 1938–46 in the West Texas Rolling Plains.) The forecasted yields for both tests I and II in the Upper Piedmont agree closely with actual yields, on the average; but in the West Texas Rolling Plains the forecasted yields were materially lower than the actual yields. The reason for this difference is that the time period for the Upper Piedmont was the same as in the correlation analysis, whereas in the Texas sample all average yields were adjusted to a 9-year basis in order to improve the yield experience. (Average yield was one factor in the regression equation.) As a downward trend existed for most sample farms in the West Texas Rolling Plains, the adjusted average yields were lower to that extent. Consequently, this reduction lowered the forecasted yearly yields relative to their corresponding actual yields (because the latter were taken at random in all periods irrespective of the time duration).

The fact that the regression coefficients could be applied with such a high degree of success to a group of farms not included in the correlation analysis indicates that fairly dependable regression coefficients must have been established by the correlation analysis. Also, the higher level of loss-costs and premiums for the more heterogeneous long-period farms shows the greater risk involved in writing insurance on these farms.

A final comment may be made concerning the small size of the computed premium rates compared with the 1945 FCIC rates in the Upper Piedmont. The difference arises because more than half of the variability in yields was removed by the regression analysis, in contrast with the FCIC rates which did not take into account the factors that influence variability of yields. In the West Texas Rolling Plains, the premium rates by both methods are in close agreement, despite the fact that the regression coefficient accounted for 44 percent of the variation in yearly yields. This indicates that the yield variability in the West Texas Rolling Plains was actually higher than reflected in FCIC rates, an expected result on the basis of the results in the main part of the analysis.

It follows that the rates derived from the regression equation are more flexible, more in line with the yield risks involved, and relatively cheaper on the less risky farms, because they reflect in part the ability of the regression coefficients to forecast yearly yields. Thus, the more successful the forecasts, the lower the error of estimate of yields and the more equitable the premium rates for crop insurance would tend to be.

In applying the regression equations to forecasting yearly yields for the 1- and 2-year farms, it was first necessary to estimate the average yield for a longer period for the farms selected for this phase of the analysis. This was accomplished by using the regression equations for average yield given in table 5, page 74. The procedure thereafter in estimating yearly yields and computing premium rates was the same as with the longer-period farms. But it is apparent from tests III and IV that the methods can be applied with only questionable success to farms having a record of one or two yearly yields.

Application of Regression Method to a Crop-Insurance Program

The first step in applying the method would be to establish for each major type-of-farming area, or for those type-of-farming areas that are closely related, the chief factors that influence yearly yields and their regression coefficients for the major categories of farms. In the interest of simplicity in operation, it would be advisable to limit the number of factors to be included in the regression equation.

In the Upper Piedmont, the quantity of fertilizer applied, the average farm yield, the percentage that cotton acreage harvested was of average acreage, and the percentage that the county's previous yearly yield was of the 6-year average yield, and their various functions, were found to explain 58 percent of the yearly variation in yields, both over time and between farms. In most humid cotton areas, these factors might be adequate. In the subhumid and semiarid areas of the West, a different set of factors would be required (table 9, p. 88).

A problem in the correlation analysis would be to determine the regression coefficients for each major category of farms in each area, if necessary, such as were calculated for a homogeneous group of farms in each of the two sample areas included in the study.[57] In both areas, however, the analysis against premium rates indicates that the regression values could be applied with only slight error to other farms with long-period records in the same homogeneous areas. Therefore, it is believed that an estimating equation based on the observed regression coefficients for an important, homogeneous group of farms might be applied to forecasting yields for all long-period farms of similar characteristics in an area, and to other long-period farms in the area, tentatively.

The use of a regression equation in estimating yields and crop-insurance premium rates would require information on a farmer's yield average and his planned production inputs for the coming crop year. With these data and certain information as to the county yield for the previous year, in relation to the 6-year average county yield, a farmer's yield prospects for the year of insurance could be evaluated. This estimate of yield, together with the calculated error of the estimate obtained from the correlation analysis, would permit the establishment of any level of insurance and of ascertaining its cost to the farmer. His planned production inputs (fertilizer and cotton acreage) would be entered on the contract and would become conditions precedent to his performance of the contract.

[57] In the Upper Piedmont, this group consisted of the owner-operated farms of white males who had bought their farms, whereas in the West Texas Rolling Plains it consisted of owner-operators who had bought their 1946 farms and share-renters, both classes being further limited to those who used hired labor or hired labor in combination with other types of labor.

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ANALYSIS OF FACTORS INFLUENCING COTTON YIELDS AND THEIR VARIABILITY
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An illustration of the application of the regression method of computing the crop-insurance coverage and rate for an individual farm is shown in table 12. This farm, operated by a white male owner who had bought it, had 56 acres, of which 27.7 were in cropland. An average of 6.3 acres of cotton were grown, on which the 1944–46 average yield was 231 pounds. It is presumed that this farmer plans to grow 5.2 acres of cotton in the year of insurance and expects to apply 600 pounds of fertilizer per acre. Therefore, his proposed cotton acreage would be 83 percent of his average acreage.

TABLE 12.—*Example of use of regression method in calculating coverages and premium rates (applied to a farm record obtained in Greenville County, S. C.)*

Factor (1)	Symbol (2)	Unit of measure (3)	Regression value (4)	Planned input (5)	Expected contribution to yield (6)
					Pounds
Fertilizer	X_2	100 pounds	10.4721	6.0	62.8
	$(X_2)^2$		−.6815	36.0	−24.5
1944–46 average yield of cotton.	X_5	100 pounds	88.5821	2.31	204.6
Fertilizer and average yield of cotton.	X_2X_5		1.3640	13.9	19.0
Fertilizer and percentage previous year's yield of cotton is of average.	X_2X_8		−.0466	594.0	−27.7
Percentage cotton acreage planted is of average.	X_9	1 percent	−.2797	83.0	−23.2
Constant additive value	a	Pound	28.8		28.8
Estimated yield following year		Pound			239.8
Estimated error					74.2
75 percent coverage					179.8
Crop insurance premium cost per acre [1]					8.9

[1] See Appendix, p. 117-119 for method of calculation.

The three factors—rate of fertilizer applied, percentage that the cotton acreage is of average, and average yield—are those required of the farmer if the method is to be applied. Another factor (not required from the farmer) is the figure for the county yield for the previous year as a percentage of the average yield for the county over the six preceding years. Although the latter percentage apparently was associated to a negligible degree with the annual yield for the farm, it does seem to be associated with farm yield through a joint association with fertilizer. The relative size of county yield for the previous year appears to reflect a tendency for good and poor crop years to recur at intervals of 5 or 6 years. In 1945, the average yield for the county in which this farm was located was 99 percent of the preceding 6-year average.

With the three farm factors and one county factor, the regression equation was used to ascertain this farmer's yield prospects for the year in question. All computations appear in table 12. Column 4 shows the regression coefficients for each factor, column 5 the planned inputs, and column 6 the effect of each factor on production (column 4 multiplied by column 5). The addition of all effects, plus the value of the constant "a," results in an estimated yield of 239.8 pounds, with a calculated "error of estimate" of 74.2 pounds. With a coverage equal to 75 percent of the predicted yield, this farmer would have an insured yield of 179.8 pounds per acre. His premium rate would be 8.9 pounds —derived from the error of estimate (74.2 pounds) by methods described in Appendix, pages 107-119.

Under field conditions it would be necessary to carry out the calculations shown in table 12. This could be done either on a calculating machine at the office from basic data obtained from the farmer when the application was taken, or earlier. A table similar to table 12 could be prepared for each insured farm, or the stubs and captions could be reversed and the calculations for several farms could be made on one sheet.

The calculations on coverage are simple and are quickly made. The premium rate would be learned by reference to a previously prepared table or graph. The yield-rate relationship could be graphed with the estimated yield on the X-axis and the premium rate on the Y-axis. Varying coverages could be plotted as different lines on the graph. If the error of estimate were considered to vary (it was not, here), a completely new graph would have to be prepared. In any event, the set of premium-rate graphs or tables would apply to an entire type-of-farming area or areas, and this might include a great many farms.

The advantages of using the regression approach for a crop-insurance program are, (1) it would provide a flexible set of yields and rates to reflect basic conditions, (2) it would show variations in production plans, and (3) it would indicate any tendency toward periodic movements in yields. To the extent that periodic variations exist and their presence is recognized, a basis would exist for farmers to profit abnormally from buying insurance when the expectation is for a poor crop year, and to lose out in buying it when a good crop year is in prospect. The regression method removes much of this bias. An additional advantage of the regression approach is that certain important production inputs, reflected in the regression estimate of the forecasted yield, could be written into the contract as controls, and could be made specific conditions for the farmer's performance of the contract. The disadvantages are that the method may be more cumbersome for use in the field than the present area-wide coverage and rate schedules. Under the proposed plan, annual (prospective) yields would be recalculated as the program progressed. However, the method lends flexibility and increased equity to the coverage and rate structure, based on fairly well-established relationships, so that the lower-risk farms have lower rates and the higher-risk farms have the higher rates. Thus, adverse selectivity is reduced.

CONCLUSIONS

The three components of variability in yields are periodic, man-made, and random. In the national yield series for cotton, cycles of 5 or 6 years and multiples of this time interval have persisted for at least the last 40 years. Although the over-all national cycle must be reckoned with, local geographic factors appear to exert a much greater influence when the yield average applies to limited areas and to counties. In the 9-sample counties from the Upper Piedmont in the Cotton Belt, a periodic element appeared in the preceding yearly yield when expressed as a percentage of the 6-year average; the relationship was inverse, and showed up in the individual farm yields. In the Texas 10-sample counties a periodic variation was isolated for the second and ninth preceding years, the former being inverse and the latter direct. Both types of cyclical variations were also found in the yearly yields of individual farms.

The man-made variations in yield may be separated into three major categories—those subject to management, those associated with operator characteristics, and those associated with the inherent characteristics of the farm—which, although not controllable, are subject to managerial selection. Certain characteristics of the farm which were found to be associated with variability of yields were: Soil texture, soil color, and topography (affecting level of yield only). The characteristics of the operator that were associated with yield variability in the Upper Piedmont were: Tenure, color, sex, origin of operator, years of schooling, years of experience, and how farm was acquired if owned. In the West Texas Rolling Plains, many of the same factors were similarly related, but some differed. They follow: Tenure, sex, age of operator, origin of operator, years of schooling, years of experience, and how farm was acquired if owned.

The factors subject to management follow. In the Upper Piedmont: Degree of erosion, kind of labor, extent of use of tractor, years "seed were planted from the breeder," regularity of seed cleaning or treatment or both, rate of fertilizer application, percentage of cropland in cotton, size of cotton enterprise, and average farm yield. In the West Texas Rolling Plains: Degree of erosion, kind of labor (this affected also the percentage abandonment), regularity of seed treatment (this affected percentage abandonment only), percentage of cropland in cotton, percentage of cotton acreage not harvested, and average farm yield. Because of limitations of sample size, it was not possible to ascertain the extent to which the qualitative factors were mutually exclusive. But the net effects of the factors that were subject to differential variation were determined by correlation methods.

Obviously, not all the factors that affected average yield or yield variability could be studied, but some attention was given to them as determined by experiment station results. These results disclosed that these additional factors influenced variability of yields: Analysis of fertilizer, application of barnyard manure, rotation of crops, use of winter cover crops, application of lime, pH of soil, and fertilizer placement with respect to seed. Fertilizer applied in contact with the seed or in close proximity thereto apparently produced very low average yields and very high variability in yields, whereas fertilizer placed in bands 3½ inches to each side of the seed produced high average yields and high yield stability irrespective of the distance of its placement below the seed.

The percentage of abandonment of cotton acreage in the West Texas Rolling Plains—the only area in which it was statistically significant—was found to be associated chiefly with five factors: City-originated farm operators, severity of soil erosion, clay soils, relatively low-efficiency labor, and irregularity of seed cleaning or treatment, or both.

The final element in yield variation is due to one or more random factors. An exhaustive analysis of this factor or factors could not be made. Nor is it possible to indicate its relative importance compared with the other two elements in yearly yields, as the sample and the methods available did not permit elimination of all elements explained in part or wholly by other factors. However, certain weather factors were included in at least one fairly comprehensive analysis in each sample area along with certain of the factors that were subject to differential variation. In the Upper Piedmont, June-plus-July rainfall and August rainfall were included; in the West Texas Rolling Plains, April, May, July, and August rainfall. The net effects of each set of rainfall factors on yearly yield in the respective sample areas probably constituted random influences. Their contributions to yearly yield were significant in both sample areas but were far greater in the West Texas Rolling Plains.

In both sample areas it was found that, as average yields increased, yield variability declined relatively but increased in absolute terms, although less than proportionately.[58] Stability in yields provides an added incentive to obtain high average yields and places a premium on the production practices and management necessary to attain them. As more factors were subject to differential variation in the Upper Piedmont and as the increase in yield from factors common to both sample areas was much greater in that area than in the West Texas Rolling Plains (because of differences in rainfall), the stimulus to reducing yield risk by building up the productivity of lands and otherwise raising the level of yield would be comparatively greater in the Upper Piedmont. Furthermore, as absolute yield variability increased proportionately less than average yield, the cost of insuring a fixed percentage of yield would vary inversely, both absolutely and relatively, with average yield.

Therefore, the cost of insuring a given percentage of the farm-average yield is an inverse function of yield level. Also, because unit costs of production decline as yield rises, the risk cost is in a way a function of the cost of production, in that it parallels cost of production in being inversely related to average yields. Therefore, when a farmer makes capital outlays to raise the level of yield on his farm, his gains are twofold—lower costs of production and lower risk costs per unit.

The returns to capital investments in land and in production improvements are enlarged by this gain in risk cost, which may come as a windfall gain if not recognized by the farmer as one of his reasons for making the expenditures of capital and effort in the first place.

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[58] Other studies have also established this relationship. See articles by MILLER and BAUER (*20, 21, 22*). HALCROW (*12*) has established the same relationship for wheat yields in the Great Plains.

In any event, farmers who have the foresight to make such outlays will probably have a more rapid accumulation of capital over time.

Other findings of notable significance to an understanding of cotton culture in the South were the effects on average yield and yield variability of color and sex of operator, farm inheritance, tractor use, erosion, percentage of cropland in cotton, kind of labor used, and fertilizer. White operators had an advantage over Negro operators in average yield and yield stability in the Upper Piedmont. Men operators showed an equally large differential compared with women operators in both areas. In both sample areas, operators who inherited the farms they were living on in 1946 had a lower average yield and somewhat higher coefficients of variation, although in certain production practices and operator characteristics this group of operators excelled those who bought their farms. The differences between these two groups in production efficiency were apparently due to the superior managerial abilities of the operators who bought rather than inherited.

In the Upper Piedmont, tractor farms had materially higher yields and lower coefficients of variation but they were superior also in most production practices. This raises a question as to whether tractors were directly responsible for the differences, but as an indicator of average yield and yield risk they may serve as a reliable index. In both areas, average yield declined with increased degree of erosion, and also with declines in efficiency of operators in the Upper Piedmont and with quality of labor in the West Texas Rolling Plains.

Variability of yields showed an irregular tendency to increase with degree of erosion. Percentage of cropland in cotton was not closely associated with size of average yield in the Upper Piedmont but was inversely related to the size of the coefficient of variation. In the West Texas Rolling Plains, however, percentage of cropland proved to be a chief factor in both production factors. It was directly associated with average yield and inversely related to yield variability.

In neither sample area was kind of labor related to variability in yields, but it had an influential bearing on average yield. In both areas, the more efficient operators obtained higher average yields from hired labor or from hired labor in combination with other types, whereas inadequate operators were more favored by family and sharecropper labor. In the West Texas Rolling Plains, the kind of labor was closely related to cotton failure, which increased strongly as the efficiency of both the operator and his labor declined. In the Upper Piedmont, the effect of rate of fertilizer application on average yield varied with location. The coefficient of variation, however, reached a minimum with applications of about 700 pounds—a point considerably short of the maximum for average yield. The tendency of the coefficient of variation to reach a minimum short of the maximum, in average yield, from fertilizer applications, was confirmed by data on fertilizer experiments at several points in the Cotton Belt.

White (men) owner-operators who had bought their farms proved to be superior operators in the Upper Piedmont, whereas share-renters were superior in the West Texas Rolling Plains. In both areas, kind of labor was a stable analytical factor from several points of view and it was markedly so in the West Texas Rolling Plains.

As many factors affect average yield and yield variability, a crop-insurance program based on only these two measures might prove to be inadequate in the long run. However, regression forecasts of yearly yields, based on a limited number of basic factors, and those subject to differential variation, indicate that a crop-insurance program based on this approach would have been a success from the loss-cost viewpoint during the years of the study. The preparation of annual forecasts of yields from an area regression equation for a homogeneous group of farms and the crop-insurance premium rate from its error of estimate provide several advantages.

The loss-cost of the insurance (premium cost to the farmer) would be more accurately measured and therefore be made more equitable among farmers. The lower rates to farmers having high average yields and low variability in yields would increase the desirability of the insurance to them; while the higher rates to other farmers would tend to require them to more nearly pay their own way. Moreover, the method would provide a flexible yield and rate structure. As several factors of production would be included in the regression equation, these in themselves would give a large combination of conditions to reflect individual differences between farms.

First, there would be considerable latitude for establishing categories of farms according to qualitative differences between them, such as color of operator, tenure status, etc. Second, a regression procedure to a certain extent gives administrators of crop insurance more controls over production performance. All factors in the regression equation that are subject to differential variation could be written into the contract and become conditions precedent to its performance. Third, as a regression equation would be set up to estimate yearly yields, there would be less necessity for contracts of several years' duration, although they might continue to be desirable from the standpoint of lowering the costs of administration. Fourth, the factors that reflect periodic variations in yields which are included would tend to decrease risk selectivity against the insurer by reducing the applicant's ability to outguess it as to yield outcome in the year of insurance.

A few suggestions may be offered relative to future studies of this sort. Additional basic information should be obtained on seeding and cultural practices, which would include details on placement of fertilizer. That more accurate information on the physical characteristics of individual farms is required appears evident from the relationships obtained in this study even with crude measures of soil type, erosion, and topography. Especially are accurate details on soil type and erosion needed. Information should be obtained as to asset structure or composition and, if possible, as to the relative size of fixed and variable costs. The findings here imply that farms with an inflexible cost structure had lower variability of yields than other farms in the category, presumably because the fluctuations in yields that could be absorbed without seriously affecting the producing unit were more limited.

Analysis of the heterogeneous and unstable tenure groups indicates the need for inclusion of a large number of "lower" class farms. This would require some form of sample stratification, or supplementary sampling, along tenure lines in order to obtain a relatively larger number of such units than of the more homogeneous owners.

A final point may be made in regard to the yield series. As long histories of yield are needed for farms in semiarid areas, field enumeration is of limited applicability. Even with such crops as cotton, in which production is measured in easy-to-remember units, it is not possible to go back in time over 3 years without the risk of serious memory bias. In the case of most other crops, it is not likely that one could get records for more than 2 years with no serious error.

In a humid area, 3 years may give considerable information as to yield variability and perhaps enough information for an initial program of crop insurance, but it is obvious that a time duration of greater length would be required for a broad and adequate program. It appears, therefore, that historical data on individual farms must be built up from the Agricultural Conservation Program, crop insurance, and cooperative accounting records wherever available. But these sources will seldom prove to be adequate. Therefore, some system of keeping records of key data (yield, acreage, fertilizer, etc.) for a group of representative farms, supplementary to the limited data which can be obtained by field enumeration, would need to be developed.

LITERATURE CITED

(1) ACKERMAN, JOSEPH, and NORTON, L. J.
1940. FACTORS AFFECTING SUCCESS OF FARM LOANS, A STUDY OF LENDING EXPERIENCE IN SEVEN COUNTIES IN EAST-CENTRAL ILLINOIS, 1917–1933. Ill. Agr. Expt. Sta. Bul. 468, pp. 520-522.

(2) BENNETT, H. H.
1939. SOIL CONSERVATION. New York and London, McGraw-Hill Book Co. pp. 217 and 220.

(3) BONSOR, H. J., KERBY, L. G., and SCHMIDT, A. K.
1944. QUALITY OF LAND AS A FACTOR IN FARM ORGANIZATION, CROP YIELDS, AND FARM INCOME IN ROANE COUNTY, TENNESSEE. Tenn. Agr. Expt. Sta. Rural Research Ser. Monog. 172, pp. iv-v.

(4) BRODELL, A. P., and EWING, J. A.
1948. USE OF TRACTOR POWER, ANIMAL POWER AND HAND METHODS IN CROP PRODUCTION. U. S. Bur. Agr. Econ. F. M. 69.

(5) BUIE, T. S., and WARNER, J. D.
1928. COTTON FERTILIZER EXPERIMENTS. S. C. Agr. Expt. Sta. Bul. 245, 32 pp., illus.

(6) CROXTON, FREDERICK E., and COWDEN, DUDLEY J.
1941. APPLIED GENERAL STATISTICS. New York, pp. 246-249.

(7) FULMER, JOHN L.
1950. AGRICULTURAL PROGRESS IN THE COTTON BELT SINCE 1920. Chapel Hill. Ch. IV.

(8) ———
1942. RELATIONSHIP OF THE CYCLE IN YIELDS OF COTTON AND APPLES TO SOLAR AND SKY RADIATION. Quart. Jour. Econ. 56: 385-405.

(9) ———
1937. TYPES OF FARMING AND FARM BUSINESS STUDIES IN SOUTH CAROLINA. S. C. Agr. Expt. Sta. Bul. 310, p. 28.

(10) GREEN, R. E. L., JAMES, BROOKS, and DAWSON, C. G.
1947. FARM MECHANIZATION IN THE PIEDMONT. N. C. Agr. Expt. Sta. Tech. Bul. 84, pp. 3, 6, 12, and 26-31.

(11) GROSS, E. E.
1938. A COMPILATION OF EXPERIMENTAL DATA ON COTTON FERTILIZERS APPLICABLE TO THE HILL SECTIONS OF MISSISSIPPI. Miss. Agr. Expt. Sta. Bul. 321, 93 pp.

(12) HALCROW, HAROLD G.
1949. ACTUARIAL STRUCTURES FOR CROP INSURANCE. Jour. Farm Econ. 31: 418-443.

(13) HALE, G. A.
1933. THE EFFECT OF LATITUDE, LENGTH OF GROWING SEASON, AND PLACE OF ORIGIN OF SEED ON THE YIELD OF COTTON VARIETIES. Jour. Agr. Research 46: 731-737.

(14) HENDRICKS, WALTER A.
1942. THE THEORY OF SAMPLING, WITH SPECIAL REFERENCE TO THE COLLECTION AND INTERPRETATION OF AGRICULTURAL STATISTICS. U. S. Bur. Agr. Econ. and N. C. State Col. Agr. and Engin. Raleigh, N. C., pp. 3-19, 102-113.

(15) HILL, F. F.
1932. AN ANALYSIS OF THE LOANING OPERATIONS OF THE FEDERAL LAND BANK OF SPRINGFIELD FROM ITS ORGANIZATION IN MARCH, 1917 TO MAY 31, 1929. N. Y. (Cornell) Agr. Expt. Sta. Bul. 549, pp. 45-48.

(16) KENDALL, MAURICE G.
1946. THE ADVANCED THEORY OF STATISTICS. Vol. II. London. Chs. 29-30.

(17) LATHAM, E. E.
1940. RELATIVE PRODUCTIVITY OF THE A HORIZON OF CECIL SANDY LOAM AND THE B AND C HORIZONS EXPOSED BY EROSION. Amer. Soc. Agron. Jour. 32: 950-954.

(18) LEIGHTY, CLYDE E.
1938. CROP ROTATION. U. S. Dept. Agr. Soils and Men, Yearbook Agr. 1938: 409.

(19) MESICK, D. O.
1949. FARM MACHINERY. U. S. Bur. Agr. Econ. [Processed.]

(20) MILLER, L. B., and BAUER, C. F.
1937. THE EFFECT OF SOIL TREATMENT IN STABILIZING YIELDS OF WINTER WHEAT. Amer. Soc. Agron. Jour. 29 (9): 728-739.

(21) ———
1938. THE EFFECT OF SOIL TREATMENT IN STABILIZING YIELDS OF CORN. Amer. Soc. Agron. Jour. 30 (8): 699-708.

(22) ———
1943. THE EFFECT OF SOIL AND SOIL TREATMENT ON STABILITY OF CROP PRODUCTION. Amer. Soc. Agron. Jour. 35 (6): 475-481.

(23) MISSISSIPPI AGRICULTURAL EXPERIMENT STATION.
1933-1950. INFORMATION SHEET. 133, 163, 234. State College.

(24) PADEN, W. R.
1937. RESPONSES FROM VARIOUS SOURCES OF NITROGEN FERTILIZER. S. C. Agr. Expt. Sta. Bul. 309, 40 pp., illus.

(25) PETERSON, M. J.
1941. AN ECONOMIC STUDY OF AGRICULTURE IN THE LITTLE BEAVERDAM CREEK AREA, ANDERSON COUNTY, SOUTH CAROLINA. S. C. Agr. Expt. Sta. Bul. 332, pp. 20-21.

(26) REYNOLDS, E. B., MCNESS, G. T., HALL, R. A., JOHNSON, P. R., STANSEL, R. H., DUNLAVY, HENRY, DUNKLE, P. B., and MORRIS, H. F.
1932. FERTILIZER EXPERIMENTS WITH COTTON. Tex. Agr. Expt. Sta. Bul. 469, 31 pp.

(27) RICE, T. D., and ALEXANDER, L. T.
1938. THE PHYSICAL NATURE OF SOIL. U. S. Dept. Agr. Soils and Men, Yearbook Agr. 1938: 892-893.

(28) ROBERT, J. C.
1940. MAXIMUM YIELDS OF COTTON WITH FOUR-TON MANURE APPLICATION. POPLARVILLE TESTS SHOW CAPACITY OF NEGLECTED SOURCE. Miss. Farm Research 3 (5): 1-2.

(29) SNEDECOR, GEORGE W.
1946. STATISTICAL METHODS. Edition 4. Ames, Iowa, pp. 40, 47-49.

(30) SOUTH CAROLINA AGRICULTURAL EXPERIMENT STATION.
1940-1943. ANNUAL REPORTS 53, 55-56. Clemson.

(31) TEXAS AGRICULTURAL EXPERIMENT STATION. PROGRESS REPORT 515, 4 pp. 1938. (Mimeographed.)

(32) TYLER, HOWARD S.
1939. FACTORS AFFECTING LABOR INCOMES ON NEW YORK FARMS. N. Y. (Cornell) Agr. Col. Ext. Bul. 401.

(33) UNITED STATES AGRICULTURAL ADJUSTMENT ADMINISTRATION.
1936. EFFECTS OF WINTER SOIL-CONSERVING CROPS. A COMPILATION OF EXPERIMENTAL WORK ON WINTER SOIL-CONSERVING CROPS IN THE SOUTHERN REGION AND NEARBY STATES. U. S. Agr. Adjust. Admin. SRAC 2, 54 pp.

(34) WEIR, WILBERT W.
1926. A STUDY OF THE VALUE OF CROP ROTATION IN RELATION TO SOIL PRODUCTIVITY. U. S. Dept. Agr. Dept. Bul. 1377, 68 pp., illus.

(35) UNITED STATES DEPARTMENT OF AGRICULTURE.
1941. CLIMATE AND MAN. U. S. Dept. Agr. Yearbook Agr. 1941. Washington, Govt. Print. Off. pp. 29 and 293.

APPENDIX

Results from Agricultural Experiments

Any study of experimental results from agricultural experiment stations in the South is subject to many obstacles. Many publications are out of print and some are not readily accessible without considerable expenditure of effort that takes time. A more important difficulty is the lack of comparability between experiments from different locations on the same subject. The differences in location are important but are not nearly so serious as are the differences in soil type and treatment of the soil before and even during the course of the experiment. Rotations, crop sequences, and manure and fertilizer treatments, vary greatly in these researches.

However, by studying the conditions of the experiments some unifying characteristics may be found, although they are often only remotely unifying. Consequently, considerable judgment was applied in the assembly and classification of experiments in order to get them in reasonably similar groups and to obtain results that were logical and subject to valid interpretation.

RESULTS FOR PIEDMONT AND COASTAL PLAIN SOILS

In table 41, pp. 154-155, are given, in condensed form, the results of a few representative experiments on the soils of the Piedmont and the Coastal Plains (*24*; *30*; *33*; *34*). The experiments were made within the 30 years between 1914 and 1943. The effects are shown of winter cover crops, liming, pH value, crop rotations, and of some of these in various combinations on (1) average yield, (2) the coefficient of variation in yields, and (3) trend in yield. In addition, in order to aid in interpretation, the table contains information on the location of the experiment and the soil type, fertilizer practices, and crop rotation followed in the experiment.

The data show many significant relationships but the main conclusion is that, irrespective of soil type, location, and other conditions that influence any given experiment, higher average yields, greater yield stability, and sharper upward trends in yields resulted from good than from poor land-management practices. With one exception, crop rotation of cotton improved the yield and lowered yield variability. The exception concerned rotation with fertilizer in the 5-year experiment at Florence, S. C. (*34, pp. 42-43*). As 1,000 pounds of fertilizer were applied, it is apparent on the basis of other results, that the minimum point in yield variability attributable to quantity of fertilizer applied had already been passed. (See fig. 11, page 60.)

In the case of winter legumes, the story is substantially the same as with crop rotation—average yield was raised and yield variability was lowered by growing and turning under Austrian peas for green manure. The one exception in yield variability occurred in the St. Joseph's (La.) experiments (*33, pp. 7-8*). These experiments which were of 6 years' duration, were conducted on Sarpy sandy loam, a soil of very low fertility, without benefit of fertilizer. It would appear that the increase in organic matter was to some extent harmful to the crop. Fertilizer would have helped undoubtedly. Sarpy soil is described as of very low fertility at St. Joseph's. However, in the Mississippi

Delta it is regarded as one of the more productive and dependable soils for cotton production.

Striking results appear both with lime and pH in the experiments that took place on the heavier soils. The effect of lime on the light soils is more intricate and difficult to interpret. In the experiments at Clemson, S. C. (*30, p. 37 of 56 annual report*), on Cecil sandy loam (a heavy soil), the effect of lime, on both increasing yields and reducing yield variability, was notable. Although the variability of yields declined with the usage of lime and fertilizer in combination, the application of lime without fertilizer gave the highest percentage increase in average yields and also the largest percentage decrease—by far—in the variability of yields.

The tests of cotton yields against various pH's bear out the findings with regard to lime. Between 5.0 and 6.5 pH, each 0.5 increase in pH raised decidedly the average yield and lowered the variability of yields. It is not easy to explain this relationship, as cotton is considered an acid-tolerant plant. It is suggested here that the increase in pH may have increased the availability of certain minerals (already present) as plant food elements in the heavy Cecil soils. The physical condition of the soil was undoubtedly improved and perhaps some minor element or elements also were made available.

The use of lime, either alone or with green manure crops and in conjunction with fertilizer, on the Tifton sandy loam in Georgia (a light soil of low fertility) tended to lower yields and to increase variability of yields, (*33, p. 32*). The best response with varying rates of fertilizer came with green manures, the poorest with lime, and there was an intermediate response when both green manures and lime were used. Typically, the coefficient of variation dropped off with increased applications of fertilizer when combined with green manure, reaching a minimum with an application of 300 pounds of 2-8-6, whereas yields continued to rise with increased applications of fertilizer. On the other hand, combining fertilizer with green manures and lime reversed this tendency, causing variability of yields to increase with increased rates of fertilizer application.

The only explanation to be offered for these relationships is that the light sandy soil in question, which is naturally deficient in minerals, was probably low in organic matter. The application of lime or a large application of fertilizer may have provided a concentration of plant food and brought about increased biological activity in the soil. As the soil is sandy, no ordinary improvement in physical structure was probable. Therefore the conclusion here drawn is that, with the experimental facts available, extensive management of the soil by the use of fertilizers and lime on such soils may be complicated and subject to difficulties.

A majority of the trends in yields were negative, not so much because of the treatment, or lack of it, as because of unfavorable weather and boll-weevil conditions which existed during the period of the experiments. However, an examination of trends shows that, almost without exception (pH is an exception), as the treatment increased in scope the trends were favorably affected. They declined less than they did under the lower type of practice being compared. That is, trend in yield tended to be improved by better land management, either from a large trend to a small negative or from a small minus or small positive trend to a healthy upward trend. The conclusion here drawn is that the desirable phases of soil management increased the level of yields and the yield stability and that the gain probably extended beyond the experimental period.

RATE OF FERTILIZER APPLICATION

In figure 15 is shown the effect of rate of application of fertilizer on yield and yield variability at three main locations in the Cotton Belt. The results are based on 16 experiments—5 in South Carolina and Georgia (*5, 11*), 6 in Mississippi (*11, 23, 28*), and 5 in Texas (*26*). (E. B. Reynolds of the College Station Staff supplied additional information for both the Angleton and College Station experiments by correspondence.) At least 16 soil types were represented, although the majority were for Coastal Plains soils. Despite determined effort by the authors to select experiments that were similar in basic conditions, considerable heterogeneity existed with respect to crop rotations, to residual effects at the beginning of the experiments, and to changes in experimental controls during the course of the experiments. Despite these difficulties, the results are in accordance with expectations, and the irregularities are not large enough to preclude interpretation.

Without dwelling on differences between the experimental groups at the different locations, several tendencies which have a bearing on the main study are selected.[50] For one thing, it is apparent that the response of yield to fertilizer applications was positive up to the limit of the rates on all except one soil category—the four terrace and bottom soils of Mississippi—where output reached a maximum at 1,800 pounds. Also, typical of such experiments, the response was greater from the earlier than from the later doses. Irregularities are to be noted between 600 and 1,200 pounds in both input-output series for the South Carolina and Georgia experiments, but the relationships shown leave little doubt of the underlying tendency for increased yields to result from the use of increased amounts of fertilizer.

In the case of the coefficient of variation, shown in the lower section of figure 15, a well-defined minimum was detected in all experimental categories, although more strongly so in the case of the South Carolina and Georgia experiments. The lowest coefficient of variation in yields (highest relative stability), took place between 400 and 1,000 pounds on the Coastal Plains soils and between 200 and 800 pounds on Piedmont soil in South Carolina. On both categories of Mississippi soils, it occurred between 600 and 1,200 pounds; and at 400 pounds as an average for the five Texas experiments. In no soil category did the greatest relative stability in yields coincide with either the greatest or the least change in input-output response. It tended to coincide with that part of the response curve in which the rate of increase in

[50] It is noted (fig. 15) that the Piedmont soil in South Carolina and Georgia appears at a lower level of yield in the early stages of the rates and contrariwise the variability ranges higher. In Mississippi, the differences between upland and bottom soils are in the same direction, and are much larger. As the former is based on only one experiment and the latter on only two, no significance should be attached either to the differences or to the associations at this point, although they are in line with findings from the farm surveys. See pp. 57-61.

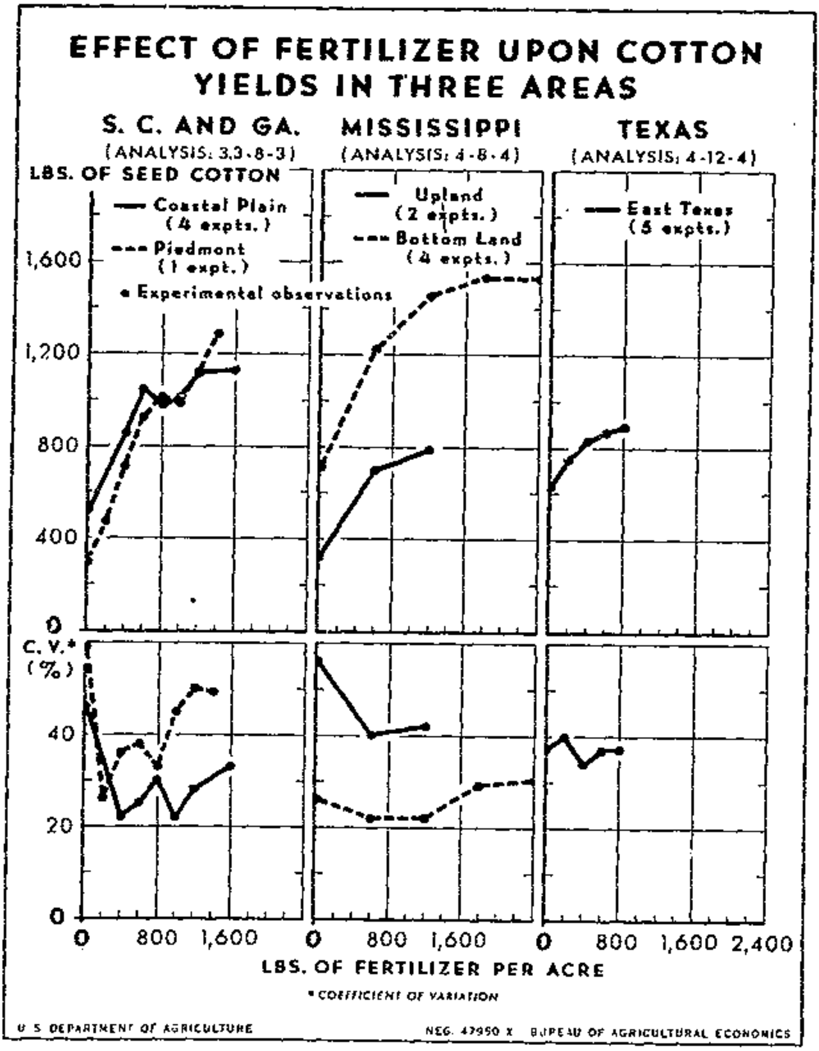

FIGURE 15.—In all States except Texas, variability of yields averaged higher on unfertilized soils. Averages for the experiments in all States show that yields responded to increased fertilizer applications at the higher rates, except on the bottom lands in Mississippi, where a decline occurred between applications of 1,800 and 2,400 pounds. There was some irregularity in response at rates between 600 and 1,200 pounds in the South Carolina and Georgia experiments; but the tendency for increasing yields to be associated with increased use of fertilizer appears to underlie the irregularities. The minimum coefficient of variation appears to have been reached on the four Coastal Plains soils (in South Carolina and Georgia) between 400 and 1,000 pounds; on both categories of soils in Mississippi between 600 and 1,200 pounds; and on five soils in Texas at 400 pounds, as an average. Only one kind of soil was reported for the Piedmont—Cecil gravelly sandy loam in South Carolina, on which the minimum was reached at 200 pounds of fertilizer, with a secondary minimum at 800 pounds. (Based on 16 experiments conducted over relatively long periods between 1920 and 1940.)

yield was moderate and after the rate of increase had begun to diminish.

The higher variability associated with the earlier stages of the output curve is perhaps due to the slow build-up in concentration of fertilizer in the soil relative to plant needs, and that in the later stages to an approaching excess concentration of fertilizer and hence damage to the plant in some seasons. So far as the intermediate stages are concerned the greater instability of the output curve probably reflects an approach to the optimum concentration of fertilizer for plant growth, considering the differences in soil texture, depth, tilth, content of organic matter, water-holding capacity, and variations in the weather by seasons.

With the exception of the Texas experiments, all soil categories had the highest variability yields when no fertilizer was used. In Texas, the variability was just slightly higher when 200 pounds were applied to the five soil types, on the average, than from the unfertilized soils. In Texas also, rainfall averages much lower than in any of the other locations. Moreover, the soils in much of Texas tend to run high in minerals because of soil processes which favor their retention, so the Texas soils do not have the need for fertilizers which some cotton soils in the Eastern States have. They are in a higher scale of fertility and the response of neither yield nor yield stability to fertilizer applications can be as great as on soils that begin at a lower scale.

From the foregoing discussion, it is apparent that not only the output response but the effects of fertilizer on yield variability vary with the inherent fertility of the soil, the soil humus, the various factors of physical structure, and the climatic factors of the locality. Consequently, each major soil type may be expected to have its own peculiar characteristics as to output response and optimum yield stability from fertilizer applications. That the 16 experiments summarized in figure 15 tended to have considerable individuality in this last-named characteristic is shown by the data in table 13. These data have been summarized as a frequency count to show where each minimum coefficient of variability of yields fell with respect to the various fertilizer rates in connection with the 16 experiments. In two of the three locations, 9 or 10 experiments had different rates for highest yield stability.

In the Texas experiments, the location varied less but even so the five experiments had three different minima for the coefficient of variation. Despite the great range in the minima, however, the character of the decrease to each of them and the character of the increase above them make the respective rate means of the minima for the group of experiments fairly representative, as shown in figure 15. These results are comparable with those obtained from the correlation analysis with farm surveys from the Upper Piedmont.

PLANT-FOOD ELEMENTS

The effect of the three major plant-food elements (nitrogen, phosphorus, and potassium) on yield and its variability is given in figure 16. The results shown are based on the five experiments made in South Carolina and Georgia (*11, 5*). As before, lack of uniformity in the basic experimental conditions affects the results, but the averages indicate the influence of the different elements on yield risk. Obviously the results from so few experiments afford only an indication of possible relationships. To gain a comprehensive and reliable view of these, many experiments, or a sampling study of sufficient scope would be required to provide the necessary statistical significance.

TABLE 13.—*Location of point of lowest coefficient of variation in yields from fertilizer experiments in different regions of the Cotton Belt*

Fertilizer application	Experiments					
	Eastern States [1]		Mississippi [2]		Texas [3]	
	Different rates	Minimum rate	Different rates	Minimum rate	Different rates	Minimum rate
Pounds	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
0	5	0	5	1	5	1
200	3	2	1	0	5	0
300	1	0				
400	4	1	1	0	5	2
600	4	0	6	1	5	2
800	4	0	2	1	5	0
900	1	1				
1,000	4	1	2	0	1	0
1,200	5	0	6	1		
1,400	3	0				
1,600	3	0				
1,800			4	1		
2,400			4	1		

[1] Four experiments in South Carolina and one in Georgia (*5, pp. 15-16; 11, pp. 8-10, 32; 28*). Of the five experiments, four were on Coastal Plain soils. On three experiments 3.3-8-3 fertilizer was used, on one 2.5-9-5, and on the other 4-8-3. Period of experiments—1920 to 1934, but primarily between 1920 and 1927.

[2] In the Mississippi experiments (*11, pp. 17, 19; 23; 28*) 4-8-4 fertilizer was used on five experiments, and 4-8-8 on one. Period of experiments—1925 to 1940, but primarily between 1931 and 1940.

[3] In the Texas experiments 4-12-4 fertilizer was used on all (five) plots (*26, pp. 11, 13, 19, 24*). Period of experiments—1927 to 1940.

The data in the chart indicate that, despite the great differences between the two soil categories, the minima in the coefficient of variability agreed except for nitrogen, which was at 3.3 percent on the sandy Coastal Plain soils and at 5 percent on the Cecil gravelly sandy loam (Piedmont soil). Contrary to the effect of rate of fertilizer application on yield variability, the highest coefficient of variation was not always found on the soils receiving zero percent of the element in question.[60] More variability was associated with some of the

[60] Zero percent for an element does not mean zero fertilizer as in the case of the rates. As the plot-rates varied between 600 and 1,000 pounds per acre, one may question whether an element effect on variability or an imbalance effect is obtained. The minimum in variability with rates of fertilizer application was reached between 400 and 1,000 pounds on the Coastal soils and between 200 and 800 on the Piedmont soil. Therefore, the experiments begin with near the optimum quantity of fertilizer for yield stability except for the element studied.

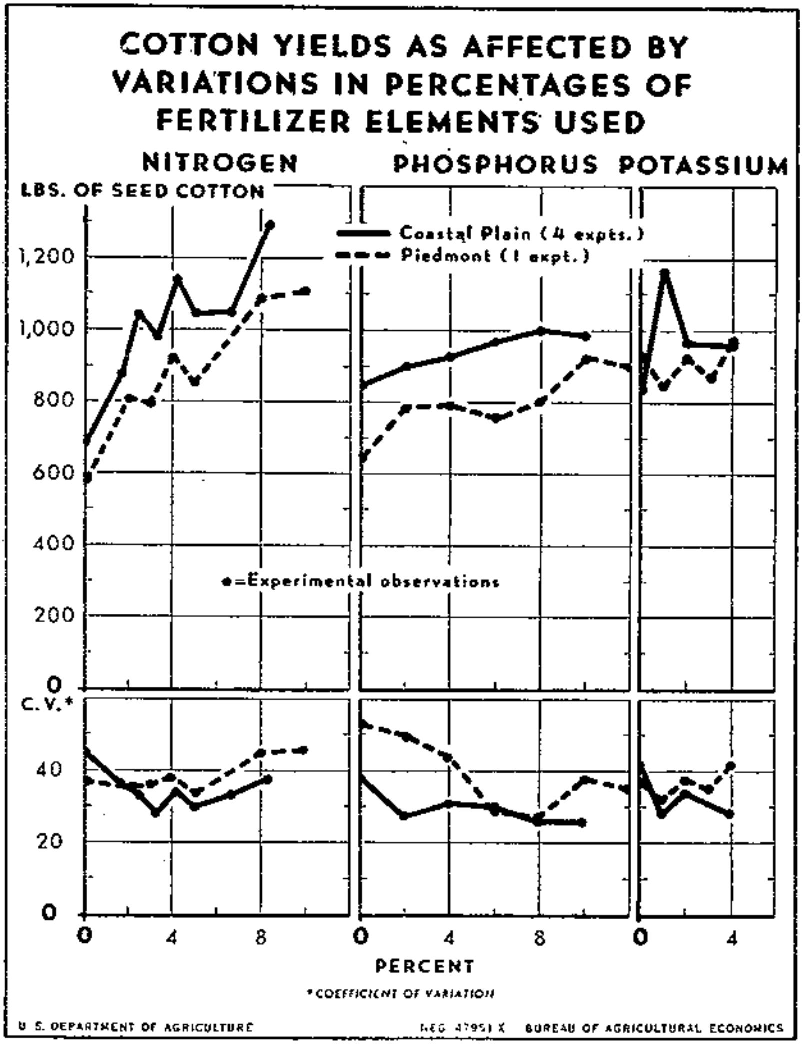

Figure 16.—On both kinds of soils the significant points (maximum average yield and minimum coefficient of variation) agreed rather closely except for nitrogen for which the minimum coefficient of variation apparently occurred at a higher concentration on the Piedmont soil (Cecil gravelly sandy loam) than on the four Coastal Plain soils. The results indicate that yield variability might be minimized with respect to all three elements with a commercial fertilizer analysis of 5-8-1 on Cecil gravelly sandy loam and 3.3-10-1 on the Coastal Plain soils. To achieve a maximum in average yield the analyses apparently would have to be 10-10-4 and 8.3-8-1 respectively. The point of most economical use of the fertilizer elements, however, would be somewhere between the analysis maximizing average yield and that minimizing variability of yields. (Based on 4 fertilizer experiments in South Carolina—3 in the Coastal Plain (*11, pp. 8-10*) and 1 in the Piedmont (*5, pp. 15-16*)—and 1 in Georgia Coastal Plain (*11, p. 32*) in which varying quantities of the fertilizer elements were used.)

higher concentrations of nitrogen and potash than at zero content, in the case of the Piedmont soil.

From the standpoint of average yield some effects of the different elements are worthy of note. Only nitrogen was associated with a strong positive influence on average yield throughout the range of the experiments on both kinds of soils, although some irregularities appear for the intermediate percentages. Phosphorus was associated with a regular and consistent increase to 8 percent, on the average, for the Coastal Plain soils. On the Piedmont soil the increases in yield associated with increased concentration were more erratic, although they persisted longer. The experiments indicate no definite effect of potassium on average yield.

Considering the average yield and the coefficient of variation together, apparently the greatest stability in yield from nitrogen was in the intermediate stage of the input-output curve, where a moderate rate of increase in output from input prevailed. In the case of phosphorus, the greatest stability occurred near the upper limit of the output curve where the increase in yield was at a low rate. With potassium, yields did not appear to be much more stable at one point on the yield curve than at another, in the case of either kind of soil.

According to these experiments, the minima in variability of yields from all three elements may be obtained by using commercial fertilizers analyzing 5-8-1 and 3.3-10-1 for the Piedmont soil and the Coastal Plain soils, respectively. The maximum average yield could be realized only by applying much more concentrated analyses to the two categories of soils—about 10-10-4 in the Piedmont and 8.3-8-1 in the Coastal Plain. These statements are not intended as recommendations of fertilizer analysis or of fertilizer use but only as summarizations of what five experiments show. The point of economic use, however, would probably be somewhere between the analysis maximizing average yield and that minimizing variability of yields.

FERTILIZER PLACEMENT

Many other problems in use of fertilizer affect variability of yields—time of application, fertilizer supplements, size of fertilizer particles in relation to soil texture, and sources of plant-food elements. All have been shown experimentally to have a bearing on average yield, and to affect somewhat the variability of yields. The scope of this investigation, however, does not permit much further exploration. In this connection, a series of experiments, the results of which should be examined, pertains to the effect of method of fertilizer placement on average yield and yield variability. This is an important question and these results indicate some of the effects to be expected from careless and excessive use of fertilizer.

These experiments were conducted during 1930–33 at Florence, S. C., on Ruston and Norfolk sandy soils (*11, p. 91*). Fertilizer of 4-8-4 analysis was applied at the rate of 800 pounds per acre. The variable under investigation was the distribution of fertilizer—as to direction, distance, and dispersion—with respect to the seed. Where used, the quantity of fertilizer (800 pounds) varied in distribution from contact with the seed to 3 inches below it, and was dispersed in single and double bands.

The results of these experiments are given in table 14. Fertilizer placed in contact with seed, in concentrated bands, and of insufficient depth, produced the poorest yields and the highest coefficients of variability (in excess of 100 percent), because of the zero yields which occurred. This may be explained on the ground that an excess con-

TABLE 14.—*Placement of fertilizer relative to seed on average yield of seed cotton and yield variability*[1]

Placement of fertilizer relative to seed	Yield of seed cotton		
	Average	Standard deviation	Coefficient of variation
	Pounds	*Pounds*	*Percent*
No fertilizer used	1,388	552	40
Fertilizer placed in contact with seed	175	290	166
Fertilizer placed in 1¾-inch single band:			
1 inch below seed	272	467	172
2 inches below seed	1,074	474	44
3 inches below seed	1,292	378	29
Fertilizer placed in 3½-inch single band:			
1 inch below seed	316	520	165
2 inches below seed	1,321	414	31
3 inches below seed	1,482	407	27
Fertilizer mixed with seed	1,399	423	30
Fertilizer placed in bands 1½ inches to each side of seed:			
1 inch below level of seed	1,536	403	26
2 inches below level of seed	1,535	329	21
3 inches below level of seed	1,628	368	23
Fertilizer placed in bands 3½ inches to each side of seed:			
1 inch below level of seed	1,604	396	25
2 inches below level of seed	1,608	376	23
3 inches below level of seed	1,620	344	21

[1] Based on fertilizer experiments at Florence, S. C., 1930 to 1933; where used, fertilizer was applied at the rate of 800 pounds of 4–8–4 per acre; soil types—Ruston and Norfolk fine sandy loam (*11, p. 91*).

centration of fertilizer prevented the seed from germinating. Bands of fertilizer, to each side of the seed and placed 3 inches below it gave the highest yields and generally the lowest variability in yields. As the unfertilized soil also produced comparatively high yields, indicating good soil, only the proper location of the fertilizer relative to the seed made it possible to obtain an economic return from the use of fertilizer. It is apparent that the higher the rate of fertilizer application the more important become the details of its distribution. This is a management problem and apparently it has a significant effect on the average level of yield and an even more vital effect on stability of yields.

BARNYARD MANURE

Although barnyard manure supplies some of the major plant-food elements, its greatest influence on plant growth comes from its effect on the physical structure of the soil through its contribution of organic matter, and as a stimulus to bacterial activity. Its effect on the structure and tilth of soils in the South, which have long been overcropped by cotton and scoured by erosion, cannot be overemphasized. Manure will increase crop yields from a "gall spot" or from lands that have lost all of the A-horizon more readily than fertilizer will, and with less danger of crop loss. Agronomists recognize this and have encouraged farmers in the region to use barnyard manure for these purposes when it is available. The characteristics of many of the soils, especially the upland soils, present strong arguments for increased livestock farming in the South.

Results of only a few experiments can be found in which the effects of manure on yields have been measured on a controlled basis over a period of years. Also, in putting together the few experiments that are available in report form, the difficulties encountered from incomparability as to conditions, of course, affect the results. Three of these experiments were selected to typify what might be expected from applications of manure (*26; 28; 30, p. 94 of 53rd annual report.*) The reader is reminded that the results provide only indications, not conclusions, as to what manure can do, because the number of experiments is small.

The results are presented in comparative charts in figure 17. In all three experiments, applications of manure had a favorable influence on both average yield and yield stability. Surprisingly, the greatest effects were obtained from the soils in Mississippi and Texas, especially Mississippi. These differences in response can be explained largely by the differences in soil fertility at the beginning of the experiments. The Cecil soil at Clemson had been subjected to good soil management over a period of years; it was in a high state of fertility. In addition, these plots received 600 pounds of 4-8-4 fertilizer and a side application of 100 pounds of nitrate of soda.

Previous studies of the effect of fertilizer on variability of yields show that this rate of application gives just about maximum yield stability. Therefore, the Clemson soil shows the effect of a high rate of fertilizer application combined with additions of manure, on yield level and variability of yields. There were further gains in stability of yields and in average yield but not so much as from the relatively poorer Ruston soil in Mississippi. On the other hand, the Clemson experiments resulted in greater gains in average yields and lesser gains in yield stability than were obtained on the Texas soils.

On the basis of the Mississippi and Texas experiments (*26, 28*), it appears that minimum variability of yields was realized with 8-10 tons of manure, whereas the limit of increase in yields appears to be somewhere beyond the experimental limit of 12 tons.[61]

[61] The Clemson experiment involved only two rates of manure application, from which the points of maximum yield and minimum yield variability were not apparent. The point of greatest economic return is almost always short of the point of maximum physical output, because the equality of marginal returns with marginal costs occurs earlier.

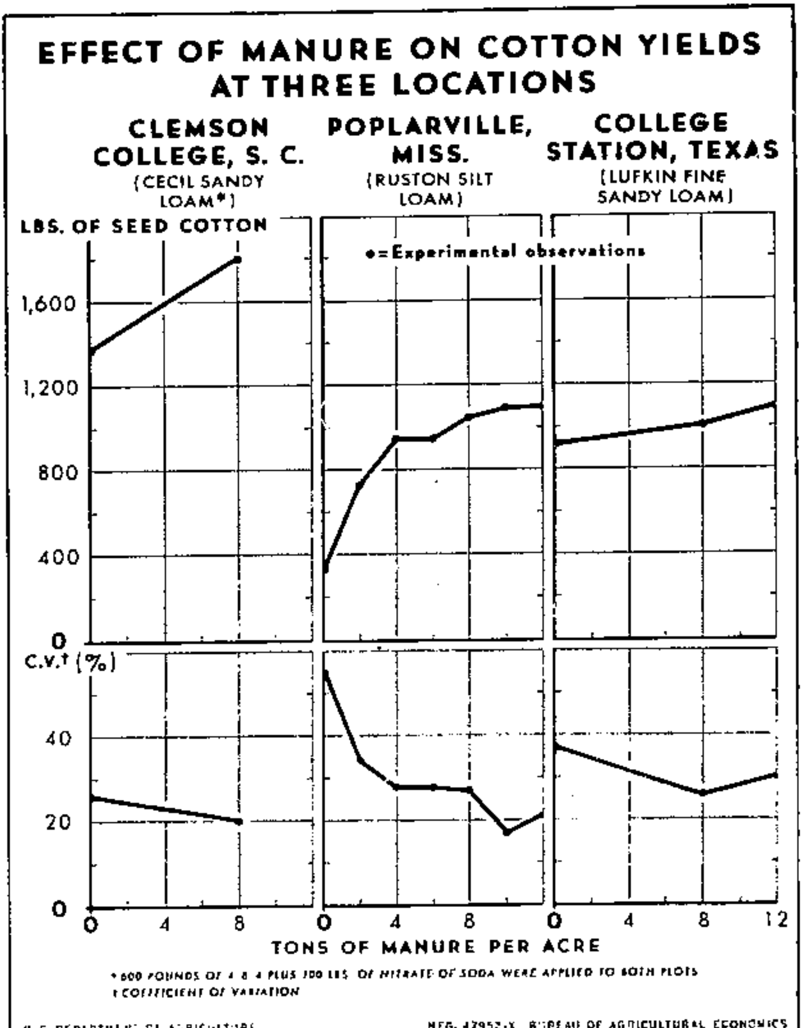

Figure 17.—Increased applications of barnyard manure were associated with higher average yields and lower variability in yields. The minimum coefficient of variation appeared to occur around 8 or 10 tons.

Methods Used in Computing Crop-Insurance Premium Rates

The method outlined below is based upon the assumption that the errors of forecasting any yearly yield are randomly distributed according to the normal curve of error. As, in any crop-insurance program, only those actual yields that fall short of the guaranteed yield would result in loss, only the contingencies of such occurrences as reflected by only one tail of the normal curve of error need be evaluated. This can be made clear by examining figure 18. This figure represents the normal probability curve. *OY* is its ordinate and *OX* its abscissa. The ordinate measures the occurrences in ratio to unity (or one), whereas the abscissa designates the possible errors in forecasted yields. The problem in calculating premium rates in crop insurance consists in evaluating the deviations in actual yield below the mean (or the level of yield selected) and the frequencies of their occurrence. The departures below the insured yield must be combined, then, with the probabilities that they will occur. When these two are put together, the actuarial rate, or cost of insuring the forecasted yield, or any percentage of it, is obtained.

In figure 18, M is the forecasted yield per acre; C equals the level of the forecasted yield that will be insured; A represents the total con-

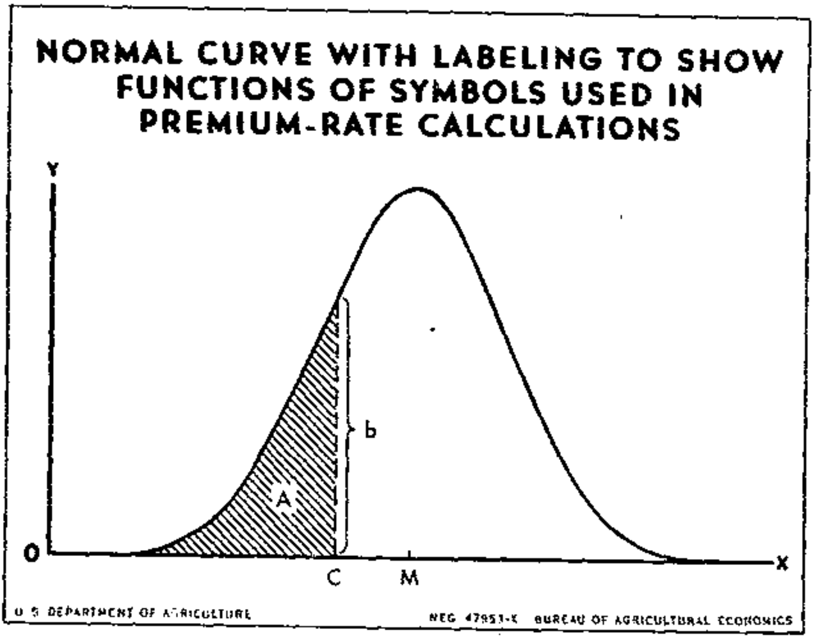

FIGURE 18.—Area "A," as a fractional part of the total area under the curve, represents the probability that the forecasted yield will fall below the insured yield "C."

tingencies (portion of the total area under the curve) falling between C and σ; b is the ordinate (frequency of occurrence reduced to a decimal fraction of the total) of the curve of errors at the yield level to be insured. In the problem, σ represents the standard error of estimate of the yearly yield in question.[62]

The formula for the loss which would be expected per acre for a large number of farms under a given yield guarantee is:

$$L=0.4\,\sigma\,(b)-A\,(M-C)$$

[62] The standard error of estimate has been used instead of the standard error of forecast (by Henry Schultz) as a large number of farms are studied. Also much labor in computation was saved by using the standard error instead of the error of forecast. Furthermore, with a fairly high index of correlation, it did not appear that the standard error of forecast would have increased the rate greatly except in a very few cases.

All symbols are as described above except L which equals the actuarial value of the loss per acre.[63] The loss may or may not be taken as the premium rate, depending upon whether corrections are to be made for risk factors not evaluated by the regression equation, and whether administrative expenses are to be included. In applying the formula, only two values must be obtained from the regression equation, M (forecasted yield) and σ (the forecasted yield's error of estimate).

To show the application of the formula, it is assumed that the yield forecast for an individual farm in the year of insurance, under several conditions that influence yield, is 348 pounds of lint cotton per acre; and that the error of estimate of this yield is 105 pounds. This means that there are two chances in three that the forecast will be off not more than 105 pounds, either plus or minus; and under the assumption that the errors are symmetrically distributed, there would be only one chance in three that the forecast will be 105 pounds too high or too low for any given year, and one chance in six that it will be too low by 105 pounds. This gives some idea of the size and probability of the loss that might be suffered. The formula enables us to evaluate both the possible departure in yield and the relative frequency of such occurrences. Under the assumption that only 75 percent of the forecasted yield would be insured, a large part, or 87 pounds (348-261) of the limit of 105 pounds would be ruled out.

The solution of the formula follows.

$M=348$ pounds of lint per acre

$C=75$ percent coverage, or 261 pounds per acre

$\sigma=105$ pounds per acre

$$\frac{M-C}{\sigma}=0.83$$

$$A=.5000-.2967=.2033$$

$$b=.7086$$

$$\begin{aligned} L&=0.4\sigma(b)-A(M-C)\\ &=0.4(105)(.7086)-.2033(348-261)\\ &=42.0(.7086)-.2033(87)\\ &=29.76-17.69\\ &=12.07 \text{ pounds}\end{aligned}$$

With $\frac{M-C}{\sigma}=0.83$, A is obtained from a table of areas for the normal curve, and b from a table of ordinates. The proof of the reliability of these results may be demonstrated by numerical integration. A simple procedure would be to break up the area of the normal curve from C to zero into increments of 0.1, and multiply the departure from C to the middle of each increment by the proportion of the total area under the normal curve falling in that increment. The many resulting products should then be added. In this case, 12.1 pounds were obtained, which is very close to that obtained by use of the simple formula given above.

[63] The formula is an adaptation of one used in the 1945 program by the Federal Crop Insurance Corporation. See BASKIN, CARLISLE W. ANALYSIS OF PREMIUM RATE DETERMINATION FOR COTTON CROP INSURANCE. Thesis (M.A. Virginia) on file in Alderman Library, University of Virginia, Charlottesville, Va.

TABLE 15.—*Characteristics of cotton farms and operators sampled in specified counties of the Upper Piedmont*

Item	Unit	South Carolina		Georgia							Nine counties
		Greenville	Pickens	Carroll	Clarke	Cobb	Douglas	Haralson	Jackson	Madison	
Farms	Number	115.0	110.0	106.0	100.0	113.0	114.0	100.0	115.0	115.0	988.0
Percentage of farms reporting 3 or more years of yields, 1938–46	Percent	74.0	74.0	64.0	49.0	55.0	71.0	55.0	57.0	68.0	63.0
Cotton harvested per farm in 1946	Acre	16.6	11.9	18.6	10.2	9.9	13.5	8.8	18.6	15.8	13.8
Soil characteristics:											
Percentage of operators reporting—											
Severe erosion	Percent	47.0	29.0	6.0	27.0	17.0	50.0	63.0	34.0	11.0	32.0
Steep and hilly topography	do	17.0	21.0	5.0	27.0	5.0	11.0	8.0	14.0	10.0	13.0
Average operator's characteristics:											
Years of schooling	Number	8.0	7.4	7.3	5.4	6.1	7.5	6.8	6.5	5.6	6.8
Operator's age in 1946	Year	52.4	51.7	48.3	53.9	50.0	53.3	47.7	50.6	50.7	51.0
Years of experience growing cotton on 1946 farm	Number	11.4	13.3	11.6	7.4	10.8	15.1	10.4	11.5	9.1	11.2
Percentage of operators—											
Engaging in off-farm work in 1946	Percent	19.0	43.0	23.0	14.0	26.0	28.0	22.0	10.0	8.0	21.0
Whose origin was a local farm	do	98.0	91.0	94.0	68.0	44.0	27.0	92.0	79.0	100.0	77.0
Whose origin was a farm elsewhere in Cotton Belt	do	2.0	7.0	5.0	31.0	42.0	68.0	3.0	17.0	0	20.0
Percentage of farms owner-operated	do	64.0	75.0	78.0	43.0	59.0	80.0	75.0	55.0	48.0	64.0
Farm practices:											
1946 rates:											
Commercial fertilizer applied per acre	100 lbs.	5.0	5.4	4.2	4.2	3.6	3.6	3.7	4.6	5.6	4.4
Ammonia applied per acre	Pound	43.0	63.0	99.0	79.0	58.0	98.0	84.0	71.0	47.0	71.0
Average during period operated, 1938–46:											
Ratio of legume acreage harvested to cotton acreage harvested		1.0	.8	.4	1.2	.8	.7	.6	1.0	1.0	.8
Percentage of cropland in cotton acreage harvested	Percent	29.7	25.0	28.9	28.4	26.2	25.8	22.7	29.4	28.8	27.3

Average percentage of operators reporting following practices during period 1938–46:											
Cropper labor employed [1]	Percent	30.0	35.0	7.0	10.0	10.0	32.0	18.0	20.0	17.0	20.0
Seed from breeder 1 year or less	do	10.0	37.0	10.0	5.0	32.0	15.0	23.0	20.0	61.0	24.0
Seed cleaned and/or treated regularly before planting	do	69.0	88.0	26.0	27.0	79.0	48.0	46.0	57.0	65.0	57.0
Farms reporting yield:											
1945	Number	103.0	92.0	66.0	57.0	66.0	86.0	55.0	67.0	90.0	682.0
1946	do	90.0	99.0	101.0	87.0	102.0	100.0	99.0	106.0	110.0	894.0
Average yield of cotton:											
1945	Pound	390.0	422.0	356.0	311.0	345.0	337.0	333.0	315.0	357.0	357.0
1946	do	349.0	367.0	286.0	283.0	298.0	277.0	317.0	292.0	319.0	310.0

[1] Reported as the sole source of labor. If cropper labor was used in combination with other types, it was not counted.

TABLE 16.—*Characteristics of cotton farms and operators sampled in specified counties of the West Texas Rolling Plains*

Item	Unit	Cottle	Fisher	Haskell	Howard	Knox	Mitchell	Nolan	Runnels	Scurry	Taylor	Ten counties
Farms	Number	46.0	77.0	72.0	47.0	85.0	66.0	84.0	67.0	101.0	17.0	662.0
Percentage of farms reporting 3 or more years of yields, 1938–46	Percent	61.0	58.0	75.0	64.0	65.0	50.0	49.0	82.0	58.0	65.0	62.0
Cotton planted per farm in 1946	Acre	118.2	81.7	80.7	107.1	113.7	81.7	71.8	70.8	85.1	36.5	87.9
Percentage of cotton planted not harvested in 1946	Percent	5.9	3.7	0	15.3	1.1	5.9	2.5	1.8	3.9	1.6	3.9
Soil characteristics:												
Percentage of operators reporting—												
Severe erosion	do	38.0	6.0	1.0	16.0	11.0	14.0	5.0	13.0	7.0	0	10.0
Steep and hilly topography	do	0	5.0	0	2.0	0	3.0	1.0	2.0	1.0	0	2.0
Average operator's characteristics:												
Years of schooling	Number	9.6	7.6	7.8	9.1	9.0	8.6	9.2	8.3	10.1	10.2	8.9
Operator's age in 1946	Year	48.4	45.5	46.7	47.6	46.7	48.0	45.4	42.2	43.4	46.9	45.8
Years of experience growing cotton on 1946 farm	Number	6.9	8.5	9.8	8.3	10.9	9.9	7.9	8.7	5.4	9.7	8.5
Percentage of operators—												
Engaging in off-farm work in 1946	Percent	4.0	18.0	20.0	32.0	22.0	9.0	12.0	3.0	8.0	24.0	14.0
Whose origin was a local farm	do	22.0	34.0	31.0	17.0	56.0	79.0	78.0	75.0	80.0	53.0	56.0
Whose origin was a farm elsewhere in Cotton Belt	do	74.0	57.0	58.0	79.0	33.0	18.0	16.0	21.0	12.0	47.0	37.0
Percentage of farms owner-operated	do	54.0	48.0	56.0	55.0	44.0	58.0	57.0	54.0	52.0	71.0	53.0
Farm practices:												
Percentage of cotton acreage—												
Planted on the contour	do	50.0	99.0	91.0	47.0	94.0	86.0	98.0	96.0	95.0	81.0	90.0
Planted after cotton and grain sorghums	do	32.0	98.0	84.0	46.0	74.0	83.0	97.0	94.0	94.0	54.0	86.0

Average during period operated, 1938–46:												
Percentage of cropland in cotton acreage harvested	do	39.0	37.8	40.1	40.7	45.5	42.7	36.9	35.0	34.1	26.0	38.6
Hired labor employed [1]	do	48.0	62.0	67.0	74.0	71.0	34.0	75.0	90.0	7.0	56.0	56.0
Seed from breeder 1 year or less	do	9.0	66.0	24.0	47.0	45.0	39.0	51.0	58.0	14.0	76.0	40.0
Seed cleaned and/or treated regularly before planting	do	30.0	44.0	50.0	30.0	39.0	36.0	27.0	89.0	10.0	71.0	39.0
Farms reporting yield:												
1945	Number	34.0	56.0	61.0	34.0	61.0	40.0	53.0	48.0	68.0	10.0	465.0
1946	do	41.0	66.0	66.0	35.0	77.0	56.0	69.0	52.0	96.0	7.0	565.0
Average yield of cotton:												
1945	Pound	133.0	137.0	159.0	127.0	196.0	140.0	164.0	155.0	101.0	154.0	147.0
1946	do	108.0	102.0	118.0	68.0	137.0	94.0	139.0	97.0	93.0	98.0	109.0

[1] Basis of hired employees only.

TABLE 17.—*Characteristics of cotton farms and operators sampled in specified regions according to time duration of yields reported during period 1938–46*

Item	Unit	Upper Piedmont			West Texas Rolling Plains		
		1 and 2 years of yields	3 or more years of yields	All farms in sample	1 and 2 years of yields	3 or more years of yields	All farms in sample
Farms	Number	364.0	624.0	988.0	251.0	411.0	662.0
Cotton planted per farm in 1946	Acre	11.5	15.4	13.9	88.6	87.4	87.9
Cotton planted not harvested, per farm, in 1946	do	.1	.5	.4	6.0	2.5	3.9
Soil characteristics:							
Percentage of operators reporting—							
Severe erosion	Percent	37.0	29.0	32.0	14.0	8.0	10.0
Steep and hilly topography	do	17.0	11.0	13.0	2.0	1.0	2.0
Average operator's characteristics:							
Years of schooling	Number	6.2	7.1	6.8	9.2	8.7	8.9
Operator's age in 1946	Year	45.6	54.2	51.0	41.5	48.3	45.8
Years of experience growing cotton on 1946 farm	Number	2.6	16.2	11.2	2.5	12.1	8.5
Percentage of operators—							
Engaging in off-farm work in 1946	Percent	21.0	22.0	21.0	16.0	13.0	14.0
Whose origin was a local farm	do	69.0	81.0	77.0	55.0	57.0	56.0
Whose origin was a farm elsewhere in Cotton Belt	do	27.0	16.0	20.0	36.0	37.0	37.0
Percentage of farms owner-operated	do	48.0	74.0	64.0	37.0	63.0	53.0
Farm practices:							
1946 rates:							
Commercial fertilizer applied per acre	100 pounds	4.3	4.5	4.4	(1)	(1)	(1)
Ammonia applied per acre	Pound	68.0	74.0	71.0	(1)	(1)	(1)
Average during period operated, 1938–46:							
Ratio of legume acreage harvested to cotton acreage harvested		.9	.8	.8	(1)	(1)	(1)
Percentage of cropland in cotton acreage harvested	Percent	28.2	26.8	27.3	40.6	37.4	38.6
Percentage of cotton acreage planted after grain sorghums or cotton	do	(1)	(1)	(1)	84.0	88.0	86.0

Average percentage of operators reporting following practices during period 1938–46:							
Cropper labor employed only [2]	do	12.0	25.0	20.0	(3)	(3)	(3)
Hired labor employed only [4]	do	(3)	(3)	(3)	52.0	59.0	56.0
Seed from breeder 1 year or less	do	27.0	22.0	24.0	41.0	40.0	40.0
Seed cleaned and/or treated regularly before planting	do	51.0	61.0	57.0	36.0	41.0	39.0
Farms reporting yield:							
1945	Number	143.0	539.0	682.0	102.0	363.0	465.0
1946	do	339.0	555.0	894.0	221.0	344.0	565.0
Average yield of cotton:							
1945	Pound	344.0	360.0	357.0	132.0	151.0	147.0
1946	do	302.0	314.0	310.0	103.0	112.0	109.0

[1] Not applicable.

[2] Reported as the sole source of labor. If cropper labor was used in combination with other types, it was not counted.

[3] Not calculated.

[4] Computed for hired labor as sole source; if combinations were employed, they were not counted.

TABLE 18.—*Comparisons of yields per animal or per acre, coefficients of variation, and other statistical measures for the United States and selected States and counties* [1]

Item	Unit	Average yield [2]	Yearly trend	Coefficient of determination [3]	Standard error of estimate	Coefficient of variation [4]
Milk: [5]						
United States	Pound	4,608.00	46.90	**0.74	96.20	2
New York	do	5,760.00	43.60	**.58	128.50	2
Wisconsin	do	5,929.00	76.80	**.83	122.60	2
Minnesota	do	5,091.00	33.00	.30	176.80	3
North Carolina	do	3,916.00	36.10	**.77	68.30	2
Texas	do	3,142.00	−13.40	−.25	81.30	3
Eggs: United States	Dozen	146.90	2.80	**.94	2.40	2
Corn: United States	Bushel	32.50	.90	*.44	3.50	11
Wheat: United States	do	16.70	.40	*.53	1.30	8
Oats: United States	do	32.60	.40	.20	3.00	9
Hay: United States	Ton	1.35	.01	.33	.04	3
Potatoes: United States	Bushel	151.60	8.20	**.83	13.00	9
Beans: United States	do	96.00	.70	.11	6.60	7
Watermelons: United States	Number	281.00	2.20	.06	29.30	10
Tobacco: United States	Pound	1,051.00	31.30	**.84	47.20	4
Cotton:						
United States	do	258.00	4.60	.35	22.00	9
South Carolina	do	314.00	7.20	.14	63.60	20
Greenville County [5]	do	352.00	1.80	.01	53.40	15
Richland County [5]	do	244.00	14.00	.28	78.80	32
Mississippi	do	329.00	6.80	.11	66.20	20
Leflore County [5]	do	413.00	3.70	.04	61.60	15
Lauderdale County [5]	do	196.00	.40	0	88.30	45
Texas	do	169.00	−.05	0	18.80	11
Ellis County [5]	do	176.00	−5.60	*−.46	21.00	12
Haskell County [5]	do	170.00	2.20	.01	69.60	41
Jim Wells County [5]	do	124.00	6.00	.30	37.20	30

[1] Computed on the basis of 11 years of yields (1938–48) because of cyclical tendency in some crops. See pp. 16, 17, and 135.

[2] Based on U. S. Department of Agriculture estimates.

[3] Variation in yield which is explained by trend, or time.

[4] Standard error of estimate expressed as a percentage of the mean.

[5] 1936–46 data.

** Significant at the 1-percent point.

* Significant at the 5-percent point.

TABLE 19.—*Yield and coefficient of variation of specified crops, United States, averages 1927–48*

Item	Yield			Coefficient of variation [1]		
	Average 1927–37	Average 1938–48	Percentage increase	1927–37	1938–48	Percentage decrease [2]
	Bushels	*Bushels*	*Percent*			
Wheat	13.50	16.70	24	10	8	20
Corn	23.30	32.50	39	18	11	39
Oats	27.70	32.60	18	18	9	50
Potatoes	111.60	151.60	36	6	9	+50
Beans	84.00	96.00	14	8	7	12
	Tons	*Tons*				
Hay	1.17	1.35	15	12	3	75
	Number	*Number*				
Watermelons	281.00	281.00	0	10	10	0
	Pounds	*Pounds*				
Tobacco	802.00	1,051.00	31	5	4	20
Cotton lint:						
United States	188.00	258.00	37	14	9	36
South Carolina	236.00	314.00	33	10	20	+100
Mississippi	222.00	329.00	48	23	20	13
Texas	146.00	169.00	16	21	11	48
California	478.00	599.00	25	5	12	+140

[1] As a trend line was fitted to the 11-year period, the coefficient of variation represents the standard error of estimate expressed as a percentage of the mean.

[2] The pluses show an increase; all others indicate a minus or decrease.

TABLE 20.—*Summary of sampling details for Upper Piedmont and West Texas Rolling Plains*

Item	Upper Piedmont [1]		West Texas Rolling Plains [2]	
	Farms	Percentage of total	Farms	Percentage of total
	Number	*Percent*	*Number*	*Percent*
Sample:				
Aerial photo:				
Farms: [3]				
Contacted:				
Usable cotton farms	790	62.5	616	59.3
No cotton grown during 1938–46	234	18.5	108	10.4
Not obtained for other reasons [4]	20	1.6	8	.8
Total contacted	1,044	82.6	732	70.5
Not contacted	220	17.4	306	29.5
Total farms	1,264	100.0	1,038	100.0
Supplementary, large farms:				
Large farms:				
Usable cotton farms	98	79.7	0	0
Not contacted	25	20.3	0	0
Total	123	100.0	0	0
Summary:				
Farms:				
Usable cotton farms	888	64.0	616	59.3
Contacted but not usable	254	18.3	116	11.2
Not contacted	245	17.7	306	29.5
Total	1,387	100.0	1,038	100.0

[1] Greenville and Pickens counties, S. C.; Carroll, Clarke, Cobb, Douglas, Jackson, and Madison counties, Ga.; no field report from the enumerator for Haralson County, Ga. could be obtained.

[2] The West Texas counties include Fisher, Howard, Haskell, Knox, Mitchell, Nolan, Runnels, Scurry, and Taylor. The field report from Cottle County was incomplete.

[3] Units correspond to AAA contract farms. The units here used are not strictly comparable with usual operator units used in farming, but it is believed this deficiency does not concern a significant number of farms; nor does this shortcoming appear to be serious for the purposes of this study. Units with operator's dwelling outside the mapped photo were excluded from the sampling universe.

[4] Only one operator in each sample area refused to cooperate in the study.

TABLE 21.—*Sample cotton farms classified according to time-duration of yields for period 1938–46* [1]

Years in yield record	Upper Piedmont		West Texas Rolling Plains	
	Farms	Percentage of total	Farms	Percentage of total
	Number	*Percent*	*Number*	*Percent*
1	207	21.0	150	22.6
2	134	13.6	100	15.1
3	78	7.9	55	8.3
4	54	5.5	54	8.2
5	37	3.7	50	7.6
6	61	6.2	41	6.2
7	47	4.8	31	4.7
8	88	8.9	48	7.2
9	282	28.4	133	20.1
Total	988	100.0	662	100.0

[1] After editing the yields for discrepancies and obvious duplications, the distributions by time intervals were changed somewhat. For instance, the total number of 1- and 2-year farms in the Upper Piedmont was increased from 341 to 364 and in the West Texas Rolling Plains from 250 to 251, which means that the number of farms of 3 or more years' duration was decreased correspondingly in the two samples.

TABLE 22.—*Absolute and relative distributions with measures of central tendency, dispersion and skewness by kind of crop year, Upper Piedmont and West Texas Rolling Plains*

Item	Farms reporting 3 or more yearly yields in period, 1938–46					
	All years		Excellent crop year [1]		Poor crop year [2]	
	Farms reporting	Percentage of farms reporting	Farms reporting	Percentage of farms reporting	Farms reporting	Percentage of farms reporting
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Upper Piedmont:						
Yield in pounds:						
1–50	21.00	0.5	--------	--------	13.00	2.7
51–100	105.00	2.5	5.00	1.0	33.00	6.8
101–150	196.00	4.6	12.00	2.5	64.00	13.2
151–200	452.00	10.7	28.00	5.8	98.00	20.3
201–250	611.00	14.4	54.00	11.2	80.00	16.6
251–300	647.00	15.4	70.00	14.6	53.00	11.0
301–350	607.00	14.3	67.00	14.0	43.00	8.9
351–400	631.00	14.9	90.00	18.8	42.00	8.7
401–450	338.00	8.0	55.00	11.5	28.00	5.8
451–500	330.00	7.8	59.00	12.3	10.00	2.1
501–550	143.00	3.4	26.00	5.4	11.00	2.3
551–600	81.00	1.9	10.00	2.1	4.00	.8
601 and over	69.00	1.6	4.00	.8	4.00	.8
Total	4,231.00	100.0	480.00	100.0	483.00	100.0
Mean	314.00	--------	348.40	--------	243.70	--------
Median	307.90	--------	353.20	--------	222.00	--------
Mode	274.70	--------	375.00	--------	183.60	--------
Standard deviation	122.00	--------	112.00	--------	123.40	--------
Skewness	+.15	--------	−.12	--------	+.53	--------
West Texas Rolling Plains:						
Yield in pounds:						
Zero yield	28.00	1.0	--------	--------	12.00	3.5
1–50	109.00	4.1	6.00	2.2	27.00	7.8
51–100	437.00	16.4	17.00	6.1	107.00	31.1
101–150	679.00	25.5	23.00	8.3	123.00	35.8
151–200	577.00	21.6	30.00	10.8	49.00	14.2
201–250	399.00	15.0	55.00	19.9	23.00	6.7
251–300	200.00	7.5	46.00	16.6	2.00	.6
301–350	122.00	4.6	43.00	15.5	--------	--------
351–400	66.00	2.5	31.00	11.2	1.00	.3
401 and over	49.00	1.8	26.00	9.4	--------	--------
Total	2,666.00	100.0	277.00	100.0	344.00	100.0
Mean	169.60	--------	257.70	--------	113.10	--------
Median	157.90	--------	259.20	--------	111.60	--------
Mode	136.20	--------	232.20	--------	109.90	--------
Standard deviation	88.00	--------	106.50	--------	62.40	--------
Skewness	+.41	--------	−.04	--------	+.07	--------

[1] 1943 in West Texas and 1944 in the Upper Piedmont.

[2] 1941 in the Upper Piedmont and 1946 in West Texas.

TABLE 23.—*Comparison of yield of cotton on sample farms with yield as reported by Crop Reporting Board, by counties in Upper Piedmont and West Texas Rolling Plains, 1946*

Region and county	Sample farms		County yield as reported by Crop Reporting Board	Sample yield as percentage of county yield
	Reporting cotton grown	Yield		
	Number	*Pounds*	*Pounds*	*Percent*
Upper Piedmont:				
South Carolina:				
Greenville	90	348.6	349.0	100
Pickens	99	366.7	342.0	107
Georgia:				
Clarke	87	282.6	258.0	110
Jackson	106	292.3	249.0	117
Madison	110	319.0	294.0	108
Cobb	102	298.0	228.0	131
Douglas	100	277.2	246.0	113
Carroll	101	285.7	256.0	112
Haralson	99	317.2	279.0	114
Total or average	894	309.5	277.9	111
West Texas Rolling Plains:				
Cottle	41	107.7	95.0	113
Fisher	66	101.6	91.0	112
Haskell	66	118.2	102.0	116
Howard	35	68.2	90.0	76
Knox	77	136.8	120.0	114
Mitchell	56	94.0	96.0	98
Nolan	69	139.0	120.0	116
Runnels	52	97.4	78.0	125
Scurry	96	92.9	96.0	97
Taylor	7	97.6	66.0	148
Total or average	565	108.6	95.4	114

TABLE 24.—*Estimates of acreage and yield per acre of cotton, as given from memory by farmers in 1947 compared with data reported annually to the Agricultural Adjustment Administration, 1943–46*[1]

Item	Farms	Reported by farmers		Difference between 1947 estimates and AAA reports	
		In 1947	To AAA annually	Actual	Percentage of AAA
	Number	*Acres*	*Acres*	*Acres*	*Percent*
Upper Piedmont: [2]					
Acreage harvested:					
1943	256	14.0	14.4	−0.4	−3
1944	142	13.4	12.9	.5	4
1945	25	8.1	7.2	.9	12
1946	14	14.7	14.1	.6	4
Total or average:					
1943–46	437	13.5	13.4	.1	1
1944–46	181	12.8	12.2	.6	5
Yield per acre harvested:					
1943	256	353.0	299.0	54.0	18
1944	142	361.0	363.0	−2.0	−1
1945	25	429.0	456.0	−27.0	−6
1946	14	317.0	327.0	−10.0	−3
Total or average:					
1943–46	437	358.0	330.0	28.0	8
1944–46	181	367.0	373.0	−6.0	−2
West Texas Rolling Plains: [3]					
Acreage planted:					
1943	96	73.1	70.4	2.7	4
1944	30	78.8	77.1	1.7	2
1945	20	57.4	60.3	−2.9	−5
1946	3	93.7	93.3	.4	(4)
Total or average:					
1943–46	149	72.5	71.0	1.5	2
1944–46	53	71.5	71.7	−.2	(4)
Yield per acre planted:					
1943	96	146.0	117.0	29.0	25
1944	30	173.0	178.0	−5.0	−3
1945	20	158.0	175.0	−17.0	−10
1946	3	112.0	89.0	23.0	26
Total or average:					
1943–46	149	152.0	136.0	16.0	12
1944–46	53	164.0	172.0	−8.0	−5

[1] AAA or subsequent organizations.

[2] Based on Pickens County, S. C., and Carroll, Clarke, Cobb, Douglas, Haralson, and Jackson counties, Ga. There were no duplicated acreages or yields in the other counties.

[3] Based on Fisher, Haskell, Knox, Mitchell, Runnels, and Taylor counties; the other counties in the sample had no duplicates in acreage or yield.

[4] Less than 0.5 percent.

TABLE 25.—*Four measures of central tendency to trend, standard deviation, and coefficient of variation of farm yields of cotton*

Item	Trend based on farms reporting 8 or 9 years of yields in period 1938–46					
	Upper Piedmont			West Texas Rolling Plains		
	Up	Down	Average	Up	Down	Average
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Trend:						
Average [1]	14	−10	6	4	−9	−5
Median	13	−11	5	4	−9	−5
Mode	16	−9	3	2	−8	−3
Average of individual farms [2]	15	−10	6	8	−10	−4
Standard deviation:						
Average [1]	40	35	37	48	56	53
Median	43	39	39	46	54	50
Mode	67	50	46	37	43	37
Average of individual farms [2]	91	86	89	78	82	81
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Coefficient of variation:						
Average [1]	12	11	11	28	31	30
Median	13	12	12	27	31	29
Mode	22	16	14	23	26	22
Average of individual farms [2]	28	26	27	45	46	46

[1] Weighted average.

[2] Average of individual farm averages. The standard deviation and the coefficient of variation were corrected for the trend.

TABLE 26.—*Effect of length of yield on average yield of cotton and coefficient of variation, by yield groups, Upper Piedmont, 1938–46*

Period and yield	Farms	Average yield	Coefficient of variation	Ratio to 1938–42 average	
				Yield	Coefficient of variation
	Number	*Pounds*	*Percent*		
Yields of cotton:					
5 years, 1938–42:					
0–100 pounds	(1)				
101–200 do	22	168	44	1.00	1.00
201–300 do	125	236	31	1.00	1.00
301–400 do	127	335	26	1.00	1.00
401–500 do	49	440	23	1.00	1.00
501–600 do	9	541	17	1.00	1.00
601–700 do	(1)				
Mean		344	28	1.00	1.00
8 or 9 years, 1938–46:					
0–100 pounds	(1)				
101–200 do	20	179	39	1.07	.89
201–300 do	92	252	30	1.07	.97
301–400 do	107	347	26	1.04	1.00
401–500 do	49	440	22	1.00	.96
501–600 do	11	534	17	.99	1.00
601–700 do	(1)				
Mean		350	27	1.02	.96
3 or more years, 1938–46:					
0–100 pounds	(1)				
101–200 do	52	174	39	1.04	.89
201–300 do	230	253	30	1.07	.97
301–400 do	235	345	26	1.03	1.00
401–500 do	88	442	20	1.00	.87
501–600 do	15	537	18	.99	1.06
601–700 do	(1)				
Mean		350	27	1.02	.96

1 Less than 3 farms.

TABLE 27.—*Yield of cotton and first differences, United States, 1908–49*

Year	Yield	First difference
	Pounds	*Pounds*
1908	203.8	
1909	156.5	−47.3
1910	176.2	+19.7
1911	215.0	+38.8
1912	201.4	−13.6
1913	192.3	−9.1
1914	216.4	+24.1
1915	178.5	−37.9
1916	165.6	−12.9
1917	167.4	+1.8
1918	164.1	−3.3
1919	165.9	+1.8
1920	186.7	+20.8
1921	132.5	−54.2
1922	148.8	+16.3
1923	136.4	−12.4
1924	165.0	+28.6
1925	173.5	+8.5
1926	192.9	+19.4
1927	161.7	−31.2
1928	163.3	+1.6
1929	164.2	+.9
1930	157.1	−7.1
1931	211.5	+54.4
1932	173.5	−38.0
1933	212.7	+39.2
1934	171.6	−41.1
1935	185.1	+13.5
1936	199.4	+14.3
1937	269.9	+70.5
1938	235.8	−34.1
1939	237.9	+2.1
1940	252.5	+14.6
1941	231.9	−20.6
1942	272.4	+40.5
1943	254.0	−18.4
1944	298.9	+44.9
1945	253.6	−45.3
1946	235.3	−18.3
1947	267.3	+32.0
1948	311.2	+43.9
1949	284.0	−27.2

TABLE 28.—*Relation of tenure status to farm average yield and coefficient of variation*

Item	Unit	Upper Piedmont				West Texas Rolling Plains			
		Owner operated	Estate operated	Cropper tenant [1]	Other tenants [2]	Owner operated	Standing rented	Share rented	Other operators [3]
Farms reporting 3 or more years of yields, 1938–46	Number	459.0	23.0	39.0	103.0	258.0	42.0	105.0	6.0
Years of experience in 1946 growing cotton on current farm	do	19.0	13.0	9.0	8.0	14.0	8.0	10.0	6.0
Average corresponding to 3 or more yearly yields reported, 1938–46:									
Cotton planted	Acre	15.7	36.8	19.8	13.6	73.6	82.5	86.3	147.6
Percentage of planted acreage not harvested	Percent	.2	.6	0	.1	2.0	.5	1.1	0
Total fertilizer applied per acre planted	100 pounds	5.1	4.8	4.9	5.1	(4)	(4)	(4)	(4)
Percentage of cotton acreage planted on the contour	Percent	(4)	(4)	(4)	(4)	92.0	94.0	89.0	83.0
Hail loss, lint per acre per year	Pound	1.2	.9	7.9	2.8	.9	.3	.2	.3
Federal crop insurance premium rate for 75-percent coverage for 1945	do	10.2	10.2	10.0	11.0	12.9	9.7	14.4	9.7
Average yield	do	320.0	282.0	310.0	296.0	166.0	156.0	169.0	153.0
Average coefficient of variation	Percent	27.0	28.0	27.0	30.0	47.0	44.0	44.0	54.0
5 years of yields, 1938–42:									
Farms reporting	Number	280.0	13.0	13.0	28.0	117.0	16.0	46.0	0
Average yield	Pound	314.0	264.0	318.0	271.0	191.0	163.0	203.0	0
Average coefficient of variation	Percent	28.0	33.0	27.0	33.0	43.0	38.0	41.0	0
8 or 9 years of yields, 1938–46:									
Farms reporting	Number	227.0	10.0	11.0	33.0	115.0	15.0	48.0	1.0
Average yield	Pound	334.0	285.0	338.0	291.0	180.0	160.0	176.0	168.0
Average coefficient of variation	Percent	27.0	32.0	26.0	31.0	46.0	39.0	48.0	56.0
Average trend in yearly yield of lint	Pound	6.0	15.0	6.0	6.0	−6.0	−8.0	−4.0	−11.0

[1] Managing cropper. See pp 28–29 for a more detailed discussion.

[2] Cash, standing, and share tenants.

[3] Estate operated, cash renters, and cropper tenants.

[4] Not applicable.

TABLE 29.—*Data relating to yield of cotton, by yield groups and by color and tenure of operator, Upper Piedmont*

Item	Unit	Operator			
		White		Negro	
		Owner	Tenant	Owner	Tenant
Years of experience growing cotton on current farm, 1946	Number	19.0	8.0	17.0	10.0
3 or more years of yields reported, 1938–46:					
Farms reporting	do	426.0	106.0	29.0	35.0
Cotton acreage planted	Acre	16.2	16.4	8.2	12.1
Percentage of planted acreage not harvested	Percent	.2	.1	1.2	.2
Fertilizer applied per acre planted	100 pounds	5.1	5.3	4.0	4.5
Loss of lint by hail, per acre per year	Pound	1.3	3.0	0	7.8
Federal crop insurance premium rate for 75 percent coverage for 1945	do	10.2	10.9	9.5	10.1
Average yield	do	326.0	315.0	246.0	256.0
Average coefficient of variation	Percent	27.0	28.0	33.0	35.0
5 years of yields, 1938–42:					
Farms reporting	Number	266.0	25.0	11.0	15.0
Average yield	Pound	318.0	314.0	203.0	243.0
Average coefficient of variation	Percent	27.0	30.0	44.0	34.0
8 or 9 years of yields, 1938–46:					
Farms reporting	Number	214.0	26.0	12.0	17.0
Average yield	Pound	340.0	340.0	211.0	249.0
Average coefficient of variation	Percent	26.0	26.0	37.0	36.0
Average trend in yearly yield of lint	Pound	6.0	4.0	12.0	9.0

TABLE 30.—*Data relating to yield of cotton, by sex of white operators, Upper Piedmont and West Texas Rolling Plains*

Item	Unit	Upper Piedmont		West Texas Rolling Plains	
		Male	Female	Male	Female
Years of experience growing cotton on current farm, 1946	Number	16.0	20.0	12.0	15.0
3 or more years of yields reported, 1938–46:					
Farms reporting	do	514.0	37.0	403.0	5.0
Cotton acreage planted	Acre	17.2	17.9	77.8	43.3
Percentage of planted acreage not harvested	Percent	.2	.1	1.7	0
Fertilizer applied per acre planted	100 pounds	5.2	5.0	(1)	(1)
Percentage of cotton acreage on the contour	Percent	(1)	(1)	92.0	88.0
Loss of lint by hail, per acre per year	Pound	1.6	2.3	.7	0
Federal crop insurance premium rate for 75-percent coverage for 1945	do	10.4	10.5	12.9	13.6
Average yield	do	325.0	290.0	165.0	158.0
Average coefficient of variation	Percent	27.0	26.0	46.0	51.0
5 years of yields, 1938–42:					
Farms reporting	Number	283.0	20.0	176.0	[2] 2.0
Average yield	Pound	318.0	283.0	192.0	187.0
Average coefficient of variation	Percent	27.0	28.0	42.0	37.0
8 or 9 years of yields, 1938–46:					
Farms reporting	Number	232.0	17.0	175.0	[2] 3.0
Average yield	Pound	343.0	280.0	178.0	169.0
Average coefficient of variation	Percent	26.0	31.0	46.0	50.0
Average trend in yearly yield of lint	Pound	6.0	3.0	−4.0	−10.0

[1] Not applicable.

[2] Too few cases to be significant.

TABLE 31.—*Comparison of effects of purchase and of inheritance of farm on farm average yield and coefficient of variation, and other specified factors, Upper Piedmont and West Texas Rolling Plains*

Item	Unit	Upper Piedmont[1]		West Texas Rolling Plains [2]	
		Acquired by purchase	Acquired by inheritance [3]	Acquired by purchase	Acquired by inheritance [3]
3 or more years of yields reported, 1938–46:					
Farms	Number	317.00	59.00	212.0	33.0
Cotton planted (1938–46 average)	Acre	16.40	15.40	73.6	62.2
Percentage of cotton acreage planted not harvested	Percent	.20	.20	1.9	2.8
Operators' characteristics:					
Years of schooling	Number	7.50	8.30	8.5	8.5
Age in 1946	Year	55.00	53.00	51.0	49.0
Years of experience growing cotton on 1946 farm	Number	18.00	24.00	14.0	14.0
Percentage of operators engaging in off-farm work in 1946	Percent	27.00	33.00	12.0	3.0
Farm practices:					
Average fertilizer applied	100 pounds	5.20	4.90	(4)	(4)
Ratio of legume acreage to cotton acreage harvested		.84	.88	(4)	(4)
Percentage of cotton acreage planted on the contour	Percent	(4)	(4)	93.0	95.0
Percentage of cropland in cotton acreage harvested	do	26.00	26.00	36.0	33.0
Percentage of farms in severe erosion class, 1946 [5]	do	22.00	30.00	6.0	16.0
Percentage of operators reporting:					
Cropper labor employed	do	27.00	36.00	(4)	(4)
Hired labor employed	do	(4)	(4)	56.0	58.0
Seed cleaned and/or treated regularly before planting	do	65.00	54.00	33.0	48.0
Average yield	Pound	332.00	304.00	165.0	158.0
Average coefficient of variation	Percent	27.00	27.00	46.0	49.0

TABLE 31.—*Comparison of effects of purchase and of inheritance of farm on farm average yield and coefficient of variation, and other specified factors, Upper Piedmont and West Texas Rolling Plains—Continued*

Item	Unit	Upper Piedmont		West Texas Rolling Plains [2]	
		Acquired by purchase	Acquired by inheritance [3]	Acquired by purchase	Acquired by inheritance [3]
8 or 9 years of yields, 1938–46:					
Farms reporting	Number	157.00	32.00	96.0	17.0
Average yield	Pound	351.00	313.00	180.0	170.0
Average coefficient of variation	Percent	25.00	27.00	45.0	46.0
Trend in yearly yield of lint	Pound	6.00	4.00	−5.0	−8.0

[1] Based on white owner-operators (male).

[2] Based on all owners. As there were only 5 female operators of farms among the 411 farms for which 3 or more years of yields were reported, it was not considered necessary to rerun the class with these 5 farms omitted. It is believed that data analyzed for these minor cases are sufficiently comparable to the more highly refined data for the Upper Piedmont.

[3] Farms were classified as to method of acquisition on the basis of how the major part of the farm was acquired.

[4] Not applicable.

[5] The degree of erosion was determined by the enumerator, generally an employee of the Production and Marketing Administration office, by observation and in consultation with the operator of the farm.

TABLE 32.—*Data relating to yield of cotton, by years of schooling of operator*

Item	Farms	Cotton planted per farm	Percentage of cotton acreage abandoned	Average yield[1]	Coefficient of variation
	Number	*Acres*	*Percent*	*Pounds*	*Percent*
Upper Piedmont:					
Years of schooling:					
0	12	15.2	0.1	282	40
1–3	57	13.1	.2	292	30
4–7	295	14.1	.1	305	28
8	93	18.2	.1	312	27
9–11					
Agricultural training:					
With	18	17.0	.4	352	31
Without	111	18.5	.2	342	25
Total	129	18.3	.2	344	26
12 and over:					
Agricultural training:					
With	24	30.7	.8	336	28
Without	14	25.3	.1	326	22
Total	38	28.7	.6	332	26
West Texas Rolling Plains:					
Years of schooling:					
0	11	83.0	1.2	160	40
1–3	10	69.2	0	171	43
4–7	99	68.6	.8	164	43
8	58	65.4	1.8	168	45
9–11					
Agricultural training:					
With	10	80.2	1.5	186	49
Without	172	75.8	1.6	165	47
Total	182	76.0	1.6	166	47
12 and over:					
Agricultural training:					
With	12	139.8	0	190	38
Without	28	126.1	3.6	163	52
Total	40	130.2	2.5	171	47

[1] Yield per harvested acre in the Upper Piedmont but yield per planted acre in the West Texas Rolling Plains.

TABLE 33.—*Data relating to yield of cotton, by origin of operator*

Item	Unit	Upper Piedmont			West Texas Rolling Plains		
		Local farm	Local town or city	Farm elsewhere in Cotton Belt	Local farm	Local town or city	Farm elsewhere in Cotton Belt
Years of experience growing cotton on current farm, 1946	Number	17.0	14.0	13.0	12.0	11.0	13.0
3 or more years of yields, 1938–46:							
Farms reporting	do	503.0	14.0	103.0	233.0	24.0	152.0
Average corresponding to 3 or more yearly yields reported, 1938–46:							
Cotton acreage planted	Acre	16.8	14.6	14.6	73.9	97.1	83.6
Percentage of planted acreage not harvested	Percent	.2	1.0	.1	1.5	4.3	1.4
Fertilizer applied per acre planted	100 pounds	5.2	4.9	4.4	(1)	(1)	(1)
Percentage of cotton acreage planted on the contour	Percent	(1)	(1)	(1)	95.0	95.0	85.0
Loss of lint by hail, per acre per year	Pound	2.3	0	0	.7	.2	.6
Federal crop insurance premium rate for 75-percent coverage for 1945	do	10.5	9.0	9.3	12.2	13.7	13.7
Average yield	do	321.0	336.0	277.0	163.0	172.0	169.0
Average coefficient of variation	Percent	27.0	30.0	28.0	46.0	49.0	45.0
8 or 9 years of yields:							
Farms reporting	Number	242.0	2.0	37.0	95.0	8.0	74.0
Average yield	Pound	336.0	356.0	274.0	173.0	188.0	182.0
Average coefficient of variation	Percent	27.0	26.0	28.0	46.0	46.0	45.0
Average trend in yearly yield of lint	Pound	6.0	8.0	6.0	−5.0	0	−3.0

[1] Not applicable.

TABLE 34.—*Relation of degree of steepness of topography to farm average yield and coefficient of variation*

Item	Unit	Upper Piedmont			West Texas Rolling Plains		
		Level and gently rolling	Rolling	Hilly and steep	Level and gently rolling	Rolling	Hilly and steep
Averages corresponding to farms reporting 3 or more years of yields, 1938–46:							
Farms reporting	Number	234.0	285.0	63.0	334.0	63.0	[1] 4.0
Cotton acreage planted	Acre	18.5	15.3	14.5	78.7	82.3	97.7
Percentage of cotton acreage not harvested	Percent	.3	.1	.3	1.3	.7	1.9
Fertilizer applied per acre planted	100 pounds	5.2	4.9	4.8	(2)	(2)	(2)
Percentage of cotton acreage planted on the contour	Percent	(2)	(2)	(2)	92.0	87.0	75.0
Percentage of cropland in cotton acreage harvested	do	(3)	(3)	(3)	37.0	38.0	42.0
Average yield	Pound	318.0	315.0	277.0	169.0	148.0	128.0
Average coefficient of variation	Percent	28.0	26.0	31.0	45.0	49.0	[1] 34.0
8 or 9 years of yields:							
Farms	Number	99.0	134.0	31.0	148.0	28.0	2.0
Average yield	Pound	336.0	324.0	292.0	179.0	169.0	149.0
Average coefficient of variation	Percent	26.0	28.0	31.0	47.0	43.0	[1] 19.0
Average trend in yearly yield of lint	Pound	6.0	8.0	4.0	−4.0	−5.0	−1.0

[1] Too few cases to be significant.

[2] Not applicable.

[3] Not calculated.

TABLE 35.—*Relation of soil color to farm average yield and coefficient of variation*

Item	Unit	Upper Piedmont				West Texas Rolling Plains				
		Dark red	Gray to gray-yellow	Red to gray-red	Other colors	Dark red	Red to gray-red	Dark brown to black	Gray to gray-yellow	Other colors
3 or more years of yields, 1938–46:										
Farms	Number	368.0	160.0	90.0	6.0	47.0	109.0	122.0	31.0	96.0
Years of experience on current farm, 1946	do	16.0	16.0	15.0	18.0	16.0	12.0	12.0	12.0	11.0
Average corresponding to 3 or more yearly yields reported, 1938–46:										
Cotton planted	Acre	17.3	15.7	13.4	19.4	65.1	89.6	80.4	66.5	74.2
Percentage of planted acreage not harvested	Percent	.2	.2	.3	.3	0	2.0	2.0	3.0	1.0
Fertilizer applied per acre planted	100 pounds	5.1	4.9	4.9	6.1	([1])	([1])	([1])	([1])	([1])
Percentage of cotton acreage on the contour	Percent	([1])	([1])	([1])	([1])	94.0	93.0	92.0	67.0	94.0
Loss of lint by hail, per acre per year	Pound	1.3	2.1	3.6	7.4	.2	.6	.8	.6	.7
Average yield	do	325.0	314.0	274.0	278.0	176.0	166.0	165.0	158.0	162.0
Average coefficient of variation	Percent	27.0	28.0	29.0	36.0	42.0	45.0	47.0	46.0	47.0
8 or 9 years of yields, 1938–46:										
Farms reporting	Number	171.0	65.0	43.0	2.0	23.0	48.0	54.0	14.0	39.0
Average yield	Pound	341.0	320.0	287.0	306.0	192.0	182.0	175.0	167.0	171.0
Average coefficient of variation	Percent	27.0	26.0	29.0	29.0	39.0	41.0	50.0	40.0	53.0
Average trend in yearly yield of lint	Pound	6.0	6.0	7.0	12.0	−5.0	−6.0	−5.0	−4.0	−3.0

[1] Not applicable.

TABLE 36.—*Relation of soil texture to farm average yield and coefficient of variation*

Item	Unit	Upper Piedmont			West Texas Rolling Plains		
		Clays	Sandy loam soils	Other textures	Clays [1]	Sandy soils	Alluvial soils
Average corresponding to farms reporting 3 or more years of yields, 1938–46:							
Farms	Number	279.0	285.0	42.0	125.0	227.0	47.0
Cotton acreage planted	Acre	15.7	16.5	14.2	74.9	82.2	72.7
Percentage of cotton acreage not harvested	Percent	.3	.2	.1	2.6	1.3	.4
Fertilizer applied per acre planted	100 pounds	4.8	5.4	4.5	(2)	(2)	(2)
Percentage of cotton acreage planted on the contour	Percent	(2)	(2)	(2)	91.0	91.0	94.0
Percentage of cropland in cotton acreage harvested	do	26.0	26.0	29.0	34.0	39.0	35.0
Average yield	Pound	298.0	334.0	299.0	154.0	176.0	145.0
Average coefficient of variation	Percent	29.0	27.0	26.0	50.0	44.0	45.0
8 or 9 years of yields:							
Farms	Number	124.0	135.0	13.0	53.0	101.0	19.0
Average yield	Pound	306.0	351.0	314.0	167.0	190.0	145.0
Average coefficient of variation	Percent	28.0	26.0	25.0	54.0	41.0	46.0
Average trend in yearly yield of lint	Pound	6.0	6.0	6.0	−3.0	−6.0	−2.0

[1] Includes gumbo and buckshot soils.

[2] Not applicable.

TABLE 37.—*Characteristics of cotton farms and operators, by use of tractors by owners and tenants, Upper Piedmont*

Item	Unit	Use of Tractor			
		Owner		Tenant	
		No use reported [1]	51–100 percent of time	No use reported [1]	51–100 percent of time
3 or more years of yields, 1938–46:					
Farms	Number	104.0	108.0	37.0	39.0
Cotton planted (1938–46 average)	Acre	20.7	27.5	19.4	32.4
Percentage of planted cotton acreage not harvested	Percent	.2	.1	.2	.1
Loss of lint by hail, per acre per year	Pound	1.3	1.1	1.0	5.0
Operator's characteristics:					
Years of schooling	Number	7.3	8.8	5.5	5.9
Age in 1946	Years	55.0	53.0	52.0	49.0
Years of experience growing cotton on 1946 farm	Number	21.0	18.0	11.0	5.0
Percentage of operators engaging in off-farm work in 1946	Percent	19.0	27.0	16.0	13.0
Percentage of farms in 1946:					
In severe erosion class	do	24.0	21.0	43.0	19.0
With steep and hilly topography	do	11.0	8.0	21.0	3.0
Farm practices:					
Average fertilizer applied	100 pounds	5.0	5.8	4.8	5.5
Ratio of legume acreage to cotton acreage harvested		.6	1.0	.6	.9
Percentage of cropland in cotton acreage harvested	Percent	27.0	27.0	28.0	27.0
Percentage of operators reporting following practices:					
Cropper labor employed	do	41.0	41.0	11.0	26.0
Seed from breeder 1 year or less	do	17.0	35.0	8.0	38.0
Seed cleaned and/or treated regularly before planting	do	56.0	80.0	51.0	82.0
Poison regularly to control boll weevil	do	25.0	28.0	69.0	64.0
Participation in Federal crop insurance [2]	do	10.0	32.0	16.0	13.0
Average yield	Pound	305.0	349.0	279.0	306.0
Average coefficient of variation	Percent	27.0	24.0	29.0	25.0

8 or 9 years of yields, 1938–46:					
Farms	Number	51.0	51.0	15.0	3.0
Average yield	Pound	307.0	370.0	289.0	363.0
Average coefficient of variation	Percent	27.0	24.0	31.0	24.0
Trend in yearly yield of lint	Pound	4.0	9.0	8.0	4.0

[1] Reporting 10 or more acres of cotton harvested.

[2] Percentage based on participation during one or more years for 1942, 1943, 1945, and 1946.

TABLE 38.—*Relation of farm average yield to operator and farm characteristics, and production practices*

Item	Unit	Yield per farm					
		Upper Piedmont [1]			West Texas Rolling Plains [2]		
		0–250 pounds	251–350 pounds	351 pounds and over	0–125 pounds	126–225 pounds	226 pounds and over
3 or more years of yields, 1938–46:							
Farms reporting	Number	57.0	134.0	126.0	32.0	139.0	33.0
Years of experience growing cotton on 1946 farm	do	17.0	19.0	17.0	11.0	14.0	13.0
Age of operator in 1946	Year	56.0	56.0	54.0	48.0	48.0	49.0
Years of schooling of operator	Number	7.0	7.0	8.0	8.0	9.0	9.0
Percentage of operators engaging in off-farm work	Percent	20.0	23.0	35.0	19.0	15.0	15.0
Soil characteristics:							
Percentage of operators reporting:							
Severe erosion	do	29.0	19.0	21.0	9.0	7.0	3.0
Steep and hilly topography	do	16.0	8.0	6.0	1.0	----------	----------
Percentage of operators reporting following practices:							
Cropper labor employed [3]	do	23.0	22.0	35.0	([4])	([4])	([4])
Hired labor employed [3]	do	([4])	([4])	([4])	88.0	90.0	85.0
Seed from breeder 1 year or less	do	9.0	18.0	32.0	53.0	40.0	45.0
Seed cleaned and/or treated regularly before planting	do	50.0	59.0	77.0	28.0	37.0	27.0
Poison regularly to control boll weevil	do	42.0	24.0	21.0	6.0	4.0	3.0
Average corresponding to 3 or more years of yields reported, 1938–46:							
Cotton acreage planted	Acre	14.3	17.6	16.0	68.6	88.5	72.3
Percentage of cotton acreage not harvested	Percent	.2	.1	.3	3.4	.6	.1
Loss by hail, per acre per year	Pound	2.1	1.4	1.1	2.6	.7	0
Fertilizer applied per acre	100 pounds	4.4	4.9	5.9	([5])	([5])	([5])
Percentage of cotton acreage planted on the contour	Percent	([5])	([5])	([5])	93.0	91.0	100.0
Ratio of legume acreage to cotton acreage harvested		.9	.7	.9	([5])	([5])	([5])

Percentage of cropland in cotton acreage	do	24.0	27.0	27.0	30.0	38.0	43.0
Average yield	Pound	212.0	307.0	414.0	97.0	175.0	247.0
Average coefficient of variation	Percent	33.0	27.0	23.0	50.0	47.0	38.0
8 or 9 years of yields, 1938–46:							
Farms reporting	Number	25.0	54.0	78.0	5.0	73.0	17.0
Average yield	Pound	222.0	315.0	417.0	109.0	182.0	240.0
Average coefficient of variation	Percent	30.0	26.0	23.0	58.0	47.0	40.0
Trend in yearly yield	Pound	7.0	8.0	5.0	−5.0	−6.0	−2.0

[1] Based on 317 white owner-operators (male) who purchased their farms.

[2] Based on 204 owner-operators and share-renters who employed hired labor only and those who employed hired labor in combination with other kinds of labor.

[3] Calculated for farms with one kind of labor only. When the specified kind was employed in combination with other kinds of labor, the farm was counted negatively in deriving the ratios.

[4] Not calculated.

[5] Not applicable.

TABLE 39.—*Relation of 1945 Federal crop-insurance premium rates to farm average yield and coefficient of variation, and to other specified factors*

Item	Unit	1945 FCIC premium rates (75 percent coverage)					
		Upper Piedmont			West Texas Rolling Plains		
		0–10 pounds	11–15 pounds	16 pounds or over	0–10 pounds	11–15 pounds	16 pounds or over
Farms reporting 3 or more years of yields, 1938–46	Number	410.0	142.0	19.0	80.0	213.0	79.0
Years of experience growing cotton on 1946 farm	do	16.0	18.0	9.0	12.0	12.0	13.0
Age of operator in 1946	Year	54.0	56.0	46.0	47.0	48.0	51.0
Years of schooling of operator	Number	7.0	7.0	6.0	8.0	9.0	8.0
Percentage of operators engaging in off-farm work	Percent	17.0	27.0	33.0	9.0	9.0	26.0
Soil characteristics:							
Percentage of operators reporting:							
Severe erosion	do	29.0	28.0	26.0	8.0	9.0	7.0
Steep and hilly topography	do	9.0	11.0	14.0	1.0	1.0	0
Percentage of operators reporting following practices:							
Cropper labor employed [1]	do	22.0	30.0	19.0	0	0	0
Hired labor employed [1]	do	(2)	(2)	(2)	60.0	54.0	63.0
Seed from breeder 1 year or less	do	18.0	30.0	36.0	54.0	36.0	32.0
Seed cleaned and/or treated regularly before planting	do	56.0	69.0	79.0	58.0	25.0	41.0
Poison regularly to control boll weevil	do	32.0	35.0	28.0	5.0	3.0	5.0
Average corresponding to 3 or more yearly yields reported, 1938–46:							
Cotton acreage planted	Acre	17.0	16.4	10.7	68.6	80.3	91.4
Percentage of cotton acreage not harvested	Percent	.3	.1	.1	1.1	1.6	1.2
Loss by hail, per acre per year	Pound	1.0	3.0	15.0	1.0	0	0
Fertilizer applied per acre	100 pounds	5.0	5.5	5.9	(3)	(3)	(3)
Percentage of cotton acreage planted on contour	Percent	(3)	(3)	(3)	92.0	92.0	91.0
Percentage of cropland in cotton acreage	do	27.0	28.0	28.0	37.0	38.0	41.0

Percentage of cropland in legumes	do	18.0	24.0	27.0	(3)	(3)	(3)
Average yield	Pound	305.0	355.0	372.0	153.0	167.0	187.0
Average coefficient of variation unadjusted [4]	Percent	28.0	29.0	29.0	42.0	46.0	42.0
Average coefficient of variation adjusted [5]	do	27.0	29.0	29.0	41.0	46.0	44.0
8 or 9 years of yields reported, 1938–46:							
Farms	Number	180.0	82.0	9.0	39.0	97.0	41.0
Average yield	Pound	310.0	364.0	388.0	156.0	176.0	201.0
Average coefficient of variation	Percent	26.0	29.0	31.0	41.0	46.0	48.0
Trend in yearly yield	Pound	7.0	4.0	7.0	−2.0	−4.0	−6.0
1945 FCIC premium rate (75 percent coverage) per acre	do	8.8	13.5	18.7	8.5	12.9	17.3
1945 FCIC rate (75 percent) in percentage of average yield, 1938–46	Percent	2.9	3.8	5.0	5.6	7.7	9.3
Average standard deviation		82.0	103.0	108.0	63.0	77.0	82.0
Percentage of all operators participating in Federal crop insurance for 1 or more years during period, 1942–46	Percent	18.0	20.0	13.0	31.0	26.0	18.0

[1] Calculated for farms with one kind of labor only. If the specified kind was employed in combination with other kinds of labor, the farm was counted negatively in deriving the ratios.

[2] Not calculated.

[3] Not applicable.

[4] Trend in yield has not been removed.

[5] Trend in yield was removed for all farms reporting 8 or 9 years of yields.

TABLE 40.—*Relation of participation of operators in Federal crop-insurance program to farm average yield and coefficient of variation, and other specified factors*[1]

Item	Unit	Operators participating in FCIC program					
		Upper Piedmont			West Texas Rolling Plains		
		3 or 4 years	1 or 2 years	Never	3 or 4 years	1 or 2 years	Never
Farms reporting 3 or more years of yields, 1938–46	Number	7.0	104.0	508.0	18.0	80.0	307.0
Years of experience growing cotton on 1946 farm	do	11.0	17.0	16.0	18.0	12.0	12.0
Age of operator in 1946	Year	55.0	55.0	54.0	48.0	48.0	48.0
Years of schooling	Number	7.0	6.0	7.0	9.0	9.0	8.0
Percentage of operators engaging in off-farm work	Percent	14.0	17.0	23.0	44.0	12.0	11.0
Soil characteristics:							
Percentage of operators reporting:							
Severe erosion	do	29.0	32.0	29.0	6.0	9.0	7.0
Steep and hilly topography	do	14.0	9.0	11.0	----	----	1.0
Percentage of operators reporting following practices:							
Cropper labor employed [2]	do	29.0	30.0	23.0	(3)	(3)	(3)
Hired labor employed [2]	do	(3)	(3)	(3)	50.0	53.0	61.0
Seed from breeder 1 year or less	do	29.0	24.0	21.0	56.0	42.0	37.0
Seed cleaned and/or treated regularly prior to planting	do	71.0	64.0	59.0	39.0	28.0	38.0
Poison regularly to control boll weevil	do	29.0	36.0	33.0	11.0	3.0	4.0
Averages corresponding to 3 or more yearly yields reported, 1938–46:							
Cotton planted	Acre	19.2	16.6	16.1	70.5	87.0	78.0
Percentage of cotton acreage not harvested	Percent	.7	.3	.2	1.6	3.5	1.1
Loss by hail, per acre per year	Pound	4.7	6.2	1.0	1.2	.8	.5
Fertilizer applied per acre	100 pounds	6.2	5.1	5.0	(4)	(4)	(4)
Percentage of cotton planted on the contour	Percent	(4)	(4)	(4)	92.0	90.0	92.0
Percentage of cropland in cotton acreage	do	28.0	27.0	27.0	36.0	38.0	37.0
Ratio of legume acreage to cotton acreage harvested		1.0	.8	.8	(4)	(4)	(4)
Average yield	Pound	361.0	324.0	311.0	185.0	166.0	165.0
Average coefficient of variation	Percent	27.0	27.0	28.0	46.0	48.0	45.0

8 or 9 years of yields reported, 1938–46:							
Farms	Number	3.0	51.0	224.0	11.0	35.0	131.0
Average yield	Pound	365.0	331.0	326.0	174.0	186.0	176.0
Average coefficient of variation	Percent	22.0	26.0	28.0	38.0	45.0	47.0
Trend in yearly yield	Pound	6.0	3.0	7.0	−4.0	−5.0	−5.0
1945 FCIC premium rate	do	10.4	10.4	10.3	11.8	12.5	13.1
Percentage 1945 premium rate is of average yield [5]	Percent	2.9	3.2	3.3	6.4	7.5	7.9

[1] FCIC program was available only during 1942, 1943, 1945 and 1946.

[2] Calculated for farms with one kind of labor only. If the specified kind was employed in combination with other kinds of labor, the farm was counted negatively in deriving the ratios.

[3] Not calculated.

[4] Not applicable.

[5] For period 1938–46 for farms reporting 3 or more years of yields.

TABLE 41.—*Relation of soil type and soil treatment to average yield and coefficient of variation and other statistical measures at specified locations in the Cotton Belt (Based on results reported by experiment stations)*

Item	Location	Type of soil	Period	Fertilizer		Years in experiment	Yield of seed cotton			Coefficient of variation	Coefficient of determination of trend
				Analysis	Quantity per acre		Average	Trend	Standard error		
					Lb.	*No.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Piedmont											
Winter cover crop											
None	Clemson College, S. C.	Cecil Sandy Loam	1926–36	6–12–6	600+	11	1,373	84	355	26	*0.41
Rye and vetch	do.	do.	1926–36	6–12–6	100 n.s.	11	1,651	96	299	18	**.56
Effect of lime											
Without fertilizer	do.	Cecil Sandy Clay Loam	1931–35	None	None						
No lime	do.	do.	1931–35	do.	do.	5	1,196	−262	426	36	−.56
With lime	do.	do.	1931–35	do.	do.	5	1,442	−101	221	15	−.71
With fertilizer	do.	do.	1931–35	3.3–8–4	600						
No lime	do.	do.	1931–35	3.3–8–4	600	5	1,722	−343	248	14	*−.86
With lime	do.	do.	1931–35	3.3–8–4	600	5	1,997	−233	255	13	−.74
Effect of pH											
5.0	do.	Cecil Sandy Loam	1940–43	5–10–0	480 with potash varying from 0 to 72.	4	1,109	−183	195	18	−.69
5.5	do.	do.	1940–43	5–10–0		4	1,292	−175	183	14	−.70
6.0	do.	do.	1940–43	5–10–0		4	1,380	−186	150	11	−.79
6.5	do.	do.	1940–43	5–10–0	do.	4	1,424	−183	121	8	−.85
Coastal Plain											
Effect of rotation											
Continuous cotton	Holly Springs, Miss.	Memphis Silt Loam	1925–35	4–8–8	600	11	1,555	−40	419	27	−.10
Two-year rotation [1]	do.	do.	1925–35	4–8–8	600	11	1,766	−32	370	21	−.08
Continuous cotton	Florence, S. C.	Orangeburg Fine Sandy Loam	1914–19	None	None	6	1,322	−123	338	26	−.36
Three-year rotation [2]	do.	do.	1914–19	do.	do.	6	1,621	50	201	12	.21
Rotation and fertilizer											
Fertilizer only	do.	do.	1914–19	4–8–4	1,000	6	1,817	−25	496	27	−.01
Fertilizer and 3-year rotation	do.	do.	1914–19	4–8–4	1,000	6	1,880	57	540	29	.04

Winter cover crop											
None	Raymond, Miss.	Oliver Silt Loam	1929–34	0–8–4	600	6	846	−110	196	23	−.57
Austrian peas	do.	do.	1929–34	0–8–4	600	6	926	−32	61	7	−.55
None	Florence, S. C.	Not given	1929–42	4–8–4 and	[3] 650	14	1,704	−9	547	32	−.01
Austrian peas	do.	do.	1929–42	5–10–5	[4] 600	14	1,920	13	586	31	.01
None	St. Joseph, La.	Sarpy Sandy Loam	1930–35	None	None	6	1,038	−16	175	17	−.23
Austrian peas	do.	do.	1930–35	do.	do.	6	1,817	−5	339	18	0
Combinations with fertilizer [5]											
None	Tifton, Ga.	Tifton Sandy Loam	1922–29	do.	do.	8	135	−8	92	68	−.06
Green manure and											
200 lbs. fertilizer [6]	do.	do.	1922–29	2–8–6	200	8	468	49	146	31	.44
300 do. do.	do.	do.	1922–29	2–8–6	300	8	670	45	130	19	**.79
400 do. do.	do.	do.	1922–29	2–8–6	400	8	743	70	208	28	.44
Lime and											
200 lbs. fertilizer	do.	do.	1922–29	2–8–6	200	8	390	29	151	39	.20
300 do. do.	do.	do.	1922–29	2–8–6	300	8	527	42	174	33	.28
400 do. do.	do.	do.	1922–29	2–8–6	400	8	630	50	165	26	.39
Green manure, lime, and											
200 lbs. fertilizer [6]	do.	do.	1922–29	2–8–6	200	8	483	74	97	20	**.80
300 do. do.	do.	do.	1922–29	2–8–6	300	8	619	77	184	30	*.55
400 do. do.	do.	do.	1922–29	2–8–6	400	8	630	50	165	26	.39

[1] Cotton and vetch. Vetch, corn with soybeans, or sorghum for silage.
[2] Corn and cowpeas. Oats followed by cowpeas. Cotton.
[3] 1930–38.
[4] 1939–42.
[5] A 3-year rotation was employed as follows: Cotton. Corn. Oats.
[6] Following oats in the rotation, a cover crop of cowpeas was turned under. This was followed by Austrian peas which were turned prior to cotton.

* Indicates that r^2 is significant at the 5-percent point.
** Indicates an r^2 that is highly significant (1 percentage point).
South Carolina Agricultural Experiment Station annual report (*30*); Paden, W. R. (*24*); Weir, Wilbert W. (*34*); Effects of winter soil conserving crops (*33*).

TABLE 42.—*Average yield, coefficient of variation, and trend, by States and counties, period 1938–46*

State	County [1]	Yield	Coefficient of variation [2]	Yearly trend
		Pounds	*Percent*	*Pounds*
Alabama	Autauga	208	36	9.7
	Baldwin	220	30	12.2
	Barbour	168	33	8.1
	Bibb	211	38	15.6
	Blount	345	11	10.5
	Bullock	130	40	5.3
	Butler	180	36	2.5
	Calhoun	226	24	3.6
	Chambers	195	24	18.1
	Cherokee	331	14	4.8
	Chilton	229	31	16.0
	Choctaw	164	40	11.4
	Clarke	151	38	8.7
	Clay	218	20	11.4
	Cleburne	229	19	3.3
	Coffee	204	31	8.3
	Colbert	322	18	16.3
	Conecuh	199	33	4.9
	Coosa	170	32	8.8
	Covington	201	34	5.8
	Crenshaw	192	31	−.5
	Cullman	402	14	11.4
	Dale	184	35	3.9
	Dallas	201	38	14.1
	Dekalb	426	12	4.8
	Elmore	239	28	6.4
	Escambia	238	32	5.3
	Etowah	331	11	8.4
	Fayette	241	35	13.0
	Franklin	256	22	14.2
	Geneva	241	33	9.5
	Greene	169	35	12.5
	Hale	201	28	17.7
	Henry	213	31	2.1
	Houston	243	26	.6
	Jackson	340	12	10.6
	Jefferson	268	20	15.5
	Lamar	243	30	13.4
	Lauderdale	283	15	12.9
	Lawrence	335	18	18.4
	Lee	165	31	7.7
	Limestone	337	11	12.6
	Lowndes	177	34	7.3
	Macon	179	25	3.5
	Madison	327	12	14.3
	Marengo	167	32	11.8
	Marion	244	22	20.5
	Marshall	417	9	5.1
	Mobile	231	34	8.8
	Monroe	214	33	7.4
	Montgomery	192	30	4.1
	Morgan	341	12	14.0
	Perry	154	35	12.7
	Pickens	234	33	14.4
	Pike	182	29	2.9

TABLE 42.—*Average yield, coefficient of variation, and trend, by States and counties, period 1938–46—Continued*

State	County [1]	Yield	Coefficient of variation [2]	Yearly trend
		Pounds	*Percent*	*Pounds*
Alabama (continued)	Randolph	244	22	12.2
	Russell	149	27	5.4
	St. Clair	247	18	8.7
	Shelby	239	22	17.0
	Sumter	169	40	14.4
	Talladega	223	24	9.5
	Tallapoosa	193	28	5.6
	Tuscaloosa	241	28	14.4
	Walker	267	29	19.6
	Washington	184	34	9.8
	Wilcox	181	34	12.1
	Winston	293	21	24.1
Arizona	Graham	510	19	−12.4
	Maricopa	413	21	2.4
	Pima	509	26	5.9
	Pinal	392	25	−6.2
	Yuma	339	19	−12.3
Arkansas	Arkansas	267	15	9.4
	Ashley	299	23	8.7
	Bradley	205	15	.3
	Calhoun	189	16	−1.4
	Chicot	287	27	−2.3
	Clark	216	23	8.1
	Clay	385	14	−.9
	Cleburne	221	14	1.0
	Cleveland	178	15	1.8
	Columbia	177	13	2.0
	Conway	212	33	3.3
	Craighead	419	12	.1
	Crawford	211	56	−12.7
	Crittenden	511	13	−5.4
	Cross	434	15	−2.2
	Dallas	195	20	5.1
	Desha	330	25	2.6
	Drew	253	17	6.7
	Faulkner	229	22	.3
	Franklin	193	37	7.1
	Fulton	225	20	2.5
	Grant	192	19	8.0
	Greene	387	16	−4.2
	Hempstead	187	27	5.0
	Hot Spring	206	25	10.4
	Howard	162	25	.6
	Independence	265	18	−5.2
	Izard	229	20	−1.8
	Jackson	302	12	−1.7
	Jefferson	361	11	8.4
	Johnson	205	47	−7.7
	Lafayette	205	28	.9
	Lawrence	308	12	−.4
	Lee	359	12	−3.6
	Lincoln	302	18	2.5

TABLE 42.—*Average yield, coefficient of variation, and trend, by States and counties, period 1938–46—Continued*

State	County [1]	Yield	Coefficient of variation [2]	Yearly trend
		Pounds	*Percent*	*Pounds*
Arkansas (continued)	Little River	164	34	−6.9
	Logan	197	34	−7.3
	Lonoke	303	14	4.6
	Miller	204	25	−4.3
	Mississippi	517	16	−8.8
	Monroe	304	12	3.6
	Montgomery	146	38	3.2
	Nevada	168	16	1.2
	Ouachita	175	18	−1.4
	Perry	192	37	.4
	Phillips	368	9	3.7
	Pike	144	24	7.5
	Poinsett	482	15	−4.2
	Polk	164	33	4.0
	Pope	189	32	3.2
	Prairie	273	19	1.1
	Pulaski	315	19	−1.5
	Randolph	309	13	.4
	St. Francis	420	14	−4.6
	Scott	168	39	−4.4
	Sebastian	191	44	−6.8
	Sevier	151	22	3.5
	Sharp	234	19	−1.8
	Union	173	32	2.9
	Van Buren	196	22	6.1
	White	249	16	2.1
	Woodruff	316	16	−.6
	Yell	207	35	−1.5
California	Fresno	598	11	−2.9
	Imperial	413	26	44.9
	Kern	680	12	−15.8
	Kings	591	18	−5.4
	Madera	505	11	−29.8
	Merced	457	18	−22.4
	Riverside	359	21	−14.9
	Stanislaus	325	28	37.1
	Tulare	585	10	−20.2
Florida	Holmes	180	26	5.0
	Jackson	175	25	9.6
	Madison	115	24	4.5
Georgia	Baldwin	181	24	−1.2
	Banks	244	16	7.4
	Barrow	282	16	−1.3
	Bartow	293	14	6.8
	Ben Hill	192	12	0
	Bleckley	204	27	.6
	Brooks	193	32	.3
	Bulloch	248	22	5.3
	Burke	233	23	10.0
	Butts	270	22	11.3
	Calhoun	223	23	10.8

TABLE 42.—*Average yield, coefficient of variation, and trend, by States and counties, period 1938–46—Continued*

State	County [1]	Yield	Coefficient of variation [2]	Yearly trend
		Pounds	*Percent*	*Pounds*
Georgia (continued)	Candler	199	22	2.4
	Carroll	264	16	7.6
	Chattooga	290	14	4.4
	Cherokee	261	12	10.2
	Clarke	245	25	11.1
	Clay	217	31	12.2
	Cobb	246	17	4.6
	Coffee	182	21	3.4
	Colquitt	230	19	.6
	Columbia	187	35	2.1
	Coweta	248	17	10.9
	Crawford	143	35	2.5
	Crisp	236	17	−1.8
	Dodge	192	25	2.0
	Dooly	230	17	−2.8
	Douglas	243	14	3.7
	Early	218	29	−1.3
	Elbert	239	31	6.7
	Emanuel	172	26	.5
	Fayette	274	16	8.9
	Floyd	255	18	2.4
	Forsyth	283	11	5.6
	Franklin	263	24	4.6
	Fulton	256	14	7.3
	Glascock	228	29	−4.7
	Gordon	302	16	3.3
	Greene	198	28	−.1
	Gwinnett	242	11	−3.3
	Hall	247	14	1.5
	Hancock	190	24	−.6
	Haralson	274	14	.9
	Harris	191	18	8.2
	Hart	295	26	4.7
	Heard	220	17	16.2
	Henry	288	20	7.1
	Houston	187	26	−.4
	Irwin	225	20	3.1
	Jackson	245	13	3.4
	Jasper	272	24	7.9
	Jefferson	226	21	8.0
	Jenkins	231	27	4.9
	Johnson	207	26	.7
	Lamar	215	25	14.5
	Laurens	207	19	6.7
	Lincoln	194	33	.1
	Lowndes	179	33	−6.8
	Macon	206	28	4.6
	Madison	279	20	8.8
	McDuffie	228	28	9.8
	Meriwether	225	21	10.0
	Mitchell	193	35	−2.2
	Montgomery	167	23	8.3
	Morgan	294	18	2.9
	Murray	294	15	4.6

TABLE 42.—*Average yield, coeficient of variation, and trend, by States and counties, period 1938–46—Continued*

State	County [1]	Yield	Coefficient of variation [2]	Yearly trend
		Pounds	*Percent*	*Pounds*
Georgia (continued)	Newton	283	21	4.0
	Oconee	270	22	10.6
	Oglethorpe	239	25	7.5
	Paulding	280	10	3.3
	Peach	222	27	1.2
	Pickens	232	12	−.1
	Pike	236	21	7.3
	Polk	285	21	5.0
	Pulaski	221	23	5.6
	Randolph	197	34	6.4
	Richmond	223	27	5.1
	Rockdale	275	23	.6
	Schley	200	33	6.0
	Screven	244	26	9.9
	Seminole	216	31	1.8
	Spalding	241	21	5.5
	Stephens	215	24	−2.2
	Sumter	241	24	3.2
	Taliaferro	181	32	4.1
	Tattnall	207	19	1.3
	Taylor	199	29	−4.4
	Telfair	158	16	9.2
	Terrell	265	21	−3.2
	Thomas	194	38	2.2
	Tift	234	18	−2.5
	Toombs	190	14	10.6
	Troup	158	29	8.4
	Turner	212	23	5.8
	Twiggs	165	29	5.5
	Walker	293	14	.4
	Walton	321	21	3.3
	Warren	243	24	1.3
	Washington	212	23	−1.0
	Whitfield	270	14	−1.1
	Wilcox	193	18	−1.6
	Wilkes	184	27	.4
	Wilkinson	167	28	2.3
	Worth	217	14	2.0
Louisiana	Acadia	295	45	−5.0
	Avoyelles	313	42	−3.9
	Bienville	139	41	−12.6
	Bossier	224	35	−15.1
	Caddo	265	32	−13.2
	Caldwell	271	43	−7.9
	Catahoula	281	50	−7.7
	Claiborne	161	26	−8.6
	Concordia	300	50	−.5
	De Soto	162	42	−13.4
	East Carroll	337	36	−15.9
	East Feliciana	175	44	−3.6
	Evangeline	290	36	1.0
	Franklin	297	28	−12.4
	Grant	245	56	1.6

TABLE 42.—*Average yield, coefficient of variation, and trend, by States and counties, period 1938–46*—Continued

State	County [1]	Yield	Coefficient of variation [2]	Yearly trend
		Pounds	*Percent*	*Pounds*
Lousiana (continued)	Jackson	152	38	−11.9
	Lafayette	269	42	.6
	Lincoln	153	31	−12.5
	Madison	330	43	−14.8
	Morehouse	336	31	−1.8
	Natchitoches	274	45	.1
	Ouachita	265	38	−5.8
	Pointe Coupee	301	41	.1
	Rapides	301	48	2.3
	Red River	194	43	−10.2
	Richland	295	30	−7.7
	Sabine	170	41	−5.3
	St. Landry	281	44	−3.3
	St. Martin	275	47	−1.0
	Tensas	336	36	−5.3
	Union	185	30	−9.2
	Vermilion	237	50	−3.7
	Washington	224	34	−13.4
	Webster	165	25	−8.6
	West Carroll	300	24	−8.2
	Winn	161	49	−8.8
Mississippi	Adams	186	51	−5.0
	Alcorn	288	23	9.4
	Amite	226	39	−8.0
	Attala	213	41	7.4
	Benton	283	23	7.4
	Bolivar	401	15	−4.8
	Calhoun	251	37	14.5
	Carroll	233	36	5.7
	Chickasaw	235	42	11.8
	Choctaw	203	49	18.3
	Claiborne	124	44	−5.1
	Clarke	191	47	14.4
	Clay	196	51	14.5
	Coahoma	442	11	−2.4
	Copiah	191	37	−6.8
	Covington	239	36	−6.0
	De Soto	357	13	0
	Forrest	209	43	−6.2
	Franklin	190	48	−5.2
	Grenada	232	30	13.0
	Hinds	238	37	−4.7
	Holmes	298	26	−1.6
	Humphreys	372	21	−2.8
	Issaquena	299	28	−3.7
	Itawamba	237	32	22.6
	Jasper	209	42	2.7
	Jefferson	209	45	−4.9
	Jefferson Davis	268	38	1.0
	Jones	244	40	−7.2
	Kemper	188	46	10.0
	Lafayette	259	27	6.5
	Lamar	231	39	−8.6

TABLE 42.—*Average yield, coefficient of variation, and trend, by States and counties, period 1938–46*—Continued

State	County [1]	Yield	Coefficient of variation [2]	Yearly trend
		Pounds	*Percent*	*Pounds*
Mississippi (continued)	Lauderdale	182	46	12.4
	Lawrence	253	37	−2.1
	Leake	258	35	3.9
	Lee	276	34	9.9
	Leflore	418	15	1.8
	Lincoln	208	42	−7.5
	Lowndes	210	45	12.9
	Madison	243	32	−2.6
	Marion	257	38	−11.0
	Marshall	267	26	5.9
	Monroe	247	34	11.7
	Montgomery	206	45	11.3
	Neshoba	239	40	5.6
	Newton	222	41	2.8
	Noxubee	200	46	12.6
	Oktibbeha	158	61	12.4
	Panola	299	21	−2.7
	Pike	214	37	−11.3
	Pontotoc	559	15	10.8
	Prentiss	281	28	23.4
	Quitman	418	13	−8.2
	Rankin	239	36	−2.5
	Scott	247	37	−2.4
	Sharkey	394	22	−6.1
	Simpson	249	36	−5.4
	Smith	265	35	−3.2
	Sunflower	397	16	.6
	Tallahatchie	403	14	−2.7
	Tate	344	23	−2.0
	Tippah	279	26	5.8
	Tishomingo	265	18	15.4
	Tunica	477	11	−10.3
	Union	272	32	6.4
	Walthall	257	33	−11.9
	Warren	259	44	−7.3
	Washington	398	18	−5.3
	Wayne	212	37	10.7
	Webster	210	42	15.4
	Wilkinson	198	51	3.5
	Winston	233	43	13.4
	Yalobusha	235	38	5.3
	Yazoo	292	29	−3.4
Missouri	Butler	338	19	−8.6
	Dunklin	452	14	−5.3
	Mississippi	515	22	−15.8
	New Madrid	459	21	−20.5
	Pemiscot	501	12	−13.4
	Scott	406	22	−3.3
	Stoddard	403	17	−15.3
New Mexico	Chaves	492	17	−5.8
	Dona Ana	602	10	−16.4
	Eddy	390	18	−9.9

TABLE 42.—*Average yield, coefficient of variation, and trend, by States and counties, period 1938–46—Continued*

State	County [1]	Yield	Coefficient of variation [2]	Yearly trend
		Pounds	*Percent*	*Pounds*
North Carolina	Alexander	364	8	57.5
	Anson	307	20	5.3
	Beaufort	299	55	11.5
	Bertie	352	36	23.1
	Bladen	251	41	9.6
	Cabarrus	340	22	24.3
	Catawba	402	10	11.9
	Chatham	265	26	23.7
	Chowan	345	42	13.2
	Cleveland	475	11	16.4
	Cumberland	324	24	9.7
	Davidson	303	17	−1.6
	Davie	315	24	−4.1
	Duplin	305	36	2.8
	Edgecombe	325	32	19.1
	Franklin	300	27	18.5
	Gaston	352	16	4.3
	Gates	351	29	21.9
	Greene	291	48	6.7
	Halifax	343	32	23.5
	Harnett	382	23	5.7
	Hertford	353	34	18.6
	Hoke	399	20	3.9
	Iredell	385	14	0
	Johnston	334	28	18.3
	Lee	316	25	6.0
	Lenoir	287	44	3.0
	Lincoln	432	10	7.9
	Martin	346	43	34.0
	Mecklenburg	330	17	13.7
	Nash	337	36	10.2
	Northampton	403	29	36.6
	Perquimans	347	44	4.0
	Pitt	300	46	15.1
	Polk	352	12	3.2
	Richmond	269	28	7.6
	Robeson	338	31	15.4
	Rowan	382	15	6.6
	Rutherford	384	10	9.8
	Sampson	346	33	3.9
	Scotland	369	23	18.4
	Stanly	370	13	34.2
	Union	359	15	21.8
	Wake	300	28	19.7
	Warren	313	23	17.3
	Wayne	305	37	6.1
	Wilson	333	38	16.8
Oklahoma	Beckham	143	25	−.4
	Blaine	160	29	−.5
	Bryan	130	22	−7.8
	Caddo	192	27	−5.3
	Canadian	189	24	−1.1
	Choctaw	132	30	−7.1

TABLE 42.—*Average yield, coefficient of variation, and trend, by States and counties, period 1938–46—Continued*

State	County [1]	Yield	Coefficient of variation [2]	Yearly trend
		Pounds	*Percent*	*Pounds*
Oklahoma (continued)	Cleveland	179	25	−8.0
	Comanche	128	34	−.5
	Cotton	138	42	−1.7
	Creek	190	35	−17.8
	Custer	160	35	4.6
	Dewey	140	29	4.3
	Garvin	152	30	−6.1
	Grady	161	26	−3.2
	Greer	133	38	.4
	Harmon	131	33	−1.1
	Haskell	156	36	−9.2
	Hughes	171	33	−11.8
	Jackson	144	43	.4
	Jefferson	145	35	−5.2
	Johnston	123	26	−8.2
	Kiowa	142	50	3.0
	Le Flore	170	41	−17.6
	Lincoln	167	43	−16.7
	Logan	169	31	−13.5
	Love	134	29	−.8
	Marshall	168	29	−8.9
	McClain	168	24	−10.2
	McCurtain	164	36	−9.7
	McIntosh	176	34	−14.9
	Muskogee	183	30	−12.4
	Okfuskee	185	31	−17.8
	Oklahoma	208	32	−16.8
	Okmulgee	195	34	−18.2
	Osage	244	29	−19.7
	Pawnee	232	32	−19.0
	Payne	212	30	−19.8
	Pittsburg	160	30	−11.8
	Pontotoc	129	31	−8.8
	Pottawatomie	165	35	−12.1
	Roger Mills	124	30	4.1
	Seminole	147	38	−12.2
	Sequoyah	169	40	−17.0
	Stephens	123	33	−1.8
	Tillman	183	35	−3.6
	Tulsa	228	31	−15.5
	Wagoner	210	31	−16.0
	Washita	171	28	−1.2
South Carolina	Abbeville	262	33	6.0
	Aiken	286	29	7.4
	Allendale	273	25	4.6
	Anderson	325	23	3.3
	Bamberg	249	35	−3.6
	Barnwell	284	29	5.7
	Berkeley	257	34	18.8
	Calhoun	327	30	8.8
	Cherokee	354	14	10.9
	Chester	319	22	21.0
	Chesterfield	283	24	3.0

TABLE 42.—*Average yield, coefficient of variation, and trend, by States and counties, period 1938–46—Continued*

State	County [1]	Yield	Coefficient of variation [2]	Yearly trend
		Pounds	*Percent*	*Pounds*
South Carolina (continued)	Clarendon	299	25	7.2
	Colleton	269	27	23.7
	Darlington	300	33	7.3
	Dillon	353	30	1.9
	Dorchester	290	28	17.9
	Edgefield	327	29	5.5
	Fairfield	243	35	4.7
	Florence	285	35	10.2
	Greenville	355	14	.2
	Greenwood	244	33	11.0
	Hampton	268	19	16.8
	Kershaw	243	36	10.6
	Lancaster	273	28	8.7
	Laurens	310	27	8.4
	Lee	339	34	16.0
	Lexington	288	33	8.2
	Marion	326	34	7.2
	Marlboro	389	26	17.4
	McCormick	231	33	4.4
	Newberry	285	31	11.4
	Oconee	325	17	7.2
	Orangeburg	318	28	6.9
	Pickens	307	16	6.0
	Richland	256	34	16.1
	Saluda	311	36	4.5
	Spartanburg	328	15	−2.0
	Sumter	322	34	12.9
	Union	255	19	16.5
	Williamsburg	298	30	4.3
	York	331	24	23.3
Tennessee	Benton	284	14	13.5
	Carroll	345	15	13.6
	Chester	356	15	17.8
	Crockett	426	14	10.2
	Decatur	269	15	12.4
	Dyer	428	13	2.6
	Fayette	309	15	12.0
	Gibson	385	11	10.5
	Giles	296	11	13.0
	Hardeman	325	16	16.2
	Hardin	270	14	19.1
	Haywood	376	16	8.0
	Henderson	353	11	16.9
	Henry	288	15	9.7
	Lake	513	15	−1.3
	Lauderdale	456	16	1.4
	Lawrence	308	13	17.1
	Lincoln	327	6	14.0
	Madison	353	13	13.8
	McNairy	333	15	17.5
	Obion	364	17	1.8
	Rutherford	332	17	6.5
	Shelby	348	14	7.5

TABLE 42.—*Average yield, coefficient of variation, and trend, by States and counties, period 1938–46—Continued*

State	County [1]	Yield	Coefficient of variation [3]	Yearly trend
		Pounds	*Percent*	*Pounds*
Tennessee (continued)	Tipton	424	14	3.9
	Wayne	273	17	16.0
	Weakley	325	14	12.8
Texas	Anderson	115	37	−11.1
	Angelina	179	31	−15.1
	Atascosa	87	29	4.0
	Austin	169	32	−8.4
	Bailey	156	43	−1.1
	Bastrop	112	13	3.1
	Baylor	149	42	−5.9
	Bee	122	26	9.1
	Bell	137	22	−2.3
	Bexar	107	42	−2.0
	Borden	164	51	−4.4
	Bosque	108	9	1.2
	Bowie	152	25	−10.7
	Brazoria	207	61	−16.4
	Brazos	209	21	−3.8
	Briscoe	152	34	6.5
	Brown	102	35	3.0
	Burleson	170	21	−10.2
	Burnet	108	16	−6.1
	Caldwell	129	22	1.8
	Calhoun	208	42	−12.5
	Callahan	123	35	−1.9
	Cameron	265	26	16.1
	Cass	143	21	−6.6
	Cherokee	120	30	−11.7
	Childress	135	55	−.2
	Clay	139	36	−4.8
	Cochran	148	62	1.3
	Coleman	117	38	−.2
	Collin	197	16	−13.5
	Collingsworth	142	31	.8
	Colorado	146	29	−.7
	Concho	122	41	1.0
	Cooke	137	21	−8.4
	Coryell	106	15	−1.8
	Cottle	153	40	−5.0
	Crosby	179	34	−7.2
	Dallas	177	17	−9.1
	Dawson	187	33	−9.1
	Delta	191	22	−21.3
	Denton	159	21	−9.8
	DeWitt	111	26	−.4
	Dickens	169	43	−7.8
	Donley	147	27	−.7
	Duval	89	26	5.8
	Ellis	173	11	−7.7
	El Paso	632	18	−2.9
	Erath	85	44	7.0
	Falls	141	24	−5.9
	Fannin	189	19	−18.6

TABLE 42.—*Average yield, coefficient of variation, and trend, by States and counties, period 1938–46—Continued*

State	County [1]	Yield	Coefficient of variation [2]	Yearly trend
		Pounds	*Percent*	*Pounds*
Texas (continued)	Fayette	144	23	2.0
	Fisher	151	31	−5.3
	Floyd	173	22	2.5
	Foard	186	35	−7.4
	Fort Bend	230	47	−9.4
	Freestone	107	25	−6.1
	Gaines	114	59	−1.3
	Garza	185	51	−6.3
	Goliad	126	20	7.9
	Gonzales	111	33	−.5
	Gray	121	28	5.5
	Grayson	171	22	−14.6
	Grimes	160	23	−8.0
	Guadeloupe	116	33	2.3
	Hale	169	22	7.7
	Hall	165	48	−.5
	Hamilton	104	21	−1.2
	Hardeman	152	38	−4.4
	Harris	171	36	−6.7
	Harrison	130	30	−12.2
	Haskell	179	30	−4.2
	Hays	125	21	2.9
	Henderson	111	29	−14.7
	Hidalgo	245	21	12.7
	Hill	149	11	−4.2
	Hockley	193	33	4.1
	Hopkins	134	24	−16.0
	Houston	151	28	−10.5
	Howard	163	42	−4.1
	Hudspeth	432	20	12.0
	Hunt	166	16	−16.0
	Jackson	177	40	−11.1
	Jim Wells	132	32	6.5
	Johnson	141	21	1.2
	Jones	149	40	−1.7
	Karnes	106	33	2.3
	Kaufman	141	18	−11.6
	Kent	144	48	−5.8
	King	153	48	−5.3
	Kleberg	155	20	6.0
	Knox	185	39	−5.7
	Lamar	168	23	−13.2
	Lamb	189	29	.5
	Lavaca	139	22	.3
	Lee	110	26	.5
	Leon	129	25	−6.1
	Liberty	186	38	−3.9
	Limestone	117	18	−5.9
	Live Oak	123	20	8.2
	Lubbock	213	26	4.8
	Lynn	191	41	−4.7
	Madison	143	31	−4.0
	Martin	167	45	−5.3
	Matagorda	234	40	−14.0

TABLE 42.—*Average yield, coefficient of variation, and trend, by States and counties, period 1938–46—Continued*

State	County [1]	Yield	Coefficient of variation [2]	Yearly trend
		Pounds	*Percent*	*Pounds*
Texas (continued)	McCulloch	112	38	1.3
	McLennan	136	17	-.4
	Midland	130	57	-2.1
	Milam	140	28	-5.1
	Mitchell	152	30	-2.6
	Montague	113	34	2.7
	Morris	143	29	-10.9
	Motley	148	31	-6.0
	Nacogdoches	142	42	-9.2
	Navarro	141	12	-6.2
	Nolan	154	33	4.6
	Nueces	237	15	0
	Panola	134	36	-8.2
	Pecos	279	22	-.6
	Polk	179	43	-9.0
	Rains	120	23	-15.5
	Red River	153	29	-10.3
	Reeves	256	28	-11.2
	Refugio	195	29	-9.8
	Robertson	165	28	-3.4
	Rockwall	181	17	-14.9
	Runnels	134	38	-2.6
	Rusk	122	36	-7.5
	San Augustine	159	35	-10.6
	San Jacinto	179	35	-10.3
	San Patricio	238	23	-7.0
	San Saba	115	31	-1.2
	Schleicher	116	43	1.6
	Scurry	155	35	-4.6
	Shelby	153	46	-9.8
	Smith	109	32	-12.2
	Starr	84	24	4.8
	Stonewall	129	38	-5.2
	Tarrant	149	20	-6.8
	Taylor	120	36	2.6
	Terry	151	46	-4.1
	Throckmorton	148	58	-.8
	Tom Green	143	44	-2.3
	Travis	140	20	.7
	Trinity	158	35	-10.8
	Upshur	112	33	-11.5
	Van Zandt	114	28	-14.7
	Victoria	156	36	-2.6
	Walker	149	26	-6.1
	Waller	173	31	-11.2
	Ward	274	23	-13.4
	Washington	163	24	-6.8
	Wharton	214	48	-13.4
	Wheeler	128	29	4.1
	Wichita	163	22	-4.8
	Wilbarger	214	29	-9.0
	Willacy	250	20	10.5
	Williamson	155	24	-3.5
	Wilson	98	40	2.9

TABLE 42.—*Average yield, coefficient of variation, and trend, by States and counties, period 1938–46*—*Continued*

State	County [1]	Yield	Coefficient of variation [2]	Yearly trend
		Pounds	*Percent*	*Pounds*
Texas (continued)	Wise	109	18	−4.4
	Wood	114	37	−11.1
	Young	115	39	1.3
Virginia	Brunswick	287	15	20.2
	Charlotte	274	17	15.6
	Dinwiddie	290	16	21.0
	Greensville	362	22	31.6
	Halifax	272	20	14.0
	Isle of Wight	352	25	33.4
	Lunenburg	287	18	13.2
	Mecklenburg	301	15	19.8
	Nansemond	373	25	33.4
	Norfolk	318	33	22.0
	Prince George	287	20	20.7
	Princess Anne	348	29	24.1
	Southampton	369	27	35.6
	Sussex	319	22	31.3

[1] Counties included for which there were 8 or more years of yields.
[2] Standard error of estimate of trend values expressed as a percentage of the mean yield.

Questionnaire and Instructions

QUESTIONNAIRE

SOUTHERN STATES COTTON YIELD VARIABILITY

Budget Bur. No. 40-R1686.1
Approval expires 10-31-47

Part I. General Information

1. Schedule number________
2. SRS–1 serial number________ SR–301 serial number________
3. Type-of-farming sub-region (leave blank)________
State________ County________ Township________
4. Type of road on which this farm tract is located (check one): Concrete________(1) tar and gravel________(2) improved and topsoil road________(3) unimproved road________(4) access road only[a]________(5)
5. Operating period of this farm:
   a. Total acreage of farm land operated in this tract in 1946________
   b. What was your first crop season on this farm as operator________
   Have you operated it continuously since then? Yes________ No________ If no, give years since 1937 when you did not operate this farm________
   c. Since 1937, has cropland been sold, given or traded from this farm? Yes________ No________ Give the last year this occurred________
   d. Since 1937, has cropland been added to this farm by purchase, or by gift or by trade? Yes________ No________ Give the last year this occurred________
   e. The operating period of this farm is from________to 1946 (Note: Enumerator, enter the latest date of b, or c, or d above)
   f. During which years in this period (5e) did you grow cotton on this tract [b]________
6. a. How many other farm tracts did you operate in 1946________
   b. Total acreage of cropland in all farm tracts operated in 1946________
   c. Acreage of cotton harvested from all tracts in 1946________
   d. Number of 500-lb. bales produced from all tracts in 1946________
   e. Total net pounds of lint cotton produced from all tracts in 1946 [c]________
   f. 1946 average yield of lint cotton per acre for all tracts (6e ÷ 6c)________
7. Landlord and operator information:
   a. 1946 landlord of this tract________
   Address________
   b. 1946 operator of this tract________
   Address________
   c. 1946 operator's status (check one): Owner-operator________(1) operated as an estate________(2) hired manager________(3) unpaid manager________(4) cash tenant________(5) standing renter________(6) share renter [d]________(7) cropper tenant [e]________(8)
   d. If owner-operator, how did you acquire this farm: By inheritance________(1) purchase________(2) mortgage foreclosure________(3) other________ (4)
   e. Education of the operator: Elementary and high school________years; agricultural college [f]________years; other college________years; studied vocational agriculture in high school________years
   f. Origin of operator (check one): From local farm________(1) from farm but elsewhere in Cotton Belt________(2) from small town in same locality________(3) from city in Cotton Belt________(4) from city outside Cotton Belt________(5) from foreign country________(6)
   g. Color of operator (check one): White________(1) black________(2) other________(3)
   h. Sex: Male________(1) female________(2)

[a] Means farm is not located on a public road but is served by an ordinary farm road.

[b] If cotton was not grown any year during the operating period (5a), discontinue the questionnaire at this point, and proceed to the next farm on the list.

[c] Gross weight of 6d minus a deduction for tare, i. e., number of bales ginned multiplied by the weight of bagging and ties—21 pounds.

[d] Share-renter furnishes all workstock and equipment and receives a share of the produce. Do not confuse with sharecropper.

[e] Cropper tenant furnishes part of the fertilizer, all labor and a type of management; and receives a share of the produce, usually one-half. This type is essentially a sharecropper but differs from the typical sharecropper in that he lives on a farm separately from the landlord and exercises considerable freedom in the choice of land used for cotton, methods of cultivation, and the use of labor on the farm. The landlord lives in town, or at some distance from the farm. It, therefore, seems best to establish a separate class for this type. All information for the period of his tenancy should be obtained directly from him.

[f] Applies only when an agricultural course was taken; if a nonagricultural course was taken in an agricultural college, show years attended under "other college."

Schedule number--------------------- Page 2

8. Off-farm work engaged in by farm operator (check one): Cotton gin--------(1) sawmill--------(2) carpenter--------(3) textile worker --------(4) merchant--------(5) other work--------(6) does not engage in off-farm--------(7)

9. Soil description of cotton land:
   a. Soil color (check one): Gray--------(1) yellow--------(2) gray-yellow--------(3) red--------(4) red-yellow--------(5) gray-red --------(6) dark red--------(7) brown--------(8) dark brown--------(9) black--------(10) other--------(11)
   b. Soil texture (check one): Clay--------(1) clay loam--------(2) sandy clay loam--------(3) sandy clay--------(4) deep sand-------- (5) rocky soil--------(6) gumbo--------(7) buckshot--------(8) other--------(9) alluvial [a]: loam--------------(10); alluvial: sand --------(11); alluvial: buckshot--------(12); alluvial: clay--------(13); alluvial: other--------(14)
   c. Extent of erosion (check one): None--------(1) scarcely none--------(2) light sheet erosion--------(3) heavy sheet erosion-------- (4) all of topsoil gone--------(5) occasional small gullies--------(6) numerous gullies--------(7)
   d. Type of topography (check one): Level--------(1) gently rolling--------(2) rolling--------(3) hilly--------(4) steep--------(5)
   e. Enter soil type if known (If not available enter as "X")--

10. Farm practices used in growing cotton:
    a. How many years from breeder do you generally plant cotton seed (check one): Direct from breeder--------(1) 1 year--------(2) 2 years --------(3) three years--------(4) other--------(5)
    b. Are seed regularly cleaned before planting: Always--------(1) never--------(2) sometimes--------(3) year started------------------
    c. Are seed generally treated before planting: Always--------(1) never--------(2) sometimes--------(3) year started------------------
    d. Poisoning: Do you apply 1-1-1 arsenic poison: Every season--------(1) never apply--------(2) apply some seasons--------(3)
       Usual number of applications per season--------
       Do you apply calcium arsenate as dust: Every season--------(1) never apply--------(2) some seasons--------(3)
       Usual number of applications per season--------

Part II. Annual Data: The operating period is from------------to 1946 (transfer from 5e)

NOTE:—Draw a line through all annual spaces below except the *operating period* above. But do not obtain data for any year during which cotton was not planted.

Items	1938	1939	1940	1941	1942	1943	1944	1945	1946			
11. Cropland: [b]												
a. Reported by AAA [c]												
b. Reported by operator	X	X	X	X	X							
12. Acreage of cropland in legumes [d]												

[a] Primarily applicable to the Mississippi Delta.

[b] Include cropland used for crops plus land temporarily idle, or fallow in any year, but only for the particular tract under investigation.

[c] Copy from SR-301 or SRS-1 forms and farm plan sheets.

[d] Include cowpeas and soybeans grown alone, lespedeza, all clovers, alfalfa, Austrian winter peas, crotolaria, kudzu, etc. Check with rotation system.

Schedule number

Items	1938	1939	1940	1941	1942	1943	1944	1945	1946			
13. Cotton acreage:												
a. Reported by AAA [a]												
b. Reported as harvested by the farmer	X	X	X	X	X							
c. Yearly acreage harvested [b]												
d. Cotton acreage planted but not harvested reported by the farmer:												
1. 1938–1942: Abandoned prior to AAA measurements and/or plowed up to meet AAA compliance						X	X	X	X			
2. 1943–1946: Abandoned because of crop failure	X	X	X	X	X							
3. 1943–1946: Acreage not harvested [c] because of lack of labor	X	X	X	X	X							
14. Production of cotton: 1943–1946:												
a. Number of 500-lb. bales produced [d]	X	X	X	X	X							
b. Total pounds net of lint cotton produced [e]	X	X	X	X	X							
15. Yield per acre (lbs. of lint):												
a. Reported by AAA [a]												
b. Reported by farmer	X	X	X	X	X							
c. Yearly average yield [b]												
16. Total lbs. of lint cotton lost by hail [f]												
17. Appraised yield for FCI listing sheets [g]												
18. Federal Crop Insurance on cotton (yes (1); no (2))	X	X	X	X			X					
19. Hail insurance[h] on cotton (yes (1); no (2))												
20. Crop insurance premium rates:												
a. 75% insured yield (lbs. of lint per acre)	X	X	X	X			X					
b. 50% insured yield (lbs. of lint per acre)	X	X	X	X			X					
21. Type of operator [i] (enter code number)												

[a] Copy from SR–301 or SRS–1 forms and farm plan sheets.

[b] Field enumerators will not fill in this space.

[c] If picked in part, exclude; but report under 13 b.

[d] Production converted to number of 500-lb. bales equivalent.

[e] Convert 14 b to total pounds gross weight; deduct allowance for tare at the rate of 21 pounds per bale ginned.

[f] Estimates by the farmer in 500-lb. equivalent bales lost by hail converted to a total net weight basis by deducting an allowance for tare.

[g] Copy only when yield is shown encircled on FCI listing sheets; enter a blank if appraised yields were not used.

[h] Refers to insurance purchased from private companies only.

[i] Owner-operator (1); estate operated (2); hired manager (3); unpaid manager (4); cash renter (5); standing renter (6); share renter (7); cropper tenant (8) (see foot note 3, page 1).

Schedule number ______________________

Items	1938	1939	1940	1941	1942	1943	1944	1945	1946			
22. Cotton acreage planted after idle land [a]												
23. Fertilizer and ammoniates:												
a. Commercially mixed fertilizer—total pounds applied per acre on cotton												
b. Ammoniates (and potash) as side dressing—total pounds applied per acre on cotton												
c. Total pounds of commercial fertilizer and ammoniates applied per acre on cotton												
24. Non-farm work of *operator*:												
a. Percentage of total *annual time* required												
b. Percentage of time required during *crop season*												
25. Percentage of operator's farm time lost during *crop season*												
a. Because of illness												
b. For other reasons than off-farm work (see 24 above)												
26. Type of labor used (share-cropper (1); hired (2); family labor (3))												
27. Tractor use:												
a. Tractor owned during (check spaces) [b]												
b. Cotton land prepared with tractor (all (1); none (2); part (3))												
c. Cotton planted with tractor (all (1); none (2); part (3))												
d. Cotton cultivated with tractor (all (1); none (2); part (3))												
28. Method of harvesting (hand picked (1); sledded (2); machine picked (3); snapped (4); sledded and snapped (5); machine picked followed by hand pickers (6); other (7))												
29. Age of operator												
30. Years of experience growing cotton:												
a. On this farm												
b. In this community												
c. In other regions of Cotton Belt												
31. Price received per lb. of lint												

[a] Land on which weeds have grown, or which has been allowed to remain idle for a period. Do not include land growing lespedeza, cut or uncut, or other hay in a regular rotation.

[b] Check all years during which a tractor was owned.

Schedule No.____________________ Page 5

32. Year of highest cotton yield since 1937:____________________(Year)

Farmer's reasons for high yield this year 1.____________________
2.____________________
3.____________________

Year of lowest cotton yield since 1937:____________________(year)

Farmer's reasons for low yield this year 1.____________________
2.____________________
3.____________________

Notes:____

Enumerator's estimate of quality of record:

Good__________ Fair__________ Poor__________ Reasons for rating____________________

Prepared by______________________________ Checked by______________________________

Instructions for Completing Southern States Cotton Yield Variability Questionnaire

Part I: GENERAL INSTRUCTIONS

1. On the basis of the aerial photos selected for the sample, make a list of the farms to be visited. Check with 1946 listing sheets to see who the 1946 owner and operator of the farm were. These data may not be available for some farms because all farms did not cooperate in 1946. Corrections can be made when you visit the farm.

When this rough working list has been prepared, attach it to your aerial photo and prepare to work in the area shown on the photo until all farms in the sample have been contacted. Work only in the part of the photo specified in the *sample.*

Obtain farms where the operator's dwelling falls within that part of photo specified. Follow this rule even though the major acreage of the farm may fall either inside or outside the part of the photo selected. When a farmer operates more than one tract,[64] either in or outside the sample section of the aerial photo, get only the farm tract on which his *dwelling* is located. Omit all other tracts except in question 6.

2. Data are to be obtained from the 1946 operator by visit and personal interview, supplemented by data from AAA files. If the operator has moved outside the community and cannot be located, turn in the form as a blank.

3. In reporting the annual data (Part II of Schedule) for each farm, begin with the year 1946 and work back year by year until the farm was subdivided, combined, or there was a change in the operator.

Only *one operator* is to be shown for *each farm* irrespective of the length of time the farm has been owned by one person.

In the case of reconstituted farms, show complete data only from the date the farm was reconstituted (subdivided or combined) until the end of crop season 1946 when operated by the same person.

> For example, suppose a farm owned by A and operated by B was subdivided in 1942 before the beginning of the crop season, although B had operated the farm since 1940. Show data for 1942 through 1946.
>
> But if a new operator, C, had come on the farm beginning with the crop of 1943, data would be shown only for 1943 to date inclusive.
>
> If the farm had never been subdivided, data would have been shown from 1940 to date in the case of operator B, or from 1943 to date in the case of operator C.

Subdivisions or combinations after the 1946 crop season may be ignored.

Study items 5b, 5c, and 5d. The shortest period established by any of these three items will determine the *operating period for the farm. This operating period will determine the maximum period for the annual data (items 11-32) but in no case will annual data be obtained for years in which no cotton was planted (items 13a, 13b, 13d-1, 13d-2, 13d-3).* If no cotton was planted during the *operating period* do not fill out the items beyond 5f.

---

[64] "Tract" means all the land included under one SRS-1 contract.

4. Enter acres to the nearest one-tenth of an acre, and yield data to the nearest pound. Show all other data to the nearest whole number.

5. Practically all data will be obtained from the farmer. But *11a, 13a,* and *15a* are to be copied from SR-301 and SRS-1. Question 17 is to be obtained from the following forms: FCI-27-C; FCI-503-C; FCI-603-C; and supplements; question 20 is to be obtained from the following forms: FCI-203-C; FCI-303-C; FCI-503-C; FCI-603-C and supplements.

Part II: INSTRUCTIONS FOR ITEMS

1. Schedule Number refers to the consecutive farm completed in your county for this study. For example, the first questionnaire you complete is to be numbered "1."

2. SRS-1 and SR-301. Show both serial numbers if applicable. This will give a check on your work. If recently reconstituted, only the SRS-1 number may be shown.

CAUTION: Some farmers may have more than one work sheet. *Be sure* to get data only for the *farm number in your sample.* Emphasize to the farmer that you want data only for *that particular* SRS-1 number.

5. Operating Period of This Farm. This section will determine the number of years to be included in answering items 11-32.

(a) Include cropland, woodland, pasture, etc., which correspond to the work-sheet unit for 1946.

(b) This item will show the period during which the farmer operated the farm *continuously* since 1937. The latest period of *uninterrupted* operation is the guide.

(c) and (d) Ascertain whether cropland has been deducted or added to the tract by any method and the *latest date* of such subdivisions or combinations in each case.

Any subdivisions or deductions from cropland occurring after the end of the 1946 crop season are to be omitted. For those during the 1946 crop season, enter an "x" only and omit all other information. However, if subdivided in April 1946, or before the beginning of the crop season, show the date.

(e) The operating period of the farm is from the latest date of either (b), (c), or (d) above, through 1946.

(f) Ascertain years during operating period in which cotton was grown. If cotton was not grown at all during the period shown in 5e, discontinue further questions on this farm and proceed to the next farm on your list. In order to keep the record straight, turn in the incomplete schedule on these noncotton farms.

6. (c) Acreage of Cotton Harvested in all tracts in 1946. Add acreage *harvested only* of all cotton in all tracts in 1946. Do not include acreage of cotton abandoned. Note: For items (a) to (f) see schedule.

7. Landlord and Operator Information.

(a) Show 1946 landlord of tract and his address as this information may help to locate the farm if the 1946 tenant has moved away.

(b) 1946 operator and his address are to be obtained when the farm is visited.

(c) Operator's status in 1946. Check the space which shows tenure status for the majority of the acreage. For example, if a certain operator owns 200 acres of cropland and rents 50 additional acres, check "owner." A farm may be operated as an estate if the owner is recently deceased.

"Hired manager" would apply if someone is paid a sum to manage the farm.

"Unpaid manager" is applicable when a relative manages the farm without compensation; or if with modest compensation, when it is not nearly appropriate to the managerial job. If paid a share of the produce, however, the relative is best classified as a paid manager. "Cash renter" applies when the operator contracts to pay a fixed sum of money for the use of the farm; "standing renter," when he contracts to pay a fixed quantity of cotton.

A "share renter" is not a "sharecropper." He owns workstock and equipment and contracts to pay a fixed share of the crop as rent, the size of the share depending upon how much the landlord furnishes in addition to land. This type of tenant has considerable freedom in the operation of the farm.

"Cropper tenant" has most of the characteristics of a sharecropper as he does not own workstock. But in this case the landlord does not live on the farm. It follows, therefore, that the cropper tenant (although in many respects a sharecropper) exercises a good deal more judgment in managing the farm, and for this reason is classed separately.

(d) If owner-operated, how did owner acquire this farm? Ascertain only in the case of *owner-operators*. Leave blanks open for all other four classes of operators. Let the highest proportion govern. For example, if the major portion of the land was obtained by inheritance, and only a small acreage by purchase, check the space after inheritance.

(e) Education of operator. For schooling of operator, show total years in elementary school and high school separately from years attended college. If a high school graduate, enter "11." Years attended agricultural college applies only when the agricultural course was taken. When both agricultural and nonagricultural college were attended, enter years attended after each type. If the farmer studied vocational agriculture in high school, show total years he studied the course.

(f) Origin of operator. Ascertain where operator grew up and lived prior to the time he became a farm operator. Be governed by the major portion of his life. For example, if he lived in a city in the Cotton Belt for 20 years and outside the Cotton Belt on a farm for 10, check the space for "from a city in the Cotton Belt."

8. OFF-FARM WORK OF THE OPERATOR. Check space to indicate the type of nonfarm work in which the operator engages regularly. If none is engaged in regularly, check the space for "7." Nonfarm work includes work for which a wage or salary is earned. Do not include in this category custom work and wage work for other farmers. Answer this question if the operator engaged in nonfarm work regularly for a few years. See Part II, number 24, for annual data on this question.

9. Soil Description of Cotton Land. Answer each subdivision—(a), (b), (c), or (d)—by placing a check mark in *the space* which meets most nearly the description of the major portion of the land normally devoted to cotton in the rotation system. If the farmer appears to know his business, his opinion regarding the soil description should be sufficient. Otherwise, reach a conclusion by personal observation of convenient fields, or by inquiring of the neighbors.

(e) Write in soil type if readily available in AAA office, or if this information can be obtained reliably from the soil survey map for the county.

10. Farm Practices Used in Growing Cotton.

(a) Years from the breeder refers to the time which has elapsed since the breeder grew the seed. If all planting seed is purchased each year from the breeder, then check "direct from the breeder." However, if the grower buys enough seed from the breeder each year to plant a field and uses the seed from this field to plant the entire crop the next year, and if he does this regularly, then check "1 year." If he carries over the same seed for a second year before seed is purchased from the breeder and the cycle repeated, then check "2 years." Be governed by the predominant practice.

However, watch a case of this kind. Farmer A may buy enough seed from the breeder each year to plant 5 acres. Then the next year he may plant his entire farm with the seed from these 5 acres. He may sell the remainder to farmer B. Both farmer A and farmer B would, therefore, be planting seed 1 year from the breeder. Also *this:* If A had held over his surplus seed instead of selling to B, and then planted the old seed the following year, he would that year also have planted seed one year from the breeder.

(d) Poisoning. 1-1-1 poison refers to a mixture of water, molasses, and calcium arsenate applied by mop, or otherwise, to the plant when it is small. The number of applications means the number of times over the entire crop. Count to the nearest whole number of times. After the plants become large, applications of calcium arsenate may be made as dust, usually with a blower type of machine, either hand or power operated.

ITEMS BY YEARS

The operating period was determined in question 5e. Transfer to this space the same date. The years included in this period will determine the years for which annual data will be obtained (items 11-32).

CAUTION: Draw a line through all the annual spaces which are prior to the first year in the *operating period.* For example, if the operator came to the farm in 1941 and no change in the cropland area of the farm has occurred since, the operating period would be 1941 to 1946. Therefore, mark out all annual spaces for 1938, 1939, and 1940, as only the period 1941 to 1946 will be used for annual data.

But even in this period annual data are to be shown only for the years when cotton was planted (item 13a, 13b, or 13d-1, 13d-2, 13d-3). If no cotton was planted in 1943, the spaces for this year would be left blank on *all pages*—not marked out. Likewise, if no cotton was planted in 1941 this year would be left blank—not marked out as described above.

11. Cropland. Include land used for crops plus land temporarily idle, or fallow, in any year. The acreage corresponds to the cropland in the AAA contract for the farm under consideration.

(a) Reported by AAA. Copy from SR-301 or SRS-1.

(b) Reported by the farmer. Obtain from the operator estimates of cropland operated on the farm tract under investigation for the period 1943 to 1946.

12. Legumes are considered to include the acreages of leguminous crops produced in any given crop year. Alfalfa and other crops left for one or more years will be counted. Include the following legumes also:

Cowpeas for hay, left for seed, or cut but not intercropped.
Soybeans for hay, left for seed, or cut but not intercropped.
Lespedeza, first year, second year, etc.
Austrian winter peas sown in fall.
Crimson clover sown in fall.
Bur clover.
Kudzu, crotolaria, sericea lespedeza.
Ladino clover.
Alsike, sweet clover, white dutch, etc.

13. Cotton Acreage.

(a) Enter from AAA records (SR-301, SRS-1 forms) the actual acreage measured by AAA representatives for the farm in July-August for the period 1938–42. This is the acreage for compliance. In some cases after initial measurement the farmer was required to plow up acreage in order to comply. This plowed-up acreage will be covered later under d-1. It is included with the abandoned acreage from the planting date under AAA measurements for compliance. Acreage for 1943 to date may or may not be available in AAA files. If the farmer has continued to cooperate, data may be obtained through 1946 from SRS-1 and from the farm plan sheets. In any event obtain cotton acreage and yields as completely as possible from AAA files.

(b) All data from 1943 to date will be as reported by the farmer. This will generally be the acreage harvested in the fall. Acreage harvested in the fall includes all acres from which some cotton was harvested. Include such acreages as were harvested in whole or in part. However, if some acres with a good crop were not touched, because of lack of labor, omit. If harvested in part, include.

(c) For office use. This *space is not to be filled* in by the enumerator.

(d) To get a picture of crop failure, this question must be obtained with some care.

(1) Pertains to the period 1938 to 1942 and is an attempt to build up the AAA measured acres as shown on SRS-1, or SR-301, for this period to a planted acreage equivalent for the farm. Include acreage abandoned (left idle or put in other crops) prior to the AAA measurements and such acreage as was plowed up to meet compliance with the farm allotment. *Do not* count crop

failure after the AAA measurements were recorded, as the average yields are computed on the basis of AAA measured acres. For example, if in 1942 a certain farmer abandoned 5 acres because of failure, etc., prior to AAA measurements and then was required to plow up 2 acres in order to meet AAA compliance, enter "7" in the space for 1942. If no acreage had been plowed up, "5" would have been entered.

(2) Pertains to the period from 1943 to 1946. We wish to get a figure that will show the difference between the farmer's planted acreage at the beginning of the crop and that acreage which he reported as harvested in the fall. Include all cotton acres abandoned because of failure, whether or not they are planted to other crops. Any acreages that were harvested in part and included in total production should not be shown here.

(3) However, if there are any acres which, although producing a crop, were not touched because of lack of labor, and if this acreage has not been included in the acreage as reported as harvested by the farmer, then this acreage would be shown as not harvested in this space.

14. Production of Cotton, 1943–46.

(a) Obtain production of cotton from the farmer in equivalent 500-lb. bales for 1943–46. This will enable computation of yields in 15b.

(b) Convert to gross weight and deduct for tare—21 pounds per bale ginned.

15. Cotton Yield.

(a) Enter the actual yield as shown on SR forms and farm plan sheets for 1938–46, or such years short of 1946 as are available in SR-301 and SRS-1 forms and farm plan sheets.

(b) For 1943–46 the data are as reported by the farmer and for part of this period may already have been obtained by the AAA and entered in SR-301 or SRS-1. If so, they will already have been entered in 13a. However, obtain 14a from the farmer for as much of the period 1943–46 as applies to the operating period. This avoids missing any years and perhaps may avoid a second trip to the farm (data for 1938–42 will always be available in AAA files). Compute yields (15b) for 1943–46 by dividing 14b by 13b.

(c) This space *is not to be filled out* by the field enumerator.

16. Hail Loss. Obtain hail loss in terms of 500-lb. bales lost. Convert to gross weight by deducting 21 pounds per bale for bagging and ties.

17. Appraised Yields. If appraised yields have been prepared for the farm in connection with the insurance program, enter yield in pounds for such years as are available. These are available from 1938 to 1942 on FCI form 27-C, which will be supplied by the State office of AAA; for 1943, 1945, and 1946 from forms FCI-303-c, FCI-503-c, and FCI-603-c. In the event no appraised yields were used, place a dash in the space.

18. Federal Crop Insurance. Indicate years when Federal Crop Insurance was in effect by writing in the appropriate code (yes (1); no (2)). The Federal Crop Insurance program was in effect in 1942,

1943, 1945, and 1946. Only these years will be considered in this question. Obtain from the farmer directly and check with such records as are available in the county office on farmer participation in the Federal Crop Insurance Program.

19. Hail Insurance. Indicate whether the farmer bought hail insurance from private companies. He may have done this irrespective of whether he purchased Federal Crop Insurance. Code proper answer as shown on schedule.

20. Crop Insurance Premium Rates. If crop insurance premium rates have been computed for this farm in connection with the Federal Crop Insurance Program, show cost per acre in pounds of lint for 75-percent coverage and for 50-percent coverage. Obtain from following FCI forms:

1942 FCI-203-c
1943 FCI-303-c
1945 FCI-503-c
1946 FCI-603-c

21. Type of Operator. Show year by year the change in the type of operator by entering an appropriate code number. See footnote 1, page 3 of the schedule.

22. Cotton Acreage Planted After Idle Land. Idle land is defined as land which was not cultivated for a period because of operator's inability to get to it or otherwise. If a crop of hay is cut, the land was not idle; also, if the system of rotation requires a hay crop, like lespedeza, which is left uncut, such land would not be considered as idle land.

Fallow land is distinguished from idle land in that it is idle land which is employed in a regular rotation for the purpose of resting the land or building up a moisture supply. Such land is plowed at intervals in order to keep down weeds.

Idle land is the term more applicable to the Eastern States and fallow to West Texas, perhaps. Enter year by year the acreage of cotton planted in *that year* which was idle for one or more years. Do not make an entry here if land was fallow. For West Texas see sheet on dry farming practices attached to questionnaire.

23. Fertilizer and Ammoniates.

(a) Commercially mixed fertilizer. Show total pounds applied per acre of all commercially mixed fertilizers.

(b) Ammoniates as side dressing. Sulphate of ammonia, nitrate of soda, calnitro, etc., applied to cotton after it is up. Enter average pounds per acre of all classes considered together; that is, if part sulphate of ammonia and part nitrate of soda are applied, show average rate per acre. Include also potash and kainite applied as side dressing.

(c) Show total of all fertilizer applied per acre of cotton. Add 23a and 23b.

24. Nonfarm Work of Operator.

(a) Show year by year the percentage of the operator's total time during entire year which was devoted to nonfarm work off the farm.

(b) Show year by year the percentage of the operator's time during the *crop growing season* which was devoted to nonfarm work off the farm. However, if the farmer engages in work only during the "lay-by" time, July 15 to August 15, do not count such time against time off during the *crop growing season.*

25. PERCENTAGE OF OPERATOR'S FARM TIME LOST DURING CROP SEASON.

(a) Because of illness. Count 7 months for the crop season. Do not count time lost during July 15 to August 15 (lay-by season).

(b) For other reasons. Time lost because of family troubles, financial troubles, police, etc.

26. to 28. See schedule.

29. AGE OF OPERATOR. Enter to nearest whole year.

30. EXPERIENCE GROWING COTTON. An actual count of years of experience the farmer has had growing cotton on the present farm. Any acreage of cotton planted in any year would be sufficient to count the year as a cotton year.

Years of experience growing cotton in the community includes those years on the farm in this record plus the years during which cotton was grown on other farms in that same community. Years of experience growing cotton in other regions should be interpreted to include production of cotton at such distance from the present farm as to represent a different set of conditions of production—soil, weather, etc.

If a farmer says he has grown cotton all his life on a particular farm, or in the community, do not enter his age as the years of experience, but make a deduction to allow for the years of his childhood when he did little or no work in the cotton fields. Ask the farmer to estimate the age at which he began working in the cotton fields and make the deduction accordingly.

31. PRICE RECEIVED FOR COTTON. Omit.

32. By referring to item 15, the years of the best and poorest cotton yields can be determined. Ask the farmer to explain why he thinks the yield was high (or low) in each of these years.

NOTES:—Enter in this space information about the farm which you think may have a bearing on variability of yield.

ENUMERATOR'S ESTIMATE OF QUALITY OF RECORD

If it is a complete and accurate record, check "good." If incomplete and inaccurate, check "poor," etc. Give reasons for rating, that is tell why it is incomplete, inaccurate, etc., or vice versa.

"Prepared by" is filled out by the person responsible for getting the data together and interviewing local farmers.

"Checked by" is filled out by the person with overhead responsibility for the report. He should check the figures for reasonableness and confer with the person who actually obtained the data relative to his methods. This assures a certain standard of performance in completing the data.

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