RELATION OF PRECIPITATION TO YIELD OF CORN.

By J. Warren Smith.
Section Director, Weather Bureau.

INTRODUCTION.

All cultivators of the soil recognize the important relation between precipitation and crop yield. Johnson[a] said in 1870: "It is a well-recognized fact that next to temperature the water supply is the most influential factor in the production of a crop."

We believe that few people have any proper appreciation of the effect of an abundant water supply upon the ultimate yield of crops, although this subject is now receiving careful investigation. In a recent publication of the Department of Agriculture[b] describing an exhaustive investigation of many types of soil under many conditions of cultivation and wide range of yields it was found impossible to correlate the yields observed with the nutritive mineral elements in the soil or in the soil solution, which latter is the immediate source from which plants feed. From this it was concluded that on the average farm the great controlling factor in the yield (but not necessarily the quality) of crop is not the amount of plant food present, but a physical factor, the exact nature of which is yet to be determined, and this idea is made more definite by the further statement "that the actual quantity of water a soil can furnish the plant, irrespective of the percentage of water actually present in the soil, has probably a very important influence on the yield."

It is self-evident that to have water furnished to the plant in any soil in sufficient quantities there must be an abundant supply available either through actual rainfall or through irrigation; so that, other things being equal, the results of the investigations of the Bureau of Soils seem to agree with the results found in practice, namely, heavy rainfall, large yields; light rainfall, small yields. And not only this, but, in a latitude and elevation favorable for the production of crops, precipitation has first place and temperature the second.

It was with something of this thought in mind that the writer, assisted by Prof. William D. Gibbs, president of New Hampshire State College, began the preparation of the accompanying charts; yet neither

[a] How Crops Feed, p. 216.

[b] Bulletin No. 22, Bureau of Soils, p. 63.

was prepared for the remarkable confirmation of their theory or the close relation between the yield of corn and the precipitation in certain definite short periods during the growth of the crop.

DATA FROM WHICH CHARTS WERE PREPARED.

Inasmuch as the greater portion of the corn produced in the United States is grown in the central part of the country, only Ohio, Indiana, Illinois, Iowa, Nebraska, Kansas, Missouri, and Kentucky are considered, both in the yield per acre and the precipitation.

As the area of greatest corn production does not include all of Ohio, Kentucky, Kansas, or Nebraska, we probably should have considered only the western parts of Ohio and Kentucky and the eastern parts of Nebraska and Kansas for both yield and rainfall. Charts 7 and 8 indicate that if this had been done there would have been an even closer relation between the curves on the preceding charts than was shown; because on charts 7 and 8, the States in the central part of the corn area, or those whose whole area is within the corn belt, show a closer relation in the curves given than do those upon either the western or the eastern edge of the corn belt.

DESCRIPTION OF CHARTS.

In all cases the precipitation is shown by the dotted line and the yield by the full line; the heavy horizontal line is the normal or average for the fifteen years for both.

CHART 1.—The full line indicates the average yield of corn per acre in bushels for the States of Ohio, Indiana, Illinois, Iowa, Nebraska, Kansas, Missouri, and Kentucky, from 1888 to 1902, inclusive. The dotted line shows the average precipitation for the month of June over the eight States and during the same period.

CHART 2.—The full line is the yield per acre, as in chart 1. The dotted line indicates the average precipitation over these States during the month of July.

CHART 3.—In this chart the yield is indicated by the full line and the precipitation for the month of August by the dotted line.

CHART 4.—"Yield" line is the same as in the above charts, and the dotted line shows the average rainfall for the months of June and July combined.

CHART 5.—The rainfall for June, July, and August is combined in the dotted line on this chart, giving the average total rainfall for those months over the eight States. The full line shows the yield.

CHART 6.—In this chart the precipitation for June and July is shown by the dotted line, as in chart 4. The "dot and dash" line indicates the lowest price of No. 2 cash corn in Chicago during the month of December of the same year, and for the same period.

CHART 7.—The yield of corn per acre is indicated by the full line and the total precipitation for June, July, and August by the dotted line, for each of the States of Ohio, Indiana, Illinois, and Iowa.

CHART 8.—This chart gives the yield per acre and precipitation during June, July, and August for the States of Nebraska, Kansas, Missouri, and Kentucky.

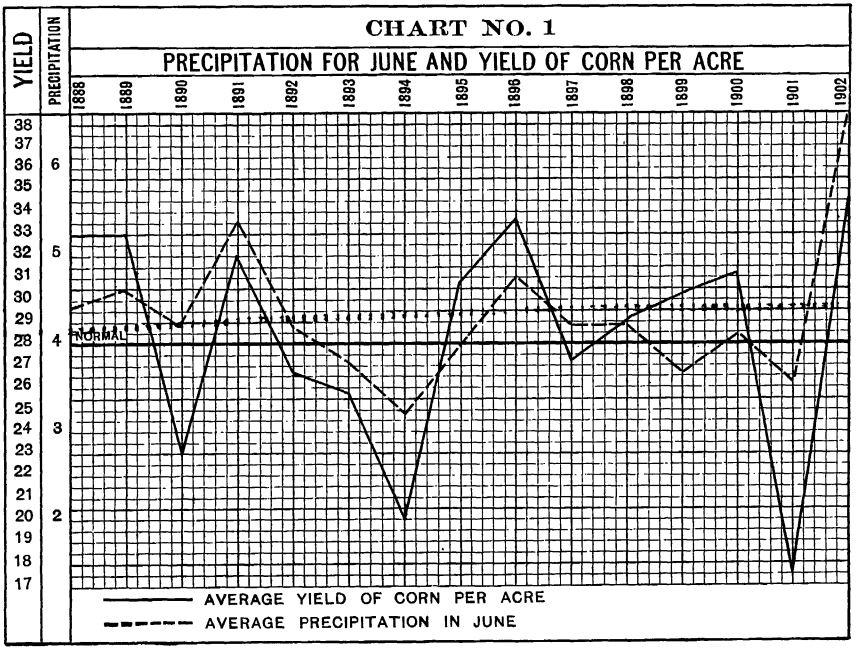

FIG. 11.—Precipitation for June and yield of corn per acre.

DISCUSSION OF CHARTS.

CHART 1.

This chart (fig. 11) shows a comparatively slight relation between the precipitation for June and the yield of corn per acre.

CHART 2.

This is probably one of the most interesting charts in the series (fig. 12). It indicates that if one knows the precipitation during the month of July over the great corn-producing district he can estimate the yield for the season very closely. There are differences, to be sure, but in the most part explainable ones. We are not sure that the statistics of yield were collected in 1888 with the care that has been exercised later. In 1891, when the yield for the district was considerably above normal, with the precipitation for July slightly below the average, there was a large June precipitation. Further, there was a very large yield in Nebraska and a moderately large yield in Kansas, Kentucky, and

Iowa, which would increase the average yield for the district. In 1896 the precipitation during July was the highest during the period, although the yield was not so large as in 1902. An examination of the meteorological records for July, 1896, however, shows that excessive showers fell across the northern part of the district. These injured corn rather than benefited it, while damage was done by drought in southern Missouri. The yield was slightly below normal in Missouri. In 1902 the yield was the greatest during the period, while the rainfall for

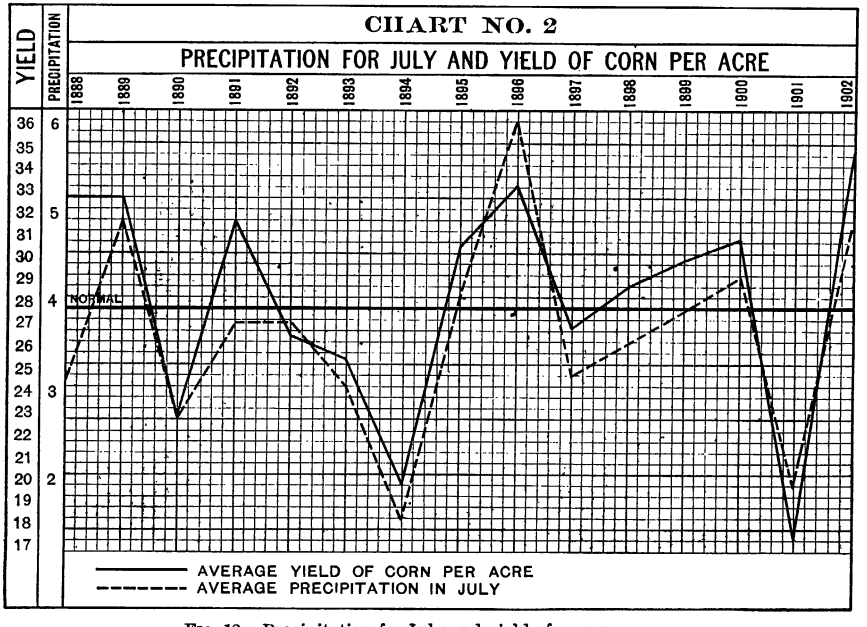

FIG. 12.—Precipitation for July and yield of corn per acre.

July was less than in 1889 or 1896. But the rainfall for June, 1902, was unusually heavy, and in connection with the abundant fall in July produced the heavy yield of that year.

CHART 3.

While the yield curve and that showing the rainfall for August agree at times, it will be readily seen that the precipitation for this month affects the general yield but little. (Fig. 13.)

CHART 4.

If the rainfall for June and July is combined, as has been done in this chart (fig. 14), the precipitation curve will follow the yield curve even more closely than the July precipitation alone, as might be expected. This is particularly true in 1891 and 1896. The agreement is not so close in 1901, however, as the rainfall for June of that year was about normal. It will be noticed that the yield was the smallest for the

period in 1901, even though the rainfall was only 2½ inches below the normal, instead of in 1894, when the rainfall for these two months was

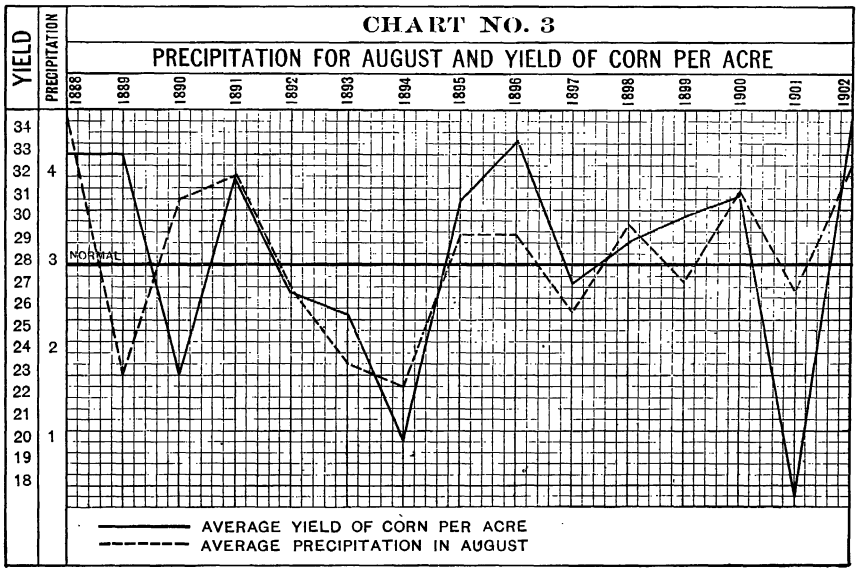

FIG. 13.—Precipitation for August and yield of corn per acre.

3¼ inches below the normal. Charts 7 and 8 show that in 1894 the yield was particularly low only in the western States, and was but slightly

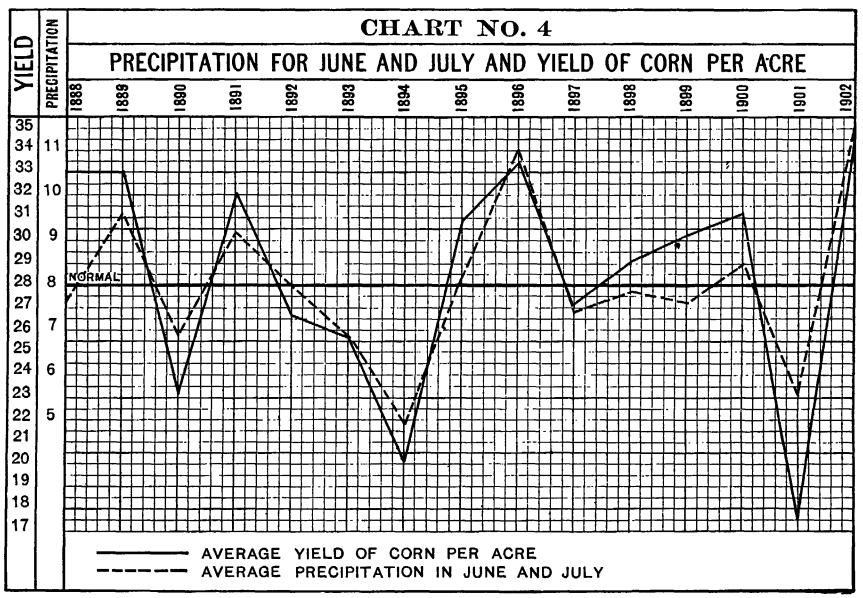

FIG. 14.—Precipitation for June and July and yield of corn per acre.

below normal in eastern districts, while in 1901 practically every State shows a small yield. The meteorological records show a severe

drought during both summers, but in 1894 the drought extended later into August, while in 1901 it began earlier in June, thus showing that it is the rainfall of June rather than that of August taken in connection with July that affects the yield most. Higher temperatures accompanied the drought in 1901, intensifying it and helping to force the yield lower than in 1894.

CHART 5.

In this chart (fig. 15) is included the rainfall for August with that for June and July. It makes the two curves agree a little more closely

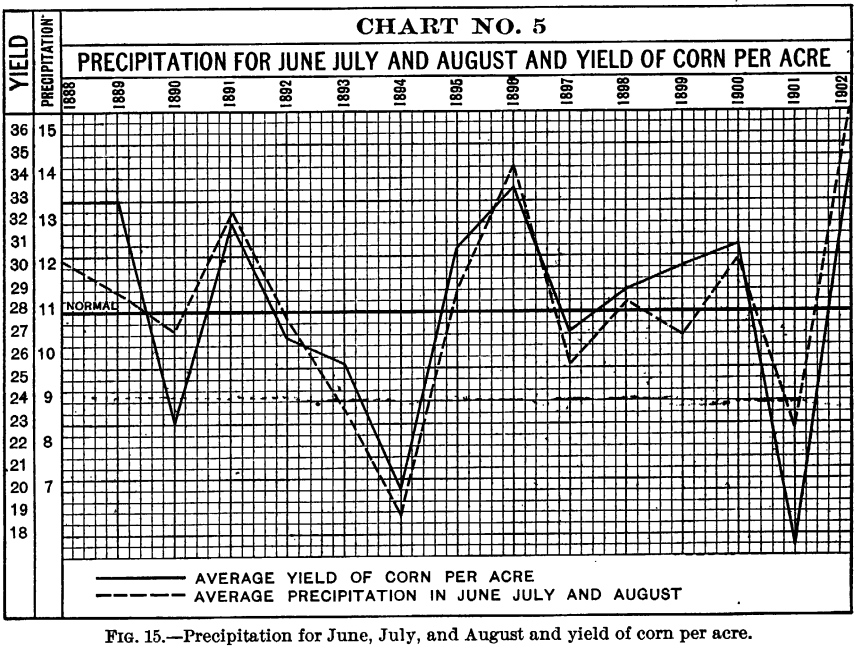

FIG. 15.—Precipitation for June, July, and August and yield of corn per acre.

in places, yet does not materially affect the results shown on either chart 2 or chart 4. It shows that the rainfall for August may or may not be included in the discussion without affecting the results to any great extent.

CHART 6.

The law of supply and demand certainly controls prices for the most part; hence, whatever affects yield affects prices. So it is only a step from the precipitation over our great corn-producing district during the vital period of its growth to the price of corn in the grain markets. One can not eliminate the factor of manipulation entirely, but it seems to be least observed in this curve of lowest cash price during December. (Fig. 16.) It is exceedingly interesting also to chart the rainfall from one season to another alongside of the price of corn on the first day of each month during the year.

CHARTS 7 AND 8.

These two charts (figs. 17 and 18) are self-explanatory, and are very interesting. The greatest yield per acre in Kansas, Nebraska, and Iowa occurred in 1889 (in Kansas far the greatest, though in Nebraska and Iowa it was only slightly greater than in 1896). In Ohio and Indiana, on the other hand, the yield was below the normal, and in Illinois and Kentucky it was about normal. The rainfall in July, 1889, was excessive in Nebraska and most of Kansas, and was abundant in most of Iowa. The fall was well distributed and in such amounts as to be very favorable to the growth of corn in those States. The rainfall was also above the normal during July in Indiana and Ohio, but it was accompanied by high winds and hail and heavy downpours, and considerable damage was done.

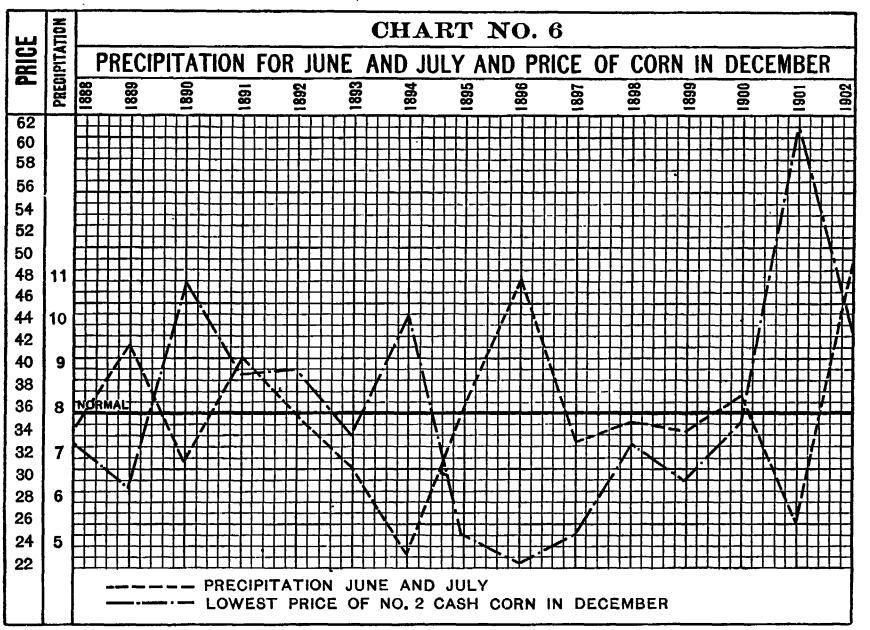

FIG. 16.—Precipitation for June and July and price of corn in December.

The year 1890 shows a uniformly low yield. It was the lowest in Ohio of all the years during the period, although the precipitation for Ohio for that summer was about the normal, as shown on the charts. The average for the State for July, however, was considerably below the normal, and in the western part of the State there was a severe drought. Many stations reported less rainfall during this month than during any other July in their history. At Dayton, Montgomery County, the total rainfall was only 0.28 inch; at Waynesville, Warren County, 0.48 inch; at North Lewisburg, Champaign County, 0.30 inch; at Wauseon, Fulton County, 0.48 inch; and at Greenville, Darke County, one of the largest corn-producing counties in Ohio, only 0.07 inch.

In 1891 the yield was somewhat above the normal in Kentucky, Kansas, and Iowa, and much above in Nebraska, agreeing very closely with

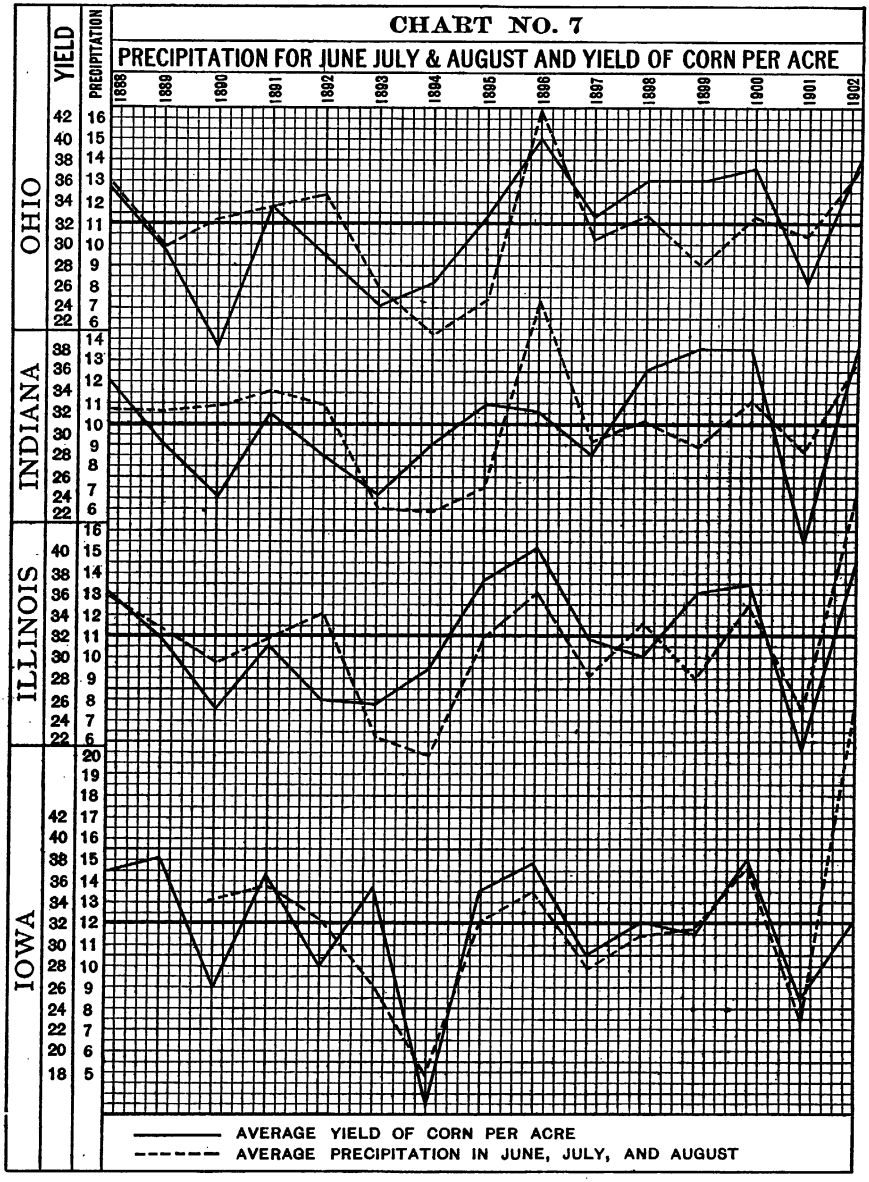

FIG. 17.—Precipitation for June, July, and August and yield of corn per acre in Ohio, Indiana, Illinois, and Iowa.

the rainfall curve. Further, the rainfall for July in Nebraska was heavy and well distributed.

In 1893 the yield for Ohio, Indiana, and Illinois was considerably below the normal. The precipitation was less than in other districts

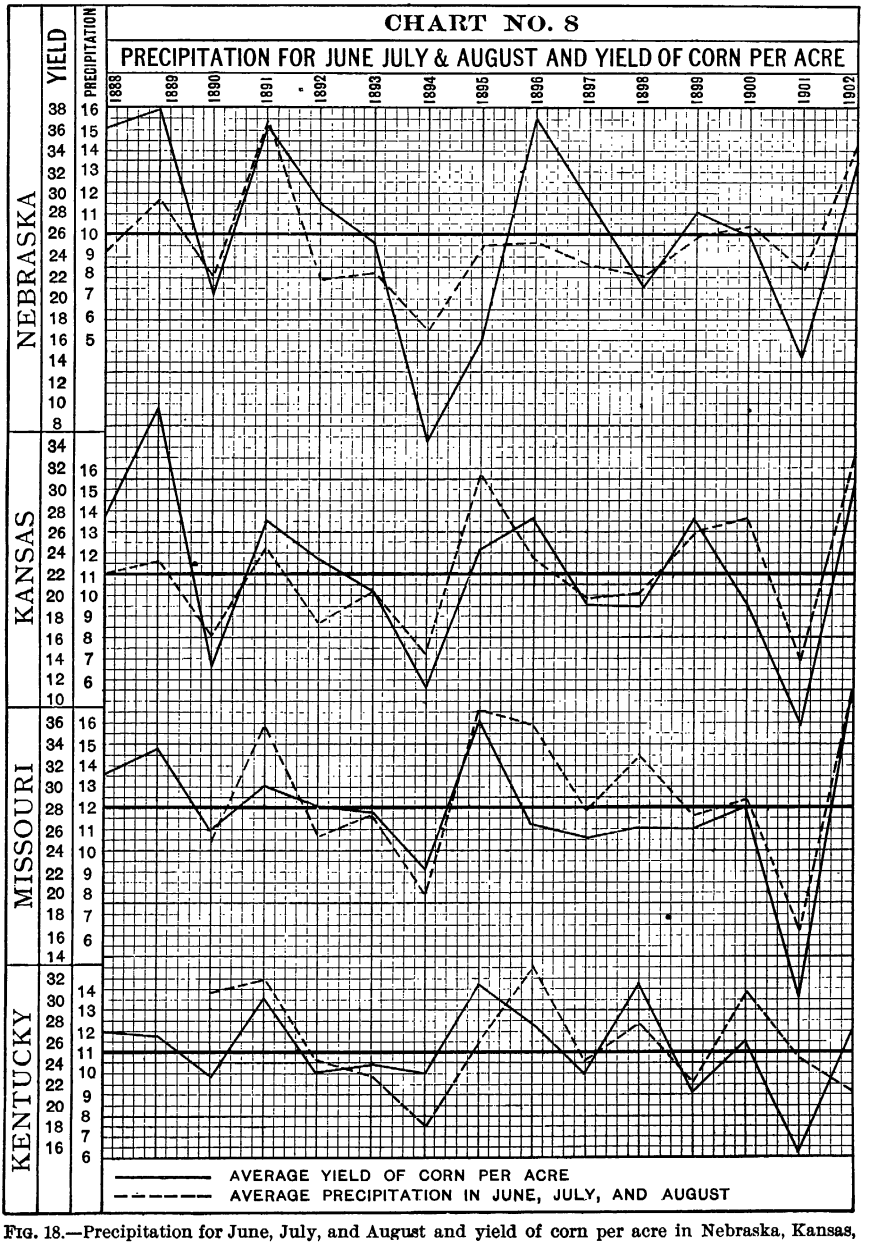

FIG. 18.—Precipitation for June, July, and August and yield of corn per acre in Nebraska, Kansas, Missouri, and Kentucky.

for the summer, and was very light during July in those States. In parts of Indiana the rainfall for July was less than 1 inch.

In 1894 the yield was generally below the normal, and was much below in Kansas, Iowa, and Nebraska—in the last two the lowest recorded in the fifteen years. In both States the precipitation for the summer was also the least recorded, while in July the average rainfall for Iowa and eastern Kansas and Nebraska was only about one-half inch. In Iowa, July, 1894, was the driest ever experienced.

In 1895 both the yield and the precipitation were highest during the fifteen years in Missouri, except in 1902. The rainfall for July of this year in Missouri was nearly 3 inches above the normal, and was well distributed. The precipitation for the summer was in excess in Kansas also, as was that for July, but the July rainfall was poorly distributed, being heavy in western counties and comparatively light in central districts.

In 1896 the yield was the greatest recorded in the period in Ohio and Illinois and was far above the normal in Nebraska. In Ohio the precipitation for the summer and that for July was the heaviest during the fifteen years. In Illinois the rainfall was not so great as in 1902, but the July rainfall was very heavy. In Nebraska, though the yield was large, the rainfall for the summer was slightly below the normal. In July, however, the rainfall was heavy in eastern counties, just where it was needed for the corn, and very light in the extreme west, thus making the average for the State only slightly above the normal, although in the great corn district it was much above. It will be noticed that in Indiana the rainfall was the greatest during the period, while the yield was but slightly above the normal. Complete data are not at hand to investigate the cause, but the rainfall was excessive during each of the summer months, particularly in July and August, probably giving too much water for the best growth and ripening.

In 1901 both the yield and the precipitation were very low, making the yield for the district the least during the fifteen years. As has been before stated, the rainfall during July of this year was everywhere below the normal, the least rainfall being in Indiana, Illinois, and Missouri, where the yields were the least.

The year 1902, on the other hand, gave the greatest yield and the heaviest summer precipitation for the district as a whole for the period. The most marked anomaly on charts 7 and 8 for this year was a very excessive rainfall in Iowa, with only a normal yield. In this State the rainfall was so excessive during July as to be damaging. Corn could not be properly worked and it was damaged on bottom lands by flooding. August was also wet and cloudy and the crop was late.

In general, charts 7 and 8 show that to draw well-defined comparisons between crop yields and summer precipitation for individual States one must take very carefully into account the geographical distribution of rainfall, the periods without rainfall, and the rate of fall.