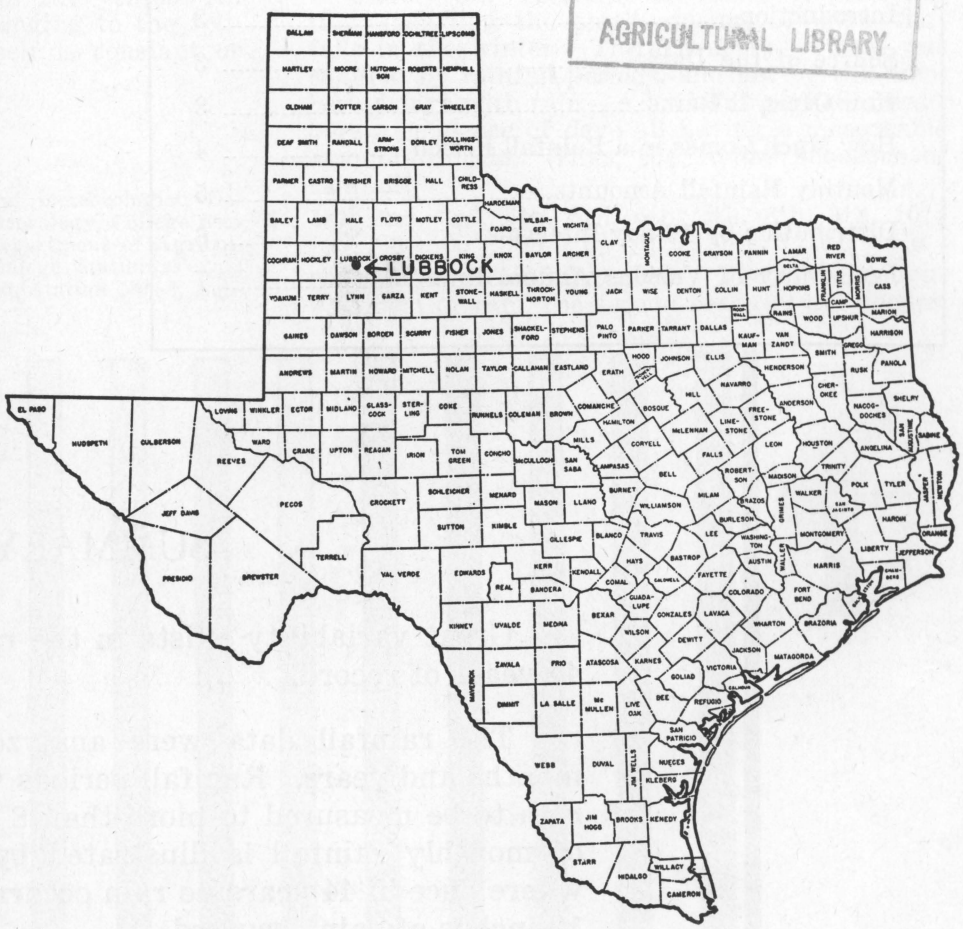
MP-211

• RAINFALL

• at

• Lubbock, Texas



June 1957

TEXAS AGRICULTURAL EXPERIMENT STATION

R. D. LEWIS, DIRECTOR, COLLEGE STATION, TEXAS

CONTENTS

SUMMARY

Great variability exists in the rainfall at Lubbock over 44 years of record.

The rainfall data were analyzed by rainfall periods, months and years. Rainfall periods varied from just enough rain to be measured to more than 8 inches. The variability of monthly rainfall is illustrated by the records for May, where once in 44 years no rain occurred and once in 44 years 12 inches of rain occurred.

This variability is due largely to the effect of infrequent heavy rains, especially in the summer. It, in turn, limits the reliability of using averages to predict the future.

Rainfall at Lubbock, Texas

W. G. Covey, R. J. Hildreth and E. L. Thaxton, Jr.*

THIS STUDY ANALYZES 44 years (1912 - 55) of rainfall data at Lubbock according to certain simple assumptions and methods. The chief assumption is, essentially, that what has been is a good (but not perfect) guide to what will be. That is, weather is controlled to a great extent by the progress of the seasons, location with respect to mountains and oceans, and other such general features of the earth and sun that do not change much in several generations. Variations and fluctuations occur through the years. All of these are considered as belonging to the "climate" of the place, which itself is constant or nearly so.

*Respectively: assistant agricultural meteorologist, Department of Oceanography and Meteorology, College Station, Texas; associate professor, Department of Agricultural Economics and Sociology, College Station, Texas; and assistant irrigation engineer, Substation No. 8, Lubbock, Texas.

SOURCE OF THE DATA

The taking of systematic weather records at Lubbock was begun on March 20, 1911 by personnel of Substation No. 8. This valuable series of observations continues, giving us 44 complete years of record through 1955 for evaluating the climate of Lubbock and surrounding regions of the Southern High Plains.

HOW OFTEN IT RAINS

Here "rain" refers to all forms of precipitation, including the small amount of snow that falls in the winter. The frequency of rain was counted by rainfall periods, and not by the number of days with rain. A "rainfall period" means here a sequence of days all having a measurable amount of rain. Thus, the 10-day sequence of rainfall:

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
0	0	.05"	.08"	0	0	1.06"	0	0	0

contains two rainfall periods. The first brought 0.13 inch of rain, the second brought 1.06 inches.

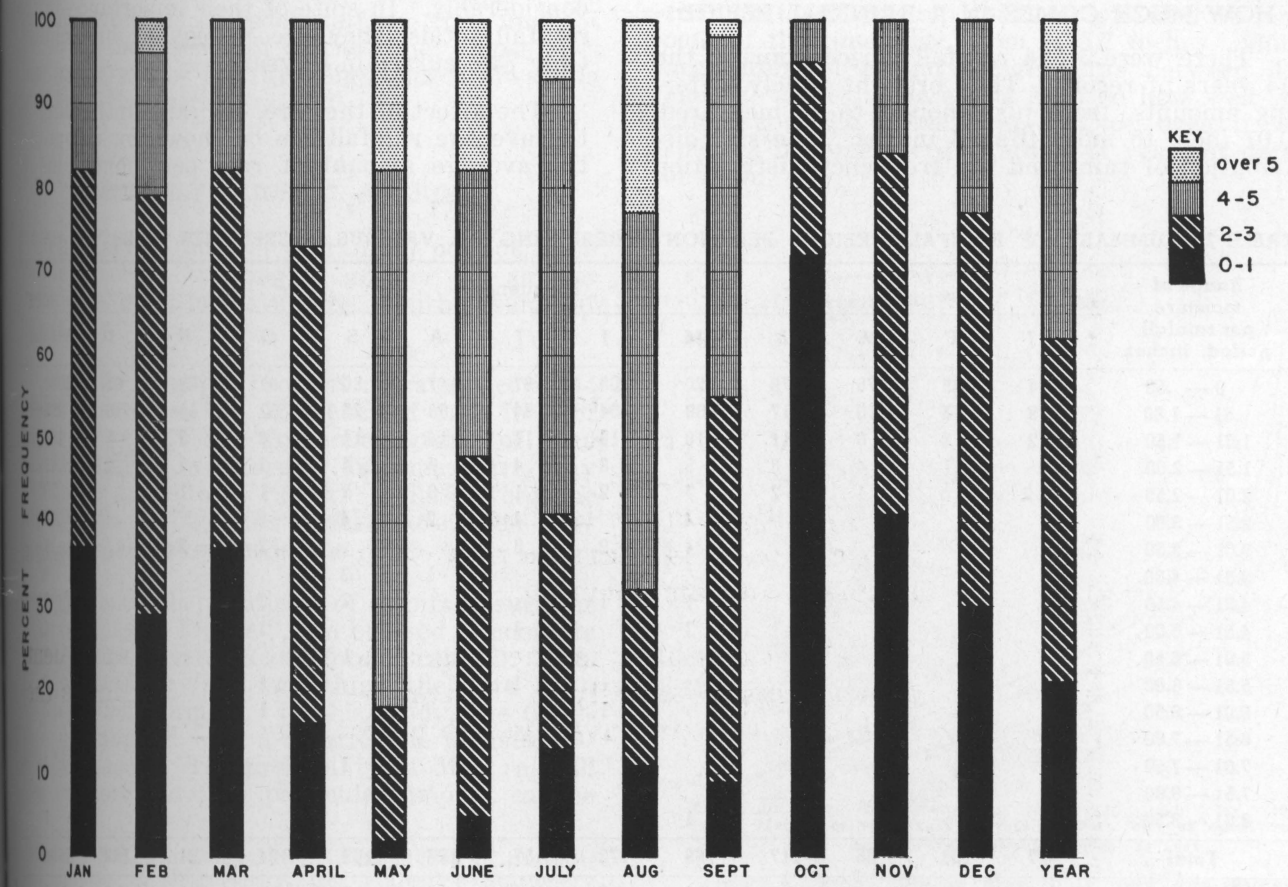


Figure 1. Percent frequency of rainfall periods by month and annually.

TABLE 1. PERCENT FREQUENCY OF RAINFALL PERIODS PER MONTH, LUBBOCK

Number of rainfall periods per month	Percent frequency												
	J	F	M	A	M	J	J	A	S	O	N	D	Annual
0	7	11	14	0	2	0	2	2	2	2	11	14	6
1	30	18	23	16	0	5	11	9	7	18	30	16	15
2	20	30	20	39	7	14	14	7	23	20	25	25	20
3	25	20	25	18	9	29	14	14	23	32	18	22	21
4	16	15	11	16	39	18	32	25	29	14	11	16	20
5	2	2	7	11	25	16	20	20	14	9	5	7	12
6		2			16	9	7	23	2	5			5
7		2			2	7							1
8						2							
Total	100	100	100	100	100	100	100	100	100	100	100	100	100
Average	2.2	2.3	2.2	2.7	4.3	3.9	3.6	4.0	3.2	2.8	2.1	2.3	3.0

In considering the number of rainfall periods per month, a period extending into the next month counts only for the month in which it began.

During some individual months in the 44 years (see Table 1), there were no rainfall periods, and during some there were as many as eight. The average number per month was greatest in summer (May 4.3 and August 4.0) and lowest in winter (November 2.1 and March and January 2.2). The percent frequency of various numbers of rainfall periods per month is shown in Figure 1.

HOW MUCH COMES IN A RAINFALL PERIOD

There were 1,564 rainfall periods during the 44 years of record. They brought widely differing amounts, from just enough to be measured, 0.01 inch, to more than 8 inches. The size distribution of rains and the frequency distribution of rainfall periods change from month to month. The numbers of rainfall periods bringing various amounts of rain at Lubbock are shown by months in Table 2.

On an annual basis, most of the rainfall periods (1,068 out of 1,564) brought only ½ inch of rain or less. Larger rains are less common than smaller rains. Seasonal differences show up at a glance at this table. Nearly all of the big rains (more than 2 inches) come in the warm-season months, May to October. These big rains are distinctive features of rainfall on the High Plains and influence the average rainfall values considerably. In spite of their importance in the rainfall totals, they are infrequent happenings. Only 73 occurred in 44 years.

The effect of the rare, big rains in holding up the average rainfall can be shown by computing the average amount of rain per month due to

TABLE 2. SUMMARY OF RAINFALL PERIODS PER MONTH RESULTING IN VARIOUS INCREMENTS, LUBBOCK, 1912-55

Range of moisture per rainfall period, inches	Frequency												
	J	F	M	A	M	J	J	A	S	O	N	D	Annual
0 — .50	84	85	75	79	120	108	97	117	80	67	71	85	1068
.51 — 1.00	9	15	10	17	36	34	34	33	25	32	13	10	268
1.01 — 1.50	2	2	6	11	10	18	15	14	14	8	3	5	108
1.51 — 2.00		1	4	8	8	6	4	7	4	2	1	2	47
2.01 — 2.50	2		1	2	7	2	1	3	5	1	1		25
2.51 — 3.00					4		1	2	4	6			17
3.01 — 3.50					1	2	3			2	2		10
3.51 — 4.00								1	3				4
4.01 — 4.50					1	1			2	3			7
4.51 — 5.00					1		1			1			3
5.01 — 5.50									1				1
5.51 — 6.00							1			1			2
6.01 — 6.50						1				1			2
6.51 — 7.00													
7.01 — 7.50									1				1
7.51 — 8.00													
8.01 — 8.50					1								1
Total	97	103	96	117	189	172	157	177	139	124	91	102	1564
Average	2.2	2.3	2.2	2.7	4.3	3.9	3.6	4.0	3.2	2.8	2.1	2.3	35.6

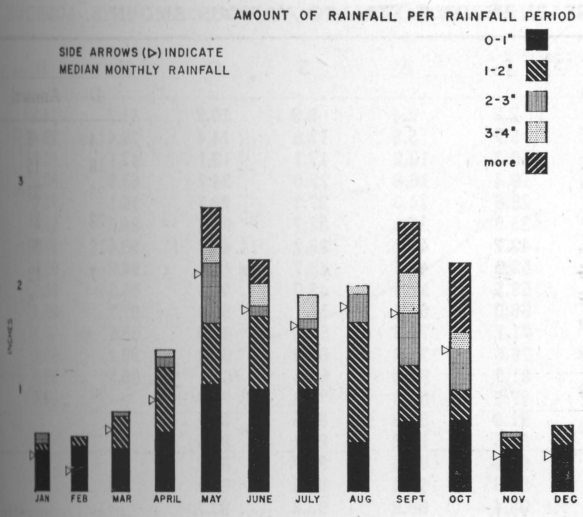


Figure 2. Average rainfall per month due to rainfall periods of various sizes.

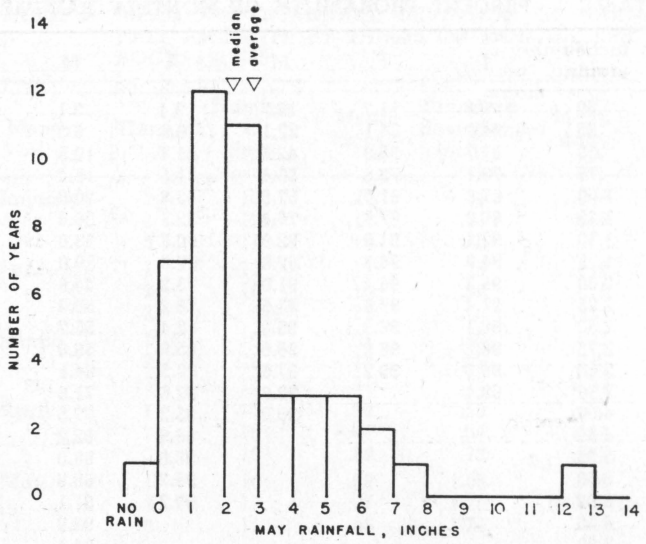


Figure 3. Frequency of May rainfall.

rainfall periods of various sizes. Figure 2 shows again that nearly all the large rains occur in the warm months. The mid-summer depression in average rainfall (July and August) is due to fewer large rains at that time. The average amount of rain due to rainfall periods totaling 2 inches or less is nearly constant from May through August.

The median monthly rainfall is indicated in Figure 2 by small side arrows. The median is the amount which is exceeded half the time and not exceeded the other half of the time. Since it is less influenced by the rare, big rains, it always is less than the average rainfall.

MONTHLY RAINFALL AMOUNTS

The varying number of rainfall periods, each rainfall period bringing a greater or smaller amount of rain, builds up the monthly sums of rainfall.

May, for example, brought no rain once in 44 years, and more than 12 inches of rain in 1 of those 44 years. The frequency graph of May rainfall is given in Figure 3. In some years, May had large amounts of rainfall. These were the times when the big rains came. More often, May rainfall was light or moderate.

Frequency distributions of rainfall, such as that for May in Figure 3, can be used to compute probabilities of various amounts of rainfall. This is done best by first smoothing the data by a mathematical formula. In this study, the Guassian distribution with a logarithmic transformation was used.[1] The probability of May rainfall less or more than any particular amount can be read from Figure 4. For example, in 25 percent of the years May rainfall will be less than 1.2 inches; and in 10 percent of the years it will be more than 5.7 inches.

The smooth curve in Figure 4 should not be taken to mean that May rainfall probabilities are known with fine precision. Rather, these are the best values obtainable today, and they are accurate enough to be useful. The amount of rainfall that, in the long run, would be exceeded 10 percent of the time, was given as 5.7 inches. More accurately, it should be given as between 4.8 and 6.7 inches. There is a limit to how well we can "know the climate" of a place, even if we spend a lifetime there or study 44 years of data, or both.

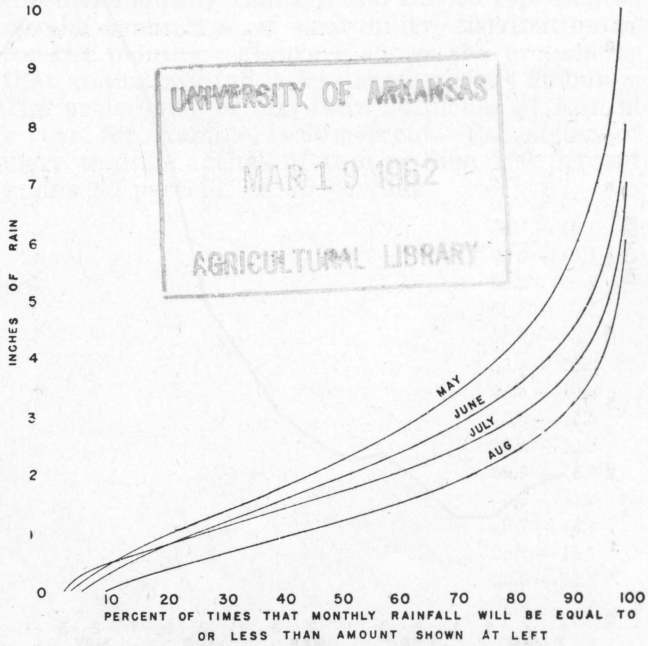


Figure 4. Probability of May, June, July and August rainfall.

[1] Brooks, C.E.P. and Carruthers, N., Handbook of Statistical Methods in Meteorology, Her Majesty's Stationery Office, London, 1953, p 102.

TABLE 3. PERCENT PROBABILITY OF MONTHLY RAINFALL LESS THAN OR EQUAL TO VARIOUS AMOUNTS, LUBBOCK

Inches of rain	J	F	M	A	M	J	J	A	S	O	N	D
.00	6.8	11.7	12.7	9.4	3.1	5.1	2.2	2.4	8.9	10.2	11.7	14.3
.25	34.1	34.1	27.1	16.6	6.3	8.9	5.7	5.5	12.6	14.4	28.4	29.4
.50	57.7	55.3	42.5	25.4	10.5	13.3	10.3	10.2	17.1	19.1	47.1	45.7
.75	73.1	70.6	56.4	34.5	15.4	19.1	18.4	16.6	22.0	24.2	63.5	60.6
1.00	82.6	81.0	67.6	43.8	20.9	25.3	26.8	24.3	27.3	29.7	76.1	72.4
1.25	88.6	87.7	76.4	52.6	26.8	31.9	35.3	32.6	32.7	35.2	84.6	81.3
1.50	92.4	91.9	82.9	60.6	33.0	38.6	43.7	41.1	38.2	40.7	90.4	87.5
1.75	94.7	94.7	87.6	67.6	39.0	45.3	52.0	49.4	43.7	46.1	94.0	91.8
2.00	96.3	96.4	91.0	73.3	44.8	51.8	59.5	57.3	49.0	51.4	96.3	94.6
2.25	97.4	97.6	93.5	78.2	50.2	57.8	66.0	64.4	54.1	56.4	97.7	96.4
2.50	98.1	98.3	95.3	82.4	55.2	63.3	71.7	70.6	58.9	61.0	98.6	97.7
2.75	98.7	98.8	96.6	85.8	59.8	68.3	76.6	75.9	63.3	65.2	99.1	98.5
3.00	99.0	99.2	97.5	88.5	64.1	72.8	81.0	80.4	67.5	69.1	99.5	99.0
3.50	99.4		98.6	92.6	71.6	80.3	87.3	87.3	74.4	75.9		99.6
4.00			99.2	95.2	77.5	86.0	91.6	91.9	80.5	81.4		
4.50				96.9	82.2	90.0	94.5	94.9	85.1	85.5		
5.00				98.0	88.0	93.0	96.3	96.8	88.7	89.2		
5.50				98.7	88.9	95.1	97.6	98.0	91.5	91.8		
6.00				99.2	91.1	96.6	98.4	98.8	93.6	93.7		
6.50					92.9	97.7	98.9	99.2	95.2	95.2		
7.00					94.4	98.4	99.3		96.4	96.4		
7.50					95.5	98.9			97.3	97.3		
8.00					96.5	99.2			98.0	97.9		
8.50					97.2				98.5	98.4		
9.00					97.7				98.9	98.9		
9.50					98.2				99.2	99.1		
10.00					98.5					99.3		

Figure 4 also shows the probabilities of various amounts of rainfall for other critical months. Table 3 gives the probabilities for all months.

DISTRIBUTION BY 10-DAY INTERVALS

The mean monthly rainfall data shows the general shape of the distribution of rainfall throughout the year. To obtain a closer look at times of maximum and minimum points, the average daily rainfall by thirds of months was computed. The first two "thirds" were taken as 10 days each, and the last third in each month included all the days left. Table 4 contains the

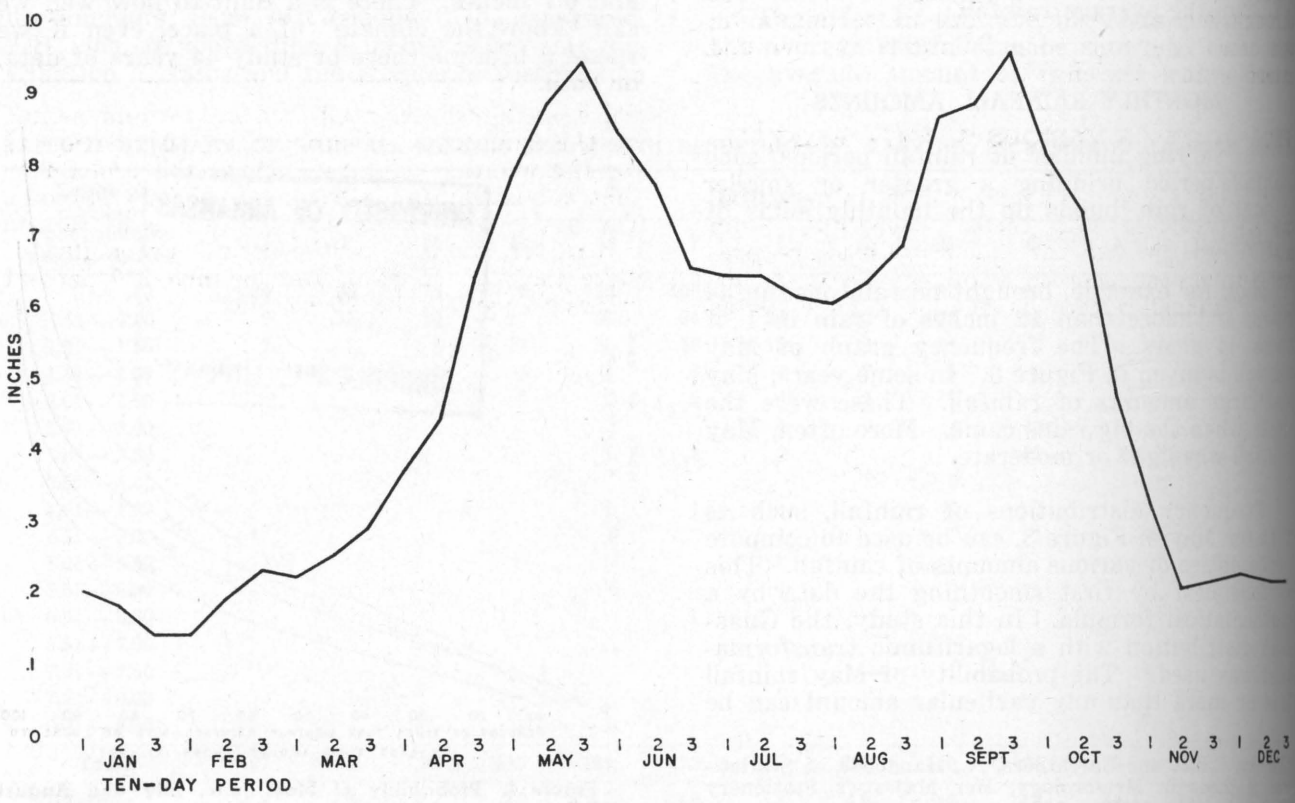


Figure 5. Moving average of rainfall by 10-day periods.

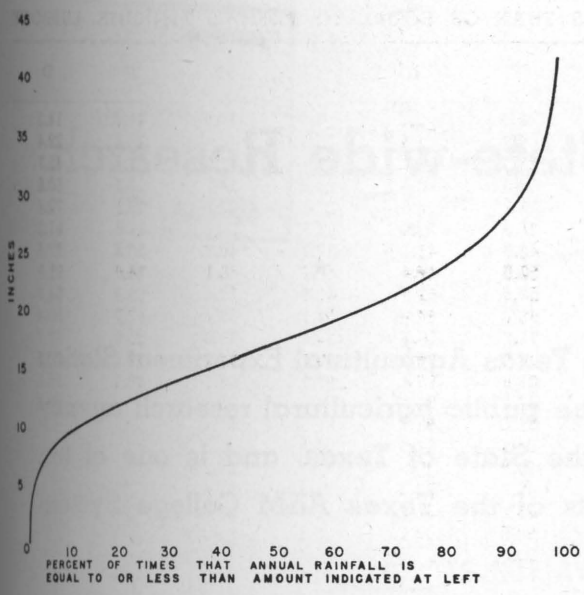


Figure 6. Probability of annual rainfall.

number of days in each period, the mean rainfall for the "10-day" period; a measure of the variability or dispersion, the standard deviation; and the mean daily rainfall. The high value of the standard deviation indicates that the means are not too reliable for this short period. The means also make an uneven pattern during the year. Therefore, the means were smoothed out by taking a running average of three means. The peaks of the two maxima are sharp, occurring in the last third of May and the last third of September, Figure 5. The mid-summer depression extends through July and August. The winter minimum is a broad one, beginning in mid-November and extending into March.

PROBABILITY OF VARIOUS ANNUAL RAINFALL

Just as a given amount of monthly rainfall can be predicted with certain probability from past records, so can the annual rainfall be predicted from past records. The frequency distribution of annual rainfall is of the same form as those of monthly rainfall, and can be represented by the same type of probability distribution as for the months. Figure 6 shows the probability that annual rainfall is less than various amounts. The probability of less than 24 inches of rain in a year, for example, is 80 percent. Probability of more than 24 inches of rain is then 100 percent minus 80 percent, or 20 percent.

TABLE 4. MEAN AND STANDARD DEVIATION OF RAINFALL AMOUNTS BY THIRDS OF MONTHS, LUBBOCK, 1912-55

Month	Third	Number of days	Mean inches	Standard deviation, inches	Mean daily
January	1	10	.24	.40	.024
	2	10	.16	.28	.016
	3	11	.14	.25	.013
February	1	10	.12	.25	.012
	2	10	.18	.32	.018
	3	8¼	.22	.40	.027
March	1	10	.25	.42	.025
	2	10	.13	.22	.013
	3	11	.41	.76	.037
April	1	10	.30	.53	.030
	2	10	.44	.64	.044
	3	10	.59	.79	.059
May	1	10	.89	1.09	.089
	2	10	.87	1.20	.087
	3	11	.96	1.26	.087
June	1	10	1.08	1.39	.108
	2	10	.56	.74	.056
	3	10	.66	.93	.066
July	1	10	.72	.97	.072
	2	10	.55	.70	.055
	3	11	.70	.97	.064
August	1	10	.63	.73	.063
	2	10	.52	.56	.052
	3	11	.82	.90	.074
September	1	10	.78	1.00	.078
	2	10	1.03	1.48	.103
	3	10	.81	1.60	.081
October	1	10	1.00	1.65	.100
	2	10	.60	.99	.060
	3	11	.65	1.15	.059
November	1	10	.21	.40	.021
	2	10	.16	.33	.016
	3	10	.22	.38	.022
December	1	10	.24	.36	.024
	2	10	.19	.33	.019
	3	11	.22	.38	.020

State-wide Research

★

The Texas Agricultural Experiment Station is the public agricultural research agency of the State of Texas, and is one of ten parts of the Texas A&M College System

Location of field research units of the Texas Agricultural Experiment Station and cooperating agencies

ORGANIZATION

IN THE MAIN STATION, with headquarters at College Station, are 16 subject-matter departments, 2 service departments, 3 regulatory services and the administrative staff. Located out in the major agricultural areas of Texas are 21 substations and 9 field laboratories. In addition, there are 14 cooperating stations owned by other agencies. Cooperating agencies include the Texas Forest Service, Game and Fish Commission of Texas, Texas Prison System, U. S. Department of Agriculture, University of Texas, Texas Technological College, Texas College of Arts and Industries and the King Ranch. Some experiments are conducted on farms and ranches and in rural homes.

OPERATION

THE TEXAS STATION is conducting about 400 active research projects, grouped in 25 programs, which include all phases of agriculture in Texas. Among these are:

Conservation and improvement of soil
Conservation and use of water
Grasses and legumes
Grain crops
Cotton and other fiber crops
Vegetable crops
Citrus and other subtropical fruits
Fruits and nuts
Oil seed crops
Ornamental plants
Brush and weeds
Insects
Beef cattle
Dairy cattle
Sheep and goats
Swine
Chickens and turkeys
Animal diseases and parasites
Fish and game
Farm and ranch engineering
Farm and ranch business
Marketing agricultural products
Rural home economics
Rural agricultural economics
Plant diseases

Two additional programs are maintenance and upkeep, and central services.

Research results are carried to Texas farmers, ranchmen and homemakers by county agents and specialists of the Texas Agricultural Extension Service

AGRICULTURAL RESEARCH seeks the WHATS, the WHYS, the WHENS, the WHERES and the HOWS of hundreds of problems which confront operators of farms and ranches, and the many industries depending on or serving agriculture. Workers of the Main Station and the field units of the Texas Agricultural Experiment Station seek diligently to find solutions to these problems.

Today's Research Is Tomorrow's Progress