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H.O. Werner
University of Nebraska-Lincoln

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SUMMARY

1. Triumph potatoes planted in mid-June on dryland in western Nebraska at an altitude of 4,000 feet and harvested on semimonthly dates provided information about the rate of tuber growth and development of tuber defects during 15 seasons.

2. In all except one year, increase in tuber production was greatest during the latter part of August. Next greatest rate of development occurred in early September. There was little increase in late September and practically none in early October.

3. The percentage of U. S. No. 1 grade A-size tubers increased as the season advanced, but the rate of increase was retarded in early September by the increase in percentages of rough and scabby tubers. Percentages of tubers cracking at harvest time or cut during digging were greatest with the latest harvest.

4. Early and final yields were greatest in years when preplanting (or at least pre-emergence) precipitation was sufficient to fill the soil to a depth of 3 or more feet and when some well distributed rains occurred during the growing season. Relatively low temperatures and evaporation rates in July and August also contributed greatly to these high yields.

5. In the years of intermediate to low yields, preplanting or pre-emergence precipitation was usually fair to low but growing season rainfall was either seriously deficient or occurred in torrential storms so that little moisture got into the ground. Summer temperatures and evaporation were usually higher than in the best years.

6. In years of very low production, pre-emergence rainfall was very low, there was little or no summer rain, and the temperature and evaporation were relatively high.

7. Significant increases in yield occurred in late September or early October only in those seasons when killing frosts were late and good rains came in late August or September. September mean temperatures and evaporation were below average in most of these seasons.

Rate of Potato Tuber Growth on Dryland at the Box Butte Experiment Farm

H. O. WERNER[1]

RELATIVELY LATE PLANTING of potatoes, i.e., between June 12 and 25, has become the prevailing practice in the dryland areas of western Nebraska. Late planting distinctly improves the color and type of tubers, and reduces losses due to insects and diseases (especially soil-borne diseases caused by Fusarium and Streptomyces).

With late planting the total yields have usually been only slightly lower and yields of U. S. No. 1 grade A-size tubers have been greater than with earlier planting, but tubers have been more immature and consequently more susceptible to mechanical damage at harvest time. Largely because of the latter difficulty, but also in the hope of obtaining greater yields, the crop has come to be harvested later than in former years, thus increasing the frost damage hazard.

Other factors tending to prolong the life of the potato plants and to delay tuber maturity have been the increased use of summer-fallowed land for growing the crop, improved cultural practices and the occasional use of improved fungicides and insecticides. The modern tendency to mechanize completely the harvesting operation presents another complication.

Growers must decide each year whether the increase in yield and tuber maturity—gained by delaying harvest—will be offset by the risk of impaired tuber quality due to scab or possible serious field frost damage. Information about the rate at which tubers are developing by various dates is essential for making such important operational decisions.

PROCEDURE

Beginning in 1937 and continuing to 1954 (in all except two years), potatoes growing with dryland culture at an altitude of 4,000 feet on the Box Butte Experiment Farm were harvested semimonthly to determine:

1. Time and rate of tuber growth.
2. Size of tubers produced by various dates.
3. Time and rate of development of scab and other defects impairing the grade quality of the tubers.
4. Change in dry matter content (specific gravity) of tubers as the seasons progressed.

[1] Horticulturist, Nebraska Agricultural Experiment Station.

Triumph potatoes of a midseason strain (Nebraska 22) planted between June 14 and 17 on land that had been summer fallowed the previous year (to assure a reserve of subsoil moisture) were harvested on September 1 and at semimonthly intervals, usually until October 16. In some of the years potatoes of the Progress, Kasota, and White Cloud varieties were also used. In seven years when tuber production was obviously quite early and workers were available, the first harvest was on August 16. At each date four or five single-row plats, usually 17 rods long, were harvested.

Mean total yields were calculated from weights of tubers obtained at harvest time for each single-row plat. The percentages of tubers of each size or grade quality were determined by sorting the potatoes from all plats harvested on one date—as a composite lot. The mean yields of U. S. No. 1 grade A-size tubers—and of other grades—were determined by applying the calculated percentages of these grades to the mean total yield. Weather data were recorded on the farm with standard equipment. The potatoes were classified according to the defect that appeared to impair the grade quality most. Consequently some potatoes classified as rough or cut may also have been scabby but were not so classified. Therefore, the percentages of various types of defects should be considered relative rather than absolute values. In 1938 the rough and harvest-cracked tubers were too few to be worth sorting out separately. Because of misunderstanding in 1942, the defective tubers were not divided into the various classes. Yields are reported for two earlier years (1929, 1930) for which data are available from another similar project but detailed information on grades was not acquired in those years. The 1929 data were acquired on a farm about 3 miles northeast of the Box Butte Experiment Farm.

YIELDS BY VARIOUS DATES

During the 15 years when potatoes were harvested at the close of each semimonthly period from mid-August to mid-October the greatest daily gain in total potato production occurred in late August. Next was that during early September and then early August. There was much less growth in late September and practically none in early October (table 1).

The trend in the production of U. S. No. 1 grade A-size tubers was quite similar to that of total yield except that very little of this grade was produced in early August and a greater percentage was produced during early September. As the season advanced the daily rate of increase of U. S. No. 1 grade A-size tubers fell behind that of the total yield because of the increase in grade-defective tubers. The average rate of tuber production during early August was 0.33 Bu./A/day, increased to 1.92 bushels during late August, and then declined to 1.85 Bu./A/day in early September. The average rate was only 1.03 bushels per day during late September (tables 1 and 4H).

TABLE 1.—Mean production of Triumph potatoes by various dates during 15 years.

Half-month period, ending	Total yields			Yield of U.S. No. 1 grade A-size		
	Mean Bu./acre at close of each half-month period	Mean daily increase Bu./acre previous half-month	Mean yield to each date as per cent mean yield on Oct. 1	Mean Bu./acre at close of each half-month period	Mean daily increase Bu./acre previous half-month	Mean yield to each date as per cent mean yield on Oct. 1
	Bushels	Bushels	Per cent	Bushels	Bushels	Per cent
August 16	29.5	1.74	22.2	5.82	.33	7.6
September 1	81.8	3.43	61.4	36.34	1.92	47.6
September 16	115.1	2.41	86.6	61.17	1.85	90.1
October 1	133.4	1.05	100.0	76.33	1.03	100.0
October 16	133.1	−0.06	99.8	75.89	0.12	99.4

During the first half of October U. S. No. 1 grade yields increased in six and decreased in nine of the years (tables 5H to 8H) with an average increase of only .12 Bu./A/day during 15 years (table 4H). The greater increases occurred in years of late frosts when moisture conditions became very favorable late in the season. The larger decreases were due to frost damage or actual loss of water and dry matter during years when vines remained alive after the soil had become very dry and the weather was dry and windy.

With the crops harvested on the four dates during the two-month period following August 16 (table 2) there was an increase in A-size tubers (over 1⅞ inches) of 31.2 per cent from 45.4 to 76.6 per cent. This was accompanied by a decrease of 13.1 per cent in B-size tubers (1½ to 1⅞ inches) from 28.6 per cent to 15.5 per cent. Contributing still more to the increase in A-size tubers was the decrease of 18.1 per cent in C-size (below 1½ inches) from 26 per cent to 7.9 per cent.

U. S. No. 1 grade A-size tubers increased 18.9 per cent from 34.2 per cent on August 16 to 53.1 per cent on October 16. The percentage

TABLE 2.—Means of percentages (for 14 years) of various grades or defect classes and tuber sizes with Triumph potatoes.

Date harvested	Means of percentages of tubers of various grade qualities and sizes									
	A-size tubers (over 1⅞")								B-size 1½" to 1⅞"	C-size under 1½"
	U. S. No. 1 grade A-size	Grade defects						Total A-size		
		Scab	Rough	Harvest cracks	Harvest cuts	Other defects	Total			
Sept. 1	34.2	2.3	6.0	1.3	1.6	0	11.2	45.4	28.6	26.0
Sept. 16	46.2	6.4	6.7	2.4	3.6	0	19.1[1]	63.7[1]	21.3	15.0
Oct. 1	51.2	7.5	7.5	2.9	2.2	1.7	21.8	72.9	17.3	9.8
Oct. 16	53.1	8.6	7.7	2.2	2.8	2.2	23.5	76.6	15.5	7.9

[1] Bushels U.S. No. 1 plus total defects of A-size do not agree with "total A-size" because of incomplete classification of defects during two of the years.

of this grade increased at a fairly constant rate until October 1, after which there was only a slight increase. The initial increase was due to the enlargement of the tubers from C- to B- to A-sizes. During early September the increase in percentages of U. S. No. 1 grade tubers was retarded by both a lessening of the increase in percentages of A-size tubers and an increase in the percentages of defective tubers. As the season advanced the greatest increase among the various defects was in scabby tubers and the next greatest was in rough tubers. Few harvest cracks occurred in the September 1 harvests but by mid-September the percentages of tubers cracking at harvest time practically doubled. On the basis of earlier studies, this increase is attributed to the decreases in temperatures and evaporation and increase in the size of the tubers as the season advanced. Accompanying the increase in size of tubers there was an increase in the percentages of tubers cut at harvest time, but these percentages like those of harvest-cracked tubers fluctuated because of changes in soil conditions that were not necessarily associated with specific dates. Apparently there was a constant increase in the percentage of U. S. No. 1 grade A-size tubers up to October 1, but after that there was little improvement.

RATE OF PRODUCTION IN VARIOUS TYPES OF SEASONS

Rates of tuber growth and quality of tubers produced during various parts of the season varied tremendously during the different years. These variations were the result of the distinctive combinations of weather conditions prevailing prior to or during the times of tuber production. An analysis of the association of these conditions with tuber production and quality is useful in understanding the responses that can be expected with the potato crop in the dryland areas of the western high plains. For convenience in presentation, the data for the various years are divided into four major groups on the basis of ranges of total yields. While there was considerable similarity in the weather conditions of the years in each of these arbitrary groups, there was also great diversity in some aspects of the weather among the years within each group.

During the three years when the specific gravity of tubers was determined, it increased on each successive date as yields increased and decreased when tuber growth decreased or when there was a shrinkage in yield at the end of the season (table 3).

Years of highest production: (Group A: 1930, 1945, 1946, 1949, 1953; tables 4 and 5, figures 1, 5, and 6.) 1930 was the year of greatest production since the establishment of the Experiment Farm and may have been the most favorable for potatoes since the crop has been grown commercially in the Box Butte County area. There was an abundance of stored moisture in the soil at planting time, and well distributed summer rains provided a constant supply of readily avail-

TABLE 3.—Mean specific gravity of potatoes harvested on several dates during three years.

Year	Date harvested			
	Sept. 1	Sept. 16	Oct. 1	Oct. 16
1952	1.0695	1.0810	1.0880	1.0870
1953	1.0695	1.0755[1]	1.0725[2]	
1954	1.0864	1.0875	1.0873	1.0855

[1] September 10 in 1953.
[2] September 21 in 1953.

able moisture. With this moisture and above-average July temperatures, vine growth was very rapid early in the summer. With August and September cooler than usual and evaporation considerably below average in August, very rapid tuber development occurred. Yields of 242.7 bushels were recorded by September 1.[2]

In three years of very high productivity—1945, 1946, 1949—the rates of tuber production were strikingly similar prior to September 16. In these growing seasons there were: adequate preplanting precipitation, numerous well distributed rains throughout the summer (none torrential except for one on September 7, 1945), and temperatures, wind movement and evaporation near or below average. In these years large vines were produced early in the season and tuber development by mid-August averaged 30 to 70 bushels per acre. The large vines remained in good condition from late August to mid-September. During early September tuber growth was rapid and at a relatively constant rate.

In 1945 and 1949 tuberization was favored greatly by well distributed rainfall, whereas in 1946 (when there was no effective rainfall between July 6 and September 7), it was favored by relatively low temperatures and evaporation. Of the two seasons 1945 and 1949, the 1945 season was most favorable because of the lower temperatures and evaporation rates in July and August. The tuber growth rate was slower after September 16 than before. The rate was greater in 1945 than in the two other years because of more rainfall throughout September and a damaging frost on September 13 in 1949.

In another year of high production—1953—the preplanting moisture deficit was offset by three rains in June totaling 3.04 inches. Soil packing caused by these saturating rains and the planting machinery created a bad structural condition which continued until harvest time

[2] Although tuber growth during late September was at a reduced rate, it probably did not drop off as much as these data indicate. In 1930 the periodic harvest records prior to October 1 were obtained by harvesting 100 hills individually by hand. Then on October 1 the larger plots were harvested with a commercial digger and because of very wet soil and deep setting of tubers in the autumn many were cut or missed.

TABLE 4.—Means of weather conditions and yield and quality of potatoes in the various groups of years producing somewhat similar total yields. (Data for individual years included in each group are presented in tables 5 to 8 and figures 1 to 6.)

Group	A. Seasonal distribution of effective precipitation[1]					B. Mean monthly temperatures				C. Total water evaporation each month			
	Oct. 1 to May 31	Growing season months											
		June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.
	in.	in.	in.	in.	in.	°F.	°F.	°F.	°F.	in.	in.	in.	in.
A-4[2]	4.24	3.21	1.01	1.33	0.93	63.3	74.1	70.4	60.1	6.65	9.32	8.39	6.64
B-5	8.34	2.69	0.91	0.95	1.04	64.6	71.7	71.6	62.1	6.92	8.54	8.94	6.33
C-3	4.16	5.60	3.01	0.89	.95	62.2	72.9	73.7	60.0	5.79	9.26	8.63	5.75
D-4	3.55	1.65	0.17	0.52	0.15	65.1	76.0	72.1	64.6	8.94	11.11	9.62	7.84
26-yr. mean	5.45	2.46	0.99	1.15	0.87	64.6	73.5	71.4	60.8	7.66	9.78	9.16	6.61

Yield and quality of potatoes produced to each date

Group	D. Total yield per acre					E. U.S. No. 1 A-size					F. Yields No. 1 A- plus B-sizes				
	Aug. 16	September 1	September 16	October 1	October 16	Aug. 16	September 1	September 16	October 1	October 16	Aug. 16	September 1	September 16	October 1	October 16
	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.
A	43.9	151.8	221.4	237.2		8.5	86.4	130.7	146.1			98.3	146.2	156.4	
B	45.0	95.8	116.0	146.5	143.9	95.4	39.9	60.6	84.5	87.3	26.6	70.8	86.7	109.1	106.4
C	13.7	65.3	94.8	106.6	100.2	0.3	15.4	29.5	36.3	37.8	0.9	37.1	51.8	60.8	57.1
D	6.2	34.0	48.2	55.6	58.9	1.2	7.1	18.4	24.3	29.1		18.9	32.7	38.1	42.0
15-yr. mean	29.5[3]	81.8	115.1	133.4	133.1	5.8	36.3	61.2	76.3	75.9					

	G. Increase total Bu./acre/day					H. Increase U.S. No. 1 Bu./acre/day					I. U.S. No. 1 A-size pct. total				
	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.
A	2.93	6.56	4.99	0.86		0.54	5.17	2.95	0.58		20.3	58.7	60.6	63.1	
B	2.93	3.29	1.33	1.96	–0.23	0.63	1.83	1.51	1.58	0.48	12.3	42.3	48.6	57.5	60.5
C	0.92	3.23	2.03	0.75	–0.42	0.13	1.01	1.21	0.43	0.07	1.0	22.2	31.9	34.7	38.3
D	0.40	1.66	1.05	0.53	0.24	0.08	0.33	0.94	0.41	0.31		15.2	30.8	42.5	47.9
15-yr. mean	1.74	3.43	2.41	1.05	0.06	0.33	1.92	1.85	1.03	0.12		34.2	46.2	51.2	53.1

Yield of tubers with various types of defects and of various sizes, as per cent of total yield

	J. Scabby, A-size					K. Rough, A-size					L. Harvest cracks, A-size				
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
A		3.7	5.2	8.7		0.9	12.8	15.1	14.1			1.8	4.2	2.0	
B		0.8	6.7	7.2	7.8	1.1	9.8	10.2	13.2	10.6		0.6	0.9	3.7	2.2
C		4.2	16.2	16.4	18.1		8.3	9.3	11.0	13.0		2.9	3.7	5.9	3.3
D		0.6	1.2	2.0	2.2		1.3	1.4	2.4	2.8		0.2	0.8	1.2	1.5
15-yr. mean		2.29	6.41	7.46	8.60		6.04	6.71	7.49	7.72		1.25	2.45	2.94	2.16

	M. Harvest cuts, A-size					N. B-size (1½ to 1⅞ in.)					O. C-size (under 1⅞ in.)				
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
A	0.5	1.9	1.8	4.1			16.4	10.6	9.4			3.8	1.8	1.1	
B	0.4	1.9	6.9	2.5	4.3	25.0	31.5	22.2	16.1	13.1	40.4	14.7	7.6	4.9	5.0
C		1.6	3.3	3.1	2.6		35.5	23.9	19.7	19.4		25.3	13.1	9.2	5.2
D		0.8	1.7	1.9	1.2		28.4	29.1	25.8	23.6		52.9	35.3	22.9	18.9
15-yr. mean		1.63	3.65	2.21	2.79		28.6	21.3	17.3	15.5		26.0	15.0	9.8	7.9

[1] "Effective" precipitation includes only rainfall of 0.5 inch or more within two successive days.
[2] Letters A to D refer to groups of years of similar weather characteristics, numbers refer to number of years in each group. Detailed data for years of each group are presented in succeeding tables.
[3] Means reported for 26-year and 15-year periods are means of individual years, not of groups of years.

TABLE 5.—Weather conditions, and yield and quality of potatoes produced in the five most productive seasons. Group A.

Year	A. Seasonal distribution of effective precipitation					B. Mean monthly temperatures				C. Total water evaporation each month			
	Oct. 1 to May 31	Growing season months											
		June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.
	in.	in.	in.	in.	in.	°F.	°F.	°F.	°F.	in.	in.	in.	in.
1930	11.60	9.85	1.52	2.52	1.38	65.2	75.6	71.6	59.0	Not Available			
1945	3.33	4.38	0.70	2.49	1.96	57.2	71.3	70.1	57.2	5.68	8.87	8.07	6.94
1946	4.03	2.95	0.56	0	1.75	64.5	74.3	69.2	60.8	7.78	8.91	8.18	5.89
1949	7.17	2.49	1.42	1.92	0	64.3	74.2	71.8	59.2	5.27	10.30	9.20	5.74
1953	2.44	3.04	1.36	0.91	0	67.3	72.8	70.9	63.0	7.85	9.21	8.11	8.00
5-yr. mean[1]	4.24	3.21	1.01	1.33	0.93	63.3	74.1	70.4	60.1	6.65	9.32	8.39	6.64
26-yr. mean[2]	5.45	2.46	0.99	1.15	0.87	64.6	73.5	71.4	60.8	7.66	9.78	9.16	6.61

Year	Yield and quality of potatoes produced to each date														
	Aug. 16	September 1	16	October 1	16	Aug. 16	September 1	16	October 1	16	Aug. 16	September 1	16	October 1	16
	D. Total yield per acre					E. U.S. No. 1 A-size					F. Yields No. 1 A- plus B-sizes				
	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.
1930	67.1	242.7	314.2	319.9											
1945	45.1	146.6	248.6	278.5	242.9	9.4	82.9	132.2	169.1	148.4	21.4	98.3	150.5	183.4	161.5
1946	30.7	138.4	213.1	235.1	239.9	5.3	106.9	169.9	188.6	203.6	19.5	121.4	181.2	296.6	212.0
1949	30.0[3]	130.9	208.6	244.5	222.2	7.5[3]	81.8	144.5	158.9	121.5		94.9	162.5	173.8	175.4
1953	70.0[3]	191.5	215.1[4]	190.8[4]		11.9[3]	73.9	86.0	67.9			78.5	90.5	72.2	
Mean	43.9	151.8	221.4	237.2		8.5	86.4	130.7	146.1			98.3	146.2	156.4	

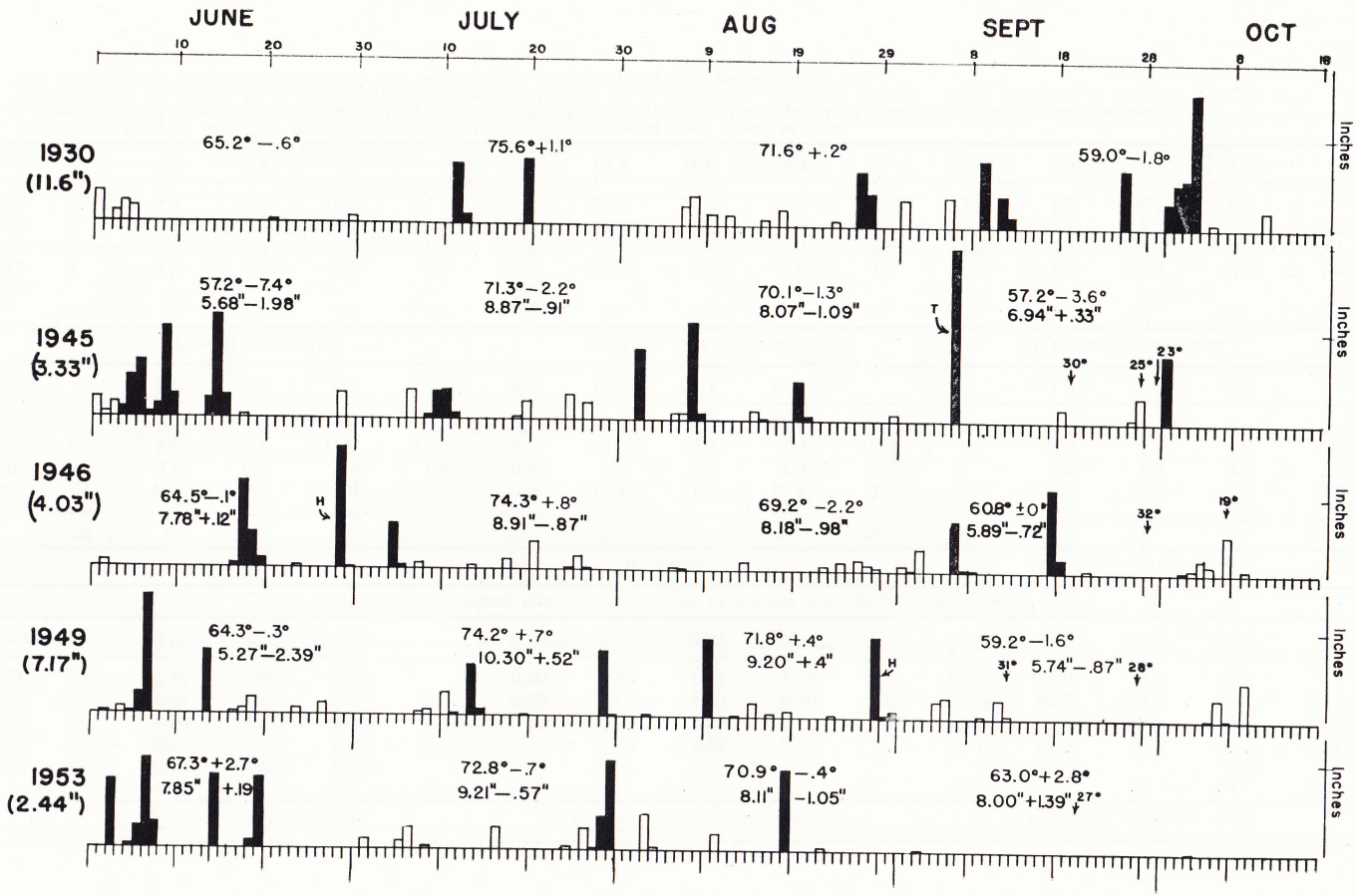
	G. Increase total Bu./acre/day					H. Increase U.S. No. 1 Bu./acre/day					I. U.S. No. 1 A-size pct. total				
	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.
1930	4.47	10.98	4.77	0.38											
1945	3.03	6.77	6.80	2.00	0.30	0.53	4.83	3.28	2.46	1.31	20.9	56.3	53.2	68.3	53.3
1946	2.05	5.99	4.98	1.38	0.28	0.35	5.61	4.38	1.16	1.16	17.3	77.2	79.7	80.2	84.9
1949	2.00[3]	5.94	5.55	2.24	–2.03	0.50[3]	4.61	4.79	0.90	–2.02	25.0[3]	62.5	69.3	68.1	54.7
1953	4.57[3]	7.53	2.62	–2.17		0.80[3]	5.64	1.34	–2.20		18.0[3]	38.6	40.0	35.6	
Mean	2.93	6.56	4.99	0.86		0.54	5.17	2.95	0.58		20.3	58.7	60.6	63.1	

Yield of tubers with various types of defects and of various sizes, as per cent of total yield

Year	J. Scabby, A-size					K. Rough, A-size					L. Harvest cracks, A-size				
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1930															
1945	.1	6.2	9.7	8.6	19.5	3.4	12.1	11.2	10.8	4.6	1.0	2.7	13.6	2.6	5.5
1946	0	0.4	0.9	2.3	1.8	0.3	4.3	7.7	7.3	5.7	0	3.2	1.8	3.9	1.3
1949	?	3.4	5.1	17.5	12.5	0	8.5	10.9	4.4	18.4	?	0.6	1.4	1.4	0.8
1953	?	5.6	4.9	6.4		?	26.4	30.6	20.0		?	0.8	0	0	
Mean		3.7	5.2	8.7		0.9	12.8	15.1	14.1			1.8	4.2	2.0	

	M. Harvest cuts, A-size					N. B-size (1½ to 1⅞ in.)					O. C-size (under 1⅞ in.)				
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1930															
1945	0	1.6	0.6	0.2	0.5	26.5	13.2	7.4	5.9	4.7	47.5	7.7	3.5	2.5	1.2
1946	2.0	2.0	2.8	2.2	1.9	46.3	10.5	5.3	3.4	3.5	34.0	2.5	1.6	0.6	0.7
1949	?	3.9	3.4	1.7	7.2	?	17.6	8.6	6.1	5.8	?	3.4	1.2	0.6	0.5
1953	?	1.9	2.2	12.3			24.2	21.0	22.3		?	1.7	0.7	0.5	
Mean	0.5	1.9	1.8	4.1			16.4	10.6	9.4		20.4	3.8	1.8	1.1	

[1] Means are for four years and do not include 1930 because of absence of some classes of data.
[2] Twenty-six year mean based on 1930 to 1954 data from Box Butte Experiment Farm and 1929 from Alliance (4.5 miles southeast).
[3] Values given for August 16 in 1949 and 1953 are estimated.
[4] In 1953 harvests were on September 10 and September 21 (severe killing frost on September 21).


JUNE
JULY
AUG
SEPT
OCT
10 20 30 10 20 30 9 19 29 8 18 28 8 18
1930
(11.6")
65.2° −.6°
75.6°+1.1°
71.6° +.2°
59.0°−1.8°
Inches
1945
(3.33")
57.2°−7.4°
5.68"−1.98"
71.3°−2.2°
8.87"−.91"
70.1°−1.3°
8.07"−1.09"
T
57.2°−3.6°
6.94"+.33"
30°
25°
23°
Inches
1946
(4.03")
64.5°−.1°
7.78"+.12"
H
74.3° +.8°
8.91"−.87"
69.2° −2.2°
8.18"−.98"
60.8° ±0°
5.89"−.72"
32°
19°
Inches
1949
(7.17")
64.3°−.3°
5.27"−2.39"
74.2° +.7°
10.30"+.52"
71.8° +.4°
9.20"+.4"
H
59.2°−1.6°
31° 5.74"−.87" 28°
Inches
1953
(2.44")
67.3°+2.7°
7.85" +.19
72.8°−.7°
9.21"−.57"
70.9° −.4°
8.11" −1.05"
63.0°+2.8°
8.00"+1.39" 27°
Inches

when the soil was very hard and broke up in large clods. Two well spaced rains in July and August provided enough moisture for strong vine growth and much early tuber growth. However, with no rain after August 19, the large vines exhausted the soil moisture so that there was little increase in yield after September 1. Under these conditions the specific gravity of the tubers was relatively low, increasing slowly until September 10 to 1.0755 and then dropping to 1.0725 by September 21. The percentage of U. S. No. 1 grade tubers was lower than in the other seasons of high productivity, chiefly because of the very large amount of poor type and rough tubers resulting from the compacted soil.

Years of good yields: (Group B: 1948, 1944, 1952, 1938, 1942; tables 4 and 6, figures 2, 5 and 6.) In this group of years there was abundant preplanting and June precipitation, but yields were good, chiefly because July and August rainfall was slightly above average.

During 1948—the best year of this group—the favorable distribution of rain and relatively low temperatures in early summer resulted in a very good rate of early tuber production. Vine growth was retarded by the lack of rain during most of August so that the rate of tuber growth—although still high—diminished considerably in early September. The resuscitation of the vines by early September rains and lack of early frosts resulted in continued good yield increase through late September. Because of the extensive vegetative growth early in the season, more than the usual number of tubers were set and consequently the percentages of B-size tubers were among the greatest of any of the years. This was satisfactory for seed production because of the relatively high yields of seed stock, i.e., U. S. No. 1 A- plus B-size stock.

The 1944 season had much rainfall and very cool weather early in the season. Early tuber yields were not as high as might be expected with such conditions because most of the early rainfall occurred as soil-packing torrential storms. Then on August 22 a very severe hailstorm damaged the plants so severely that practically no tuber growth occurred again until the last half of September when it proceeded at the rapid rate of 4 Bu./A/day. Although the tubers grew until a killing frost on October 7, the maximum yield was only slightly above

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FIGURE 1.—Rainfall for each day from June 1 to October 18 of the five years with highest yields (Group A). Black histographs represent "effective" rainfall, i.e., 0.5 inch or more within two consecutive days. Parenthetical number under year number is effective rainfall from previous October 1 to May 31. Numbers under each month of each year are mean temperature (upper) and total evaporation for the month, and the deviations from the respective 25-year averages. Other designations on specific days are: T = torrential rain; H = hailstorm; isolated numbers reporting degrees temperature (toward the end of some seasons) = first freezing temperature in the autumn.

TABLE 6.—Weather conditions, and yield and quality of potatoes produced by various dates, in the five years of Group B with medium to high production.

Year	A. Seasonal distribution of effective precipitation					B. Mean monthly temperatures				C. Total water evaporation each month			
	Oct. 1 to May 31	Growing season months											
		June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.
	in.	in.	in.	in.	in.	°F.	°F.	°F.	°F.	in.	in.	in.	in.
1948	4.79	2.38	1.51	1.02	1.95	63.8	72.0	71.5	65.3	6.10	8.78	8.76	7.53
1944	6.39	6.43	1.65	1.38	0	60.9	70.0	71.3	60.5	6.95	7.42	8.78	6.01
1952	5.67	1.80	0	1.80	0	70.3	72.5	72.6	63.9	8.33	10.35	9.33	7.05
1938	9.83	1.69	1.37	0.55	2.53	66.1	72.0	72.8	63.6	8.59	7.90	9.47	5.88
1942	15.03	1.14	0	0	0.70	62.0	72.0	69.8	57.0	4.66	8.27	8.40	5.22
5-yr. mean	8.34	2.69	0.91	0.95	1.04	64.6	71.70	71.6	62.1	6.92	8.54	8.94	6.33
26-yr. mean[1]	5.45	2.46	0.99	1.15	0.87	64.6	73.5	71.4	60.8	7.66	9.78	9.16	6.61

Yield and quality of potatoes produced to each date

Year	D. Total yield per acre					E. U.S. No. 1 A-size					F. Yields No. 1 A- plus B-sizes				
	Aug. 16	September 1	September 16	October 1	October 16	Aug. 16	September 1	September 16	October 1	October 16	Aug. 16	September 1	September 16	October 1	October 16
	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.
1948	50.0	116.9	156.2	182.5	164.4	0.2	33.9	79.6	104.9	91.4	15.9	103.9	134.0	150.7	126.6
1944	18.5	76.4	74.4	134.4	148.8	0.2	19.5	16.7	51.1	72.6	4.4	38.2	36.0	68.8	89.2
1952	16.0[2]	81.3	91.6	139.9	117.4	3.0[2]	46.1	45.6	75.7	71.5	?	66.5	688	98.4	84.6
1938	56.3	90.0	123.9	138.7	158.6	13.2	35.4	86.5	107.1	122.8	55.5	63.0	98.1	125.7	142.5
1942	84.4	114.6	133.7	137.1	130.4	31.1	64.5	74.7	83.5	78.1	57.4	82.4	96.6	101.9	88.9
Mean	45.0	95.8	116.0	146.5	143.9	95.4	39.9	60.6	84.5	87.3	26.6	70.8	86.7	109.1	106.4

	G. Increase total Bu./acre/day					H. Increase U.S. No. 1 Bu./acre/day					I. U.S. No. 1 A-size pct. total				
	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.
1948	3.33	4.46	2.62	1.64	–1.01	0.01	1.87	3.67	1.58	–0.75	0.3	29.0	51.0	57.5	55.6
1944	1.23	3.86	–0.13	4.00	0.96	0.01	1.22	–0.18	2.29	1.43	0.9	25.5	16.7	38.0	48.8
1952	1.07[2]	3.84	0.61	3.02	–2.05	0.20[2]	2.54	–0.03	2.00	–3.82	?	56.8	49.8	54.1	60.9
1938	3.75	2.27	2.26	0.85	1.41	0.88	1.28	3.41	1.46	1.12	23.4	43.7	69.8	77.2	77.4
1942	5.27	2.01	1.27	0.23	–0.45	2.07	2.23	0.68	0.59	–0.36	36.9	56.3	55.8	60.9	59.9
Mean	2.93	3.29	1.33	1.96	–0.23	0.63	1.83	1.51	1.58	0.48	12.3	42.3	48.6	57.5	60.5

Yield of tubers with various types of defects and of various sizes, as per cent of total yield

Year	J. Scabby, A-size					K. Rough, A-size					L. Harvest cracks, A-size				
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1948	0	1.1	3.6	6.1	9.0	0	0.6	1.0	1.7	2.5	0	0.3	2.6	3.8	0.9
1944	0	1.0	12.3	10.2	9.8	3.3	22.2	18.5	21.9	17.2	0	0.1	0.2	4.9	2.0
1952	?	0.4	4.0	5.1	4.6	?	6.6	11.2	16.1	12.1	?	1.3	0	2.5	3.8
1938	0	0	0.1	0.1	0.1	0		None					None		
1942		Not determined					Not determined					Not determined			
Mean[3]		0.83	6.67	7.16	7.83	1.10	9.80	10.23	13.23	10.60		0.57	.93	3.73	2.23

	M. Harvest cuts, A-size					N. B-size (1½ to 1⅞ in.)					O. C-size (under 1⅞ in.)				
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1948	0	0.3	2.9	1.9	6.4	31.3	59.9	34.8	25.1	21.4	68.3	8.8	4.2	3.8	2.4
1944	?	3.7	15.6	4.3	4.8	22.9	24.6	18.7	13.2	11.2	72.9	22.9	12.0	6.6	5.2
1952	?	2.3	8.1	2.0	4.6	?	25.1	23.6	16.4	12.4	?	7.4	3.4	2.5	1.2
1938	0.4	1.2	1.2	1.7	1.3	39.6	30.7	17.4	13.4	12.4	36.3	24.0	10.8	6.4	7.0
1942		Not determined				31.1	17.1	16.4	13.4	8.3	24.2	10.5	7.4	5.4	9.3
Mean		1.87[4]	6.95[4]	2.47[4]	4.27[4]	25.0	31.5	22.2	16.1	13.1	40.4	14.7	7.6	4.9	5.0

[1] See footnote 2, table 5.
[2] Values for August 16, 1952 were estimated.
[3] Three-year means—1938 and 1942 omitted.
[4] Four-year means—1942 omitted.

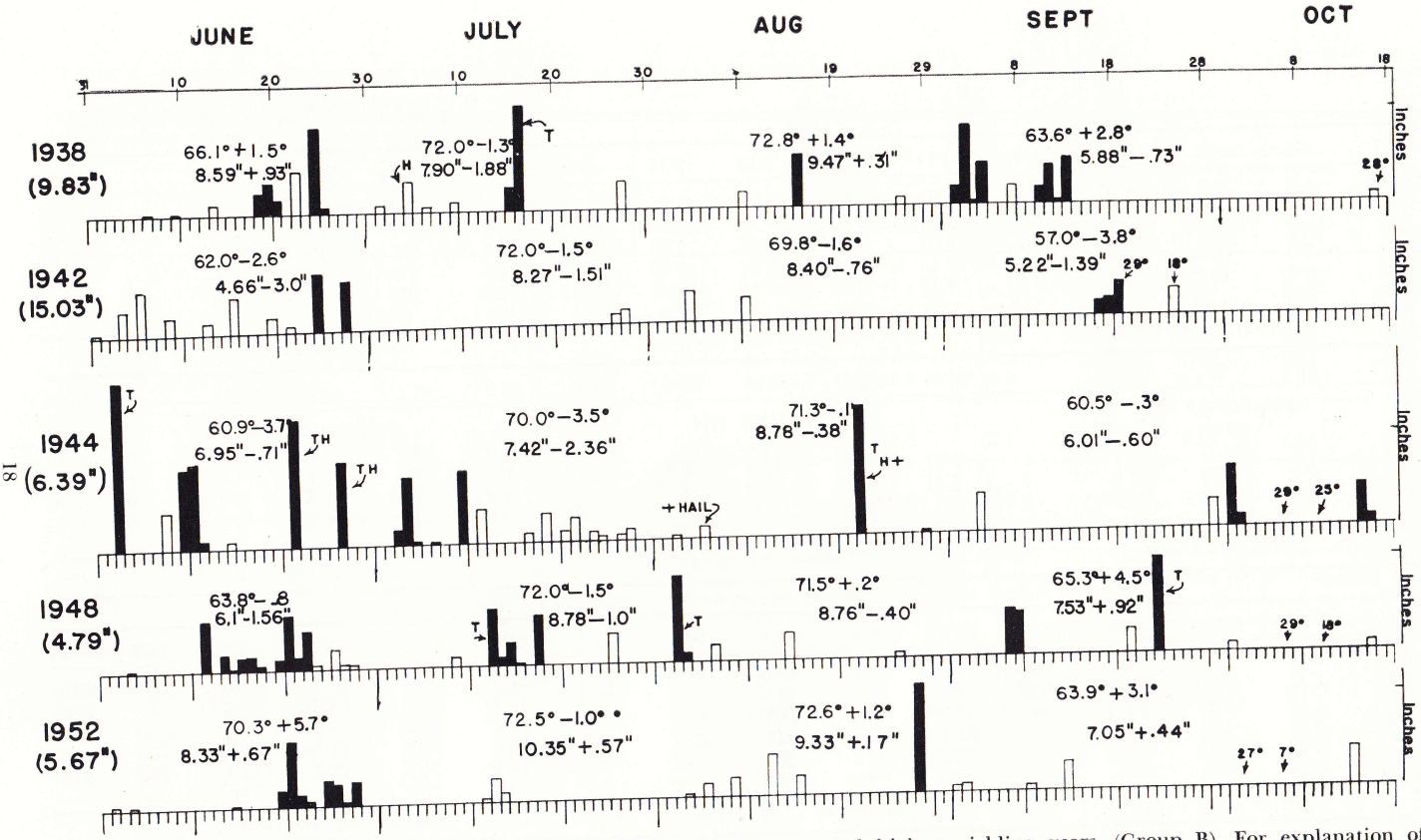

FIGURE 2.—Rainfall for each day from June 1 to October 18 of the five second highest yielding years (Group B). For explanation of other details of the graphs see figure 1.

the 15-year average. The quality of the crop was relatively poor because of the very high percentage of rough tubers following the vine damage by the beating rain and hail of August 22.

In 1952 there was adequate pre-emergence soil moisture but temperatures and evaporation were very high and there was no effective rain until August 28. Vines were small, yet a crop of 81.3 bushels per acre was produced by September 1. The rain of 1.80 inches on August 28 resuscitated the senile vines but little tuber growth occurred in early September. However, with the new foliage, tuber enlargement in late September was exceptionally rapid until the vines were frosted severely on September 28. With this late summer revival of the plants, the percentage of rough tubers increased greatly so that the percentage of U. S. No. 1 potatoes was only slightly above the 15-year average. The mean specific gravity of the tubers increased from 1.0695 on September 1 to 1.088 on October 1.

In 1938 early tuber growth was rapid and continued at a fairly rapid rate to a final maximum of 158.6 bushels per acre on October 15 when the vines were still not entirely dead, not having been killed completely by frost until October 18. With abundant preplanting precipitation and a number of heavy summer rains, higher yields might have been expected. However, the crop suffered from a hailstorm that damaged the young plants severely on July 5, a torrential soil packing rain on July 16-17, and above-average temperatures throughout August and September. Nevertheless, largely because of the very high percentage of U. S. No. 1 grade and a high percentage of B-size tubers, yields of seed size (No. 1 A+B) were very satisfactory by September 16 and later.

The season of 1942 was unusual. There was an extraordinary amount of preplanting precipitation and very little summer rainfall, but temperature and evaporation were considerably below average all summer. The only effective precipitation—September 17 to 19—was accompanied by a vine killing minimum temperature of 29° on the 19th. Under these conditions tuber growth prior to August 16 was the greatest of any season. However, with tuber production entirely dependent on stored moisture, the later tuber growth occurred at a steadily decreasing rate—considerably slower than in most of the other years—and there was very little growth after September 16. The high percentage of A-size potatoes early in the season is attributed to the light tuber set resulting from the scant vegetation which occurred because the moisture supply was limited entirely to that stored in the soil.

Years of low but slightly profitable production: (Group C: 1941, 1947, 1943, 1929; tables 4 and 7, figures 3, 5 and 6.) A variety of seasonal conditions occurred during the third group of years whose total yields to October 1 ranged from 95.8 to 114.6 bushels per acre. Yields

TABLE 7.—Weather conditions, and yield and quality of potatoes produced by various dates, in the four years of Group C with fair to low production.

Year	A. Seasonal distribution of effective precipitation					B. Mean monthly temperatures				C. Total water evaporation each month			
	Oct. 1 to May 31	Growing season months											
		June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.
	in.	in.	in.	in.	in.	°F.	°F.	°F.	°F.	in.	in.	in.	in.
1941	2.74	7.33	2.34	1.31	1.03	63.0	71.8	72.4	58.6	5.90	7.54	8.47	4.82[2]
1947	3.03	6.30	0.54	0	0.82	61.0	73.2	75.3	62.7	5.56	8.03	9.64	6.94
1943	6.72	3.16	3.15	1.36	0	62.6	73.6	73.4	58.6	5.76	11.31	7.79	5.49
1929[1]	5.87	1.35	0.54	0.57	1.98	65.0[1]	77.2	78.0	57.3				
4-yr. mean[3]	4.16	5.60	3.01	0.89	.95	62.2	72.9	73.7	60.0	5.79	9.26	8.63	5.75
26-yr. mean[4]	5.45	2.46	0.99	1.15	0.87	64.6	73.5	71.4	60.8	7.66	9.78	9.16	6.61

Yield and quality of potatoes produced to each date

Year	D. Total yield per acre					E. U.S. No. 1 A-size					F. Yields No. 1 A- plus B-sizes				
	Aug. 16	September 1	September 16	October 1	October 16	Aug. 16	September 1	September 16	October 1	October 16	Aug. 16	September 1	September 16	October 1	October 16
	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.
1941	15.1	80.7	105.0	114.6	104.5	0.5	21.6	29.5	32.2	31.9	2.8	40.2	52.4	56.9	57.3
1947	10.0[5]	51.9	95.3	108.3	105.6	0[5]	2.6	18.4	27.2	27.7	?	30.9	44.2	60.0	46.9
1943	16.0[5]	63.5	84.0	96.9	90.6	0.5[5]	22.0	40.5	49.5	52.7	?	40.3	58.6	65.5	67.0
1929	24.4	45.5	66.2	95.8											
Mean[3]	13.7	65.3	94.8	106.6	100.2	0.3	15.4	29.5	36.3	37.8	0.9	37.1	51.8	60.8	57.1

	G. Increase total Bu./acre/day					H. Increase U.S. No. 1 Bu./acre/day					I. U.S. No. 1 A-size pct. total				
	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.
1941	1.01	4.37	1.62	0.64	–0.67	0.06	1.39	0.53	0.18	–0.02	3.1	26.9	28.1	28.1	30.5
1947	0.67[5]	2.34	3.10	0.76	–0.18	0[5]	0.16	1.19	0.52	0.03	?	5.0	19.4	25.1	26.2
1943	1.07[5]	2.97	1.37	0.86	–0.42	0.05[5]	1.47	1.90	0.60	0.20	?	34.7	48.2	51.0	58.9
1929	1.57	1.41	1.38	1.31											
Mean[3]	0.92	3.23	2.03	0.75	–0.42	0.13	1.01	1.21	0.43	0.07	1.0	22.2	31.9	34.7	38.3

Yield of tubers with various types of defects and of various sizes, as per cent of total yield

Year	J. Scabby, A-size					K. Rough, A-size					L. Harvest cracks, A-size				
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1941	0	6.3	12.7	8.4	7.5	0	11.9	14.4	14.6	21.4	0	7.1	8.1	11.3	9.3
1947	0	6.4	36.0	38.8	44.5	0	6.7	6.2	8.0	7.0	0	0.3	0.4	1.7	0
1943	0	0	0	1.9	2.3	0	6.2	7.2	10.4	10.5	0	1.3	2.5	4.6	0.7
1929															
Mean[3]		4.2	16.2	16.4	18.1		8.3	9.3	11.0	13.0		2.9	3.7	5.9	3.3

	M. Harvest cuts, A-size					N. B-size (1½ to 1⅞ in.)					O. C-size (under 1⅞ in.)				
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1941	0	2.1	1.1	0.2	0.3	15.3	23.0	21.8	21.5	24.3	81.6	22.6	17.8	16.0	6.5
1947	?	0	0.3	0.8	0.8		54.8	28.1	21.0	18.2		26.8	9.8	4.6	3.1
1943	?	2.6	8.6	8.4	6.6		28.8	21.8	16.5	15.7		26.4	11.8	7.1	6.0
1929															
Mean		1.6	3.3	3.1	2.6		35.5	23.9	19.7	19.4		25.3	13.1	9.2	5.2

[1] Alliance weather data used for 1929.
[2] Mitchell evaporation readings used after September 11 in 1952.
[3] Mean of three years (1929 omitted because some data were not acquired).
[4] See footnote 2, in table 5.
[5] Data for August 16 estimated in 1943 and 1947.

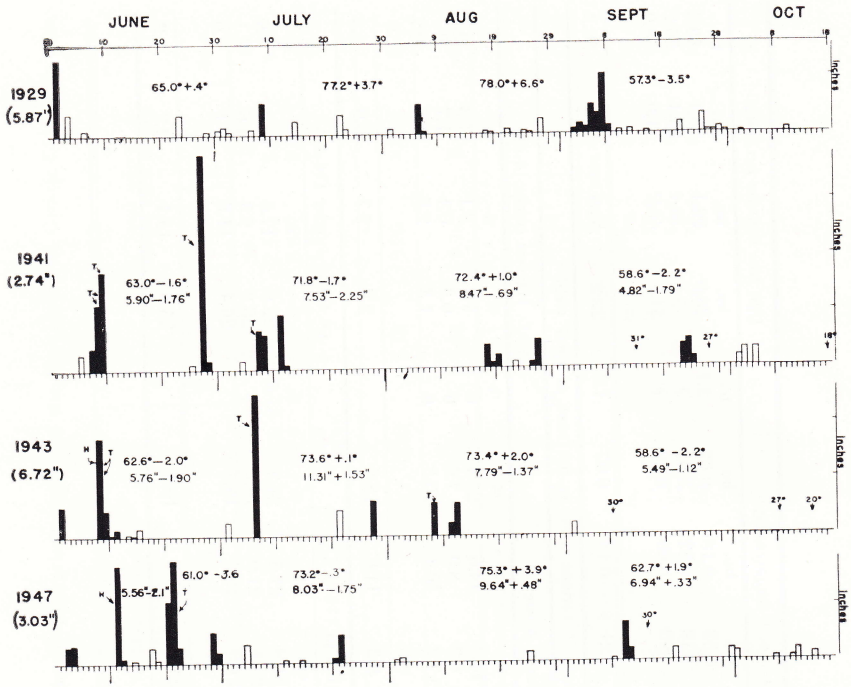

FIGURE 3.—Rainfall for each day from June 1 to October 18 of four years of intermediate or low productivity (Group C). For explanation of other details of the graphs see figure 1.

were of borderline economic status either because of lack of summer rain or unusually high temperatures in July and August. Because of these conditions, vine growth was usually relatively small and tuber production was late. With early vine maturity, due to drought and heat, there was less tuber growth throughout September.

In 1941 practically all of the abundant June and July precipitation occurred in torrential rains, much of which ran off. As a consequence the soil was packed severely and was hard and somewhat impermeable to the few scattered rains later in the summer. Possibly it was the moderate temperatures that enabled tubers to grow more rapidly than the average rate during August. With September relatively dry and a frost on September 14, only 29.1 per cent of the crop was produced after September 1. With high percentages of rough scabby tubers and small tubers, the percentage and yield of U. S. No. 1 grade A-size was very low.

In 1947 June rains were copious but so torrential that the soil was packed severely. With practically no effective summer rainfall and very high temperatures, conditions were unfavorable for tuber

production. The percentages of scabby tubers, which increased as the season advanced, were by far the highest of any year.

The 1943 season had torrential packing rains early in the season. With the high temperatures and no rain after a torrential rain in early August, tuberization was slow and meager until a killing frost on September 9 practically terminated the growing season.

In 1929 there was practically no summer rain and temperatures were extraordinarily high.

Years of very low production: (Group D: 1954, 1939, 1940, 1937; tables 4 and 8, figures 4, 5, and 6.) This group of years had total yields by October ranging from 35.4 bushels to 74.4 bushels per acre. There was a severe scarcity of preplanting precipitation (except in 1954), adequate but modest precipitation during June for starting the crop, but practically no rain during the remainder of the summer, and the temperature and evaporation rates were very high. In all these years except 1954 there was a steady increase in yield until the end of September. In 1954 there was no increase after September 15 because of the early death of the plants by drought. The relatively high yields in 1954 are believed to have resulted from a number of light showers. Although these rains supplied little usable soil moisture, they increased the humidity and—with the accompanying clouds—reduced evaporation so that it was relatively low even though the summer temperatures were high. The specific gravity of the tubers was relatively high by September 1 in 1954 and remained practically constant at the later harvesting dates.

That the low yields were due to inability of the tubers to enlarge and not to a lack of tuber set is shown by the very high percentages of B- and C-size tubers. The percentages of scabby, rough, and otherwise defective tubers were among the lowest of all the years.

Probably none of these seasons would have netted production costs on a table-stock market but if the crop was grown for seed production, costs would probably have been realized in one or two of the years.

TABLE 8.—Weather conditions, and yield and quality of potatoes produced by various dates, in the four years of Group D with least production.

Year	A. Seasonal distribution of effective precipitation					B. Mean monthly temperatures				C. Total water evaporation each month			
	Oct. 1 to May 31	Growing season months											
		June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.
	in.	in.	in.	in.	in.	°F.	°F.	°F.	°F.	in.	in.	in.	in.
1954	5.83	1.91	0	0.56	0	65.8	76.2	71.8	65.1	8.39	10.48	8.52	6.69
1939	3.41	1.38	0	0.50	0	64.2	76.5	69.9	64.3	10.06	10.64	9.36	8.67
1940	2.37	1.08	0	0	0.62	67.8	77.1	71.1	65.5	9.65	11.83	9.36	5.92
1937	2.51	2.23	0.67	1.13	0	62.4	74.3	75.5	63.4	7.65	11.49	11.23	8.07
4-yr. mean	3.55	1.65	0.17	0.52	0.15	65.1	76.0	72.1	64.6	8.94	11.11	9.62	7.84
26-yr. mean[1]	5.45	2.46	0.99	1.15	0.87	64.6	73.5	71.4	60.8	7.66	9.78	9.16	6.61

Year	D. Total yield per acre					E. U.S. No. 1 A-size					F. Yields No. 1 A- plus B-sizes				
	Aug. 16	September 1	September 16	October 1	October 16	Aug. 16	September 1	September 16	October 1	October 16	Aug. 16	September 1	September 16	October 1	October 16
	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.
1954	20.0[2]	63.1	76.2	74.4	72.2	5.0[2]	22.2	43.7	43.7	42.7	?	49.9	66.0	62.8	59.2
1939	5.0[2]	44.5	57.8	72.0	68.3	0[2]	4.3	19.2	34.2	39.4	?	18.7	38.6	48.0	50.4
1940	0[2]	16.8	29.0	40.5	54.1	0[2]	0.4	3.0	9.3	19.5	?	2.2	9.4	21.5	35.1
1937	0[2]	11.7	29.7	35.4	40.8	0[2]	1.6	7.3	10.0	14.6	?	4.7	16.6	20.0	23.4
Mean	6.2	34.0	48.2	55.6	58.9	1.2	7.1	18.4	24.3	29.1		18.9	32.7	38.1	42.0

	G. Increase total Bu./acre/day					H. Increase U.S. No. 1 Bu./acre/day					I. U.S. No. 1 A-size pct. total				
	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.	bu.
1954	1.25[2]	2.27	1.31	–0.09	–0.01	0.33[2]	0.91	2.15	0	–0.06	?	35.2	57.3	58.7	59.2
1939	0.33[2]	2.47	0.89	0.95	–0.25	0[2]	0.29	0.99	1.00	0.36	?	9.6	33.2	47.5	57.6
1940	0[2]	1.12	0.81	0.77	0.91	0[2]	0.03	0.20	0.40	0.69	?	2.4	10.5	22.9	36.0
1937	0[2]	0.78	1.20	0.48	0.32	0[2]	0.11	0.39	0.25	0.26	?	13.7	22.1	40.8	38.8
Mean	0.40	1.66	1.05	0.53	0.24	0.08	0.33	0.94	0.41	0.31	?	15.2	30.8	42.5	47.9

Yield of tubers with various types of defects and of various sizes, as per cent of total yield

Year	J. Scabby, A-size					K. Rough, A-size					L. Harvest cracks, A-size				
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1954	?	2.4	3.6	5.1	8.6	?	4.5	2.7	4.6	3.0	?	0.8	0	0	0
1939	?	0	0.3	0.3	0.2	?	0.5	0.6	1.0	4.2	?	0	2.6	3.8	2.6
1940	?	0	0	0	0	?	0.4	2.4	3.9	4.2	?	0	1.1	0.8	3.4
1937	?	0	1.0	0.5	0	?		None				None (or with cuts)			
Mean		0.60	1.22	1.97	2.20		1.35	1.42	2.37	2.85		0.20	0.82	1.15	1.50

	M. Harvest cuts, A-size					N. B-size (1½ to 1⅞ in.)					O. C-size (under 1⅞ in.)				
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1954	?	0	1.8	3.5	3.8	?	43.9	29.3	25.6	22.9	?	13.2	4.7	2.0	2.1
1939	?	0	1.1	2.2	0.7	?	32.0	33.5	19.1	16.1	?	55.3	26.9	17.9	12.9
1940	?	0	0	0	0	?	10.6	22.0	30.2	28.8	?	86.6	63.8	42.0	27.4
1937	?	3.3	3.7	1.9	0.2	?	26.7	31.4	28.3	26.5	?	56.3	45.9	29.5	33.1
Mean		0.82	1.65	1.90	1.18		28.4	29.1	25.8	23.6		52.9	35.3	22.9	18.9

[1] See footnote 2, table 5.
[2] Data for August 16 estimated in all years.

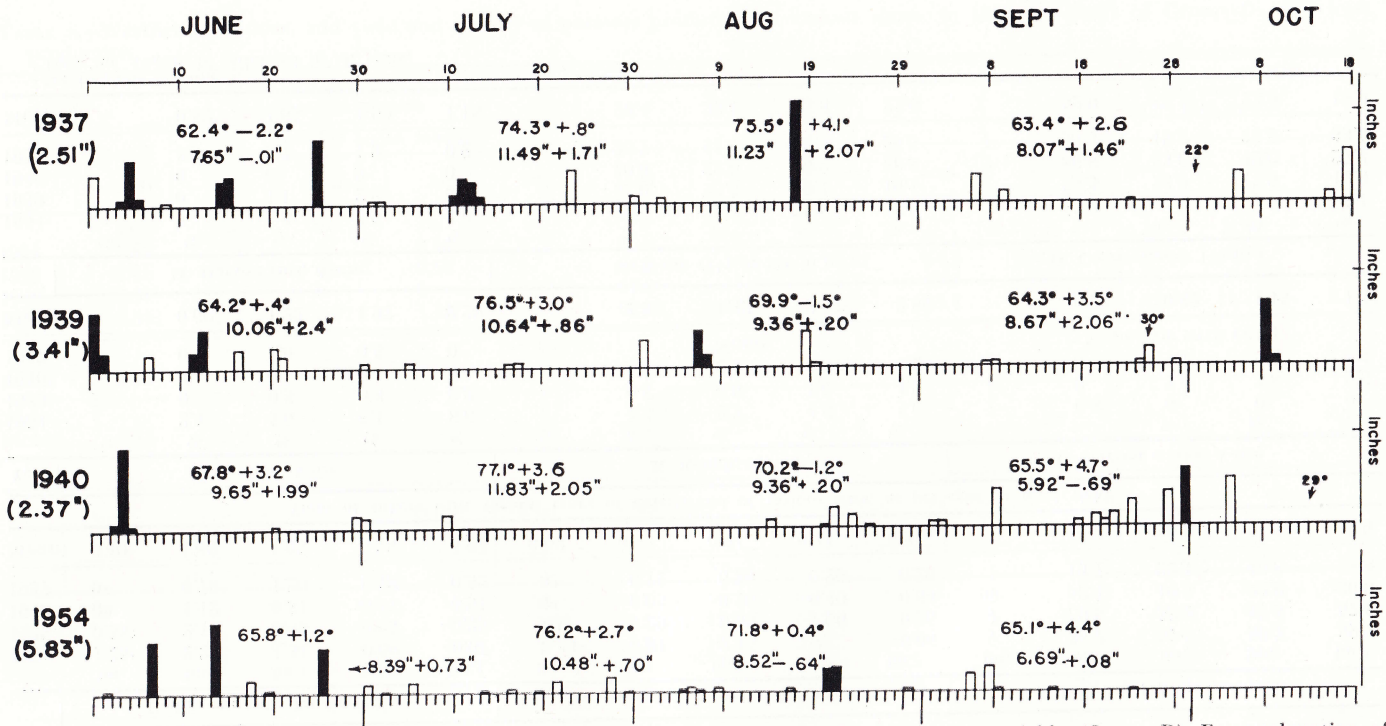

FIGURE 4.—Rainfall for each day from June 1 to October 18 of the four years of poorest potato yields (Group D). For explanation of other details of the graphs see figure 1.

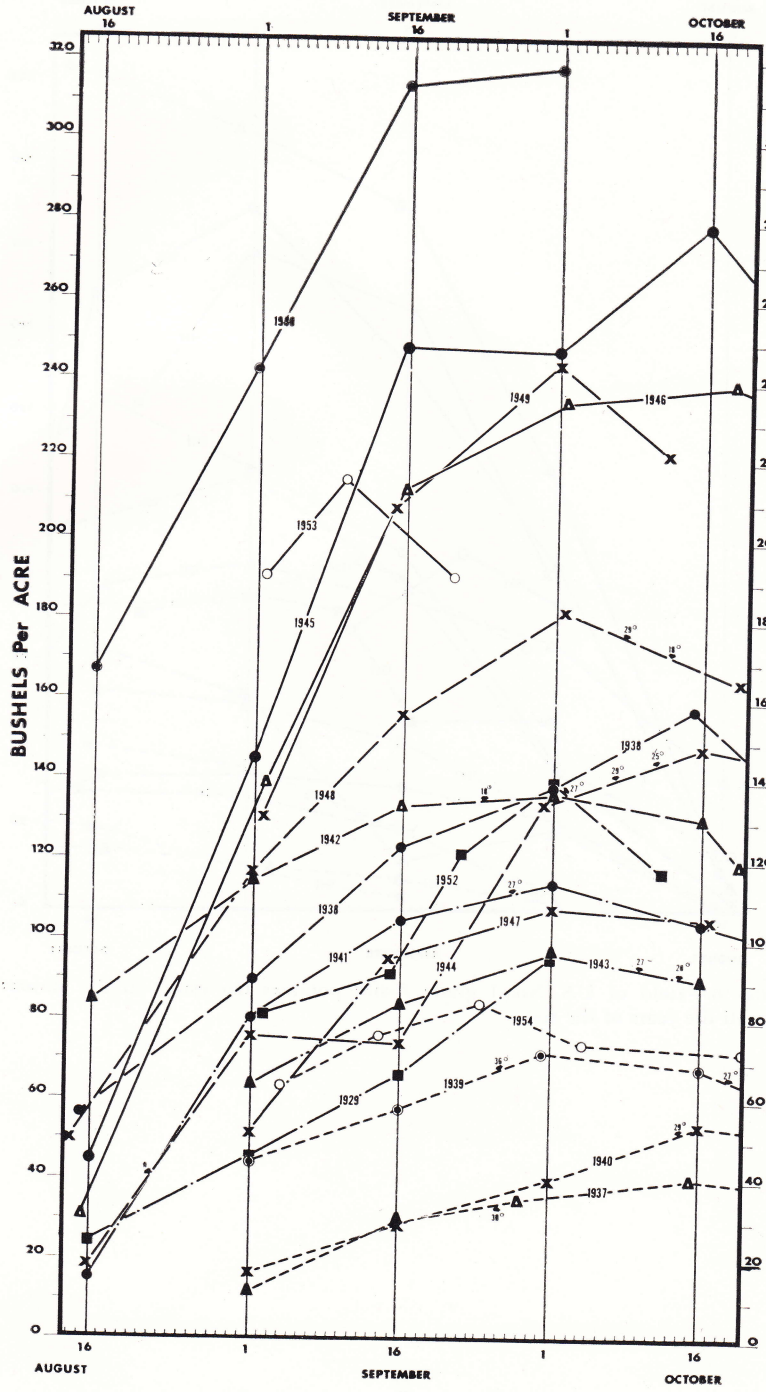

FIGURE 5.—Total yield of potatoes by various harvesting periods in all the years of the test. The earliest freezing temperatures in the autumn are shown on the lines for the various years at the time they occurred.

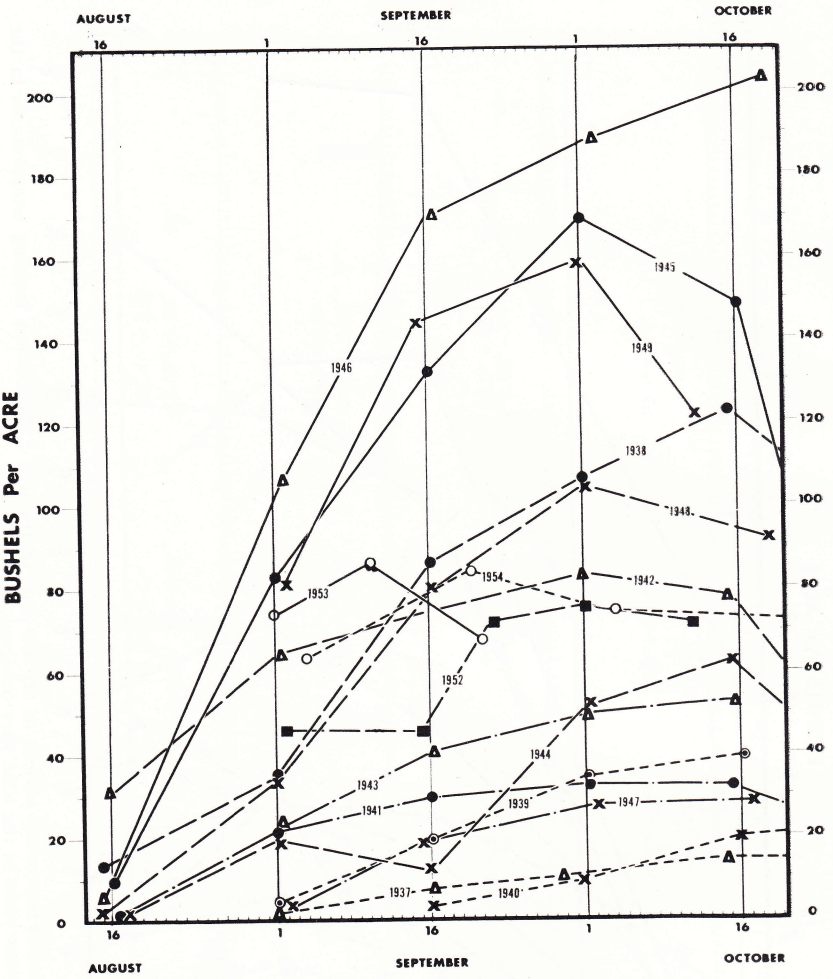

FIGURE 6.—Yield of U.S. No. 1 grade A-size potatoes harvested on the various dates in all the years of the test.