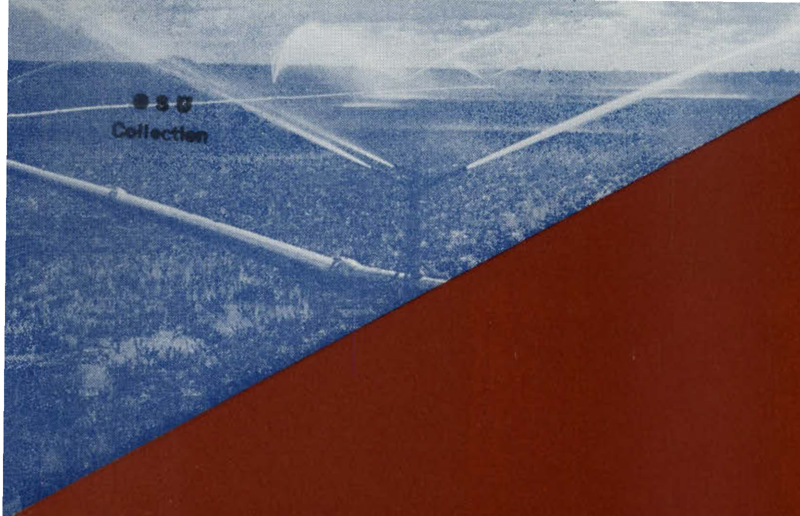

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Salt Accumulation in Irrigated Soils

The Prospect in Oklahoma

By HORACE J. HARPER and ORVILLE E. STOUT

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The Prospect, in Brief

The danger of irrigated land being damaged by an accumulation of salts depends upon the type of soil and the climate, as well as upon the amount of salts dissolved in the water used for irrigation. This bulletin summarizes available information bearing on this problem in Oklahoma. Further research is under way at several points in the State, and results will be reported as rapidly as definite, practical information becomes available.

From present knowledge, it appears that there is less likelihood of damaging salt accumulation in Oklahoma from waters that would be harmful than under similar desert irrigation conditions. *However, the danger is great enough to warrant careful tests of both soil and water before money is spent on land preparation and installation of irrigation equipment.*

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The Prospect in Oklahoma

By HORACE J. HARPER and ORVILLE E. STOUT
Respectively: Soils Scientist, and former Assistant Soils Scientist.

One of the hazards of irrigation is the tendency for salts contained in the water to accumulate in the soil and thereby reduce yields. In areas where crops depend entirely upon irrigation, the salt content of the soil sometimes becomes high enough to ruin the land.

Increased use of irrigation in Oklahoma has raised the question: "Will irrigated soils in this state eventually be damaged by salt accumulation?"

The answer appears to be, in general, that there is less danger of serious salt accumulation under irrigation in Oklahoma than in areas where crops are entirely dependent upon artificial watering.

Most irrigation in Oklahoma will be supplemental. Water will be applied only when rainfall is lacking. Therefore the quantity of salts put into the soil will be less than in an arid region where crops are irrigated regularly, because over a period of years less water will be used. Furthermore, water from rainfall dissolves the salts in the surface soil layer; and during periods when rainfall is abundant the dissolved salts will be carried into the subsoil below the zone where most plant roots develop, if the soil is sufficiently permeable.

However, with some types of water and on certain soils, enough salts could accumulate to seriously reduce crop yields. The danger is great enough that a careful study of both the water supply and the soil to be irrigated should be made before money is spent on an irrigation system. If information is not available from your county agent, the necessary water and soil analyses can be made by the Experiment Station's soils laboratory at Stillwater.

The danger limits for use of saline water in supplemental irrigation are not too well known, because most of the research on this subject has been done in states further west, under desert conditions. The Oklahoma Station now has under way a study of the problem as it exists in Oklahoma. Meanwhile, the information in this bulletin has been assembled as a guide for current irrigation projects. It will also be of help in interpreting laboratory reports on waters being considered for use in irrigation.

QUALITY STANDARDS FOR IRRIGATION WATER

The U. S. Salinity Laboratory at Riverside, Calif., classifies irrigation water as follows:

Good to Excellent. Containing less than 177 parts per million of chlorine, with sodium making up less than 60 percent of the total bases.

Good to Injurious. Containing from 177 to 354 parts per million

Water is pumped from an irrigation well into a concrete box equipped with gates to direct the flow into different head ditches.

of chlorine, with sodium making up 60 to 75 percent of the total bases.

Injurious to Unsatisfactory. Containing more than 354 parts per million of chlorine, with sodium making up more than 75 percent of the total bases.

It is probable that these standards are somewhat too low for water to be used for supplemental irrigation in Oklahoma. However, they do furnish a guide until such time as standards for Oklahoma can be determined by research now under way.

The allowable salt content of an irrigation water depends in part on the crop to be grown. For example, a water might be objectionable for the several applications needed to produce a good yield of alfalfa in a dry season yet be satisfactory for an occasional application such as is needed to produce a crop of cotton or grain sorghum.

Water high in calcium sulfate (gypsum) is satisfactory for irrigation if it does not contain too much chloride in addition to the gypsum. A preliminary study made by the Oklahoma Station in 1941-43* indicated that water which contains less than 1,000 parts per million of total salts exclusive of calcium sulfate is usually suitable for supplemental irrigation. A combination of gypsum and sodium chloride or sodium sulfate is less objectionable than either or both of the latter two salts and little or no gypsum. (In fact, the unfavorable effect of too much sodium in a soil can be neutralized by the addition of gypsum. Oklahoma has an abundant supply of gypsum which could be used for this purpose.)

Good irrigation water should contain more calcium than sodium**. If the water contains twice as much sodium as calcium,† and exchangeable calcium is not present in the soil in sufficient quantities to offset the excess in the water, the sodium disperses the clay particles and creates a physical

*See Okla. Agri. Exp. Sta. Tech. Bul. No. T-39, *The Relation of Soil Texture to Soluble Salt Accumulation in 29 Irrigated Soils in Oklahoma,* by Horace J. Harper.

**See publications cited in footnote to appendix.

†Strictly speaking, if the calcium-sodium milliequivalent ration is 0.5 or less.

condition which retards the absorption and downward movement of water.

Where the proportion of sodium to calcium is more than two to one, a water having low totals of both is to be preferred to one where both sodium and calcium are high.

The danger of injury from accumulation of sodium salts is least on deep, well drained soils with a good supply of exchangeable calcium. In the 1941-43 study, 10 of the 18 water samples had an undesirable calcium-sodium ratio, but the high calcium content of the irrigated soils had prevented any undesirable physical changes in the soil up to the time the samples were taken.

At the Southwest Oklahoma Cotton Station near Tipton, cotton has been irrigated for ten years using well water containing 190 parts per million of sodium and 90 of calcium. The standards of the U. S. Salinity Laboratory would classify this water as "good to injurious," since sodium makes up 67 percent of the total bases. But chemical analyses of the irrigated soil at Tipton indicate that the sodium content has not been greatly increased.* The total amount of water applied is not definitely known; but two inches was usually applied at each irrigation and the cotton was watered from two to four times a year.

RELATION OF SOURCE AND QUALITY OF WATER**

Irrigation water in Oklahoma may come from three sources: wells, ponds and reservoirs, or streams. Each of these involves problems of quantity as well as quality. This bulletin deals only with the latter.

Wells

The chemical composition of Oklahoma ground water is quite variable. Water from shallow wells is usually less saline than from deep wells. Water in deep wells is often saline because one or more of the geological formations through which the ground water has moved from the surface of the earth downward into the subterranean reservoir was high in soluble salts.

Ponds and Reservoirs

Water impounded in reservoirs is composed principally of rain water. Therefore it normally contains a negligible quantity of soluble salts, and is an excellent source of water for irrigation.

Streams

The quality of the water in Oklahoma streams is quite variable. Common salt and other chlorides are present in some streams in large quantities because of salt springs. In other instances both small and large streams have been polluted from salt water associated with oil field development.

Some of the larger streams in Oklahoma which are salty because

*Tests of the Tipton soil are reported in more detail in the appendix.

**Data on the chemical composition of water from many different sources in Oklahoma are presented in Publication No. 62 of the Oklahoma Engineering Experiment Station, Vol. 12. No. 1, October, 1942 (Stillwater, Okla.)

A pond north of Seminole, Okla., that has been used to irrigate an adjacent area of bottomland during the last four years.

of a geological influence include the Salt Fork of the Arkansas River, the Cimarron River east of Edith, and the Elm Fork of Red River. There are several small streams which are naturally saline, but the volume of water carried by these streams is relatively small.

Streams polluted with salt originating from oil fields include the North Canadian River eastward from Oklahoma City; Little River, Salt Creek and Wewoka Creek in central Oklahoma; and several small streams in Osage, Kay and Creek Counties.

The salt content of streams affected by salt water from oil fields declines after production of oil ceases, but the decline takes a considerable period of time because salt continues to leach into the streams from polluted soil or underground formations. The Chikaskia River is a good example of this condition. It was formerly very salty, but the quality of the water is gradually improving as less salt from oil field operations finds its way into the stream.

The salinity of the water in a stream depends upon stream flow, being higher at low-water stages than following flood periods. Therefore it is possible that some streams could be used for irrigation providing the water was tested for chloride each time the pump was operated. The test is no more difficult than that for soil acidity, and can be made in a few minutes. Simple testing kits could be made available for home use if a demand for them arose.

Two examples illustrate the variability in salt content of some Oklahoma streams:

(1) Twenty-six samples were taken from Black Bear Creek during 1947. Twenty-four of these samples had less than 300 parts per million of chloride and averaged less than 100 parts per million. They would be satisfactory for irrigation. But samples taken on March 17 and July 2 showed, respectively, 1,255 and 659 parts per million of chloride. Water in the creek at those times was undesirable for irrigation.

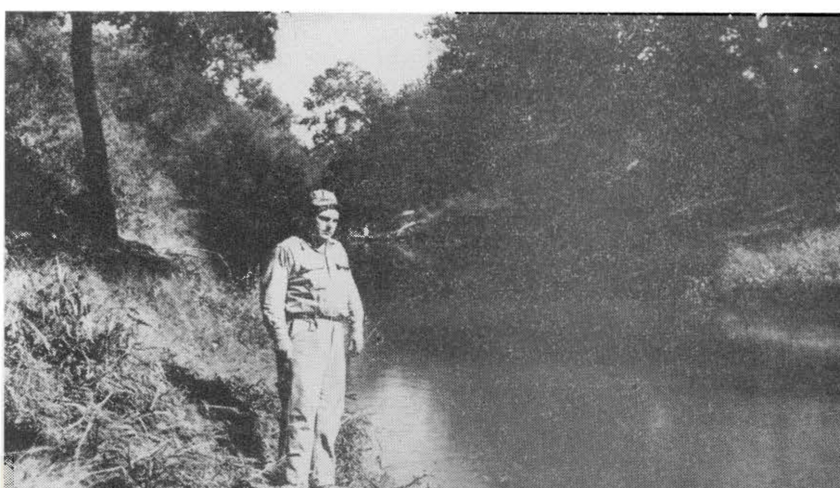
(2) Studies made by the U. S. Geological Survey show that water in the South Canadian River near Whitefield is also quite variable in chloride content. During January and February, 1947, the water in this stream varied from eight parts per million on February 17 to 2700 parts per million on February 21. Four of the 17 water samples analyzed during this two-month period contained sufficient quantities of chloride to render them unfit for application to the soil.

Water from that part of a stream lying below a large reservoir is usually safe for irrigation because it is principally flood water retained in the reservoir and released gradually to produce power. Examples in Oklahoma are the Arkansas River south and east of its junction with the Grand, and the Red River east of Denison Dam. Both are excellent sources of water for irrigation, having a low salt content and a favorable calcium-sodium ratio.

PROBABILITY OF SALT ACCUMULATION

The amount of injurious salt which accumulates in an irrigated soil depends upon:

(1) The amount and kinds of



A farmer near Skedee, Okla., stands by Black Bear creek, from which he has irrigated his corn crop during the last four years and has averaged more than 100 bushels per acre.

salt in the water used.

(2) The soil type; that is, whether the soil is porous enough to let rain water seep through and carry away salts deposited by the irrigation water.

(3) The method used in applying irrigation water.

(4) The amount of rainfall, which determines:

  (a) How often the land must be irrigated; and

  (b) The extent to which salts left by irrigation water will be leached into the subsoil by rain.

Of these four factors, the indefinite one is rainfall. Desirability of the water and the soil for irrigation can be determined ahead of time; and proper methods of irrigation can be learned. Therefore, in estimating the probable danger from salt accumulation, the points considered were (1) the probable frequency of irrigation and (2) the degree to which rainfall could be expected to leach away salts left in the soil by irrigation water.

Effect of Frequency of Irrigation

One reason for believing that salt accumulation is less of a hazard to irrigation in Oklahoma than under desert conditions is that Oklahoma crops seldom if ever will need to depend entirely on irrigation for their total supply of water. In most years, irrigation will merely be used to "fill in" during dry spells; i. e., it will be *supplemental* irrigation.

This does not mean, however, that irrigation is unimportant. In some seasons, one irrigation at the right time can mean the difference between a good crop and a poor one. With irrigation available on a standby basis, water can be applied before plants wilt and thus keep them growing rapidly throughout the season. The fact that irrigation in Oklahoma is supplemental is emphasized here only to point out that less water will be applied than in desert irrigation. In some years no irrigation will be needed. In others, a crop may need an irrigation only once or twice.

The situation in Oklahoma is illustrated by records of corn yield in relation to rainfall at the Experiment Station's farm at Perkins, south of Stillwater, for the years 1931 to 1947, inclusive (Table I). During this 17-year period, probably not more than 25 irrigations would have been needed to get the highest corn yields the soil was capable of producing (See note to Table I).

An interesting sidelight on the data in Table I is the indication that it may be June droughts which cut corn yields in Oklahoma (average 8 poor crops in 41 years), as well as July droughts as is commonly believed.

The opinion that not more than two to four irrigations would be needed in most years is also supported by results of time-of-irrigation experiments made by Oklahoma Station horticulturists with sweet corn and other vegetable crops (See Okla. Agri. Exp. Sta. Cir. C-131, pp. 18 to 21).

These corn and vegetable studies, it should be noted, were made in Payne county where rainfall averages 35 inches per year. Farther west in the state, naturally, more irrigations would be needed,

TABLE I.—A comparison of Corn Production in Relation to Drought Periods of 21 Days or Longer; Perkins Farm, 1931 to 1949.

Year	Date of drought period	Total rainfall between droughts (inches)	Corn yield (bu. per A.)	Seasonal rainfall; Jan. 1 to Aug. 1	Estimated irrigations needed
1931	April 26 to May 18	4.11			
	June 16 to July 8				
	July 10 to Aug. 2	2.09	11.0	14.49	3
1932	July 7 to July 26		36.6	14.97	1
1933	May 28 to July 14		8.3	11.67	4
1934	May 12 to June 10				
	July 2 to Aug. 21	2.57	10.0	11.29	4
1935	July 2 to Aug. 28		31.2	19.92	1
1936	June 6 to Sept. 16		12.1	10.93	2
1937	June 17 to July 10		17.2	15.62	2
1938			38.2	24.77	0
1939	April 6 to May 6		26.3	16.41	1
1940			23.5	14.85	2
1941			36.1	17.41	0
1942	June 31 to Aug. 6		25.5	25.08	1
1943	June 9 to Aug. 4		16.9	16.21	2
1944			35.4	20.75	0
1945	May 1 to June 5		32.4	21.53	1
1946	June 1 to June 28				
	June 31 to Aug. 24	2.07	22.4	20.47	2
1947			33.2	19.26	0
Average			24.5	17.39	

NOTE: In the four years 1938, 1941, 1944, and 1947 there was no drought, and yields were as high as can be expected on the upland soil at Perkins. In three other years, 1932, 1935, and 1945, yields were above 30 bushels; but one irrigation might have been applied to supplement July rainfall, which is normally deficient in seven years out of ten. One or two irrigations might have been needed in June or early July of 1936, 1937, 1942, 1943 and 1946. The drought years, 1931, 1933, and 1934 would have required three or four, and perhaps five, irrigations. In 1940 there was no well-defined drought, but the low yield suggests an irrigation or two would have made more corn.

on the average. But nowhere in Oklahoma does the rainfall average much below 20 inches, as compared to 8 and 10 inches in areas where most of the large irrigation projects are located at present.

Effect of Leaching by Rainfall

Another reason for believing that supplemental irrigation in Oklahoma does not present as much salt hazard as is found in irrigated soils in the extremely dry areas farther west is that above average rainfall occurs every few years which dissolves accumulated salts and carries them into the subsoil below the zone of maximum root development.

The extent to which salts are carried downward by rain water depends, of course, on the texture of the soil. Sandy subsurface layers provide excellent drainage. A dense clay subsoil retards downward movement of water. Occasionally a high water table may appear in irrigated areas because of lateral seepage toward low-lying areas. In such cases, drainage must be provided for successful irrigation.

Station soils scientists have studied 29 locations in Oklahoma where the land had been irrigated for varying periods of time.* Soluble salts had not accumulated where the soil texture varied from sandy loam to clay loam and the irrigation water was low in total salt content. Salt accumulation tended to increase with increase in salt content of the water, increase in clay content of the soil, or both. Crop injury had occurred on only one of the areas. In several areas, salt was accumulating in the soil but had been carried by rainfall to a depth below 12 inches.

The general tendency of central Oklahoma soils to accumulate salt was tested by analyzing eight soil profiles from unirrigated areas. Results are shown in Table II. Of the eight soils studied, only two showed a high accumulation of salts. The two exceptions were the samples from the Agronomy Farm at Stillwater. These showed a tendency for sulphates to accumulate, but at a depth of about four feet, which is below the root zone of most crops. This soil is dense enough in the second and third one-foot layers to prevent downward movement of water when it is wet; but the clay subsoil cracks open during dry weather and permits water to move into the subsoil until the cracks are again closed by swelling of the clay. Soluble salts are commonly observed in the lower portion of the claypan soil profiles; and on this type of land the improper use of saline water would eventually result in a salt accumulation harmful to plant growth.

What can happen on land with a very deep, impervious clay subsoil is illustrated by soil profiles taken on adjacent areas in Greer county (Table III). On one of these areas alfalfa made good growth. On the other it was killed by salt accumulation as a result of capillary rise from a saline water table. (The water table was less than five feet from the surface at the time the samples were taken. Where alfalfa survived, it was more than five feet.) The salt content of the three- to five-foot layer was about the same in both areas; but it was much higher in the surface foot on the barren area than on the productive area. Soluble salts had accumulated in the barren area because water rose by capillary attraction, evaporated at the surface, and left the salts in the top layer of soil. The salt concentration at the surface eventually accumulated in sufficient quantity to kill the young alfalfa plants before their root system could extend downward into less saline soil. Other studies have shown that under such conditions the salt content in the surface inch is often much higher than the average of the surface foot, especially during warm weather when the rate of evaporation from the soil is high.

Accumulation of salts due to evaporation from a water table near the surface can sometimes be prevented by providing for artificial drainage through the compact clay layer which supports the high water table. That, of course, adds to the cost of irrigation. It is another reason why suitability of the land for irrigation must be carefully considered before equipment is installed.

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*See Okla. Agri. Exp. Sta. Tech. Bul. T-39, "The Relation of Soil Texture To Soluble Salt Accumulation in 29 Irrigated Soils in Oklahoma."

TABLE II.—Total Water Soluble Salts, Chloride and Sulfur (Calculated as Sulfur Trioxide) in Eight Central Oklahoma Soil Profiles.

County and Location	Depth of sample (feet)	Analysis (parts per million) Total salts	Chlorides	Sulfur trioxide
Payne, Plot 8124, Agronomy Farm, Stillwater; 8900 lbs. gypsum applied, 1916-1933	1	408	4.6	61.8
	2	600	13.7	75.5
	3	1796	9.1	776.0
	4	5560	22.9	2904.0*
	5	1744	32.1	840.0
	6	1476	45.8	681.0
	7	668	64.1	432.0
	8	1064	68.6	444.0
Payne, Plot 8125, Agronomy Farm, Stillwater; no fertilization	1	312	4.6	34.3
	2	276	4.6	79.6
	3	644	22.9	100.0
	4	2028	41.2	933.0
	5	1176	41.2	469.0
	6	884	32.1	314.0
	7	728	36.6	295.0
	8	648	45.0	267.0
Kay, SW¼ 2-26-1W	1	590	7.0	4.5
	2	500	3.5	6.2
	3	1090	29.9	6.6
	4	530	3.5	3.3
	5	680	7.0	4.9
	6	820	12.4	5.7
	7	520	10.5	2.9
Grant, SW¼ 27-27-3W	1	530	2.5	4.7
	2	600	4.5	5.4
	3	950	17.7	8.4
	4	1110	9.5	25.8
	5	1140	15.6	38.3
	6	820	18.9	76.6
	7	800	21.4	102.3
Kingfisher, SW¼ 33-19-6W	1	600	24.4	2.5
	2	320	19.5	2.5
	3	580	7.0	1.0
	4	200	1.4	.8
	5	200		1.2
	6	230	61.3	1.0
	7	370	8.4	.8
Alfalfa, NW¼ 29-25-9W	1	330	3.5	1.6
	2	240	11.9	1.0
	3	240	5.6	4.1
	4	120	14.6	1.6
	5	270	9.8	2.0
	6	270	10.5	2.9
	7	270	11.2	.8
Logan (near Crescent)	1	180		.8
	2	360	2.8	2.5
	3	740	18.1	11.1
	4	1060	27.9	15.2
	5	1330	42.5	15.6
	6	1110	41.8	21.0
Garfield, NE¼ 34-20-6W	1	350	3.5	4.0
	2	240	5.6	1.0
	3	240	6.3	1.0
	4	200	2.1	1.0
	5	250	10.5	.4
	6	250	13.3	.8
	7	300	8.4	1.6

*One to five extract yielded 5,800 P.P.M. of SO_3.

SUMMARY

Water can be used for supplemental irrigation in Oklahoma that contains more soluble salts than would be safe for use in a region where crops depend almost entirely upon irrigation for moisture.

Water from ponds or reservoirs is excellent for irrigation because it normally is very low in soluble salts. The water in Oklahoma wells and streams is quite variable in chemical composition; consequently, both water and soil should be tested to determine if the salt content of the water is below the safe limit for the soil on which it is to be used.

On land where soluble salts had accumulated in sufficient quantities to kill alfalfa, approximately 24 inches of annual rainfall over a period of six years had removed the soluble salts from the soil so that good crops could again be grown.

Of seven soil profiles collected to a maximum depth of eight feet in central Oklahoma, only one contained any appreciable quantity of soluble salts. This was a claypan soil near Stillwater.

The chemical composition of soil samples collected from irrigated land on the Southwest Oklahoma Cotton Station near Tipton had not been changed appreciably over a period of ten years by use of irrigation water with a sodium-calcium ratio of two to one. There was some indication that the clay in the subsurface layers of the irrigated land was more highly dispersed than in the non-irrigated soil.

Treatment of the soil with gypsum or lime will eventually be required to maintain a favorable physical structure of the soil on land where irrigation water containing an unfavorable sodium-calcium ratio is applied over a long period of time.

TABLE III.—Relation of Water Soluble Salts in Soil to Growth of Alfalfa; Bottomland Along Salt Fork of Red River, M. H. Pace Farm, Southwest of Mangum, Okla.

Condition of Alfalfa	Depth of sample (feet)	Chemical Composition of Soil Extract (parts per million)					
		pH	Sulfur trioxide	Chlorine	Calcium	Sodium	Total salts
Excellent Crop	0-1	7.4	63	11	53	57	318
	1-2	7.3	122	28	66	70	726
	2-3	7.4	543	51	208	114	1,464
	3-5	7.4	4,475	110	1,581	210	8,490
Alfalfa Killed	0-1	7.4	4,404	890	1,331	780	10,806
	1-2	7.4	4,493	395	1,497	590	10,002
	2-3	7.6	3,509	397	1,168	322	6,828
	3-5	7.5	4,174	178	1,679	252	8,172

APPENDIX

Effect of a Wide Sodium-Calcium Ratio in Irrigation Water on Soil Conditions at the Southwest Oklahoma Cotton Station, Tipton, Oklahoma.

Cotton has been irrigated for 10 years on the Southwest Oklahoma Cotton Station near Tipton, using well water containing 190 parts per million of sodium and 90 parts of calcium.

Chemical studies on soils which have been irrigated with water containing twice as much sodium as calcium have been made by several investigators (1, 2, 3). Normally water of this type eventually will harm the physical structure of the soil by dispersing the clay particles if exchangeable calcium is not present in sufficient quantities to counteract the undesirable effect of the sodium. The total amount of water applied is not known, but usually about two inches of water was applied at each irrigation and the cotton was watered from two to four times each year. Assuming that approximately five feet of water was applied to this soil during this period, the total sodium applied in the water would be approximately 2500 pounds per acre.

The chemical analyses of composite soil samples collected from three different profiles on the irrigated area and on the non-irrigated area are given in Appendix Table I. It will be observed that the pH of the irrigated soil is higher than the pH of the non-irrigated land. Water extracts of soils from the irrigated area were higher in sodium than water extracts of soils from the non-irrigated area. Very little water soluble potassium was present in either the irrigated or non-irrigated samples. The exchangeable sodium content of this soil has not been increased appreciably by the application of the irrigation water. For some reason the 24- to 30-inch layer in the irrigated soil profile has developed a physical structure which was highly dispersed and the soil suspension was difficult to filter when the water extraction was made. This condition cannot be explained from either the pH value or chemical composition. The exchangeable potassium content of the irrigated and non-irrigated

(1) Jour. Amer. Soc. Agron. 30:789-796 (1938)
(2) Soil Sci. 49:95-107 (1940)
(3) U.S.D.A. Tech. Bul. 937 (1948)

APPENDIX TABLE I.—Effect of Supplemental Irrigation Using Water With a Sodium-Calcium Ratio of Approximately 2 to 1 on Sodium Absorption; Southwest Oklahoma Cotton Station, Tipton. (Average of triplicate samples)

Depth of Soil (Inches)	pH	Chemical composition of water-soluble salts extracted from soil (Parts Per Million)			Exchangeable Bases (Parts Per Million)		
		Sodium	Potassium	Calcium	Sodium	Potassium	Calcium
			Irrigated				
0-6	8.0	72	8	15	64	303	2,225
6-12	7.9	115	9	24	85	265	2,225
12-18	7.7	111	5	15	126	295	2,051
18-24	7.7	120	0	9	136	316	2,005
24-30	7.7	120	0	6	121	186	1,906
30-42	8.0	137	0	45	98	179	5,224
42-50	8.1	129	0	72	63	175	8,407
			Non-irrigated				
0-6	7.3	10	16	36	43	304	1,973
6-12	7.6	7	11	54	57	273	5,045
12-18	7.7	10	7	90	51	282	5,269
18-24	7.7	7	3	150	60	255	5,139
24-30	7.9	7	0	75	62	212	5,704
30-42	7.9	7	0	90	65	180	5,474
42-50	7.8	18	0	75	62	166	5,685

land was very similar. The exchangeable calcium content of the irrigated soil was much lower than that of the non-irrigated land. This difference cannot be explained on the basis of soil texture. The internal drainage of the non-irrigated soil was somewhat less permeable than the irrigated area since more calcium carbonate was present in the lower layers of these profiles. This condition may have been partly responsible for the higher content of exchangeable calcium in the non-irrigated soil.