THE EFFECT OF IRRIGATION ON THE CHEMICAL PROPERTIES OF SOME KEARNY COUNTY SOILS

by

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B. S., Kansas State College
of Agriculture and Applied Science, 1957

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1958

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INTRODUCTION

Irrigation has been a dominant factor in the agricultural livelihood in the Arkansas River bottomland area of Kearny County, Kansas. The construction of three principal irrigation ditches around 1900 marked the genesis of a major portion of the irrigation projects in the area. However, some of the land has been irrigated for 75 years, while other land is still being placed under irrigation for the first time.

The principal crops now grown under irrigation are wheat, sorghums and alfalfa. In past years sugar beets and other truck crops were of more importance. Many persons concerned with the agriculture of the area have noted that crop yields were lower than should be expected. They suggested that this might be the result of salt accumulation in the soil. Therefore, the present study was undertaken specifically to determine the effect that irrigation has had upon the salt content and other chemical properties of some typical Kearny County soils.

WATER SOURCES AND QUALITY

In the valley area, well over half of the individual farmers' irrigating water supply was drawn from one of the three large ditches, the Amazon, the Great Eastern, or the South Side irrigating ditches (Fig. 1). Each ditch originated in the Arkansas River, and the water quality has varied directly with the amount of stream flow as a general rule. Table 1 lists the water quality of a number of samples taken from the Arkansas River in this area at different times.

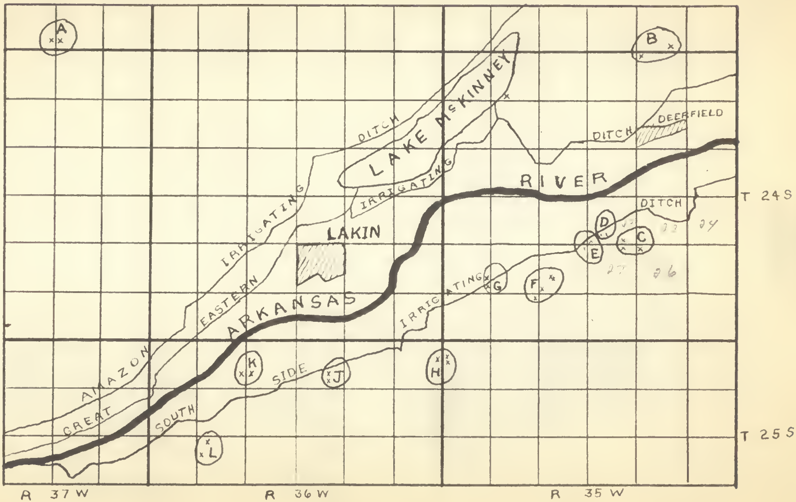

Fig. 1. Part of Kearny County, Kansas, showing relative locations of the sites studied.

Table 1. Chemical analyses of surface waters originating in the Arkansas River.

Date	Total	Ca	Mg	Na	CO_3	HCO_3	Cl	SO_4
	Parts per Million							
May, 1956[1]	1185	142	52	168	7.3	209	61	631
April, 1957[1]	2502	264	103	380	0	239	117	1500
June, 1958[2]		247	74	451				

Most valley farms had shallow wells as supplementary water sources, while a few had deep wells. The water table was found at a depth of 25 feet or less, according to McLaughlin (6). This made the use of shallow wells quite practical. The wells yielded over the range of 100 to 4,500 gallons per minute. The higher yields were from batteries of five to eight wells incorporated into one unit. The quality of water from these sources varied from one well to another (6).

At the time of this study irrigation was only beginning on the uplands. In this area, deep wells provided the only water sources as the water table was located from 150 to 200 feet below the land surface. Irrigation in both areas was entirely of the flood type, either in basins or furrows.

The remaining water source was precipitation which averaged about 17 inches annually, with over 70 percent falling in the six month period from April through September.

[1] Information supplied by the Kansas State Board of Health, Division of Sanitation, Topeka, Kansas. Samples were taken at Dodge City, Kansas.

[2] Average of five samples of ditch water from the South Side irrigating ditch, Kearny County, Kansas.

The intensity and amount of rain which fell in each storm varied greatly. The usefulness of the rainwater depended upon when it fell, and this in turn determined the extent to which the well water and possibly the ditch water were used. According to Teakle (13) a very small amount of salts could have been added to the soil through rainwater.

SAMPLING

Within each comparison samples were taken from sites that had been irrigated for 50 years or more and from sites that had been irrigated only a short time or not at all. The sites in each comparison were sampled so that the soil would be as nearly alike as possible. Two samples were taken on the uplands northwest of Lakin, on the Richfield, Ulysses, Colby soil association. Three more samples were taken north of Deerfield on the Ulysses, Colby soil association. These two associations were quite similar in characteristics, being very deep, grayish brown, silt loam soils with very little profile development. The rest of the sites were located in the valley area on recent alluvium. These soils were quite stratified with no profile development and varied in the texture of the surface layer. In practically all of the valley sites sampled, a layer of loose sand was encountered at a depth of four to five feet. Figure 1 is a map of the sampling area showing the relative locations of the different sampling sites.

Samples were taken with a three-inch diameter hand auger by six-inch depths to five feet. Enough soil was obtained from each six-inch interval to fill completely a one quart water proof ice cream carton. The samples were transported back to the laboratory in Manhattan, Kansas in these containers. The 27 sites were sampled and the soils transported to the laboratory over a span of four days.

The land sampled was nearly level, and there was no particular microrelief to deal with in most instances. The exceptions were found in fields where row crops (sorghums) had been planted. In these cases the samples were taken between the rows as recommended by Wadleigh and Fireman (15) and the United States Salinity Laboratory staff (14, p. 41). This was done in order to give the profile on which to study salinity as it affects crop growth.

PROCEDURE

Immediately upon arrival at the laboratory the samples were placed on sheets of brown wrapping paper and allowed to air dry. The sands were sieved through a number 18 sieve and replaced in the ice cream cartons.[3] The finer textured soils were ground in a Braun Pulverizer, and also replaced in the ice cream cartons for storage.

EXTRACTIONS

The soils were extracted for water soluble cations and anions and for extractable cations. For the water soluble extract a saturation paste was prepared according to the method described by the United States Salinity Laboratory staff (14 p. 34) (method 2). Five hundred grams of

[3]These samples were lost when the east wing of Waters Hall, Kansas State College, burned, August 25, 1957.

soil were used. The saturation percentage was determined from the amount of water needed to bring the air dry soil to saturation. In mixing up the soil paste, care had to be taken to get each soil at the saturation point. By using the above mentioned criteria (14), reproducable results could be obtained between samples and among workers. However, on the sandier soils there was a tendency to use too much water while on the fine clay soils the tendency was to use too little water. A Beckman pH meter with a glass electrode assembly was used to determine the pH of the soil paste. The saturation paste was allowed to stand for 4 to 16 hours in a Buchner funnel (14, p. 88, method 3a) so that the gypsum might reach equilibrium. During this time the Buchner funnel was covered with a paper towel saturated with water, to prevent evaporation. Suction was then applied with a vacuum pump, and as much extract obtained as possible. This extract was transferred to 125 ml. Erlenmeyer flasks for storage in a refrigerator.

Extractable cations were obtained by shaking 10 g. of soil and 50 ml. of neutral 1 N ammonium acetate together in a 125 ml. Erlenmeyer flask. The mixture was shaken for 10 minutes on a Burrell model DP wrist action mechanical shaker. The extract was then filtered and stored in the refrigerator in 125 ml. Erlenmeyer flasks.

METHODS OF ANALYSES

The electrical conductivity of the saturation extract (referred to hereafter as conductivity) was obtained on an Industrial Instruments, model RC - BC, conductivity bridge with a pipette type conductivity cell. The water soluble cations were determined on a Beckman model DU flame photometer with a No. 4300 photomultiplier attachment. The settings used are listed in Table 2. Determinations were run on 35 to 40 samples at a time. The concentrations used for standards in determining the standard curves are listed in Table 3. New graphs were drawn for each set of samples.

Table 2. Instrument settings on the Backman flame photometer used in determining water soluble and extractable cations.

Element	Wave length (mu.)	resistor	multiplier	slit width (mm.)	zero suppression	oxygen (psi)	acetylene (psi)
K	768	3	3	0.10	0 or 1	10	4
Ca	554	2	2	0.14	0	10	4
Mg	285.5	2	4	0.08	0	10	4
Na	589	2	1	0.09	0	10	4

Table 3. Concentrations of standards used on the Beckman flame photometer in determining water soluble and extractable cations.

Element	Concentrations of standards in ppm.					
K	25	20	15	10	5	0
Ca	100	80	60	40	20	0
Mg	50	40	30	20	10	0
Na	10	8	6	4	2	0

The water soluble anions were determined on the same saturation extract. The following procedures were used as listed by the United States Salinity Laboratory staff (14). The carbonate and bicarbonate ions were determined titrimetrically using standardized sulfuric acid (14, p. 98, method 12). The chloride ion was determined by titration using standardized silver nitrate with potassium chromate as the indicator (14, p. 98, method 13). The sulfate ion was precipitated as gypsum and determined by electrical conductivity (14, p. 99, method 14b) on an Industrial Instruments Conductivity Bridge, Model RC 16 B1. A water bath was used to maintain the temperature of solutions at 25° C.

The extractable cations were determined on the Beckman Model DU flame photometer on 35 to 40 samples at a time just as the water soluble cations were. Instrument settings and concentrations of standards (Tables 2 and 3, respectively) were identical with those used for the water soluble cations. The only difference was that the standards for the extractable cations were made up in neutral 1 N ammonium acetate.

Exchangeable cations were determined by subtracting the water soluble cations from the extractable cations. The exchange capacity was obtained by adding the quantities of the four exchangeable cations together. All water soluble and exchangeable ions were reported as milliequivalents per 100 g. soil. The exchangeable sodium percentage (ESP) was then obtained by dividing the cation exchange capacity into the exchangeable sodium and multiplying by 100.

INTERPRETATION OF ANALYSES

Growth deficiencies of grain crops in the area studied would be anticipated with extract conductivity readings of about six millimhos per cm. (14). Values of 10 millimhos per cm. or higher would be considered too high for growth of these crops. Alfalfa had about the same range of tolerance except that the above mentioned conductivity values should be placed at 4 and 12 millimhos per cm., respectively.

The exchangeable sodium in the soil may be injurious to the land.

This is due usually to the adverse physical condition (dispersion) imposed when the exchangeable sodium percentage reaches a level of 10 to 15 percent. The former figure is used as the danger point by the Kansas State Soil Testing Laboratory, while the United States Salinity Laboratory uses the latter value.

RESULTS AND DISCUSSION

The pH measurement proved to be of no value in determining the salinity or alkalinity of the soil. Invaribly the values were between 7.4 and 8.0, being more concentrated near the middle of that range. There was no discernable trend found from one site to another, or with depth within a single profile. This was likely due to the high amount of salts in the profile.

The 27 sites sampled were divided into 11 comparisons. The following discussion deals with each comparison separately.

Richfield, Ulysses, Colby Soil Association

The soils for the first comparison, listed A (Tables 4 and 5), were taken on the level uplands northwest of Lakin. All irrigation in this area had been from deep wells as the water table was from 150 to 200 feet below the land surface. The soil, a loess deposit of the Richfield, Ulysses, Colby soil association varied little from one location to another. Irrigation in this area was only in its infant stages, and much of the land was still in the process of being leveled. Very few, if any, wells had been in operation more than five years. For these reasons only one comparison study was made for the entire area. Soil

Table 4. Effect of irrigation on saturation percentage, conductivity, and exchangeable cations on the Richfield, Ulysses, Colby soil association.

Depth	Saturation percent	Conductivity E.C. X 10^3	Exchangeable cations - me./100 g. soil K	Ca	Mg	Na	Exchange capacity me./100 g. soil	Exch. Na percent
A - 1: SE¼, SW¼, Sec. 34; T 23; R 37.							Irrigation: 1 year	
0 - 6	35.2	0.96	1.75	11.35	2.73	0.11	16.95	0.66
6 - 12	42.8	0.70	0.86	13.89	4.28	0.07	19.10	0.35
12 - 18	46.2	0.61	1.05	22.80	6.42	0.34	29.89	1.14
18 - 24	45.6	0.50	0.85	20.87	13.05	0.18	34.95	0.52
24 - 30	49.6	0.89	0.91	18.09	7.16	0.21	26.37	0.80
30 - 36	47.2	1.21	1.42	21.42	6.67	0.37	29.88	1.24
36 - 42	42.0	1.13	1.55	22.47	16.52	0.65	41.39	1.57
42 - 48	41.0	1.39	1.72	20.80	13.72	0.76	37.00	2.06
48 - 54	40.1	1.26	1.76	23.60	15.80	0.92	42.08	2.19
54 - 60	45.2	2.29	1.50	15.33	7.11	4.42	28.36	15.37
A - 2: SW¼, SW¼, Sec. 35; T 23; R 37.							Irrigation: none	
0 - 6		0.90	1.29	14.04	7.47	0.08	22.88	0.35
6 - 12	44.0	0.63	0.92	15.24	4.11	0.07	20.34	0.34
12 - 18	46.3	0.52	1.06	13.98	5.46	0.01	20.61	0.05
18 - 24	50.4	0.71	1.09	20.02	6.82	0.06	27.99	0.21
24 - 30	52.0	0.98	1.29	17.60	6.49	0.41	25.79	1.59
30 - 36	59.2	0.82	1.24	18.86	6.64	0.37	27.11	1.36
36 - 42	47.4	0.80	1.46	17.70	7.42	0.52	27.10	1.92
42 - 48	41.6	0.56	1.61	22.55	5.90	0.69	30.75	2.25
48 - 54	41.8	0.68	1.78	21.35	6.03	0.32	29.48	1.08
54 - 60	42.0	0.63	1.77	21.06	6.45	0.98	30.26	3.24

Table 5. Effect of irrigation on water soluble ions on the Richfield, Ulysses, Colby soil association.

Depth	Water soluble ions - me./100 g. soil									
	Cations					Anions				
	K	Ca	Mg	Na	Total	CO_3	HCO_3	Cl	SO_4	Total
A - 1: SE¼, SE¼, Sec. 34; T 32-W; R 37-W.							Irrigation: 1 year			
0 - 6	0.06	0.15	0.07	0.02	0.30		0.17	0.02	0.07	0.26
6 - 12	0.02	0.16	0.07	0.03	0.27		0.19	0.04	0.04	0.27
12 - 18	0.01	0.25	0.06	0.02	0.35		0.17	0.03	0.09	0.28
18 - 24	0.01	0.23	0.05	0.01	0.30		0.13	0.02	0.01	0.15
24 - 30	0.03	0.19	0.10	0.08	0.40		0.18	0.04	0.01	0.23
30 - 36	0.03	0.23	0.09	0.11	0.46	0.02	0.13	0.08	0.03	0.24
36 - 42	0.03	0.23	0.09	0.17	0.52		0.25	0.06	0.04	0.35
42 - 48	0.04	0.21	0.10	0.18	0.52					
48 - 54	0.03	0.20	0.06	0.16	0.45		0.08	0.10	0.19	0.37
54 - 60	0.04	0.17	0.15	0.88	1.24		0.54	0.09	0.20	0.82
A - 2: SW¼, SW¼, Sec. 35; T 23-S; R 37-W.							Irrigation: none			
0 - 6										
6 - 12	0.02	0.16	0.09	0.02	0.29		0.23	0.02	0.09	0.34
12 - 18	0.01	0.22	0.06	0.07	0.36		0.15	0.02	0.08	0.25
18 - 24	0.02	0.18	0.10	0.04	0.34		0.15	0.02	0.03	0.20
24 - 30	0.04	0.20	0.14	0.05	0.43		0.19	0.03	0.06	0.28
30 - 36	0.04	0.18	0.11	0.06	0.40		0.16	0.05	0.03	0.25
36 - 42	0.04	0.10	0.08	0.13	0.34		0.22	0.04	0.01	0.38
42 - 48	0.02	0.15	0.03	0.13	0.33		0.52	0.02	0.01	0.65
48 - 54	0.01	0.14	0.04	0.16	0.35	0.01	0.18	0.01	0.09	0.28
54 - 60	0.02	0.09	0.03	0.18	0.32		0.26	0.01	0.07	0.33

samples were taken from profiles in two fields, one of which had been irrigated for one year, while the other had not been irrigated. Both fields had been cultivated for about 15 years, and both were fallow at the time of sampling. The analyses seemed to indicate that the two sites were essentially duplicates. There was a slight increase in the conductivity and concentration of total water soluble ions in the irrigated soil, A - 1, over the non-irrigated soil, A - 2. This trend should be checked if a similar study is run in the future. The analyses indicated that the effects of salinity on crop growth would be almost negligible on these soils (14, p. 9).

Ulysses, Colby Soil Association

The soils for comparison B (Tables 6 and 7) were taken north of Deerfield on the Ulysses, Colby soil association. These samples represented both the soils and the effects of irrigation on the soils of this area very well. Site B - 1 was located on a field which had been irrigated for 50 years using ditch water. The principal crops grown recently were milo, wheat, and barley. Alfalfa had been grown in the past. The field was fallow when sampled. Site B - 2, which had never been cultivated, was located nearby in a former churchyard. There was a noticeable increase in the conductivity and concentration of total water soluble ions in the irrigated soil below the 18 inch level. This was apparently caused by an increase in the concentration of water soluble calcium, magnesium, and sodium cations, and the water soluble sulfate anion. This suggested that the sulfate salts were being washed out of the surface and being accumulated in the lower part of the profile. There was

Table 6. Effect of irrigation on saturation percentage, conductivity, and exchangeable cations on the Ulysses, Colby soil association.

Depth	Saturation percent	Conductivity E.C. X 10^3	Exchangeable cations - me./100 g. soil K	Ca	Mg	Na	Exchange capacity me./100 g. soil	Exch. Na percent
B - 1: SE¼, SE¼, Sec. 2; T 24-S; R 35-W.						Irrigation: 40 to 50 years		
0 - 6	41.5	0.85	1.09	16.80	3.63	0.56	22.08	2.54
6 - 12	41.0	1.04	0.96	18.45	6.67	0.92	27.00	3.41
12 - 18	44.2	1.45	0.74	16.43	5.00	0.77	22.94	3.36
18 - 24	42.9	3.13	0.84	16.50	5.40	0.69	23.43	2.94
24 - 30	37.2	2.83	1.12	19.40	4.74	0.99	26.25	3.77
30 - 36	40.0	2.92	0.90	17.30	2.61	0.62	21.43	2.89
36 - 42	34.8	4.05	1.42	18.30	4.32	1.04	25.08	4.15
42 - 48	36.0	4.92	1.11	16.71	4.08	0.92	22.82	4.03
48 - 54	36.0	5.03	1.64	18.66	4.98	2.44	27.72	8.81
B - 2: NW¼, NW¼, Sec. 11; T 24-S; R 35-W.						Irrigation: none		
0 - 6	41.5	0.97	1.71	16.72	0.55	0.30	19.28	1.56
6 - 12	40.7	0.95	1.26	20.77	2.78	0.13	24.94	0.52
12 - 18	41.0	0.76	0.72	24.70	3.67	0.10	29.19	0.34
18 - 24	45.2	0.81	0.66	19.31	1.17	0.08	21.22	0.38
24 - 30	38.0	0.66	0.90	17.47	2.66	0.07	21.10	0.33
30 - 36	37.8	1.33	1.24	20.14	7.38	0.26	29.02	0.90
36 - 42	38.0	0.52	1.74	19.25	9.54	0.18	30.71	0.59
42 - 48	46.4	0.95	1.78	18.36	6.48	0.70	27.32	2.56
48 - 54	39.2	0.90	2.03	18.79	5.60	0.75	27.17	2.98
54 - 60	35.0	1.32	1.96	17.85	9.62	1.14	30.57	3.83

Table 7. Effect of irrigation on water soluble ions on the Ulysses, Colby soil association.

Depth	K	Ca	Mg	Na	Total	CO_3	HCO_3	Cl	SO_4	Total
	Water soluble ions - me./100 g. soil									
	Cations					Anions				
B - 1: SE¼, SE¼, Sec.						Irrigation: 40 to 50 years				
0 - 6	0.02	0.10	0.06	0.14	0.32		0.19	0.09	0.06	0.34
6 - 12	0.02	0.10	0.28	0.26	0.66		0.16	0.07	0.49	0.73
12 - 18	0.02	0.29	0.10	0.28	0.69					
18 - 24	0.05	0.60	0.15	0.67	1.47		0.12	0.22	1.29	1.63
24 - 30	0.03	0.50	0.43	0.46	1.42		0.11	0.03	1.33	1.47
30 - 36	0.04	0.60	0.24	0.45	1.33		0.08	0.03	1.67	1.78
36 - 42	0.04	0.82	0.68	0.53	2.07		0.19	0.04	2.01	2.25
42 - 48	0.07	0.71	0.42	0.72	1.92		0.10	0.10	2.17	2.36
48 - 54	0.08	0.59	0.42	0.86	1.96					
B - 2: NW¼, NW¼, Sec.						Irrigation: none				
0 - 6	0.06	0.40	0.28	0.04	0.78		0.21	0.01	0.15	0.37
6 - 12	0.03	0.33	0.05	0.05	0.46		0.15	0.01	0.31	0.47
12 - 18	0.01	0.30	0.06	0.03	0.40	0.01	0.11	0.02	0.03	0.16
18 - 24	0.02	0.24	0.45	0.02	0.73		0.16	0.08	0.06	0.30
24 - 30	0.02	0.13	0.38	0.02	0.55		0.13	0.07	0.04	0.23
30 - 36	0.04	0.34	0.08	0.06	0.53		0.08	0.14	0.31	0.54
36 - 42	0.03	0.15	0.05	0.04	0.27		0.14	0.03	0.10	0.27
42 - 48	0.06	0.12	0.21	0.12	0.50		0.10	0.24	0.10	0.44
48 - 54	0.03	0.16	0.06	0.16	0.46	0.01	0.18	0.02	0.18	0.39
54 - 60	0.05	0.15	0.05	0.21	0.45		0.10	0.04	0.38	0.51

a higher exchangeable sodium percentage (ESP) throughout the profile of site B - 1 than in site A - 2. The exchangeable potassium and calcium apparently had not been altered by irrigation. The slight accumulation of salt in this comparison was not enough to make the land harmful for crop growth.

In this area, one extra soil, site B - p (Table 8) was sampled because it was known to have been a problem soil. It should be emphasized that this soil was not typical of the area. It was located within 500 yards of the east shore of Lake McKinney. The lake was retained by a dyke so that the water level was often higher than the surrounding land. This caused the water table to rise, bringing salts to the surface. Although it was not evident at the time of sampling, the landowner stated that on occasions in the past a white crust had covered the land surface. The land was to be returned to cultivation in the fall of 1957, after lying fallow for a few years. As shown in Table 8, the soil was quite saline. The conductivity readings ranged from 5 to 10 millimhos per cm., the peak being in the second foot depth. These readings were caused by water soluble ion concentrations as high as 4.5 me. per 100 g. soil. The cations were distributed among calcium, magnesium, and sodium, with the latter usually in highest concentration. The chloride:sulfate ratio below the first foot was slightly less than 1:2 which was as high as found in any of the sites sampled for the study. The ESP was 10 or above in the top three feet and up to 14 in the surface six inches. Both the conductivity and the ESP values indicated the land would grow only salt tolerant plants. The landowner's experience proved the tests to be reliable in this case. No particular signs of dispersion were noticed

Table 8. Effect of irrigation on salt content and other chemical properties on a problem soil in the Ulysses, Colby soil association.

Depth	Saturation percent	Conductivity E.C. X 10^3	Exchangeable cations - me./100 g. soil K	Ca	Mg	Na	Exchange capacity me./100 g. soil	Exch. Na percent
B - p: SW¼, NE¼, Sec. 5; T 24-S; R 35-W.						Irrigation: 40 to 50 years		
0 - 6	42.2	6.60	1.81	18.61	6.19	4.34	30.95	14.05
6 - 12	43.8	6.06	1.49	17.98	6.08	3.51	29.06	12.10
12 - 18	42.2	10.24	1.20	17.17	6.62	3.73	2[illegible].72	13.00
18 - 24	43.4	7.88	0.76	20.55	9.74	4.15	35.20	11.80
24 - 30	40.6	8.28	0.72	17.19	5.87	2.67	26.45	10.09
30 - 36	41.8	7.47	1.00	17.45	4.93	2.68	26.06	10.28
36 - 42	36.0	5.84	1.24	20.39	5.99	2.40	30.02	7.78
42 - 48	39.0	6.62	1.13	17.63	4.60	3.77	27.33	13.81
48 - 54	36.7	4.70	1.34	25.13	6.99	1.91	35.37	5.39
54 - 60	36.2	5.12	1.28	15.03	9.32	1.99	27.62	7.22

Depth	Water soluble ion - me./100 g. soil Cations K	Ca	Mg	Na	Total	Anions CO_3	HCO_3	Cl	SO_4	Total
B - p: SW¼, SW¼, Sec. 5; T 24-S; R 35-W.								Irrigation: 40 to 50 years		
0 - 6	0.08	0.89	0.70	1.65	3.32	0.01	0.15	0.26	2.67	3.09
6 - 12	0.06	0.94	0.73	3.09	4.82		0.15	0.93	3.34	4.42
12 - 18	0.06	1.23	1.17	2.86	5.33		0.29	1.42	2.69	4.40
18 - 24	0.04	1.10	0.67	1.193	3.74		0.09	1.36	2.43	3.88
24 - 30	0.03	1.21	1.18	1.76	4.19		0.09	1.20	2.27	3.56
30 - 36	0.06	1.00	0.84	1.46	3.46		0.09	1.02	2.50	3.61
36 - 42	0.05	0.71	0.48	1.08	2.32		0.08	0.65	2.00	2.73
42 - 48	0.07	0.87	0.70	1.31	2.89		0.10	0.56	2.65	3.32
48 - 54	0.05	0.62	0.39	0.87	1.92		0.06	0.41	2.04	2.51
54 - 60	0.05	0.77	0.64	0.89	2.36		0.08	0.25	1.89	2.22

at the time of sampling, however, the land was fairly dry, but not dry enough to crack.

Valley Alluvium Area

The remaining comparisons were taken from the valley alluvium as this was where most of the long time irrigation was found. These soils were quite variable so a number of comparisons were obtained. Samples within a comparison were taken as close together as possible to eliminate differences in soil.

Comparison C (Tables 9 and 10) included soils from three sites: one of long time irrigation (C - 1), one which had been haphazardly irrigated for a number of years (C - 2), and a dryland field (C - 3). The first site was in sorghum at the time of sampling, while the last two were fallow. The field in which site (C - 1) was located was one of the first pieces of land in the area to be put under irrigation about 75 years ago. For the first fifty years the land was watered entirely from the ditch. About 25 years ago a shallow well was added as a supplementary water source. The site (C - 2) land had been irrigated haphazardly for the last 40 to 50 years by both ditch and shallow well. The land had not been leveled for irrigation, although it was naturally well adapted. The land of site (C - 3) had been cultivated for 12 to 15 years but had not been irrigated. It, too, was naturally level and was soon to be put under irrigation. The values of the saturation percentages showed that the soils were of similar texture. The soil of the long time irrigated site (C - 1) showed a salt accumulation compared to the dryland soil (C - 3) below the surface six inches. The sample from site (C - 2) showed a similar increase in salts below the

Table 9. Effect of irrigation on saturation percentage, conductivity, and exchangeable cations of the Valley alluvium, Comparison C.

Depth	Saturation percent	Conductivity E.C. X 10^3	Exchangeable cations - me./100 g. soil: K	Ca	Mg	Na	Exchange capacity me./100 g. soil	Exch. Na percent
C - 1: NW¼, NE¼, Sec. 22; T 24-S; R 35-W.						Irrigation: 75 years		
0 - 6	41.4	1.67	1.10	19.75	5.23	1.20	27.28	4.40
6 - 12	42.4	4.16	0.72	18.79	4.77	0.71	24.99	2.84
12 - 18	41.4	2.51	0.44	17.44	4.77	0.88	23.64	3.72
18 - 24	39.0	3.99	0.63	17.54	5.00	0.77	23.94	3.22
24 - 30	32.0	4.26	0.47	53.79	0.95	0.54	55.75	0.96
30 - 36	29.6	4.48	0.46	33.81	0.83	0.53	35.63	1.49
36 - 42	30.6	4.32	0.55	44.32	0.72	1.02	46.61	2.19
42 - 48	33.6	4.70	0.27	22.25	1.22	0.58	24.32	2.39
48 - 54	35.6	4.83	0.29	17.84	2.40	0.48	21.01	2.28
54 - 60	41.8	5.27	0.43	17.34	4.27	0.53	22.47	2.36
C - 2: NW¼, NE¼, Sec. 27; T 24-S; R 35-W.						Irrigation: 40 to 50 years		
0 - 6	36.7	0.78	1.00	15.59	4.18	0.62	21.39	2.90
6 - 12	36.4	1.17	0.66	15.02	3.44	0.55	19.67	2.80
12 - 18	37.7	1.80	0.68	14.75	4.60	0.74	21.56	3.44
18 - 24	38.8	3.57	0.51	13.54	3.62	0.54	18.21	2.96
24 - 30	31.6	4.29	0.31	56.30	1.07	0.42	58.10	0.72
30 - 36	32.4	4.62	0.29	54.00	1.01	0.31	55.61	0.56
36 - 42	30.1	4.16	0.70	21.77	0.74	0.52	24.73	2.10
42 - 48	40.6	[illegible]	0.44	48.47	2.02	0.85	51.78	1.64
48 - 54	36.0	4.34	0.33	39.77	2.42	0.67	43.19	1.55
54 - 60	43.3	[illegible]	0.58	24.11	1.44	0.94	27.07	3.47
C - 3: NW¼, NW¼, Sec. 26; T 24-S; R 35-W.						Irrigation: none		
0 - 6	43.2	[illegible]	1.45	20.39	5.46	0.71	28.01	2.54
6 - 12	47.0	1.16	1.12	22.64	5.94	1.21	30.91	3.92
12 - 18	47.2	1.36	1.10	22.64	3.60	1.03	28.37	3.64
18 - 24	41.0	1.91	0.59	21.36	4.14	1.07	27.16	3.94
24 - 30	45.4	2.01	0.44	17.66	5.37	0.87	24.34	3.57
30 - 36	34.2	2.68	0.29	17.68	3.59	0.64	23.10	2.90
36 - 42	33.3	2.86	0.24	16.81	4.06	0.88	21.99	4.00
42 - 48	26.1	2.66	0.14	14.94	1.73	0.65	17.46	3.72

Table 10. Effect of irrigation on water soluble ions of the Valley alluvium, Comparison C.

Depth	Water soluble ions - me./100 g. soil									
	Cations					Anions				
	K	Ca	Mg	Na	Total	CO_3	HCO_3	Cl	SO_4	Total
C - 1: SW¼, SE¼, Sec. 22; T 24-S; R 35-W. Irrigation: 75 years										
0 - 6	0.03	0.15	0.17	0.27	0.62	0.01	0.19	0.02	0.22	0.43
6 - 12	0.04	0.96	0.40	0.57	1.97		0.16	0.03	2.18	2.37
12 - 18	0.02	0.46	0.14	0.46	1.07		0.20	0.04	0.93	1.17
18 - 24	0.03	0.70	0.30	0.53	1.57		0.11	0.05	1.89	2.05
24 - 30	0.03	0.71	0.45	0.48	1.66		0.05	0.04	1.56	1.63
30 - 36	0.03	0.69	0.40	0.49	1.62		0.05	0.04	0.69	0.78
36 - 42	0.02	0.68	0.34	0.57	1.61		0.09	0.10	1.70	1.88
42 - 48	0.03	0.75	0.51	0.62	1.91		0.10	0.14	1.60	1.84
48 - 54	0.03	0.81	0.57	0.66	2.07		0.09	0.09	2.03	2.21
54 - 60	0.04	0.96	0.43	1.15	2.59		0.09	0.39	2.32	2.79
C - 2: NW¼, NE¼, Sec. 27; T 24-S; R 35-W. Irrigation: 40 to 50 years										
0 - 6	0.02	[illegible]	[illegible]	0.13	1.01		0.21	0.03	0.06	0.29
6 - 12	0.02	0.18	0.06	0.21	0.47		0.23	0.02	0.08	0.32
12 - 18	0.02	0.26	0.04	0.11	0.43		0.14	0.04	0.65	0.82
18 - 24	0.02	0.56	0.58	0.57	1.73				0.95	
24 - 30	0.02	0.70	0.40	0.60	1.72		0.07	0.05	1.77	1.89
30 - 36	0.02	0.80	0.40	0.71	1.93		0.10	0.12	1.82	2.04
36 - 42	0.02	0.63	0.30	0.49	1.44		0.06	0.18	1.51	1.75
42 - 48	0.04	0.87	0.36	0.89	2.15		0.16	0.09	2.24	2.49
48 - 54	0.02	0.73	0.74	0.74	2.23				1.79	
54 - 60	0.03	0.89	0.41	0.86	2.20		0.09	0.22	2.25	2.56
C - 3: NW¼, NW¼, Sec. 26; T 24-S; R 35-W. Irrigation: none										
0 - 6	0.03	0.18	[illegible]	0.17	0.38	0.01	0.17	0.10	0.07	0.36
6 - 12	0.03	0.11	0.06	0.29	0.49	0.02	0.29	0.04	0.08	0.42
12 - 18	0.01	0.26	0.07	0.34	0.68	0.01	0.16	0.03	0.44	0.64
18 - 24	0.01	0.29	0.05	0.42	0.76	0.02	0.11	0.04	0.65	0.82
24 - 30	0.01	0.39	0.09	0.50	0.99	0.02	0.09	0.12	0.82	1.06
30 - 36	0.01	0.47	0.10	0.43	1.00		0.05	0.03	0.29	0.37
36 - 42	0.01	0.49	0.12	0.17	0.78		0.07	0.03	1.23	1.32
42 - 48	0.01	0.39	0.17	0.24	0.81	0.01	0.07	0.02	0.78	0.88

18 inch level. In both cases the increase seemed to be due to higher concentrations of water soluble calcium, magnesium, and sulfate ions. The two irrigated sites differed in that the long time irrigated soil, (C - 1), had higher concentrations of these same ions in the surface 18 inches. Irrigation apparently increased the exchange capacity of the soil below the two-foot depth. This may have resulted from the irrigation water causing a downward movement of clay. However, an increase in clay content was not indicated by the saturation percentages. Exchangeable calcium increased below the two-foot depth, whereas exchangeable magnesium decreased. This suggested that the irrigation waters were high in calcium.

Comparison D (Tables 11 and 12) consisted of soils from two sites, one that had been irrigated for 75 years (D - 1) and was in alfalfa when sampled, the other which had been irrigated for 7 to 8 years and was fallow when sampled. The latter had been irrigated by ditch and shallow well during the last seven to eight years as had the former for the past 25 years. Prior to that time the site (D - 1) soil was irrigated only by ditch. Site (D - 2) was located at the lower end of an irrigated run where the water tended to collect and stan . This comparison showed a definite accumulation of salt with irrigation. This accumulation was more pronounced in the subsoil. The conductivity was slightly increased in the surface but it was doubled in the subsoil under the long time irrigation. The conductivity after 75 years of irrigation had reached values of 6 to 7 millimhos per cm. at a depth of 2 to 4 feet. The surface reading of 3.4 millimhos per cm. was high enough to be of moderate concern. The concentrations of water soluble cations except potassium

Table 11. Effect of irrigation on saturation percentage, conductivity, and exchangeable cations of the Arkansas Valley alluvium, Comparison D.

Depth	Saturation percent	Conductivity E.C. X 10^3	Exchangeable cations-me./100 g. soil K	Ca	Mg	Na	Exchange capacity me./100g. soil	Exch. Na percent
D - 1: SW¼, SW¼, Sec. 22; t 24-S; R 35-W.						Irrigation: 75 years		
0 - 6	50.9	3.44	1.10	18.20	6.54	1.29	27.13	4.76
6 - 12	49.0	4.23	1.09	23.07	9.83	1.70	35.69	4.77
12 - 18	52.6	4.62	0.84	18.56	6.25	4.66	30.31	15.40
18 - 24	52.7	5.41	0.70	18.76	6.36	3.47	29.29	11.85
24 - 30	52.0	6.60	0.76	24.16	7.74	3.03	35.69	8.50
30 - 36	64.0	7.61	0.92	23.62	7.70	2.02	34.26	5.90
36 - 42	57.6	6.15	0.87	63.00	6.72	3.61	73.20	4.93
42 - 48	60.0	7.33	0.96	48.43	6.15	4.30	59.84	7.39
48 - 54	56.4	5.68	0.84	43.04	6.31	6.83	57.02	11.95
54 - 60	52.0	5.02	0.79	44.62	6.59	1.87	53.87	3.47
D - 2: SW¼, SW¼, Sec. 22; T 24-S; R 35-W.						Irrigation: 7 to 8 years		
0 - 6	32.0	2.74	1.27	21.89	7.22	1.47	31.85	4.61
6 - 12	56.7	2.90	1.07	16.80	5.62	1.10	24.59	4.47
12 - 18	50.0	3.08	0.92	15.89	5.37	0.94	23.12	4.06
18 - 24	48.2	2.47	1.00	18.38	5.02	1.06	25.46	4.16
24 - 30	55.0	3.28	1.31	18.95	7.43	1.05	28.74	3.79
30 - 36	60.4	3.06	1.01	16.66	6.68	1.34	25.69	5.22
36 - 42	55.0	3.07	0.96	16.29	6.97	1.28	25.50	5.02
42 - 48	52.8	2.76	1.02	17.07	5.62	1.36	25.07	5.42

Table 12. Effect of irrigation on water soluble ions of the Arkansas Valley alluvium, Comparison D.

Depth	Water soluble ions - me./100 g. soil									
	Cations					Anions				
	K	Ca	Mg	Na	Total	CO_3	HCO_3	Cl	SO_4	Total
D - 1: SW¼, SW¼, Sec. 22; T 24-S; R 35-W.							Irrigation: 75 years			
0 - 6	0.03	0.80	0.33	0.87	2.04		0.22	0.11	2.07	2.41
6 - 12	0.02	0.93	0.50	0.86	2.32		0.19	0.06	2.65	2.90
12 - 18	0.03	1.04	0.55	1.34	2.96		0.13	0.13	3.11	3.37
18 - 24	0.03	1.04	0.40	1.33	3.30		0.19	0.24	3.79	4.22
24 - 30	0.03	0.74	0.46	2.20	3.43		0.12	0.37	4.22	4.71
30 - 36	0.04	1.12	1.20	6.08	8.44		0.16	0.91	5.24	6.31
36 - 42	0.04	0.98	0.66	2.14	3.81		0.13	0.92	3.36	4.41
42 - 48	0.06	1.37	1.10	4.95	7.48		0.19	1.06	4.92	6.17
48 - 54	0.06	1.06	1.07	1.97	4.16		0.11	0.44	3.89	4.44
54 - 60	0.03	0.88	0.94	1.36	3.21		0.12	0.19	3.33	3.64
D - 2: SW¼, SW¼, Sec. 22; T 24-S; R 35-W.							Irrigation: 7 to 8 years			
0 - 6	0.02	0.36	0.28	0.39	1.06		0.18	0.07	0.89	1.14
6 - 12	0.05	0.61	0.28	0.76	1.71		0.40	0.12	1.42	1.94
12 - 18	0.04	0.62	0.36	0.82	1.83		0.20	0.14	1.44	1.78
18 - 24	0.03	0.50	0.16	0.75	1.45	0.03	0.10	0.08	1.04	1.21
24 - 30	0.04	0.64	0.97	0.85	2.50		0.17	0.06	1.94	2.17
30 - 36	0.04	0.71	0.39	0.86	2.01		0.13	0.13	1.91	2.17
36 - 42	0.03	0.61	0.31	0.81	1.76		0.14	0.13	1.66	1.93
42 - 48	0.04	0.55	0.33	0.64	1.56		0.13	0.12	1.46	1.71

increased with irrigation. Water soluble sodium increased the most. Sulfate was the only anion which showed an increased concentration. The analyses of the soil from site (D - 1) also showed an appreciable increase in exchangeable sodium between a depth of 12 and 30 inches, even to the point of being excessive for good crop growth. Like the irrigated soil in comparison C, this irrigated soil also showed increased exchange capacity in the subsoil, probably due to the translocation downward of fine material. However, in this case the exchangeable magnesium did not decrease as noted previously. The accumulation of salt in the irrigated subsoil indicated that if enough water was applied, the profile might be leached to a point of uniform salinity throughout.

The sites selected for comparison E (Tables 13 and 14) introduced a new situation. The land of site (E - 1) had been irrigated for about 40 years using ditch water but with a deep well as a supplementary source. Site (E - 2) was located on land which had been irrigated for 7 to 8 years using water from ditch and shallow well. Both sites were fallow at the time of sampling. The analyses showed that the soils of both sites were similar. This meant that irrigation had not affected the salt accumulation, or that all of the alteration was accomplished during the first seven to eight years. It should be noted that the concentrations of the water soluble calcium and magnesium ions were lower in the long time irrigation than in the short, while the concentration of sodium ion was higher. This indicated that the irrigation water used on the long time irrigation was high in sodium ions. The sample from site (E - 2) was taken at the upper end of the same field in which site (D - 2) was located. Examination of the two analyses showed them to be quite similar,

Table 13. Effect of irrigation on saturation percentage, conductivity, and exchangeable cations of the Arkansas Valley alluvium, Comparison E.

Depth	Saturation percent	Conductivity E.C. X 10^3	Exchangeable cations - me./100 g. soil K	Ca	Mg	Na	Exchange capacity me./100 g. soil	Exch. Na percent
E - 1: NE¼, NE¼, Sec. 28; T 24-S; R 35-W.						Irrigation: 40 years		
0 - 6	49.2	2.26	1.03	21.61	7.78	3.02	33.44	9.03
6 - 12	36.3	2.64	0.71	16.33	5.91	1.22	24.17	5.06
12 - 18	34.5	3.94	0.70	16.11	4.80	0.77	22.38	3.44
18 - 24	31.3	3.56	0.52	13.99	3.62	0.56	18.69	3.00
24 - 30	27.2	4.22	0.47	13.34	3.58	0.24	17.63	1.36
30 - 36	25.6	3.30	0.32	12.16	3.04	0.34	15.86	4.15
36 - 42	22.8	2.75	0.27	11.42	2.26	2.26	14.58	4.32
E - 2: SW¼, SW¼, Sec. 22; T 24-S; 35-W.						Irrigation: 7 to 8 years		
0 - 6	46.8	2.07	0.87	20.58	8.31	1.22	30.98	3.94
6 - 12	46.4	3.57	0.84	22.05	5.75	0.70	31.90	2.20
12 - 18	39.5	3.64	0.54	19.91	5.02	0.69	26.16	2.64
18 - 24	39.8	4.12	0.40	19.32	4.16	0.99	24.87	3.98
24 - 30	38.0	4.23	0.50	17.02	4.57	0.66	22.75	2.90
30 - 36	33.3	4.01	0.38	18.54	3.88	0.60	23.40	2.56

Table 14. Effect of irrigation on water soluble ions of the Arkansas Valley alluvium, Comparison E.

Depth	Water soluble ions - me./100 g. soil									
	Cations					Anions				
	K	Ca	Mg	Na	Total	CO_3	HCO_3	Cl	SO_4	Total
E - 1: NE¼, NE¼, Sec. 28; T 24-S; R 35-W.						Irrigation: 40 years				
0 - 6	0.03	0.23	0.22	0.56	1.03	0.03	0.32	0.04	0.94	1.33
6 - 12	0.02	0.27	0.12	0.80	1.22					
12 - 18	0.04	0.45	0.28	1.14	1.91					
18 - 24	0.02	0.36	0.15	0.66	1.18					
24 - 30	0.02	0.36	0.23	0.85	1.46					
30 - 36	0.02	0.29	0.12	0.54	0.96					
36 - 42	0.01	0.26	0.16	0.42	0.84					
E - 2: SW¼, SW¼, Sec. 22; T 24-S; R 35-W						Irrigation: 7 to 8 years				
0 - 6	0.02	0.42	0.19	0.45	1.08		0.23	0.05	0.83	1.11
6 - 12	0.02	1.07	0.15	0.36	1.60		0.13	0.02	2.05	2.20
12 - 18	0.02	1.14	0.33	0.46	1.94		0.15	0.02	1.89	2.06
18 - 24	0.02	0.84	0.44	0.55	1.85		0.11	0.02	2.15	2.28
24 - 30	0.01	0.86	0.35	0.73	1.96				2.22	
30 - 36	0.01	0.73	0.30	0.47	1.52		0.12	0.03	1.71	1.86

with the exception that the ESP values were slightly higher in part of the D - 2 profile. This may have been due to the fact that the water tended to stand on the area where site D - 2 was located, as mentioned previously.

Comparison F (Tables 15 and 16) included two principal sites and two problem sites. The soil of site F - 1 had been irrigated for 75 years with ditch and deep well water, while that of site F - 2 had been irrigated for 40 years with ditch and shallow well water. Apparently site F - 2 had not been irrigated as intensively as site F - 1. So much silty ditch water had been used to irrigate site F - 1 that the field was elevated approximately one foot above the surrounding land. At the time of sampling, the land of site F - 1 was in alfalfa, while that of site F - 2 was fallow. Also included in this comparison were two sites, F - 3 and F - 4, which the farm operator stated were problem areas. They were not being cropped at the time of sampling. This land had the same history as site F - 1. Site F - 3 and F - 4 were not so elevated. However, they were so stony that samples could only be taken to a depth of 18 inches. These soils (sites F - 1, 3 and 4) showed a definite accumulation with the longer time of irrigation. The conductivity and water soluble cation content showed general increases. The sulfate ion was again the increased anion. The principal difference encountered in the problem areas was the increased salinity of the surface six inches of soil. The surface conductivity reading of the site F - 3 soil was 3.7 and the site F - 4 soil 4.0 compared with a reading of 1.6 millimhos per cm. for the site F - 1 soil. The higher value in the site F - 3 soil was due to increases in calcium and sulfate ions, while in the site F - 4

Table 15. Effect of irrigation on saturation percentage, conductivity, and exchangeable cations of Arkansas Valley alluvium, Comparison F.

Depth	Saturation percent	Conductivity μ.S. X 10^3	Exchangeable cations - me./100 g. soil: K	Ca	Mg	Na	Exchange capacity me./100 g. soil	Exch. Na percent
F - 1: SW¼, SW¼, Sec. 28; T 24-S; R 35-W.						Irrigation: 75 years		
0 - 6	48.1	1.64	0.91	17.05	7.42	0.82	26.21	3.13
6 - 12	58.7	4.32	.91	20.18	5.84	1.10	28.03	3.92
12 - 18	50.0	4.24	.66	23.94	6.21	.90	31.71	2.84
18 - 24	34.2	4.97	.41	16.15	3.62	.99	21.17	4.68
24 - 30	32.4	5.13	.35	15.87	4.30	.63	21.15	2.98
30 - 36	35.7	5.27	.42	19.09	4.67	.70	24.88	2.82
36 - 42	37.2	5.71	.40	19.57	5.14	.98	24.37	4.03
42 - 48	34.2	6.04	.29	15.80	5.47	.96	22.52	4.26
48 - 54	29.0	6.45	.23	12.34	4.44	.69	17.70	3.90
54 - 60	24.0		Sample lost in fire					
F - 2: NE¼, NE¼, Sec. 32; T 24-S; R 35-W.						Irrigation: 40 years		
0 - 6	35.0	0.81	1.69	18.36	4.90	0.42	25.37	1.65
6 - 12	30.0	.67	1.21	17.63	1.52	.30	20.16	3.97
12 - 18	27.6	.68	.78	17.60	1.48	.51	20.37	2.50
18 - 24	24.4	.66	.39	15.66	1.05	.43	17.58	2.73
24 - 30	27.0	.87	Sample lost in fire					
30 - 36	23.2	.90	.25	14.63	.89	.51	17.28	2.95
36 - 42	23.0	1.87	Sample lost in fire					
42 - 48	20.9	2.53						
F - 3: NE¼, SW¼, Sec. 28; T. 24-S; R 35-W.						Irrigation: 75 years		
0 - 6	28.3	3.72	0.68	15.17	2.91	0.45	19.21	2.34
6 - 12	36.4	4.29	.35	18.55	2.28	.73	21.91	3.34
12 - 18	24.3	5.31	.29	18.40	3.06	2.81	24.56	12.60
F - 4: NE¼, SW¼, Sec. 28; T 24-S; R 35-W.						Irrigation: 75 years		
0 - 6	48.2	4.04	1.01	20.15	7.43	1.03	29.62	3.48
6 - 12	42.4	4.72	.80	19.87	6.10	2.79	29.26	8.50
12 - 18	30.8	4.76	.49	17.45	4.05	.79	22.78	3.47

Table 16. Effect of irrigation on water soluble ions of Arkansas Valley alluvium, Comparison F.

Depth	Water soluble ions - me./100 g. soil									
	Cations					Anions				
	K	Ca	Mg	Na	Total	CO_3	HCO_3	Cl	SO_4	Total
F - 1: SW¼, SW¼, Sec. 28; T 24-S; R 35-W.							Irrigation: 75 years			
0 - 6	0.03	0.33	0.13	0.36	0.84		0.26	0.05	0.11	0.42
6 - 12	0.04	1.20	1.09	0.94	3.26		0.26	0.05	0.97	3.28
12 - 18	0.02	1.16	1.01	1.02	3.32		0.18	0.08	2.67	2.92
18 - 24	0.02	0.65	0.46	0.78	1.91		0.12	0.16	2.04	2.31
24 - 30	0.02	0.73	0.60	0.67	2.11		0.13	0.07	2.03	2.23
30 - 36	0.02	0.77	0.71	0.90	2.39	0.12	0.13	0.06	2.34	2.60
36 - 42	0.02	0.68	0.76	1.04	2.50		0.11	0.24	2.46	2.80
42 - 48	0.02	0.75	1.38	1.14	3.28		0.08	0.16	2.46	2.70
48 - 54	0.02	0.56	0.88	0.87	2.34		0.09	0.15	2.22	2.46
54 - 60	0.01	0.36	0.69	0.73	1.79		-	-	-	-
F - 2: NE¼, NE¼, Sec. 32; T 24-S; R 35-W.							Irrigation: 40 years			
0 - 6	0.02	1.04	0.14	0.08	1.28		0.21	0.05	0.04	0.30
6 - 12	0.02	0.75	0.10	0.08	0.95		0.16	0.01	0.05	0.22
12 - 18	0.01	0.65	0.09	0.09	0.84		0.12	0.01	0.05	0.18
18 - 24	0.01	0.44	0.09	0.07	0.60		0.12	0.01	0.03	0.16
24 - 30	0.01	0.08	0.02	0.11	0.22	Sample lost in fire.				
30 - 36	0.01	0.07	0.09	0.08	0.24		0.08	0.01	0.07	0.15
36 - 42	0.01	0.32	0.06	0.08	0.47	Sample lost in fire.				
42 - 48	0.01	0.46	0.10	0.08	0.65	Sample lost in fire.				
F - 3: NE¼, SW¼, Sec. 28; T 24-S; R 35-W.							Irrigation: 75 years			
0 - 6	0.03	0.73	0.37	0.24	1.37					
6 - 12	0.02	0.65	0.49	0.75	1.91					
12 - 18	0.01	0.45	0.59	0.88	1.93					
F - 4: NE¼, SW¼, Sec. 28; T 24-S; R 35-W.							Irrigation: 75 years			
0 - 6	0.04	0.02	0.60	0.82	2.49		0.13	0.04	2.26	2.43
6 - 12	0.03	0.81	0.46	1.03	2.32		0.11	0.07	2.33	2.50
12 - 18	0.02	0.80	1.05	0.76	2.63		0.08	0.10	1.69	1.87

soil calcium, sodium and sulfate ions had increased. These conductivity values were high enough that salts might have caused germination difficulties. Below the surface six inches all three soils had conductivity readings from four to five millimhos per cm. However, by the time the seedling roots reach this depth, the plant can usually endure more saline conditions (14, p. 65). The ESP was also higher under the longer irrigation and may have caused part of the problem. Observations led to the belief that part of the difference between the salinity levels of sites F - 1 and F - 2 was due to textural differences. This will be discussed later.

In comparison G (Tables 17 and 18), the land of site G - 1 had been irrigated about 40 years with water from the ditch and deep well. The site G - 2 land had been irrigated about 10 years from the same water sources. Both sites were fallow at the time of sampling. This comparison actually showed no change or even a slight reduction of salt content with time of irrigation. This reduction under long time irrigation was shown by a lower concentration of water soluble calcium, sodium, and sulfate ions below the two foot level. In all other categories the two soils were apparently about the same. Again the major change may have taken place during the first 10 years of irrigation. The salinity and alkalinity levels were not high enough to cause concern.

Comparison H (Tables 19 and 20) included soil from three sites, one of long time irrigation and two of short time irrigation. The soil of site H - 1, which was planted to sorghum at time of sampling, had been irrigated for 50 years using ditch and shallow well water. The soils of sites H - 2 and H - 3 had been broken from sod and irrigated from shallow wells for 5 and 2 years, respectively. The site H - 2 soil was planted

Table 17. Effect of irrigation on saturation percentage, conductivity, and exchangeable cations of Arkansas Valley alluvium, Comparison G.

Depth	Saturation percent	Conductivity E.C. X 10^3	Exchangeable cations - me./100 g. soil K	Ca	Mg	Na	Exchange capacity me./100 g. soil	Exch. Na percent
G - 1: NE¼, SW¼, Sec. 30; T 24-S; R 55-W.							Irrigation: 40 years	
0 - 6	55.2	2.07	1.26	19.95	7.50	0.75	29.54	2.54
6 - 12	48.6	1.96	1.24	21.72	8.84	1.00	32.80	3.06
12 - 18	32.0	2.43	0.49	13.50	2.99	0.50	17.48	2.85
18 - 24	32.0	2.14	0.47	14.33	4.02	0.39	19.21	2.04
24 - 30	30.6	2.42	0.56	15.13	5.19	0.52	21.40	2.43
30 - 36	32.6	2.77	0.51	14.66	3.64	0.49	19.30	2.55
36 - 42	32.0							
G - 2: NW¼, SE¼, Sec. 30; T 24-S; R 35-W.							Irrigation: 10 years	
0 - 6	36.8	1.81	0.95	14.60	4.10	0.68	20.33	3.35
6 - 12	43.0	1.69	1.00	15.20	5.21	0.94	22.35	4.22
12 - 18	56.2	3.65	1.16	18.31	5.31	0.84	25.62	3.28
18 - 24	51.6	1.88	0.82	22.76	5.75	0.97	30.30	3.20
24 - 30	50.0	4.50	0.65	18.12	5.10	0.84	24.71	3.40
30 - 36	45.6	3.54	0.28	29.03	4.53	0.72	34.56	2.08
36 - 42	44.6	5.02	0.62	15.59	4.93	0.98	22.12	4.44
42 - 48	39.4	4.43	0.55	55.00	3.07	0.77	58.39	1.32
48 - 54	35.0	4.38	0.36	19.85	5.07	0.65	25.93	2.51
54 - 60	32.5	4.54	0.37	13.80	2.83	0.75	17.81	4.21

Table 18. Effect of irrigation on water soluble ions of Arkansas Valley alluvium, Comparison G.

Depth	Water soluble ions - me./100 g. soil									
	Cations					Anions				
	K	Ca	Mg	Na	Total	CO_3	HCO_3	Cl	SO_4	Total
G - 1: NE¼, SE¼, Sec. 30; T 24-S; R 35-W.							Irrigation: 40 years			
0 - 6	0.05	0.51	0.20	0.54	1.30	0.04	0.34	0.16	0.80	1.34
6 - 12	0.02	0.40	0.51	0.45	1.38		0.15	0.04	0.67	0.86
12 - 18	0.01	0.34	0.14	0.27	0.76		0.12	0.05	0.66	0.83
18 - 24	0.01	0.35	0.29	0.30	0.94	0.01	0.11	0.03	0.67	0.82
24 - 30	0.01	0.37	0.39	0.30	1.06		0.08	0.05	0.72	1.07
30 - 36	0.01	0.42	0.16	0.32	0.92		0.10	0.11	0.86	4.38
36 - 42						0.04	0.03	0.61	3.70	0.85
G - 2: NE¼, SE¼, Sec. 30; T 24-S; R 35-W.							Irrigation: 10 years			
0 - 6	0.02	0.36	0.12	0.26	0.75		0.18	0.09	0.10	0.36
6 - 12	0.02	0.18	0.09	0.37	0.66		0.21	0.08	0.43	0.72
12 - 18	0.05	0.92	0.24	1.10	2.31		0.18	0.03	1.76	2.24
18 - 24	0.02	0.39	0.13	0.38	0.92	0.02	0.14	0.06	1.00	1.22
24 - 30	0.04	1.08	0.52	0.93	2.58		0.08	0.24	2.61	2.93
30 - 36	0.03	0.72	0.34	0.72	1.80		0.10	0.10	1.90	2.10
36 - 42	0.04	0.91	0.57	1.01	2.53		0.09	0.24	2.59	2.93
42 - 48	0.03	0.80	0.41	0.77	2.01		0.07	0.26	2.03	2.35
48 - 54	0.02	0.70	0.25	0.68	1.65		0.06	0.30	1.74	2.10
54 - 60	0.02	0.65	0.24	0.66	1.58		0.06	0.34	1.61	2.00

Table 19. Effect of irrigation on saturation percentage, conductivity, and exchangeable cations on the Arkansas Valley alluvium, Comparison H.

Depth	Saturation percent	Conductivity E.C. X 10^3	Exchangeable cations-me./100 g. soil K	Ca	Mg	Na	Exchange capacity me./100g. soil	Exch. Na percent
H - 1: SW¼, NE¼, SEC. 1; T 25-S; R 36-W.						Irrigation: 50+ years		
0 - 6	28.0	0.78	0.94	17.71	4.56	1.09	24.30	4.48
6 - 12	27.2	1.46	0.59	16.23	4.05	0.93	21.80	4.26
12 - 18	31.3	2.04	0.63	17.99	4.29	0.85	23.76	3.58
18 - 24	29.6	2.60	0.55	14.70	3.76	0.60	19.61	3.06
24 - 30	26.0	2.65	0.40	16.07	2.37	0.59	19.43	3.04
30 - 36	33.2	2.21	0.32	19.92	2.71	0.70	23.65	2.96
36 - 42	38.6	3.59	0.47	18.30	3.61	0.80	23.18	3.45
42 - 48	32.5	3.68	0.20	15.53	2.47	0.89	19.09	4.66
H - 2: SW¼, NW¼, Sec. 6; T 25-S; R 35-W.						Irrigation: 5 years		
0 - 6	29.8	2.45	0.43	15.50	3.50	0.66	20.09	3.28
6 - 12	29.5	3.71	0.30	15.10	2.71	0.84	18.95	4.43
12 - 18			0.38	14.20	2.90	0.75	17.81	4.21
18 - 24	29.8	3.90	0.29	14.51	3.05	0.69	18.54	3.72
24 - 30	26.2	3.94	0.16	12.09	1.70	0.48	14.44	3.35
30 - 36	22.2	4.81						
H - 3: SW¼, NW¼, Sec. 6; T 25-S; R 35-W.						Irrigation: 2 years		
0 - 6	30.6	1.88	0.90	16.26	5.10	0.88	23.14	3.81
6 - 12	33.0	2.99	0.69	14.04	3.51	0.74	18.98	3.90
12 - 18	44.8	3.03	0.85	21.94	4.57	1.47	28.93	5.08
18 - 24	54.4	3.86	0.60	24.26	5.36	1.65	31.87	5.16
24 - 30	37.8	6.68	0.30	15.74	2.58	1.56	20.18	7.74
30 - 36	29.2	4.36	0.27	15.33	1.34	0.60	17.54	3.42
36 - 42	36.8	5.16	0.31	16.40	3.13	1.17	21.28	5.50
42 - 48	30.7	4.52	0.16	13.29	1.90	0.55	15.90	3.43

Table 20. Effect of irrigation on water soluble ions of Arkansas Valley alluvium, Comparison H.

Depth	Water soluble ions - me./100 g. soil									
	Cations					Anions				
	K	Ca	Mg	Na	Total	CO_3	HCO_3	Cl	SO_4	Total
H - 1: SE¼, NE¼, Sec. 1; T 25-S; R 36-W.						Irrigation: 50+ years				
0 - 6	0.01	0.04	0.03	0.17	0.25					
6 - 12	0.01	0.07	0.05	0.22	0.34					
12 - 18	0.01	0.16	0.10	0.30	0.57					
18 - 24	0.02	0.30	0.10	0.55	0.95					
24 - 30	0.01	0.26	0.17	0.30	0.74					
30 - 36	0.01	0.28	0.12	0.36	0.77					
36 - 42	0.01	0.60	0.25	0.74	1.59					
42 - 48	0.01	0.62	0.24	0.42	1.28					
H - 2: NW¼, NW¼, Sec. 6; T 25-S; R 35-W.						Irrigation: 5 years				
0 - 6	0.01	0.30	0.10	0.34	0.76	0.01	0.08	0.09	0.59	0.77
6 - 12	0.02	0.40	0.23	0.58	1.24		0.11	0.13	0.16	1.40
12 - 18										
18 - 24	0.01	0.49	0.19	0.48	1.14	0.01	0.06	0.09	1.43	1.59
24 - 30	0.02	0.61	0.17	0.36	1.16		0.07	0.16	1.06	1.29
30 - 36	0.01	0.41	0.28	0.49	1.18		0.07	0.11	1.19	1.37
H - 3: SW¼, NW¼, Sec. 6; T 25-S; R 35-W.						Irrigation: 2 years				
0 - 6	0.02	0.29	0.10	0.24	0.65	0.03	0.13	0.02	0.15	0.33
6 - 12	0.02	0.42	0.19	0.48	1.12		0.16	0.02	0.97	1.15
12 - 18	0.03	0.66	0.19	0.67	1.56	0.03	0.40	0.05	1.34	1.82
18 - 24	0.02	0.94	0.58	1.13	2.67		0.15	0.12	2.35	2.62
24 - 30	0.02	0.98	0.32	1.06	2.40		0.15	0.40	2.38	2.93
30 - 36	0.01	0.52	0.40	0.66	1.68		0.06	0.21	1.26	1.53
36 - 42	0.01	0.82	0.29	0.88	2.01		0.10	0.48	1.76	2.25
42 - 48	0.01	0.45	0.25	0.62	1.33		0.09	0.24	1.39	1.72

to sorghum and that of site H - 3 to alfalfa when sampled. This comparison showed a slight decrease in salinity with irrigation as indicated by the conductivity and concentrations of practically all the water soluble ions. The same was true of the alkalinity as indicated by the ESP values. Irrigation, therefore, definitely had not hurt this land from the standpoint of salinity and alkalinity, but rather had been beneficial. In this case the short time irrigation had not been in operation long enough for many changes to have taken place over the virgin condition. The analyses indicated that salinity of the three soils would not have hindered the growth of the crops usually grown.

Comparison J (Table 21) was located on land directly south of Lakin. The site J - 1 soil had been cultivated about 25 years and irrigated the last four years from the ditch and shallow well. The land of site J - 2 had not been cultivated as it was low and stony, permitting sampling of only the top foot of soil. The analyses showed the conductivity and ESP to be higher in the top foot of the irrigated land, which indicated salt accumulation. However, the comparison was not very good due to the poor soil of site J - 2. This made it difficult to draw useful conclusions. Values of all analyses placed the soil well within the suitable range for plant growth.

Comparison K (Tables 22 and 23), located southwest of Lakin, consisted of two soil sites, one which had been irrigated only four years (K - 2). Both soils were watered from the ditch and shallow wells, and both were fallow at the time of sampling. The surface six inches showed an increase in salinity with long irrigation. The subsoil showed a decrease in salinity. The analyses of the latter showed a decrease in

Table 21. Effect of irrigation on salt content and other chemical properties of Arkansas Valley alluvium, Comparison J.

Depth	Saturation percent	Conductivity E.C. X 10^3	Exchangeable cations - me./100 g. soil: K	Ca	Mg	Na	Exchange capacity me./100 g. soil	Exch. Na percent
J - 1: NW¼, NW¼, Sec. 3; T 25-S; R 36-W.						Irrigation: 4 years		
0 - 6	26.8	4.21	0.76	14.87	4.32	0.73	20.68	3.53
6 - 12	32.2	3.98	0.67	18.70	5.46	0.65	25.48	2.55
12 - 18	30.8	3.91	0.35	16.78	3.87	0.91	22.11	4.16
18 - 24	24.2	2.92	0.15	13.30	3.64	0.82	17.91	4.58
24 - 30	29.2	4.59	0.15	12.82	4.31	0.88	18.16	4.85
30 - 36	25.6	4.87	0.12	14.70	1.36	0.94	17.12	5.49
J - 2: SW¼, SE¼, Sec. 3; T 25-S; R 36-W.						Irrigation: none		
0 - 6	37.0	2.77	1.07	17.39	3.85	0.41	22.72	1.80
6 - 12	31.2	3.42	1.20	16.59	3.79	0.16	21.74	0.74

Depth	Water soluble ions - me./100 g. soil — Cations: K	Ca	Mg	Na	Total	Anions: CO_3	HCO_3	Cl	SO_4	Total
J - 1: SW¼, SE¼, Sec. 3; T 25-S; R 36 W.							Irrigation: 4 years			
0 - 6	0.03	0.60	0.27	0.41	1.31		0.07	0.02	1.21	1.30
6 - 12	0.02	0.80	0.24	0.47	1.53		0.10	0.03	1.46	1.58
12 - 18	0.01	0.62	0.31	0.41	1.34		0.11	0.01	1.51	1.62
18 - 24	0.00	0.22	0.13	0.26	0.66		0.08	0.01	0.77	0.86
24 - 30	0.00	0.43	0.49	0.67	1.60		0.08	0.02	1.01	1.11
30 - 36	0.00	0.55	0.52	0.51	1.58		0.07	0.02	1.50	1.58
J - 2: SW¼, SE¼, Sec. 3; T 25-S; R 36-W.							Irrigation: none			
0 - 6	0.08	0.86	0.29	0.06	1.29		0.09	0.00	1.27	1.36
6 - 12	0.08	0.76	0.35	0.13	1.32		0.12	0.01	1.20	1.33

Table 22. Effect of irrigation on saturation percentage, conductivity, and exchangeable cations Arkansas Valley alluvium, Comparison K.

Depth	Saturation percent	Conductivity E.C. X 10^3	Exchangeable cations - me./100 g. soil K	Ca	Mg	Na	Exchange capacity me./100 g. soil	Exch. Na percent
K - 1: SW¼, SW¼, Sec. 4; T 25-S; R 36-W.						Irrigation: 50 years		
0 - 6	34.8	3.88	0.97	18.33	4.28	0.55	24.13	2.28
6 - 12	42.6	4.16	1.13	18.55	5.03	1.11	25.82	4.29
12 - 18	24.3	2.51	0.76	13.86	3.78	0.86	19.26	4.47
18 - 24	24.8	3.40	0.43	14.67	3.30	0.63	19.03	3.31
24 - 30	37.6	3.97	0.68	15.64	4.29	0.92	21.53	4.27
30 - 36	42.0	4.62	1.52	15.50	6.48	0.86	24.36	3.54
36 - 42	21.2	3.79	0.45	11.67	3.26	0.44	15.71	2.80
K - 2: SW¼, SW¼, Sec. 5; T 25-S; R 36-W.						Irrigation: 4 years		
0 - 6	44.2	2.61	1.04	17.55	4.30	0.83	23.72	3.50
6 - 12	42.0	4.87	0.64	16.25	5.26	1.27	23.42	5.42
12 - 18	41.4	4.94	0.57	18.65	5.20	1.26	25.68	4.91
18 - 24	50.6	4.52	0.50	18.90	5.40	1.02	25.72	3.97
24 - 30	31.5	4.61	0.22	13.97	2.90	0.50	17.59	2.84
30 - 36	26.2	5.91	0.27	12.04	3.38	0.93	16.62	5.59
36 - 42	35.8	5.91	0.41	15.70	4.70	3.27	24.08	13.57
42 - 48								
48 - 54	38.2	5.52	0.35	14.90	5.84	2.68	23.77	11.29
54 - 50	27.4	5.27	0.23	12.73	2.99	0.72	16.67	4.32

Table 23. Effect of irrigation on water soluble ions of Arkansas Valley alluvium, Comparison K.

Depth	Water soluble ions - me./100 g. soil									
	Cations					Anions				
	K	Ca	Mg	Na	Total	CO_3	HCO_3	Cl	SO_4	Total
K - 1: SW¼, SW¼, Sec. 4; T 25-S; R 36-W.						Irrigation: 50 years				
0 - 6	0.06	0.57	0.35	0.58	1.56					
6 - 12	0.05	0.62	0.17	0.61	1.45	0.04	0.16	0.08	1.64	1.92
12 - 18	0.02	0.21	0.12	0.28	0.63					
18 - 24	0.03	0.47	0.30	0.40	1.20		0.09	0.06	1.18	1.33
24 - 30	0.07	0.60	0.36	0.52	1.55		0.08	0.11	1.82	2.01
30 - 36	0.09	0.79	0.65	0.72	2.26					
36 - 42	0.04	0.33	0.27	0.28	0.92					
42 - 48							0.09	0.10	2.92	3.12
K - 2: SE¼, SE¼, Sec. 5; T 25-S; R 36-W.						Irrigation: 4 years				
0 - 6	0.04	0.63	0.15	0.46	1.28	0.02	0.25	0.11	1.18	1.57
6 - 12	0.03	0.80	0.44	0.90	2.17		0.17	0.20	2.33	2.70
12 - 18	0.02	0.80	0.50	0.91	2.23		0.16	0.17	2.33	2.66
18 - 24	0.02	0.97	0.47	1.21	2.68		0.20	0.15	3.04	3.39
24 - 30	0.01	0.53	0.34	0.78	1.66		0.10	0.07	2.00	2.17
30 - 36	0.01	0.46	0.37	0.80	1.64		0.10	0.06	1.91	2.07
36 - 42	0.01	0.52	0.11	1.13	1.77		0.09	0.08	2.41	2.58
42 - 48										
48 - 54	0.02	0.69	0.56	1.22	2.49		0.09	0.11	2.75	2.95
54 - 60	0.01	0.52	0.48	0.83	1.84		0.07	0.08	1.90	2.05

concentration of calcium, sodium, bicarbonate, and sulfate ions with the longer time of irrigation. The conductivity readings were slightly affected in the same direction, being three and five millimhos per cm. for the long and short time irrigation, respectively. The latter was high enough to cause moderate concern. The data for the two soils showed that long irrigation had reduced the ESP slightly. The comparison indicated that the soil was fairly saline originally and that the water quality was high enough that it tended to leach the salts and improve the soil. The saturation percentages of the two soils indicated that the soil of site K - 2 (short time irrigation) was heavier than that of site K - 1, which may have had some bearing on the situation. This aspect will be discussed next.

The last Comparison L (Tables 24 and 25), did not deal with a difference in length of irrigation but rather with a soil textural difference. The two sites were located in a field which had been irrigated 50 years using ditch and shallow well water. The field, about 40 acres, had been managed as a unit. At the time of sampling, the field was in alfalfa. There was a marked change in soil texture within the field, and the dividing line was quite apparent in the growth of the alfalfa. The coarser textured soil there was fairly good, green growth, while the finer soil produced a thin stand with yellow, spindly growth. The saturation percentage of the two soils reflected the differences is soil texture. The finer soil, site (L - 1), had percentages around 25. In the profile of site (L - 1) there was an abrupt change in the saturation percentabe. It dropped sharply from 60 percent in the 42 to 48 inch depth to 19 percent in the 48 to 54 inch depth. This indicated the depth at which the loose sand was encountered. The analyses

Table 24. Effect of irrigation on saturation percentage, conductivity, and exchangeable cations of Arkansas Valley alluvium, Comparison L.

Depth	Saturation percent	Conductivity E.C. X 10^3	Exchangeable cations - me./100 g. soil: K	Ca	Mg	Na	Exchange capacity me./100 g. soil	Exch. Na percent
L - 1: SW¼, NW¼, Sec. 17, T 25-S; R 36-W.						Heavy soil		
0 - 6	47.8	5.50	1.09	20.48	7.17	4.42	33.16	13.33
6 - 12	58.0	8.18	1.09	19.62	7.84	4.41	32.60	14.62
12 - 18	48.2	8.01	0.88	18.90	6.87	3.67	30.32	12.11
18 - 24	52.0	6.47	0.61	16.79	5.26	9.72	32.38	30.00
24 - 30	50.3	5.58	0.52	17.59	3.81	3.82	25.74	14.47
30 - 36	51.2	5.07	0.57	19.69	6.37	2.60	29.23	8.90
36 - 42	66.8	4.41	0.61	22.06	9.22	1.95	33.84	5.76
42 - 48	59.8	3.88	0.56	19.15	6.99	4.03	30.73	13.13
48 - 54	29.2	3.59	0.19	10.39	2.72	0.54	13.34	3.90
L - 2: NW¼, NW¼, Sec. 17; T 25-S; R 36-W.						Light soil		
0 - 6	26.8	1.60	0.55	12.86	2.39	0.37	16.17	2.29
6 - 12	23.8	1.86	0.47	14.02	1.31	0.52	16.32	3.19
12 - 18	27.8	1.48	0.23	11.89	1.79	0.28	14.19	1.98
18 - 24	27.5	2.44	0.29	12.37	1.60	0.35	14.61	2.40
24 - 30	33.0	3.00	0.35	15.02	1.84	0.36	17.57	2.05
30 - 36	22.8	3.54	0.19	13.11	1.17	0.18	14.65	1.23
36 - 42	21.2	3.42	0.14	13.20	0.60	0.26	14.19	1.84
42 - 48								
48 - 54	22.6	3.09						

Table 25. Effect of irrigation on water soluble ions on the Arkansas Valley alluvium, Comparison L.

Depth	Water soluble ions - me./100 g. soil									
	Cations					Anions				
	K	Ca	Mg	Na	Total	CO_3	HCO_3	Cl	SO_4	Total
L - 1: SW¼, NW¼, Sec. 17; T 25-S; R 36-W.							Heavy soil			
0 - 6	0.03	0.94	0.95	1.43	3.36		0.13	0.08	3.04	3.25
6 - 12	0.05	0.88	0.76	3.74	5.43		0.14	0.35	5.47	5.96
12 - 18	0.03	0.92	0.68	3.06	4.69		0.14	0.51	3.93	4.58
18 - 24	0.03	0.86	0.44	1.79	3.12		0.17	1.13	2.68	3.98
24 - 30	0.03	1.19	0.30	1.48	3.00		0.16	1.24	2.05	3.46
30 - 36	0.02	1.26	0.93	1.07	3.28		0.10	0.65	2.71	3.46
36 - 42	0.02	1.54	0.62	1.13	3.30	0.01	0.12	0.21	3.44	3.78
42 - 48	0.02	1.09	0.71	1.82	3.62		0.13	0.23	3.05	3.41
48 - 54	0.01	0.40	0.22	0.46	1.09		0.01	0.08	1.14	1.30
L - 2: NW¼, NW¼, Sec. 17; T 25-S; R 36-W.							Light soil			
0 - 6	0.02	0.24	0.11	0.15	0.52		0.14	0.03	0.35	0.52
6 - 12	0.01	0.20	0.27	0.17	0.66		0.06	0.05	0.29	0.40
12 - 18	0.01	0.21	0.07	0.14	0.43		0.10	0.03	0.27	0.40
18 - 24	0.03	0.38	0.11	0.17	0.70		0.09	0.11	0.54	0.74
24 - 30	0.02	0.76	0.16	0.22	1.16		0.08	0.06	1.25	1.39
30 - 36	0.01	0.63	0.16	0.13	0.93		0.06	0.03	0.98	1.06
36 - 42	0.01	0.63	0.10	0.19	0.93		0.06	0.06	1.12	1.24
42 - 48										
48 - 54	0.01	0.55	0.20	0.10	0.86					

showed this sand to be much less saline or alkaline than the finer soil immediately above it.

The conductivity values showed the finer soil (L - 1) to be too saline except for more tolerant plants (14, p. 9), while the coarser soil (L - 2) would restrict growth of only sensitive plants. All water soluble cations and anions were found in greater concentration in the finer soil. The exchange capacity of the finer textured soil was about double that of the coarser textured soil. The ESP values of the coarser soil were three or less, while in the finer soil the values were mostly above 12. The latter indicated the land to be high in alkali. A hard soil condition had been noted at the time of sampling. This indicated that the soil may have been dispersed, which is characteristic of soils with ESP values that high.

A check of the saturation percentages of soils of other sites in the study showed similar trends although not as clear cut as in comparison L. The soils of sites F - 1 and F - 2 (Tables 15 and 16) may be used as previously mentioned. In this case the salt accumulation on the site F - 1 soil was caused by two factors, soil texture and length of time of irrigation. Management had likely produced the modification of texture, through the use of silty irrigation water.

In comparison K it was mentioned that textural differences may have been partly responsible for a slight reduction of salinity with irrigation. In this case, however, the long time irrigation, site K - 1, (Tables 22 and 23) was on the coarser soil so did not show the salt accumulation as did the short time irrigation, which was on the finer soil.

The soils of two other sites, C - 1 (Tables 9 and 10) and D - 1, (Tables 11 and 12) illustrate this point also. Both of these sites were in the same irrigation unit, having been irrigated for about 75 years. The saturation percentage of the sample from site C - 1 was from 30 to 40 while that of the site D - 1 sample was about 50 percent. Correspondingly, the conductivity, probably due to increased concentration of sodium sulfate, and the ESP values were higher in the soil of site D - 1 than that of site C - 1. The salinity and alkalinity values place the finer soil from site D - 1 in a range where it might readily restrict crop growth. The coarser soil would have caused little harm to the crops grown.

The importance of the texture of the soil being irrigated has been overlooked quite often when planning irrigation projects. As can be seen, it may be of paramount importance. Had all of the field studied in comparison 1 been on the coarser soil, the problems in crop production probably would not have been encountered.

SUMMARY AND CONCLUSIONS

Twenty-seven sites were sampled in Kearny County, Kansas, to study the effect of irrigation on the chemical properties of the soil. Two sites were located on the Richfield, Ulysses, Colby soil association northwest of Lakin, three on the Ulysses, Colby soil association north of Deerfield, and the remainder on the valley alluvium south of Lakin. On three of the soils only tolerant plants would be expected to grow. Five other soils might have reduced crop growth. The rest of the soils would have caused no salinity or alkalinity problems. The 27 sites were grouped into 11 comparisons for the purpose of study. The two soils on the Richfield, Ulysses, Colby soil association were essentially duplicates, with very low salinity and alkalinity. The soils of the Ulysses, Colby soil association comparison showed slight accumulation of salts with irrigation, but still with low salinity and alkalinity. A problem soil, not typical of extensive acerages in this area showed excessive salinity and alkalinity. Four of the nine comparisons on the alluvium showed salt accumulation, with the soil of one site showing high salinity. Four comparisons showed no change or an actual reduction of salt content. The ninth set of samples compared textural differences. The finer textured soil showed a much greater accumulation of salts than did the coarser soil. Other sites studied also showed similar trends.

This study led to the conclusion that not nearly enough emphasis has been placed on soil texture in planning irrigation projects. There were two factors which permitted irrigation to be conducted on the valley alluvium for a number of years with sometimes questionable water. First, even though the water often contained appreciable sodium, the soil contained enough gypsum to prevent soil dispersion, and also to maintain a favorable sulfate:chloride ratio. The second was the excellent subsurface drainage provided by the layer of loose sand which was found under the area at a depth of four to five feet. However, in spite of this favorable balance of gypsum and almost ideal subsurface drainage, the results of these analyses from site L - 1 showed clearly that salt accumulated in fine textured soils and that the ESP reached an injurious level. Again, this stresses the fact that more care must be exercised in the selection of land for irrigation.

ACKNOWLEDGMENT

"With thy knowledge, get thee understanding,
With thy understanding, get thee knowledge."

The author wishes to express deep gratitude for the friendship and wise guidance freely given by his major professor: Dr. J. Arthur Hobbs. The time and effort willingly donated by Dr. Hobbs for this research is greatly appreciated.

Thanks go also to Dr. Roscoe Ellis, Jr., for his invaluable help with the analyses and their interpretation, and to Mr. Homer Watkins, work unit conservationist of Soil Conservation Service in Lakin, Kansas, who made the selection of proper soil sites possible.

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THE EFFECT OF IRRIGATION ON THE CHEMICAL PROPERTIES
OF SOME KEARNY COUNTY SOILS

by

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B. S., Kansas State College
of Agriculture and Applied Science, 1957

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1958

Twenty-seven sites were sampled in Kearny County, Kansas to study the effect of irrigation on the chemical properties of the soil. Two sites were located on the Richfield, Ulysses, Colby soil association northwest of Lakin, three on the Ulysses, Colby soil association north of Deerfield, and the remainder on the valley alluvium south of Lakin. The 27 sites were grouped into 11 comparisons for the purpose of study. Irrigating on the uplands was all done by deep well, while in the valley ditch, shallow wells and deep wells were all used.

Sites were sampled by six inch depths to five feet. Analyses for the principal water soluble and extractable ions were made on each sample. Cations were determined on the Beckman Model DU flame photometer. The sulfate ion was determined conductimetrically as gypsum, and the other anions titrimetrically. The conductivity of the saturation extract was determined and the exchangeable cations and exchangeable sodium percentage (ESP) were calculated.

Only three of the soils produced analyses which placed them in the range where only salt tolerant plants would be expected to grow. Five other soils might have hindered crop growth while the rest would have caused no salinity or alkalinity problems. The two soils on the Richfield, Ulysses Colby soil association were essentially duplicates, with very low salinity and alkalinity. The soils of the Ulysses, Colby soil association showed slight accumulation of salts with irrigation, but still with low salinity and alkalinity. A problem soil, not typical of extensive acerages in this area showed excessive salinity and alkalinity. Four of the nine comparisons on the alluvium showed salt accumulation, with the soil of one site showing high salinity. Four comparisons showed no change or an actual reduction of salt content. The ninth set of samples compared textural differences. The finer soil showed a much greater accumulation of salts than did the coarser soil. Other fine-textured sites studied also showed similar trends.

This study led to the conclusion that not nearly enough emphasis had been placed on the soil texture in planning irrigation projects. There were two factors which permitted irrigation to be conducted on the valley alluvium for a number of years with sometimes questionable water. First, even though the water often contained appreciable sodium, the soil contained enough gypsum to prevent soil dispersion, and also to maintain a favorable sulfate to chloride ratio. The second was the excellent subsurface drainage provided by the layer of loose sand which underlaid the area at a depth of four to five feet. In spite of this favorable balance of gypsum and almost ideal subsurface drainage, results of these analyses showed clearly that salt accumulated in fine textured soils and that the exchangeable sodium percentage reached an injurious level. Again, this stresses the fact that more care must be exercised in the selection of land for irrigation.