THE USE OF SALINE AND ALKALINE WATERS IN GREENHOUSES

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A plentiful supply of a reasonably pure water is of importance in greenhouse growth. Such waters are limited in many sections of Oklahoma. Sodium, calcium, and magnesium chlorides occur in deep well waters and in rivers and springs near our salt deposits, calcium sulphate in the leachings from our gypsum hills, and magnesium sulphate in many of our shallow wells. The bicarbonates are general in the western part of the State. Waters as saturated as ocean brines are not uncommon. Under the circumstances it is not surprising that greenhouses frequently encounter difficulties.

The danger of these waters in field irrigation has been given considerable attention but not so much information is available in regard to the greenhouse problem. Yet in greenhouses the problem is more difficult due to frequent waterings, shallow beds, salt accumulation, rapid evaporation, and year-round concentrated production. The study here reported was planned to determine the toxic limits of these salts, singly and in combination, under greenhouse conditions.

METHOD

Tomatoes and geraniums were used in the tests. The soil was a mixture of loam and compost. The salts used in the preparation of the solutions were sodium bicarbonate and the chlorides and sulphates of sodium, calcium, and magnesium.

The plants were grown in 6″ pots and watered daily. Records were made of the average amount of water used, the length of life, general appearance, and dry weight for each concentration of solution. At the end of the experiment the plants were clipped at the ground level, dried, and the plants and soils analyzed by methods recommended by the Association of Official Agricultural Chemists.

OBSERVATIONS

1. Plants receiving high concentrations of salts stopped growing, their leaves turned yellow and began to fall. Lower concentrations of salts produced similar conditions at a later date.
2. Injury to plants was characterized by lower leaves dying, and this condition was especially pronounced in plants receiving sodium bicarbonate.
3. Plants receiving sodium and magnesium sulphate maintained a dark green color until injury was very pronounced.
4. Leaves of plants receiving chloride salts turned yellowish green though they did not wilt.
5. In all cases where injury was noted, the amount of water utilized by the plants was reduced.
6. Plants receiving salts did not wilt as readily as the checks.
7. Plants receiving sodium chloride and sulphates had fewer and smaller leaves.
8. The soil receiving sodium bicarbonate developed a thick, black, top crust, while that treated with sodium and magnesium sulphate formed a white covering.

TABLE 1

Analysis of tomato plants

(dry)

SALT	CONC. OF SALT	LENGTH OF LIFE	TOTAL WATER ADDED	TOTAL DRY WEIGHT	PLANT ASH	PLANT Ca	PLANT Na	PLANT Mg
	p. p. m.	days	gal.	gm.	%	%	%	%
Control	None	Alive	5.3	14.90	19.75	2.382	0.515	0.763
NaCl	3000	93	2.3	6.18	40.81	2.573	8.917	0.681
NaCl	5000	89	2.1	5.67	42.99	2.073	8.527	0.650
NaCl	7000	78	1.5	3.86	41.65	1.997	8.140	0.709
$CaCl_2$	3000	88	2.0	7.31	36.25	8.014	0.544	0.570
$CaCl_2$	5000	86	1.8	5.38	39.40	8.926	0.305	0.484
$CaCl_2$	7000	68	1.8	4.13	37.22	8.218	0.276	0.541
$NaHCO_3$	3000	78	1.6	5..82	24.51	1.688	5.689	0.556
$NaHCO_3$	5000	48	0.9	4.19	23.24	1.597	4.975	0.607
$NaHCO_3$	7000	44	0.7	2.93	22.47	1.431	5.658	0.648
Na_2SO_4	3000	98	3.4	7.79	28.21	1.734	4.868	0.649
Na_2SO_4	5000	101	3.2	6.56	29.47	1.607	5.291	0.600
Na_2SO_4	7000	99	3.1	5.66	34.02	1.699	7.087	0.527
$MgSO_4$	3000	139	3.8	15.47	28.34	1.013	0.417	3.966
$MgSO_4$	5000	126	3.6	5.99	25.82	0.954	0.318	3.884
$MgSO_4$	7000	101	1.7	3.47	24.96	0.810	0.229	3.712
$MgCl_2$	3000	95	1.9	7.28	25.37	1.795	0.653	4.812
$MgCl_2$	5000	78	1.5	5.02	27.21	2.377	0.413	5.129
$MgCl_2$	7000	78	1.5	4.14	27.66	2.126	0.340	4.731

TABLE 2

Analyses of geranium plants

(dry)

SALT	CONC. OF SALT	AVE. LENGTH OF LIFE	AVE. TOTAL WATER ADDED	AVE. TOTAL DRY WEIGHT	PLANT ASH	PLANT Ca	PLANT Na	PLANT Mg
	p. p. m.	days	gal.	gm.	%	%	%	%
NaCl	3000	128	2.90	5.08	19.45	2.089	2.643	0.618
NaCl	5000	127	2.80	4.14	33.04	2.418	6.590	0.573
NaCl	7000	124	2.80	3.17	20.45	2.016	2.491	0.625
$CaCl_2$	3000	126	2.80	5.79	20.45	3.411	0.603	0.687
$CaCl_2$	5000	121	2.80	4.89	21.61	3.748	0.747	0.620
$CaCl_2$	7000	121	2.80	3.89	18.77	3.134	0.703	0.659
$NaHCO_3$	3000	146	3.20	5.26	18.13	2.076	2.135	0.569
$NaHCO_3$	5000	140	3.10	3.78	18.66	1.888	2.627	0.576
$NaHCO_3$	7000	143	3.10	3.78	16.45	1.905	1.791	0.553
Na_2SO_4	3000	131	2.90	7.32	17.86	1.874	2.354	0.543
Na_2SO_4	5000	130	2.90	5.42	18.52	1.889	2.178	0.617
Na_2SO_4	7000	128	2.80	4.11	20.04	1.935	2.408	0.584
$MgSO_4$	3000	128	2.90	7.65	17.14	1.726	0.701	1.302
$MgSO_4$	5000	121	2.80	5.37	18.09	1.594	0.590	1.500
$MgSO_4$	7000	123	2.80	4.39	17.13	1.739	0.686	1.559
$MgCl_2$	3000	119	2.50	6.29	17.44	1.993	0.592	1.372
$MgCl_2$	5000	115	2.30	3.87	18.00	2.030	0.721	1.296
$MgCl_2$	7000	120	2.25	3.67	19.35	2.139	0.886	1.230
Control	None	Alive	3.30	5.88	17.32	1.928	1.208	0.607
Control	None	Alive	3.10	4.50	18.16	2.467	0.957	0.649

RESULTS

The addition of saline waters of various concentrations to tomato and geranium plants was repeated many times. The average results of the analyses of plants are presented in tables 1 and 2.

An examination of the tables permits several conclusions to be drawn for the tomatoes receiving 3000 to 7000 p.p.m. salt solutions:

1. Effect on the percent of ash in the plants:
   $NaCl > CaCl_2 > Na_2SO_4 > MgSO_4 > MgCl_2 > NaHCO_3 >$ Checks
2. Effect on the sodium content of the plants:
   $NaCl > Na_2SO_4 > NaHCO_3 > MgCl_2 > MgSO_4 > CaCl_2 >$ Checks
3. Effect on the calcium percentage:
   $CaCl_2 >$ NaCl > Checks $> MgCl_2 > Na_2SO_4 > NaHCO_3 > MgSO_4$
4. Effect on the content of magnesium:
   $MgCl_2 > MgSO_4 >$ Checks $>$ NaCl $> Na_2SO_4 > NaHCO_3 > CaCl_2$
5. Order of toxicity for plants receiving 3000 p.p.m. salt:
   $NaHCO_3 >$ NaCl $> MgCl_2 > CaCl_2 > Na_2SO_4 > MgSO_4$
6. Weight of plant:
   Checks $> MgSO_4 > Na_2SO_4 > CaCl_2 > MgCl_2 >$ NaCl $> NaHCO_3$
7. Water requirement:
   Checks $> Na_2SO_4 > MgSO_4 > CaCl_2 >$ NaCl $> MgCl_2 > NaHCO_3$

DISCUSSION

1. There was a difference in salt content of tomato plants at the time of death in different seasons. This may be explained by the fact that the higher the transpiration ratio the larger the absorption of salts.

2. The amount of salt absorbed was not in proportion to soil concentration because of ionic antagonism.

3. The ash content varied with the degree of salinity of the soil. For this reason plants treated with salts contained more ash than did the checks.

4. Tomatoes were aided in growth by a slightly acid soil. The determinations of the soil treated with sodium bicarbonate showed that an increase in alkalinity above 7.0 caused injury to the plants.

5. With solutions containing sodium bicarbonate, over 500 p.p.m. seemed to be objectionable; with other salts, 1500 p.p.m. seemed to be as much as would permit normal growth.

6. The more permeable the soil the higher the salt concentration that could be used. Sodium bicarbonate decreased permeability so rapidly that only small amounts of solutions could be used without injury. More magnesium and calcium salts could be tolerated without ruining the soil, as they did not seem to interfere with permeability.

CONCLUSIONS

1. The salts produced substantially the same effects on the geraniums as on the tomato plants.

2. The ash content of plants increased as the concentrations of salt solutions were increased.

3. Check plants grew larger than plants treated with salt solutions.

4. High concentrations of salts stunted growth of the plants, reduced their water consumption, and produced greatest injury.

5. The sodium salts, especially sodium bicarbonate, decreased the permeability of the soil.

6. Certain anions produced striking characteristics: Chloride produced yellow leaves that did not wilt; and sulphate increased the green color of the leaves, making them darker than the checks.