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LEACHING REQUIREMENT FOR SALINITY CONTROL. II. OAT, TOMATO, AND CAULIFLOWER

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ABSTRACT

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Leaching requirement, defined as the minimum leaching fraction that maintains full crop production, was determined in field plots at the U.S. Salinity Laboratory for three crops; oat, tomato, and cauliflower. Six replicated leaching-fraction treatments were pulse-irrigated daily with water having an electrical conductivity of 2.1 dS/m. All three crops were grown in rotation during 1977 and 1978 with a third tomato crop in 1979.

The leaching requirement (L_r) was 0.10 for oat grain, 0.21 for tomato fruit, and 0.17 for cauliflower heads. For oat forage, the L_r was more than 0.17. These values agree closely with those predicted by a leaching-requirement model based on an exponential crop water-uptake pattern. Evapotranspiration during each crop's growing season coincident with the leaching requirement was 390, 850, and 230 mm for oat, tomato, and cauliflower, respectively.

INTRODUCTION

In a recent study (Hoffman et al., 1979), data were published on crop yields and salinity profiles that develop when various leaching fractions were maintained over long periods of time with frequent irrigations. The primary objective of that study was to determine the leaching requirement, defined as the leaching required to maintain full crop production. Although the results of that study and other published data confirm the predictions of the leaching-requirement model proposed by Hoffman and Van Genuchten (in press) further confirmation is required before this generalized model, presented in terms of the crop-salt tolerance threshold (Maas and Hoffman, 1977) and the salinity of the applied water, can be recommended without reservation. Thus, the experiment reported by Hoffman et al. (1979) was continued with only a change in crop rotation to provide additional leaching-requirement data.

EXPERIMENTAL PROCEDURE

An annual crop rotation of oat (*Avena sativa*, cv. Montezuma), tomato (*Lycopersicon esculentum*, cv. UC82A), and cauliflower (*Brassica oleracea* Var. *botrytis*, cv. 'Snowball') was grown at the U.S. Salinity Laboratory in field plots. These crops were selected because of their importance in irrigated regions where salinity is a hazard and their suitability for an annual crop rotation. Oat, sown the first of January and harvested the last of May, was followed by tomato, planted as 1-month-old seedlings, harvested the last of September. One-month-old cauliflower seedings were then transplanted into the plots and harvested the last of December. Both tomato and cauliflower were started from seed in a greenhouse. This rotation was followed in 1977 and 1978, and a third crop of tomato was grown in 1979 following a barley crop. Oat seed, spaced on seed tape at intervals of 10 mm, was sown at a depth of 10 mm in rows 0.23 m apart. Tomato and cauliflower seedlings were placed at intervals of 0.43 m in rows 0.46 m apart.

The experimental design was similar to that reported by Hoffman et al. (1979). Only pertinent details and changes in experimental procedure are presented here. The design consisted of six replicated leaching fractions (*L*'s) of 0.17, 0.13, 0.09, 0.07, 0.04. and 0.02. These were selected to span the range anticipated to give full production in some treatments and yield depressions in others.

All 12 plots received irrigation water having a total salt concentration of 1350 g/m^3, an electrical conductivity of 2.1 dS/m, and an osmotic potential of -88 J/kg (-880 mb or -88 kPa). This concentration is equal to that projected for the lower reaches of the Colorado River in the year 2000 and is about 1.5 times the river's present concentration. The amounts of solutes in the irrigation water during this study, in mol/m^3 of solution, were Ca, 4.0; Mg, 1.6; Na, 9.4; K, 0.1; $CO_3 + HCO_3$, 3.3; Cl, 7.0; SO_4, 3.7; and NO_3, 3.6. The pH of this water is 7.6, and the sodium-adsorption ratio is 4.0 (mol/m^3)$^{1/2}$.

Nitrogen fertilizer in the form of calcium nitrate was added continuously to the irrigation water at an average rate of 1.8 mol/m^3. The annual application rate for oat ranged from 90 to 210 kg/ha of nitrogen as *L* increased from 0.02 to 0.17. The application rate was 110 to 190 kg/ha for tomato and 50 to 120 kg/ha for cauliflower. Before each cauliflower crop, phosphorus in the form of superphosphate was applied to the soil surface at a rate of 170 kg/ha before cultivating to a depth of 15 cm.

The irrigation system passed frequently over each plot and applied water through vertical tubes midway between every second row of oat and along each row of tomato and cauliflower. The system applied 0.2-mm depth of water each irrigation pass, based on the total surface area of the plot. Thus, if the required irrigation depth was 5 mm for a given day, the system made 25 passes.

Leaching fractions (*L*) were controlled by maintaining the desired ratio between the depth of drainage water (D_d) and the depth of irrigation water (D_i) (i.e., $L = D_d/D_i$). Drainage was assumed to be leachate collected from a suction lysimeter, 80 × 45 × 60 cm deep, in each plot. Irrigation and drainage water volumes were measured several times weekly, and the amount of irrigation was adjusted to maintain the desired value of L.

Soil matric potential was monitored in each plot at two locations with tensiometers at soil depths of 10, 40, and 60 cm. Soil salinity was measured at three locations with salinity sensors at soil depths of 20 and 40 cm. After each harvest, the soil was sampled to a depth of 1.5 m and analyzed for chloride concentration and water content. Three consecutive monthly samples of irrigations and drainage waters were combined before analyzing for individual ion concentrations.

At harvest, grain and total shoot dry weights were measured for oat. For tomato, mature fruits were harvested weekly until the final harvest, when all the remaining fruits were harvested and shoot dry weight was measured. At 2-week intervals during the 6-week harvest period for tomato in 1978 and 1979, samples of 50 fruits were selected at random from each plot for quality analysis. The fruits were cleaned and their specific gravity was determined. Then the total number of loculi and the number of hollow loculi were counted as each fruit was sliced before blending it for 1 min at low speed. The blended tomatoes were then filtered, and the filtrate was analyzed for total soluble solids by a Brix refractometer, for titratable acid, and for pH. For cauliflower, the fresh weights of marketable head and total shoot were determined. After each harvest, the plots were cultivated to a depth of about 15 cm and releveled.

RESULTS

Leaching fractions

This experiment was a continuation of a 4-year study; the same water quality and method of irrigation were used, so quasi-steady-state conditions had been reached before the present experiment began. However, any significant changes in crop water requirement or irrigation management influenced drainage from the lysimeter within a few days, depending on the magnitude of the change. Thus, the desired L for each crop could not be maintained precisely, and the results are therefore reported in terms of actual L's attained during each crop.

Table I gives the total depths of irrigation and drainage for each crop as a function of the leaching treatment. The amounts are reported as the equivalent depth of water applied uniformly over the entire surface area of a plot (18.23 m^2). As expected, irrigation and drainage depths were greatest for tomato which was grown in summer, when evaporative demand is high. The lowest values were for cauliflower, grown in autumn.

Because chloride does not precipitate, is not adsorbed by the soil, and is

TABLE I

Irrigation and drainage depths measured for each crop as a function of leaching-fraction treatment

Year	Irrigation depth (D_i) for indicated leaching-fraction treatment (mm)						Drainage depth (D_d) for indicated leaching-fraction treatment (mm)					
	0.17	0.13	0.09	0.07	0.04	0.02	0.17	0.13	0.09	0.07	0.04	0.02
Oats												
1977	787	550	434	408	351	280	135	73	42	33	16	8
1978	525	494	417	333	288	278	96	60	37	22	11	5
Mean	656	522	426	370	320	279	116	66	40	28	14	7
Tomato												
1977	922	813	788	696	669	576	151	118	70	55	28	14
1978	1183	978	876	809	734	642	202	132	81	61	32	11
1979	936	844	759	644	603	540	214	142	106	84	39	13
Mean	1014	878	808	716	669	586	189	131	86	67	33	13
Cauliflower												
1977	326	282	238	213	200	178	74	44	25	23	14	7
1978	276	284	186	176	204	182	60	50	24	17	7	5
Mean	301	283	212	194	202	180	67	47	24	20	10	6

not taken up by plant roots in significant amounts, it can be used as an indicator of L. Thus, in addition to calculating L as the ratio of the depths of drainage and irrigation (D_d/D_i), leaching fraction was also calculated as the ratio of the chloride concentration (Cl) in the irrigation and drainage waters (Cl_i/Cl_d). The volume-weighted average compositions of the drainage waters, including chloride concentration and electrical conductivity (σ), are given in Table II for each leaching treatment. The total salt concentration of the irrigation and drainage waters (approximated by σ_i/σ_d) has also been suggested as an estimate of L, but it is of course subject to errors caused by salt precipitation. In Table III, the L calculated by both of these methods for each crop is compared with that measured by depth of irrigation and drain water. With tomato and cauliflower, overirrigation to ensure seedling survival caused L's to be somewhat higher than the target values. Furthermore a relatively high leaching requirement was anticipated for cauliflower, so the L treatments were purposely maintained above the target values. As was found previously (Hoffman et al., 1979), the L's calculated from the Cl ratio were slightly higher than those based on the water—depth ratio. Part of this discrepancy may be caused by chloride uptake by the crops, but the largest part is no doubt due to calculating the weighted average of the chloride concentration of drainage waters of composite samples. Again, as reported previous-

TABLE II

Average composition of drainage waters as a function of leaching fraction for all three crops

Leaching fraction treatment	Electrical conductivity (σ_d) (dS/m)	Osmotic potential (ψ_o) (K/kg)	Sodium-adsorption ratio $(mol/m^3)^{1/2}$	pH	Ca^{2+} (mol/m^3)	Mg^{2+} (mol/m^3)	Na^{1+} (mol/m^3)	K^{1+} (mol/m^3)	HCO_3^{1-} (mol/m^3)	Cl^{1-} (mol/m^3)	SO_4^{2-} (mol/m^3)	NO_3^{1-} (mol/m^3)
0.17	6.3	–250	11	7.6	11.4	3.6	43.5	0.1	6.0	30.1	17.8	2.0
0.13	8.9	–360	14	7.8	16.3	3.9	64.4	0.1	5.7	45.4	26.4	2.6
0.09	11.3	–450	19	7.8	18.5	3.6	89.3	0.1	5.3	66.1	30.5	1.8
0.07	12.2	–490	22	7.8	17.1	3.4	100.4	0.2	4.9	69.4	33.0	2.2
0.04	17.1	–680	25	7.7	22.5	6.5	132.2	0.1	3.9	131.5	28.6	2.3
0.02	22.8	–910	23	7.4	38.0	8.4	159.0	0.1	2.6	210.6	19.6	2.6

TABLE III

Leaching fraction by crop computed as the ratio of water depths (D_d/D_i), chloride concentrations (Cl_i/Cl_d), and total salt concentration (σ_i/σ_d) of the irrigation and drainage waters

Year	D_d/D_i for indicated leaching-fraction treatment						Cl_i/Cl_d for indicated leaching-fraction treatment						σ_i/σ_d for indicated leaching-fraction treatment					
	0.17	0.13	0.09	0.07	0.04	0.02	0.17	0.13	0.09	0.07	0.04	0.02	0.17	0.13	0.09	0.07	0.04	0.02
Oats																		
1977	0.17	0.13	0.10	0.08	0.05	0.03	0.25	0.12	0.11	0.10	0.07	0.04	0.34	0.21	0.20	0.18	0.16	0.12
1978	0.18	0.12	0.09	0.07	0.04	0.02	0.25	0.17	0.09	0.09	0.05	0.03	0.35	0.23	0.17	0.17	0.12	0.10
Mean	0.18	0.13	0.09	0.07	0.04	0.02	0.25	0.15	0.10	0.10	0.06	0.03	0.34	0.22	0.18	0.18	0.14	0.11
Tomato																		
1977	0.16	0.14	0.09	0.08	0.04	0.02	0.17	0.19	0.12	0.09	0.06	0.04	0.30	0.27	0.20	0.18	0.11	0.10
1978	0.17	0.14	0.09	0.08	0.04	0.02	0.26	0.20	0.12	0.13	0.04	0.03	0.35	0.26	0.19	0.17	0.11	0.09
1979	0.23	0.17	0.14	0.13	0.06	0.02	0.26	0.16	0.10	0.11	0.05	0.03	0.39	0.25	0.21	0.20	0.13	0.08
Mean	0.19	0.15	0.11	0.10	0.05	0.02	0.23	0.18	0.11	0.11	0.05	0.03	0.35	0.26	0.20	0.18	0.12	0.09
Cauliflower																		
1977	0.23	0.16	0.11	0.11	0.07	0.03	0.24	0.12	0.08	0.08	0.05	0.03	0.31	0.20	0.16	0.14	0.11	0.09
1978	0.22	0.18	0.13	0.10	0.03	0.03	0.24	0.15	0.10	0.13	0.05	0.03	0.35	0.25	0.19	0.19	0.12	0.08
Mean	0.22	0.17	0.12	0.10	0.05	0.03	0.24	0.13	0.09	0.10	0.05	0.03	0.33	0.22	0.18	0.16	0.12	0.08

ly, *L*'s calculated from the total salt concentration of the irrigation and drainage waters were even higher than those based on chloride. After corrections for salt precipitation and nitrogen loss (Hoffman et al., 1979) were made, the values of σ_i/σ_d were comparable to those for Cl_i/Cl_d. Without these corrections, ratios of total salt content are poor indicators of *L*.

Yields

Crop production is given in Table IV as a function of the *L* treatment. Oat yield is reported as grain, tomato as vine-ripe fruit, and cauliflower yield as marketable heads. Also given is the total shoot growth for each crop.

TABLE IV

Crop production as a function of leaching-fraction treatment for oats, tomato, and cauliflower

Year	Yield[a] for indicated leaching-fraction treatment							Total shoot growth for indicated leaching-fraction treatment						
	0.17	0.13	0.09	0.07	0.04	0.02	LSD[b]	0.17	0.13	0.09	0.07	0.04	0.02	LSD[b]
Oats (g/m^2, dry weight)														
1977	252	268	256	194	147	131		978	908	721	617	435	388	
1978	194	233	219	196	147	88		834	608	673	569	341	315	
Mean	223	250	238	195	147	110	50	906	758	697	593	388	352	123
Tomato (yield: kg/m^2, freshweight; total shoot growth: g/m^2, dry weight)														
1977	10.4	8.0	7.5	7.4	5.5	3.2		989	848	798	713	633	489	
1978	7.1	7.2	5.6	5.7	4.7	2.9		898	739	711	686	582	558	
1979	7.9	5.7	4.9	4.2	3.6	2.0		666	530	537	470	443	431	
Mean	8.5	7.0	6.0	5.8	4.6	2.7	1.2	851	706	682	623	553	493	49
Cauliflower (g/plant, fresh weight)														
1977	156	146	136	112	121	84		894	838	712	636	617	443	
1978	215	222	160	164	171	93		898	904	629	550	580	356	
Mean	186	184	148	138	146	88	32	896	871	670	593	598	400	127

[a] Yield for oat is grain; for tomato it is vine-ripe fruit only; and for cauliflower it is the marketable head.

[b] Least significant difference at the 5% probability level.

Fig. 1 gives the relative crop yield as a function of measured *L*. The minimum *L* consistent with maximum crop production (L_r) for oat is about 0.10, based on linear regression analysis of data below this *L*. The least significant difference (LSD given in Table IV) indicates that yield at an *L* of 0.07 was significantly less than that at an *L* of 0.13. Thus, the L_r for oat is 0.10. Of the six crops tested to date, oat is the only one to

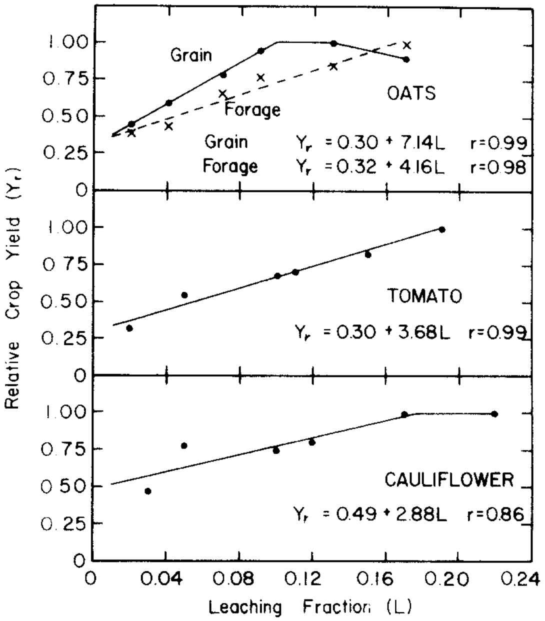

Fig. 1. Influence of leaching fraction on relative crop yield for oats, tomato, and cauliflower with an irrigation water quality of 2.1 dS/m. The linear equations apply to the portion of the curves where the relative yield is reduced below 1.0.

show reduction for an L treatment above the L_r. For oat forage, yield decreases linearly as L decreases, throughout the range of L tested. The LSD for the total shoot growth of oat also indicates that forage at an L of 0.13 is significantly less than that at an L of 0.17. Thus, the L_r for oat forage is at least 0.17.

The yield of tomato fruit decreases linearly as L decreases throughout the range of L's tested. The yield at an L of 0.15 (0.13 treatment) was significantly less than that at an L of 0.19 (0.17 treatment). Thus, the L_r for tomato is at least 0.19.

The L_r for cauliflower, based on linear regression analysis, is 0.17 (see Fig. 1). The LSD indicates a significant yield and total shoot growth reduction between an L of 0.17 and 0.12. Thus, the L_r for cauliflower is 0.17.

Tomato fruit quality

During tomato harvests, both the number and mass of the fruits were determined. Likewise, mean fruit mass and specific gravity were measured on fruit samples taken for quality determinations. For the 3 years of study the 0.17-L treatment yielded 8.5 kg/m^2, the number of ripe fruits harvested averaged 227/m^2, and mean fruit mass was 39 g (fresh weight). The effect of L on yield, fruit size, and fruit number are shown for comparison in Fig. 2.

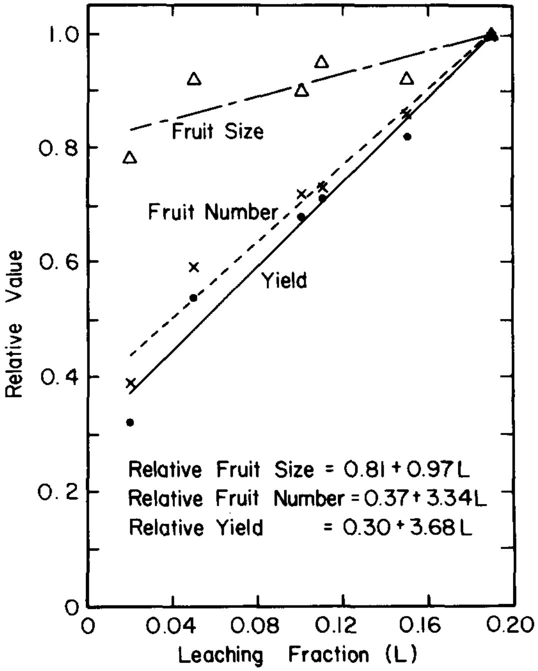

Fig. 2. The effect of leaching fraction on the yield, fruit size (volume) and the number of tomato fruit harvested.

Linear regressions drawn through these data sets indicate that reducing *L* from 0.19 to 0.02 reduces yield by 63% and the number of fruits harvested by 56%, while decreasing fruit size only by 17%. Clearly, yield reduction was dominated by a decrease in the number of fruits harvested.

In addition to decreasing the yield, reduced leaching delayed the harvest. Production for the 0.02-*L* treatment was 1 week behind that for the 0.17-*L* treatment.

Table V summarizes the influence of *L* on various fruit and juice quality characteristics. With reduced leaching, specific gravity increased significantly. This increase in specific gravity is caused in large part by a decrease in the number of hollow loculi within the fruit. This variety typically has two or three loculi per fruit. In our experiment, only about 10% of the fruit sampled had more than three loculi. The number of loculi per fruit, the amount of titratable acid, and the pH of the filtered juice were not significantly affected by the *L* treatment. Total soluble solids, however, increased significantly with decreasing *L*. As a result the solids-to-acid ratio increased from 8.5 to 10.8 as the *L* treatment decreased from 0.17 to 0.02.

Water use

The evapotranspiration (ET) for each *L* treatment can be calculated from

TABLE V

Influence of leaching-fraction treamtnet on various fruit and juice quality characteristics for tomato. Data are the means of several 50-fruit samples taken from each plot in 1978 and 1979

Leaching-fraction treatment	Specific gravity	Number of hollow loculi per 50-fruit sample	Fraction of fruit sample with:		Total soluble solids (%)	Titra-table acid (%)	pH
			2 loculi	>3 loculi			
0.17	0.97	19	0.24	0.11	4.1	0.48	4.2
0.13	0.97	17	0.24	0.07	4.1	0.47	4.2
0.09	0.98	7	0.23	0.12	4.3	0.49	4.1
0.07	0.99	11	0.25	0.12	4.6	0.50	4.1
0.04	0.99	12	0.29	0.07	5.0	0.50	4.2
0.02	1.00	7	0.34	0.07	5.6	0.52	4.1
LSD[a]	0.01	7	NS	NS	0.3	NS	NS

[a] LSD, least significant difference at the 5% confidence level. NS indicates no significant difference.

(D_i–D_d) in Table I. In Fig. 3 these calculated values of ET are shown as a function of relative crop yield. As would be anticipated from the method of calculating ET, relative crop yield decreased linearly after ET dropped below

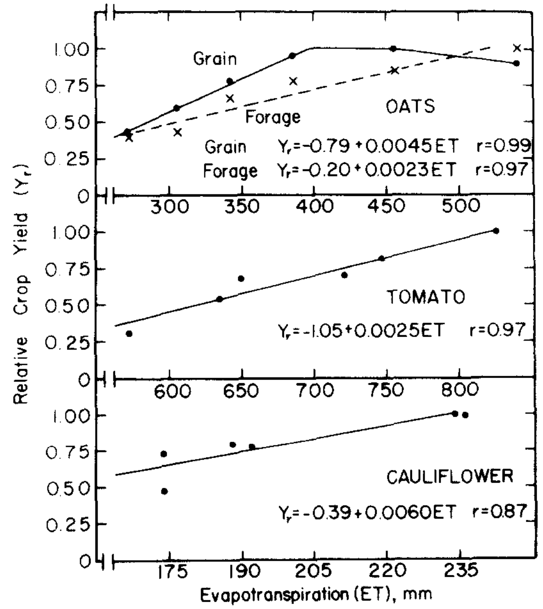

Fig. 3. Relative yield of oats, tomato, and cauliflower as a function of evapotranspiration. The linear equation applies to the portion of the curve where relative yield is reduced below 1.0.

a threshold level. Grain yield of oat was not increased above an ET of 400 mm, although forage yield increased linearly as ET increased up to at least 500 mm. For cauliflower, yield did not increase above an ET of 235 mm; however, the maximum ET achieved was only about 240 mm. Tomato yield increased linearly as ET increased to 825 mm. Larger water applications might have resulted in more ET and larger tomato yields, although the yields for this processing variety were high.

Pan evaporation was recorded daily at the plots and at an official weather station located 8 km east. Fig. 4 shows the average daily rate of pan evaporation (E) by month for both stations during 1977, 1978, and the tomato crop of 1979. It also shows the average maximum and minimum rates of ET. The maximum ET was calculated as the average of the 0.17- and 0.13-*L* treatments and the minimum as the average of the 0.04- and 0.02-*L* treatments.

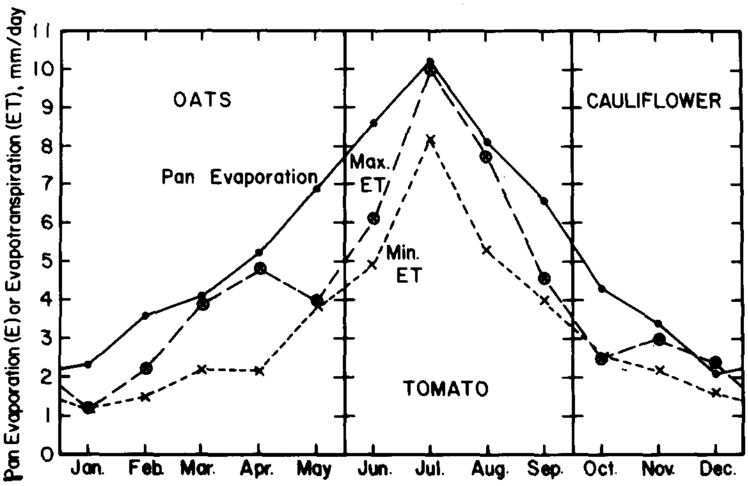

Fig. 4. Average daily rate of pan evaporation and the maximum (average of the 0.17- and 0.13-leaching treatments) and minimum (average of the 0.04- and 0.02-leaching treatments) evapotranspiration by month for 1977, 1978, and the tomato crop in 1979.

The average annual pan evaporation was 2000 mm for this time period. Pan evaporation during the oat, tomato, and cauliflower crops averaged 670, 1025, and 305 mm, respectively. For all three crops, the maximum annual ET was 1600 mm and the minimum was 1180 mm. Thus, the annual pan factor (ET/E) was 0.8 for the maximum and 0.6 for the minimum *L* treatments. The pan factors by month for each crop for maximum and minimum ET treatments are given in Fig. 5. To maintain an *L* of 0.17, the pan factor exceeded 0.8 for at least 2 months during the rapid growth stage of each crop; for an *L* of 0.02, the pan factor never exceeded 0.8. For an *L* of 0.17, the average pan factors for oat, tomato, and cauliflower were 0.81, 0.81, and 0.77, and for an *L* of 0.02, they were 0.41, 0.56, and 0.57, respectively.

As leaching was reduced from 0.17 to 0.02, ET was reduced about 50%

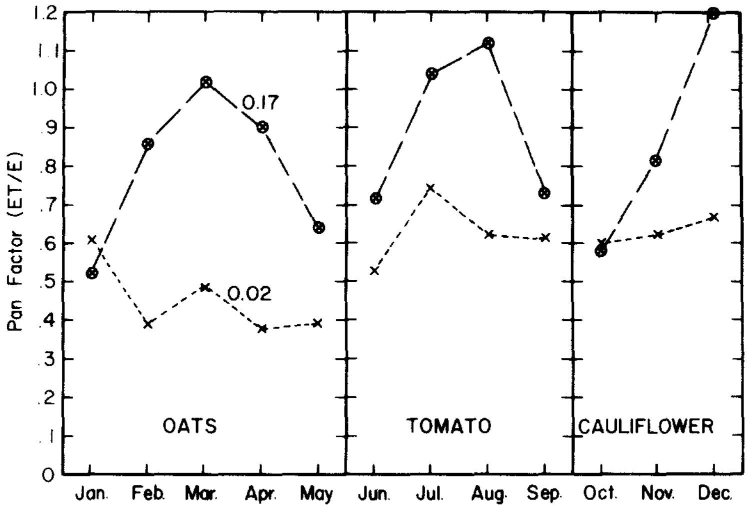

Fig. 5. Monthly pan factors (evapotranspiration/pan evaporation; ET/E) for oats, tomato, and cauliflower required to maintain leaching fraction of 0.17 and 0.02.

for oat, 30% for tomato, and 25% for cauliflower. These ET reductions with reducing L are all larger than the 15% reduction in ET reported for the rotation of wheat, sorghum, and lettuce (Hoffman et al., 1979).

Soil salinity

Leaching fraction can also be calculated from the chloride concentrations determined from the soil samples taken after each crop harvest. Because the suction lysimeters intercept only a small part of the drain water from the plots, their L may not be the same as the average for the plot. However, L's calculated from Cl_i/Cl_d, where Cl_d is the average chloride value from soil samples taken below the 75-cm soil depth, were 0.23, 0.07, and 0.03 for the 0.17-, 0.07-, and 0.02-leaching treatments, respectively. This corresponds to average values of 0.19, 0.09, and 0.02 for D_d/D_i and 0.24, 0.10, and 0.03 for Cl_i/Cl_d where Cl_d is a volume-weighted average of drainage samples taken from the suction lysimeter in each plot (see Table II).

Average chloride concentrations from soil samples taken in the crop row after each crop are given in Fig. 6 along with the soil water contents at the time of sampling. The data are the averages for all samples. Because soil sampling was delayed for several days after the last irrigation for each crop, soil water content near the soil surface is lower than reported earlier (Hoffman et al., 1979), and chloride concentrations are correspondingly slightly higher. The patterns of water uptake calculated from soil chloride concentrations are very similar to those reported in the first experiment and are not repeated here.

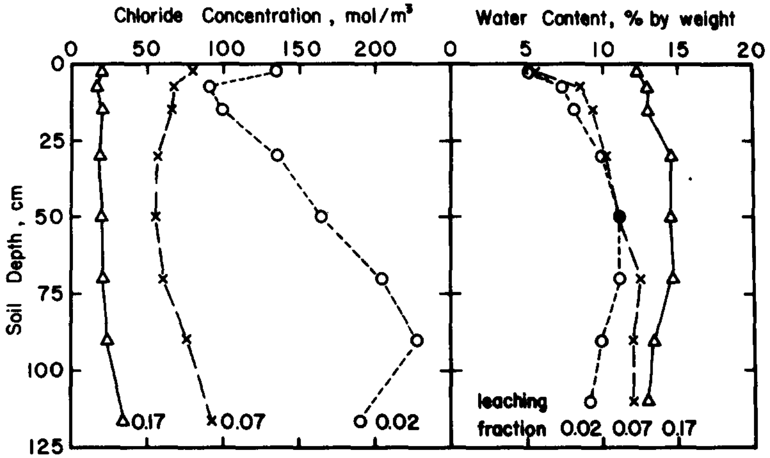

Fig. 6. Influence of leaching fraction on the chloride concentration of the soil water and on soil water content through the soil profile below the crop row.

DISCUSSION

The data indicate clearly that the L_r for oat grain is about 0.10 for irrigation water of this quality. For oat forage the L_r is more than 0.17 because no yield plateau was found. Although oat yields were only about two-thirds of those for variety field trials near Riverside under nonsaline conditions (Isom et al., 1976), it is not expected that the relationship between relative yield and L would be altered with higher yields.

Several proposed L_r models can be tested with the experimentally measured L_r's reported here. The model of Hoffman and Van Genuchten (in press) is based on an exponential water-uptake distribution pattern, while the model of Rhoades (1974) is based on the "40—30—20—10" water-uptake partition by quarter fractions of the rootzone. Both models require the salinity of the applied water and the crop salt tolerance threshold as input. Unfortunately, no salt-tolerance information on oat is available. Unpublished data, however, indicate that oat grain is moderately tolerant and oat forage is moderately sensitive. The mean crop salt tolerance thresholds for moderately tolerant and moderately sensitive crops have σ_e's of 4.5 and 2.2 dS/m, respectively (Maas and Hoffman, 1977). The electrical conductivity of the applied water is 2.1 dS/m. The L_r's predicted for this water quality and these assumed threshold values from the L_r model of Hoffman and Van Genuchten (in press) are 0.09 and 0.18, respectively, and from the L_r model of Rhoades (1974), they are 0.11 and 0.25. These predicted L_r's are corroborated by the experimentally measured values of 0.10 for grain and more than 0.17 for forage.

Various varieties of processing tomatoes have been field tested in the San Joaquin Valley of California (Sims et al., 1979). Test yields in 1979 averaged

9.2 kg/m^2. Thus, our average yield of 8.5 kg/m^2 at an L of 0.17 is about 8% lower than the average under nonsaline conditions. If the linear relationship of yield and L (Fig. 2) is extrapolated to this average field yield an L_r of 0.21 is projected. In corroboration of this L_r, Shalhevet and Yaron (1973), using σ_i's of 1.6, 3.8, 6.0, and 10.2 dS/m, reported that the yield of a processing variety of tomato was not reduced significantly when the L was reduced from 0.55 to 0.18. Furthermore, if the σ_e for the salt tolerance threshold for processing tomato is taken as 2.0 dS/m (Shalhevet and Yaron, 1973), L_r's of 0.19 and 0.28 are predicted from the L_r models of Hoffman and Van Genuchten (in press) and Rhoades (1974), respectively.

Shalhevet and Yaron also reported that the percentage of total soluble solids in tomato fruit increased from 4.5 to 5.9% as the average soil salinity increased from 1.9 to 6.0 dS/m. We found nearly identical increases as the L decreased from 0.17 to 0.02. A discrepancy between our results and those of Shalhevet and Yaron, however, concerns the influence of salinity on the number of fruit harvested. They found no reduction in fruit number with increased salinity, whereas we found significant reductions in fruit number as the L decreased. This discrepancy may be explained, however, by Shalhevet and Yaron's initiation of the saline treatments 50 days after planting. It is possible that fruit numbers were physiologically determined in their experiment before the soil became saline.

The experimentally determined L_r for cauliflower is 0.17. As for oat the salt tolerance of cauliflower is not known quantitatively, but cauliflower is rated qualitatively as moderately sensitive. Assuming that the salt tolerance threshold has an σ_e of 2.2 dS/m, the predicted L_r's are 0.18 for the model of Hoffman and Van Genuchten and 0.25 for the model of Rhoades.

The field plot trials of Robinson et al. (1976) indicate that cauliflower yield is not significantly reduced as the irrigation-to-pan evaporation ratio drops from 1.05 to 0.75 with the same water quality (1350 g/m^3) in the Imperial Valley of California. Our irrigation-to-pan ratio was 0.7 for the 0.09-leaching treatment (the first leaching treatment below the L_r) and 0.9 for the 0.13-leaching treatment (the first leaching treatment above the L_r). Thus our results support their conclusion that cauliflower yield is not affected by an irrigation-to-pan ratio above 0.75 and their results confirm a yield plateau above a ratio of 0.75, and presumably higher L's.

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