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EFFECT OF SALINITY AND WATER TABLE ON THE MINERAL CONTENT OF PLUM AND PEACH

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ABSTRACT

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The effects of combinations of salinity and water table on the mineral content of plum and peach were studied in lysimeters.

Chloride content (Cl) in the leaves and the roots of plum and in the leaves of peach increased with salinity, whereas Cl in peach roots was not affected. Leaves of peach contained higher amounts of Cl than the leaves of plum. The opposite trend was observed in the roots.

Sodium content (Na) increased with salinity in plum, whereas in peach it was not affected.

The effect of salinity on calcium content (Ca) was not consistent in plum and peach.

Potassium content (K) in the leaves of plum and peach decreased with salinity, whereas in the roots it was not affected.

The Ca/K ratio in plum leaves increased with salinity, whereas in peaches it decreased in the 4000 p.p.m. treatment.

Leaf phosphorus content (P) in the plum and the 'Balady' peach decreased with salinity, while in 'Mit Ghamre' peach it was not consistently affected. In plum root, P increased with salinity, whereas the effect was the opposite in peach.

Magnesium content (Mg) was not significantly affected.

The depth of the water table had no consistent effect on the Cl, Na, Ca, K, Ca/K ratio, P and Mg contents in the leaves and roots of plum or peach.

The interaction between salinity treatments and water table levels was not significant in most cases.

INTRODUCTION

Intensive studies have been made concerning the effect of salinity on the mineral content of fruit trees, but very little work has been done on the effect of the water table.

The combined effect of salinity and water table is not known either. Therefore, our investigation concerned the effect of salinity and water table on the mineral content of plum and peach.

MATERIALS AND METHODS

The investigation used the plum, *Prunus triflora*, Roxb cultivar 'Golden Japanese' budded on 'Marianna' rootstock, and the peach *Prunus persica* Batsch cultivars 'Mit Ghamre' budded on 'Balady' rootstock, and 'Balady' raised from seeds.

One-year-old seedlings were planted in lysimeters (1 m^3) with a clay loam soil in February 1970 and were allowed to grow for 4 months before the start of the treatments, which lasted from June 1970 until October 1972.

The salinity treatment included 3 levels, namely control (tap water without added salts), 2000 and 4000 p.p.m. equal weight of NaCl and $CaCl_2$. Each of these salt treatments was maintained at depths of 30, 60 or 90 cm from the soil surface, so that the experiment included 9 treatments, each replicated 4 times.

Leaf samples of approximately 150 leaves each were taken from each plant on dates indicated in the tables. Feeder root samples and soil samples were also taken. Oven-dried leaves and roots were digested according to Chapman and Pratt (1961). The digested plant material and the soil extract were used for Ca, Mg, Na, K, P and Cl determinations, using only the soluble salts in the soil extract. The soil pH was determined according to Richards (1949). The Sodium Adsorption Ratio (SAR = $Na/\sqrt{\{\frac{1}{2}(Ca + Mg)\}}$ as an index of alkalinity in the soil solution was calculated.

Analysis of variance was followed according to Steel and Torrie (1960) and the least significant differences at 5% were calculated.

RESULTS

Since in most cases interactions between salinity and water table levels were absent, the effects of salinity will be averaged over the 3 water table levels, and vice versa.

Chloride (Cl). — The data in Table 1 show that on the different sampling-dates the absorption of Cl, and consequently its accumulation in plum and peach plants, increased with increasing salinity. Leaves of peach contained higher amounts of Cl than those of plum. Conversely, the Cl content in peach roots was generally lower than in plum roots. It was also noticed that the root Cl content in plum gradually increased as the level of salinity increased, whereas its level in the peach was not significantly affected by salinity.

Cl content in the leaves and roots of plum and peach was not significantly affected by the change in the depth of the water table.

Sodium (Na). — In the plum there was a gradual increase in the Na content as the salinity of the irrigation water was increased (Table 2).

For the 2 peach cultivars, the Na content in the leaves and roots was not significantly affected by salinity treatments.

Na content in plum leaves tended to increase with increasing the depth of the water table, except in October 1970.

In 'Mit Ghamre' peach, leaf Na content was often higher at 30 cm water table than at 90 cm, whereas in 'Balady' peach the leaf Na was slightly lower at 30 cm level than at 90 cm. In roots, the Na content in plum and peach decreased as the depth of the water table increased from 30 to 90 cm.

Calcium (Ca). — Ca content in the plum leaves, collected in October of the 3 growing-seasons, gradually increased with increasing salinity in the irrigation water (Table 3). The Ca content in the plum roots followed the same trend as in the leaves in most cases. In the peaches, the leaf Ca was lower in the 4000 p.p.m. treatment than in the control and 2000 p.p.m. treatments. On the other hand, root Ca varied slightly with the change in the salinity level (Table 3).

The effect of water table on Ca content in leaves and roots of plum and peach did not show a consistent trend and the differences were not significant in most cases.

Potassium (K). — The leaf K, as an average of the 3 water table levels in a given salinity treatment, was significantly higher in the control treatment than in the 4000 p p.m. treatment in most cases of plum and peach (Table 4). In the roots of the plum and peach the K content was not significantly affected by the salinity treatments.

In general, the K content in plum and peach leaves tended to decrease at the water table level of 30 cm, when compared with the deeper water table level of 90 cm. For plum roots the K content at 30 cm was higher compared with the 90 cm level in 1971 and the 60 cm level in 1972. The opposite trend was obtained for peach roots.

Calcium—potassium ratio (Ca/K). — The data in Table 5 indicate that salinity treatments significantly increased the Ca/K ratio in the plum leaves, while the effect was variable in the peach leaves.

The Ca/K ratio was a little higher at the 30 cm water table level than at the 60 cm water table in most cases.

Phosphorus (P). — There was a general decrease in the P content in the leaves of plum and 'Balady' peach, as the salinity level was increased (Table 6). On the other hand, the P content was not consistently affected in 'Mit Ghamre' peach. In the plum roots the P content followed an opposite trend to that of the leaves, i.e. it increased as the salinity level was increased. In peach roots the P content was generally decreased in the presence of salinity in the irrigation water.

Magnesium (Mg). — Mg content in the leaves and the roots of plum and peach did not show any consistent trend with respect to salinity effect and

differences among the treatments were insignificant (Table 7).

The Mg content in the leaves and roots of plum and peach did not vary significantly either by the change in the depth of water table.

Combined effects. — The results of the analysis of variance indicated that the level of salinity in the irrigation water was the predominant factor, which means that the effects on the mineral contents were primarily due to salinity and not to the depth of the water table. This result is illustrated by the analysis of the saturation extract of the soil samples which were taken from the major root zone at the end of the experiment (Table 8). The salinity of the soil solution (Ece, expressed as mmhos/cm at 25°C), SAR, Ca^{++}, Na^{+} and Cl^{-} in the saturation extract increased markedly with increasing the salinity level in the applied water. On the other hand, the depth of the water table had only a small effect on the saturation extract of the major root zone.

DISCUSSION

The results of the foregoing experiments indicated that the absorption of Cl, and consequently its accumulation in plum and peach plants, increased with increasing salinity. Hayward et al. (1946), Brown et al. (1953), Bernstein et al. (1956) in stone fruits, and Pearson et al. (1957) and Minessy et al. (1973) in Citrus, observed a corresponding increase in the leaf Cl with increasing salinity in the substrate.

The leaf injury symptoms and die-back in our investigation could be explained by the excessive accumulation of Cl in the leaves. Peaches suffer more severely than plums. This might be due to the greater accumulation of Cl in the peach, as indicated, or to 'Marianna' rootstock in which the Cl content was greater than in peach roots. In this respect, Bernstein et al. (1956) reported that 'Marianna' rootstock effectively reduced Cl accumulation in the leaves of stone fruits, while 'Lovell' rootstock tended to produce higher Cl accumulation in the leaves of stone fruit plants.

Our results showed that in plum there was a gradual increase in the Na content as the salinity of the irrigation water was increased. This result is in line with Lilleland et al. (1945) and Brown et al. (1953) for stone fruits, and with Pearson et al. (1957) and Minessy et al. (1973) for Citrus. In the 2 peach cultivars, the Na content in the leaves and roots was not significantly affected by salinity treatments. These results are in line with Richards (1954), who reported that excess soluble Na in the substrate may or may not be reflected in the Na content of leaf tissues.

There was a gradual increase in the Ca content of plum leaves with increasing salinity, whereas in the peaches the leaf Ca was lower in the 4000 p.p.m. treatment than in the control and 2000 p.p.m. treatments. On the other hand, the effect of salinity on root Ca was not consistent. Similar results were obtained for stone fruits by Brown et al. (1953), Bernstein et al. (1956) and Dilley et al. (1958).

The leaf K, as an average of the 3 water table levels in a given salinity treatment, was significantly higher in the control treatment than in the 4000 p.p.m. treatment in most cases of plum and peach. In the roots of the plum and peach the K content was not significantly affected by the salinity treatments. The results of Bernstein et al. (1956) for stone fruits, and Pearson et al. (1957), Kanwar and Bhambota (1968) and Minessy et al. (1973) for Citrus, showed that the leaf K was decreased with increasing salinity in the irrigation water.

Our data indicated that salinity treatments significantly increased the Ca/K ratio in the plum leaves, while the effect was often the opposite in the peach leaves. This might be due to the increase in the plum-leaf Ca and to the decrease in the peach leaf Ca. Bernstein et al. (1951) for potato and bean, and Gorton and Cooper (1954) for Citrus, reported that increasing Ca content of irrigation water increased Ca/K ratio in the leaves.

There was a general decrease in the P content in the leaves of plum and 'Balady' peach, as the salinity level was increased, but the P content was not consistently affected in 'Mit Ghamre' peach. In plum roots the P content followed an opposite trend to that of the leaves, whereas in peach roots, P content was generally decreased in the presence of salinity in irrigation water. Dilley et al. (1958) and Faruque (1968) found in different fruit trees that salt treatment had no marked effect on the P leaf-content. In Citrus, Daito (1967) and Minessy et al. (1973) found that the salt treatment increased the leaf P.

The effect of salinity on the Mg content in the leaves and roots of plum and peach was not consistent. Similar results were obtained in Citrus by Cooper et al. (1952) and Daito (1967). Bernstein et al. (1956) for stone fruits and Minessy et al. (1973) for Citrus, found that the leaf Mg varied slightly as the salinity level was increased, whereas Pearson et al. (1957) for Citrus reported that Mg was inversely related to salinity.

Our results showed that the effect of the water table level on the mineral content (Cl, Na, Ca, K, Ca/K, P and Mg) of plum and peach was not consistent. In other words, water table had a negligible effect on the mineral content. These results are in line with Pearson et al. (1957) and Minessy et al. (1970, 1971 and 1973). In this connection, the analysis of the saturation extract of the soil samples taken from the major root zone at the end of the experiment showed that the salinity of the soil solution in the saturation extract increased markedly with increasing salinity level in the applied water, and that the depth of the water table had only a small effect.

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TABLES 1–7

Mineral contents in leaves and roots of 'Golden Japanese' plum, 'Mit Ghamre' peach and 'Balady' peach, as influenced by salinity and water table level, expressed as % dry weight. Treatments = 0, 2000, 4000 p.p.m. salt, averaged over 3 water table levels. 30, 60, 90 cm water table levels, averaged over 3 salinity levels. s = significant difference at 5% level with 0 p.p.m. or 30 cm. — = dead plants.

TABLE 1

Chloride

Treatment	Leaves					Roots	
	Oct. 70	May/ June 71	Oct. 71	May/ June 72	Oct. 72	Oct. 71	Oct. 72
'Golden Japanese' plum							
0 p.p.m.	0.42	0.37	0.40	0.53	0.71	0.29	0.29
2000	0.55	0.47s	0.53	0.99s	0.92s	0.60s	0.61
4000	0.60	0.57	0.65	0.80	0.82	0.64s	0.68s
30 cm	0.53	0.44	0.50	0.86	0.85	0.47	0.53
60	0.50	0.43	0.52	0.68s	0.77	0.51	0.49
90	0.53	0.51	0.49	0.72	0.82	0.51	0.41s
'Mit Ghamre' peach							
0 p.p.m.	0.64	0.61	0.54	—	—	0.23	—
2000	1.07s	1.19	1.92	—	—	0.23	—
4000	1.46s	1.05	1.15	—	—	0.23	—
30 cm	0.88	0.70	0.48	—	—	0.23	—
60	0.90	0.91	1.12	—	—	0.23	—
90	1.01	0.92	1.35	—	—	0.22	—
'Balady' peach							
0 p.p.m.	0.78	0.61	0.62	—	—	0.20	—
2000	1.27s	1.03	1.08	—	—	0.22	—
4000	1.24s	—	—	—	—	—	—
30 cm	0.91	0.61	0.80	—	—	0.23	—
60	1.11	0.96	0.93	—	—	0.26	—
90	1.04	0.90	0.83	—	—	0.14	—

TABLE 2

Sodium

Treatment	Leaves					Roots	
	Oct. 70	May/ June 71	Oct. 71	May/ June 72	Oct. 72	Oct. 71	Oct. 72
'Golden Japanese' plum							
0 p.p.m.	0.20	0.16	0.21	0.20	0.27	0.45	0.25
2000	0.22	0.18	0.23	0.29s	0.29	0.53s	0.41s
4000	0.22	0.28s	0.32s	0.30s	0.31	0.59s	0.42s
30 cm	0.24	0.18	0.24	0.23	0.28	0.55	0.39
60	0.20s	0.22	0.24	0.24	0.27	0.51	0.29s
90	0.19	0.20	0.26	0.28	0.30	0.49	0.32
'Mit Ghamre' peach							
0 p.p.m.	0.24	0.21	0.23	—	—	0.16	—
2000	0.25	0.25	0.21	—	—	0.18	—
4000	0.27	0.21	0.25	—	—	0.13	—
30 cm	0.26	0.21	0.24	—	—	0.28	—
60	0.26	0.22	0.23	—	—	0.16	—
90	0.24	0.24	0.22	—	—	0.15	—
'Balady' peach							
0 p.p.m.	0.21	0.20	0.23	—	—	0.17	—
2000	0.19	0.23	0.22	—	—	0.16	—
4000	0.21	—	—	—	—	—	—
30 cm	0.20	0.20	0.22	—	—	0.17	—
60	0.20	0.23	0.25	—	—	0.18	—
90	0.22	0.23	0.22	—	—	0.15	—

TABLE 3

Calcium

Treatment	Leaves					Roots	
	Oct. 70	May/ June 71	Oct. 71	May/ June 72	Oct. 72	Oct. 71	Oct. 72
'Golden Japanese' plum							
0 p.p.m.	1.06	1.22	1.27s	1.44	1.27	0.51	0.46
2000	1.02	1.09	1.65s	1.52	1.46	0.51	0.65s
4000	1.08	1.30	1.73s	1.43	1.58s	0.51	0.73s
30 cm	1.07	1.18	1.72	1.50	1.35	0.50	0.58
60	1.20	1.26	1.44s	1.39	1.38	0.50	0.57
90	0.91	1.16	1.46s	1.48	1.46	0.57s	0.58
'Mit Ghamre' peach							
0 p.p.m.	1.76	1.50	1.78	—	—	0.36	—
2000	1.78	1.60	1.99	—	—	0.25	—
4000	1.40s	1.48	1.16	—	—	—	—
30 cm	1.61	1.66	2.02	—	—	0.35	—
60	1.67	1.49	1.62	—	—	0.30	—
90	1.73	1.51	1.80	—	—	0.31	—
'Balady' peach							
0 p.p.m.	1.75	1.57	1.48	—	—	0.36	—
2000	1.56	1.55	1.48	—	—	0.44	—
4000	1.44s	—	—	—	—	—	—
30 cm	1.55	1.40	1.39	—	—	0.42	—
60	1.55	1.65	1.69	—	—	0.40	—
90	1.55	1.62	1.41	—	—	0.40	—

TABLE 4

Potassium

Treatment	Leaves					Roots	
	Oct. 70	May/ June 71	Oct. 71	May/ June 72	Oct. 72	Oct. 71	Oct. 72
'Golden Japanese' plum							
0 p.p.m.	1.47	1.25	1.28	1.26	1.05	0.47	0.41
2000	1.38	1.10s	1.20	1.12	1.80	0.52	0.39
4000	1.29s	0.98s	1.09s	1.06s	0.72	0.45	0.42
30 cm	1.41	1.02	1.29	1.28	0.67	0.60	0.42
60	1.33	1.13	1.28	1.27	0.90	0.50	0.38
90	1.42	1.16s	1.22	1.11	0.83	0.38	0.39
'Mit Ghamre' peach							
0 p.p.m.	1.48	1.36	0.85	—	—	0.41	—
2000	1.24s	1.06	0.53	—	—	0.44	—
4000	1.20	0.30	0.39	—	—	—	—
30 cm	1.30	1.41	0.58	—	—	0.42	—
60	1.30	1.25	0.62	—	—	0.42	—
90	1.35	0.30	0.83	—	—	0.44	—
'Balady' peach							
0 p.p.m.	1.09	1.33	0.70	—	—	0.44	—
2000	0.85	1.50	1.06	—	—	0.46	—
4000	0.96	—	—	—	—	—	—
30 cm	1.02	1.25	0.99	—	—	0.40	—
60	0.96	1.18	0.99	—	—	0.49	—
90	0.94	1.18	0.67	—	—	0.49	—

TABLE 5

Calcium/potassium ratio

Treatment	Leaves					Roots	
	Oct. 70	May/ June 71	Oct. 71	May/ June 72	Oct. 72	Oct. 71	Oct. 72
'Golden Japanese' plum							
0 p.p.m.	0.64	0.98	1.02	1.24	1.43	1.14	1.16
2000	0.81	1.17	1.32s	1.42	2.23s	1.07	1.73s
4000	0.84	1.43	1.76	1.60	2.72s	1.42s	1.78s
30 cm	0.81	1.28	1.27	1.54	1.82	0.93	1.38
60	0.86	1.20	1.11	1.23	1.72	1.01	1.51
90	0.66	1.00	1.33	1.39	2.06	1.51	1.50
'Mit Ghamre' peach							
0 p.p.m.	1.39	1.16	2.46	—	—	0.79	—
2000	1.52	1.50	3.94	—	—	0.33	—
4000	1.05	1.55	4.03	—	—	—	—
30 cm	1.43	1.12	3.68	—	—	0.83	—
60	1.24	1.32	3.06	—	—	0.71	—
90	1.35	1.48	3.21	—	—	0.64	—
'Balady' peach							
0 p.p.m.	1.79	1.20	2.22	—	—	0.87	—
2000	1.83	1.52	1.53	—	—	0.78	—
4000	1.61	—	—	—	—	—	—
30 cm	1.80	1.17	1.67	—	—	0.99	—
60	1.76	1.52	1.84	—	—	0.79	—
90	1.68	1.39	2.12	—	—	0.71	—

TABLE 6

Phosphorus

Treatment	Leaves					Roots	
	Oct. 70	May/ June 71	Oct. 71	May/ June 72	Oct. 72	Oct. 71	Oct. 72
'Golden Japanese' plum							
0 p.p.m.	0.17	0.13	0.27	0.23	0.39	0.37	0.31
2000	0.14	0.09s	0.28	0.14s	0.27s	0.49s	0.37s
4000	0.15	0.10	0.19s	0.14s	0.26s	0.44s	0.37s
30 cm	0.16	0.10	0.27	0.17	0.28	0.49	0.37
60	0.13	0.11	0.24	0.21	0.34	0.49	0.31s
90	0.17	0.11	0.26	0.15	0.36	0.31s	0.34
'Mit Ghamre' peach							
0 p.p.m.	0.18	0.35	0.22	—	—	0.30	—
2000	0.18	0.24	0.30	—	—	0.20	—
4000	0.22	0.13	0.27	—	—	0.11	—
30 cm	0.19	0.28	0.30	—	—	0.24	—
60	0.19	0.18	0.27	—	—	0.22	—
90	0.18	0.25	0.21	—	—	0.25	—
'Balady' peach							
0 p.p.m.	0.14	0.16	0.27	—	—	0.27	—
2000	0.15	0.16	0.22	—	—	0.15	—
4000	0.13	—	—	—	—	—	—
30 cm	0.14	0.17	0.25	—	—	0.17	—
60	0.13	0.19	0.23	—	—	0.23	—
90	0.14	0.14	0.27	—	—	0.23	—

TABLE 7

Magnesium

Treatment	Leaves					Roots	
	Oct. 70	May/ June 71	Oct. 71	May/ June 72	Oct. 72	Oct. 71	Oct. 72
'Golden Japanese' plum							
0 p.p.m.	0.37	0.28	0.51	0.41	0.75	0.40	0.49
2000	0.37	0.26	0.51	0.36	0.69	0.56	0.60
4000	0.35	0.35	0.45	0.39	0.55	0.71	0.48
30 cm	0.37	0.28	0.47	0.46	0.75	0.56	0.49
60	0.30	0.28	0.46	0.35	0.69	0.43	0.47
90	0.37	0.32	0.55	0.36	0.68	0.68	0.38
'Mit Ghamre' peach							
0 p.p.m.	0.55	0.51	0.47	—	—	0.44	—
2000	0.48	0.47	0.43	—	—	0.48	—
4000	0.56	0.43	0.53	—	—	0.48	—
30 cm	0.49	0.60	0.42	—	—	0.33	—
60	0.55	0.48	0.49	—	—	0.44	—
90	0.52	0.43	0.53	—	—	0.54	—
'Balady' peach							
0 p.p.m.	0.48	0.43	0.56	—	—	0.33	—
2000	0.50	0.51	0.61	—	—	0.34	—
4000	0.57	—	—	—	—	—	—
30 cm	0.49	0.52	0.69	—	—	0.27	—
60	0.54	0.40	0.52	—	—	0.31	—
90	0.52	0.51	0.54	—	—	0.43	—

TABLE 8

Some soil properties in the major root zone at the end of the experiment. Meq/L = Milli-equivalent of each ion in the soil extract. ECe = electrical conductivity in mmhos/cm at 25° C. S.P. = Saturation percentage of soil = ml water/100 g soil. S.A.R. = Sodium Adsorption Ratio.

Treatment	Element in saturation extract Meq/L					ECe	pH	S.P.	S.A.R.
	Cl^-	Na^+	Ca^{++}	K^+	Mg^{++}				
0 p.p.m.	6.62	17.26	4.25	0.08	1.23	1.24	7.9	51.7	7.94
2000	37.33	57.36	16.88	0.20	6.24	4.78	7.8	54.2	16.92
4000	63.14	96.79	28.62	0.34	5.66	7.49	7.8	54.4	23.50
30 cm	34.54	59.73	15.77	0.19	3.78	4.41	7.9	52.2	16.93
60	34.90	56.22	15.99	0.21	5.12	4.38	7.7	56.2	16.08
90	36.69	55.48	17.95	0.21	4.22	4.64	7.8	51.9	15.28