EFFECTS OF SALINITY IN WATER SUPPLIES ON ROSE PRODUCTION: EXPERIMENT ONE.

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Early work on salinity established tolerance levels for survival. Growers cannot afford mere "survival", and proceeding from Schekel's work on carnations (CFGA Bul. 251, 253), we began to study the same problems with greenhouse roses. As shown previously (Bul. 251), any unnecessary increase in total salinity will reduce yield and quality. Depending upon characteristics of the water supply and fertilizer practices of the grower, rose yield and quality can be reduced from 10 to 50% when total salt level in the irrigation water exceeds 1600 micromhos per cm (160 reading on an RD-15). An irrigation supply which is not "physiologically" balanced can show yield reduction at 1300 μmhos/cm.

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The presence of small quantities (1 meq/l) of bicarbonate (HCO_3), sodium (Na) or chloride (Cl), and a salt reading over 1300 mhos reduced yield by more than 15%. If a water supply contained high magnesium (Mg), increasing calcium (Ca) and potassium (K), so that Ca was equal to Mg, tended to offset effects due to high Mg. "Balancing" appeared to work up to total concentrations of 1800 μmhos. Above 1800, yield was 25% less than the roses grown in the control solution.

Bicarbonate was the most toxic of all ions, and is commonly present in well waters of Colorado. Sulfate did not appear to effect rose production except as the ion increased total salinity. There was considerable variability in soil treatments, symptoms of salt damage requiring 3 to 4 weeks longer to appear as compared to roses grown in gravel. However, no differences in plant symptoms as the result of the various treatments were observed. Gravel accentuated and accelerated reactions resulting from the particular treatments.

Materials and Methods

Forever Yours were grown in individual, 5 gallon plastic buckets in a fiberglass-covered greenhouse. Heating was to 63°F nights and to 72°F days, with ventilation at 80°F. CO_2 was injected whenever the exhaust fans were off. Relative humidity was maintained during the day between 70 to 85% by high pressure mist. The pots were placed on benches, two rows per bench, with the nutrient solutions supplied through plastic tubing from the respective nutrient barrels. The pots were watered automatically, once to 5 times daily depending upon the season. Seven-year-old rose plants, selected for uniformity were employed.

The experiment began August 2, 1974, when the plants were cut back to 12 inches and divided into 14 treatments with 17 plants in each treatment (Table 1). Table 2 shows the range that can be expected in Denver waters (CFGA Bul. 280) compared to the recommendations formulated by Sadasivaiah and Holley (Roses, Inc. Nov; 1973). The treatments were completely randomized. The roses were pinched 21 days after cut back, and watered for 51 days with standard fertilized water. The treatments (Table 1) were started September 22, 1974, and terminated on April 4, 1975.

Measurements included: 1) yield, 2) stem length, 3) stem weight. A quality code was attached to each cut flower to show whether the flower was salable, unsalable, chlorotic or non-chlorotic.

Results

All treatments in this experiment were compared to the control treatment (Tables 1 and 2) and expressed as a percentage of the control. Our work supports Sadasivaiah and Holley's conclusions in that any variation from their recommendations, decreased yield and quality (Fig. 1).

Table 1: Nutrient solutions supplied in Experiment 1, starting Sept. 22, 1974.

Treatment Number	Ion (meq 1^{-1})											
	K	Ca	Mg	NH_4	Na	NO_3	SO_4	H_2PO_4	HCO_3	Total MEQ/L	EC[1]	Ph
Control												
1.	4	6	1	1	0	10	1	1	0	24	1250	6.3
Increasing Concentration-Balanced												
2.	6	9	1.5	1.5	0	15	1.5	1.5	0	32	1870	6.3
3.	8	12	2	2	0	20	2	2	0	48	2750	6.2
Na_2SO_4 Series												
4.	4	6	1	1	1	10	2	1	0	26	1320	6.4
5.	4	6	1	1	4	10	5	1	0	32	1750	6.3
6.	4	6	1	1	12	10	13	1	0	48	2620	6.4
$NaHCO_3$ Series												
7.	4	6	1	1	2	10	1	1	2	28	1370	7.4
8.	4	6	1	1	6	10	1	1	6	32	1750	7.4
9.	4	6	1	1	10	10	1	1	10	44	1870	8.5
Ca-Mg Imbalance - No Na												
10.	8	10	5	1	0	14	5	1	4	48	2220	7.4
11.	4	5	10	1	0	10	5	1	4	40	1750	7.8
Ca-Mg Imbalance - $NaHCO_3$ Added												
12.	4	10	3	1	4	10	7	1	4	44	1600	8.0
13.	4	8	5	1	6	10	7	1	6	48	1870	8.1
14.	4	7	7	1	8	10	8	1	8	54	2000	8.3

1. Electrical conductivity, μmhos/cm.

Table 2: Variations in soluble salt content of shallow wells in the Denver area and current nutrient recommendations given in milliequivalents per liter (meq l^{-1}) for roses.

Ion	Range of salt content found in Denver wells. (meq l^{-1})	(PPM)	Recommended Nutrients[1] in good water. (meq l^{-1})	(PPM)
K^+	trace	trace	4	156
Ca^{++}	0.0-10.1	0-202	6	120
Mg^{++}	0.5-13.7	6-164	1	12
NH_4^+	trace	trace	1	18
Na^+	0.5-15.4	12-354	—	—
NO_3	trace	trace	10	620
SO_4	0.8-22.9	38-1100	1	80
H_2PO_4	trace	trace	1	97
Cl	0.2-7.3	7-256	—	—
HCO_3	2.0-9.2	122-561	—	—

[1]Pounds per 50 gal. concentrate, 1:200 proportion or 10,000 gal water: KNO_2-33, $CA(NO_3)_2$-50, $MgSO_4$-10, NH_4NO_3-7, H_3PO_4-6 or: 17 lbs. KNO_3, 12.5-KCL, 60 lbs. $Ca(NO_3)_2$, 7-NH_4NO_3, 10 lbs. $MgSO_4$, 6 lbs. H_3PO_4.

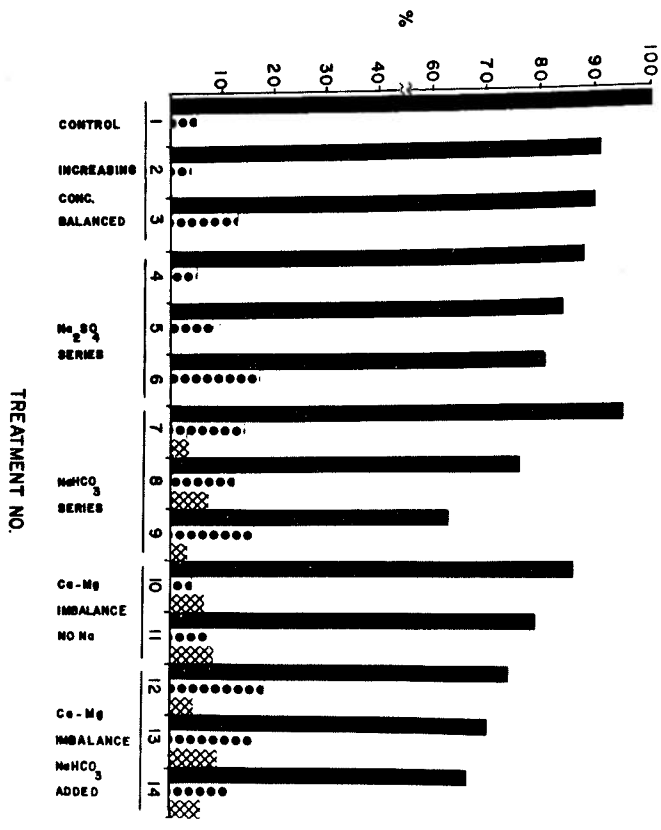

Fig. 1: Comparison of total yield of Forever Yours roses as a percentage of the control treatment (100%), percent unsalable and percent salable but chlorotic when subjected to different salinity treatments in Experiment 1. Salinity treatments given in Table 1.
Solid color: Yield
Solid circles: Unsalable
Cross-hatched: Salable but chlorotic.

As total concentration of the control solution increased (Solutions 1 through 3, Table 1), a 10% drop in total yield occurred. The percentage of unsalable flowers did not exceed 5% until the highest concentration (2750 mhos, Solution 3) was reached. At the highest concentration, average stem length and weight was significantly reduced. None of the flowers cut in this series were chlorotic.

Generally, high total concentration of a "balanced" solution did not reduce production as much as "unbalanced" solutions of the same concentrations. At comparative high concentrations, the "unbalanced" solutions caused 10 to 28% lower yield than the "balanced" treatments. Adding sodium sulfate (Na_2SO_4) to the solutions (Solutions 4 through 6) caused a rapid decrease in yield (Figures 1 and 2). Both Na and SO_4 are common in Colorado wells. But, no chlorosis was noted. When bicarbonate (HCO_3) was added to the solution (Solutions 7 through 9), decreased yield was most serious of any of the treatments. With 2 meq/l HCO_3, yield was within 5% of the control, but chlorosis became readily apparent, and the most severe effect of HCO_3 was on quality (Figures 1 and 2). The number of unsalable flowers was nearly three times that for the control (Solution 1) for all HCO_3 treatments. All treatments with HCO_3 significantly reduced stem length and weight. Comparisons of Na and HCO_3 alone and in combination suggested that these two ions have a synergistic effect. Greater reductions in yield and quality occur with the two together than either alone.

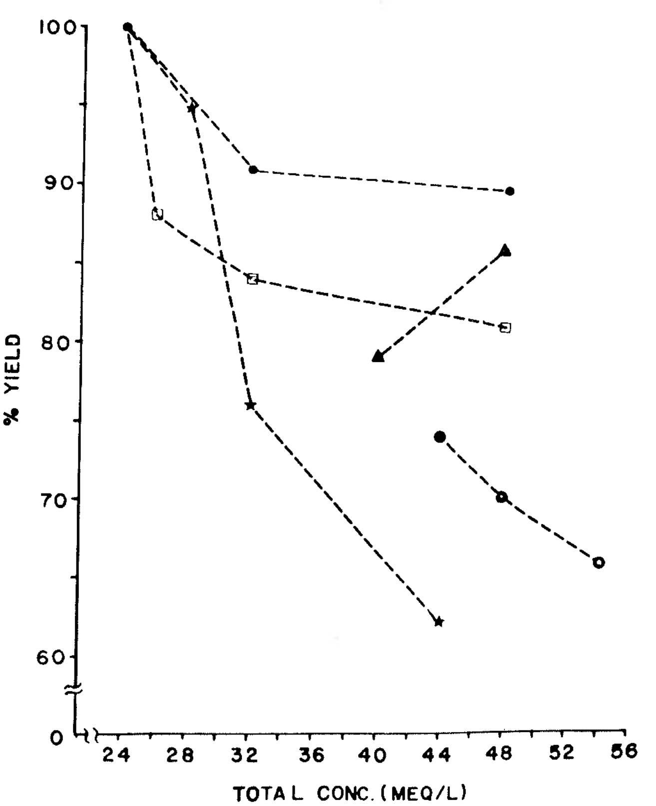

Fig. 2: Yield of Forever Yours roses expressed as a percentage of the control solution in Experiment 1. Each point represents the treatment number of that series. Composition of the salinity treatments given in Table:
- *● — Concentration series balanced.*
- *□ — Sodium sulfate series. (Na_2SO_4)*
- *★ — Sodium bicarbonate series. ($NaHCO_3$)*
- *▲ — Calcium-Magnesium Imbalance, no sodium.*
- *○ — Calcium-Magnesium Imbalance, sodium bicarbonate added.*

Solutions 10 through 14 represented the Ca-Mg concentrations often found in shallow wells. In all cases, total yield was well below Solution one (control). As total concentration increased (Solutions 10 and 11), yield and percentage of flowers suprisingly increased. Note, however, that the proportions of Ca and Mg were reversed (Table 1), 10 meq/l Ca and 5 Mg for Solution 10 at 2220 μmhos, compared to 5 Ca and 10 Mg in Solution 11 at 1750 μmhos total salt. On the other hand, when Na and HCO_3 were added (Solutions 12 through 14), increasing concentrations resulted in greatly reduced yield and more unsalable flowers. Chlorosis was a severe problem. The Ca-Mg ratio appeared to be critical in a saline solution. Chlorosis was substantially reduced as the concentrations of Ca and Mg were brought closer to control Solution one.

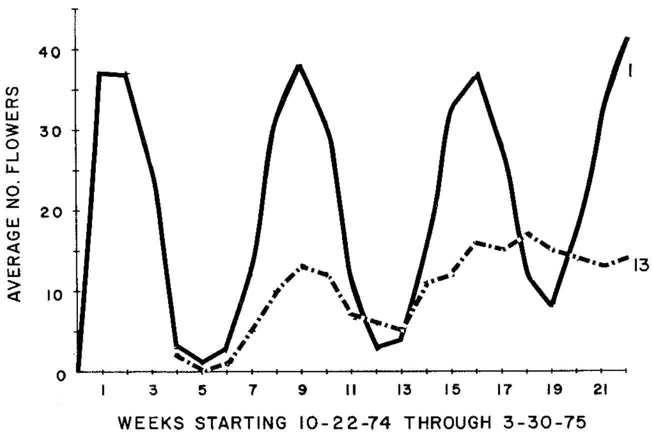

Fig. 3: Effect of extreme treatments on average number of flowers produced per week per treatment. Comparison between Treatment 1, control, and Treatment 13, containing 5 meq l^{-1} Na, 7 SO_4, 6 HCO_3, 8 Ca, and 5 meq l^{-1} Mg.

Summary

The results confirm the sensitivity of roses to salinity. Depending upon characteristics of the water supply, net production was reduced 10 to 50% when electrical conductivity of the irrigation water exceeded 1300 μmhos/cm. If the respective ions in solution were kept balanced, no loss occurred until about 1600 μmhos/cm. Bicarbonate is the most toxic of all non-nutrient ions. Concentrations over 2 meq/l (112 ppm) can reduce production by as much as 20% compared to a "balanced", non-saline, irrigation water. Chlorosis was the major problem when HCO_3 was added to the water. The sulfate ion did not appear to have a specific effect, but the use of sulfate-containing fertilizers would increase total salinity with resultant effect on yield.

It is important to remember that HCO_3, Na and SO_4 are commonly found in Colorado water supplies, along with Mg and Ca. Therefore, it is important to know what is in the water prior to injecting additional fertilizers.

The second year's experiment will be presented in Part II.

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