Bulletin 453
March 1988
Edited by Joe J. Hanan

research bulletin

Published by the Colorado Greenhouse Growers' Assoc., Inc. in cooperation with Colorado State University

Colorado State University

MANIPULATION OF NUTRITION USING A SALTY WATER

Joe J. Hanan[1]

More than 30 years of nutrition and salinity work at Colorado State University were summarized in CGGA Bulletin 413, with some basic work on leaching common greenhouse soils by Kerr in Bulletin 402. In just the past year, there has been increasing realization that improper nutrient injection — the most common fertilization practice in greenhouse production — can seriously reduce quality and yield. Under these conditions, water and fertilizer costs are not cheap. In particular, the majority fail to account for what is present in their raw water supply, and economic production is often achieved through expensive trial and error. Precision nutrient regulation can only be obtained through the use of basic physical units which allow one to manipulate injection on sound physical principles. Only in the past few years have we suggested that growers should test their water on a monthly basis. Water quality can change radically over the year.

For example, a commercial greenhouse range, situated in the South Platte River Valley, and using a shallow well, recently forwarded the results of their water analyses for a full year. We have plotted the total salinity in **Fig. 1** showing a range from 936 micromhos/cm (RD-15 reading=94×10^{-5} mhos/cm) in November to a maximum of 1474 μmhos/cm (147×10^{-5} mhos/cm) in May. Although one year's data is insufficient to definitely state this is the pattern to be found for shallow wells in the South Platte River Plain, the change, in general, accords with what could be expected when the water is directly influenced by leaching from irrigated fields. This means, obviously, large changes in some individual ion concentrations such as calcium, sodium and nitrate (Fig. 2). The fact that this is the first water analyses we have seen with significant concentrations of ammonium indicates the rapidity of movement from surface irrigation into the water table from which the greenhouse pumps.

As noted in **Fig. 2**, nitrate (NO_3^-) can reach 2.5 milliequivalents per liter (meq/1) which is equivalent to 35 ppm nitrogen. Calcium, in this test series, varied from 80 to nearly 160 ppm. One can appreciate that a nutrient recommendation for injection, based upon a single water analysis, can be highly dangerous, and the grower is continually fighting problems of unsatisfactory nutrition and salt control. The variability of this particular water supply should give one concern about herbicide damage. For example, 2,4-D from off a corn field which may get into this water supply quite easily. There have been several instances of weed killer damage in contaminated water supplies in Colorado.

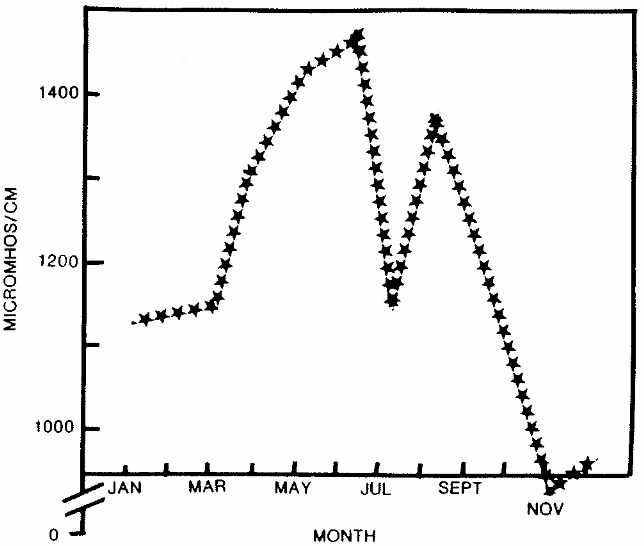


Fig. 1: Variation in total salinity in a shallow well in the South Platte River Valley over one year.

---

[1] *Professor.*

This bulletin is published in cooperation with Colorado State University Experiment Station and Cooperative Extension Service. The information given here is supplied with the understanding that no product discrimination is intended and that no endorsement of a product is implied. This bulletin is mailed as a service to grower members and associate members of the association. The cost to non-members is $5.00 per copy. For information regarding membership or back copies contact the Colorado Greenhouse Association, 2785 N. Speer Blvd., #230, Denver, CO 80211. When ordering, request bulletin by its number, Library of Congress ISSN 0889-8642.

The Colorado State University recommendations for nutrient injection in a **good** water supply are:

Calcium	3.0 meq/1	(60 ppm Ca)
Magnesium	2.0 meq/1	(24 ppm Mg)
Potassium	6.0 meq/1	(234 ppm K)
Ammonium	2.5 meq/1	(35 ppm N)
Nitrate	10.4 meq/1	(146 ppm N)
Sulfate	2.0 meq/1	(32 ppm S)
Phosphate	1.1 meq/1	(34 ppm P)

Fort Collins water usually has a basic salt level of 100 micromhos/cm (10×10^{-5} mhos/cm) with about 0.5 meq/1 bicarbonate. Since we use phosphoric acid, this generally results in a pH after injection of 6.5 with a total salt level of 1200 to 1400 μmhos/cm ($120\text{-}140\times10^{-5}$ mhos/cm). During certain times of the year, bicarbonate can disappear with a consequent reduction of pH to below 4.0 after injection (CGGA Bul. 426).

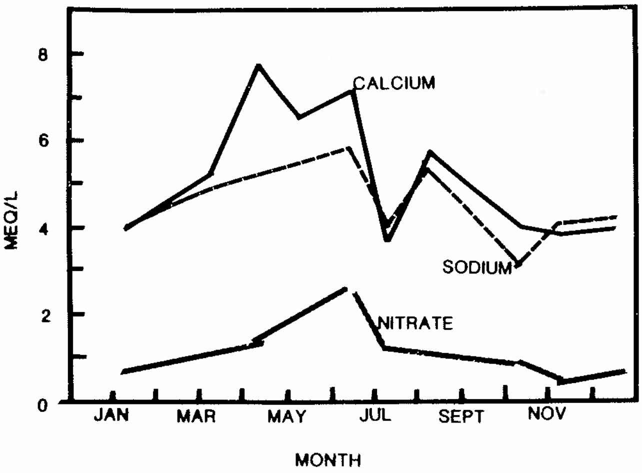


Fig. 2: Variation in calcium, sodium and nitrate concentrations in a shallow well in the South Platte River Valley over one year. Parts per million concentrations can be calculated by multiplying the meq/1 amounts by 20 for calcium, 32 for sodium and 62 for nitrate. To convert NO_3^- to N divide by 4.425.

Based upon these suggestions, which have been in use at the Colorado State University research range for the past 20 years, **Tables 1** and **2** are suggested possibilities for nutrient injection when total salts are 936 μmhos/cm (Table 1) and when total salts are 1474 μmhos/cm (Table 2). Note that we have attempted to make use of what is in the raw water, and secondly, to get rid of the bicarbonate through acidification (phosphoric and nitric acids). Based upon previous work (CGGA Bul. 384) we estimate the total salinity of this solution at 1830 μmhos/cm (193×10^{-5} mhos/cm), although the U.S. Salinity Laboratory's data suggest total salts closer to 2000 μmhos/cm. Complete neutralization of bicarbonate (HCO_3^-) eliminates any buffering so that excess acid can rapidly lower pH. It is probably safer to put up with 0.5 meq/1 bicarbonate, or do not allow the pH to drop below 6.5.

In **Table 2**, adding the bare minimum of essential nutrients, with acidification, resulted in an estimated total salt reading of 2580 μmhos/cm. This is approaching the upper limit for successful irrigated agriculture (3000 μmhos/cm), and the amount of leaching must be increased significantly. Not less than 50% of the total water applied to a bench must pass through the root zone and be wasted. Or, the total water-holding capacity of the container must be replaced twice. The fertilized water in **Table 1** contains 153 ppm nitrogen from nitrate and 28 ppm nitrogen from ammonium. This is not too far from the 200 ppm N usually found in recommendations. In both tables, potassium concentration remains 234 ppm, whereas in **Table 2**, nitrogen from nitrate is 199 ppm. Ammonium is essential in waters of this type if calcium is to be available. Dry, preplant additions of limestone or calcium sulfate should still be made since the high sodium will tend to replace calcium on the soil colloids. Superphosphate may also be applied dry before planting. Excess phosphate, within limits, should not cause problems in most soil-based media. On the other hand, increasing phosphate in the injection solution will increase total salts unnecessarily.

It is unfortunate that this water will continue to cause problems regardless of what manipulations are made. Leaching with plain water cannot reduce total salts below what is in the water (936 to 1474 μmhos/cm). As nitrate is highly mobile, it will become deficient in a relatively short time with continued leaching. Sodium also competes with potassium uptake as well as replacing calcium on the soil colloids —

Table 1: Manipulation of a water supply for constant feed injection which has a basic total salinity of 936 micromhos/cm (94×10^{-5} mhos/cm)

	Milliequivalents/liter										
			Cations						Anions		
	H^+	Ca^{+2}	Mg^{+2}	K^+	Na^+	NH_4^+	NO_3^-	$H_2PO_4^-$	SO_4^{-2}	HCO_3^-	Cl^-
Raw water analysis		3.8	1.4	0.2	4.0	—	0.5	T	3.2	3.6	1.7
Potassium nitrate				5.8			5.8				
Phosphoric acid	1.0							1.0			
Nitric acid	2.6						2.6				
Ammonium nitrate						2.0	2.0				
Total	—[a]	3.8	1.4	6.0	4.0	2.0	10.9	1.0	3.2	—[a]	1.7
Total cations-anions			17.2			+			16.8		= 34.0

[a] Bicarbonate (HCO_3^-) neutralized by acid (H^+ ion). May require some testing to reduce pH to between 6.5 and 7.0. 0.5 meq/1 bicarbonate may be desirable for buffering. pH control becomes critical when all HCO_3^- is eliminated. Estimated total salinity 1850 micromhos/cm. Trace element additions of boron and iron may be necessary, especially for carnations. Lack of 0.5 meq/1 to electrically balance cations-anions due to small amounts of other elements in solution.

eventually causing structural loss in soil-based media. Chlorine (Cl^-) approaches phytotoxic levels during the mid to late summer period. Sodium can also be accumulated to toxic levels in roses. Nonessential materials such as sodium and chlorine cannot be removed without desalinization through such processes as reverse osmosis, electrodialysis or deionization. Fluoride has also been found in this water which can cause serious problems with sensitive foliage plants. It is not necessary to remove all ions from the water supply, but if the total salinity could be reduced to below 700 μmhos/cm, and maintained consistently below that level, costs of fertilization and the amounts of water necessary would be significantly reduced and plant growth greatly improved.

Table 2: Manipulation of a raw water supply for constant feed injection which has a basic total salinity of 1474 micromhos/cm (147×10^{-5} mhos/cm)

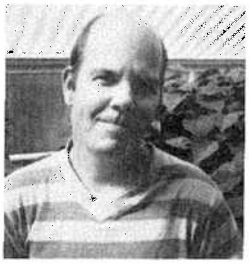
	Milliequivalents/liter										
			Cations						Anions		
	H^+	Ca^{+2}	Mg^{+2}	K^+	Na^+	NH_4^+	NO_3^-	$H_2PO_4^-$	SO_4^{-2}	HCO_3^-	Cl^-
Raw water analysis		7.1	2.6	0.3	5.8	—	2.5	—	5.5	5.0	2.6
Potassium nitrate				5.7			5.7				
Phosphoric acid	1.0							1.0			
Nitric acid	4.0						4.0				
Ammonium nitrate						2.0	2.0				
Total	—[a]	7.1	2.6	6.0	5.8	2.0	14.2	1.0	5.5	—[a]	2.6
Total cations-anions			23.5				+		23.3		= 46.8

[a] Bicarbonate (HCO_3^-) neutralized by 5.0 meq/1 acid (H^+ ion). Nitrate (NO_3^-) is high, might be better to leave 1.0 meq/1 HCO_3^- in water to reduce NO_3^- concentration. pH would be above 7.0. Estimated total salinity for this water 2580 micromhos/cm. Ammonium required to ensure calcium availability (NH_4^+).

NEW AND DEPARTING AT COLORADO STATE UNIVERSITY


Durkin


Elenes-Fonseca


Coker


Byong-Ryong


Harkess

We were pleased last fall to have Dr. Dominic Durkin, The Rutgers University, visit us for a week. Rose growers will recognize the name as one of the principal investigators on rose cut flower keeping. Dominic was interested in our use of acoustic emissions to evaluate water stress in roses. He spent most of his time, as shown, seated in our climate controlled greenhouses "listening" to roses cavitate. Hopefully, he may provide us with an article for the Bulletin in the future.

Crecencio Elenes-Fonseca finished his work for the M.S. Degree. You have seen his results in Bulletins 449 and 450. Crecencio was supported by the Mexican government. He returned to his job at the Center for Agricultural Investigations in Sonora last December.

Frank Coker, who came to us from The Stephen Austin University, Nacogdoches, Texas, also completed his thesis for the M.S. Degree on Effects of Greenhouse Covers and Shading on 'Samantha' Roses. You will be seeing his work in the Bulletin in the near future. Frank is now back in Texas, and he is planning to continue his work for a Ph.D. in the near future.

Both "Chenco" and Frank did their work in the "Heat Houses" at Colorado State University with very interesting results. We are proud to have had them here and wish them luck in their careers.

Jeong Byong-Ryong, a native Korean, came to us last fall via Oregon State University where he obtained his M.S. Degree. He is presently working on his dissertation for the Ph.D. under the direction of Dr. C.W. Lee. His work deals mostly with flowering pot plants, their nutrition, and production in soilless substrates. No doubt you will be hearing from him in the future.

Richard Harkess received his B.S. Degree from the University of Minnesota, and worked for Harold Wilkins. Richard has had considerable practical experience, having worked for Ecke Poinsettias, and served as intern in commercial ranges in Denmark. He will be "listening" to roses in the "Heat Houses", trying to get some idea of cavitation variability in roses.

FORT COLLINS GREENHOUSE CLIMATOLOGICAL SUMMARY FOR FIVE WEEKS, BEGINNING DECEMBER 27, 1987.

(See Bulletin 426 for details.)

	Week beginning									
	Dec. 27		**Jan. 3**		**Jan. 10**		**Jan. 17**		**Jan 24**	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Average outside temperature (°F)	23	15	14	7	35	28	28	22	40	29
Maximum outside temperature (°F)	42	43	25	22	60	54	43	52	56	47
Minimum outside temperature (°F)	4	-3	1	-5	17	7	16	1	17	7
Degree-days of heating	42	50	51	58	30	37	37	43	25	36
Accumulated total solar radiation (MJ/sq.m.)	53	1	47	1	49	1	53	1	63	1
Average relative humidity (%)	62	80	71	77	46	54	53	62	44	59
Maximum relative humidity (%)	88	98	91	90	84	85	95	91	70	86
Minimum relative humidity (%)	21	29	44	40	14	20	27	26	23	21
Average absolute vapor pressure (mb)	3	3	2	2	3	3	3	3	4	3
Average wind speed (mph)	2	2	1	1	6	4	7	4	4	2
Maximum wind speed (mph)	29	29	8	10	50	50	14	54	40	32
Average CO_2 concentration (Pascal)	30	0	44	0	37	0	36	0	38	0
Maximum CO_2 concentration (Pascal)	40	0	63	0	49	0	47	0	46	0
Accumulated gas consumption (cu.ft./sq.ft.)	61	167	75	182	53	135	78	154	50	119

cga

Editor
Department of Horticulture
Colorado State University
Fort Collins, Colorado 80523
Bulletin 453

NONPROFIT
ORGANIZATION
U.S. POSTAGE
PAID
Fort Collins, Colorado 80523
Permit Number 19