HortScience 33(2):247–250. 1998.

Impact of Salinity and Media on Growth and Flowering of a Hybrid *Phalaenopsis* Orchid

Yin-Tung Wang

Department of Horticultural Sciences, Texas A&M University System Agricultural Research and Extension Center, 2415 East Highway 83, Weslaco, TX 78596

Additional index words. pH, electrical conductivity, potted plants, mineral analysis, nutrition

Abstract. **The effects of water salinity [0.05, 0.40, 0.75, 1.10, and 1.40 dS·m^{-1} of electrical conductivity (EC)] on *Phalaenopsis* orchids grown in 100% fine-grade fir bark or a combination of 80% bark and 20% sphagnum peat were studied. In both media, flower diameter decreased slightly as salinity increased. Plants in bark had more flowers as salinity increased, but had fewer flowers than those grown in bark/peat. In either medium, salinity had no effect on the number of new leaves produced. As salinity increased, plants in bark had increasingly larger total leaf area, with a maximum at EC = 1.10 dS·m^{-1}. Leaf area of plants in bark/peat was greater than that of those in bark, but was unaffected by salinity. Root fresh mass was lower with increasing salinity in both media. Media had no effect on mineral concentration in the leaf. In bark, increasing salinity increased the Ca and Na concentrations but had no effect on the concentration of other minerals in leaves. As salinity increased in the bark/peat medium, leaf concentrations of P, Fe, and Cu decreased and those of K, Ca, Mg, Na, and Zn increased, but the concentration of N was unaffected by salinity. Leachate from bark/peat had twice the EC and lower pH (4.9) than bark (5.7).**

Millions of *Phalaenopsis* orchids are produced as potted blooming plants (Griesbach, 1995). In their natural habitats in tropical and subtropical areas, these orchids grow on tree trunks or limbs under heavy leaf canopy. Their roots are exposed to and depend on rain and dew for moisture supply, hence these roots are not exposed to water with high salt content. Thus, these plants may be less tolerant to increased salinity than many terrestrial plant species (Miles, 1982).

How increased salinity influences the performance of the *Phalaenopsis* orchids is difficult to assess because research has been limited. Earlier reports provided a wide range of electrical conductivity (EC) for *Phalaenopsis*, between 0.63 and 3.8 dS·m^{-1}, measured in leachate samples collected from various media used for growing *Phalaenopsis* (Wang, 1996; Wang and Gregg, 1994). The flower count on *Cymbidium* orchid spikes was unaffected by increasing EC from 0.6 to 1.4 dS·m^{-1}, but plants produced more spikes per square meter of growing area as salinity increased (de Kreij and van der Berg, 1990). The results on *Cymbidium* may be a function of increasing fertility because the change in EC was solely due to the increased fertilizer concentration.

Artificial saline water is often used to assess the effect of salinity on crop performance, often at levels exceeding that commonly found in nurseries (Awang and Atherton, 1994; Compos and Reed, 1994; Nolan et al., 1982; Taylor et al., 1987). In addition, the artificial saline water lacks many minerals present in irrigation water. Consequently, the results of experiments using solely sodium chloride or a combination of sodium and calcium chloride to create salt stress may vary from those using water containing a variety of minerals, particularly over an extended growing period.

The objective of this study was to determine the effect of irrigation water salinity on vegetative growth, flowering, and leaf mineral concentration of *Phalaenopsis* grown in media differing in water and nutrient-holding capacities. Changes in medium pH and EC were also monitored during the course of this experiment.

Materials and Methods

'TAM Butterfly' hybrid *Phalaenopsis* orchid (*Phalaenopsis* Taisuco Eagle x *Phalaenopsis* Taisuco Rose) were seed-propagated on 6 Sept. 1992 under aseptic conditions. Seedlings measuring 15 to 18 cm in leaf spread were potted in 0.6-L pots on 21 Mar. 1994 in either 100% fine-grade fir bark or in a mix of 80% fine-grade fir bark : 20% sphagnum peat (by volume). To each liter of both media, 0.25 g Micromax (Scotts, Marysville, Ohio), 3.0 g powdered dolomitic limestone, and 0.93 g AquaGro wetting agent (Aquatrols of America, Pensauken, N.J.) were added and mixed into the media prior to potting.

The uppermost leaf of each plant was marked so new leaves could be counted. Plants were irrigated with reverse osmosis (R.O.) water mixed with either 0%, 25%, 50%, 75%, or 100% tap water, creating solutions with EC of 0.05, 0.40, 0.75, 1.10, and 1.40 dS·m^{-1}, respectively. The tap water had a pH between 7.2 and 7.4 and the concentrations of the major minerals are shown in Table 1. For three consecutive irrigations, 1.0 g·L^{-1} of a soluble 20N–8.7P–16.6K fertilizer (Scotts) was added to each treatment solution, raising EC levels of each salinity treatment by an additional 0.8 dS·m^{-1}. For the fourth irrigation, calcium nitrate at 100 mg·L^{-1} Ca^{2+} was used in place of the soluble fertilizer to avoid potential Ca deficiency, particularly in those plants irrigated with water containing less minerals. The above cycle was repeated throughout the experiment. At each irrigation, 180 mL of treatment solution was applied evenly on the surface of the medium in each pot and the excess solution was allowed to drain from the pot. Photosynthetic photon flux, measured at solar noon, varied from a maximum of 385 (Apr. 1994) to a minimum of 222 (Jan. 1995) μmol·m^{-2}·s^{-1} on clear sunny days. Soon after potting, many plants produced flowering spikes that were removed.

At monthly intervals between Mar. and Dec. 1994 and in Mar. 1995, ≈30 mL samples of leachate were collected from five random pots of each treatment using the pour-through technique (Yeager et al., 1983). The EC and pH of each sample were immediately determined.

Dates of spiking (the protrusion of an elongating flowering shoot through the base of the subtending leaf) in the fall and opening of the first flowers were recorded. Flower count, diameter of the first flower, number of new leaves, leaf drop, area of the largest leaf, and total leaf area were determined for each plant. The fresh mass of shoot and roots were measured separately.

The second acropetal mature leaf was collected from each of five randomly selected plants in each treatment of both media. Leaves were washed in a dilute detergent and rinsed under running tap water, followed by three rinses in distilled water. These leaves were

Table 1. Concentrations of major ions in the municipal water used for preparing solutions of various levels of salinity.

pH	Electrical conductivity (dS·m^{-1})	N	P	K	Ca	Mg	Na	B	Zn	Cl
		(mg·L^{-1})								
7.2	1.44	0	0.06	4.4	51.3	18.2	132	0.2	0.1	140

Received for publication 4 Nov. 1996. Accepted for publication 21 July 1997. The costs for mineral analyses were defrayed by donations from several orchid societies and individuals in the United States. The excellent technical assistance of Lori L. Gregg is highly appreciated. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

dried at 70 °C in a forced-air oven for 3 d, ground into a fine powder, and analyzed for concentrations of minerals (Scotts Testing Laboratory, Allentown, Pa.).

The experiment was a randomized complete-block design with 30 single plant replications per treatment. Data were subjected to linear and quadratic regression analyses using irrigation water EC as the independent variable. The F test was used to compare mean values for the two media.

Results

In 100% bark, plants irrigated with 0.75 $dS \cdot m^{-1}$ EC water flowered later than plants receiving water with either higher or lower salinity (Table 2). Plants grown in the bark/peat medium were unaffected by salinity and generally bloomed earlier than those in the bark medium.

In both media, flower diameter decreased slightly as salt concentration in the water increased (Table 2). Plants in bark produced increasingly more flowers as salinity increased, whereas those in the bark/peat medium were unaffected. Plants grown in bark/peat produced substantially more flowers than those in bark alone.

In both media, salinity had no effect on leaf production. However, increasing salinity promoted the abscission of lower leaves. Plants grown in the bark medium had larger total leaf area and shoot fresh mass as salinity increased, reaching a maximum at EC = 1.10 $dS \cdot m^{-1}$. Further increases in salinity restricted leaf expansion (Table 2). Increasing salinity had no effect on total leaf area of plants grown in the bark/peat medium. However, shoot fresh mass declined at higher salinity levels, probably because of the collective effects of slightly smaller or thinner leaves at the higher salinity levels.

In general, the addition of 20% sphagnum peat to fir bark resulted in increased leaf number, total leaf area, and shoot fresh mass than plants in the 100% bark medium (Table 2). Root fresh mass decreased with increasing salinity in both media. Severe root dieback occurred on plants grown in bark/peat and irrigated with 1.40 $dS \cdot m^{-1}$ water.

There was an interaction between medium and water salinity on leaf mineral concentration. When plants were grown in 100% bark, water salinity had no effect on the concentration of most minerals in the leaf (Table 3), except that the concentrations of Ca and Na increased with increasing salinity. For plants grown in bark/peat, concentrations of N, Mn, and B in the leaves were unaffected by salinity (Table 3). As salinity increased from 0.05 to 1.40 $dS \cdot m^{-1}$, tissue P, Fe, and Cu concentrations decreased, where concentrations of K, Ca, Mg, Na, and Zn increased. The largest change in concentration was Na, increasing from 2350 $mg \cdot kg^{-1}$ dry mass at 0.05 $dS \cdot m^{-1}$ to an average of 13250 $mg \cdot kg^{-1}$ dry mass at 1.40 $dS \cdot m^{-1}$, regardless of the medium used for production. Medium had no effect in leaf mineral concentrations.

Between Mar. and Dec. 1994, the pH of all leachate samples from both media at all salinity levels declined (Table 4). The rate of decline was faster in bark/peat than bark alone, with a lower final pH in the former (5.1 to 4.7 vs. 5.9 to 5.5 in bark). In each medium, pH increased with salinity in certain months. Salinity had no effect on pH after May in the bark

Table 2. Effects of irrigation water salinity on growth and flowering of the *Phalaenopsis* orchids grown in either fine fir bark or a mixture of 80% fine fir bark : 20% sphagnum peat (by volume). Soluble fertilizer contributed an additional 0.8 $dS \cdot m^{-1}$ to each EC treatment.

Water EC ($dS \cdot m^{-1}$)	Bloom date	Flower diam (cm)	Total flower no.	No. new leaves	Leaf drop	Area of largest leaf (cm^2)	Total new leaf area (cm^2)	Fresh mass (g) Shoot	Fresh mass (g) Root
				In bark					
0.05	4 Feb.	9.63	26.8	5.8	0.00	182	746	188	100
0.40	9 Feb.	9.74	28.1	5.8	0.00	196	775	220	89
0.75	14 Feb.	9.58	28.6	6.0	0.00	199	814	218	76
1.10	6 Feb.	9.44	35.6	6.1	0.04	209	911	236	71
1.40	4 Feb.	9.23	31.0	5.7	0.32	223	757	203	77
Significance[z]	Q**	L**	L**	NS	L*	L*	Q**	Q*	L*
				In bark/peat					
0.05	31 Jan.	9.36	38.2	7.0	0.00	207	1014	272	93
0.40	1 Feb.	9.47	36.3	6.8	0.08	210	1041	271	72
0.75	28 Jan.	9.60	42.1	6.7	0.04	206	990	273	69
1.10	28 Jan.	8.93	39.1	7.1	0.20	192	990	265	81
1.40	31 Jan.	8.83	39.5	7.1	0.63	195	964	242	49
Significance[z]	NS	L**Q*	NS	NS	L***	NS	NS	L*	L*
Media	**	**	***	***	NS	NS	***	***	NS

[z]L and Q, linear and quadratic response, respectively.
NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Table 3. Effects of water salinity on concentrations of minerals in leaves of *Phalaenopsis* orchids grown in a medium consisting of either 100% fine fir bark or a mixture of 80% fine fir bark : 20% sphagnum peat (by volume). EC = electrical conductivity of the irrigation water.

Water EC	Concn (% dry mass)					Concn ($mg \cdot kg^{-1}$ dry mass)						
($dS \cdot m^{-1}$)	N	P	K	Ca	Mg	Na	Fe	Mn	Cu	Zn	Al	B
					In bark							
0.05	1.70	0.52	3.10	2.60	0.62	2327	23	284	5.9	30	33	44
0.40	1.79	0.57	3.86	2.91	0.66	6170	29	429	12.5	36	48	52
0.75	1.69	0.52	3.25	2.95	0.62	9313	25	346	4.4	18	43	52
1.10	1.64	0.54	3.23	3.19	0.53	10376	38	376	6.4	30	53	42
1.40	1.55	0.48	2.57	3.51	0.65	14007	24	351	3.9	49	40	46
Significance[z]	NS	NS	NS	L**	NS	L***	NS	NS	NS	NS	NS	NS
					In bark/peat							
0.05	1.59	0.59	3.86	2.46	0.48	2362	28	307	6.2	22	48	49
0.40	1.64	0.53	3.65	3.11	0.51	5100	24	343	3.9	25	48	41
0.75	1.54	0.41	3.03	3.01	0.50	7716	23	268	4.0	36	53	44
1.10	1.50	0.42	2.82	3.06	0.58	11122	22	284	3.4	55	49	51
1.40	1.52	0.38	2.39	3.18	0.68	12552	21	318	3.3	35	33	44
Significance[z]	NS	L***	L***	L*	L***	L***	L***	NS	L***	L*	Q*	NS
Medium	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS

[z]L and Q, linear and quadratic response, respectively.
NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Table 4. Effects of salinity on pH of leachate from two media used to produce *Phalaenopsis* orchids.

Water EC (dS·m⁻¹)	Leachate pH 1994 Mar.	May	July	Sept.	Nov.	Dec.	1995 Mar.
			In bark				
0.05	6.54	6.82	6.58	6.29	5.68	5.59	5.45
0.40	6.57	6.74	6.87	6.11	5.21	5.28	5.66
0.75	6.90	6.79	7.04	6.29	5.75	5.85	5.82
1.10	6.97	6.78	6.92	6.30	5.47	5.40	5.68
1.40	6.76	6.76	6.95	6.25	5.72	5.74	5.94
Significance[z]	L***Q**	NS	NS	NS	NS	NS	L*
			In bark/peat				
0.05	6.33	6.12	6.20	5.17	4.37	4.27	4.77
0.40	6.53	6.11	6.26	5.82	5.40	5.11	5.10
0.75	6.49	6.05	6.30	5.65	4.98	4.44	5.16
1.10	6.59	5.98	6.39	5.54	4.73	4.53	4.93
1.40	6.52	6.13	6.44	6.29	5.04	5.01	4.69
Significance[z]	L*	NS	L*	L***	NS	NS	NS
Media	***	***	***	***	***	***	**

[z]L and Q, linear and quadratic response, respectively.
NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Table 5. Effects of irrigation water salinity on EC of leachate from two media used to produce *Phalaenopsis* orchids.

Water EC (dS·m⁻¹)	Leachate EC (dS·m⁻¹) 1994 Mar.	May	July	Sept.	Nov.	Dec.	1995 Mar.
			In bark				
0.05	0.37	0.27	0.30	0.27	0.41	0.24	0.26
0.40	0.42	0.36	0.30	0.37	0.53	0.37	0.31
0.75	0.58	0.35	0.54	0.51	0.72	0.52	0.52
1.10	0.66	0.70	0.70	0.57	0.87	0.66	0.53
1.40	0.64	0.72	0.66	0.71	1.00	0.85	0.73
Significance[z]	L***	L***	L***	L***	L***	L***	L***
			In bark/peat				
0.05	0.62	0.78	0.63	0.62	0.82	0.59	0.64
0.40	0.81	1.02	0.85	0.96	1.00	0.97	0.88
0.75	0.90	1.12	0.98	1.07	1.17	1.13	1.14
1.10	1.08	1.38	1.24	1.17	1.48	1.45	1.44
1.40	1.09	1.56	1.42	1.73	1.64	1.74	1.65
Significance[z]	L***	L***	L***	Q***	L***	L***	L***
Media	***	***	***	***	***	***	***

[z]L and Q, linear and quadratic response, respectively.
***Significant at $P \leq 0.001$.

medium and after Sept. in the bark/peat medium.

As expected, regardless of which medium was used, leachate had increasingly higher EC when salinity of the irrigation water increased (Table 5). The leachate samples from the bark/peat had much higher EC than those from the bark medium during the course of this study.

Discussion

Although Thomas (1989) suggested that water with EC >0.2 dS·m⁻¹ is undesirable, in this study water with an EC as high as 1.10 dS·m⁻¹ produced good *Phalaenopsis* plants with large leaves and many flowers (Table 2). The most obvious adverse effect of increasing salinity was the degree of root injury, particularly at the highest salinity. As salinity increased, more roots died and became hollow. The injury first started at the root tips and progressed to the base. Roots of plants grown in 100% bark appeared to be more tolerant of the highest salinity level used in this experiment (greater fresh mass), possibly due to the retention of lower quantities of salts than that in the bark/peat medium (Table 5).

Regardless of salinity, the vigorous plants grew faster in a mixture of bark and sphagnum peat than in bark alone (Table 2). Since a rapid increase in leaf area shortens the juvenile period of this orchid (Lee, 1990), the accelerated plant growth in the bark/peat medium would be expected to shorten both production time and cost.

Campos and Reed (1994) found that increasing salt concentration (NaCl and CaCl) from 0 to 2000 mg·L⁻¹ did not affect N, K, Ca, and Mg concentrations in the leaf of *Spathiphyllum* Schott 'Petite' (a salt-sensitive plant). Although the *Phalaenopsis* foliar N and K levels were unaffected in this experiment, increased salinity resulted in elevated foliar Ca concentration in both media and higher Mg concentration in plants produced in the bark/peat medium. Nitrogen, Ca, and Mg levels in leaf tissues were similar to levels reported by Poole and Seeley (1978). Although the presence of high Ca may antagonize Mg uptake (Mengel and Kirkby, 1982), in both media, the increased leaf Ca concentration was not associated with decreased Mg levels in either medium (Table 3).

The decreased foliar P level from 0.59% to 0.38% (a 36% decline) as the result of increased salinity (Table 3) affected neither flower count nor flowering date when plants were grown in bark/peat (Table 2). Wang (1996) reported that when *Phalaenopsis* plants were grown in a mixture of 70% fir bark and 30% peat, flower number and size were unaffected by fertilizer solutions having a 12-fold difference in P concentrations. Plants used in this study received P at 87 mg·L⁻¹ from the fertilizer solutions. The leaf P concentrations found in this study (Table 3) were much higher than those (≈0.1% to 0.15%) reported by Gomi et al. (1980) when tiny plantlets were supplied with P at 15.5 mg·L⁻¹. Poole and Seeley (1978), who supplied P at 20 mg·L⁻¹ in a nutrient solution that was used to soak the roots three times daily, found 0.24% to 0.29% P in leaf tissue of small plants. However, neither paper reported which leaves were sampled and their plants did not bloom due to their small size. Consequently, the P levels in these plants cannot be related to flowering characteristics.

Plants grown in bark alone or in bark/peat had similar levels of all nutrients, except for Mn, which was slightly higher when produced in bark. Differences in pH between the two media (Table 4) did not result in differences in leaf nutrient concentration. This suggests that nutrient absorption by the *Phalaenopsis* orchid was unaffected by the range of pH found in this study. Due to their much larger mass, plants in bark/peat absorbed a greater amount of each mineral.

The progressively smaller flowers with increased salinity confirmed the results of a previous report (Wang, 1995), but this effect has no apparent commercial significance. Decreased yield of *Dendrobium* sprays at high fertilizer rates was attributed to the increased salt level in the root zone (Imamura et al., 1986).

Fresh fir bark is hydrophobic and does not retain water well (Arp, 1980). Plants grown in bark medium often have less than adequate moisture supply during the first several weeks, resulting in stressed plants with slow initial growth and a final size of 80% of those grown in bark/peat (Table 2). The increased retention of water (as judged by pot mass) and nutrients (as indicated by high EC values) in the bark/peat medium may have increased plant vigor and growth.

Literature Cited

Arp, G.K. 1980. Red lava rock—A reasonable substitute for fir bark. Bul. Amer. Orchid Soc. 49:1384–1386.

Awang, Y.B. and J.G. Atherton. 1994. Salinity and shading effects on leaf water relations and ionic composition of strawberry plants' growth on rockwool. J. Hort. Sci. 69:377–383.

Campos, R. and D.W. Reed. 1994. Influence of irrigation water salinity on optimal nitrogen, phosphorous, and potassium liquid fertilizer rates for *Spathiphyllum* 'Petite'. J. Environ. Hort. 12:104–107.

de Kreij, C. and T.J.M. van den Berg. 1990. Effect of electrical conductivity of the nutrient solution and fertilization regime on spike production and quality of *Cymbidium*. Scientia Hort. 44:293–300.

Glomi, K., Y. Ogino, and T. Tanaka. 1980. Fertilization and potting media for *Phalaenopsis* hybrid. Bul. Faculty Agr., Miyazaki Univ., Japan.

Griesbach, R.J. 1995. A *Phalaenopsis* in every pot. Orchid Dig. 59(1):42–43.

Imamura, J.S., T. Higaki, and J. Kunisaki. 1986. Interactions of culture, medium, and fertilizer on *Dendrobium* Jaquelyn Thomas. College of Trop. Agr. and Human Resources Res., Ser. 050, Univ. of Hawaii.

Lee, N. 1990. Forcing culture of *Phalaenopsis* in Taiwan. Food and Fert. and Tech. Ctr. Book Series No. 41:169–176.

Mengel, K. and E.A. Kirkby. 1982. Principles of plant nutrition. 3rd ed. Intl. Potash Inst., Bern, Switzerland.

Miles, K. 1982. Growing equitant Oncidiums. Bul. Amer. Orchid Soc. 51:155–169.

Nolan, S.L., T.H. Ashe, R.S. Lindstrom, and D.C. Martens. 1982. Effect of sodium chloride levels on four foliage plants grown at two light levels. HortScience 17:815–817.

Poole, H.A. and J.G. Seeley. 1978. Nitrogen, potassium and magnesium nutrition on three orchid genera. J. Amer. Soc. Hort. Sci. 103:485–488.

Taylor, R.M., L.B. Fenn, and C.A. Pety. ^{15}Nitrogen uptake by grapes with divided roots growing in differentially salinized soils. HortScience 22:664.

Thomas, W. 1989. Growing orchids in rockwool. Bul. Amer. Orchid Soc. 58:1212–1219.

Yeager, T.H., R.D. Wright, and S.J. Donohue. 1983. Comparison of pour-through and saturated pine bark extract N, P, K, and pH levels. J. Amer. Soc. Hort. Sci. 108:112–114.

Wang, Y.T. 1995. Medium and fertilization affect performance of potted *Dendrobium* and *Phalaenopsis*. HortTechnology 5:234–237.

Wang, Y.T. 1996. Effects of six fertilizers on vegetative growth and flowering of *Phalaenopsis* orchids. Scientia Hort. 65:191–197.

Wang, Y.T. and L.L. Gregg. 1994. Medium and fertilizer affect the performance of *Phalaenopsis* during two flowering cycles. HortScience 29:269–27.