

EFFECT OF IRRIGATION WATER SALINITY ON POSTHARVEST PERFORMANCE OF
CYCLAMEN GROWN ON ROCK WOOL AND POTTING COMPOST

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Abstract

The effect of four levels of salinity of the irrigation water on plant performance of cyclamen grown on rock wool and potting compost was studied in a trial that included thirteen weeks of postharvest life. To obtain varying irrigation water salinity, salts similar to those in surface water were added to desalinized water in increasing amounts. After adding nutrients, the electrical conductivity (EC) of the four waters was 2.0, 2.8, 3.6 and 4.3 mS/cm at 25 °C, while the chloride contents were 0, 160, 320 and 480 mg/l.

At the marketable stage, plant quality showed a slight decrease at an irrigation water salinity higher than 2.8 mS/cm. So did plant fresh and dry weight at the end of the experiment, only more so.

Neither weekly flowering performance nor flower yield over the entire postharvest period showed a significant response to irrigation water salinity. Irrigation water salinity was increasingly deteriorative to leaf colour and new bud formation. Analytical data of both root medium and plant tops reflected clearly increasing levels of irrigation water salinity. Mineral contents of the plant suggest that beside osmotic effects, too high a pH and excess of sodium and chloride contribute to the salt injury occurring in the trial.

Finally, the present study focused attention on the risk of unfavourable postharvest conditions in promoting rapid build-up of salts, thereby enhancing the detrimental effects of irrigation water salinity on plant performance.

Introduction

Saline irrigation water is known to be a common cause of poor postharvest performance of pot plants, but little quantitative information is available on this subject.

The purpose of this study was to determine in what way and to what degree postharvest performance of cyclamen responds to salinity of irrigation water.

Materials and methods

The trial included two substrates, factorially combined with four levels of salinity of irrigation water. The two substrates were:

1. Blocks of rock wool (RW) measuring 10 × 10 × 10 cm.
2. Potting compost (PC) consisting of 3 parts by volume of sphagnum peat moss and 1 part by volume of granulated polyurethane lined with 3 g of dolomitic limestone per litre up to an initial pH of 6.0; this mixture was used in 0.6-litre clay pots.

The composition of the four irrigation waters used is presented in Table 1.

The first one is desalinated water. The composition of the second, third and fourth irrigation water was derived from that of the surface water in the Western part of The Netherlands, which usually contains about 5.18 meq Na^+ , 6.22 meq Ca^{2+} , 2.08 meq Mg^{2+} , 6.2 meq Cl^- , 3.11 meq HCO_3^- and 4.13 meq SO_4^{2-} per litre.

The ratio among the different ionic constituents in the three irrigation waters was kept equal to that for the surface water. To feed the plants, a nutrient solution commonly used in rock wool culture was added to each of the four irrigation waters. This solution, made up of 0.833 g Nutriflora-t 2 + 11 + 40 (a commercial fertilizer from Windmill Holland B.V., Vlaardingen) and 1 g calcium nitrate per litre, contains 7 meq K^+ , 11 meq Ca^{2+} , 1 meq Mg^{2+} , 12 meq NO_3^- , 1 meq H_2PO_4^- , 6 meq SO_4^{2-} , 0.6 mg Fe (as DTPA), 1.1 mg Mn, 0.35 mg B, 0.25 mg Zn, 0.058 mg Mo and 0.017 mg Cu per litre. This solution raised the EC-value of the first, second, third and fourth irrigation water to 2.0, 2.8, 3.6 and 4.3 mS/cm, respectively.

Four-months' old cyclamen seedlings were set out in the above substrates on 7 June 1978 and raised at the Research Station at Aalsmeer. When marketable, which was on 2 November 1978, the plants were transferred to a glasshouse at the Institute for Soil Fertility at Haren in which they were kept until 1 February 1979 to be tested for postharvest performance. Day temperature was held between 22 and 24 °C, night temperature at 18 °C and relative air humidity at 60%. These climatic conditions were assumed to approach approximately those prevailing in the living room. The irrigation waters were applied throughout the whole trial period. The trial treatments were replicated five times (1 unit = 3 pots).

When marketable, plant quality was rated on a scale: 3 = very poor; 5 = insufficient; 7 = fair; 9 = very good.

Leaf colour was rated on 22 December 1978 and 18 January 1979 on a scale: 1 = light; 3 = dark.

For an evaluation of flowering performance, an obvious criterion of cyclamen ornamental value, the number of good flowers per plant was recorded weekly during the postharvest period.

On 22 December 1978 and 18 January 1979, intensity of flowering was rated on a scale: 0 = no flowers; 10 = abundance of flowers and, in addition, intensity of new bud formation on a scale: 0 = no buds, 10 = abundance of buds. Also flower yield over the entire postharvest period was determined.

On 1 February 1979 the aerial parts of the plants were harvested and measured for plant fresh and dry weight.

It should be noted that establishment of the plants on transplanting into the rock wool blocks was rather slow. Because of this delay in growth the plants grown in rock wool were, on the average, inferior to those grown in potting compost. Actually, the poor establishment of the plants on transplanting from the seed compost into the rock wool blocks is one of the major problems remaining to be solved in the rock wool culture of cyclamen.

Results

Table 2 shows that response of plant growth at the marketable stage to the salinity of the irrigation water was not very pronounced. Nevertheless it was found to be significant, average plant quality starting to decline at an EC of 2.8 mS/cm in the irrigation waters. A more marked influence of the salts in the irrigation water was shown by the plant fresh and dry weight at the termination of the trial (Table 2), both declining sharply at a salinity of the irrigation water higher than 2.8 mS/cm.

Dry-matter content of plant tops was not affected by the treatments. Neither weekly flowering performance nor flower yield over the entire postharvest test period showed a significant response to the irrigation water salinity (Table 3). Accordingly, it was absent in both flowering intensity ratings. New bud formation (Table 4) on 22 December 1978 did not respond to the salts in the irrigation water. It clearly did so, however, on 18 January 1979, showing a sharp reduction at EC-levels in the irrigation water over 3.6 mS/cm.

At the marketing stage, leaf colour was not visibly affected by irrigation water salinity. In the course of the postharvest test, however, a salinity effect on leaf colour became more and more apparent, indicating that salt injury was steadily aggravating (Table 4). On 22 December 1978 the salt level of the irrigation water at which the foliage started to yellow was 3.6 mS/cm; about four weeks later this threshold value was as low as 2.8 mS/cm.

As for substrate effects, plants grown on potting compost were distinctly superior to plants grown on rock wool in quality, size, weekly flowering performance and flower production. This is chiefly due to the growth delay that the plants grown on rock wool suffered in the beginning of the trial.

Salinity in the root medium increased with the increasing salt levels in the irrigation water. At the marketable stage (Table 5) this effect was not very large; the salinity in the root medium with the most saline irrigation water may still be regarded as moderate. This explains the relatively small response of plant growth to irrigation water salinity. To make a comparison of the EC-values found for both substrates possible, firstly, it may be assumed that the rock wool leachate closely resembles a saturation extract and, secondly, the EC-values for the 1 : 1½-volume extract of the potting compost should be converted into those for the saturation extract, which can be effected by multiplying them by a factor of 2.6 (Arnold Bik and Boertje, 1975). This gives saturation extract values of 2.6, 4.9, 5.7 and 7.0 mS/cm for the irrigation waters 1, 2, 3 and 4, respectively. These values practically coincide with those found in the rock wool leachate. It was noted earlier that plant quality at the marketable stage declined from the irrigation water second lowest in salts and upwards. This limit corresponds to an average EC-value of 4.1 mS/cm in the rock wool leachate (assumed to be identical with a saturation extract) or 4.9 mS/cm in the potting compost saturation extract. These limits agree well with the ones found earlier for gloxinia (Arnold Bik, 1970).

Table 5 also shows that a more saline irrigation water also resulted in a higher pH and a higher chloride content. A pH-value of 8.0 may be rated as exceptionally high in potting compost.

An immense build-up of salts in the root medium must have occurred during the first eight weeks of the postharvest test period, as is evident from the data of Table 6, showing the analytical results of the leachates of both substrates on 29 December 1978. Root medium salinity was far beyond the maximum allowable, even in the irrigation water lowest in salts. Furthermore, an enhancement of the effect of irrigation water salinity is apparent, since the rate of increase in the EC-values of the leachate with increasing salt levels in the irrigation water is far steeper than eight weeks earlier. The increase in salt injury, as was evident from the steady deterioration of leaf colour, may undoubtedly be attributed to this salt accumulation. Apparently, the conditions during the postharvest period were much more conducive to a build-up of salts than in the preceding period. It can be expected that this postharvest salt build-up will eventually kill all plants. It is noteworthy that all thirteen plants lost in the trial (i.e. 11% of the total) died in the course of January 1979; ten of those had been treated with the irrigation water highest in salts.

Although osmotic effects are predominant in causing salt injury, specific-ion effects cannot be ignored. They may be judged by the plant's mineral contents. At the marketable stage the chloride content of the plant (Table 7) showed a sharp increase due to the increase of the chlorides in the irrigation water from the first to the second level. At higher chloride levels in the irrigation water the rise in chloride content of the plant was less. The course of the sodium content of the plant followed a similar pattern. Earlier, the second level of irrigation water salinity was found to be the maximum allowable. Therefore, the concomitant chloride and sodium contents in the plant at this stage are not likely to have been toxic; neither are those at the higher levels of irrigation water salinity in view of their slight differences from the former.

The average nitrogen contents in the plant were 2.63, 2.57, 2.37 and 2.19% for the first, second, third and fourth irrigation waters, thus showing a decrease at higher irrigation water salinity.

The potassium content of the plants, which ranged from 5.75 to 6.32%, was not affected.

Remarkably, the phosphorus content in the plant decreased sharply with higher irrigation water salinity. The same tendency can be noted for the manganese and iron content of the plant, certainly in the case of rock wool. These effects resulted from the increase in pH of the root medium at higher irrigation water salinity; a higher pH is known to lower the availability to plants of the three elements mentioned. The plants grown on rock wool at the highest irrigation water salinity may well be considered deficient in phosphorus as well as manganese.

The postharvest salt accumulation strongly accentuated the effects of irrigation water salinity on the plant's mineral contents on 1 February 1979 (Table 8). At this time an increase in calcium and magnesium content of the plant was noticeable, while the negative effect of the pH-rise in the root medium on the phosphorus, iron and manganese content of the plant had become more pronounced. With the most saline irrigation water, the chloride contents in the plants had reached toxic levels. Furthermore, the concomitant phosphorus, manganese and iron contents of the plant were as low as, or even lower than, the respective deficiency levels. These results suggest that, apart from the main role of the osmotic effects, chloride and sodium excess and

too high a pH in the root medium contributed to the salt injury observed in this trial.

The results clearly indicate the necessity of special measures to control build-up of salts during the postharvest life of pot plants, like use of irrigation water low in salts, judicious application of fertilisers, and especially periodic leaching of the root medium.

References

- Arnold Bik, R., 1970. Nitrogen, salinity, substrates and growth of gloxinia and chrysanthemum. Agricultural Research Report 739. Pudoc, Wageningen.
- Arnold Bik, R., and Boertje, G.A., 1975. Fertilizing standards for potting composts based on the 1 : 1½ volume extraction method of soil testing. Acta Hortic. 50: 153 - 156.

Table 1 - Chemical composition of the four experimental irrigation waters.

Irr.w. no.	pH	EC*	meq/l					
			Na ⁺	Ca ²⁺	Mg ²⁺	Cl ⁻	HCO ₃ ⁻	SO ₄ ²⁻
1	5.7	0.00	0	0	0	0	0	0
2	8.0	1.01	3.77	4.52	1.51	4.51	2.26	3.0
3	8.0	1.85	7.58	9.03	3.02	9.03	4.52	6.0
4	8.1	2.68	11.31	13.55	4.53	13.55	6.77	9.0

*) electrical conductivity in mS/cm at 25 °C

Table 2 - Quality rating on 2 Nov. 1978, plant fresh and dry weight on 1 Feb. 1979 for two substrates and four irrigation waters.

Sub- strate	Irr.w. no.	Qual. rating	g/plant	
			fr.wt	dr.wt
RW	1	6.6	148	13.7
RW	2	7.1	180	15.9
RW	3	6.8	103	10.4
RW	4	6.6	68	7.1
PC	1	8.7	329	29.4
PC	2	8.5	347	28.6
PC	3	7.9	302	26.6
PC	4	8.0	205	18.6
Significant effects ¹⁾				
Substrate		***	***	***
Irrigation water		*	***	***

1) Statistically significant at P= 0.05 : * , P= 0.01 : **
and P= 0.001 : ***

Table 3 - Average number of good flowers per plant per week, total flower yield per plant and flowering intensity ratings for two substrates and four irrigation waters.

Sub- strate	Irr.w. no.	Fl/plant per week	Fl.yield fl./pl.	Rating of fl.intensity	
				11 Dec	18 Jan
RW	1	1.8	13.7	4.5	3.2
RW	2	1.9	12.9	3.2	4.1
RW	3	2.3	16.9	4.5	4.0
RW	4	2.5	17.1	4.8	4.2
PC	1	2.9	24.4	5.3	5.5
PC	2	3.2	24.6	5.4	5.5
PC	3	3.7	26.0	5.0	6.0
PC	4	3.6	25.4	5.4	5.6
Significant effects					
Substrate		***	***		
Irrigation water					

Table 4 - Ratings of leaf colour and new bud formation for two substrates and four irrigation waters.

Substrate	Irr.w. no.	Leaf colour rating		Rating of new bud f.	
		22 Dec	18 Jan	22 Dec	18 Jan
RW	1	2.7	2.5	6.9	5.2
RW	2	2.7	2.3	6.9	5.3
RW	3	2.5	2.0	6.5	4.7
RW	4	2.3	1.8	5.6	2.5
PC	1	2.5	2.5	7.4	4.7
PC	2	2.5	2.1	7.2	5.7
PC	3	2.1	1.7	6.8	5.8
PC	4	1.6	1.3	6.8	4.3
Significant effects					
Substrate		**	**		
Irrigation water		**	***		***

Table 5 - EC in mS/cm at 25 °C, pH and chloride content in meq/l on 2 November 1978 for four irrigation waters and two substrates (for the rock wool in the leachate, for the potting compost in the 1 : 1½-volume extract).

Substrate	Irr.w. no.	EC	pH	Cl ⁻
RW	1	3.5	7.0	2.4
RW	2	4.1	7.6	4.8
RW	3	5.4	7.9	10.0
RW	4	7.2	8.1	10.0
PC	1	1.0	6.0	0.2
PC	2	1.9	7.1	1.8
PC	3	2.2	7.4	4.7
PC	4	2.7	8.0	9.4

Table 6 - EC in mS/cm at 25 °C, pH and chloride content in meq/l in the leachate on 29 December 1978 for rock wool and potting compost and four irrigation waters.

Substrate	Irr.w. no.	EC	pH	Cl ⁻
RW	1	10.9	5.2	0.8
RW	2	13.1	7.3	30.9
RW	3	18.7	8.0	77.1
RW	4	19.7	8.1	95.9
PC	1	10.1	5.9	0.9
PC	2	14.2	7.5	35.2
PC	3	23.1	7.9	104.8
PC	4	26.8	7.8	142.0

Table 7 - Mineral composition of aerial parts of plants on 2 November 1978 for two substrates and four irrigation waters.

Substrate	Irr.w. no.	Per cent of dry weight					mg/kg dr.wt		
		Cl	Na	Ca	Mg	P	Fe	Mn	
RW	1	1.04	0.81	0.78	0.30	0.32	90	48	
RW	2	2.54	1.52	0.89	0.36	0.22	98	36	
RW	3	3.07	1.43	0.79	0.33	0.20	80	33	
RW	4	2.82	1.42	0.76	0.35	0.16	76	23	
PC	1	0.96	0.74	0.81	0.30	0.32	64	61	
PC	2	3.42	1.33	0.78	0.34	0.31	83	54	
PC	3	3.42	1.36	0.82	0.31	0.24	49	46	
PC	4	3.75	1.55	0.82	0.34	0.20	51	65	

Table 8 - Mineral composition of aerial parts of plants on 1 February 1979 for two substrates and four irrigation waters.

Substrate	Irr.w. no.	Per cent of dry weight					mg/kg dr.wt		
		Cl	Na	Ca	Mg	P	Fe	Mn	
RW	1	1.46	0.74	1.12	0.35	0.38	102	60	
RW	2	4.32	1.80	1.24	0.42	0.19	74	30	
RW	3	5.66	2.61	1.42	0.49	0.13	56	26	
RW	4	6.14	3.13	1.40	0.47	0.10	48	21	
PC	1	0.99	0.65	1.34	0.39	0.37	88	84	
PC	2	4.09	1.85	1.30	0.41	0.28	54	50	
PC	3	5.78	2.76	1.57	0.53	0.19	47	55	
PC	4	6.50	3.93	1.62	0.57	0.14	39	47	

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