Medium Nutrient Extraction with the Pour-through and Saturated Medium Extract Procedures for Poinsettia

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Abstract. The relationship between medium nutrient levels extracted with the pour-through (PT) and the saturated medium extract (SME) procedures was investigated. These procedures were used as indicators of plant nutrient uptake and growth of poinsettia, *Euphorbia pulcherrima* Wind. ex. Klotzch. The medium nutrient levels and electrical conductivity associated with optimal plant growth were about two times greater for PT than for SME. The pH values were similar for both procedures. Regression analysis of the relationship between applied and extracted nutrient levels gave higher R^2 values for the SME, although the relationship for PT was acceptable. Both procedures provided an acceptable and similar correlation between the level of $\text{NO}_3\text{-N}$ extracted and the level of N absorbed by the plants. The results demonstrate the utility of both PT and SME as indicators of the nutritional status of a greenhouse medium.

The pour-through (PT) nutrient extraction method is a procedure for monitoring container medium soluble salts, individual nutrients, and pH. In the PT method, a known volume of water is poured on the surface of the container medium, and the leachate is collected and analyzed. One major advantage of the procedure is that the overall nutritional status of a crop, as indicated by the electrical conductivity (EC) in the medium, can be determined rapidly and with the use of a portable conductivity meter. Its effectiveness in monitoring the nutritional status of the container medium for woody nursery crops (Wright, 1986, 1987; Yeager et al., 1983) and foliage plants has been demonstrated (Poole and Chase, 1987).

As with any nutrient extraction procedure, individual nutrient levels and EC that correspond to optimal plant growth for different plant species must be established, since values generated for other procedures may not be applicable. It is essential to generate nutrient extraction data for the PT method that correlate with optimal growth of greenhouse crops.

The purposes of this research were to 1) determine the medium nutrient and EC levels extracted with the PT technique required for optimal growth and quality of poinsettia, and 2) compare the PT's effectiveness to that of

the commonly used saturated media extract (SME) method.

Rooted cuttings of 'Gutbier V-14 Glory' poinsettia were potted on 9 Sept. 1988 in 1.57-liter (15-cm) plastic azalea pots with a Metro-Mix 360 (W.R. Grace, Cambridge, Mass.). Plants were grown in a glasshouse until 22 Sept. with 4 hr/night interruption (PPFD of $4 \mu\text{mol}\cdot\text{s}^{-1}\cdot\text{m}^{-2}$ incandescent lamps) and ambient temperatures of 16C minimum night and cooling during days begun at 21C.

Plants were soft-pinned to an average of six nodes on 16 Sept. and artificial short days initiated on 23 Sept. by covering plants with black cloth from 1700 to 0800 HR. Plants were sprayed with Cycocel at $1500 \text{ mg}\cdot\text{liter}^{-1}$ on 30 Sept. Fertilization, initiated on 13 Sept., was accomplished by applying 200 ml of a Peters 15 N-2.2P-21K Poinsettia Peat-lite fertilizer (W.R. Grace, Fogelsville, Pa.) at the following N concentrations: 25, 75, 125, 175, 225, 275, and $375 \text{ mg}\cdot\text{liter}^{-1}$. Nitrogen form in the fertilizer was 4.17% NH_4 and 10.83% NO_3 . Treatments were applied by

hand with each irrigation required, 5 days a week, with all treatments receiving tap water ($\text{EC} = 0.2 \text{ dS}\cdot\text{m}^{-1}$) as needed on the other two days. About 100 ml of solution leached from the container at each irrigation.

After potting, but before fertilization began, five samples of medium and five PT water samples were collected for nutrient analysis. The sample of medium was obtained by mixing the medium from a single pot and removing a 250-ml portion and placing it in a plastic bag for shipping. The PT sample was obtained from five plants by pouring 100 ml of distilled water on the medium surface and collecting the leachate (Wright, 1986). For subsequent sampling, PT was conducted and media samples were collected 2 hr after fertilization. Medium nutrient analysis was made for each treatment on 21 Oct. and again on 7 Dec., when the experiment was terminated (plants reached anthesis/salable stage). Nutrients were extracted from the medium samples by W.R. Grace using the SME method (Warncke, 1986). Nutrient concentrations in the extracts from both the PT and SME were analyzed as follows: $\text{NO}_3\text{-N}$ and $\text{NH}_4\text{-N}$ by non-selective electrodes, and other nutrients by inductively coupled plasma emission spectroscopy. EC and pH were determined on the extract with a conductivity and a pH meter, respectively. At each sampling date, plants growing in the five pots from which the medium was removed for the SME were analyzed for shoot dry weight and total shoot N. Total N content of the plants was determined by Micro-Kjeldahl (Peterson and Chesters, 1964).

A randomized complete-block design with five replicates and four plants per replicate (two plants per replicate for each sampling date) was used. Statistics used were Analysis of Variance and General Linear Models Procedures (SAS Institute, 1985).

Total shoot dry weight was not different due to treatment on 21 Oct. (Table 1). The initial nutrient content of the medium likely supplied adequate nutrients to the plants for some time regardless of fertilizer treatment. For example, there was an average of 57 mg $\text{NO}_3\text{-N/liter}$, 19 mg $\text{NH}_4\text{-N/liter}$, and $4.5 \text{ dS}\cdot\text{m}^{-1}\text{EC}$ in the leachate immediately after

Table 1. Shoot dry weight and N content of poinsettia fertilized with various concentrations of a 15 N-2.2P-21K soluble fertilizer with each irrigation.

N concn ($\text{mg}\cdot\text{liter}^{-1}$)	Shoot					
	Dry wt (g)		Percent N		Total N (mg)	
	21 Oct.	7 Dec.	21 Oct.	7 Dec.	21 Oct.	7 Dec.
25	1.8	5.6	3.5	1.6	63	90
75	2.1	10.1	4.1	2.5	86	253
125	2.4	9.9	4.1	2.7	98	267
175	2.1	12.1	4.2	2.8	88	339
225	2.3	9.6	4.2	2.9	96	278
275	2.2	10.8	4.5	3.1	99	335
325	2.2	9.4	5.5	3.2	121	301
Significance						
Linear	NS	*	**	**	NS	**
Quadratic	NS	**	NS	**	NS	**

NS*,**Nonsignificant or significant at $P = 0.05$ or 0.01 , respectively.

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Fig. 1. Relationship between PT and SME extract NQN levels and percent shoot N of poinsettia.

potting (data not shown). Shoot dry weight for the final harvest (7 Dec.) increased as fertilizer rate increased from 25 mg to 75 mg N/liter, with no increase in dry weight beyond 75 mg N/liter. Visual plant quality as judged by bract color and foliage quality, was, however, optimal in the 125 and 175 mg·liter⁻¹ treatments. Percent N and total plant N increased with treatment rate, especially on the final harvest (Table 1).

The relationship between fertilizer application rate and solution pH, EC, and nutrient levels for the two extraction methods on 7 Dec. is shown in Table 2. Data from the October sampling date were similar (not shown). Regression analysis shows that while

SME has higher R^2 values for the relationship between applied fertilizer rate and extracted levels, PT is also an effective indicator of the level of nutrients in the medium solution. The EC level and nutrients extracted with PT are always higher than for SME. This difference exists because of less dilution with PT, since the water applied to the container surface displaces the medium solution with limited dilution, whereas water is added to the medium sample for SME, causing a dilution of the nutrients. The greater degree of variability for PT may be due to different amounts of the applied water mixing with the actual medium solution or differences in volume of water in medium before

displacement. All nutrients except Mo increased in response to fertilizer treatment. The reduction in Mo levels at higher fertilizer levels was likely due to the acidifying reaction of the fertilizer, which reduces the volatility of Mo (Mengel and Kirkby, 1987).

The pH determinations for the two methods were quite close, except for readings taken for 25 pnd 75 mg N/liter, where pH was > 7.0 for both methods. In the range optimal for most greenhouse crops (5.2 to 6.3), both methods gave similar readings. The differences in the amount of NH₄-N extracted the two methods was striking. Much higher NH₄-N levels were detected with PT than with the SME method. We have not determined how this occurred, but speculate that the differences may be due to the greater dilution by SME, as already discussed, or to greater vitrification in the -medium sample than leachate (PT) sample and fixation of NH₄⁺ by the medium components between the time of sampling and analysis. Both PT and medium samples were always shipped the day they were taken, with medium extraction (SME) and analysis completed within 24 to 48 hr of receipt.

An indicator of the effectiveness of an extraction procedure in assessing nutrient availability is the relationship between levels of nutrients extracted and actual plant nutrient content. A strong correlation between percent tissue N and the amount of N extracted from the medium for both extraction procedures was obtained (Fig. 1). Correlation coefficients for total plant N were 0.77 and 0.79 for PT and SME, respectively.

Electrical conductivity and nutrient values that correspond to optimal growth of greenhouse crops have been established for the SME extraction procedure (Table 2). Those SME values that corresponded to the treat-

Table 2. Pour-through (PT) and saturated media extract (SME) pH, electrical conductivity (EC), and nutrient levels (mg·liter⁻¹) at various application rates of a 15N-2.2P-21K soluble fertilizer.

N concn (mg·liter ⁻¹)	pH	EC (dS·m ⁻¹)	NO ₃ -N	NH ₄ -N	P	K	Ca	Mg	Fe	Mn	Mo	Zn	Cu	B
<i>PT^a</i>														
25	7.3	0.5	11	1.2	3	34	37	10	0.17	0.00	0.20	0.42	0.04	0.01
75	7.2	1.7	145	9.0	16	286	87	33	0.47	0.04	0.48	1.04	0.14	0.07
125	7.0	2.4	235	11.4	18	446	139	48	0.65	0.07	0.42	1.14	0.23	0.07
175	6.5	4.0	376	16.2	28	670	223	85	1.17	0.12	0.31	1.25	0.42	0.14
225	6.4	3.8	411	20.4	38	698	209	90	1.42	0.22	0.31	1.30	0.17	0.19
275	5.9	4.8	506	34.3	56	872	243	123	2.37	0.45	0.23	1.67	0.23	0.27
325	5.6	4.8	502	45.1	69	898	216	125	3.35	1.02	0.17	1.96	0.25	0.29
R ²	0.77	0.77	0.77	0.90	0.88	0.79	0.68	0.76	0.89	0.87	0.72	0.90	0.43	0.81
<i>SME^a</i>														
25	8.0	0.3	7	0.0	3	35	22	6	0.14	0.01	0.08	0.12	0.01	0.02
75	7.6	0.7	41	0.0	8	121	37	13	0.20	0.03	0.22	0.44	0.04	0.03
125	6.9	1.2	115	0.0	12	220	67	26	0.38	0.08	0.21	0.55	0.05	0.07
175	6.4	1.7	150	0.2	17	315	98	43	0.76	0.29	0.19	0.60	0.06	0.10
225	6.2	1.9	206	0.6	23	344	100	51	0.97	0.51	0.13	0.60	0.05	0.14
275	5.9	2.5	314	9.5	32	469	131	71	1.60	0.77	0.14	0.84	0.07	0.18
325	5.8	2.5	316	13.0	35	467	118	73	2.00	1.01	0.14	0.79	0.07	0.17
R ²	0.98	0.97	0.92	0.91	0.98	0.98	0.88	0.96	0.98	0.94	0.84	0.88	0.73	0.99
SME stan- dard values ^b	5.2	0.75	35	0.0	5	35	40	20	0.3	0.02	0.01	0.3	0.001	0.05
	6.3	3.5	180	20	50	300	200	100	3.0	3.0	0.1	3.0	0.5	0.5

^aThere was a significant difference in extract values between extraction procedures at $P = 0.01$.

^bRange of extract levels recommended for SME by W. R. Grace for optimal growth of greenhouse crops growing in soilless media.

ments (125 and 175 mg N/liter) that gave optimal plant growth and quality fell within these ranges (Table 2). Thus, the values obtained by PT for these two treatments could be used to predict nutrient status for optimal growth of poinsettia. For example, if one used the PT method and obtained EC and $\text{NO}_3\text{-N}$ values ranging from 2.5 to 3.2 dS·m⁻¹ and 230 to 312 mg·liter⁻¹, respectively, optimal growth and quality of poinsettia could be expected, provided environmental factors were not limiting. The above values are predicted values from regression analysis of data in Table 2 rather than the actual values.

This work supports the use of PT as a rapid and easy method for monitoring medium soluble salts and specific nutrients to indicate whether optimal nutrient levels are

present for promotion of plant growth. We caution about the use of standard values established for other extraction techniques for making assessments of the nutritional status of a crop with the PT method. Additional work and grower experiences are needed to establish PT medium nutrient levels that promote optimal growth of other greenhouse crops.

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Leaf Tipburn in Cauliflower as Affected by Cultivar, Calcium Sprays, and Nitrogen Nutrition

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Abstract. Two separate field experiments were conducted to determine the influence of Ca sprays and N fertilizer rate on leaf tipburn incidence in 'Snow Crown', 'Self Blanche', and 'Imperial 10-6' cauliflower. Incidence of leaf tipburn was highest in 'Snow Crown' each year and varied with year in 'Self Blanche' and 'Imperial 10-6'. Delaying planting of 'Snow Crown' by 3 weeks decreased tipburn incidence by 20% and decreased the number of tipburned leaves per tipburned plant by 60%. Sprays of CaCl₂ or calcium chelate had no effect on cauliflower productivity, nutrition, or tipburn incidence. Increasing N fertilizer rate from 67 kg N/ha to 201 kg N/ha linearly increased yield without significantly affecting tipburn incidence. Concentrations of Ca in tips of nontipburned leaves were two to five times greater than those in tips of tipburned leaves of comparable physiological age. Basal leaf regions had similar Ca concentrations, regardless of tipburn status. Use of resistant cultivars appears to be the best method of reducing tipburn incidence in cauliflower.

Leaf tipburn in cauliflower is characterized as a tip necrosis of young expanding leaves surrounding the enlarging curd. Necrotic leaves can lower product quality and, in severe cases, may discolor the curd due to secondary pathogen infection and cause a loss in marketable heads (Maynard et al., 1981). Similar disorders have been reported in other vegetable crops, including cabbage (Maynard et al., 1965), brussels sprouts

(Maynard and Barker, 1972), and lettuce (Thibodeau and Minotti, 1969) and all have been related to Ca nutrition. Maynard et al. (1981) reported that Ca concentrations in cauliflower leaves were generally lower in tipburned regions of leaves than in similar regions in nontipburned leaves. A Ca gradient within tipburned leaves has also been reported, with lower concentrations near the leaf tip and higher concentrations near leaf basal areas (Rosen et al., 1987). Although Ca nutrition has been implicated in these disorders, applications of Ca to the soil in field studies have shown inconsistent effects on preventing tipburn incidence (Rosen et al., 1987). Effects of foliar applications of Ca sprays were not successful in preventing tipburn incidence in lettuce (Misaghi et al., 1981), but no data could be found for cauliflower.

Exploiting genotypic differences in susceptibility to tipburn has been an effective means of reducing the problem (Nieuwhof, 1960). Tipburn incidence, however, can be modified by several environmental factors, including relative humidity, temperature, soil moisture, and soil fertility (Collier and Tibbitts, 1982). Increasing the air temperature, lack of soil moisture, or excessive soil moisture tend to enhance tipburn incidence. One common characteristic of tipburn is that occurrence is usually greatest in young, rapidly growing leaf tissue, particularly during curd enlargement. High rates of N fertilizer have been reported to increase incidence and/or severity of tipburn in cauliflower (Jenkinson and Campbell, 1957) and cabbage (Nieuwhof et al., 1960). The finding with cauliflower prompted Jenkinson and Campbell (1957) to suggest that tipburn-resistant genotypes be selected under conditions of high N fertility.

The objective of the present experiments was to evaluate the response of three commonly grown cauliflower cultivars to foliar-applied Ca sprays and N nutrition in relation to productivity, nutrition, and tipburn incidence.

The study was conducted over 2 years (1986-1987) at the Sand Plain Research Farm in Becker, Minn., on a Hubbard loamy sand (Udorthentic Haploboroll). Soil properties before planting were similar each year. Selected chemical properties averaged over years are as follows (0 to 15 cm): organic matter (wet digestion), 2.3%; pH [1 soil : 1 water (w/v)] 6.4; P (Bray Pi), 37 mg·kg⁻¹; K, Ca, and Mg (1 N ammonium acetate), 135, 694, and 192 mg·kg⁻¹, respectively. Extractable nitrate-N (2 N KCl) in the top 0.3 m was 6 mg·kg⁻¹.

In 1986, the effects of foliar-applied Ca sprays on tipburn incidence and cauliflower productivity were evaluated. In 1987, using the same cultivars, the effects of N nutrition and planting date were evaluated. In both years, 'Snow Crown' (early season maturing), 'Imperial 10-6' (mid- to late-season

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