DETERMINATION OF THE EFFECT OF MOLYBDENUM WHEN ADDED TO THE SOIL OF POINSETTIA PLANTS[1]

J. K. Aderhold and R. E. Widmer[2]

Molybdenum is the element used in the smallest quantity by higher plants. It is essential in nitrogen fixation by both symbiotic and free-living soil organisms, and is the metal constitutent of nitrate reductase in higher plants (6). Plants grown in soils deficient in molybdenum will be stunted or show chlorosis between the leaf veins. Average molybdenum content in the plant is around 2 ppm (6). The toxic level is extremely high. Hewitt (2) found the range between deficiency and toxic levels of molybdenum is 50 times that of other essential micro elements. Jungk (4) and Paul Ecke (1) have shown that leaf injury in poinsettias can be caused by lack of molybdenum.

Various interactions involving molybdenum and the other elements have been noted. McKay (5) found that a proper balance of copper and molybdenum is important if deficiencies or toxicities of both elements are to be prevented. Various interactions between molybdenum and lime were noted by Gupta (3).

Plant molybdenum content differs with different types of soils (3). Certain areas of the world have high quantities of molybdenum in the soil. In parts of England, Germany, Japan and Nevada there are toxicity areas.

The objectives of this study were to determine (1) whether molybdenum (Mo) deficiency and toxicity symptoms of poinsettias could be induced, and (2) the tolerance level of poinsettias to molybdenum.

Materials and Methods

Cuttings of the cultivar White Annette Hegg were rooted in 2½" clay pots containing moss peat with a slow release fertilizer. Intermittant mist was used to hasten rooting.

One week after removal from the mist (October 15, 1971), the plants were divided into two similar groups of 40 plants each. One group was planted in 4-inch plastic pots in a soil mixture of 1 part loam and 1 part moss peat to which superphosphate (0-20-0) had been added. The second group was planted in moss peat enriched with the following nutrients per bushel:

Limestone	200.00 grams
Magnesium sulfate	20.00 grams
Calcium nitrate	6.25 grams
0-0-60	4.00 grams
0-20-0	12.50 grams
Osmocote 14-14-14	16.00 grams
Sodium borate	0.40 grams

[1] Paper No. 8362 Scientific Journal Series, Agricultural Experiment Station, University of Minnesota.

[2] Study conducted by Mr. Aderhold when he was senior student majoring in floriculture.

Copper sulfate	0.60 grams
Ferrous sulfate	1.80 grams
Manganous sulfate	0.60 grams
Zinc sulfate	0.60 grams
Chelated iron	1.00 grams

All plants were fertilized at every watering with equal parts of ammonium nitrate and potassium nitrate at the rate of 200 ppm nitrogen. On November 1, each group was divided into five similar lots of eight plants each and the following five treatments were initiated for plants in both growth media.

Treatments

I Control (No Mo added)
II 0.1 ppm Mo
III 0.2 ppm Mo
IV 0.8 ppm Mo
V 3.2 ppm Mo

A solution of ammonium molybdate was used to provide the molybdenum which was added to the ammonium and potassium nitrate fertilizer solution applied in every watering. Plants were kept vegetative by interrupting the night with four hours of light.

Results and Discussion

Unpredictably, on the night of December 12, 1971, a thermostat controlling the temperature levels of the greenhouse failed to operate properly. The night temperature up to this time was 68^{o}F. Many plants were killed when the temperature dropped close to the freezing point, (table 1).

Table 1. Plants killed per treatment by the sudden temperature drop December 12.

Peat-loam mix			Nutrient-enriched moss peat		
Treatment	Number	Percent	Treatment	Number	Percent
I Control	5	62.5	I Control	2	25.0
II 0.1 ppm Mo	3	37.5	II 0.1 ppm Mo	2	25.0
III 0.2 ppm Mo	2	25.0	III 0.2 ppm Mo	3	37.5
IV 0.8 ppm Mo	6	75.0	IV 0.8 ppm Mo	6	75.0
V 3.2 ppm Mo	2	25.0	V 3.2 ppm Mo	2	25.0
Total	18		Total	15	

Plant loss from freezing occurred in all treatments but was not uniform across the bench. This was probably due to variations in microclimates which enabled some plants to survive better than others.

At this time the plants grown in moss peat were larger, greener and more succulent than those grown in the soil mix. Plant loss of the more succulent peat grown plants was no greater, but the surviving peat-grown plants showed more severe injury symptoms (chlorosis and leaf loss) than those grown in the soil mix.

Although plants in treatment IV, which had received 0.8 ppm Mo with every watering, showed the greatest plant loss, correlation of plant loss with rate of Mo application was neither consistent nor clearly evident. After a two week waiting period to determine which plants were going to survive and resume normal growth, molybdenum applications were resumed December 26. Lighting to provide a long photoperiod was discontinued in the belief that a reproductive plant might develop molybdenum toxicity symptoms sooner.

Soil analysis in mid-January, 1972 indicated that soluble salts, nitrate nitrogen and potassium levels were higher than desired, especially in the moss peat medium. Therefore, the two media were leached and no fertilizer applied for one week. At this point a 20-20-20 soluble fertilizer was substituted for the ammonium and potassium nitrate mix, as phosphorus was also needed.

Since molybdenum toxicity was not visibly evident after three months of molybdenum applications, application rates were tripled February 4, 1972. New treatments were: control (no molybdenum added), 0.3 ppm, 0.6 ppm, 2.4 ppm and 9.6 ppm which was 48 times the suggested normal application rate of 0.2 ppm (1).

Final Results of the Experiment

All treatments were terminated February 25, 1972 when plants were in full bloom. Visible symptoms of molybdenum toxicity, evident in treatments IV and V, were chlorotic leaves with less chlorosis in treatment IV than in V. Foliar samples were analyzed to determine the relative quantities of elements present. (tables 2 and 3.)

Table 2. Elements in the leaves of plants grown in soil-peat mix.

	Concentrations* of elements under indicated treatments				
Element	I	II	III	IV	V
Phosphorous (%)	.4009	.3731	.4403	.5633	.3370
Potassium (%)	1.1185	1.1944	.7297	1.1151	1.1185
Calcium (%)	.5662	.4362	.4920	.8036	.9489

Table 2. Elements in the leaves of plants grown in soil-peat mix, (con't)

	Concentrations* of elements under indicated treatments				
Element	I	II	III	IV	V
Aluminum ppm	1932.48	2500.57	266.29	1221.19	2040.54
Sodium (%)	.1183	.1001	.2064	.2731	.2450
Iron (%)	111.97	81.25	74.46	100.00	147.27
Magnesium (%)	.2174	.1870	.2477	.4113	.4006
Zinc ppm	23.05	26.34	31.31	33.88	44.15
Copper ppm	9.25	6.52	9.98	12.58	14.32
Molybdenum ppm	33.59	high**	high**	high**	high**
Maganese ppm	30.05	22.25	25.71	43.08	72.75
Boron ppm	22.27	19.77	23.68	26.34	35.14

* Dry weight basis
** Above the normal scale

Table 3. Elements in the leaves of plants grown in moss peat.

	Concentrations* of elements under indicated treatments				
Element	I	II	III	IV	V
Phosphorous (%)	.2731	.1651	.1503	.1962	.2076
Potassium (%)	1.2599	.8273	.6458	.7157	1.0355
Calcium (%)	.6795	.3421	.2396	.3265	.3151
Aluminum ppm	3236.24	1591.52	1331.02	1174.58	2070.46
Sodium (%)	.2478	.0924	.0975	.1419	.0770
Iron (%)	247.11	75.31	55.85	76.16	94.02
Magnesium (%)	.3446	.1702	.1402	.1810	.1527
Zinc ppm	55.31	22.61	22.46	24.38	27.71
Copper ppm	19.58	5.94	5.80	8.25	6.38
Molybdenum ppm	high**	high**	high**	high**	59.70
Manganese ppm	70.12	29.18	19.65	23.98	21.02
Boron ppm	28.38	20.40	22.43	25.71	23.68

* Dry weight basis
** Above the normal scale

Table 4. Mean plant height at termination of the study*

Treatment	Medium: Soil mix	Medium: Moss peat
I	27 mm	39
II	30	33
III	29	32
IV	30	30
V	24	30

*Measured from the top rim of the pot to the bottom of the flower

Foliar samples indicate that molybdenum readings were above the normal range in almost all of the treatments. Comparison of the nutrient contents of plants grown in the two media shows some interesting differences. In plants grown in the soil mix, calcium, sodium, iron, magnesium, zinc, copper, manganese and boron frequently increased in direct proportion to the levels of molybdenum applied. In plants grown in the peat mix, the reverse was true. The levels of the elements indicated above usually decreased proportionally with increasing applications of molybdenum and were always below those in control plants. Such findings indicate that the other elements may have been leached out of the peat medium or possibly tied up in proportion to the molybdenum applied, thus making the other elements unavailable to the plants.

Poinsettias grown in peat were taller than those grown in soil. Plants tended to be shorter in both media with increased rates of application of molybdenum. Under high levels of Mo, plants grown in peat were generally taller than plants grown in the soil mix.

Summary

1. Molybdenum deficiency symptoms were not evident in poinsettias grown in either a soil mix or moss peat with no applications of molybdenum for over four months.

2. No molybdenum toxicity symptoms were evident in vegetative plants which had received Mo at rates up to 16 times the recommended rate of 0.2 ppm with every watering for a two month period.

3. Molybdenum toxicity symptoms were evident after three weeks of application of molybdenum at 12 and 48 times the recommended rate, when the plants were reproductive.

4. Toxicity symptoms noted were chlorosis between the veins and leaf abscission which occurred mainly at the higher rate of application.

5. Although molybdenum deficiency symptoms could not be induced on poinsettias grown in this study, no injurious effects should develop from normal applications of this nutrient as suggested by Paul Ecke, Jr.

Literature Cited

1. Ecke, Paul Jr., and O. A. Matkin. 1971. The Poinsettia Manual, Paul Ecke Poinsettias, 92-3.

2. Hewitt, E. J. 1951. Annual Review of Plant Physiology, 25-52.

3. Gupta, U. C. 1969. Effect and Interaction of Molybdenum and Limestone on Growth and Molybdenum Content of Califlower, Alfalfa and Bromegrass on Acid Soils, Soil Science Society American Proceedings, 33:929-32.

4. Jungk, A., Malaheb and Wehrmann. 1971. Molybdenum Deficiency on Poinsettias, a Cause of Leaf Damage, North Carolina Flower Grower's Bul., Oct.

5. McKay, D. C. and others. 1966. Copper and Molybdenum Nutrition of Crops Grown on Acid Sphagnum Peat Moss, Soil Science Society American Proceedings, 30:755-9.

6. Purvis, Ernest R. 1955. The Role of Molybdenum in Soils and Plants, Journal of Agricultural and Food Chemistry, 3(8) 666-669.