Iron toxicity in *Pentas Lanceolata*

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Summary. Interveinal chlorosis of lower (oldest) leaves followed by development of interveinal necrotic spots, marginal necrosis, downward cupping of leaves, and leaf abscission were symptoms of a disorder commonly observed during production of potted pentas. The disorder was determined to be an Fe toxicity problem associated with accumulation of extremely high levels of foliar Fe (649 to 1124 ppm). Cultivars varied in their response to soil-applied Fe-DTPA chelate solutions: 'Starburst', 'Mauve' and 'Ruby Red' were very susceptible, 'Pink Profusion' was intermediate, and 'White', 'Lavender Delight', and 'Pink Rose' were resistant. Potted plant production in a root medium with an initial pH of 6.7 ± 0.1 and a end pH of 6.4 ± 0.2 reduced the accumulation of foliar Fe to levels ranging from 59 to 196 ppm and prevented development of significant visual symptoms for all Cultivars.

Pentas lanceoiata Benth. production as a potted plant has increased recently due to availability of new cultivars. desire for drought tolerant plants, and increased demand for plants in butterfly gardens. *Pentas* is not a new crop in the United States, as it has been grown here for many years, but few growers have produced the crop in large quantities, and production research for potted plants is scarce (Armitage, 1988; Kofranek and Kubota, 1982). While working on production systems for potted pentas, a disorder that affected the lower foliage often was observed. The symptoms appeared in the initial stages of development as an interveinal chlorosis of the lower leaves. As the plant matured, the symptoms included interveinal chlorosis and necrosis, marginal necrosis, downward cupping of the leaves, and leaf abscission. These symptoms were characteristic of micronutrient toxicity problems previously observed on floricultural crops over the years and typical of Mn and Fe toxicities of bedding plants (Albano, 1993; Biernbaum et al., 1988) and other crops (Fey et al.). The purpose of this research was to determine if micronutrient imbalances were the cause of this problem, the role of root medium pH, and the sensitivity of different pentas cultivars to the micronutrients involved

Materials and methods

Experiment 1: Determination of micronutrients causing a nutritional disorder in pentas. Single node stem cuttings of 'Ruby Red' pentas were rooted in coarse builder's sand to minimize nutrient uptake and loading during rooting. After 5 weeks, one rooted cutting was transplanted per 12.5-cm pot containing a 3 peat : 2 perlite : 1 sand (by volume) root medium amended with 0.6 $kg \cdot m^{-3}$ of hydrated and calcitic lime. The adjusted root medium pH was 5.5 ± 0.2. Plants in all treatments were fertilized twice weekly with 50 ml of a solution containing (in ppm) 200 N–50P–200 K from $NH_4H_2PO_4$, KNO_3, and NH_4NO_3.

Five single-micronutrient solutions and a solution containing all five micronutrients were compared to a control treatment with no micronutrients. Micronutrient solutions were formulated with a ratio similar to commercial fertilizer formulations used for floricultural crops. Micronutrient sources used and solution ppm were 20 Fe (Fe-DTPA chelate), 10 Mn ($MnSO_4H_2O$), 5 Zn ($ZnSO_4 \cdot 7H_2O$), 5 Cu ($CUSO_4 \cdot 5H_2O$), and 1 B (H_2BO_3). Solutions were applied as a soil drench in 50-ml aliquots twice weekly for 12 weeks. The growing environment was a fan-and-pad-cooled glasshouse, where the day/night temperature range was 33C/18C. Shade was provided by exterior paint, and the midday PPF ranged from 600 to 800 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (3000 to 4000 ft c).

Fully expanded, mature leaf samples were taken 13 weeks after initiation of treatments, and foliar microelement concentrations were determined by inductively coupled argon plasma spectrophotometry (model 61E; Jarrel-Ash, Franklin, Mass.). A subjective microelement toxicity rating from 1 to 5 was used to evaluate symptom development as follows: 1 = no symptoms; 3 = interveinal chlorosis of lower leaves; and 5 = interveinal chlorosis and necrosis, marginal necrosis, and downward cupping of lower leaves. Treatments were replicated three times with three plants per experimental unit. Means of foliar nutrient content and toxicity ratings were separated by Dunnett's test-($P < 0.05$) for comparison of means with a control.

Experiment 2: Cultivar sensitivity to Fe. A 7 (cultivar) × 2 (root medium pH) factorial experiment was designed to test the sensitivity to Fe of commercially available pentas cultivars when grown in low- or high-pH root media. The root media contained 4 sphagnum peat : 2 horticultural vermiculite: 1 sand: 1 perlite (by volume) amended with either 0.6 $kg \cdot m^{-3}$ (low pH) or 3 $kg \cdot m^{-3}$ (high pH) of hydrated and calcitic lime. The initial pH 4 weeks after mixing was 4.8 ± 0.1 for the low pH medium and 6.7* 0.1 for the high pH medium. The pH at the end of the experiment (13 weeks) was 5.2 ± 0.2 for the low medium pH or 6.4 ± 0.2 for the high medium pH. Both media were amended with (in $kg \cdot m^{-3}$): 0.6 $MgSO_4$, 1.2 single superphosphate, and 7.0 Osmocote controlled-release 14N-6P-12Kfertilizer. A 5-ppm Fe solution (Fe-DPTA chelate) was applied weekly as a 100-ml soil drench to induce Fe toxicity symptoms on susceptible cultivars.

Single-node vegetative stem cuttings of the seven cultivars were rooted in perlite for 3 weeks. Three rooted cuttings were transplanted into 12.5-cm pots containing either the low- or high-pH root medium. 'Mauve', 'Ruby Red', 'White', and 'Pink Rose' were pinched to two nodes after 20 days since this is a commercial practice for these cultivars, which do not branch well in pots without pinching.

Fully expanded, mature leaves were sampled for foliar Fe analyses, and a subjective toxicity rating was given 13 weeks from transplanting (see Expt. 1). Treatments were replicated five times with three plants per pot and two pots per experimental unit. Mean separation was by Duncan's multiple

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Table 1. *Response of Pentas lanceolata 'Ruby Red' to microelement solutions containing (in ppm) 20 Fe, 10 Mn, 5 Zn, 5 Cu, or 1 B.*

Treatments	Foliar tissue analyses (ppm) Fe	Mn	Zn	Cu	B	Foliar toxicity rating (5 = severe)
Control (none)	147	232	39	2.0	18	1.0
Fe	987*	196	29	3.0	19	4.3*
Mn	77	616*	37	1.3	17	1.0
Zn	155	243	87*	2.3	18	1.0
Cu	115	201	31	5.0*	17	1.0
B	145	239	35	2.0	41*	1.0
All	657*	491*	51*	5.3*	40*	3.0*

[z]*Toxicity ratings on a scale of 1 to 5, where 1 = no symptoms, 3 = interveinal foliar chlorosis, 5 = interveinal foliar chlorosis and necrosis, marginal necrosis and downward cupping of leaves.*
**Values in columns significantly different from the control treatment by Dunnett's test, P = 0,05,*

range test for comparison of cultivars.

Results

Experiment 1. Foliar micronutrient levels were higher for plants fertilized with one or all micronutrients compared to foliar micronutrient concentrations in control plants (Table 1). Foliar Fe (987 ppm) and Mn (616 ppm) were extremely high for plants fertilized with Fe or Mn and far exceeded the normal range of 75 to 125 ppm Fe and 50 to 100 ppm Mn reported for most ornamental plants (Joiner et al., 1983). Even control plants had relatively high foliar Fe (147 ppm) and Mn (232 ppm), which indicated luxuriant and highly efficient absorption of these nutrients in peat-based media. However, only plants that received the Fe solution and combined micronutrient solution containing Fe expressed toxicity symptoms. Thus, the disorder was determined to be an Fe toxicity problem associated with accumulation of high foliar Fe levels.

Experiment 2. Interactive effects of cultivar with root medium pH were significant for foliar Fe levels and toxicity ratings, indicating cultivar response depended on root medium pH. With low-pH root medium, 'Starburst' (1124 ppm) and 'Mauve' (1024) had the highest foliar Fe levels (Table 2). 'Ruby Red' and 'Pink Profusion' also had extremely high foliar Fe concentrations, but about half the levels of 'Starburst' or 'Mauve'. The other cultivars had foliar Fe concentrations (108 to 201 ppm) within or slightly higher than the normal range for ornamental plants . With high-pH root medium, there were no significant differences in foliar Fe levels for the seven cultivars, and all were within or slightly higher than expected concentrations.

Foliar toxicity ratings for plants grown in low-pH root medium were highest for 'Starburst', 'Mauve', and 'Ruby Red', intermediate for 'Pink Profusion', 'White', and 'Lavender Delight', and lowest for 'Pink Rose'. With high-pH root medium, foliar toxicity ratings were similar and ranged between 1 and 2, indicating little or no visible Fe toxicity symptoms. In general, the higher the foliar tissue levels the higher the toxicity rating. The most notable exception was that, although 'Ruby Red' had an intermediate level of Foliar Fe, its toxicity rating was similar to that of 'Starburst' and 'Mauve', which had twice the foliar Fe concentration.

Table *2. Response of seven pentas cultivars to 5-ppm Fe solutions when grown in low-[z] and high-pH root media.*

Cultivar	Foliar Fe levels (ppm) Low pH	High pH	Foliar toxicity rating (5 = severe)[y] Low pH	High pH
Starburst	1124 a[x]	105 c	4.1 a	1.7 bcd
Mauve	1024 a	196 c	3.6 a	1.0 d
Ruby Red	649 b	135 c	3.3 a	2.0 bc
Pink Profusion	664 b	89 c	2.4 b	1.1 d
White	201 c	59 c	1.9 bc	1.0 d
Lavender Delight	133 c	96 c	2.1 bc	1.4 cd
Pink Rose	108 c	93 c	1.4 cd	1.3 cd

[z]*The low-pH medium* had an *initial pH (4 weeks) of 4.8± 0.1 and end pH (13 weeks) of 5.2 ± 0.2, and the high-pH medium had an* initial *pH of 6.7± 0.1 and end pH of 6.4 ± 0.2.*
[y]*Toxicity ratings on a scale of 1 to 5, where 1 =* no symptoms, *3 = interveinal foliar chlorosis, 5 = interveinal foliar chlorosis and necrosis, marginal necrosis and downward*
[x]*Means within foliar tissue levels and toxicity rating groups followed by the same letter are not signifcantly different by Duncan's multiple range test, P< 0.05.*

Conclusions

Interveinal chlorosis and necrosis, marginal necrosis and downward cupping of lower leaves of pentas plants were found to be characteristic symptoms of foliar Fe toxicity. Some cultivars of pentas appear to be very efficient in Fe uptake when grown in low-pH root media and can accumulate toxic levels of Fe in peat-based root media, even when micronutrients are not added. Cultivars respond quite differently to Fe applied to the root medium in their uptake ability and expression of symptoms. Production of pentas in high-pH root media and cultivar selection can prevent development of the disorder.

Literature Cited

Albano,J.P. 1993. Iron deficiency and toxicity in marigold (Tagetes *erecta* L.): Growth and physiology. MS thesis, Clemson Univ., Clemson, S.C.

Armitage, A.M. 1988. Influence of photoperiod, supplemental light, and growth regulators on growth and flowering of *Pentas lanceolata.* HortScience 23:349–351.

Biemzbaum,J.A., W.H. Carlson, *C.A. Shoemaker, and R. Heins. 1988. Low* pH causes iron and manganese toxicity. Greenhouse Grower 6(3):92-93, 97-98.

Fey, C. D., R.L. Chancy, and M. C. White. 1978. The physiology of metal toxicity in plants. Annu. Rev. Plant Physiol. 29:511-566.

Joiner, J. N., R. T. Poole, and *C.A.* Conover. *1983.* Nutrition and fertilization of ornamental greenhouse crops, p. 317403. In: J. Janick (cd.). Horticultural reviews. vol 5. AVI, Westport, Conn.

Kofranek, A.M. and J. Kubota. 1982. Culture and postharvest handling of galaxy flowers, *Pentas lanceolata.* Flor. Rev. 170(4419):14.