EFFECT OF VARYING LEVELS OF MANGANESE AND PH ON THE GROWTH OF THREE CULTIVARS OF *ACER RUBRUM*[1]

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Abstract. A greenhouse study revealed that dry weights of new shoots and roots, and foliar levels of manganese of 3 cultivars of red maple ('Armstrong,' 'October Glory,' and 'Red Sunset') were unaffected by manganese levels in the nutrient solution during the duration of this experiment. Multivariate regression analysis of the factors affecting the percent of new stem growth showed that the percent of new stem growth of 'Armstrong' is lowered as pH is increased. The percent of new stem growth of 'October Glory' is unaffected by changes in pH and that of 'Red Sunset' is increased as the pH is increased.

Additional index words. Red maple, foliar analysis, sand culture.

In recent years, nurserymen, homeowners, and urban foresters have observed a distinct chlorosis associated with manganese deficiency on certain red maple cultivars when grown in alkaline sites (12). Chlorosis is observed on the leaf margin and interveinal areas. The midrib, main veins and adjacent bands of tissue of varying width remain green. In severe cases, foliage may become entirely chlorotic with necrotic spots, followed by defoliation. Manganese deficiency has been one explanation for the malady of maples known as maple decline (6).

Considerable variation is known to exist among species in regard to manganese levels in the plants and tolerance to both deficiency and toxicity (7,9). In addition, cultivars and varieties of apple, peach, wheat, barley and oats exhibit different responses to low or high levels of available manganese either in the soil or in applied nutrient solution (1,2,3,10). Experimentation by Neenan and Foy et al. has established certain wheat varieties for acid soils in which manganese toxicity often occurs (2,10). Work by Gallagher and Walsh on oats, wheat and rye showed that effects of manganese deficiency or unavailable manganese in soils can be overcome by suitable varietal choice (3).

Consequently, this study was conducted to determine if cultivar differences of red maple exist, thereby establishing the cultivar(s) most tolerant of the manganese deficient soils commonly found in Ohio.

Dormant rooted cuttings of 'Armstrong,' 'October Glory' and 'Red Sunset' were purchased during the second week of April, 1980. These were kept moist and stored at 40°F until potted into 1 liter plastic pots in coarse purified (4) river sand on April 25. The potted plants were placed on greenhouse benches in a completely randomized design, consisting of 8 treatments, each having 4 replications of 6 plants each. Treatments involved hand watering of the plants as needed with freshly prepared ½ strength modified Hoagland's solution (5) containing 4 levels of manganese as $MnCl_24H_2O$ (0.0 ppm, 0.01 ppm, 0.10 ppm, 1.00 ppm). The pH of the four initially prepared solutions was 5.5. A second set of treatments at pH 7.5 was obtained by careful addition of 1 N NaOH. The pH and soluble salt levels of the sand media were monitored biweekly. Soil temperatures remained low during the month of May. Air infiltration was slow and plant growth was limited.

Plants were then transplanted into 869 ml white styrofoam cups (6.35 cm taller than the previous pots) to increase air infiltration of the media the second week of June. The micronutrient levels in solution were increased to full strength Hoagland's with manganese levels altered to 0.02 ppm; 0.20 ppm and 2.00 ppm, as previous treatments were found to be low. The control, 0.0 ppm, remained unchanged. With increasing soil temperature and greater media heights plants re-

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quired water 2-3 times per week. Growth rates then increased.

Plants were harvested on August 1 after one growing season (4 months in the media). Leaf samples of the most recently matured leaves were sent to the Ohio Agricultural Research and Development Center, Wooster, OH for analysis by emission spectrometry. Plants were then oven-dried and dry weights recorded.

All cultivars showed a lack of response in root or shoot growth to addition of manganese in the nutrient solution. This is explained by the anlysis of the recently matured leaves, which revealed no significant increase in foliar manganese with increases in manganese in the nutrient solution (Table 1). This is in conflict with the findings of others (7,8,9). Because cuttings grown at 0.0. ppm contained low but sufficient amounts of manganese at the termination of the experiment (11), it is likely that the rooted cuttings contained enough manganese in the tissues to initially supply the actively growing parts, regardless of availability of manganese in the nutrient solution. Levels of foliar manganese did not show the expected decrease as pH was increased from 5.5 to 7.5 (Table 2). The single growing season duration of the experiment combined with sufficient internal supply of manganese may have resulted in this response. Other nutrients were found in ranges normally considered to be sufficient in all cultivars at both pH levels (Table 3).

Differences in foliar manganese levels did exist among cultivars and between pH levels in the level of manganese in the recently matured leaves (Table 2). The variety 'October Glory' had the lowest level of foliar manganese at both pH levels. The variety 'Armstrong' contained more manganese at the higher pH level. These findings can be explained by the differences in the average dry weights of both root and new stem growth (Table 4). 'Armstrong' had significantly smaller roots and shoots when grown at the higher pH, with plants appearing stunted and chlorotic. The presence of higher levels of manganese at pH 7.5 may indicate slow utilization of the initial or recent-

Table 2. The effect of pH on the manganese levels in ppm of recently matured leaves of *Acer rubrum* 'Armstrong,' 'October Glory' and 'Red Sunset.'[z]

Cultivar	*pH 5.5*	*pH 7.5*
'Armstrong'	79.9	121.6
'October Glory'	34.8	38.4
'Red Sunset'	93.7	84.9

HSD P = .05, 37.93

[z] Average of 16 plants.

Table 1. The effect of manganese in the nutrient solution on the levels of manganese in the recently matured leaves of *Acer rubrun* 'Armstrong,' 'October Glory' and 'Red Sunset.'[z]

Mn, ppm	*Foliar Mn Levels (ppm) pH 5.5*			*Foliar Mn Levels (ppm) pH 7.5*		
	'Armstrong'	*'October Glory'*	*'Red Sunset'*	*'Armstrong'*	*'October Glory'*	*'Red Sunset'*
0.00	48.49	24.79	102.39	98.12	30.45	66.01
0.02	24.01	16.27	88.42	156.47	23.34	92.60
0.20	142.13	55.02	96.02	125.51	37.06	41.24
2.00	104.96	43.24	88.50	106.33	62.92	138.01

HSD P = .05, 98.36

[z]Average of 4 plants.

Table 3. Nutrient levels of recently matured leaves of *Acer rubrum* 'Armstrong,' 'October Glory,' and 'Red Sunset.'[z]

Cultivar	*pH*	*Level of Nutrient, ppm*					
		P	**K**	**Ca**	**Mg**	**Mn**	**Fe**
'Armstrong'	5.5	2315	36956	10478	4817	80	45
	7.5	2280	39703	10338	4428	122	50
'October Glory'	5.5	1922	25929	9914	3982	35	47
	7.5	1683	28746	8930	3632	38	45
'Red Sunset'	5.5	2386	24913	10955	3925	94	56
	7.5	2295	29274	11735	4013	85	47

[z] Average of 16 plants.

Table 4. The effect of pH on the dry weight of *Acer rubrum* 'Armstrong,' 'October Glory' and 'Red Sunset' roots and shoots.

pH	*'Armstrong'*	*'October Glory'*	*'Red Sunset'*
		Root weight (gm)[z]	
5.5	5.29	5.28	7.86
7.5	3.50	5.25	6.08
		New growth of stems (gm)[z]	
5.5	11.8	9.25	13.3
7.5	6.9	8.35	11.8

HSD P = .05, For roots 1.371; for shoots 1.793

[z] Average weight of 8 plants.

ly accumulated manganese in the cutting as a result of poor growth. In contrast, 'October Glory' did not show a significant decrease in growth as a result of an increase in pH. Shoot growth was significantly higher than the other two cultivars, with average manganese levels lower. This suggests that (1) initial manganese levels in the dormant cuttings were lower, and/or (2) the vigorously growing plants were utilizing the available manganese and that lower levels reflected increased growth. 'Red Sunset' showed a decrease in the amount of roots at the higher pH but this was not reflected in the amount of new stem growth. 'Red Sunset' was also significantly larger in overall size than 'Armstrong' at the higher pH.

Stepwise regression at P = .05 were run for each cultivar to determine the factors affecting percent new stem growth (new stem growth/total growth). The dependent factor, percent new stem growth, was chosen to eliminate the variations in original cutting size. Independent factors included pH, foliar manganese and (foliar manganese)^2. The regression equations substantiated the difference in cultivar response to pH. They also indicated no significant response to foliar manganese levels. The equations are as follows:

'Armstrong' new stem growth = 0.661 - 0.045 (pH).

'October Glory new stem growth had no dependence on the factors studied.

'Red Sunset' new stem growth = 0.148 + 0.035 (pH).

Percent new stem growth of 'October Glory' shows no dependence on pH. Percent new stem growth of 'Armstrong' is negatively correlated to increasing pH, while that of 'Red Sunset' shows positive correlation (Fig. 1).

The landscape implication of these results is that 'Red Sunset' and 'October Glory' may perform better than 'Armstrong' on the more alkaline sites of Ohio.

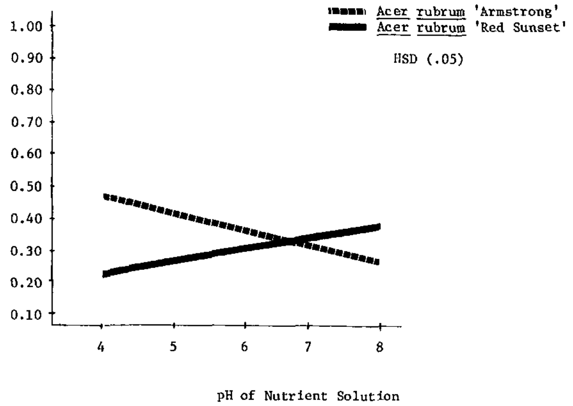

Fig. 1. The effect of pH on the percentage of new growth of *Acer rubrum* 'Armstrong' and 'Red Sunset' after 12 weeks.

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ABSTRACT

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Suppose a deciduous tree is removed in leaf and bare root from the field prior to vegetative maturity. It is placed in a controlled environment that is sequentially programmed to induce vegetative maturity and leaf abscission to bring about cold acclimation and dormacy. The storage environment is thus programmed to end dormacy and acclimate the plant to the climate of the area in which the plant will be marketed. In the end, a grower would have a tree that is tailored to its new environment. The post-harvest environment can be controlled in many ways. For example, plant moisture loss can be regulated by adjusting relative humidity and plant temperature. The air composition of the environment and light (photoperiod, intensity, and quality) can also be controlled. Determining the environmental requirements of specific woody plants after removal from the field is an area of research that needs special emphasis and attention. Although extensive research has been done on the post-harvest physiology and handling of cut flowers, surprisingly little work has been done on the requirements of woody plants.