9° F (−13° C) was recorded in Gainesville. However, the long exposure to low temperatures severely injured many plants.

The effect of low temp on *Callistemon* species is shown in Table 1. Any plant with a rating of 2.0 or less would be well suited for landscapes in north Florida. Several of the commonly grown species, *C. citrinus, C. rigidus* and *C. speciosus,* were in this group. Other species which had ratings less than 2.0 were *C. acuminatus, C. paludosus* and *C. semperflorens.* There was no physical evidence of cold damage to *C. violaceus, C. sieberii, C. jeffersii, C. hortensis* and *C. brachyandrus.*

Plants with a rating of greater than 2.0 and less than 2.5 would be considered acceptable for use in north Florida landscapes. Plants in this group had damage confined mainly to the branch tips. *Callistemon pityoides* was the only sepcies in this group.

Plants with ratings of 2.6 or higher would not be suited for landscapes in north Florida. The bark of many of these species was split just above the soil surface, and they did not survive even when severely pruned back. Species in this group were *C. falcatus, C. rosea, C. saugaus, C. comboynensis* and *C. formusus.* All plants of species *C. pinifolus* and *C. viminalis* were killed.

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NUTRIENT REMOVAL BY WATERHYACINTHS FROM SOLUTION CULTURES[1]

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Abstract. **Effects of 3 rates of Cu, Mn and Zn were evaluated on growth, leaf and root tissue nutritional levels of** Eichhornia crassipes **(Mart.) Solms (waterhyacinth) grown in 50% Hoagland's solution. Number of plants increased from 10 to 35 after 7 weeks in solution culture. Leaf and root tissue levels of N, P, Fe, Mn and Zn were increased after 7 weeks.**

Eutrophication of natural waters by soluble nutrients is a serious pollution problem. Nutrients stimulate over production of algae and microbes which ultimately result in O_2 deficits, undesirable taste and odor of water (3). Tertiary treatment of sewage waste water to remove nutrients is an expensive and sophisticated procedure (1). It has been proposed that certain aquatic plants could be used to remove nutrients from water resources. Rogers and Davis (7) found that a single plant of waterhyacinth absorbs up to 20.8 mg N per day and they proposed that 1 hectare of waterhyacinths under optimum conditions could absorb the average daily N and P waste production of over 800 people. Conceivably aquatic plants such as *E. crassipes* could be utilized in municipal sewage treatment facilities to aid in excess nutrient removal. This research was conducted to determine the effectiveness of *E. crassipes* in absorbing the heavy metals Cu, Mn and Zn.

Materials and Methods

Ten uniform *Eichhornia crassipes* (Mart.) Solms (waterhyacinth) plants were placed in 15 L glazed crocks containing 10 L solution on October 1, 1976 and grown in glass greenhouses maintained at a minimum temperature of approximately 21° C.

Solutions contained 50% Hoagland's I formulation (4), except Cu, Mn and Zn levels were varied at 1.0, 2.5, 5.0 and 10.0 mg/l. Solutions were aerated, maintained at pH of 6.0 and changed weekly. The experiment was completely randomized with 5 replications and 1 crock (10 leaf-plants per crock) as the experimental unit.

Nutrient analyses of root systems and the most recently matured leaf blades were taken at the outset and termination of the experiment after 7 weeks. Number of plants was also recorded at the beginning and termination of the experiment. Data were analyzed by analysis of variance method and treatment means separated by Duncan's New Multiple Range Test.

Results and Discussion

All treatments showed an increase of approximately 25 plants over a 7 week period. Penfound and Earle (6) estimated that 10 plants could produce 655, 360 plants in a single season, so a 25 plant increase is low and possibly due to short days and the 21° C glass house temperature.

Differences in foliar and root nutrient levels from initial and final sample collections are shown in Table 1. Increases of N and P in leaf tissue were 410 and 114% respectively

Table 1. Foliar and root nutrient content of *Eichhornia crassipes* before and after 7 weeks in aerated 50% Hoagland's solutions.[z]

Treatment	N (%)	P (%)	K (%)	Ca (%)	Mg
Leaves					
Initial	1.08	.57	4.39	1.520	.890
Final	5.51	1.32	4.04	.975	.461
Change	+4.43	+ .75	— .35	— .545	—.429
Roots					
Initial	2.15	.53	1.28	.780	.360
Final	2.71	.94	3.10	.419	.301
Change	+ .56	+ .44	+1.82	— .361	—.059
	Cu (mg/g)	Fe (mg/g)	Mn (mg/g)	Zn (mg/g)	
Leaves					
Initial	25	215	513	691	
Final	21	238	1645	765	
Change	— 4	+ 23	+1132	+ 74	
Roots					
Initial	29	3230	230	799	
Final	23	11393	4000	881	
Change	— 6	+8163	+3770	+ 82	

[z]Initial leaf and root sample taken at outset experiment and final after 7 weeks.

[1]Florida Agricultural Experiment Stations Journal Series No. 824.

while increases in root tissue were less. Rogers and Davis (7) similarly observed large N and P increases in waterhyacinth leaf tissue. The remaining macro-elements, except K in root tissue, were reduced from initial to final analyses. K was apparently not translocated to leaf blades and Ca and Mg not even accumulated by root mass.

Fe, Zn and especially Mn were held in root system and also transported to leaf tissue. Boyd (2) also observed extensive uptake of Fe and Mn by waterhayacinths.

Increased rates of Cu, Mn and Zn had no influence on N, K, Mg and Ca foliar nutrient levels and produced variable effect on P (Table 2).

Table 2. Influence of increased Cu, Mn and Zn rates on foliar nutrient content of *Eichhornia crassipes*.

Treatment[y]	Foliar Content				
Cu Rates (mg/l)	P (%)	Cu (mg/g)	Fe (mg/g)	Mn (mg/g)	Zn (mg/g)
1.0	1.22bc[z]	24bc	218ab	1835ab	786c
2.5	1.16ab	18a	237b	1850bc	800c
5.0	1.25c	23ab	243b	1636a	746b
10.0	1.10a	29c	195a	2050c	720a
Mn Rates (mg/l)					
1.0	1.23b	21ab	290c	1550a	738a
2.5	1.26b	19a	235b	2220b	823b
5.0	1.10a	20a	210a	3900c	802b
10.0	1.19b	26b	218a	4200d	805b
Zn Rates (mg/l)					
1.0	1.20c	15a	250b	1450a	770a
2.5	1.07b	19a	215a	1825b	754a
5.0	1.18c	32b	260b	1450a	840b
10.0	1.08b	33b	255b	1760b	893c

[y]Fertilizer Source: Cu-Cu $SO_4 \cdot 5H_2O$, Mn-Mn $SO_4 \cdot 4H_2O$, Zn-Zn $SO_4 \cdot 7H_2O$.

[z]Means within column followed by same letter are not significantly different at the 5% level.

Increased rates of Cu in soln had inconsistent effects on Cu, Zn and Mn leaf tissue levels. Increases of Mn resulted in higher Mn leaf levels, but had variable effects on Cu and Zn. Fe was decreased in leaf tissue with higher Mn levels. Antagonism between Mn and Fe has been demonstrated in numerous plants (5, 8). Higher rates of Zn in solution increased Zn foliar levels, but produced no consistent changes in Cu, Fe and Mn.

Macro-nutrient levels in root tissue of all treatments were similar, except P which showed inconsistent differences between various treatments (Table 3).

Greater amounts of Cu in soln resulted in accumulation in root tissue. Although Cu accumulation in leaf tissue was minimal, the root system shows potential for removing large quantities of Cu from solns. Increased Mn levels resulted in higher root tissue levels of Mn, Zn and Cu, but lower levels of Fe. Zn tissue levels were increased with higher levels in soln.

Waterhyacinths accumulated N, P, Cu, Fe, Mn and Zn in leaf and/or root tissues. Such nutrient removal from soln indicates a possible role for this plant in removing nutrients from municipal effluent.

Table 3. Influence of increased Cu, Mn and Zn rates on root nutrient content of *Eichhornia crassipes*.

Treatment[y]	Foliar Content				
Cu Rates (mg/l)	P (%)	Cu (mg/g)	Fe (mg/g)	Mn (mg/g)	Zn (mg/g)
1.0	1.11a[z]	23.2a	13755c	1875a	894a
2.5	1.13a	30.0b	10072a	2185a	831a
5.0	1.03a	43.8c	11054ab	2875b	876a
10.0	1.02a	52.6d	12028b	2155a	911a
Mn Rates (mg/l)					
1.0	1.01b	23.8a	17388c	1875a	875a
2.5	1.03b	22.0a	16690c	2867b	961a
5.0	1.10b	28.2b	11013b	3050b	968a
10.0	1.27a	33.8c	9440a	4075c	2788b
Zn Rates (mg/l)					
1.0	1.08b	22.6a	11137ab	2050a	874a
2.5	1.12b	22.6a	14800c	2058a	901a
5.0	1.22a	25.0a	11615a	3850b	3260b
10.0	1.06b	21.2a	10258a	3350b	5137c

[y]Fertilizer Source: Cu-Cu $SO_4 \cdot 5H_2O$, Mn-Mn $SO_4 \cdot 4H_2O$, Zn-Zn $SO_4 \cdot 7H_2O$.

[z]Means within column followed by same letter are not significantly different at the 5% level.

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