Growth and Flowering of Three Garden Chrysanthemum Cultivars Produced in Plastic or Copper-Impregnated Fiber Containers[1]

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Abstract

A study was conducted with three garden chrysanthemum cultivars (*Dendranthemum x grandiflorum* (Ramat.) Kitamura), 'Grenadine', 'Nicole', and 'Tolima' to evaluate growth and flowering in 2.6 liter (#1) black plastic containers compared to copper hydroxide ($Cu(OH)_2$) impregnated fiber containers. For all three cultivars, growth indices, shoot and root dry weights, and total biomass increased for plants grown in fiber containers. Total number of flower buds per plant increased 30 to 32% for 'Grenadine' and 'Nicole' and 53% for 'Tolima' in fiber containers. Plants grown in $Cu(OH)_2$-impregnated fiber containers had less root coverage at the container:substrate interface and no observable root circling in contrast to visible root circling of plants grown in black plastic containers. Foliar nutrient analysis on the cultivar 'Grenadine' showed that K decreased and Fe and Cu increased when grown in $Cu(OH)_2$-impregnated fiber containers. No visible nutrient abnormalities were observed.

Index words: container production, copper hydroxide.

Species used in this study: Garden chrysanthemum (*Dendranthemum x grandiflorum* (Ramat.) Kitamura).

Significance to the Nursery Industry

With concerns about recycling of black plastic containers, use of biodegradable containers manufactured from recycled paper fiber is an appealing alternative for nurseries and consumers. While nontreated fiber containers degrade too quickly under hot, humid conditions in the southern United States, fiber containers impregnated with copper hydroxide ($Cu(OH)_2$) have a potential longevity of approximately two years. Results indicate that growth and flowering of garden chrysanthemum cultivars can be enhanced by producing plants in $Cu(OH)_2$-impregnated fiber containers compared to black plastic containers. Growth and flowering enhancement occurred with no further modifications in existing production practices other than changing container design. Increased plant size and number of flowers may increase product value and use of a biodegradable container may appeal to consumers.

Introduction

Garden chrysanthemums are a versatile crop and are available in a wide assortment of colors and flower forms. Their popularity among consumers increased 39% between the years of 1984 and 1989, with an estimated crop value of $36 million in 1989 (3).

Poor aeration/overwatering and high root-zone temperatures during the summer months are two problems associated with the production of garden chrysanthemums in containers (1, 10). Growers have noted that production of garden chrysanthemums in fiber containers reduced plant losses by up to 10% compared to plants grown in black plastic containers (1). Decreased container-substrate temperatures and increased container porosity were suggested as possible reasons for improved plant growth, though container degradation was noted as a production problem with fiber containers.

Fiber containers treated with cupric hydroxide ($Cu(OH)_2$) have retained structural integrity under production conditions for up to two years (personal observation), thereby eliminating container degradation as a production problem for most crops. Previous research with $Cu(OH)_2$-impregnated fiber containers showed root and shoot growth of *Plumbago auriculata* Lam. increased compared to plants produced in black plastic containers (11). The purpose of this study was to evaluate the growth and flowering characteristics of three garden chrysanthemum cultivars produced in black plastic or $Cu(OH)_2$-impregnated fiber containers.

Materials and Methods

The experiment was conducted outdoors under full sun at Wight Nurseries in Cairo, Georgia, using standard cultural practices. Uniform rooted cuttings of *Dendranthemum* x *grandiflorum* (Ramat.) Kitamura 'Grenadine', 'Nicole', and 'Tolima' were transplanted into containers on June 28, 1993. Black plastic containers had a height of 16 cm (6.3 in), a top width of 16 cm (6.3 in) and a bottom width of 13 cm (5.1 in) for a volume of 2.6 liters (0.7 gal). Fiber containers had a height of 18 cm (7.1 in), a top width of 18 cm (7.1 in) and a bottom width of 14 cm (5.5 in) for a volume of 3.6 liters (1.0 gal). Fiber containers were manufactured by Keiding, Inc. (Milwaukee, WI) and had approximately 3000 mg/kg (ppm) $Cu(OH)_2$ impregnated within the container walls after the molding and drying manufacturing process as verified by Inductively Coupled Plasma Emission Spectroscopy.

Potting medium was milled pine bark and sand (4:1 by vol) amended with dolomitic limestone at 4.2 kg/m^3 (7.0 lb/yd^3) and 0.9 kg/m^3 (1.5 lb/yd^3) micronutrient mix (Graco Fertilizer Co., Cairo, GA). The same volume of potting medium (2.6 liters (0.68 gal)) was added to each container type. Liquid fertilizer (12.5–3.3–9.5) was applied at each irrigation at 70 mg N/liter (ppm). Plants were irrigated as needed

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at 1.3 cm (0.5 in) using solid set sprinklers. Plants received one manual pinching to remove the terminal and induce branching on July 12, 1993. The experiment was conducted with plants sorted by cultivar and containers arranged in randomized complete blocks with 10 replications.

Plants were harvested on September 27, 1993, just as flower buds were beginning to open on the three cultivars. A growth index [(height + width east-west + width north-south) / 3] in cm was measured and number of flower buds per plant determined. Root coverage (a visual rating of the amount of root area present at the container:substrate interface) was rated using the scale: 1 = < 25% of the container:substrate interface covered with white roots; 2 = > 25 but < 50% coverage; 3 = > 50 but < 75% coverage; and 4 = > 75% coverage. Shoot and root dry weights were determined after plants had been oven-dried at 70C (158F) for 72 hr.

Foliage of the cultivar 'Grenadine' was removed after dry weight was determined, ground to 20 mesh, and duplicate 1-g samples were analyzed for N by the macro-Kjeldahl method (6). Phosphorous was determined using the molybdovandate method while leaf K, Ca, Mg, Zn, Mn, Fe, and Cu were determined by atomic absorption spectrophotometry. Data were evaluated by analysis of variance using SAS (12). Means were compared by LSD.

Results and Discussion

All three cultivars of garden chrysanthemums had increased growth indices, shoot and root dry weights, total biomass, and number of flower buds when grown in copper-impregnated fiber pots compared to black plastic containers (Table 1). Increases in growth indices for plants in fiber containers ranged from 10% for 'Grenadine' to 21% for 'Tolima'.

Shoot dry weights of 'Grenadine', 'Nicole', and 'Tolima' increased 33%, 29%, and 42%, respectively when grown in fiber pots compared with black plastic (Table 1). Corresponding increases in root dry weights for the three cultivars in fiber pots were 36%, 78%, and 52%, respectively. Total biomass, the sum of shoot and root dry weight, increased 34% for 'Grenadine', 52% for 'Nicole', and 46% for 'Tolima'. Container type did not affect the root:shoot ratio of plants in this study (data not shown).

When grown in copper-impregnated fiber containers, the cultivars 'Grenadine', 'Nicole', and 'Tolima' had 30%, 32%, and 53% more flower buds per plant, respectively, than plants grown in black plastic containers (Table 1).

Plants grown in copper-impregnated fiber containers had less root coverage at the container:substrate interface than plants in the black plastic containers (Table 1). Similar control of root growth at the container:substrate interface was seen with *Coreopsis verticillata* L. 'Moonbeam' and *Plumbago auriculata* Lam. (11). No visible roots were seen on 'Grenadine' in fiber pots, whereas some root matting occurred on the other cultivars. Root circling occurred on plants grown in black plastic containers but not on plants in fiber pots.

Foliar K concentrations were less when 'Grenadine' plants were grown in copper-impregnated fiber pots than when grown in black plastic containers (Table 2). In contrast, foliar Fe and Cu concentrations increased 33% and 103%, respectively, for plants in fiber pots. Container type had no effect of foliar N, P, Ca, Mg, Zn, or Mn concentrations (Table 2). Sawtooth oak (*Quercus acutissima* Carruth) had more Cu in the foliage when grown in $Cu(OH_2)$-treated plastic containers compared to nontreated plants (2).

For most crop species, Cu toxicity occurs when foliar concentrations are above 20 to 30 mg/kg dry weight (8). Plank (9) noted that typical Cu concentrations found in chrysanthemums ranged from 5 to 50 mg/kg. Although no nutrient toxicity symptoms were noted for plants grown in copper-impregnated fiber pots, a foliar Cu concentration of 67 mg/kg can be considered excessive based on previous literature (7, 9). High concentrations of Cu have been noted to induce Fe deficiencies, however, foliar Fe increased when plants were grown in fiber pots (Table 2). Foliar Fe concentrations for both container types were within an acceptable range (50–300 mg/kg) for chrysanthemums (9). Foliar K concentrations were low (1.9 and 1.6%, respectively, for black plastic and fiber pots) compared to a normal range (3.5 to 6.0%) for chrysanthemum (9); but were above the level (1.3%) of K

Table 1. Influence of container design on the growth and flowering of three chrysanthemum cultivars.

Cultivar	Container design	Growth index[x]	Shoot dry wt. (g)	Root dry wt. (g)	Total biomass (g)	No. of flower buds	Root coverage[x]
Grenadine	Black plastic	32.6	57.1	58.8	115.9	212	3.7
	Fiber + $(Cu(OH)_2)$	35.8	75.8	80.0	155.7	276	1.0
P>F[z]		**	**	*	**	**	**
Nicole	Black plastic	27.3	56.8	51.1	107.9	255	4.0
	Fiber + $(Cu(OH)_2)$	30.6	73.1	90.8	163.9	336	2.0
P>F		**	**	**	**	**	**
Tolima	Black plastic	28.3	54.0	49.7	103.7	186	3.4
	Fiber + $(Cu(OH)_2)$	34.2	76.5	75.5	152.0	285	1.8
P>F		**	**	*	**	**	**

[z]P>F: ** ≤ 0.01, * ≤ 0.05, NS > 0.05 (n = 10).

[y]Growth index = [(height + width east-west + width north-south) / 3].

[x]Root coverage = 1 = < 25% of the container:substrate interface covered with white roots; 2 = > 25 but < 50% coverage; 3 = > 50 but < 75% coverage; and 4 = > 75% coverage.

Table 2. Foliar nutrient concentrations (% dry wt. basis) of chrysanthemum 'Grenadine' grown in black plastic or fiber containers containing $Cu(OH)_2$.

Container design	N	P	K	CA	Mg	ZN	MN	FE	CU
	(%)					(mg/kg)			
Black plastic	2.6	0.3	1.9	0.9	0.5	68	77	160	34
Fiber + ($Cu(OH)_2$)	2.6	0.3	1.6	1.0	0.5	73	83	213	67
P>F[z]	NS	NS	*	NS	NS	NS	NS	*	**

[z]Significance tests: ** ≤ 0.01, * ≤ 0.05, NS ≥ 0.05.

which was associated with 90% of maximum yield for the cultivar 'Bright Golden Anne' (5). For both container types, foliar N and Ca were considered low whereas foliar Zn concentrations were high (9). Low foliar concentrations of N and K seen in this study can be attributed to the low liquid feed program used by the nursery (70 mg N/liter and 45 mg K/liter) compared to a minimum recommendation of 200 mg N/liter and 200 mg K/liter for garden chrysanthemums (4, 10).

Results of this study indicate that vegetative growth and flowering of garden chrysanthemums can be increased when $Cu(OH)_2$-impregnated fiber containers are used instead of black plastic with little or no modification of existing production practices. The improved growth seen in this study is interpreted to be the result of improved aeration and lower container substrate temperatures. A result of fiber containers being porous is increased aeration of the substrate, thereby reducing chances of the substrate remaining too wet for extended periods, a common problem for garden mums produced in plastic containers. Maximum container substrate temperatures during the summer months are typically 10C (18F) cooler in fiber containers compared to black plastic containers (unpublished data). Therefore, the combination of improved substrate aeration and lower substrate temperatures in conjunction with possible benefits from copper root pruning resulted in improved growth of garden mum cultivars grown in copper hydroxide impregnated fiber containers.

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