Influence of Container Mulches on Irrigation and Nutrient Management[1]

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Abstract

An experiment was conducted in 2005 and repeated in 2006 to determine the influence of mulch products and controlled release fertilizer (CRF) placement on irrigation and nutrition requirements of container-grown crops. Hydrangea (*Hydrangea macrophylla* 'Fasan' and 'Endless Summer') were grown in 2.7 liter (#1) containers with CRF placed above or below the mulch. Non-mulched controls were also maintained. Mulch products included geotextile discs, coco discs, plastic discs, hazelnut shells, sawdust, Biotop, and crumb rubber. Hydrangea growth, plant quality, foliar color, and foliar nutrition were measured, as well as water loss from containers. Controlled release fertilizer placed below mulch resulted in larger plants with higher quality ratings and foliar N levels compared to CRF placed above the mulch, and similar or superior size, quality and foliar N compared to non-mulched containers. After correcting for differences in plant size, there were few and minor differences in water loss from hydrangea between mulched and non-mulched containers.

Index words: alternative weed control, non-chemical weed control, disc, controlled release fertilizer, fertilizer placement.

Significance to the Nursery Industry

Preemergence herbicides are the primary tools used for weed control in container production. However, preemergence herbicides cannot be used in every production situation, most notably on herbicide-sensitive species or in enclosed production areas where herbicides are not labeled. There are several commonly used alternatives to preemergence herbicides including discs and mulches made from a wide variety of natural and synthetic materials. Covering the container surface with any material may require changes in some aspects of the production and maintenance of container nursery crops, in particular fertilization and irrigation practices. Data herein demonstrated that controlled release fertilizer (CRF) placement below the mulch product produced plants with similar or greater size, plant quality, and foliar nutrition compared to non-mulched plants. Placement of CRF above the mulch product reduced plant size and quality compared to placement below mulch or non-mulched crops. Mulch products caused few or minor differences in water loss from hydrangea compared to non-mulched controls.

Introduction

Weeds in container systems are commonly controlled with preemergence herbicides; however, herbicides are not acceptable in every situation. Some crops such as hydrangea (*Hydrangea macrophylla*) and azalea (*Rhododendron obtusum*) are sensitive to preemergence herbicides (17), and no preemergence herbicide is labeled for use inside enclosed structures such as greenhouses. Nursery growers in Oregon frequently use mulches for weed control among herbicide-sensitive crops or inside enclosed structures (personal observation).

Products used or with potential for use in the Pacific Northwest (PNW) region of the United States and Canada include; geotextile discs, coco discs, plastic discs, hazelnut (*Corylus avellana*) shells, Biotop, sawdust, and crumb rubber. Geotextile discs are a non-woven polypropylene fabric coated on one side with cupric hydroxide. Coco-discs are a byproduct of coconut (*Cocos nucifera*) processing where longer fibers are extracted from the coconut fruit pith and used for making weed discs among many other products (brooms, door mats, etc.). Coco discs are approximately 0.6 cm (0.25 in) thick. Hazelnut shells are a byproduct of processing nuts from that tree and crushed to a particle size <0.6 cm (0.25 in). Plastic weed discs have been manufactured with several designs, but most are composed of a thin but rigid plastic material that covers the container surface, with preformed holes for air and water infiltration. Biotop is mulch composed of starch and plant fibers used throughout Oregon, Washington, and British Columbia. Sawdust in the PNW is primarily from Douglas fir (*Pseudotsuga menziesii*) trees and can be obtained in a variety of particle sizes. Crumb rubber is produced by mechanically removing the steel radials from tires, then shredding the rubber portions. Crumb rubber can be processed in batches of different particle size <0.6 cm (0.25 in). Weed control efficacy has been evaluated for geotextile discs (6, 13, 15, 16), coco discs (11), hazelnut shells (19), plastic discs (6, 11), Biotop (9, 11), sawdust from Douglas fir trees (11), and crumb rubber (7).

There are advantages and disadvantages to all methods of chemical and non-chemical weed control (2, 6). Many Oregon nursery producers have adopted one or more of the previously mentioned alternative weed control methods. With adoption of these methods, questions have arisen about changes in irrigation and fertilization practices to account for anticipated changes in evapotranspiration (ET) rates and potential nitrogen (N) immobilization. Some research has addressed ET rates from mulched container substrates (primarily peat-based) and found that water loss is reduced when the container surface is covered (4, 12). However, Medina et al. (14) reported little or no evaporation from 57 liter (#15) containers in pot-in-pot culture; transpiration was the pri-

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mary factor driving water loss. Glenn et al. (8) demonstrated that recycled paper mulch with high carbon (C):N would immobilize some fraction of a topdressed CRF, with greater immobilization when CRF was placed above the mulch compared to below the mulch.

Due to increased use of alternative weed control methods in Oregon, and the relative lack of information on how these mulch products affect irrigation and nutrition practices, the objective of our research was to 1) evaluate the influence of commonly used mulch products on water loss, and 2) evaluate placement of topdressed CRF on plant growth and nutrition.

Materials and Methods

On May 25, 2005, hydrangeas (*Hydrangea macrophylla* 'Fasan') were potted from 10 cm (4 in) pots into 2.7 liter (#1) containers using a 4:1 Douglas fir bark:sphagnum peat moss substrate (v/v) amended with 1.8 kg/m^3 (3 lb/yd^3) dolomitic lime, 2.2 kg/m^3 (3.8 lb/yd^3) gypsum, and 0.9 kg/m^3 (1.5 lb/yd^3) Micromax micronutrients (The Scotts Co., Marysville, OH). Hydrangeas were approximately 13 cm (5 in) tall and 5 cm (2 in) wide at the time of potting. Nitrogen (N), phosphorus (P), and potassium (K) were topdressed in the form of Osmocote 15N–3.9P–9.9K (15–9–12 Northern, 8 to 9 month release, The Scotts. Co.) CRF at 19 g/container (0.67 oz/container), either above or below the mulch. Mulch products included sawdust [<0.6 cm (0.25 in)], coco discs (Timm Enterprises, Oakville, Ontario, Canada), plastic discs (Terra Link, Abbotsford, British Columbia, Canada), Biotop (Plantech Control Systems, White Rock, British Columbia, Canada), and crumb rubber [0.6 cm (0.25 in)] (Magnum Industries, Regina, Saskatchewan, Canada). After potting, hydrangeas were grown in a retractable roof greenhouse with the roof remaining open at all times. Hydrangeas were grown with an overhead irrigation system applying water twice daily at 0.6 cm (0.25 in) per irrigation event. Plants were arranged in a completely randomized design with 16 single-container replications per treatment. All containers were maintained weed free via periodic handweeding.

Data collected included growth indices [(height + width + width) ÷ 3] and a subjective quality rating on a scale from 0 to 10 (0 = lowest quality and 10 = highest quality) measured 4 and 15 weeks after potting (WAP). Water lost in a 24 hour period was measured 4 and 15 WAP by weighing containers after saturating with irrigation, then allowing containers to dry for 24 hr (irrigation and rain withheld) in their previously described production environment before weighing again. Weather conditions 4 and 15 WAP were clear with high temperatures of 27 and 33C (81 and 93F), respectively. Water loss was calculated as the initial plant weight minus the final plant weight (after 24 hr). Water loss was measured on six single-plant replications per treatment. Recently matured leaves from three single-plant replications were collected 4 WAP and analyzed for N, P, K, Ca, Mg, S, B, Fe, Mn, Cu, and Zn. Foliar N was determined by combustion analysis using a 1500 N analyzer (Carlo Erba, Milan, Italy). The remaining nutrients were determined by inductively coupled plasma-emission spectrometry (ICP) (Thermo Jarrel Ash, Offenbach, Germany). Foliar chlorophyll content was measured 15 WAP with a SPAD-502 chlorophyll meter (Minolta, Ramsey, NJ). The experiment was terminated 15 WAP (September 6, 2005) at which time hydrangea shoot dry weight (SDW) was measured by severing shoots at the substrate surface and oven-drying them at 60C (106F) for 72 hr.

The experiment was repeated in 2006 with the following changes. Containers were filled March 15, 2006, with 100% Douglas fir bark amended with 1.8 kg/m^3 (3 lb/yd^3) dolomitic lime and 0.9 kg/m^3 (1.5 lb/yd^3) Micromax micronutrients. Containers were potted with 'Endless Summer' hydrangea (*Hydrangea macrophylla*). A 17N–2.6P–9.9K (Apex 17–6–12, 12 to 14 month release, Simplot Turf and Horticulture, Lathrop, CA) CRF was topdressed either above or below mulch products at a rate of 16 g/container (0.56 oz/container). Due to lack of availability, Biotop and crumb rubber were not included; geotextile discs (Texel USA, Inc., Henderson, NC) and hazelnut shells were added. There were 15 single plant replications per treatment combination. Data collected included growth indices and quality ratings 11 and 16 WAP. Plant water loss was determined 16 WAP using eight single container replications. Foliar samples were collected 16 WAP and analyzed similarly to experiment 1, but using five single container replications. The experiment was terminated 27 WAP (September 22, 2006) by measuring hydrangea SDW.

Data were subjected to analysis of variance using the general linear model procedure in SAS (SAS Version 8, SAS Institute, Cary, NC), correlation analysis, regression analysis, and Fisher's protected least significant difference test (LSD, $\alpha = 0.05$) where appropriate. Water loss data were subjected to analysis of covariance to adjust for the influence of plant size on water loss. Least squared means of water loss in mulched containers, adjusted for plant growth index, were compared to non-mulched controls using the Dunnett-Hsu adjustment.

Results and Discussion

2005. By 4 WAP, hydrangea growth index was affected by mulch type and fertilizer placement, but the interaction was not significant (Table 1). When averaging across fertilizer placement, only Biotop reduced hydrangea growth index compared to non-mulched controls. Across mulch types, hydrangea with CRF placed below the mulch were larger compared to those with CRF placed above ($p < 0.0001$), and similar to non-mulched controls ($p = 0.255$). This differs from observations by Glenn et al (8) who reported shoot dry weight of two species of petunia (*Petunia floribunda* 'Midnight Madness' and *P. grandiflora* 'Ultra Blue') were reduced with CRF placement either above or below a recycled paper mulch, compared to non-mulched controls. Quality ratings for all plants 4 WAP were similar to non-mulched plants with the exception of those mulched with Biotop (regardless of CRF placement) and sawdust (CRF applied below mulch).

Foliar N, P, and K were affected by an interaction between mulch type and fertilizer placement. Foliar N and P were lower when CRF was placed above Biotop, coco discs, and crumb rubber, but not affected by placement among containers treated with sawdust and plastic discs. Glenn et al. (8) reported that CRF placement with respect to mulch had no effect on foliar N compared to non-mulched controls in two petunia species. All treatments relative to non-mulched controls responded similarly with respect to foliar N and P, and across all treatments the two variables were highly correlated ($r = 0.783$, $p < 0.001$, $n = 33$) with a linear relationship ($P = 0.064 \times N + 0.076$). Differences in N and P across treatments could have been caused by either nutrient immobilization from the mulch or reduced fertilizer release rates from

Table 1. Growth and water loss for hydrangea potted in a Douglas fir bark substrate, covered with various mulch products, and topdressed with controlled release fertilizer placed either above or below the mulch product, 2005.

		4 WAP[z]						15 WAP				
Product	Fertilizer placement	Growth index[y] (cm)	Quality rating[x]	N (%)[w]	P (%)	K (%)	Water loss[v] (L)	Growth index	Quality rating	Water loss (L)	SPAD[u]	SDW (g)[t]
Biotop	above	7.7	6.4	2.1	0.23	2.3	0.13	15.5	9.2	0.25	40.3	32.9
	below	8.7	9.0	2.8	0.30	2.4	0.15	17.6	9.5	0.27	44.9	49.6
Coco disc	above	8.4	9.2	2.9	0.26	2.4	0.14	15.8	8.9	0.23	39.8	37.6
	below	9.3	9.6	3.5	0.31	2.2	0.17	17.9	9.4	0.30	45.2	52.2
Plastic disc	above	8.6	9.3	3.3	0.30	2.5	0.13	16.1	8.9	0.23	41.8	40.4
	below	9.0	9.7	3.4	0.28	2.0	0.14	17.6	9.4	0.29	44.4	45.1
Crumb rubber	above	8.4	9.3	2.3	0.19	1.8	0.14	15.6	8.7	0.23	38.5	37.4
	below	9.4	9.6	3.2	0.28	1.8	0.15	17.2	9.1	0.32	42.5	53.4
Sawdust	above	8.8	9.6	3.2	0.27	1.8	0.15	17.4	9.6	0.29	43.3	47.3
	below	9.2	8.8	3.1	0.27	2.1	0.17	17.1	9.4	0.33	43.0	54.6
Control		9.5	9.9	3.2	0.27	1.9	0.17	17.8	9.4	0.31	42.8	52.1
LSD (0.05)		0.8	0.7	0.4	0.04	0.3	0.03	1.3	0.5	0.06	3.8	7.8
		P-values										
Contrast statements												
Above vs. control[s]		<0.001	<0.001	0.007	0.190	0.043	0.004	0.001	0.044	0.004	0.165	<0.001
Below vs. control		0.255	0.059	0.798	0.368	0.121	0.166	0.563	0.755	0.530	0.430	0.704
Above vs. below		<0.001	0.001	0.000	0.001	0.384	0.008	<0.001	0.004	<0.001	<0.001	<0.001
Mulched vs. control		0.012	0.002	0.107	0.823	0.062	0.026	0.035	0.223	0.064	0.754	0.016
Main effects												
Mulch type		0.035	<0.001	<0.001	0.013	<0.001	0.057	0.413	0.012	0.100	0.319	0.009
Fertilizer placement		<0.001	0.001	0.000	0.001	0.384	0.008	<0.001	0.004	<0.001	<0.001	<0.001
Interaction		0.631	<0.001	0.008	0.007	0.028	0.650	0.051	0.311	0.374	0.260	0.114

[z]Weeks after potting; hydrangea were potted May 25, 2005.

[y]Growth index = (height + width + width)/3.

[x]Quality rating on a scale from 0 to 10 where 0 = plant with poor vigor and foliar color and 10 = vigorous plant with dark foliar color.

[w]N, P, and K are the percent nitrogen, phosphorus, and potassium in hydrangea foliage, expressed as a percent of dry matter (n = 3).

[v]Water loss was measured as the weight of container and plant after saturation minus its weight 24 hours later.

[u]SPAD-502 chlorophyll meter (Minolta, Ramsey, NJ).

[t]Shoot dry weight of hydrangea plants severed at the soil line.

[s]Above and Below are in reference to fertilizer placement with respect to the mulch product.

the CRF. Foliar K among plants receiving a mulch treatment was similar to or higher than non-mulched containers.

Mulch type affected water loss from containers at 4 WAP ($p = 0.057$), although differences were relatively small. Across mulch treatments, water loss was less in containers with CRF placed above mulch products compared to below ($p = 0.008$). However, water loss was more a function of plant size than CRF placement. Water loss was correlated to plant growth index ($r = 0.451$, $p < 0.001$, $n = 68$). Controlled release fertilizer placement below mulch products generally resulted in larger plants, which in turn transpired more water. Analysis of covariance was used to compare water loss in mulched containers to non-mulched, adjusted for plant growth index (Table 2). Containers covered with the plastic discs and crumb rubber lost less water than non-mulched containers, although differences were relatively small.

By 15 WAP, mulch type did not affect hydrangea growth index, although effect of fertilizer placement was similar to that described 4 WAP. Foliar N, P, and K were not measured 15 WAP, however, SPAD readings followed a trend similar

Table 2. Least squared means of water loss (L) from container-grown hydrangea grown with various mulch treatments, adjusted for plant size.

	Water loss in 24 h (L)		
	2005		2006
Mulch product	4 WAP[z]	15 WAP	16 WAP
Biotop	0.15	0.27	—
Coco disc	0.16	0.27	0.23
Plastic disc	0.14*	0.26	0.23
Crumb rubber	0.14*	0.29	—
Sawdust	0.16	0.30	0.28
Hazelnut shells	—	—	0.28
Geotextile disc	—	—	0.24
Control	0.17	0.29	0.27

[z]Weeks after potting; hydrangea were potted May 25, 2005 and March 15, 2006.

*Indicates a significant difference between the mulch treatment and non-mulched controls, according to Dunnet-Hsu comparisons of adjusted means ($\alpha = 0.05$).

to that for foliar N at 4 WAP. Others have documented strong correlation between SPAD and foliar N in other crops (18, 20). Similar to 4 WAP, water loss at 15 WAP was correlated to growth index (r = 0.743, $p < 0.001$, n = 66) and thus primarily a function of plant size. No mulch treatment reduced water loss compared to non-mulched controls 15 WAP (Table 2). At the conclusion of the study hydrangea SDW, with respect to CRF placement, responded similarly to growth index at 4 and 15 WAP.

2006. Hydrangea in this experiment responded similarly to those in 2005, thus for brevity only data collected 16 WAP will be presented and discussed. Fertilizer placed below mulch products increased plant growth compared to non-mulched plants while placement above the mulch reduced plant growth (contrast analyses, Table 3). Quality ratings, SPAD readings, and foliar N all followed a similar general trend in that placing CRF below the mulch products resulted in improved plant performance compared to non-mulched controls, while placement above the mulch product reduced plant performance. Foliar P did not respond to treatment and foliar K was greater when CRF was placed above mulch products compared to placement below (p = 0.001). Lack of response in foliar P could have been caused by use of a different CRF product. Similar to the 2005 experiment, water loss was highly correlated to plant size (r = 0.837, $p < 0.001$, n = 88). Water loss among mulched containers was similar to non-mulched controls after adjusting for plant size (Table 2). At the conclusion of the study, SDW of hydrangea responded to mulch type and fertilizer placement. Differences in SDW were greater in response to fertilizer placement, in that CRF placement above mulch products greatly reduced plant growth. Shoot dry weight differences followed a similar trend to that observed in the 2005 study (in response to fertilizer placement), although differences in 2006 were more pronounced. The release intervals for the CRF formulations used in 2005 and 2006 were 8 to 9 months and 12 to 14 months, respectively. The slower release rate of the CRF used in 2006 likely exacerbated differences in plant response from fertilizer placement.

Medina et al., (14) reported little or inconsequential evaporation across ten species of shade tree growing in 57 liter (15 gal) containers in pot-in-pot culture. They concluded water loss from these containers was due to transpiration and primarily a function of canopy size and structure. Substrate in the study described by Medina et al. were comprised primarily of Douglas fir bark. Other substrate types may respond differently. Argo and Biernbaum (4) demonstrated covering several peat-based substrates with a plastic evaporation bar-

Table 3. Growth and water loss of hydrangea 16 weeks after potting (WAP) in a Douglas fir bark substrate, covered with various mulch products, and topdressed with controlled release fertilizer placed either above or below the mulch product, 2006.

Mulch product	Fertilizer placement	Growth index[z] (cm)	Quality rating[y]	SPAD[x]	N[w] (%)	P (%)	K (%)	Water loss[v] (L)	SDW[u] (g)
Coco disc	Above	18.2	2.6	26.6	1.6	0.23	2.1	0.14	16.1
	Below	33.1	4.4	42.2	2.7	0.22	1.5	0.32	60.3
Plastic discs	Above	15.7	2.6	21.6	1.1	0.26	1.7	0.12	9.6
	Below	34.2	4.6	43.1	2.5	0.21	1.3	0.30	65.0
Sawdust	Above	24.0	3.8	35.9	2.5	0.20	1.9	0.26	38.4
	Below	30.4	4.0	40.0	2.6	0.23	1.6	0.31	55.8
Hazelnut shell	Above	24.2	3.5	32.7	2.6	0.25	2.1	0.27	45.9
	Below	34.4	4.4	41.7	2.8	0.25	1.7	0.35	62.3
Geotextile	Above	22.4	3.4	35.0	2.3	0.18	1.7	0.18	30.3
	Below	29.0	4.1	39.6	2.8	0.22	1.6	0.27	49.4
Control		27.1	3.9	37.3	2.5	0.20	1.7	0.26	44.0
LSD (0.05)		3.6	0.4	4.1	0.5	NS	0.5	0.04	7.4
		P-values							
Contrast statements									
Above vs. control[t]		<0.001	<0.001	<0.001	0.018	0.503	0.193	0.000	<0.001
Below vs. control		<0.001	0.006	0.015	0.247	0.485	0.562	0.004	<0.001
Above vs. below		<0.001	<0.001	<0.001	<0.001	0.960	0.001	<0.001	<0.001
Mulched vs. control		0.685	0.425	0.351	0.506	0.475	0.704	0.562	0.816
Main effects									
Mulch type		0.008	0.005	0.001	<0.001	0.352	0.191	<0.001	<0.001
Fertilizer placement		<0.001	<0.001	<0.001	<0.001	0.960	0.001	<0.001	<0.001
Interaction		<0.001	<0.001	<0.001	0.001	0.454	0.624	<0.001	<0.001

[z]Growth index = (height + width + width) / 3.

[y]Quality rating on a scale from 0 to 10 where 0 = plant with poor vigor and foliar color and 10 = vigorous plant with dark foliar color.

[x]SPAD-502 chlorophyll meter (Minolta, Ramsey, NJ).

[w]N, P, and K are the percent nitrogen, phosphorus, and potassium in hydrangea foliage, expressed as a percent of dry matter (n = 5).

[v]Water loss was measured as the weight of container and plant after saturation minus its weight 24 hours later.

[u]Shoot dry weight of hydrangea plants severed at the soil line, measured 27 WAP.

[t]Above and Below are in reference to fertilizer placement with respect to the mulch product.

rier reduced the number of irrigation events and total applied water in Easter lilies (*Lilium longiflorum*). They suggested peat fibers act as a wick, moving substrate moisture to the container surface. Substrates used in our studies contained 20 and 0% peat moss in 2005 and 2006, respectively, and were composed primarily of Douglas fir bark which lacks the capillarity and wicking properties of peat (3).

Another factor that could lead to different interpretations of how mulch products affected water loss rates is canopy coverage of the substrate surface. Lohr and Pearson-Mims (12) demonstrated that prior to canopy cover, impatiens (*Impatiens wallerana*) required more frequent irrigation to maintain 40% container capacity when not mulched compared to containers mulched with either pine bark or sphagnum peat. After canopy closure, plants required similar irrigation frequency regardless of mulch. Our study used hydrangea as the test plant which have large leaves and probably provided complete canopy cover more quickly than impatiens.

Controlled release fertilizer placement greatly affected plant nutrition, in that CRF placed above the mulch product generally reduced plant growth and quality relative to non-mulched controls, while placement below the mulch product improved plant growth and quality. Glenn et al. (8) demonstrated that a recycled paper mulch reduced petunia growth, foliar color, and flower number compared to non-mulched controls, and that CRF placement above mulch reduced these parameters even more than placement below mulch. Glenn et al. (8) reported the recycled paper to have a C:N ration of 500:1. Carbon:nitrogen ratios of the organic mulches in our study were not determined, however C:N of Douglas fir sawdust has been reported to be 593:1 (1). Douglas fir sawdust used in our study had similar C:N as the recycled paper used by Glenn et al. (8), however, Douglas fir sawdust did not reduce plant growth, quality, or foliar nutrition of hydrangea in either 2005 or 2006, regardless of CRF placement. Glenn et al. (8) also described the recycled paper product as being very absorptive of water, swelling to twice its original volume when irrigated. None of the mulches in our study were as absorptive as recycle paper. It is possible that much of the intercepted N in the study by Glenn et al. (8) was a result of the water absorptiveness of the mulch product (N being absorbed along with its solvent water), and not necessarily biological N immobilization. Fertilizer salts in solution would not have been intercepted in our study to the degree that they were with recycled paper. Furthermore, containers covered with plastic discs were affected by CRF placement at 15 WAP in 2005 and 2006 when plastic discs would presumably have no N immobilization potential. Another factor that could explain differences in plant response to CRF placement is differential nutrient release rates from the CRF caused by different temperatures above and below the mulch product (10). Broschat (5) showed that CRF release is slower when placed on the surface of a pine bark substrate compared to covering with silica sand or additional pine bark. Hydrangea grows quickly during early spring in the PNW, and slow N and P release from CRF placed above mulch products early in the growing season are likely responsible for the reduced plant size and quality of those crops.

In conclusion, use of mulch products on the substrate surface should not reduce water requirements of plants growing in coarse bark substrates. When topdressing CRF, nursery growers should apply the CRF prior to mulching. Placement of CRF above some mulch products will reduce plant growth. While this research was conducted on CRF applications at potting, it is reasonable to suggest that CRF applications that occur later in the production cycle will be similarly affected by placement with respect to mulch product. Results of this research are based on production of a relatively fast growing, large leaf species in a relatively small container. Slower growing crops, or crops grown in larger containers may respond differently.

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