FORCING PERENNIALS

– Root Zone Management –

Learn the growing conditions to avoid or embrace.

Editor's note: Michigan State University and GREENHOUSE GROWER bring you our second series on forcing perennials. This group of articles will be bound into another GG Plus booklet: Firing Up Perennials II. Part 12 focuses on root zone management.

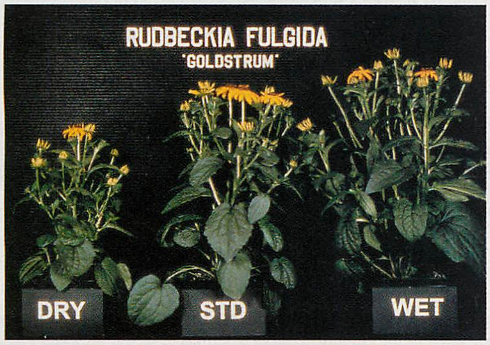

Figure 1. As moisture level increased, *Rudbeckia fulgida* 'Goldsturm' obtained greater plant mass in a 5$^1/_2$-inch container.

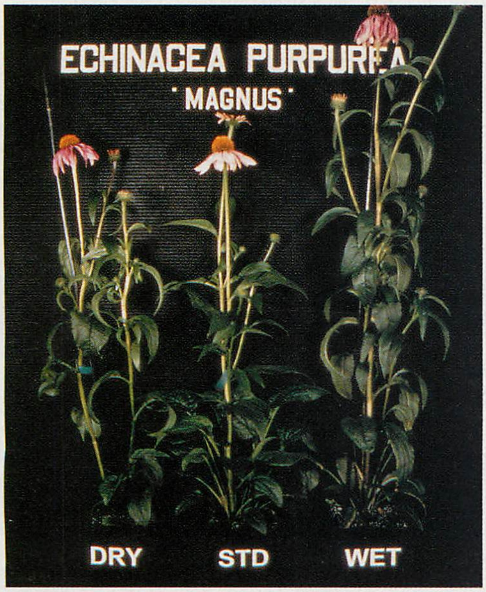

Figure 2. *Echinacea purpurea* 'Magnus' plant height increased when container moisture level was kept above 75% container capacity at a constant liquid fertilizer rate of 125-12-125 ppm NPK.

by ***JOHN BIERNBAUM*** *and* ***MARY-SLADE MORRISON***

PROVIDING optimum environmental conditions is difficult when many species are being grown in one area. Fortunately, when it comes to water, media, fertilizer, or pH, rarely do we need to provide for the best growth. Growers simply need to know which conditions provide acceptable growth and which conditions to avoid. Usually, plants tolerate a wide range of root zone conditions and only a few must be avoided.

Michigan State University's (MSU) perennial forcing research team has successfully grown a wide range of crops in one area at one time. All species were grown under one general root zone management program – one fertilizer solution applied to one root medium to maintain a desired pH and electrical conductivity (EC).

Last year, we evaluated root zone conditions outside the standard range and observed plant response. From October 1- June 1, 18 herbaceous perennials were forced in a 20°C greenhouse under 16-hour days with HPS supplemental lighting and no growth regulators. All crops were grown in 5-inch square pots containing root media formulated at MSU.

Since flower initiation is regulated by temperature or photoperiod, differences because of water or nutrient management were not expected. There were statistical differences in days to flower and flower number, but no species varied in days to flower by more than 5-7 days. Actually, more flowers developed under high moisture conditions, not high fertilizer rates.

Water Availability

We used three watering levels: standard, dry, and wet. Using the standard treatment, we added 8 fluid ounces when 50% of container capacity was lost. For the dry treatment, we maintained the medium at less than 60% of container capacity. And for the wet treatment, the medium was kept at greater than 75% of container capacity, but not saturated, by adding 4 fluid ounces of water when the pot, medium, and plant reached a predetermined weight.

Like bedding plants, responsiveness to water varied among herbaceous perennial species (see Table 1). Several species increased in plant size with each increase in water. Some species increased in plant size with only wet conditions, and a few species decreased in size when kept dry. The wet treatment increased plant size but not the height of several species (Figure 1) because of larger leaves or lateral

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branching. For echinacea only (Figure 2), the wet treatment increased internode length and final height.

In a second set of treatments, we compared the standard root medium (70% peat/30% perlite) with a 100% peat medium and a medium comprised of 50% composted bark, 30% peat, and 20% perlite. There were no differences among plants grown in the three root media.

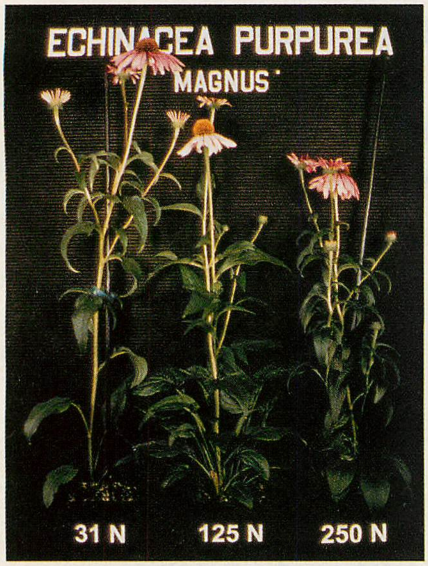

Figure 3. *Echinacea purpurea* 'Magnus' height increased as constant liquid fertilizer rate decreased from 125 ppm N to 31 ppm N.

By managing water to prevent saturation or excess drying, herbaceous perennials can be grown in a wide range of component blends. Using a larger container size is helpful because it provides adequate drainage and aeration. Plants that are grown outside or in potentially saturating conditions would benefit from a porous root medium.

Fertilizer Concentration

We applied three levels of macronutrient fertilizer to evaluate plant response. The standard nutrient solution contained 125 ppm nitrogen (N), 12.5 phosphorus (P), 125 potassium (K), 133 calcium (Ca), 30 magnesium (Mg), 25-30 sulfur (S), and micronutrients. We altered nutrient availability by

Table 1.

Root Zone Management: Key Concerns For Herbaceous Perennials

Species	*Observations and Key Concerns*
Astilbe chinesis	Leaf area, plant size increased with high moisture. Chlorosis with basic nutrient solution (NS) and high medium pH. Avoid low H_2O.
Campanula carpatica 'White Clips'	Tolerates all conditions. Branching, buds increase with 250 ppm.
Coreopsis grandiflora 'Sunray'	Plant size increases with more water. Taller plants grown at highest H_2O.
Coreopsis verticillata 'Moonbeam'	Plant size increases and taller plants grown at highest H_2O. Chlorotic leaves with pH > 7.0. Sensitive to acidic drench. Low K.
Delphinium grandiflorum	Challenging plant, weak roots. Moisture, pH extremes.
'Blue Mirror'	Avoid rushed production.
Echinacea purpurea 'Magnus'	Leaf area, plant size increase at highest H_2O. Height, root increase at low fertilizer. High H_2O increases plant height by internode stretch.
Gaillardia x *grandiflora* 'Goblin'	Plant size increases with increasing H_2O without changing height. Low rate of constant liquid fertilizer (CLF) may decrease plant size.
Hemerocallis 'Stella de Oro'	Low H_2O increases days to flower and decreases plant height, size. Plant size decreases with basic NS. Sensitive to low H_2O. Basic NS leading to high pH. Leaf tissue elements are low.
Heuchera sanguinea 'Firefly '	Leaf area, plant size increase at highest H_2O, peat medium, and lowest fertilizer. Avoid excessive fertilization.
Hibiscus moscheutos 'Disco Belle Hybrids'	Plant size, height increase with increasing H_2O. High CLF rate decreases plant height. Avoid low Ca, low pH leading to Fe and Mn in tissue. Avoid low temperatures and HPS lighting.
Hosta 'Undulata Variegata'	Plant size increases at highest H_2O. Root mass increases at low CLF. Avoid excessive fertilization. Leaf tissue elements are low.
Lavandula angustifolia 'Munstead'	Leaf area, plant size increase at highest H_2O, while plant height unaffected. Shorter plant grown under low H_2O.Sensitive to high pH, excessive fertilization. Watch roots.
Leucanthemum x *superbum* 'Snow Cap'	Plant size increases with more water. High K. Low rate of CLF may decrease plant size.
Perovskia atriplicifolia	Plant size increases with more water, height differences at extremes. Possible longer time to flower under dry conditions.
Rudbeckia fulgida 'Goldsturm'	Leaf area, plant size increase with more water. Shorter plant with less water. Avoid pH and fertilizer extremes. Fe, Mn accumulation at pH < 5.5.
Salvia x *superba* 'Blue Queen'	Tolerated all conditions, except smaller plant with less water. Low amounts of water decrease plant size.
Scabiosa caucasica 'Butterfly Blue'	Tolerated all conditions. Plant size increased with more water.
Sedum 'Autumn Joy'	Tolerated all conditions except smaller plants with less water. Leaf tissue elements out of average range.

changing the concentration of N, P, and K while keeping a constant level of micronutrients or by eliminating the water soluble P from the base nutrient solution.

At the experiment's start, N and K concentrations were 62, 125, or 250 ppm with P at 6, 12.5, or 25 ppm, respectively. Because there was no difference in soluble salt levels between the low and medium treatments, we reduced the low treatment to 31-3-31 ppm NPK 5 weeks into the study. Irrigation was from the top of the pot, and we kept water collection trays under each pot to prevent leaching.

The low rate of constant liquid fertilizer combined with preplant fertilizer and no leaching produced acceptable plants for most species. Some differences at the low fertilizer rate were decreased overall plant size, increased plant height (Figure 3), or increased overall plant size.

In a few cases, increased fertilizer rate (250 ppm N and K) decreased plant height or height and overall plant size. In most cases, using high fertilizer rates did not affect growth enough to justify the increased risk of high soluble salts or fertilizer runoff.

The root system's size and the balance between shoot and root growth has a significant impact on the quality and performance of container-grown plants. Lower fertilization rates favor the development of a strong root system. This was particularly evident for hosta (Figure 4), hemerocallis, and echinacea.

Contrary to some recommendations, high P rates did not stimulate root growth. The balance of root to shoot growth is more sensitive to changes in N than to P levels. We tried to establish P deficiency symptoms by using a zero P nutrient solution, but all species showed adequate levels.

Root Medium pH

We altered root medium pH in three ways: by drenching the medium with sulfuric acid; by using a basic drench of K bicarbonate within 2 weeks of planting; or by slowly applying a high nitrate fertilizer with high alkalinity water or a high ammonium fertilizer with a low alkalinity water. The rapid pH change using sulfuric acid or K bicarbonate was phytotoxic to some species.

Most species tolerated a wide range of media pH, but some were sensitive to low pH, high pH, or both (Figure 5). It was not our intent to define a pH optimum, only to indicate whether high or low pH can result in problems (see Table 1).

Although the herbaceous perennials tested tolerated a wide pH range, our recommended strategy is to maintain a pH of 5.8-6.5. Below 5.8, some species accumulate excessive iron (Fe) or manganese (Mn), which can alter nutrient balance. At this level, P is more soluble and prone to leaching, and nitrification is inhibited.

At pH levels greater than 6.5, trace element deficiency and low P are concerns. We detected high levels of Fe and Mn in rudbeckia, la-

Figure 4. Hosta 'Undulata Variegata' increased root mass with decreased constant liquid fertilizer rate (31-3-31 ppm, 125-12-125 ppm, 250-26-250 ppm NPK).

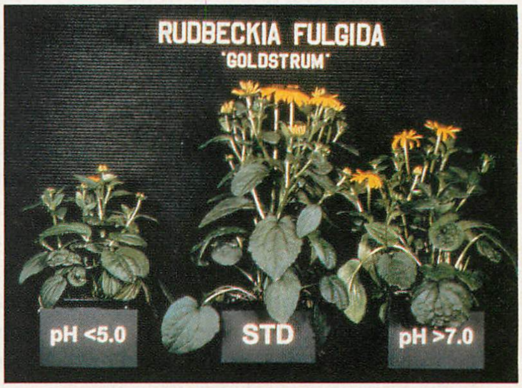

Figure 5. Growth and development of *Rudbeckia fulgida* 'Goldsturm' were stunted at pH extremes.

Figure 6. *Rudbeckia hirta* 'Goldsturm' exhibited purplish tissue dominating on the underside of older leaves, which showed an accummulation of Fe and Mn in tissue analysis at low pH.

Formula For Success: Root Zone Management

1 Establish a correct pH (5.8-6.5) and use a properly limed root medium. Balance the irrigation water alkalinity, nitrogen form, and acids to provide a neutral reaction nutrient solution. Select nitrogen form on the desired reaction – acidic or basic – and not on the type of growth desired.

2 Herbaceous perennials can be grown with low rates of fertilization. A constant, minimal leaching application of 125-12-125-100-30-30 ppm N-P-K-Ca-Mg-S with micronutrients is a good place to start.

The fertilization goals are to account for the water nutrient content when preparing the nutrient solution. Maintain the root medium EC at 0.5-1.5 (SME) or 0.3-0.75 (1:2), and consider soil tests and plant appearance. Lowering macronutrients, not micronutrients, will require some adjustments in formulating water-soluble fertilizers.

3 Media moisture level controlled by irrigation method and timing will have the biggest impact on plant size and quality if media pH and nutrient levels are properly maintained. Develop watering recommendations for each crop based on the desired plant size.

4 Flower initiation is tightly regulated by temperature or photoperiod, not water or nutrient management, so follow recommendations for proper temperature and photoperiod.

5 Leaf tissue analysis can be a useful prevention and problem-solving tool. Ask for help from an experienced professional to interpret results. Keep organized records of any tissue analysis samples.

vandula, and hibiscus in leaf tissue samples in the standard and acidic treatments.

The acidic nutrient solution had low Ca and Mg, while the basic nutrient solution had high levels. We did not observe any detrimental effects from either low or high levels of Ca and Mg. Since we adjusted pH with hydrated lime, there was minimal residual lime. The less lime in the media and the longer the crop time, the greater the probability of low Ca and Mg levels.

Leaf Nutrient Analysis

When nutrient problems arise, the most reliable analytical tool is often leaf nutrient analysis. For many plants, we can compare leaf nutrient levels to a common standard acceptable range and determine if a particular nutrient is deficient or toxic. For herbaceous perennials forced in the greenhouse in soilless mixes, few standard values exist.

We collected leaf samples and analyzed six of the 12 treatments. Mature leaves were gathered from the middle of the plant at flowering. Usually, leaf samples are collected before flowering, but this was not feasible since we had to collect flowering and plant size data from the same plants.

The N content for all species under the standard treatment only ranged from 5.2%-5.6%, and the values were similar at low, standard, and high N fertilization rates. The K levels of leaf tissue ranged from 1.8%-7.3%, but for most species was within the expected range of 2%-5% (see Table 2).

The range of Ca, Mg, Fe, and Mn values were large among species. Fe levels are usually twice as high as Mn levels in plant tissue, but in four species, Mn was two or more times Fe levels with no detrimental effect. Foliar symptoms associated with nutrient problems were chlorosis in hibiscus and distortion in rudbeckia. The root of these problems was not clearly determined, but leaf samples contained higher than average Ca and Fe levels.

With rudbeckia, we think there is a strong probability of Fe or Mn toxicity at low to medium pH, levels similar to geraniums. Symptoms include a darkening of the underside of older leaves followed by tissue death (Figure 6). Since rudbeckia is the perennial plant of the year for 1999, many growers will be producing this crop. Plan to keep medium pH up like you would with geraniums.

Eight species had abnormally high Mg levels. Sampling technique, old leaf age, or MSU's water, which is high in Mg, could be the culprits. Zinc (Zn) levels in seven crops were higher than the normally accepted upper range. Hosta and hemerocallis, two plant species which account for a large percentage of all perennials sold, tended to have lower than average leaf K, Ca, Mg, Fe, Mn, and Zn levels. **GG**

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Table 2. **Leaf Tissue Analysis from Root Zone Management Experiment**

Interpretation Ranges	N %	P %	K %	Ca %	Mg %	S %	Na ppm	Fe ppm	Mn ppm	Zn ppm	B ppm	Cu ppm	Mo ppm
Minimum Critical	2.0#	0.2	2.0	0.5	0.3	0.1	@	50	30	20	25	5	0.25
Desired Lower Range	3.0	0.4	3.0	0.6	0.4	0.2	100	75	50	25	30	10	0.50
Desired Upper Range	5.0	0.8	5.0	2.0	0.8	0.4	3000	300	300	75	80	20	5.00
Maximum Critical	6.0?	2.0?	6.0*	4.0**	2.0**	***	6000?	500	500	200?	200?	50?	15?
Campanula carpatica	5.4	0.7	5.0	1.6	1.1	0.2	142	200	98	190	68	3	0.26
Coreopsis grandiflora	5.4	0.4	3.5	2.1	1.4	0.2	185	262	160	101	63	4	0.12
Coreopsis verticillata	5.4	0.4	1.8	1.2	0.6	0.2	87	102	198	59	73	3	0.12
Delphinium grandiflorum	5.4	0.8	6.0	1.6	1.1	0.2	182	88	69	100	22	8	0.12
Echinacea purpurea	5.6	0.7	4.6	1.6	1.5	0.2	234	84	138	43	136	4	0.24
Gaillardia x grandiflora	5.2	0.5	6.0	2.1	0.9	0.2	466	67	77	60	45	5	0.43
Hemerocallis	5.3	0.3	3.0	0.6	0.3	0.2	111	72	97	21	55	2	0.12
Heuchera sanguinea	5.5	0.4	2.1	1.1	0.6	0.2	258	57	78	45	32	7	0.12
Hibiscus moscheutos	5.4	0.4	2.4	3.2	1.7	0.2	291	885	202	147	56	3	0.12
Hosta	5.4	0.3	4.2	1.0	0.7	0.2	530	53	96	20	24	4	0.12
Lavandula angustifolia	5.3	0.4	3.9	2.0	1.2	0.2	216	1130	446	96	39	3	0.12
Leucanthemum x superbum	5.2	0.9	7.3	1.5	1.1	0.2	106	64	160	133	26	4	0.12
Perovskia atriplicifolia	5.5	0.5	5.3	0.9	0.4	0.2	123	99	87	50	51	6	0.12
Rudbeckia fulgida	5.3	0.3	3.3	3.3	1.3	0.2	132	1078	198	108	66	4	0.12
Salvia x superba	5.4	0.8	4.4	1.7	0.9	0.2	149	100	200	50	48	5	0.47
Scabiosa caucasica	5.3	0.5	5.2	0.9	0.4	0.2	216	155	108	35	47	6	0.16
Sedum	5.4	0.9	4.3	4.4	1.1	0.2	230	81	227	133	76	8	0.12
Difference to Consider	0.3	0.1	0.5	0.3	0.1	0.0	115	150	37	20	8	1	0.15

Minimum Critical: Values below the minimum usually indicate a need for additional fertilizer and a possible growth limiting situation.
# indicates critical values will likely vary depending on the plant type. Some landscape plants survive with low N concentration.
@ Na, sodium is not an essential plant nutrient and is not required for normal plant growth.

Maximum Critical: Values above the critical usually indicate overfertilization. Toxicities and possible reduction in growth would be possible for Na, Fe, Mn, Zn, and B.
? indicates that maximum critical values are not firmly established.
*K can accumulate to as much as 10% without detrimental effects other then inducing deficiencies of other elements such as Ca and Mg.
**Ca and Mg are not expected to be toxic, but can lead to induced deficiencies of other elements, particularly Fe and Mn if Mg is excessive.
***S has not been shown to accumulate to toxic levels.