Nutrition and Management of Perennial Stock Plants©

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INTRODUCTION

Nutritional management is an area of concern for producers of horticultural products due to basic production requirements and environmental impact. With an increased public focus on environmental issues, fertility inputs should be carefully regulated. Nitrogen is an element used widely in horticulture and can be applied in considerable amounts both in horticulture and agriculture (Mengel and Kirkby, 2001). The federal limit for nitrate levels in water is 10 $mg \cdot L^{-1}$ (10 ppm N), and nitrogen is a non-point-source type of pollution that is impacting water quality in the U.S.A. (Fenn, et al., 1998; Gustafson and Wang, 2002). A growing number of states have laws regulating run-off (and leached materials) from agricultural and horticultural operations, and states that don't yet have laws regarding containment of plant nutrients probably will have them soon (Lea-Cox and Ross, 2001; Lea-Cox, 2001). From typical perennials fed at 136 ppm N, leachate can contain 1 to 96 $mg \cdot L^{-1}$ nitrate (Adam and Sluzis, 2005). According to recently published research, 0.5%–15% of the container leachate could be running off propex-covered growing areas, with the remainder sinking into subtending base materials or soil (Million et al., 2005). Growers and propagators have an interest in the careful management for the compliance with laws that are intended to benefit the environment, and a number of growers are demonstrating leadership in their communities with serious dedication of their time and monies to environmental enhancement projects.

Proper management and efficiency in the production of plants results in high yields. Stock plant culture is typically an area of production where efficiency and management are of particular importance, and to attain consistently high yields, plant production should be optimized. To optimize the production of stock, proper nutritional information is critical. While herbaceous perennial plants continue to increase in demand, the nutrient requirements of these perennial plants are not well documented (Dubois et al., 2000; Perry and Adam Jr. 1990; Rowe and Cregg, 2002). Some research has been published recently, but more work is required to significantly cover this important topic in production and propagation (Dubois et al., 2000; Kraus et al., 2002). Growers and propagators benefit from careful management of nutrient inputs by efficiency gains in operations, quality gains in product, and enhanced environmental quality.

BACKGROUND

Stock plant management can be influenced by the lifecycle of the stock plant, the stock plant culture, the environmental conditions the plant is subjected to, and the source material. Nutritional management will involve the quantity of nutrients, the quality of nutrients (how they are proportioned and formulated), and the influences of water pH and water quality. Stock plant nutritional management is one of the variables in production under direct control by the grower, and the successful management of the fertility situation (and the stock environment) will yield the correct C : N ratio for the cutting material to be harvested. Cuttings with the proper C : N ratios will have optimal growth and development when placed in the proper environment for rooting (Hartmann et al., 2002).

Herbaceous perennials as a commodity group is challenging in the respect that there are a considerable number of genera, species, cultivars, and selections that are grown, with more arriving every season. Many perennials are undocumented in their nutritional requirements and environmental responses (when compared to the annual and bedding plants, greenhouse foliage and flowering products, and woody trees and shrubs).

Stock plants typically have a lifespan and yield potential that are determined by the variables that propagators manage, including nutrition (Fig. 1). Proper nutrition will extend the lifespan of the stock plant but not beyond what is typical for that cultivar or management strategy (such as plant spacing or pot diameter). Growers planting new stock typically start with divisions, seedlings, or rooted cuttings, and these are potted up into larger sizes. These stock plants may be potted directly into 1-gal pots or larger or could be potted into an intermediate size prior to their final productive size. Cutting yields may be harvested in a few days to a week after potting (Hartmann et al., 2002). When starting with an unpinched, single-shoot liner, the yield of cuttings typically doubles for most perennials until the plant canopy has become full. When the plant has attained a full canopy for the container size and spacing, the cutting yield seems to level off due to shoot crowding, light inception, and plant-to-plant crowding. Many perennials will initiate new shoots from the crown as the stock ages and also lose productivity of stems that have been repeatedly cut and become mature. The attrition of older stems, balanced with the production of new shoots if well managed, will result in a leveling off of the yield curve and a plateau effect of the number of cuttings harvested. The length of the plateau is influenced by culture (Fig. 2).

When the plateau begins to taper off and yields drop, it is time to replace the stock. Eventually the plants will become too pot-bound to maintain proper (plant) water requirements or may succumb to the cumulative effects of insects and disease problems. The uniformity of cuttings harvested decreases with increasing stock age and plant vigor problems. Each perennial taxon will have its own curve and plateau length, although there will be similarities within groups (Fig. 3). *Geranium ×cantabrigiense* selections and hybrids are very close in performance ('Biokovo', 'Berggarten', and 'St. Ola'). Many *Phlox paniculata* hybrids and selections are also quite similar in yields and longevity. The yield and duration of productive yield can also be regulated by management objective, as in the case of mum production where stock plants yield cuttings on a one-time harvest basis.

Nutritional requirements of herbaceous perennials vary, and each species or cultivar should be grown at the optimum nutritional level (Fig. 4). Nitrogen research conducted at Temple in 2002 from the testing of 10 species of perennials indicated that nitrogen levels greater than 136 ppm N (applied every other irrigation) were not significant in terms of whole plant growth. Plants were typically averaging 2%–3% tissue nitrogen percent in this experiment (at 136 ppm N), but some species tested indicated an ability to act in environmental applications by taking up to as much as 5% tissue N. Leachates increased with increasing treatment level in 2002, and nitrates at the upper treatment levels were typically well above the federal limit of 10 $mg{\cdot}L^{-1}$.

The variability of perennial species grown in industry, the list of the species suggested for Pennsylvania and New Jersey state Department of Environmental Protection planting recommendations for environmental projects, and the Perennial Plant Associations's generosity led to the research of an additional 10 species in 2003. *Symphyotrichum* (syn. *Aster*) *novae-angliae* 'Purple Dome', *Chelone lyonii, Coreopsis verticillata* 'Moonbeam', *Dryopteris intermedia, Heliopsis helianthoides, Monarda* 'Marshall's Delight', *Penstemon digitalis* 'Husker's Red', *Phlox glaberrima* 'Morris Berd', *Polemonium reptans,* and *Zizia aurea* were submitted to the same methods used in the 2002 study. Similar results occurred, in that no growth benefits of significance occurred above the 136 ppm treatment level (averaging 2%–3.2% tissue N) as with 2002. Some species (*S. novae-angliae* 'Purple Dome' and *H. helianthoides*) demonstrated an excellent potential as plants for environmental use in nitrogen removal from ground and surface water by attaining tissue levels above 4% N.

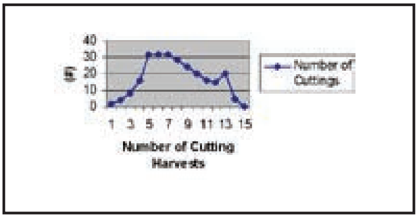

Figure 1. Cutting yield of *Phlox paniculata.*

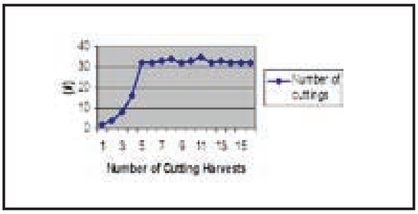

Figure 2. Cutting yield of *Phlox paniculata.*

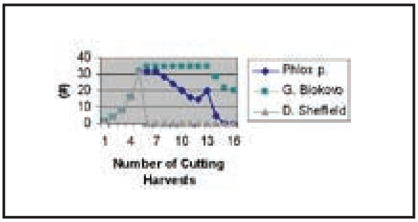

Figure 3. Cutting yield of *Phlox paniculata, Geranium ×cantabrigiense* 'Biokovo', and *Dendranthema* 'Sheffield'.

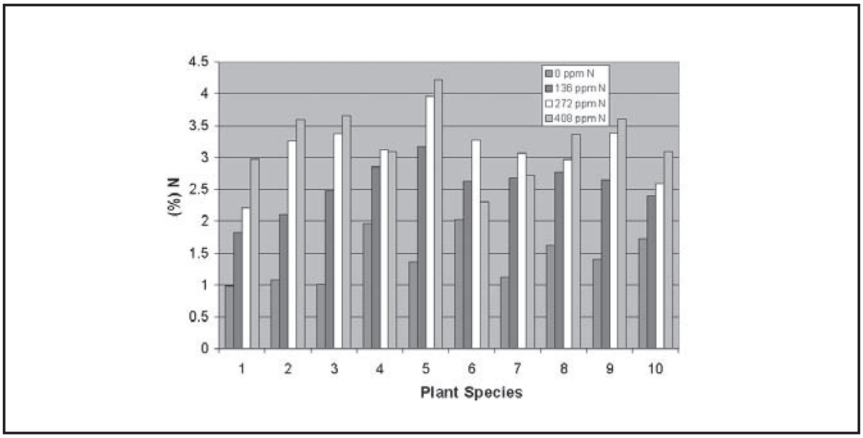

Figure 4. Tissue nitrogen levels of 10 herbaceous perennials (1 = *Eupatorium purpreum* subsp. *maculatum*, 2 = *Hibiscus moscheutos*, 3 = *Lobelia cardinalis,* 4 = *Phlox paniculata,* 5 = *Rudbeckia fulgida,* 6 = *Solidago caesia,* 7 = *Osmunda claytoniana*, 8 = *Dryopteris marginalis*, 9 = *Eupatorium coelestinum,* 10 = *Tiarella cordifolia*).

Nursery experimentation with *Heuchera* 'Snow Angel' has indicated a similar trend to Temple-based research, in that a 125–130 ppm N range (using Peters Peat Lite Special 15–16–17) works best for weekly feed, versus 80–90 ppm N for constant feed (2002–2003). *Heuchera* 'Snow Angel' takes 4 to 6 weeks for cutting development on stock plants, and takes slightly longer than the typical 2 to 4 weeks to root into a 70-unit flat.

Nutritional rates should also be adjusted for environmental changes and plant growth cycle phases. Growth of perennials in the low-light months will be reduced, and feed should be correspondingly reduced by 1/2 to 2/3 for most plants and eliminated for plants in dormancy. Greenhouse growth of *Sedum makinoi* 'Ogon' (in September and October) progresses steadily showing a significant increase in plant material and plant canopy increase. With further reductions in light and day length, however, growth will slow, and reductions in fertility should be implemented. By November *S. makinoi* 'Ogon' slowed in growth considerably and produced comparatively little harvestable material for cutting relative to the amount available in the September-October period.

Nutritional management for high yields as well as low environmental impact should be theoretically based and locally enforced. Each individual operation has unique water, media, temperature, light, air circulation, and management conditions. Local enforcement simply stated is taking the set of conditions that exist and choosing the best fertility plan to meet the plant requirement and those circumstances. The choice of using soil incorporated, soil surface applied, liquid applied, or a combination of fertilizer application methods is therefore relative to the individual operation and its production methods. The level established by the 2002–2003 work provides a good guideline as to N rate for the 20 species tested, but questions such as preferred N form, N form ratio, sustainable levels of N fertilization, and N-level cycling remained. So too did the question as to what the upper end of N tolerance was for the species tested in 2002–2003 that showed potential for environmental applications.

METHODS 2004

The five species of herbaceous perennial plants that demonstrated the greatest tissue levels of nitrogen in 2002–2003 were subjected to two experiments in 2004. *Symphyotrichum novae-angliae* 'Purple Dome', *H. helianthoides, M.* 'Marshall's Delight', *P. reptans,* and *Rudbeckia fulgida* var. *sullivantii* 'Goldsturm' were potted into 15.24 cm (6 in. std.) containers filled with Sunshine Mix #2 (Sungro Inc., Bellview, Washington). Sunshine mix #2 is a peat-based potting medium with no nutrient starter charge and only dolomitic limestone added. In the first experiment, the five perennial plant selections were placed in the Temple University Ambler greenhouses in a complete randomized block design with seven replicates. Nitrogen treatment levels were set at 0, 45.33, 90.66, and 135.99 ppm N applied as NH_4NO_3. Potassium was supplied at 79 ppm K, as KCl, and micronutrients as S.T.E.M. (Scotts-Sierra Co., Marysville, Ohio) in a one-time treatment at the beginning of the experimental period. Super phosphate (0-45-0) was incorporated at the rate of 1.3 $kg \cdot m^{-3}$ of medium. Nitrogen and potassium were applied by hand every other irrigation (up to three times per week) with a nutrient solution providing the ammonium nitrate and potassium chloride and irrigation volume was 400 ml per pot (which provided a 10% leached fraction). Container leachate and pH were monitored throughout the experimental period, and leachate was analyzed for nitrogen content (Cedar

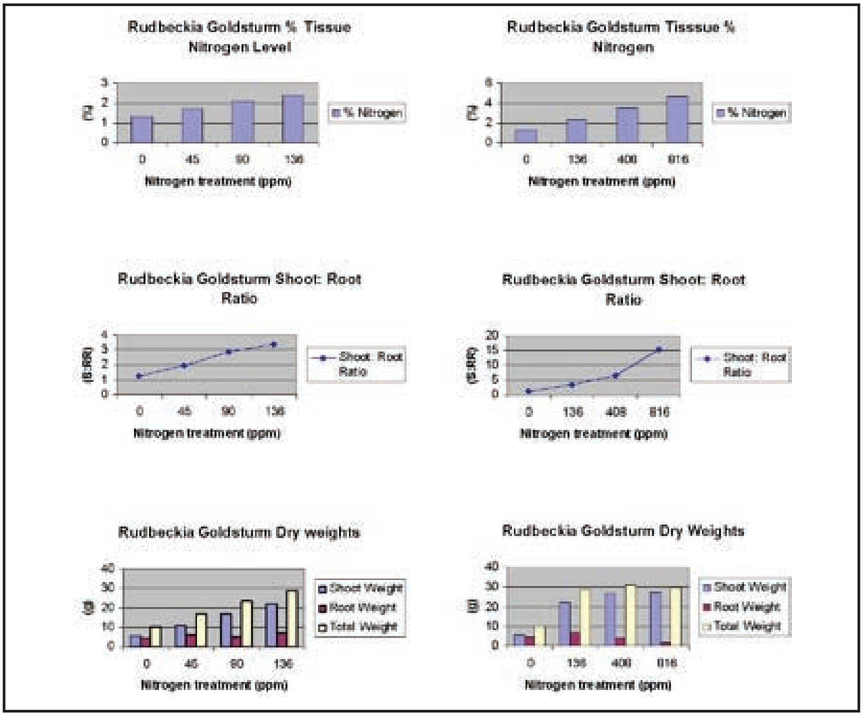

Figure 5. *Rudbeckia fulgida* var. *sullivantii* 'Goldsturm' tissue nitrogen levels, dry weights, and shoot to root ratios.

Grove Laboratories Downingtown, Pennsylvania). Light level was measured with a LI-Cor LI 250 light meter and a LI-190SA quantum sensor (LI-Cor Biosciences Lincoln, Nebraska), and greenhouse temperatures were monitored and recorded. Plant grade (a subjective salability rating) from 0–5 (0 being dead and 5 denoting exceptional size and depth of green foliar color) was recorded on a monthly basis, as were plant height, width, growth index (height + width + width)/3, and chlorophyll level (SPAD 502 Minolta), and representative digital images were created. At the end of the experimental period (90 days), the roots were washed free of the substrate, and each plant was separated into roots and shoots. Fresh and dry weights were measured for shoots and roots. Plant shoot tissue was analyzed for nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, boron, copper, iron, manganese, zinc, and sodium (Spectrum Technologies Washington Courthouse, Ohio). Data were analyzed by analysis of variance and regression where applicable. Variables were transformed where necessary to satisfy normality and homogeneity of variance.

A second experiment was set up in the Temple University greenhouses that evaluated the upper end of the nitrogen level tests. This was identical to the first in all respects except the nitrogen treatment levels. Levels in the second experiment were 0, 136, 408, 816 ppm N applied as NH_4NO_3.

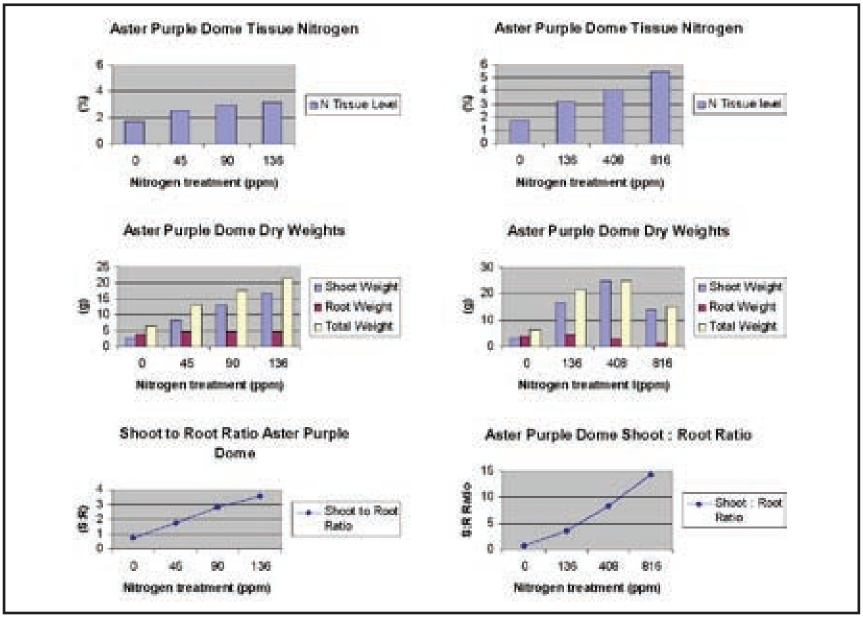

Figure 6. *Symphyotrichum novae-angliae* 'Purple Dome' tissue nitrogen levels, dry weights, and shoot to root ratios.

RESULTS 2004 EXPERIMENTS

In both experiments, *S. novae-angliae* 'Purple Dome', and *R. fulgida* var. *sullivantii* 'Goldsturm' showed similar trends in nitrogen uptake and growth. In the first experiment tissue levels of chlorophyll (SPAD) increased with increasing treatment, as did weight gains and size measurements.

For *R. fulgida* var. *sullivantii* 'Goldsturm', plant weights were greatest at the 136 ppm N treatment, plant height, width, growth index, and percent tissue N all indicated no significant differences above the 90 ppm N level, and chlorophyll (SPAD) measures that numerically increased with increasing N treatment level was not significant above the 45 ppm N treatment level (Fig. 5). Shoot to root (S : R) ratios were above 1 at the control treatment level and were not significantly different from each other above the 90 ppm N treatment level. In the second experiment root injury was observed at the 816 ppm treatment level, and the shoot to root ratio was 15.22, which was significantly different from all the lower treatment levels. Chlorophyll level and tissue N significantly increased with increasing treatment levels exhibiting similar results to the S : R ratio. As in the 2002–2003 studies, there was no significant difference in weight, plant dimensions, or growth index above 136 ppm N treatment level.

Symphyotrichum novae-angliae 'Purple Dome' also exhibited significant weight gains at all treatment levels in the first experiment (0, 45, 90, 136 ppm N) (Fig. 6). Growth index, width, and percent tissue N were not significantly different above the 90 ppm N treatment level. Plant grade and chlorophyll level (SPAD) were not significantly different above the 45 ppm N treatment level. In the second experiment, plant weights exhibited no significant differences above 136 ppm N treatment for root and total plant dry weight. Shoot weight was greatest at the 408 ppm N treatment level. Plant grade height, width, and growth index all showed no significant differences with higher treatment levels than 136 ppm N, which was also the case with chlorophyll (SPAD) measurements.

CONCLUSIONS

Optimum growth occurred for *R. fulgida* var. *sullivantii* 'Goldsturm', and *S. novae-angliae* 'Purple Dome' at 136 ppm N, but sustainable growth occurred at 90 ppm N for both perennials. Plants at this treatment level produced a 2.86 and 2.83 S : R ratio for *Rudbeckia* and *Symphyotrichum*, respectively, which corresponded with a range of 2%–3% tissue N. Established plants grown at the 90 ppm nitrogen treatment level would provide sufficient cutting material for suitable harvests in propagation.

As stock plants mature over their productive life cycle, root systems develop in the containers and the percent of the plant weight harvested in the normal propagation cycle diminishes compared to the total plant weight. This trend would result in a diminished removal of total plant nutrients through the harvesting of the cuttings from the stock plant. The percent of added nutrition for stock plant growth (compared with container plant production for sale) should be equal to the sustainable rate plus the nutrients removed by harvesting the cuttings. For *Rudbeckia* and *Symphyotrichum,* the harvested percent of nutrients would be estimated to range from 1%–10% of the plant weight. The 1%–10% rate, when added to the sustainable N production level, should maintain the S : R ratio of 2.85, an ample amount of shoot production for harvest. However, this is an estimate based on the results of our research, and further experimentation should be undertaken to test the inference.

Perennials grown for stock plants can be cultivated at 60–150 ppm N. Many species, cultivars, and hybrids of perennials can probably be grown at lower N levels than expected, and advantages could be obtained by reduction of the nutrient levels prior to harvesting cuttings. For species that have been tested in the 2002–2004 period, the following nitrogen fertility strategy is recommended for stock plant culture: 125–100 ppm N for the early phase of growth, followed by 80–90 ppm N, and then 50–75 ppm N just prior to harvest of cuttings. This strategy would reduce the nutrient impact for three out of the four intervals (or weeks) in the production cycle, without compromising cutting yield or stock plant quality.

More research is required for completion of the perennial production and propagation picture. Cutting yield should be documented and tested against nutritional inputs directly. Other nutrient elements should be investigated in their role in perennial stock management and cutting yields as well. Then too, many perennials remain, yet to be investigated in their nutritional needs and growth.

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Germination of *Rudbeckia fulgida* var. *sullivantii* 'Goldsturm'©

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INTRODUCTION

Rudbeckia fulgida var. *sullivantii* 'Goldsturm' is a popular, award-winning perennial. It has consistently remained a top-three-selling perennial at Raker over the last 10 years. Raker annually produces in excess of 2 million 'Goldsturm' plugs from seed.

Like many perennials, consistent success with germinating *Rudbeckia* 'Goldsturm' is challenging, as germination and seed vigor can vary significantly from seed lot to seed lot, regardless of supplier. In our experience, 'Goldsturm' germination typically ranges from 20%–80% for standard lots.

ENHANCED SEED

There are now multiple suppliers offering enhanced 'Goldsturm' seed, including Benary (ApeX), Jelitto (Gold Nugget®), and Kieft (TunedSeed®). Our trial results with each product have unfortunately been inconsistent from seed lot to seed lot.

Germination of enhanced seed, regardless of supplier, generally ranges from 60%–90% in our experience. At least some of the inconsistent performance may be due to shelf-life issues with the enhanced products.

Methods for enhancing 'Goldsturm' seed are secret and proprietary. The treatments may include priming, hormone treatment (gibberellic acid), or multi-step processes. Raker uses our own proprietary seed treatment when enhanced 'Goldsturm' seed is not available from suppliers.