Ratios and Concentrations of Nitrogen, Phosphorus, and Potassium Affect Production of Herbaceous Perennials

By Helen T. Kraus and Stuart L. Warren

Both the concentration and ratio of N, P, and K affect flowering and growth of herbaceous perennials. Based on experiments to determine the effects of N, P, and K and their ratio, it appears that herbaceous perennials N requirements are similar to herbaceous annual plants, but require lower P and K concentrations, more similar to woody perennial plants.

Successful container-grown plant production requires management of many variables. Nutrient management includes appropriate selection of both the fertilizer rate and ratio to optimize plant growth. However the nutrient needs of many ornamental plants are not well defined. Additionally, producers who grow many varieties of ornamental plants cannot afford the time or fertilizer products to selectively meet the nutrient needs of each species. If the nutritional needs of certain groups of plants were known, a plant producer could choose from a selection of fertilizers that would meet the objectives of plant production, economics, and environmental stewardship.

Many herbaceous perennials have the same rapid growth rate as herbaceous annual plants, but they also store nutrients in roots for re-growth following a dormant season like a perennial woody plant. Research to date has provided few recommendations for appropriate nutrient concentrations and ratios for container production of herbaceous perennials. Complicating nutrient recommendations for herbaceous perennials is their tendency for luxury consumption.

Four experiments were conducted to determine the effects of N, P, and K concentrations and their ratio on flowering and vegetative growth of *Hibiscus moscheutos* L. (hibiscus) and *Rudbeckia fulgida* var. *sullivantii* Ait. 'Goldsturm' (rudbeckia). These plants were selected as models of herbaceous perennials, which flower profusely and have rapid growth rates.

Beginning in the summer of 2005, a series of experiments were conducted. Initially two concurrent but separate experiments evaluated treatments consisting of either six N:P or six N:K ratios in the fertilizer solution. The six N:P ratios (1:1, 2:1, 4:1, 8:1, 16:1 or 32:1) were evaluated with the N and K concentrations held constant at 100 and 50 mg/L, respectively. The six N:K ratios (1:2, 1:1, 2:1, 4:1, 8:1, or 16:1) had N and P concentrations held constant at 100 and 25 mg/L, respectively. Based on results from these experiments, further research was conducted evaluating six concentrations of P (50, 33, 25, 12.5, 8, or 4 mg/L) and six concentrations of K (100, 66, 50, 25, 16, or 8 mg/L) producing six N:P:K ratios (2:1:2, 3:1:2, 4:1:2, 8:1:2, 12:1:2 and 24:1:2) with the concentration of N held constant at 100 mg/L. A final experiment was conducted that considered three N concentrations (200, 100, or 50 mg/L) and three N:P:K ratios (4:1:2, 8:1:2 and 12:1:2). All plants were grown in 1-gallon pots with a pine bark/sand substrate. The nutrient solutions were added during each irrigation event.

Plant growth and flowering of both hibiscus and rudbeckia were influenced by concentration and ratio of N, P, and K (**Figure 1**). When N was held constant at 100 mg/L, 4:1 N:K and 16:1 N:P were optimal for growing hibiscus. However, a higher K concentration (200 mg/L K) and lower P concentration were required for optimal growth of rudbeckia. When holding N constant at 100 mg/L and varying both P and K in the fertilizer solutions, higher P and K concentrations and a 2:1:2 ratio best supported hibiscus growth, while a 3:1:2 ratio optimized growth of rudbeckia. Finally, when both N concentration and N:P:K ratio were altered, optimum growth of both hibiscus and rudbeckia was achieved at similar and lower P and K concentrations (200 mg N/L, 25 mg/L P, and 50 mg/L K). An 8:1:2 ratio was optimum for production of both hibiscus and rudbeckia (although a 12:1:2 ratio produced similar growth of rudbeckia).

Common abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium.

Growers of ornamental plants like Rudbeckia (commonly called coneflowers or black-eyed-susans; top) and Hibiscus (bottom) would benefit from more plant-specific fertilizer recommendation systems.

Both species required surprisingly high levels of P (25 mg/L P) and K (50 mg/L K) in fertilizer solutions when the N concentration was also high. Plants grown with the highest concentrations of N (200 mg/L) were larger than when supplied with less N, but the lower N treatment still had excellent visual quality (see photo). Additionally, hibiscus and rudbeckia grown with 100 mg/L N and an 8:1:2 ratio had leaf N, P, and K concentrations similar to those deemed optimal in our initial experiments (**Figure 2**).

We found that foliar N concentration increased by 26% as N concentration in the fertilizer solution increased from 100 to 200 mg/L. Foliar P concentrations increased slightly as the

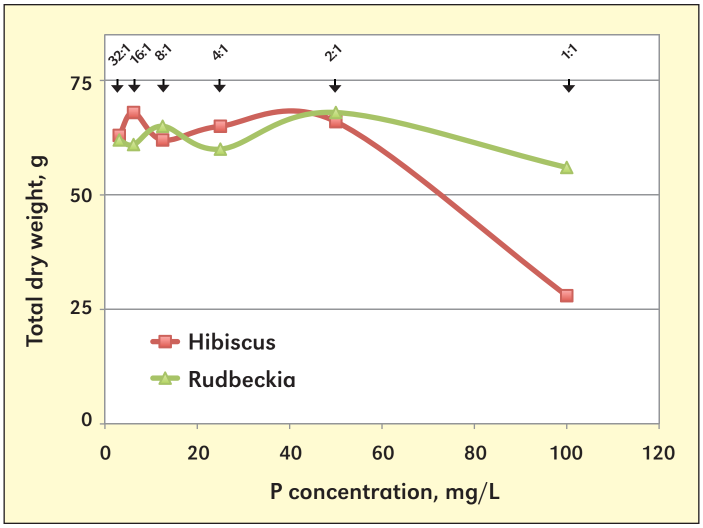


Figure 1. The effect of P concentration and the N:P ratio (denoted by arrows) on the total plant dry weight (roots and shoots) of rudbeckia and hibiscus. The N concentration was maintained at 100 mg/L and the K concentration was 50 mg/L. Each data point is the mean of six plants.

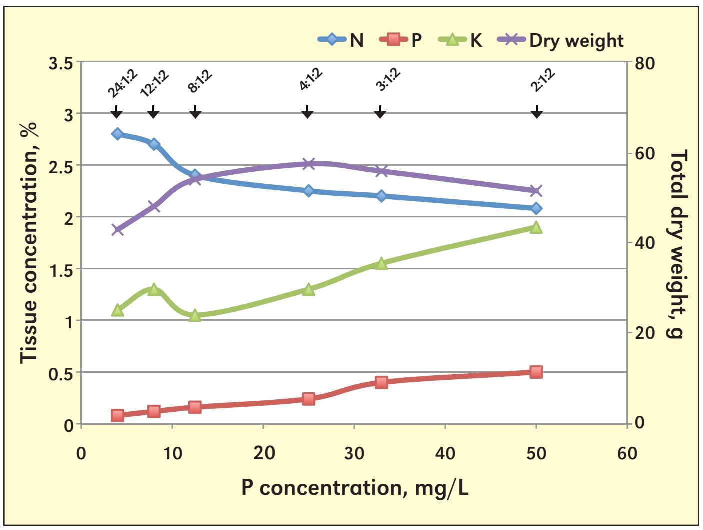
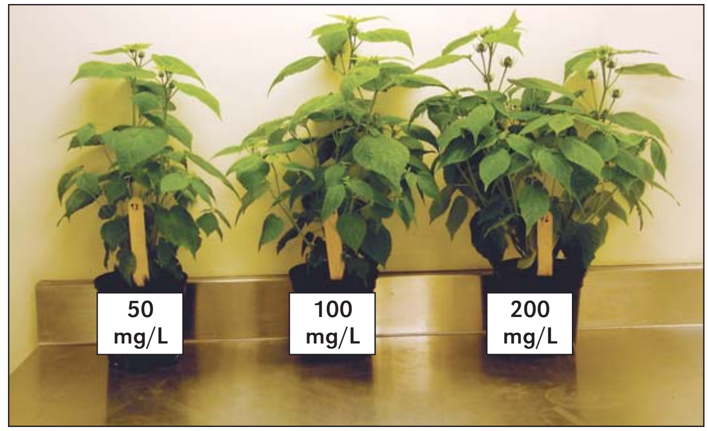
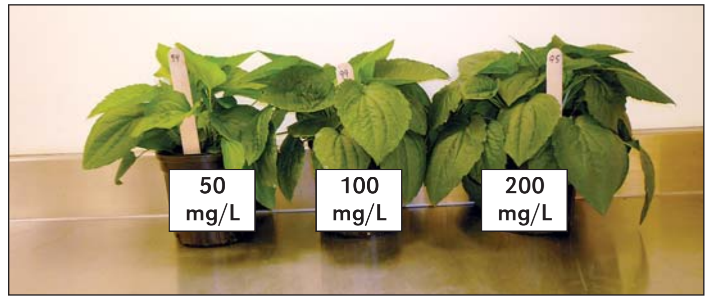


Figure 2. The effect of P and K concentrations and the N:P:K ratio (denoted by arrows) on leaf tissue concentrations and the total plant dry weight (roots and shoots) of hibiscus. The N concentration was maintained at 100 mg/L. Each data point is the mean of six plants.

N concentration was increased, while foliar K concentrations decreased by over 20%.

Average plant biomass was reduced 24% when fertilized with 100 mg/L N and an 8:1:2 compared to 200 mg/L N and the same 8:1:2 ratio. Maximum plant size is not always the goal with landscape plants when shipping, environmental impacts, and fertilizer costs are considered. Although, plants grown with 200 mg/L N were larger and had more flower buds (hibiscus), they would have been more prone to breakage during shipping. Fertilizing with the lower N concentration (100 mg N/L) and a 8:1:2 ratio will also lessen the potential for nutrient loss with inadvertent leakage from the production area.





Hibiscus (top) and rudbeckia (bottom) growth with 50, 100, or 200 mg N/L (left to right) and an 8:1:2 N:P:K ratio.

Similar results were reported by Adam and Sluzis (2005) where growth of a variety of species of herbaceous perennials was enhanced with increasing N rate. They also reported acceptable growth was often achieved at a lower N rate (136 mg/L N) and that luxury consumption was prevalent with many species. Adam and Sluzis (2005) suggest fertilizer application rates be used to achieve 85% to 95% of maximum growth. Using their guideline of 85 to 95% application rates, this would result in a N recommendation of 175 to 190 mg N/L in our study. The growth stimulation observed with higher N concentrations may not be desirable for producing marketable plants.

Based on our growth and foliar nutrient measurements, we recommend that 100 mg/L N, a 50% reduction in N concentration from what would produce maximum growth, in an 8:1:2 ratio is the most appropriate fertilizer regime for the production of most herbaceous perennials.

Additional details of these results are available in Kraus et al. 2011. BC

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Dr. Helen T. Kraus (e-mail:helen_kraus@ncsu.edu) is an Assistant Professor of Horticulture, North Carolina State University, Raleigh, NC 27695-7609. Dr. Stuart L. Warren is a Professor and Head, Department of Horticulture, Forestry and Recreation Resources, Kansas State University, Manhattan, KS 66506.

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