Determination of nursery crops yields, nutrient content, and water use for improvement of water and fertilizer use efficiency

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INTRODUCTION

There is increasing interest in the development of fertilizer and irrigation best management practices for commercial nurseries. Some of the information necessary for the development of BMPs for nurseries is available. For example, some information about water and nitrogen requirements of 1-gallon container nursery stock has been published, and a few studies have addressed questions about the effects of fertilizer N form, concentration, and frequency of delivery, and the effects of plant development on nutrient uptake. Although such studies yield much useful information, they are not well suited to provide general guidelines for fertilizer management of the immense range of nursery crops in California. This project was undertaken to provide the nursery industry with basic information about the quantities of nitrogen, phosphorus, potassium, and water needed by their crops.

OBJECTIVES

1. Determine the NPK uptake of 75 container-grown ornamental crops at commercial maturity.
2. Measure water use of these crops at key stages of development and relate values to reference evapotranspiration.
3. Estimate and prepare recommendations for overall crop water and fertilizer needs based on values obtained from preceding objectives.

DESCRIPTION

A wide range of nursery crops was grown in the Environmental Horticulture outdoor nursery on the UC Davis campus. Plants were fertilized with a complete controlled-release fertilizer or with a complete liquid feed fertilizer. Fresh and dry weights and NPKcontents of the roots and shoots of propagules and finished crops were determined. Evapotranspiration was monitored throughout crop production. Data for Years 1-3 are presented here.

RESULTS AND DISCUSSION

Year 1

Daily water use of the one-gallon sun and shade crops grown in Year 1 varied with weather conditions and crop age. Water use of plants grown in full sun did not exceed 250 mL/day on any day, and usually was less than 200 mL/day. Water use of plants grown under shade cloth never exceeded 200 mL/day, and usually was less than 150 mL/day. The crop coefficients for crops grown in full sun ranged from 0.9-1.8 (based on water use relative to ET_o for the soil surface area), but seasonal changes in k_c never exceeded 0.29 for a particular shrub species. The values were generally lower for shade-grown species, but remained relatively constant over time for only two of the species. For the other shade-grown species, k_c increased by as much as 0.73 as plants increased in size.

Applied fertilizer rate (low and high rates recommended by the manufacturer) had no significant effect on yields, and these woody species did not appear to have luxury consumption of the macronutrients analyzed. Dry weights and tissue nutrient concentrations of finished plants are presented in Table 1. Four species (Aucuba, Camellia, Dietes, and Juniperus) grew slowly and had relatively small dry weight gains. Tissue nitrogen concentrations were acceptable in all species, but P was low in several species and K was unusually low in Camellia. Camellia took up extremely small amounts of N and no measurable amounts of P or K during the growing season (Table 2). Among the species with more normal growth, N uptake ranged from 70 mg by Aucuba to 598 mg by Lavandula (Table 2). P uptake among most species was between 30-50 mg, but uptake by Aucuba, Camellia, Dietes, and Juniperus was 11 mg or less. K uptake also varied widely.

Cumulative water use (transpiration plus evaporation) ranged from about 11-15 liters for most species (Table 3). The maximum ratio of N uptake to total water use was 56 mg/l, and the average value was 25 mg/l.

Year 2

The experiments in Year 2 were focused on herbaceous species and were grown in containers ranging in size from 4-inch to 1-gallon, depending on species. The yields differed significantly among species, and the applied fertilizer rate affected yields and nutrient content in coleus, cosmos, and pepper plants (Table 4). Average yield for all species fertilized at the high-recommended rate was 14.4 g, compared to 13.3 g for plants fertilized at the low recommended rate.

Shoot N, P, and K concentrations were significantly different among species, and tissue N concentrations were affected by fertilizer concentration, but shoot K and P concentrations were affected only by species (Table 5). The lower N and K concentrations in plants fertilized at the low fertilizer rate could account for the lower yields observed at that fertilizer concentration, although NPK concentrations were within the published acceptable ranges for all species except pepper (and perhaps cosmos, for which no published data are available).

The highest quantity of N uptake was 883 mg by cosmos plants (Table 6). Average N uptake was 346 mg at the low fertilizer rate and 446 mg at the high rate. Fertilizing at the high-recommended rate resulted in greater N uptake by coleus, cosmos, impatiens, nepeta, pepper, and Perovskia, but only coleus, cosmos, and pepper plants responded with higher yields.

The calculated ratio of N uptake:water uptake over the course of the experiment indicates that most of these herbaceous species readily take up about 100-150 mg N/l, 20 mg P/l, and 120-150 mg K/l (Table 7). Luxury consumption of N occurs in most of the species tested.

Evapotranspiration did not exceed 250 ml/day, and usually was less than 150 mL/day. Cumulative water use ranged from 1.6 l for New Guinea impatiens to 3.9 l for impatiens (Table 7). Only geranium, cosmos, nepeta, and perovskia, the crops with the greatest leaf area, exceeded ET_o. The crop coefficient, k_c, tended to increase as plants matured. For most species, k_c did not increase dramatically until the week of harvest. Values in the first 2 weeks after planting ranged from 0.2 to 0.6 (based on water use relative to ET_o for the area occupied by each plant). At commercial maturity, k_c ranged from 0.4 for New Guinea impatiens to 1.5 for cosmos.

Year 3

Plants in Year 3 were grown in 1-gallon pots using UC Mix as the potting medium and fertilized with half-strength or quarter-strength Hoagland's solution with each irrigation. Yields differed among species, but the fertilizer rate only affected the yield of Hemerocallis (Table 8).

Shoot N, P, and K concentrations and total uptake were significantly different among species and fertilizer rates (Tables 9 and 10). The crops for which fertilizer rate affected shoot N were Aptenia, Euonymus, Gazania, Hemerocallis, Lagerstroemia, Miscanthus, Pachysandra, Parthenocissus, Phalaris, Prunus, Pyracantha coccinea. The higher fertilizer rate also increased shoot P in Pachysandra and Parthenocissus, and increased shoot K in Aptenia, Armeria, Gazania, Pachysandra, and Phalaris.

The highest quantity of N uptake was 1.25 g, by Hemerocallis plants (Table 10). Average N uptake was 379 mg at the low fertilizer rate and 530 mg at the high rate. P uptake averaged 77 and 100 mg at the low and high fertilizer rates, and average K uptake was 490 and 615 mg. It is important to note, however, that only the yield of Hemerocallis was affected by fertilizer uptake.

The calculated ratio of nutrient uptake:water uptake over the course of the experiment indicates that, except for Hemerocallis, all of these crops achieve acceptable yields at ratios of about 50 mg N/l, 20 mg P/l, and 50 mg K/l (Table 11). Aptenia apparently took up K at a ratio well in excess of the concentration applied, but yield was not affected significantly in this experiment.

Phalaris had the highest average rate of water use at 398 ml/day, and the highest water use on any single day was 602 ml, by Phalaris. The overall average for daily evapotranspiration was 150 ml, but values ranged from 77 to 398 ml. Cumulative water use ranged from 6.3 l for Spiraea to 16.6 l for Hypericum (Table 11).

CONCLUSIONS

Nursery crops vary widely in both nutrient and water consumption, hence it is difficult to establish a fertilizer recommendation that satisfies all common nursery crops. In most cases, however, woody species should receive adequate nutrition from a liquid feed containing 50 mg N/l, 20 mg P/l, and 50 mg K/l. Most herbaceous species require about 100-150 mg N/l, 20 mg P/l, and 120-150 mg K/l. Water use in one-gallon or smaller containers rarely exceeds 250 ml/day (about one-half pint), but it is not well correlated with ET_o. It is unlikely that reliable crop coefficients can be established for most of these crops.