NUTRITION OF ORNAMENTAL CROPS[1]

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Nutrition of ornamental crops is a complex problem. For example, Brewer (2) reported containerized *Ilex crenata* growth was maximized with 400 ppm N, 15 ppm P, and 120 ppm K in the irrigation water. Gouin and Link (7) reported growth of containerized *Taxus* × *media* 'Hatfieldii' was maximized at 224 ppm N, 75 ppm P, and 135 ppm K. Plant materials grown in nursery operations are diverse, the nutritional factors which result in growth maximization of one plant type often do not produce equivalent results with others.

Leibig in 1843, developed what has become known as the "Law of the Minimum." The law states that, if any essential element is deficient with all others at optimum levels, growth is controlled by the deficient element. This premise holds for any essential component of the cultural system (light, water, temperature, pH, drainage). Thus growers may be employing similar nutritional practices yet obtaining different growth results because other cultural factors are limiting.

Response from Nurserymen. A questionnaire to determine fertilization practices of ornamental plants (3,4) showed that of 45 nurserymen responding, 18% grew ground covers, 87% evergreens (narrow and broadleaf), 70% deciduous shade trees, 66% deciduous shrubs, and 61% small to medium-sized ornamental trees. Of these, 18% grew one group of plants, 9% two, 20% three, 33% four, and 20% five. Most nurserymen grow many types of woody plants and cannot maximize growth with a single nutritional regime.

The growing systems used included field production (59%), containers (10%), or a combination (31%). The total acreage in field production was 20,534 while container production was about 25,000,000 cans per year.

A regular fertilizer program was used by 91% while 9% had no program. With respect to determining when and in what quantities to fertilize we found that no one used plant analysis alone, 58% used soil analysis; 18% used plant and soil analyses and half of those were from Ohio nurseries. There were 19% who fertilized when time permitted, while 5% applied fertilizer when they thought the plants needed it. A fertilization program can be based on either soil or tissue analysis. Due to the wide-

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spread access to soil testing laboratories, soil analysis is most commonly used by nurserymen.

Most nurserymen (83%) applied elements other than N and indicated a definite benefit was derived from this practice. The principal elements applied were P, K and Fe but 17% applied only N and, in fact, could not see any benefit in increased growth or appearance with other essential elements. This 17% constituted field production operations where immediate responses are not always evident.

Over half (52%) reported that excess soil salinity and pH did not present cultural problems. However, 29% (all container growers) indicated excess salts could be or were a significant problem. The pH presented a cultural problem to 11% and 8% had no idea if these factors were affecting growth.

A diversity of nitrogenous fertilizers is used by nurserymen. Ammonium nitrate, urea, and 20-20-20 were reported as used most frequently. Many nurserymen use a "complete" fertilizer and the N carrier is usually mono- (11-48-0) or di-(18-46-0) ammonium phosphate. The higher analysis granular or water soluble fertilizers are often composed of ammoniated phosphates, NH_4NO_3 and/or urea. One Ohio nurseryman noted that "growers might take a close look at costs versus N source, it can be shocking." The lowest priced N source is anhydrous ammonia yet growers tend to avoid it. Special application equipment is required and there is the possibility of injury to plants. However, an Illinois nurseryman has successfully adopted anhydrous ammonia into his cultural program. He noted the spring flush of growth was not as pronounced as with NH_4NO_3 but over the entire growing season the results from each source proved equal. The reason for the slow growth in spring from anhydrous fertilization is the reduced conversion rate of NH_4-N to NO_3-N. This does not occur rapidly until soil temperatures reach the 60°F plus stage.

It becomes difficult to compare the degree of growth on similar plant types from operation to operation simply because of the great differences in cultural and fertilizer programs. The quantity of N applied to nursery stock varied tremendously. For example, at the low range field-grown yews and junipers received 20 lb N/A/year while ornamental shade and flowering trees received 250 lb N/A/year. The average range for field crops was 75 to 100 lb N/A/year. For container plants, the low rate was 75 ppm N/watering and the high rate 300, these two rates were both used for juniper. The average range was 150-200 ppm N/watering. Variable container fertilization rates are often due to the medium employed; a bark mix has a higher N requirement than a peat:sand mix.

Half of the respondents thought growth was maximized by the cultural and fertilizer practices they employed; 37% said growth had not been maximized and 13% did not know. Half were not confident of their fertilization practices and the results obtained. When growth is not maximized, time, land, labor and supplies are partially wasted and maximum dollar turnover is not realized.

The questionnaire and the literature indicated neither nurserymen nor researchers have adequately studied the effects of mineral nutrition on woody ornamental plant growth and quality. The diversity of plants and the myriad production techniques prohibit defining optimum nutritional levels for every plant type. One nurseryman succinctly summarized the state of woody plant mineral nutrition by noting that he and other nurserymen were "struggling and attempting to find the best fertilizer combinations; perhaps more of an art than science. Probably stumble and stay locked in some of the shotgun methods we are using."

Nutrition and Plant Hardiness. Reduction of cold hardiness has been associated with excess N applications especially those applied late in the growing season but researchers have been unable to show any positive correlation between the factors (4). *Cotoneaster divaricatus, Forsythia* × *intermedia* 'Beatrix Farrand', and *Viburnum plicatum* var. *tomentosum* grown in sand culture and fertilized with KNO_3, $Ca(NO_3)_2$, NH_4NO_3, 20-20-20, urea or $(NH_4)_2SO_4$; at 100, 200 or 400 ppm every watering produced the greatest growth with NO_3-N alone. The plants were NO_3-N combinations and finally NH_4-N alone. The plants were then hardened off and subjected to freezing temperatures. Those grown with NH_4-N alone or NH_4-N plus NO_3-N were more severely injured than those grown with NO_3-N alone. The 400 ppm N rate also resulted in greater freezing susceptibility than the lower rates. In a field study *Cornus sericea* forma *baileyi, Forsythia* × *intermedia* 'Spring Glory', and *Juniperus chinensis* 'Hetzii' were fertilized with either 2, 4, 6, or 8 lb N/per 100 sq ft using NH_4NO_3, $Ca(NO_3)_2$, urea, or 12-12-12. In the following spring the plants were rated for frost injury. *Forsythia* was injured at the highest N rate regardless of source but no injruy was apparent on *Cornus* or *Juniperus*.

It is difficult to extrapolate the results of greenhouse studies to field studies. The standardization of fertilizer and cultural practices within the nursery industry is impossible because of the great diversity of plant material and cultural systems, as well as the wide latitude of climates in which many plants are grown. Improvements can be made in the present fertilizer and cultural systems that will be of significant economic benefit to the nurseryman. In many repsects the most applicable research is that conducted by each nurseryman and the subsequent gearing of the successes and failures to improve his particular system.

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HYPOBARIC STORAGE — AN OVERVIEW

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Hypobaric or low pressure storage (LPS) is a relatively new technology that may significantly alter many production and/or marketing procedures presently being used in horticulture. It is the purpose of this paper to briefly introduce LPS by discussing the history, principles, capabilities and present status of this technology.

History. The storage of horticultural commodities and other perishables is limited by pathological and/or physiological disorders. Of major concern is the influence of carbon dioxide,