# EFFECTS OF OSMOCOTE, DOLOMITE AND MICROMAX DURING PROPAGATION ON THE SUBSEQUENT GROWTH OF FOUR ORNAMENTAL SPECIES

By

CHARLES LARRY NICHOLS

Bachelor of Science in Agriculture

Oklahoma State University

Stillwater, Oklahoma

1977

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July, 1982

EFFECTS OF OSMOCOTE, DOLOMITE AND
MICROMAX DURING PROPAGATION ON
THE SUBSEQUENT GROWTH OF
FOUR ORNAMENTAL SPECIES

Thesis Approved:

Carl Whitcomb
Thesis Adviser

Dallas L. Wadsworth

Paul J. Mitchell

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

I wish to express sincere appreciation to Dr. Carl Whitcomb. His enduring patience and guidance have allowed me to gain a great deal of knowledge in the field of horticulture. The experiences and knowledge gained through my graduate assistantship have provided me with much more than a college degree.

Thanks also to Dr. Whitcomb's wife LaJean for her kind hospitality, along with committee members Dr. Grant Vest, Dr. Dallas Wadsworth, and Paul Mitchell for their helpful guidance.

Assistance provided by fellow graduate students Susan Kenna, Bonnie Appleton, Gary Hickman, and Chris Threadgill as well as undergraduates Jerry Williams, Frank Babcock, and Bob Bridel is gratefully acknowledged.

The guidance and help of Charlie Gray and Billy Cavanough has been of immense value to my education.

Sincere appreciation is given to my financee Janna Russell for her patience and many sacrifices that have made this degree possible.

TABLE OF CONTENTS

## LIST OF TABLES

| Table | | Page |
|---|---|---|

## FIGURE

# CHAPTER I

## INTRODUCTION

The nursery industry has one important characteristic that separates it from most others: the unusually long time it takes to produce a salable product. Propagation and production techniques that reduce production time enable the nurseryman to be more flexible to market demands.

The benefits derived from improved propagation techniques are with little or no cost to the producer, while increasing plant growth and quality substantially (4).

Asexual propagation by cuttings is a rapid and relatively inexpensive means of reproducing many ornamental trees and shrubs. It is particularly important with many woody species to maintain a desirable or well adapted cultivar. If propagated by seed the plants would loose these unique genetic characteristics due to gene segregation. Reproduction by cuttings also allows for good uniformity.

Over the past four decades, there have been numerous achievements in developing methods for plant propagation. Recently researchers have devoted much time to find an optimum nutritional program for ornamental plants (3, 8, 9, 21, 27, 29, 31).

Providing nutrients during propagation is a relatively new practice. A concept that began in the mid 1960's was the application of nutrients during misting (20). However, this method provided little benefit to the plants, but a favorable condition for the growth of algae and other organisms.

Recently the technique of adding slow-release fertilizers to the rooting medium before the cuttings are stuck has shown much promise (36). This practice could have value as a labor saver if used on plants to be grown in containers after propagation. Slow-release fertilizers offer a potential means of optimizing crop production with improved fertilizer efficiencies.

# CHAPTER II

# LITERATURE REVIEW

## Asexual Propagation

Cloning plants from cuttings is a routine method used by the nursery industry for propagating plants. It provides an economical and relatively easy way to perpetuate a desirable cultivar. However, like many other propagation techniques, it also has some disadvantages. Cuttings must be removed from the parent plant at a particular stage of growth during the season. As a rule, hardwood cuttings are made from wood of the past growing season when the wood is one year old (19). The diameter of the stems from which hardwood cuttings are taken can be important when rooting certain species. Humidity, ventilation, photoperiodism, and temperature must also be given consideration (32).

## Nutrition During Propagation

If optimum root initiation and development is to be achieved, a continuous and adequate supply of all nutrients must be available to the cutting during propagation. The medium, container, stock plant, and type of fertilizer used all influence response to fertility. The response also varies among species. In order to obtain a proper nutritional balance over a prolonged period of time, a slow release fertilizer or nutrient mist system must be used (24). As suggested by Maynard and Lorenz (21) there are four ways release rates can be controlled:

1. The application of low solubility coatings to soluble fertilizers.
2. The manufacture of compounds with low solubility.
3. The manufacture of low solubility compounds that require microbial activity for release of the nutrient.
4. The use of treated natural organic materials that require microbial action for release of nutrients.

The use of slow-release fertilizers offers potential means of reducing losses due to leaching from the root zone, fixing the fertilizers into the unavailable chemical forms by the soil and volatilization into the atmosphere (with regard to nitrogen) (1).

Barron (1) states that slow-release fertilizers should release in a pattern coinciding reasonably well with the uptake pattern of the crop. Also a high proportion of supplied nutrients should be released during that crop cycle. The release pattern of controlled-release fertilizers can be affected by soil temperature, moisture content and microbial activity. These variable factors make the pattern of release more difficult to predict. There are several slow-release fertilizers on the market. The majority provide only nitrogen (N), phosphorus (P), and potassium (K).

Osmocote is an N-P-K water soluble fertilizer prill with a multiple, plastic polymer coating (21). As the soil temperature increases the resin expands and the rate of release increases.

It is believed that moisture enters the Osmocote prill largely in the vapor phase, which explains why the amount of water in the soil has only minor effects on the rate of nutrient release (1).

By incorporating a slow release fertilizer in the rooting medium, the formation of algae on the surface of the rooting medium can be minimized or eliminated. The release rate of Osmocote 18-6-12 within the first few days is rather slow. This release parallels a similiar lapse of time between the sticking of cuttings and the initiation of roots. A sufficient level of nutrients should be available in the medium to encourage plant growth at the time new roots initiate (9).

An experiment done by Schulte and Whitcomb (28) using *Ilex cornuta* 'Burford' showed increased root quality with a increased rate of Osmocote in the rooting medium. This increase was significant up to a rate of 0.1345 kg/m$^2$/year (1,200 lbs. of nitrogen per acre per year) (91 ppm nitrates). A study done by McGuire and Bunch (24) showed that the best growth of viburnum and pachysandra cuttings resulted from the use of Osmocote, when compared to Mag-Amp or Ureaformaldehyde. They also found root mass diameter during propagation was larger with the slow-release fertilizer treatments, as opposed to the control with no nutrients.

Osmocote in the propagation medium has been shown to have a carryover effect by stimulating growth following transplanting. Whitcomb, Gibson and Storjohann (41) studied the effects of 3.56, 7.12 and 10.68 kg/m$^3$ of Osmocote (6, 12 and 18 lbs. per yd$^3$ respectively) on Ilex crenata 'Hetzi' and Ilex cornuta 'Burford'. They found Osmocote did not influence rooting of the cuttings, however, subsequent plant growth was stimulated. Based on this study, another experiment was designed to compare Osmocote formulations 19-6-12 (3 to 4 month release pattern), 18-6-12 (6-9 month formulation) and 18-5-11 (12 to 14 month release pattern) (36). Each was incorporated at three rates into a rooting medium. Test species were Lagerstroemia indica, Euonymus fortunei and Ligustrum vicaryi. With euonymus, the formulation of Osmocote had little effect. However, top weight, visual root grade and budbreaks were greatest when 7.12 kg/m$^3$ (12 lbs. per yd$^3$) of Osmocote was used. Ligustrum with Osmocote 18-6-12 had the greatest top weight and visual root grade. Also, no significant differences in top and root weight appeared with either the 4.75 kg/m$^3$ (8 lbs. per yd$^3$) or 7.12 kg/m$^3$ (12 lbs. per yd$^3$) rates. Crapemyrtles increased in the number of budbreaks as the rate of Osmocote increased, however, top weight, root weight and visual root grade were not affected. On all species, nutrition during propagation stimulated further growth following transplanting. It was suggested this stimulation was due to nutrients being absorbed into the cuttings following rooting, thus increasing subsequent plant vigor.

Research by Ward and Whitcomb (31) with Osmocote (18-6-12) on _Ilex crenata_ 'Hetzi' showed plants propagated with Osmocote increased in growth response to subsequent fertilizer sources, and were much larger in size than those without Osmocote during propagation.

Johnson and Hamilton (15) used _Juniperus conferta_ and _Ligustrum japonicum_ to determine the effects of top dressing Osmocote 18-6-12 at 7.5 (0.18 lbs. per $yd^3$) and 15.0 (0.36 lbs. per $yd^3$) grams per 0.093 $m^3$ (1.196 lbs. per $yd^3$) onto the rooting medium compared to a control. They observed that the highest percent of rooting with _Juniperus conferta_ occurred at the low Osmocote rate (7.5 grams per 0.093 $m^3$). Fresh weight of roots did not differ among treatments at the of 8 weeks, however, Osmocote improved root development after ten weeks. The high rate (19.2 gram/$m^3$) (0.50 lbs. per $yd^3$) of 18-6-12 initially inhibited root development of both species. It was theorized that this was probably due to the initial quick release of nutrients and subsequent "burning" of newly formed roots. Top growth of cuttings in all treatments was similiar. Osmocote 18-6-12 increased top development following root development and subsequent nutrient uptake.

Glenn, Hogan and Whitcomb (7) used three levels of nitrogen from Osmocote 18-6-12 at 0, 0.0896 (800 lbs. per acre/yr) and 1.345 (1,200 lbs. per acre/yr) kg/m$^2$/yr on Ilex crenata 'Hetzi', Ilex cornuta 'Burford', Ilex fosteri, Ligustrum japonicum and Juniperus chinensis 'Hetzi'. They found with an increase of Osmocote in the rooting medium, the root grade increased for burford and hetzi hollies. They also reported that the addition of Osmocote had no effect on the rooting of foster's holly, wax leaf ligustrum or hetzi juniper. However, after one growing season the number of branches per plant was 42 percent higher on japanese holly, 39 percent higher on burford holly and 41 percent higher on wax leaf ligustrum when treated with the 1.345 kg/m$^2$/yr (1,2000 lbs. per acre/yr) rate of Osmocote in the rooting medium as compared to 0.0 or 0.0896 kg/m$^2$/yr (800 lbs. per acre per yr) of Osmocote.

Carney and Whitcomb (2) worked with japanese holly, pyracantha, and azalea cuttings in a 1:1 mixture of peat-perlite. Osmocote 27-12-0 was added at 0, 0.6 (1.08 lbs. per yd$^3$), 1.0 (1.80 lbs. per yd$^3$) and 1.5 kg (2.52 lbs. per yd$^3$) of nitrogen (from Osmocote 27-12-0) per m$^3$ and Osmocote 0-0-46 at 0.45 (0.72 lbs. per yd$^3$), 0.72 (1.20 lbs. per yd$^3$) and 1.10 (1.68 lbs. per yd$^3$) kg/m$^3$. After 13 weeks there was no significant difference in azalea cuttings caused by the different treatments. But after 22 weeks azalea liners with nitrogen added during propagation had a positive effect on visual grade while potassium had little or no effect. They suggested that the most practical current product for propagation was Osmocote 18-6-12 used at 2.37 (4 lbs. per $yd^3$) to 3.56 (6 lbs. per $yd^3$) $kg/m^3$.

Diver and Whitcomb (5) noted that dolomite is not beneficial during propagation, but the addition of calcium and magnesium nay produce a beneficial interaction with the addition of Micromax and a nitrate source. Large additions (9.5 $kg/m^3$) (6 lbs. per $yd^3$) of dolomite are used during propagation in many European countries (5). Diver and Whitcomb conducted a study to determine if dolomite would prove beneficial under North American conditions. The species tested were _Pyracantha coccinea_ and _Juniperus procumbens_. Treatments of 0, 2.37 (4 lbs. per $yd^3$), 4.74 (8 lbs. per $yd^3$) and 9.48 (16 lbs. per $yd^3$) $kg/m^3$ of dolomite and Micromax micronutrients at 0 and 0.59 (1 lb. per $yd^3$) $kg/m^3$ were incorporated into propagation media consisting of 50:50 peat:perlite and 100 percent peat. Since most growers in Europe propagate in 100 percent peat they pointed out that it was important to contrast differences in media. Pyracantha growth was not affected by dolomite added during rooting. On the other hand, the juniper cuttings had a lower visual root grade when treated with dolomite. After growing the junipers 5 months in 3.81 liter (one gallon) containers, the detrimental effect of dolomite during propagation was still significant.

Even though micronutrients are needed only in small amounts, their presence plays an important role in growth and development of plants.

Henderson (13) used Micromax at 0, 0.44 (0.75 lbs. per $yd^3$), 0.89 (1.50 lbs. per $yd^3$) and 1.33 (2.25 lbs. per $yd^3$) $kg/m^3$ in factorial combination during propagation and production to test the growth of *Juniperus procumbens* and *Ilex crenata* 'Hetzi'. *Ilex crenata* 'Hetzi' visual rating was highest with the addition of 0.44 $kg/m^3$ (0.75 lbs. per $yd^3$) of Micromax during propagation. Micromax also significantly increased root and top weight during production. *Juniperus procumbens* overall plant growth was best with 0.89 $kg/m^3$ (1.50 lbs. per $yd^3$) or 1.33 $kg/m^3$ (2.25 lbs. per $yd^3$) of Micromax both during propagation and production.

## Nutritional Conditions of the Stock Plant

The nutrition of the stock plant prior to taking the cutting has an effect on the ability of cuttings to root and future growth of that cutting (14). Cuttings should not be taken from poorly ripened wood or from shoots with an excessive amount of vegetative growth. An actively growing shoot that has a high level of nitrogenous compounds and is low in carbohydrates is not desirable as a stock plant (28). Stoutemyer (28) also states that cuttings having a low carbohydrate-nitrogen ratio do not root well.

Research findings vary somewhat on this subject and among species. Hess (14) noted that cuttings taken from stock plants grown with high levels of nitrogen rooted poorly. In contrast Maire (20) noted that cuttings taken from nursery stock on a good nutritutional program consistently out-perform those taken from less-cared-for stock. Taking cuttings from healthy stock plants can also prevent heavy population losses due to diseases (28).

Johnson and Midcap (16) recommend a fertilizer ratio of 3-1-2 at 0.0896 to 0.100 $kg/m^2/yr$ (800-900 pounds of nitrogen per acre per year) for stock plants. This amount will produce sufficient nitrogen and carbohydrate levels in the stock plant tissues. They also suggest using a complete micronutrient fertilizer or at least boron and zinc (since these two micronutrients are particularly important for root initiation and development) (3). Coorts (3) found that japanese holly cuttings taken from parent plants that were deficient in boron and manganese showed poor root quality. Whitcomb (34) showed that micronutrients incorporated into the growing medium of parent plants, stimulated growth and also influenced the rooting of cuttings taken from those plants. In another experiment Ward and Whitcomb (31) found liners from parent plants grown with isobutyldyene (IBDU) a 31 percent nitrogen source, had superior root systems when compared to liners from plants receiving liquid or Osmocote fertilization.

Pridham (24) took cuttings from field grown etiolated Rhododendron catawbiense. Etiolation was accomplished by enclosing the upper portion of the shoot in a 254 mm (10 inch) black manila envelope. The mortality of cuttings from etiolated stock plants was higher than cuttings from non-etiolated stock plants. The quality of roots initiated from cuttings and subsequent growth may depend upon the maturity and treatment of the stock plant (3). Coorts (3) notes that the major element nutrition of the stock plant exerts a strong influence on the development of roots and shoots from cuttings taken from those stock plants.

## The Time Cuttings Are Taken

The time of year cuttings are taken is an important factor in the initiation of roots. Semi-hardwood and hardwood cuttings are generally taken during the dormant season (i.e., late fall or early winter) from wood of the previous season growth (11). The success associated with the use of root-promoting substances such as indolebutyric acid (IBA) also depends on the time cuttings are taken (19). Lamphear and Meahl (19) showed that pfitzer juniper had a greater response to IBA when cuttings were taken in January than in November or December. IBA reduced the rooting percentage during the spring and summer. Conditions which stimulated active growth, inhibited rooting, whereas, inhibition of growth was associated with an increase in rooting (16, 19).

According to Stoutemyer (28) when the natural auxin within the cutting are highest, cuttings will root quicker and have more root surface area. As cold weather approaches, starch disappears from the bark and increases in the internal tissues, particularly in the pith and around the nodes. The starch is transformed into other compounds through enzymes, due to the low activity during winter, when there is little utilization through respiration (28).

The diameter and overall size of the cutting may have an effect on its rootability. This effect varies among species (30). Stoutemyer (28) reported that the rooting obtained from cuttings of black locust which had a diameter greater than 12 mm (0.47 inches) was far superior to that in cuttings from smaller stems.

## Leaching of Nutrients Under Mist

Intermittent mist is widely used by nurserymen in the rooting of cuttings. Misting enables the propagator to root softwood and hardwood cuttings of species that are otherwise difficult to root. It is believed that frequent misting can cause water to saturate the leaf tissues, resulting in the leaching and subsequent loss of nutrients. Sorenson and Coorts (27) noted that every plant exposed to frequent misting had, to some degree, lost nutrients by leaching. They also noted nitrogen, phosphorus, potassium, calcium and magnesium are leached from hardwood cuttings, which resulted in only small gains in dry weight while rooting under mist. They compared the nutrient content of the cuttings before and after nutrient misting. The results showed that the nitrogen content was maintained or increased by the misting. Phosphorus content was also increased, while potassium content decreased.

All the common inorganic nutrients can be leached, including both the macro and micronutrients (29). In addition large quantities of organic materials are also susceptible to leaching. These include amino acids, organic acids, simple sugars and other carbohydrate material (29).

The loss of nutrients by leaching is influenced by the maturity of the cuttings. Mature hardwood cuttings are much more susceptible to leaching than rapidly growing softwood cuttings (3, 8). Mineral deficiencies observed in young cuttings are apparently caused by a dilution of the original nutrients as a result of growth (8).

An experiment using the second initiated leaf from two-week-old squash plants was conducted by Tukey (29). The plants had previously absorbed $Ca^{45}$ through the roots. The results showed that by soaking the plants in distilled water for 24 hours, the mineral was leached out of the squash leaves. The solution in the vessel was poured off at hourly intervals and replaced with fresh water. The radioactivity of each leachate was then determined. The same procedure was followed with the second initiated leaves from four-week-old plants. The loss from the older leaves were consistently greater than the loss that occurred in younger leaves, especially during the first 9 hours of leaching. If the leaching period was again extended, loss of nutrients would eventually total several times the amount. Tukey (29) speculated that as the nutrients are leached from the leaves, they are replaced by translocation from the stems and roots.

Maire (20) noted that nutrient misting has little effect on root initiation but it does influence the percentage and quality of root systems.

In 1975 Hall and Whitcomb (10) studied the effects that antitranspirants (plastic or wax coatings) had when they were substituted for intermittent misting on juniper and ligustrum. Earlier research conducted in Florida showed cuttings with antitranspirants rooted far better than those rooted under intermittent misting. It was believed that at least part of the benefit received using coatings may have been due to the reduction or elimination of leaching from the leaves. It was found that the technique of dipping cuttings in antitranspirants to assist propagation did not work in Oklahoma. This was due to the lower relative humidity. In Florida, the relative humidity did not drop below 85% during the entire time the experiments were being conducted. The moisture stress to the leaves was, therefore, much higher in Oklahoma.

## Propagation Media

Many materials have been used as a rooting medium over the years. A good rooting medium should provide sufficient aeration to allow proper drainage and nutrient uptake by the plant. It is through air-filled pores that gases are exchanged between the medium and the atmosphere (30). Without proper water drainage, the amount of oxygen diffusing to the root system is decreased. However, the amount of carbon dioxide is increased since the carbon dioxide comes from the living roots, bacteria and fungi in the soil. Evidence suggests that the carbon dioxide content alone, if it reaches too high a level, can be toxic to roots (35). Therefore, if some other aspect such as oxygen restricts rooting or root activity, response of cuttings to nutrients added during propagation will be restricted. Van Doren (30) noted that restricted aeration could:

1. Be the greatest limiting factor in the development of an extensive root system.
2. Impair the essential process of respiration of an established root system and retard both water and nutrient absorption.
3. Prevent the orderly functioning of the essential biological processes associated with good fertility.
4. Increase the probability of root disease problems.

Researchers are in disagreement over the exact material or combination of materials that results in the highest quality root system. Again as with other variables in plant propagation, the optimum combination of media components varies among species. To contrast this Rauch (25) compared sand, perlite, sand-perlite, sand-peat, peat-perlite and sand-peat-perlite on two cultivars of Euonymus fortunei 'Acutus' and 'Jewell'. He concluded there was a significant effect on the number of roots produced per cutting due to the rooting medium. There was also a difference in root weight between the two clones. Further analysis showed cuttings propagated without peat as a component produced heavier root systems. He also stated that peat and perlite provide a better medium for the propagation of chrysanthemums.

Once a desirable material or materials (i.e., peat, perlite, sand, peat-perlite) has been selected (i.e., particle size distribution) careful consideration should be given to the price and availabilities of these materials. Also, the material should be free of pathogens.

Whitcomb, Gibson and Storjohann (36) compared three different formulations of Osmocote with two different types of rooting medium (i.e, peat-perlite, peat-bark). They found that Lagerstroemia indica, Euonymus fortunei, and Ligustrum vicaryi rooted better in peat-perlite than in peat-bark. They suggested that the peat-perlite allowed better aeration. Using pyracantha and juniper, Diver and

Whitcomb (5) found that using a peat-perlite mixture, resulted in inferior root systems, when compared to 100 percent peat.

## Container Production

The nutritional regime during propagation plays an important role in producing a quality container plant. The use of slow release fertilizers generally sustains subsequent plant growth, but supplementary nutrients following propagation give the liner an additional boost, thus enhancing plant growth and quality.

The addition of nitrogen (nitrate) at the time of transplanting into containers may be of immense value to subsequent plant growth (37). Also this would compensate for that nitrogen used in the medium which is thought to be decomposed by microorganisms (37).

With the limitations and high cost of various media components researchers have strived to determine the most feasible component to use as a medium (i.e., bark-peat-sand, sawdust-peat). In selecting these components Pokorny (23) suggests considering the following:

1. particle size
2. bulk density
3. total porosity
4. percent air capacity
5. percent water holding capacity

Recently nurserymen have been substituting part of the peat moss with shredded pine bark to reduce costs (12). Pine bark can vary considerably in its texture and physical properties. Pokorny (23) found pine bark samples differ in their aeration, porosity, water holding capacities and total porosities. Elstrodt and Milbocker (6) determined particle size could have an effect on root development. Plants grown in media composed of large particles had root systems superior to those grown in media of small particle size.

The age of pine bark following removal from the tree may also have some effect on plant growth in containers. Laiche (18) studied the effects of 10 to 15 year old pine bark versus new bark (bark peeled and milled less than 2 weeks prior to use). Junipers, pyracantha, youpon holly and burford holly were grown in 19.05 liter (5 gallon) containers and fertilized with 5.93 $kg/m^3$ (10 lbs. per $yd^3$) of 18-6-12 controlled release fertilizer. Superior growth and quality was obtained with the older bark.

## CHAPTER III

## METHODS AND MATERIALS

Terminal stem cuttings of japanese holly, *Ilex crenata* 'Hetzi', tam juniper, *Juniperus sabina* 'Tamariscifolia', japanese boxwood, *Buxus microphylla* and pyracantha, *Pyracantha* X 'Mojave' were taken December 15, 16, 18 and 22, 1980, respectively. Japanese holly cuttings were taken from existing stock plants grown under uniform conditions. The pyracantha, boxwood and tam juniper cuttings were taken from plants on the Oklahoma State University campus. All cuttings were treated with a talc preparation of 8,000 parts per million indolebutyric acid (IBA) to stimulate root formation.

The study was conducted as a randomized complete block design with eighteen treatments and eight replications, with four subsamples per replication. Treatments were two levels of Micromax[a] micronutrients, three levels Osmocote[b]

---

[a]A micronutrient fertilizer manufactured by Sierra Chemical Co., Milpitas, Ca. Contains Fe - 12%, Mn - 2.5%, Zn - 1.0%, Cu - 0.5%, B - 0.1%, Mo : 0.005%, and S - 15%.

[b]A controlled release nitrogen, phosphorus and potassium fertilizer manufactured by Sierra Chemical Co., Milpitas, Ca.

(18-6-12) and three levels of dolomite[c] in factorial combination incorporated into the propagation medium (Table I). Bedding plant trays with four cells measuring 5.7 cm (2.25 in.) per side and 5.7 cm (2.25 in.) in depth comprised the four subsamples (Figure 1). A total of 576 cuttings per species were placed in the propagation medium with each cutting being stuck approximately 3 cm (1.2 in.) deep in the mix.

All containers were placed in a gas-heated, fiberglass covered propagation house on expanded metal benches. Cuttings were grouped by species and were misted for 3 seconds every 6 minutes during the daylight hours. THe average night temperature was 15.6 C (60 F) and the average day temperature was 32.2 C (90 F).

A visual evaluation of root development was made of the tam juniper on February 10 and 12, 1981, pyracantha - February 12, 1981, japanese holly and boxwood - March 3, 1981. For accuracy, a set of standards (1 = no roots, 4 = minimum acceptable roots for transplanting, 7 = good root development, 10 = excellent roots) was established. All cuttings were evaluated using this system. Following evaluation, all cuttings were returned to their original propagation container and held until the frost free date.

---

[c]A natural source of calcium and magnesium. Mg content not less than 10 percent. Ca content not less than 20 percent. Ca content not more than 24 percent. Mined by Delta Mining Corp, Mill Creek, Ok.

TABLE I

LEVELS OF MICROMAX, DOLOMITE AND OSMOCOTE INCORPORATED DURING PROPAGATION

| Rates | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| Micromax | 0.0 | 0.59 kg/$m^3$ (1 lb/$yd^3$) | |
| Osmocote (18-6-12) | 0.0 | 1.78 kg/$m^3$ (3 lbs/$yd^3$) | 3.56 kg/$m^3$ (6 lbs/$yd^3$) |
| Dolomite | 0.0 | 3.56 kg/$m^3$ (6 lbs/$yd^3$) | 7.12 kg/$m^3$ (12 lbs/$yd^3$) |

A. Liner transplanted into standard production mix
B. Liner transplanted into additional phosphorus
C. Liner discarded

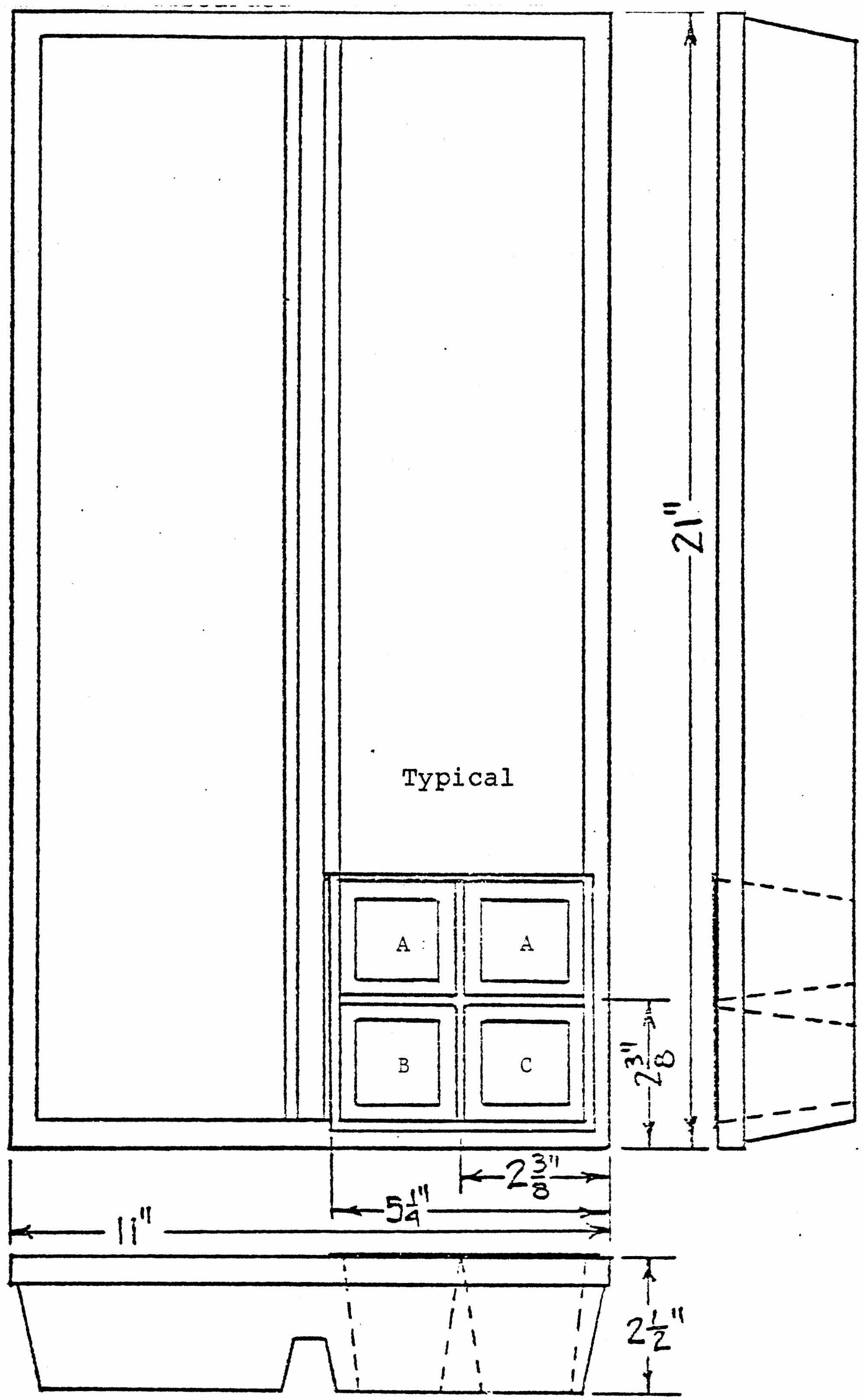


Figure 1. Disposition of Subsamples Following Propagation

On March 20, 1981 all species were removed from the propagation house and placed in a structure with 30 percent saran shade for approximately two weeks acclimitization. A total of 576 liners per species were used up to this point of the experiment. All data taken during propagation and production were analyzed by analysis of variance (AOV) using Least Significant Difference for mean separation (LSD).

## Growth and Development During Production

Following the two-week acclimation period japanese holly, boxwood and tam juniper liners were transplanted into 3.81 liter (1 gallon) white-on-black poly bags. Due to the anticipated rapid growth of pyracantha, liners were transplanted in 11.40 liter (3 gallon) black-on-black poly bags.

Within each treatment subsample, the liner that was most unlike the other three (i.e., lack of sufficient root system and undesirable branching was discarded to control the size of the experiment and decrease error due to liner variability. Two of the remaining three liners within each subsample were transplanted into a standard production mix consisting of a 3:1:1 by volume ratio of ground pine bark, spaghnum peat moss and sand respectively. Incorporated into this mix was Osmocote (17-7-12) at 8.31 $kg/m^3$ (14 lbs. per $yd^3$), dolomite 4.75 $kg/m^3$ (8 lbs. per $yd^3$) and Micromax 0.89 $kg/m^3$ (1.5 lbs. per $yd^3$). In addition, one liner was transplanted into the standard production mix with an additional 1.78 $kg/m^3$ (3 lbs. per $yd^3$) single superphosphate (Figure 1) to determine if supplementary phosphorus had any benefit for container-grown nursery stock. A comparison was made between those plants receiving additional phosphorus and those obtaining only the standard production mix.

Following transplanting, holly and boxwood plants were grown throughout the production cycle in a quonset structure with thirty percent saran shade cloth.

To meet the pyracantha and juniper's high light requirement they were placed on the production bed in full sun.

In order to stimulate branching, all plants were pruned lightly within the first sixty days of the production phase.

Water was supplied as needed through overhead sprinklers. In order to control weed seed germination, oxiadiazon (Ronstar) 2 percent G at 6 pounds active ingredient per acre was broadcast onto each container.

During mid-July unicorn caterpillars were feeding on pyracantha. However, the damage was held to a minimum as the insecticide Orthene was applied to the plant foliage.

Branch count[d] was taken on pyracantha and japanese holly on August 8 and 19, 1981 respectively. This data was obtained on the plants receiving additional phosphorus and

---

[d]Branch count was taken only on two of the four species tested to obtain an idea of the growth at an early stage during production.

on one of the two plants growing in the standard production mix.

At the end of the growing season final data recorded for all species was categorized into the following: visual grade based on a standard scale (1-10 with 1 = poor, 4 = fair, 7 = good, 10 = excellent) with three evaluations per plant. These visual evaluations were averaged before AOV. Visual grades of pyracantha, juniper, boxwood and holly were recorded November 2, 20, December 3, and 12, 1981 respectively. Plants receiving additional phosphorus were compared to plants receiving only the standard production mix. The two plants grown in the standard production mix following propagation were visually averaged together to obtain data for visual grade of each species.

Following visual grades, top and root weights were obtained from all species. To control the size of the study, only one of the two plants receiving the standard production mix was used for obtaining top and root weights.

CHAPTER IV

# RESULTS AND DISCUSSION

## *Pyracantha* X 'Mojave'

After 10 weeks all cuttings had substantial root formation. The visual root grade was higher when either 1.78 or 3.56 kg/$m^3$ (3 or 6 lbs. per $yd^3$) of Osmocote 18-6-12 was used compared to plants with no Osmocote (Table II). These results are in agreement with Johnson and Hamilton (17) who observed that cuttings of *Ligustrum japonicum* doubled their root weights at two week intervals and that all Osmocote treatments were beneficial to root development after twelve weeks. Other researchers (2, 9, 36) have found that nutrient applications had little effect on the early stages of root development.

After 6.5 months in 11.40 liter (3 gallon) containers, number of branches was greatest when the high rate of Osmocote was incorporated into the rooting medium (Table II). Visual grade after nine months increased with each increase in Osmocote level (Table II). On the other hand, top and root weight increase was significant only between 0.0 and either level of Osmocote (Table II). The increase with each Osmocote level on visual grade apparently reflects

TABLE II

EFFECTS OF OSMOCOTE DURING PROPAGATION ON THE GROWTH AND DEVELOPMENT OF MOJAVE PYRACANTHA

| | Osmocote Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 1.78 | 3.56 | .05% |
| Visual Root[y] Grade at 10 Weeks | $5.51_b$[z] | $6.35_a$ | $6.87_a$ | 1.42 |
| Branches at 6.5 Months | $36.42_c$ | $49.46_b$ | $55.52_a$ | 5.39 |
| Visual Grade of Shoots[x] at 9 Months | $6.37_c$ | $7.83_b$ | $8.54_a$ | 0.54 |
| Top Weight (Grams) at 9 Months | $207.40_b$ | $254.0_a$ | $278.21_a$ | 44.63 |
| Root Weight (Grams) at 9 Months | $99.83_b$ | $129.81_a$ | $135.75_a$ | 14.19 |

[z]Means within a row followed by the same letter are not significantly different at the .05% level using a protected LDS test.

[x]Based on a scale: 1 = poor; 10 = excellent. Based on the mean of three observations.

[y]Based on a scale: 1 = poor; 10 = excellent. Based on the mean of four observations.

the increase in number of branches since the increase in top weight between 1.72 and 3.56 kg/$m^3$ (3 or 6 lbs. per $yd^3$) of Osmocote during propagation is relatively small. This is in agreement with other researchers (7 ,26).

An interaction between Osmocote and dolomite showed that without the addition of Osmocote in the propagation medium, the 3.56 kg/$m^3$ (6 lbs per $yd^3$) rate of dolomite provided the highest visual grade (Table III). However, as Osmocote levels increased, visual grade increased significantly. At the low level of Osmocote, visual grade was highest with 7.12 kg/$m^3$ (12 lbs. per $yd^3$) of dolomite, but at the high level of Osmocote, dolomite had no effect on the ultimate visual grade of the plants (Table III). Branch count showed a similiar interaction (Table IV) and is probably the primary factor affecting the visual appearance of the plants.

## Buxus microphylla

After 16 weeks, the visual root grade of boxwood cuttings was significantly lower when the high rate of dolomite was present in the rooting medium as opposed to no dolomite (Table V). This agrees with the growth response of juniper as reported by Diver and Whitcomb (5). They incorporated 0.0, 2.37 and 3.56 kg/$m^3$ (0, 4 and 6 lbs. per $yd^3$ respectively) of dolomite into 100 percent peat and 50 percent peat-perlite. The absence of dolomite in both propagation media, improved the rooting of cuttings and

TABLE III

INTERACTION OF OSMOCOTE AND DOLOMITE DURING PROPAGATION ON THE VISUAL GRADE OF MOJAVE PYRACANTHA AT 9 MONTHS

| | Dolomite Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 3.56 | 7.12 | .05% |
| Visual Grade at 9 Months | | | | |
| Osmocote Level 0.0 kg/m$^3$ | $6.18_{b3}$ | $7.68_{a12}$ | $5.25_{c2}$ | 0.94 |
| Osmocote Level 1.78 kg/m$^3$ | $7.31_{b2}$ | $7.25_{b2}$ | $8.93_{a1}$ | |
| Osmocote Level 3.56 kg/m$^3$ | $8.37_{a1}$ | $8.50_{a1}$ | $8.75_{a1}$ | |

[z]Means within a row followed by the same letter or within a column followed by the same number are not significantly different at the .05% level using a protected LSD test.

TABLE IV

INTERACTION OF OSMOCOTE AND DOLOMITE DURING PROPAGATION ON THE BRANCH COUNT OF MOJAVE PYRACANTHA AT 6.5 MONTHS

| | Dolomite Levels kg/m³ | | | LSD |
|---|---|---|---|---|
| | Ø.Ø | 3.56 | 7.12 | .Ø5% |
| Branches at 6.5 Months | | | | |
| Osmocote Level Ø.Ø kg/m³ | $33.56_{b2}$[z] | $43.93_{a2}$ | $31.31_{b2}$ | 9.34 |
| Osmocote Level 1.78 kg/m³ | $52.ØØ_{ab1}$ | $43.ØØ_{b1}$ | $53.37_{a1}$ | |
| Osmocote Level 3.56 kg/³ | $54.68_{a1}$ | $54.ØØ_{a1}$ | $57.93_{a1}$ | |

[z]Means within a row followed by the same letter or within a column followed by the same number are not significantly different at the .Ø5% level using a protected LSD test.

TABLE V

EFFECTS OF DOLOMITE DURING PROPAGATION ON THE VISUAL ROOT GRADE OF JAPANESE BOXWOOD AT 16 WEEKS

| | Dolomite Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | Ø.Ø | 3.56 | 7.12 | .Ø5% |
| Visual Root[y] Grade at 16 Weeks | 4.23$_a$[z] | 3.65$_{ab}$ | 3.Ø9$_b$ | Ø.83 |

[z]Means within a row followed by the same letter are not significantly different at the .Ø5% level using a protected LSD test.

[y]Based on a scale: 1 = poor; 1Ø = excellent. Based on the mean of four observations.

subsequent growth.

The root weights of boxwood after 9.5 months increased significantly with each increase in the rate of Osmocote (Table VI). Likewise as the rate of Osmocote increased from 1.78 to 3.56 kg/$m^3$ (3 to 6 lbs. per $yd^3$) top weight also increased. This correlates with the findings of Schulte and Whitcomb (26) who reported that increasing the Osmocote rates resulted in higher plant quality of _Ilex cornuta_ 'Burford'.

Visual root grade after 16 weeks and root and top weight after 9.5 months showed a three way interaction between Osmocote, dolomite and Micromax (Tables VII, VIII, IX). With no Micromax or Osmocote added to the propagation medium, root grade was not affected by dolomite. However with either level of Osmocote and no Micromax visual root grade improved somewhat regardless of whether or not dolomite was present, except for the combination of the high rate of Osmocote and dolomite which greatly restricted rooting. The only significant increase other than with the high levels, resulted from the combination of the low level of Osmocote and low dolomite compared to low dolomite and no Osmocote (Table VII). On the other hand when Micromax was present in the rooting medium, the combination of the high rate of dolomite and Osmocote did not have the striking restriction on root visual grade as noted without Micromax. With Micromax in the rooting medium, the greatest restriction to root development was with high Osmocote and

TABLE VI

EFFECTS OF OSMOCOTE DURING PROPAGATION ON THE ROOT AND TOP WEIGHT OF JAPANESE BOXWOOD AT 9.5 MONTHS

| | Osmocote Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 1.78 | 3.56 | .05% |
| Root Weight (Grams) at 9.5 Months | 16.23$_c$[z] | 19.64$_b$ | 23.02$_a$ | 2.52 |
| Top Weight (Grams) at 9.5 Months | 17.80$_b$ | 20.33$_b$ | 24.25$_a$ | 2.94 |

[z]Means within a row followed by the same letter are not significantly different at the .05% level using a protected LSD test.

TABLE VII

INTERACTION OF OSMOCOTE, DOLOMITE AND MICROMAX ON THE VISUAL ROOT GRADE OF JAPANESE BOXWOOD AT 16 WEEKS

| | Dolomite Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 3.56 | 7.12 | .05% |
| Visual Root Grade[y] at 16 Weeks | | | | |
| | Micromax Level 0.0 kg/m$^3$ | | | |
| Osmocote Level 0.0 kg/m$^3$ | $3.78_{a1}$[z] | $3.12_{a1}$ | $3.72_{a12}$ | 2.04 |
| Osmocote Level 1.78 kg/m$^3$ | $4.15_{a1}$ | $5.53_{a1}$ | $5.25_{a1}$ | |
| Osmocote Level 3.56 kg/m$^3$ | $5.62_{a1}$ | $5.03_{a1}$ | $2.81_{b2}$ | |
| | Micromax Level 0.59 kg/m$^3$ | | | |
| Osmocote Level 0.0 kg/m$^3$ | $3.15_{a1}$[z] | $3.06_{a1}$ | $4.40_{a1}$ | |
| Osmocote Level 1.78 kg/m$^3$ | $3.25_{a1}$ | $2.50_{a1}$ | $3.03_{a1}$ | |
| Osmocote Level 3.56 kg/m$^3$ | $2.37_{b1}$ | $4.25_{a1}$ | $3.46_{ab1}$ | |

[z]Means within a row followed by the same letter or within a column followed by the same number are not significantly different at the .05% level using a protected LSD test.

[y]Based on a scale: 1 = poor; 10 = excellent. Based on the mean of four observations.

TABLE VIII

INTERACTION OF OSMOCOTE, DOLOMITE AND MICROMAX
ON THE ROOT WEIGHT OF JAPANESE BOXWOOD
AT 9.5 MONTHS

| | Dolomite Levels kg/$m^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 3.56 | 7.12 | .05% |
| Root Weight (Grams) at 9.5 Months | | | | |
| | Micromax Level 0.0 kg/$m^3$ | | | |
| Osmocote Level 0.0 kg/$m^3$ | $13.00_{b2}$ | $16.37_{ba2}$ | $20.75_{a1}$ | 6.17 |
| Osmocote Level 1.78 kg/$m^3$ | $23.37_{a1}$ | $23.87_{a1}$ | $14.38_{b2}$ | |
| Osmocote Level 3.56 kg/$m^3$ | $22.50_{a1}$ | $25.85_{a1}$ | $13.50_{b2}$ | |
| | Micromax Level 0.59 kg/$m^3$ | | | |
| Osmocote Level 0.0 kg/$m^3$ | $16.25_{ax}$ | $18.75_{a1}$ | $19.75_{a1}$ | |
| Osmocote Level 1.78 kg/$m^3$ | $22.75_{a1}$ | $21.25_{a1}$ | $20.25_{a1}$ | |
| Osmocote Level 3.56 kg/$m^3$ | $15.87_{b2}$ | $24.37_{a1}$ | $20.62_{a1}$ | |

[z]Means within a row followed by the same letter or within a column followed by the same number are not significantly different at the .05% level using a protected LSD test.

TABLE IX

INTERACTION OF OSMOCOTE, DOLOMITE AND MICROMAX ON THE TOP WEIGHT OF JAPANESE BOXWOOD AT 9.5 MONTHS

| | Dolomite Levels kg/m³ | | | LSD |
|---|---|---|---|---|
| | Ø.Ø | 3.56 | 7.12 | .Ø5% |
| Top Weight (Grams) at 9.5 Months | | | | |
| | Micromax Level Ø.Ø kg/m³ | | | |
| Osmocote Level Ø.Ø kg/m³ | $15.5Ø_{b2}$[z] | $18.37_{ab2}$ | $23.ØØ_{a1}$ | 7.21 |
| Osmocote Level 1.78 kg/m³ | $23.ØØ_{a1}$ | $25.87_{a1}$ | $15.37_{b2}$ | |
| Osmocote Level 3.56 kg/m³ | $23.25_{a1}$ | $29.5Ø_{a1}$ | $12.75_{b2}$ | |
| | Micromax Level Ø.59 kg/m³ | | | |
| Osmocote Level Ø.Ø kg/m³ | $18.87_{a1}$ | $19.62_{a1}$ | $19.62_{a1}$ | |
| Osmocote Level 1.78 kg/m³ | $22.62_{a1}$ | $24.12_{a1}$ | $2Ø.87_{a1}$ | |
| Osmocote Level 7.12 kg/m³ | $15.62_{b1}$ | $23.75_{a1}$ | $22.5Ø_{a1}$ | |

[z]Means within a row followed by the same letter or within a column followed by the same number are not significantly different at the .Ø5% level using a protected LSD test.

no dolomite. In general, root visual grade was lower when Micromax was present in the rooting medium. Generally the 3.56 $kg/m^3$ (6 lbs per $yd^3$) of Osmocote alone or with 3.56 $kg/m^3$ (6 lbs. per $yd^3$) of dolomite or 1.78 $kg/m^3$ (3 lbs. per $yd^3$) of Osmocote plus 3.56 $kg/m^3$ (6 lbs. per $yd^3$) or 7.12 $kg/m^3$ (12 lbs. per $yd^3$) of dolomite without Micromax provided the best visual root grade (Table VII).

Usually the three way interaction for root and top weight showed the same trend as the visual root grade following propagation. With the high level of dolomite in combination with either level of Osmocote and no Micromax being detrimental as well as high Osmocote and no dolomite and with Micromax (Tables VIII, IX). This plant response parallels the visual root grade of eight months earlier. Although it is difficult to understand at this point why these specific combination of nutrients during propagation would restrict plant growth, the effect is consistent and significant.

## *Juniperus sabina* 'Tamariscifolia'

The only significant treatment effects on visual root grade of tam juniper during propagation resulted from the use of dolomite. Dolomite at 3.56 or 7.12 $kg/m^3$ (6 or 12 lbs. per $yd^3$) improved the visual root grade compared to no dolomite (Table X). These results are in contrast with the study done by Diver and Whitcomb (5). They found dolomite to have a detrimental effect on the rooting of juniper

TABLE X

EFFECTS OF DOLOMITE DURING PROPAGATION ON THE VISUAL ROOT GRADE OF TAM JUNIPER AT 14 WEEKS

| | Dolomite Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 3.56 | 7.12 | .05% |
| Visual Root[y] Grade at 14 Weeks | $4.67_a$[z] | $5.62_b$ | $5.54_b$ | .67 |

[z]Means within a row followed by the same letter are not significantly different at the .05% level using a protected LSD test.

[y]Based on a scale: 1 = poor; 10 = excellent. Based on the mean of four observations.

cuttings. The only significant response of juniper after nine months, to nutrients added during propagation, was to Micromax. Junipers grown with no Micromax added during propagation had a greater root weight than plants with Micromax during propagation (Table XI). This should not be taken to mean that juniper does not require micronutrients for satisfactory growth. All plants in this study had micronutrients added to the medium for the production phase whereas the effect on growth was a result of micronutrients added during propagation.

## *Ilex crenata* 'Hetzi'

Throughout the entire production cycle, japanese holly lacked the accelerated growth generally observed in past studies. During the root weight termination, it was noted very few roots were present in the bottom of the containers. This may have been due to excessive watering during production, thus, reducing the oxygen supply to the root system. Also previous experiments (1980) were performed using aged pine bark, whereas fresh bark was the major component of this medium. The age and texture of pine bark can have a significant effect on plant growth and development (18).

After 16 weeks, Osmocote at the 3.56 kg/$m^3$ (6 lbs. per $yd^3$) rate caused visual root grade to be lower (Table XII). This was not surprising, since previous studies with Osmocote have shown little or no effect during propagation.

TABLE XI

EFFECTS OF MICROMAX DURING PROPAGATION ON THE ROOT WEIGHT OF TAM JUNIPER AT 9 MONTHS

| | Micromax Levels kg/m$^3$ | | LSD |
|---|---|---|---|
| | 0.0 | 3.56 | .05% |
| Root Weight (Grams) at 9 Months | $25.95_a$[z] | $24.0_b$ | 1.81 |

[z]Means within a row followed by the same letter are not significantly different at the .05% level using a protected LSD test.

TABLE XII

EFFECTS OF OSMOCOTE DURING PROPAGATION ON THE VISUAL ROOT GRADE OF HETZI HOLLY AT 16 WEEKS

| | Osmocote Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | Ø.Ø | 1.78 | 3.56 | .Ø5% |
| Visual Root[y] Grade at 16 Weeks | $5.8Ø_a$[z] | $5.34_{ab}$ | $4.76_b$ | Ø.77 |

[z]Means within a row followed by the same letter are not significantly different at the .Ø5% level using a protected LSD test.

[y]Based on a scale: 1 = poor; 1Ø = excellent. Based on the mean of four observations.

However the influence of its effect from propagation on subsequent growth has been of immense value to plant growth and development (2, 9, 36).

Adding dolomite during propagation impaired visual root grade at 10 weeks, top weight, root weight and visual grade at 9 months and branch count at 6.5 months (Table XIII). This supports past findings that dolomite is detrimental when used during propagation (5).

The combination of Osmocote at 3.56 $kg/m^3$ (6 lbs. per $yd^3$) and Micromax at 0.59 $kg/m^3$ (1 lbs. per $yd^3$) during propagation produced greater root weights after nine months than either nutrient source independently (Table XIV). In general, with Micromax present, root weight increased as Osmocote level increased. However, in the absence of Micromax root weight was slightly less as Osmocote increased. This supports data by others (3, 26) that suggest both micronutrients and macronutrients influence plant growth best when used together during propagation as opposed to using either alone. In the presence of Micromax during propagation the high level of Osmocote produced holly plants with greater top weights than either Osmocote or micronutrient levels alone, however the best nutrient combination was not different from no Osmocote or Micromax during propagation (Table XV).

Number of branches after 6.5 months was generally higher without the addition of Osmocote when Micromax was not added to the propagation medium. However, the best

TABLE XIII

EFFECTS OF DOLOMITE DURING PROPAGATION ON THE GROWTH AND DEVELOPMENT OF HETZI HOLLY

| | Dolomite Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 3.56 | 7.12 | .05% |
| Visual Root[y] Grade at 10 Weeks | $6.96_a$[z] | $4.83_b$ | $4.10_b$ | 0.77 |
| Branches at 6.5 Months | $10.85_a$ | $10.10_a$ | $8.23_b$ | 1.67 |
| Top Weight (Grams) at 9 Months | $38.85_a$ | $29.75_b$ | $23.90_c$ | 4.65 |
| Root Weight (Grams) at 9 Months | $40.62_a$ | $32.95_b$ | $28.40_b$ | 6.12 |
| Visual Grade[x] at 9 Months | $5.56_a$ | $5.43_a$ | $4.46_b$ | 0.63 |

[z]Means within a row followed by the same letter are not significantly different at the .05% level using a protected LSD test.

[x]Based on a scale: 1 = poor; 10 = excellent. Based on the mean of three observations.

[y]Based on a scale: 1 = poor; 10 = excellent. Based on the mean of four observations.

TABLE XIV

INTERACTION OF OSMOCOTE AND MICROMAX DURING PROPAGATION ON THE ROOT WEIGHT OF HETZI HOLLY AT 9 MONTHS

| | Osmocote Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 1.78 | 3.56 | .05% |
| Root Weight (Grams) at 9 Months | | | | |
| Micromax Level 0.0kg/m$^3$ | $37.87_{a1}$[z] | $32.42_{a1}$ | $32.67_{a1}$ | 8.66 |
| Micromax Level 0.59 kg/m$^3$ | $26.10_{b2}$ | $32.83_{b1}$ | $42.10_{a1}$ | |

[z]Means within a row followed by the same letter or within a column followed by the same number are not significantly different at the .05% level using a protected LSD test.

TABLE XV

INTERACTION OF OSMOCOTE AND MICROMAX DURING PROPAGATION ON THE TOP WEIGHT OF HETZI HOLLY AT 9.5 MONTHS

| | Osmocote Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 1.78 | 3.56 | .05% |
| Top Weight (Grams) at 9.5 Months | | | | |
| Micromax Level 0.0 kg/m$^3$ | $34.17_{a1}$ [z] | $22.54_{b1}$ | $27.33_{b1}$ | 6.58 |
| Micromax Level 0.59 kg/m$^3$ | $23.96_{b2}$ | $25.62_{b1}$ | $35.37_{a1}$ | |

[z]Means within a row followed by the same letter or within a column followed by the same number are not significantly different at the .05% level using a protected LSD test.

treatment combination resulted using the highest Osmocote level with Ø.59 kg/$m^3$ (1 lb per $yd^3$) of Micromax (Table XVI). Again after 9.5 months visual plant grade was significantly better without the addition of Micromax at the Ø.Ø kg/$m^3$ Osmocote level. But, the combination of Ø.59 kg/$m^3$ (1 lb per $yd^3$) Micromax and 3.56 kg/$m^3$ (6 lbs per $yd^3$) Osmocote was equal to it (Table XVII).

An interaction between dolomite and Micromax influenced visual grade after 9.5 months. The addition of Ø.59 kg/$m^3$ (1 lb per $yd^3$) of Micromax with 3.56 kg/$m^3$ (3 lbs per $yd^3$) of dolomite restricted visual grade (Table XVIII). However, with no Micromax and the 7.12 kg/$m^3$ (12 lbs per $yd^3$) of dolomite a significant decrease occurred compared to the 3.56 kg/$m^3$ (3 lbs per $yd^3$) rate and no Micromax. No significant difference resulted from adding Micromax in the absence of dolomite (Table XVIII).

The same interaction between Micromax and dolomite generally occurred when the branch count was taken 6.5 months into production. The most interesting aspect of this interaction is the similiar plant response with Micromax and no dolomite or dolomite at 3.56 kg/$m^3$ (6 lbs. per $yd^3$) and no Micromax (Table XIX). Further increases in dolomite with or without Micromax restricted branch count. This suggests that the addition of either product at lower rates may prove beneficial or that some, as yet unknown, factor is influencing plant growth.

Interaction between Osmocote and dolomite influenced

TABLE XVI

INTERACTION OF OSMOCOTE AND MICROMAX DURING PROPAGATION ON THE BRANCH COUNT OF HETZI HOLLY AT 6.5 MONTHS

| | Osmocote Levels kg/$m^3$ 0.0 | 1.78 | 3.56 | LSD .05% |
|---|---|---|---|---|
| Branches at 6.5 Months | | | | |
| Micromax Level 0.0 kg/$m^3$ | $10.16_{a1}$ [z] | $9.46_{a1}$ | $9.00_{a2}$ | 2.37 |
| Micromax Level 0.59 kg/$m^3$ | $7.50_{c2}$ | $9.92_{b1}$ | $12.33_{a1}$ | |

[z]Means within a row followed by the same letter or within a column followed by the same number are not significantly different at the .05% level using a protected LSD test.

TABLE XVII

INTERACTION OF OSMOCOTE AND MICROMAX DURING PROPAGATION ON THE VISUAL GRADE OF HETZI HOLLY AT 9.5 MONTHS

| | Osmocote Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | Ø.Ø | 1.78 | 3.56 | .Ø5% |
| Visual Grade of Shoots[x] at 9.5 Months | | | | |
| Micromax Level Ø.Ø kg/m$^3$ | 5.79$_{a1}$[z] | 5.Ø8$_{a1}$ | 5.Ø8$_{a1}$ | Ø.89 |
| Micromax Level Ø.59 kg/m$^3$ | 4.42$_{b2}$ | 4.92$_{ab1}$ | 5.62$_{a1}$ | |

[z]Means within a row followed by the same letter or within a column followed by the same number are not significantly different at the Ø.Ø5% level using a protected LSD test.

[x]Based on a scale: 1 = poor; 1Ø = excellent. Based on the mean of three observations.

TABLE XVIII

INTERACTION OF MICROMAX AND DOLOMITE DURING PROPAGATION ON THE VISUAL GRADE OF HETZI HOLLY AT 9.5 MONTHS

| | Dolomite Levels kg/m³ | | | LSD |
| --- | --- | --- | --- | --- |
| | 0.0 | 3.56 | 7.12 | .05% |
| Visual Grade of Shoots[x] at 9.5 Months | | | | |
| Micromax Level 0.0 kg/m³ | $5.62_{a1}$[z] | $6.12_{a1}$ | $4.21_{b1}$ | 0.89 |
| Micromax Level 0.59 kg/m³ | $5.50_{a1}$ | $4.75_{a2}$ | $4.70_{a1}$ | |

[z]Means within a row followed by the same letter or within a column follwed by the same number are not significantly different at the .05% level using a protected LSD test.

TABLE XIX

INTERACTION OF MICROMAX AND OSMOCOTE DURING PROPAGATION ON THE BRANCH COUNT OF HETZI HOLLY AT 6.5 MONTHS

| | Dolomite Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 3.56 | 7.12 | .05% |
| Branches at 6.5 Months | | | | |
| Micromax Level 0.0 kg/$^3$ | $10.20_{a1}$[z] | $11.50_{a1}$ | $6.91_{b2}$ | 2.37 |
| Micromax Level 0.59 kg/m$^3$ | $11.50_{a1}$ | $8.71_{b2}$ | $9.54_{b1}$ | |

[z]Means within a row followed by the same letter or within a column followed by the same number are not significantly different at the .05% level using a protected LSD test.

visual grade after 9.5 months. As the rate of Osmocote increased in the absence of dolomite visual grade increased (Table XX). The addition of either 1.78 or 3.56 $kg/m^3$ (3 or 6 lbs. per $yd^3$) of Osmocote restricted visual grade when interacting with 3.56 or 7.12 $kg/m^3$ (6 or 12 lbs. per $yd^3$) of dolomite. The addition of Osmocote increased the number of branches at 6.5 months without the incorporation of dolomite into the propagation medium. Fewer branches developed at the high rate of dolomite with or without Osmocote. The addition of 3.56 $kg/m^3$ (6 lbs. per $yd^3$) of dolomite increased the number of branches when no Osmocote was incorporated into the propagation medium (Table XXI). By increasing dolomite to 3.56 or 7.12 $kg/m^3$ (6 or 12 lbs. per $yd^3$) there was a significant restriction in root weight at the two highest Osmocote levels as compared to no Osmocote and dolomite. Again, the best treatment combination occurred at the high Osmocote level without dolomite (Table XXII).

A similar interaction occurred on top weight after nine months. However, in this case adding dolomite at both Osmocote levels restricted top weight. Plants grown with 3.55 $kg/m^3$ (6 lbs. per $yd^3$) of Osmocote during propagation were larger than all others except the 1.78 $kg/m^3$ (3 lbs. per $yd^3$) rate of Osmocote (Table XXIII).

TABLE XX

INTERACTION OF OSMOCOTE AND DOLOMITE DURING PROPAGATION ON THE VISUAL GRADE OF HETZI HOLLY AT 9.5 MONTHS

| | Dolomite Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 3.56 | 7.12 | .05% |
| Visual Grade of Shoots[x] at 9.5 Months | | | | |
| Osmocote Level 0.0 kg/m$^3$ | $4.68_{b2}$[z] | $6.44_{a1}$ | $4.18_{b1}$ | 1.09 |
| Osmocote Level 1.78 kg/m$^3$ | $5.68_{a12}$ | $4.93_{ab2}$ | $4.37_{b1}$ | |
| Osmocote Level 3.56 kg/m$^3$ | $6.31_{a1}$ | $4.93_{b2}$ | $4.81_{b1}$ | |

[z]Means within a row follwed by the same letter or within a column followed by the same number are not significantly different at the .05% level using a protected LSD test.

[x]Based on a scale: 1 = poor; 10 = excellent. Based on the mean of three observations.

TABLE XXI

INTERACTION OF OSMOCOTE AND DOLOMITE DURING PROPAGATION ON THE BRANCH COUNT OF HETZI HOLLY AT 6.5 MONTHS

| | Dolomite Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 3.56 | 7.12 | .05% |
| Branches at 6.5 Months | | | | |
| Osmocote Level 0.0 kg/m$^3$ | $7.81_{b2}$[z] | $11.62_{a1}$ | $7.06_{b1}$ | 2.90 |
| Osmocote Level 1.78 kg/m$^3$ | $10.68_{a2}$ | $9.44_{a1}$ | $8.93_{a1}$ | |
| Osmocote Level 3.56 kg/m$^3$ | $14.06_{a1}$ | $9.25_{b1}$ | $8.68_{b1}$ | |

[z]Means within a row followed by the same number or within a column followed by the same number are not significantly different at the .05% level using a protected LSD test.

TABLE XXII

INTERACTION OF OSMOCOTE AND DOLOMITE DURING PROPAGATION ON THE ROOT WEIGHT OF HETZI HOLLY AT 9 MONTHS

| | Dolomite Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 3.56 | 7.12 | .05% |
| Root Weight at 9 Months | | | | |
| Osmocote Level 0.0 kg/m$^3$ | $30.44_{ab2}$ [z] | $40.68_{a1}$ | $24.81_{b1}$ | 1.09 |
| Osmocote Level 1.78 kg/m$^3$ | $42.44_{a1}$ | $27.00_{b2}$ | $28.44_{b1}$ | |
| Osmocote Level 3.56 kg/m$^3$ | $49.00_{a1}$ | $31.18_{b12}$ | $31.94_{b1}$ | |

[z]Means within a row followed by the same letter or within a column followed by the same number are not significantly different at the .05% level using a protected LSD test.

TABLE XXIII

INTERACTION OF OSMOCOTE AND DOLOMITE DURING PROPAGATION ON THE TOP WEIGHT OF HETZI HOLLY AT 9 MONTHS

| | Dolomite Levels kg/m$^3$ | | | LSD |
|---|---|---|---|---|
| | 0.0 | 3.56 | 7.12 | .05% |
| Top Weight at 9 Months | | | | |
| Osmocote Level 0.0 kg/m$^3$ | $27.12_{a2}$ [z] | $25.67_{a1}$ | $21.56_{a1}$ | 8.06 |
| Osmocote Level 1.78 kg/m$^3$ | $34.25_{a12}$ | $22.50_{b1}$ | $24.50_{b1}$ | |
| Osmocote Level 3.56 kg/m$^3$ | $40.18_{a1}$ | $28.25_{b1}$ | $25.62_{b1}$ | |

[z]Means within a row followed by the same letter or within a column followed by the same number are not significantly different at the .05% level using a protected LSD test.

Plants grown with additional phosphorus in the large containers of the production phase responded similiarly in all growth parameters measured and are therefore not presented.

CHAPTER V

# SUMMARY AND CONCLUSIONS

The objective of this study was to evaluate the effects of Osmocote 18-6-12, dolomite and Micromax micronutrients on the rooting during the propagation phase and on the subsequent growth of Japanese holly, Japanese boxwood, tam juniper and mojave pyracantha.

A total of 2,304 cuttings were evaluated during propagation, but only 1,728 were carried through the production phase of growth.

There were numerous interactions with all nutrients on pyracantha, boxwood and holly. Plant response of juniper was affected only by Micromax and dolomite acting alone.

Osmocote 18-6-12 during propagation generally had a positive influence on subsequent plant growth. In most cases dolomite restricted subsequent plant growth, especially when used at the high level (12.12 $kg/m^3$ or 12 lbs. per $yd^3$). Micromax alone was generally detrimental to plant growth, however when interacting with Osmocote it had a positive effect on growth in some cases. These data indicate Osmocote may be even more beneficial if increased to 4.74 to 5.95 $kg/m^3$ (8 to 10 lbs. per $yd^3$). Dolomite, if used, should not exceed 3.56 $kg/m^3$ (6 lbs per $yd^3$).

Micromax should be maintained at its present level of Ø.59 kg/$m^3$ (1 lb per $yd^3$) or even reduced.

## LITERATURE CITED


1. Barron, Hollis M. 1974. The use of slow release fertilizers for ornamental crops. Proc. Int. Pl. Prop. Soc. 24:221-229.

2. Carney, M. and C. E. Whitcomb. 1981. Effects of slow release sources of nitrogen and potassium on the propagation and subsequent growth of *Ilex crenata* 'Hetzi', *Pyracantha coccinea wateri* and Rhododendron X 'Fashion'. Ok. Agri. Exp. Sta. Res. Rep. P-818, 19-20.

3. Coorts, Gerald. 1969. The effect of minor element deficiency on rooting of woody ornamentals The Plant Prop. 15(3):15-16.

4. Davidson, H. and R. Mecklenburg. 1981. Nursery Management. Prentice Hall Inc. Englewood Cliff, N. J. pp. 1-437.

5. Diver, S. and C. E. Whitcomb. 1981. The effects of dolomite, Micromax, and propagation media on the rooting and subsequent growth of *Pyracantha coccinea* and *Juniperus procumbens*. Ok. Agr. Exp. Sta. Res. Rep. P-818, 21-22.

6. Eldstradt, Milbocker. 1975. Root development as affected by particle size in container media. Proc. S. Nur. Assoc. Res. Conf. 20:36.

7. Glenn, R. C. Hogan and C. E. Whitcomb. 1975. Effects of Osmocote in the rooting medium and auxin levels in rooting and subsequent growth of cuttings. Ok. Agr. Exp. Sta. Res. Rep. P-724, 43-45

8. Good, G. L. and H. B. Tukey, Jr. 1973. Leaching of nutrients from cuttings under mist. Int. Pl. Prop. Soc. Proc. 23:138-141.

9. Govin, Francis. 1974. Osmocote in the propagation house. Int. Pl. Prop. Soc. Proc. 24:337-241.

10. Hall, G. C. and C. E. Whitcomb. 1975. Plant water loss as influenced by antitranspirants. Proc of S.N.A. Research Conf. pp. 50-51.

11. Hartmann, H. T. and D. E. Kester. 1975. Plant Propaation: Principles and Practices. 3rd ed. Englewood Cliffs, N. J. Prentice Hall. pp. 1-647.

12. Havis, J. R. and W. N. Hamilton. 1976. Physical properties of container media. Jour. of Arb. 2(7):139-140.

13. Henderson, Susan. 1981. The effect of rate and time of application of three micronutrient products during production of woody and herbaceous species. M.S. thesis, Oklahoma State University. Stillwater, Oklahoma.

14. Hess, C. E. 1963. Why certain cuttings are hard to root. Int. Pl. Prop. Soc. Proc. 13:63-70.

15. Johnson, Charles R. and D. F. Hamilton. 1977. Effects of media and controlled release fertilizers on rooting and leaf nutrient composition of Juniperus conferta and Ligustrum japonicum cuttings. J. Amer. Soc. Hort. Sci. 102:32-322.

16. Johnson, Charles R. and James T. Midcap. 1979. How to handle woody stem cuttings. Am. Nurs. 11:9-11.

17. Kelly, James D. 1959. Fertilizer studies with container grown nursery stock. Amer. Nurs. 109(10):12-14, 79-84.

18. Laiche, A. J. 1973. Old bark versus new fresh bark growing media studies. S.N.A. Res. Rep. 18:6-7.

19. Lamphear, F. O. and R. P. Meahl. 1963. Influence of endogenous rooting cofactors and environment on the seasonal fluctuations in root initiation of selected evergreen cuttings. Proc. Amer. Soc. Hort. Sci. 83:811-818.

20. Maire, Richard G. 1970. The role of plant nutrition. Int. Pl. Prop. Soc. Proc. 20:164-167.

21. Maynard, D. N. and O. A. Lorenz. 1979. Controlled release fertilizers for horticultural crops. Horticulture Reviews 1:81-98.

22. McGuire and Bunch. 1970. The use of slow-release fertilizers in a propagation medium. The Plant Prop. 16(2):10-14.

23. Pokorny, F. A. 1975. A physical characterization of pine bark used in six commercial nurseries. S.N.A. Res. Rep. 20:25-27.

24. Pridham, M. S. 1942. Factors in rooting cuttings and the growth of young plants. J. Amer. Soc. Hort. Sci. 40:579-582.

25. Rauch, Fred D. 1972. Influence of rooting medium on rooting cuttings of easy-to-root plants. The Pl. Prop. 18(2):4-7.

26. Schulte and Whitcomb. 1973. Effects of slow release fertilizer in the rooting medium on rooting of cuttings and subsequent growth response. Ok. Ag. Exp. Sta. Res. Rep. P-691, 28-31.

27. Sorenson and Coorts. 1968. The effect of nutrient mist on propagation of selected woody ornamental plants. J. Amer. Soc. Hort. Sci. 92:696-703.

28. Stoutemyer, V. T. 1969. Hardwood Cuttings. The Pl. Prop. 15(3):10-14.

29. Tukey, H. B. 1958. Loss of nutrients by foliar leaching as determined by radioisotopes. Amer. Soc. Hort. Sci. 71:496-50.

30. Van Doren, David. Determination of air filled pore space for container-grown nursery stock. Int. Pl. Prop. Soc. Proc. 23:232-233.

31. Ward, J. D. and C. E. Whitcomb. 1979. Nutrition of Japanese holly during propagation and production. J. Amer. Soc. Hort. Sci. 104:523-526.

32. Waxman, S. and J. P. Nitsch. 1956. Influences of light on plant growth. Amer. Nurs. 104(10):11-12.

33. Wheeldon, Thomas. 1959. Propagating holly under mist. Amer. Nurs. 110(10):32, 33, 36, 41, 42, 44, 46.

34. Whitcomb, C. E. 1980. The carryover effect of micronutrients in container production and more. Ok. Ag. Exp. Sta. Res. Rep. P-803.

35. Whitcomb, C. E. 1979. Understanding the container system. Ok. Ag. Exp. Sta. Res. Rep. P-791.

36. Whitcomb, Gibson, Storjohann. 1977. Effects of Osmocote use in rooting media. Ok. Ag. Exp. Sta. Res. Rep. P-760, 54-56.

37. Whitcomb, C. E. Personal communication. February, 1982. Oklahoma State University, Stillwater, Oklahoma.

VITA

Charles Larry Nichols

Candidate for the Degree of

Master of Science

Thesis: EFFECTS OF OSMOCOTE, DOLOMITE AND MICROMAX DURING PROPAGATION ON THE SUBSEQUENT GROWTH OF FOUR ORNAMENTAL SPECIES

Major Field: Horticulture

Biographical:

Personal Data: Born in Holdenville, Oklahoma, December 19, 1955.

Education: Graduated from Wetumka High School, Wetumka, Oklahoma, in May, 1972; received Bachelor of Science in Agriculture from Oklahoma State University in 1977; completed requirements for the Master of Science degree at Oklahoma State University in July, 1982.

Professional Experience: Inspected structural foundations on major construction sites for Standard Testing and Engineering; Plant Breeding technician at Oklahoma State University; Research assistant in Nursery Production at Oklahoma State University.