EFFECTS OF GROWING MEDIUM AND SLOW-
RELEASE FERTILIZER ON DEVELOPMENT
OF *PHILODENDRON HASTATUM* HORT.
POT PLANTS GROWN WITH
CAPILLARY MAT
WATERING

By

STEVEN WYLIE GEORGE

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1970

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
May, 1980

Thesis
1980
G349e
cop. 2

OKLAHOMA STATE
UNIVERSITY
LIBRARY

EFFECTS OF GROWING MEDIUM AND SLOW-

RELEASE FERTILIZER ON DEVELOPMENT

OF <u>PHILODENDRON</u> <u>HASTATUM</u> HORT.

POT PLANTS GROWN WITH

CAPILLARY MAT

WATERING

Thesis Approved:

R. N. Payne
Thesis Adviser

[illegible]

Robert M. Reed

Norman N Durham
Dean of the Graduate College

1057835

ACKNOWLEDGMENTS

I would like to express my sincere appreciation to Dr. Richard Payne, my major professor, for his guidance, instruction and true friendship offered so freely throughout both my research efforts and graduate studies. I would also like to thank Dr. Robert Reed, Dr. C. E. Whitcomb, Dr. Grant Vest, and Dr. R. W. McNew, for their advice and counsel during the preparation of this thesis.

Special gratitude is extended to Mr. Paul Mitchell who, in addition to serving as a member of my graduate committee, has also been teacher, confidant, and friend throughout my years in horticultural study. His patience and kindness during our many "extended" office visits have been a vital source of education and inspiration for me.

I am deeply indebted to Mr. H. C. Macklin, greenhouse superintendent, and Mr. Charles Steel, assistant greenhouse superintendent, for their cooperation, advice, and expertise provided so willingly throughout this research study.

Lastly, my greatest love and appreciation goes to my wife Brenda whose encouragement, undying faith, and many hours of hard work made this thesis and my graduate program a reality. I wish to dedicate this study to her and to Barry, whose love and loyalty sustained me through many a troubled time.

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

LIST OF FIGURES

Figure | Page

Figure | Page

CHAPTER I

INTRODUCTION AND REVIEW OF LITERATURE

Background

The increasing concern about environmental quality beginning in the mid 1960's triggered a tremendous resurgence in the popularity of indoor plants. New and creative methods of indoor display, such as terrariums and hanging baskets, were devised. Sales of larger potted materials increased due, in part, to new building construction which was designed to utilize plants in large groupings or as single specimens to soften architectural lines and separate work areas (43).

Foliage plants are particularly well-suited to this increased indoor use because they perform well with minimum care and unlike flowering house plants, many of which require high light intensities and cool night temperatures to bloom, they tolerate the low light, low humidity, and high temperature conditions common to so many indoor environments (2, 12, 15).

The genus Philodendron in particular became exceedingly popular during the "houseplant boom" and is now undoubtedly our most important decorative tropical plant group (2). The name Philodendron, which was derived from phileo - to love, and dendron - a tree, referred to their tree-climbing habit. Philodendrons, members of the family Araceae, are evergreen inhabitants of tropical American forests, often characterized by long aerial roots and thick, handsome leaves (15).

From the more than 200 species of philodendron, thousands of hybrids have been developed providing a great range of leaf sizes and shapes as well as variations in basic plant form (12). Two general growth forms exist--climbing or vining and non-vining or self-heading (15). Most climbing types used in interior landscapes are trained against slabs of bark-covered wood for support (12).

Philodendron hastatum Hort., chosen as the plant species for this study, is a climbing type from Brazil with bright green, arrow-shaped leaves and is one of the most popular philodendrons. Since this study was initiated, the botanical name of this plant has been changed to *Philodendron domesticum* Bunt. in *Hortus Third* as edited and revised by the staff of the Liberty Hyde Bailey Hortorium in 1976. *P. hastatum variegatum* is similar except its leaves are beautifully variegated with white (15). *P. hastatum*, commonly known as arrowhead philodendron, can be propagated from seed, tip cuttings or stem cuttings. When grown from single-eye cuttings, it can be used in dish gardens and small planters while the mature forms are excellent for training on totem poles (2, 8). Ball et al. (2) stated that arrowhead philodendron was very salable in small sizes while Conover and Poole (11) included it in their list of most profitable foliage species for production in the northern United States.

In the past, a great many foliage plants were field-grown in tropical areas of Florida and the Caribbean, then shipped to northern outlets for sale. With demand for foliage plants exceeding supplies, and in the face of rising transportation costs, many growers in the temperate climates began to convert a portion of their holdings to foliage production (11). In order to compete successfully, these growers had to choose those genera which would yield a profit, reduce unnecessary labor and increase production efficiency.

When analyzing production costs, one fact looms large--labor is the greatest single expense, almost double that of marketing, its nearest competitor. Grimmer (17) found that labor costs, including benefits, account for 34.8 percent of the total of all greenhouse production costs, with many growers expending as much as 50 percent for labor if they are not mechanized, and if their volume is low.

Mechanization is important because it can reduce production costs and make the growing operation more efficient, more profitable and less dependent on the dwindling supply of skilled labor (2). One area very critical to quality plant production and one greatly in need of added efficiency is that of plant watering.

Development of Capillary Irrigation

Water is tremendously important in plant growth. It acts as a major component of physiologically active tissue, a reactant in photosynthesis and in hydrolytic processes such as starch digestion, and as a solvent in which salts, sugars and other solutes move within plant tissue. Water also plays an essential role in the maintenance of turgidity which is necessary for cell enlargement and growth (28).

Traditionally, greenhouse crops have been watered by hand through the use of rather cumbersome hoses. While this method can produce very salable plants, it is plagued by several less than desirable characteristics. Most importantly, it requires an exorbitant amount of labor. Furthermore, the personnel doing the watering must possess both judgment and experience if the crop is to be grown successfully. Such personnel are difficult to find and costly to employ. Hose watering can also dislodge small containers, encourage foliar diseases by wetting the leaves, hinder root growth through compaction of the growing medium, and spread various water-borne diseases if strict sanitation procedures are not practiced (42, 44, 50).

Because of the expense and production problems associated with hose watering, various methods of mechanized or automatic irrigation have been devised.

During the early 1940's, Post and Seeley (49) and others, experimented with various methods of subirrigation to meet the wartime demand for labor-saving devices. In 1948, Seeley (44) developed an automatic irrigation system for use in pot plant production which centered around the capillary movement of water through the soil. In this system, pots were placed on or plunged into a layer of sand located in a water tight bench with a constant water level one inch below the pots. Water moved from the sand through the walls of the pot and into the soil by capillary action. While this method had many advantages and was commonly used in some areas, its need for accurately level benches with waterproof bottoms and sides, plus the considerable weight of the sand-water layer and the requirement that pots be set to a reasonably uniform depth in the sand, hindered its widespread adoption (3, 50).

Two new developments in the mid 1960's rekindled interest in capillary irrigation. First was the ready availability of polyethylene film to be used as a waterproof bench covering and the second was the introduction of fiber mats as a replacement for sand in the capillary system. Now growers had only to spread a sheet of polyethylene film over a reasonably level bench and cover it with capillary matting, which was light in weight and easily trimmed to shape. Small diameter watering tubes (Chapin or spaghetti-type), or perforated soaking tubes could be used with automatic time controls to moisten the mats (25).

The effective life of the mats varied from 6 to 12 months for the woven fiber products to as long as three years for those composed of petro chemicals (3).

This new system became extremely popular in Europe where much of the floral production was in smaller size containers (equivalent to 3, 4, and 5 inch) and individual water tubes to each pot were not practical (25).

There were several advantages to this new form of capillary irrigation:

1. Labor reduction: once system is in operation, there is virtually labor-free watering. Plus the most knowledgeable personnel had only to adjust the amount of water being applied to the mats once, which freed them for other duties.
2. Ease of management: Poole and Conover (38) felt that mat irrigation would substantially reduce the judgment required in irrigation management as the plant could now partially regulate its own water supply.
3. Size flexibility: containers of various sizes and configurations, from small plastic flats to large clay pots, could be grown on the same bench with the same irrigation setting.
4. Placement flexibility: pots could be moved, respaced, and sorted for orders with ease, without worry of watering tubes being dislodged.
5. Suitability for small containers: individual water tubes to smaller pots simply aren't practical due to excessive setup

time. Millions of two and one-half inch (6.35 centimeter) pot mums are grown in Denmark on mats with excellent results (3). No more small pots being dislodged as during hand watering.

6. Avoidance of cultural problems: disease possibilities were reduced since foliage is not wetted, plus disease is not spread by contaminated water hoses. Soil compaction is reduced for better root growth.

7. Increased fertilizer efficiency: Ball et al. (30) found that only small quantities of slow-release fertilizer were required when capillary mats were used. Fertilizer runoff and pollution would have been negligible.

8. Water conservation: Wilfret and Green (55) reported that the total water usage of the capillary system was only one-third that of overhead watering.

With such an impressive list of attributes, many researchers began more extensive investigations into the use of capillary or subirrigation mats. After a comprehensive test using poinsettias, Larson and Hilliard (30) could detect no important difference in plants grown with capillary mats, spaghetti tubes, or hand watering. They also grew pot mums, lilies, azaleas, and cinerarias on the same mat-irrigated bench with excellent results. No root-rot problems were encountered even with such a susceptible crop as poinsettia. Kiplinger et al. (25) have grown lilies, poinsettias, and pot mums on subirrigation mats. While the lilies grew taller than desired due to lack of water stress, they found no essential difference between pot mums and poinsettias grown on mats as compared to those watered overhead. They too encountered no root disease problems despite wetness of the medium and attributed this to the aeration provided by the non-capillary pores in a well-prepared medium. Hanning (3) found that Reiger begonias on mats produced significantly more growth than with spaghetti-tube irrigation. Research by Koths and Judd (27) indicated that mat-irrigated poinsettias and Reiger begonias exhibited enhanced root activity in comparison to similar plants watered from overhead. Furthermore, subirrigated Easter lilies were found to have a lower incidence of root disease than did their conventionally watered counterparts.

Lastly, experimentation by Poole and Conover (38) indicated that foliage plants, such as Nephrolepis exaltata 'Florida Ruffle' and Aphelandra squarrosa 'Dania', could be produced with a high level of quality and only a minimum of labor when capillary mats were utilized.

Two concerns involving capillary matting were discussed in the literature. First, while unsightly, the algal growth on mats, which was accelerated when liquid fertilizers were applied to the mat surfaces, did not seem to interfere with capillary water movement into containers. Such algal accumulations would, however, have to be removed by washing or scraping prior to the start of a second crop. Secondly, no problems with accumulations of soluble salts were encountered, but periodic leaching of long-term crops by overhead irrigation would alleviate such a condition if it did occur (25, 30).

Composition of Growing Media as Related to Plant Growth and Quality

The purpose of any growing medium is to provide physical support for plants and to act as a reservoir for ozygen, water and nutrients (26).

How well a given medium fulfills these requirements determines its suitability for use in containers.

Of all the various factors involved in the creation of an effective container growing medium, perhaps none is more important than media aeration or percent air space. Paul and Lee (34) determined that where frequent irrigations are desirable, container plants should be grown in well-aerated media to insure healthy roots and attractive top growth. Ball et al. (2) reported that regardless of medium composition, it must not pack and must provide adequate soil aeration. They also contended that many foliage plant problems in both home and greenhouse environments were directly attributable to poorly-drained growing media and that it was better to err on the side of a medium which was too loose rather than one which was too compact. Research by Elstrodt and Milbocker (14) indicated that tomato root development in media composed of large particles (i.e. well-aerated) was superior to that in media composed of very small particles (i.e. poorly aerated). Several researchers have suggested that air-filled porosity levels in the 10 to 15 percent range resulted in excellent plant growth (32, 34).

According to findings published by Stephens and Volz (49), adequate aeration, brought about in large part by the presence of macropores between the larger media particles, was particularly important under subirrigation conditions as the micropores or capillary pores were normally clogged with water in this system and could provide little aeration.

Besides aeration and water and nutrient holding capacity, several other factors, such as uniformity, light weight, ability to conduct moisture through capillary action, freedom from diseases, insects and weed seeds, sterilization requirements, freedom from herbicide contamination, availability, cost, etc. can influence media composition. Self (45) reported that while pine shavings had several qualities desired in an azalea mix, they did require additional amounts of nitrogen to insure proper plant nutrition. Percent air space in a medium containing large quantities of pine shavings can be reduced drastically in four to six months due to rapid decomposition of the shaving material. Henley (20) stated that members of the Cordyline and Dracaena genera were very sensitive to fluoride levels and suggested that media components high in fluorides, such as perlite and German peat, not be utilized in the growth of these plants. Lindstrom (31) contended that transportation cost was such an important expense in azalea production that many greenhouse growers were reluctant to buy azaleas grown in sand due to the high freight charges. Further study by Lindstrom indicated it was possible to eliminate or substantially reduce the use of peat moss in azalea media and that when the cost of foreign peat moss was considered, the use of locally obtained organic amendments should be considered.

While countless individuals have worked for years to determine the single medium best suited to container production of foliage plants, both research findings and grower experiences have clearly indicated that many different media can produce excellent foliage plants. A good medium for a particular grower must satisfy the requirements of his specific growing system and of the crop being produced (36, 40). Researchers at Cornell University have recommended a 1:1 mixture of sphagnum peat moss and vermiculite while Poole and Waters have found peat:perlite or vermiculite:shavings an excellent light-weight mix (40). Ball et al. (2) maintained that a very loose, well-drained, sterile medium was a must for the production of quality foliage plants and had excellent results with a 1:1 mix of sphagnum peat and horticultural-grade perlite. They also found many good media combinations that were variations of a soil, sand, peat formula. Conover and Poole (11) suggested that foliage plants grew best in mixtures containing 50 percent or more organic components and recommended a 2:1:1 peat, sand, pine bark or perlite, or a 2:1 peat, pine bark or cypress shavings mixture.

Growing media for use with capillary mats must be tailored specifically for this unique watering system to insure maximum plant growth and quality. Optimum levels of water-free air space, created by the presence of macropores, were vital since the micropores were usually filled with capillary water and thus unable to supply needed aeration (49). Kiplinger et al. (25) found an absence of disease problems on capillary mats and attributed this result to the large numbers of air-filled non-capillary pores in a well-prepared medium. Ball et al. (3) cautioned against the use of straight soil on mats as it became muddy and lacked all-important aeration. Several researchers found that peat-lite mixes performed very well with mat irrigation while Cornell recommended 3 peat:1 soil:1 perlite and Virginia 65 percent peat, 25 percent perlite, 10 percent loam for this use. Pierce (35) emphasized the need for careful attention to growing medium for use with mat watering and suggested 1 peat: 1 perlite, bark or vermiculite for best results. Tests done on capillary mats at Ohio State (5) involving pot mums in a 2:1:1 (soil, peat, perlite) soil mix and in a commercial peat-lite mix, produced much larger flowers and heavier plants in the peat-lite medium. Ball et al. (30) reported equal plant growth in a 3:1 (bark, sand) or a 2:1:1 (peat, soil, sand) with mat irrigation, spaghetti tube or hand watering.

Plant Nutrition on Capillary Mats

Simply put, the objective of any plant production system is to produce quality plants in an optimum time at minimum cost and proper plant nutrition is fundamental to this process (16, 37).

There are 17 nutrients that are known to be essential to plant growth and there is ample scientific evidence to show that it is the relative balance between nutrients, rather than their absolute amounts, which is so important in optimum plant performance. For example, Whitcomb (53) reported that plants did not respond to high levels of nitrogen without the addition of micronutrients. Furthermore, if micronutrients were added, but nitrogen levels were too low, there was little or no growth response. From this he concluded that a proper proportion or balance between the two nutrient sources must be met to insure maximum growth and that the possibility existed that such a balance could vary between different types of plants. In work done with *Litchi chinensis* in sand culture, Joiner and Dickey (24) discovered that the plants slowed in their growth when additional amounts of nitrogen fertilizer were applied, probably because the higher levels of nitrogen and potassium suppressed micronutrient uptake. Nutritional studies by Hogan and Shanks (22) indicated that higher levels of potassium did not increase the fresh weight of roots of *Philodendron cordatum* cuttings unless phosphorus had been applied as well.

It is extremely important that plants be supplied with optimum amounts of nutrients throughout the production cycle because excessive amounts can result in root injury and even plant death while deficiencies are evidenced by a general reduction in vigor (often uniform throughout the entire crop and thus difficult to detect), smaller leaves, thinner stems, and shorter internodes (13).

Various fertilizer types, including regular dry, controlled-release, and liquid, have been used with varying success to satisfy the nutritional requirements of greenhouse crops. To reduce labor costs and avoid the risk of dry fertilizers and the bulk and expense of liquid fertilizer injectors and storage tanks, many growers have switched to controlled-release forms of fertilizers in recent years (47).

Ideally, a controlled-release fertilizer should release nutrients in a manner that conicides with the nutrient uptake pattern of the crop. Furthermore, a majority of the applied nutrients should be released during the production cycle so the plants reach the retail market with adequate, but not excessive, levels of fertilizer salts to facilitate the acclimatization process (47).

One very popular form of controlled-release fertilizer is Osmocote, made through the application of multiple plastic polymer coatings to prills of water-soluble fertilizers. When placed in contact with moist media, water moves through the coating (principally in the vapor phase) to dissolve the soluble core. Once in solution, the nutrients then diffuse outward through the membrane and into the root zone area (47).

The use of a controlled-release fertilizer such as Osmocote offers a grower several advantages. When compared to constant liquid fertilizer application, Hasek and Sciaroni (19) found Osmocote reduced labor requirements substantially while providing a more stable nutrient level between irrigations. Barron (7) reported greater efficiency with controlled-release fertilizers due to their leaching resistance which also would reduce pollution of runoff water and allow comparatively lower fertilizer rates with reduced costs per plant unit. Lastly, many researchers have found that plants fertilized with Osmocote were equal or superior to those produced with liquid fertilizers (41).

Controlled-release fertilizers are especially well-suited to production on capillary mats because fertilizer injection into the irrigation water and onto the mat would cause a very rapid accumulation of algae. Researchers at North Carolina State reported that without fertilizer injection, capillary mats remained fairly clean for four to five months whereas with injection, they were algae-covered within a week (3). Kiplinger (25) also warned that the use of fertilizer in the irrigation water would result in rapid algae buildup. In addition to the use of controlled-release fertilizers, some researchers have covered the mats with thin black polyethylene, perforated with hundreds of tiny holes, which allow moisture movement into containers while shading out the algae (4).

The release rates of the various formulations of Osmocote have been the subject of much research. For example, a single application of Osmocote 14-14-14 at planting fulfilled the nutrient requirements of cut mums for 90 to 120 days (47) and work by Poole and Waters (41) indicated that healthy, attractive azaleas could be grown for five months with a single application of Osmocote 18-6-12. Waters and Llewellyn (51) reported Osmocote 14-14-14 prompted a steady increase in soil salinity for approximately two months, followed by a steady decrease in salinity after the eight-week period. In their tests with pot mums fertilized with Osmocote 14-14-14, Hammer and Boodley (18) determined that the peak nutrient release of the Osmocote coincided with the time of most active plant growth.

The external factors influencing the release rate of Osmocote have also come under close scrutiny. Barron (6) maintained that only two external factors were important: (1) as soil temperature increased, release rate increased, (2) intermittent drying, as might occur with surface application of the fertilizer, slowed the release rate due to the lack of continual moisture to carry out the release process. He went on to explain that because moisture enters the Osmocote prill principally in the vapor phase, the amount, rather than the sustained presence, of soil moisture has only a minor effect on release rate. Whitcomb (52) also described the release rate of Osmocote as being very slow in cool weather, very fast in high temperatures. Interestingly enough, soil pH and microbial activity had little effect on rate of release according to a study conducted by Waters and Llewellyn (51).

In her work with African violets on capillary mats, Adams (1) concluded that incorporation of the Osmocote granules, rather than top dressing, was the most practical application method. This view was also shared by Barron (7). Lastly, complete distribution of the Osmocote granules throughout the growing medium resulted in the highest quality *Celosia argentea cristata* and reduced leaching losses in a study conducted by Johnson and Warden (23).

An almost overwhelming amount of experimental work has been done concerning optimum fertilizer rates. Conover (9) suggested that fertilizer requirements varied between plant species and were influenced by such factors as rate of plant growth, light intensity required for optimum growth and by soluble salt tolerance of the plant species in question.

There is also great diversity in recommended rates of controlled-release fertilizers. Thirteen lbs./yd.^{3} of Osmocote 14-14-14 is a commonly recommended rate for pot plants (48). Poole and Waters (41) reported that 10 lbs./yd.^{3} of Osmocote 18-6-12 produced high quality azaleas while Laiche (29) found four lbs./yd.^{3} of the same fertilizer gave satisfactory growth of camellias and azaleas. Poole et al. (39) indicated a rate of 12-18 lbs./yd.^{3} of Osmocote 18-6-12 produced excellent growth and quality in *Philodendron selloum*. Poole and Conover (37) used Osmocote 14-14-14 at a rate of 10 lbs./yd.^{3} to provide proper nutrition to three foliage plant species under study.

Fertilizer rate recommendations for use with capillary mats follow a similar pattern. Kiplinger et al. (25) found that 10 lbs./yd.^{3} of Osmocote 18-9-13 gave very satisfactory plant growth on mats while mat-watered Rieger begonias at Cornell (3) performed best at the four lbs./yd.^{3} rate. Ball et al. (5) reported that pot mums grown using 20 lbs./yd.^{3} of Osmocote 14-14-14 performed better than those grown at the 5 and 10 pound rates.

As with any fertilization program, it is important to monitor closely the salinity or total soluble salt levels throughout the crop production cycle because these levels are an indication of fertilizer concentrations present in the media and because extremes in salinity levels, either high or low, can result in reduced plant growth (21).

While salt injury has not proven to be a problem, the use of capillary mats does place added emphasis on total soluble salt levels due to possible surface accumulation of salts through capillary movement and evaporation of water and due to the lack of significant leaching during normal watering. Kiplinger et al. (25) reported no salt problems on mat-watered pot mums supplies with controlled-release fertilizer, but mentioned the possibility of soluble salt accumulation in the upper regions of containers due to upward capillary movement of moisture. Periodic leaching through thorough overhead irrigation was recommended in this eventuality. Ball et al. (3) and Larson and Hilliard (30) could find no evidence of salt injury on mat-grown plants from either controlled-release or soluble fertilizers and attributed this lack of injury to the dilution effect of high moisture levels in the growing medium. They did, however, advocate leaching the crop every four weeks and especially just prior to sale to better acclimate plants to the drier conditions of the average home environment. Work by Hammer and Boodley (18) with subirrigated pot mums fertilized with Osmocote 14-14-14 indicated that soluble salt levels increased while media pH decreased as the sampling height rose from the bottom to the top of the container. Patel and Tinga (33) also discovered a similar accumulation of soluble salts in their work with subirrigated azalea and wax myrtle.

As discussed previously, maximum plant performance is possible only when a proper balance of all essential nutrients is available for plant uptake, Since most commercial fertilizers supply only the primary nutrients such as nitrogen, phosphorus, and potassium, many growers incorporate dolomite and a source of micronutrients to insure adequate amounts of all essential nutrients. In their study of foliage plant propagation, Conover et al. (10) found that additions of dolomite supplied small amounts of calcium and magnesium and raised the pH of the peat moss medium, thus creating more favorable conditions for nutrient uptake which had been previously suppressed by the very acid conditions. Subsequent studies showed that additions of dolomite at 7 lbs./yd.^{3} and

Perk, a micronutrient source, at up to 1 1/2 lbs./yd.^{3} were beneficial to the root development and growth of several foliage plant species. Whitcomb (54) reported excellent results with four different shrub species when 4-6 lbs./yd.^{3} Perk and 8 lbs./yd.^{3} dolomite were incorporated in the growing medium. Lastly, Self (46) included dolomite at the rate of 10 lbs./yd.^{3} as one of the basic fertilizer additives to a 3 bark:1 peat:1 slate medium to help insure optimum nutrition for azaleas, camellias, and gardenias.

Research Objectives

The specific objectives of this study were:

1. To compare the effectiveness of 1:1 formulations (by volume) of sphagnum peat moss with vermiculite, perlite, and sand as well as 2:1:1 formulations of sphagnum peat moss with vermiculite and perlite and vermiculite and Turface (calcined clay) as a soilless growing medium for culture of *P. hastatum* on the capillary mat.
2. To determine the optimum rates of Osmocote 14-14-14 to incorporate into the various growing media necessary to maintain plants in good condition for three to five months.
3. To test the seasonal aspect of the above variables, that is observe both a spring and summer crop of *P. hastatum* to determine if results are similar or if seasonal variation affects the performance of plants in the various media, and fertilizer treatments.

CHAPTER II

MATERIALS AND METHODS

This research was conducted in the horticulture greenhouses at the Oklahoma State University, Stillwater, Oklahoma (36^{o} 9' north latitude, 97^{o} 5' north longitude).

Subirrigation Equipment

The subirrigation equipment (Figure 1) consisted of the following: 3/4 inch (1.91 cm.) PVC main water supply line, one electric solenoid valve controlled by day-night and interval clocks, 3/4 inch (1.91 cm.) PVC header pipe bisecting the length of the combined benches, and 320 Chapin tubes, 0.045 inch (0.114 cm.) inside diameter, with their outlets covered by 2.75 inch x 1.75 inch (6.99 cm. x 3.40 cm.) pieces of aluminum foil to prevent wetting of foliage and insure adequate moisture levels in the subirrigation mats. To prevent the leachate from one container influencing the growth of adjacent plants, each experimental unit was placed on its own 6.5 x 5.6 inch (16.51 x 16.51 cm.) piece of subirrigation matting which was underlaid with a matching piece of 6 mil. black plastic to insure adequate wetting. The particular matting utilized was Vattex Mat composed of natural and synthetic fibers and manufactured by the United States Vattex Company. To reduce the possibility of disease, the mats were premoistened with clear water and then a mixture of Dexon

Figure 1. Components of Subirrigation System--Polyethylene Underlayer, Subirrigation Matting, Water Header and Individual Tubes

(Lesan) and Benlate at 1/2 rate[1] was pumped through the entire irrigation system 24 hours prior to planting.

Also before planting, the media-filled pots were placed on the mats and watered thoroughly from above to establish capillary action between the medium and the mat. Initially, the day-night and interval clocks were set to furnish 10 seconds of water at 30 minute intervals from 9 a.m. to 5 p.m. Four weeks later, the application period was reduced to six seconds every 30 minutes, 9 a.m. to 5 p.m. This proved to be adequate even during the summer months. It also significantly reduced pools of standing water under the benches and the fungus gnats that were often attracted.

Composition and Preparation of Growth Media

Five different soilless media were prepared. 1:1 Formulations (by volume) of sphagnum peat moss with vermiculite, with perlite and with builder's sand were prepared, as well as 2:1:1 formulations of sphagnum peat moss with vermiculite and perlite and sphagnum peat, vermiculite and Turface (calcined clay). Both the builder's sand and Turface were steam sterilized for four hours at 180^{o}F (83.23^{o}C) to avoid potential pest problems.

Applications of 5, 10, 15, and 20 pounds per cubic yard (2.97, 5.94, 8.91, 11.88 kg./cu.m.) of 14-14-14 Osmocote[2] were made to the various

---

[1]Four ounces of Dexon (Lesan) 35 W.P. and four ounces of Benlate 50 W.P. in 100 gallons of water or one gram of each chemical per 3.78 liters of water.

[2]Osmocote obtained from Sierra Chemical Company, Newark, California.

media mentioned above in an effort to determine the optimum rate required to maintain plants in good nutrition for 3-5 months.

Dolomitic limestone and Perk Trace Element Mixture[3] were also added to the different media at rates of five pounds and 2.5 pounds per cubic yard (2.97 kg./cu.m. and 1.49 kg./cu.m.) respectively.

All components of a specific growing medium were combined in a previously disinfected cement mixer and mixed thoroughly to insure homogeneity.

Transplanting and Cultural Procedures

Both a spring and a summer crop were grown, the first running 12 weeks (from March 2, 1976 to May 25, 1976) with the second running 16 weeks (July 25, 1976 to November 14, 1976).

P. hastatum Super Seedlings[4] were utilized for both crops. These seedlings were shipped in specially-designed styrofoam trays nestled inside cardboard boxes, which were opened promptly upon receipt to allow for plant examination. Spot watering, as well as a single application of dilute liquid fertilizer (20-20-20, 250 ppm. N, P_2O_5, K_2O) were accomplished prior to planting as required.

Seedlings were transplanted into new 4 1/2 inch (11.43 cm.) plastic pots, one seedling per pot. The pots were equipped with both side and

---

[3]Perk, a micronutrient blend, was obtained from Kerr-McGee Chemical Company, Jacksonville, Florida. Principal constituents and their percentages by weight included copper sulfate (.29), manganese sulfate (2.96), iron sulfate (4.92), chelated iron (.33), total iron sulfate (5.25), free sulfur (4.50), total magnesium (15.20), water soluble magnesium (15.20), zinc sulfate (.86), borax (.074), sodium molybdate (.003), and chlorine (1.00).

[4]Super Seedlings obtained from Pan American Plant Company, West Chicago, Illinois.

bottom openings as well as short (2 mm.) ridges located near the outer bottom edge. Pot spacing was seven inches (17.8 cm.) center to center (Figure 2).

Approximately 39.5 cu.in. (647.29 cu.cm.) of growing medium was placed in each pot, then the media and subirrigation mats were moistened to insure rapid establishment of capillary action. Gentle overhead watering was utilized immediately after transplanting to settle media around roots. Lastly, surface sprays of Dexon (Lesan) and Benlate at 1/2 rate[5] were applied both before and after transplanting to prevent damping-off.

Foliar applications of 1/2 rate Dexon (Lesan) and Benlate[6] were made at transplanting and at approximately six-week intervals throughout the production cycle to prevent disease. Insect control measures were employed only as needed and consisted of Vapona fumigations plus soil drenches with Diazinon 50 W.P. at full rate.[7]

Cheesecloth was used overhead to regulate the amount of incoming light, to provide the proper light intensity to all treatments equally. The average intensity for Crop 1 was 1890 ft. candles (20,343.96 lumens/m^2), measured at mid day, while the average from Crop 2 was 1410 ft. candles (15,177.24 lumens/m^2).

Average night temperatures were 66.19^{o}F (19^{o}C) for Crop 1 and 68.27^{o}F (20.15^{o}C) for Crop 2. Maximum daytime temperatures under sunny

---

[5]Four ounces of Dexon (Lesan) 35 W.P. and four ounces of Benlate 50 W.P. in 100 gallons of water or one gram of each chemical per 3.78 liters of water.

[6]Ibid.

[7]15.87 ounces of Diazinon 50 W.P. per 100 gallons of water or 4.5 grams per 3.78 liters of water.

Figure 2. Seedlings of Spring Crop on Benches Two Weeks After Transplanting

conditions averaged 80.86°F (27.15°C) and 82.45°F (28.03°C) for Crops 1 and 2 respectively.

Experimental Design

The randomized complete block design was utilized with a 4 x 5 factorial (fertilizer rate x growing media), 20 treatments, 16 plants per treatment, four plants per replicate for a total of 320 experimental plants. Randomization of treatment placement and transplanting sequence was done by computer. A single row of guard plants completely surrounded the experimental units to further reduce environmental variation within the experimental area (Table I).

In the results and discussion section, the various media combinations of peat-vermiculite, peat-perlite, peat-sand, peat-vermiculite-perlite, and peat-vermiculite-turface will be abbreviated as P-V, P-P, P-S, P-V-P, and P-V-T respectively.

Data Recorded

The following measurements and tests were made with a substantial amount of the resultant data being stored in the computer:

Physical Properties of Growth Media

1. Percent air space (non-capillary pore space), percent water space (capillary pore space), percent total pore space and percent solids: five containers of known volume were completely filled with each growth medium (25 containers total). The media were then saturated with water, allowed to stand for 12 hours, at which time additional water was added to insure complete

TABLE I

EXPERIMENTAL TREATMENTS

Twenty Treatments Were Established:

Treatment Number	Growth Media Composition	Rate of 14-14-14 Osmocote
1	1 Peat 1 Vermic.	5#/cu.yd.(2.97 kg./cu.m.)
2	1 Peat 1 Vermic.	10#/cu.yd.(5.94 kg./cu.m.)
3	1 Peat 1 Vermic.	15#/cu.yd.(8.91 kg./cu.m.)
4	1 Peat 1 Vermic.	20#/cu.yd.(11.88 kg./cu.m.)
5	1 Peat 1 Perlite	5#/cu.yd.(2.97 kg./cu.m.)
6	1 Peat 1 Perlite	10#/cu.yd.(5.94 kg./cu.m.)
7	1 Peat 1 Perlite	15#/cu.yd.(8.91 kg./cu.m.)
8	1 Peat 1 Perlite	20#/cu.yd.(11.88 kg./cu.m.)
9	1 Peat 1 Builder's Sand	5#/cu.yd.(2.97 kg./cu.m.)
10	1 Peat 1 Builder's Sand	10#/cu.yd.(5.94 kg./cu.m.)
11	1 Peat 1 Builder's Sand	15#/cu.yd.(8.91 kg./cu.m.)
12	1 Peat 1 Builder's Sand	20#/cu.yd.(11.88 kg./cu.m.)
13	2 Peat 1 Vermic. 1 Perlite	5#/cu.yd.(2.97 kg./cu.m.)
14	2 Peat 1 Vermic. 1 Perlite	10#/cu.yd.(5.94 kg./cu.m.)
15	2 Peat 1 Vermic. 1 Perlite	15#/cu.yd.(8.91 kg./cu.m.)
16	2 Peat 1 Vermic. 1 Perlite	20#/cu.yd.(11.88 kg./cu.m.)
17	2 Peat 1 Vermic. 1 Turface	5#/cu.yd.(2.97 kg./cu.m.)
18	2 Peat 1 Vermic. 1 Turface	10#/cu.yd.(5.94 kg./cu.m.)
19	2 Peat 1 Vermic. 1 Turface	15#/cu.yd.(8.91 kg./cu.m.)
20	2 Peat 1 Vermic. 1 Turface	20#/cu.yd.(11.88 kg./cu.m.)

saturation. The amounts of water added were carefully recorded and used to calculate the percent total pore space. Next, each container was allowed to drain for 10 minutes, then shaken 20 times. The amounts of drainage water represented non-capillary pore space and were used to calculate percent air space. The amounts of water retained in the media represented capillary pore space and were the basis for percent water space calculations. Container volumes minus total cubic centimeters of water added were used to determine percent solids.

Interval Growth Measurements (every two weeks)

1. Stem length (mm.) measured from surface of growth medium to base of most recently opened leaf.
2. Number of leaves.

Final Growth Measurements (at termination of experiment)

1. Overall stem length (mm.).
2. Total number of leaves.
3. Dry top weight (gms.).
4. Nitrogen analysis of above-ground plant tissue (1 plant per treatment per block selected at random; ground and passed through 20 mesh screen prior to Kjeldahl N analysis).

Final Quality Determinations (at termination of experiment)

1. Top grade: subjective rating, on a scale of 1-4 (1 = poor, 4 = excellent), of overall plant quality.

2. Root grade: subjective rating, on a scale of 1-4 (1 = poor, 4 = excellent), of overall root quality.

<u>Supporting Laboratory Data</u> (at termination of experiment-second crop only)

1. pH of growth media: one plant per treatment per block. Beckman Model 300 pH Meter utilized for tests with a dilution of 30 cc. of distilled water per 4.5 grams of air-dried medium. The Osmocote granules were not removed from media samples prior to testing.
2. Total soluble salts of growth media: one plant per treatment per block using the same experimental units as in the pH tests. RD15 Solubridge Tester utilized for tests with a dilution of 50 cc. distilled water per 10 grams of air-dried medium. Again, the Osmocote granules were not removed from the various media prior to testing.
3. pH and total soluble salts of root balls split into thirds: four root balls randomly selected from the P-S 10 pound treatment as well as four similarly selected from the P-V-P 10 pound treatment were split as evenly as possible into three equal portions--top, middle, and bottom. The pH and total soluble salt levels were then determined for each sample, using the methods described above, to show more precisely if and where salts were being concentrated in the root zone.

CHAPTER III

RESULTS AND DISCUSSION

To facilitate a more clear understanding of this work, the experimental data gathered was divided into three major time periods--preplant determinations of media characteristics, biweekly growth measurements, and final growth and quality assessments.

Physical Properties of Growth Media

It is a maxim of greenhouse production that a healthy, well-developed root system is tremendously important to efficient, profitable plant growth. Future plant survival and performance in the less-than-ideal environment of the average home or office place even more stringent demands on the plant's root system. Because the physical properties of a growth medium often exert considerable influence on root system development and thus plant performance in general, these characteristics will be discussed first.

As shown in Table II and Figure 3, very significant differences existed between the various media in percent air space. At 4.68 and 5.03 percent respectively, P-V-T and P-S were the most poorly aerated media by a wide margin. P-V-P and P-V however, exhibited aeration levels of 13.28 and 14.11 percent which is clearly within a very desirable aeration range for container production according to Paul and Lee (34). P-P at 23.47 percent showed the highest level of media aeration.

TABLE II

PHYSICAL PROPERTIES OF GROWTH MEDIA

Growth Medium	% Air Space LSD $_{.05}$ = 2.62[y]	% Water Space LSD $_{.05}$ = 2.05	% Total Pore Space LSD $_{.05}$ = 2.29	% Solids LSD $_{.05}$ = 2.29	% Water Retained LSD $_{.05}$ = 3.72
P-V	14.11 b	50.50 c	64.61 d	35.39 a	78.18 b
P-P	23.47 c	40.36 a	63.83 cd	36.17 ab	63.40 a
P-S	5.03 a	43.01 b	48.04 a	51.96 d	89.20 c
P-V-P	13.28 b	48.78 c	62.06 bc	37.94 bc	78.64 b
P-V-T	4.68 a	56.33 d	61.01 b	38.99 c	92.40 c

[y]Means within a given column (top-to-bottom) followed by different letters are significanlty different at the five percent level. LSD $_{.05}$ for comparing various means within a particular column is given in the heading of that column.

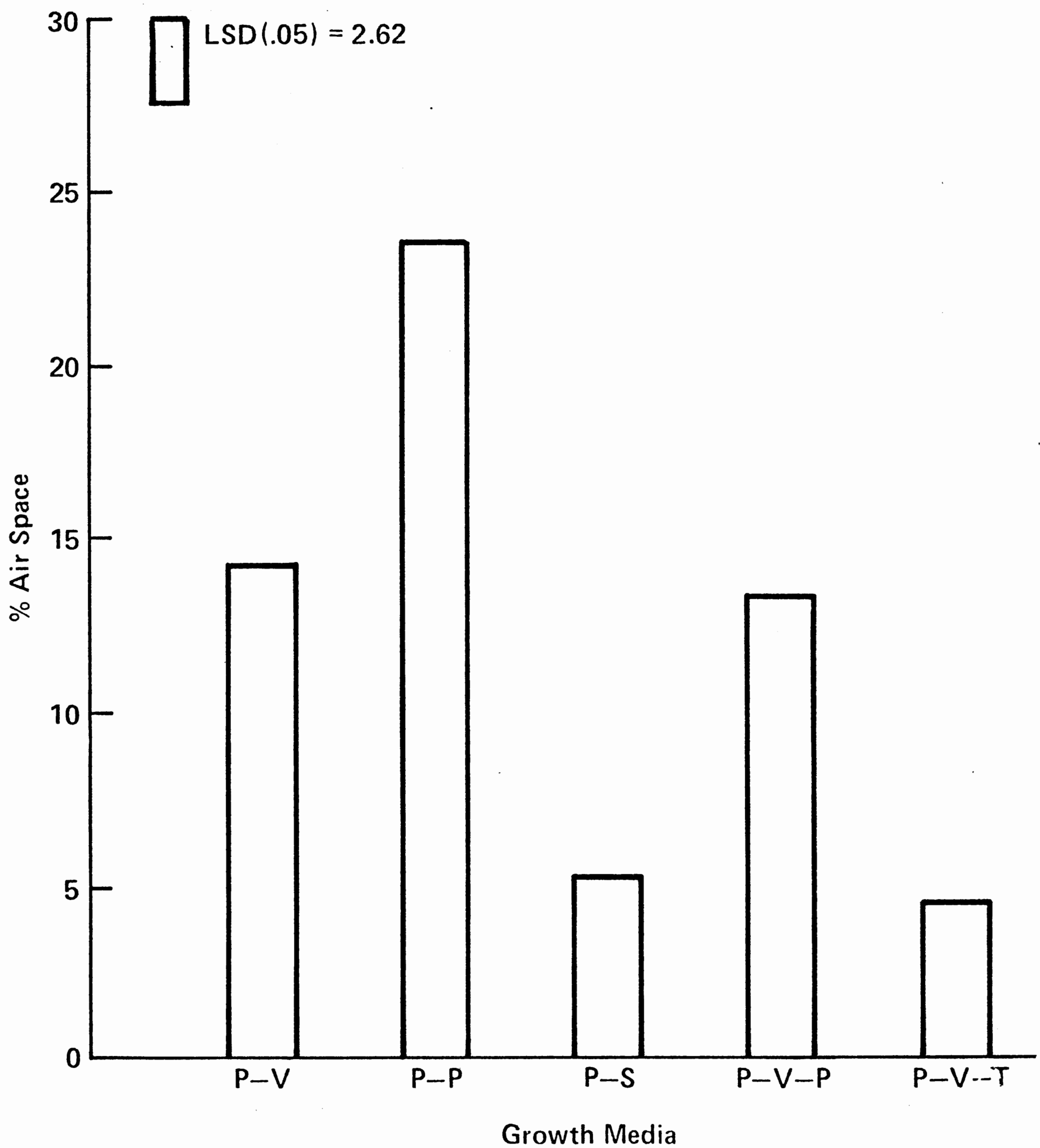

Figure 3. A Comparison of Air Space Percentages of the Various Growth Media

P-P had the lowest percentage (40.36) of capillary water space as was expected due to its high percentage of air space. P-V and P-V-P gave quite similar water space percentages at 50.5 and 48.78 respectively. But while P-S and P-V-T gave similar air space percentages, their percentages of capillary water space differed dramatically (43.01 compared to 56.33). This difference resulted from the much greater percentage of solid particles present in P-S.

All media were in the same general range of percent total pore space and percent solids except P-S. It was interesting to note that two different media, such at P-V-P and P-V-T, could be so similar in percent total pore space but so dissimilar in percent air and percent water space, the components of total pore space.

As expected, the percent water retained results (Table II) were inversely proportional to percent air space readings.

Biweekly Growth Measurements

Influence of Growing Media on Number of Leaves

The influence of growing medium on the number of leaves produced during the spring crop was quite interesting. At Week 2, the first reporting period, statistical analysis indicated certain, though not necessarily major, differences with P-S and P-V-P having the fewest leaves, 5.0 and 5.1 respectively, while P-V-T exhibited the greatest number of leaves (5.6)(Table III).

From Week 4 to Week 10 however, there were no significant differences in leaf number due to growing medium.

TABLE III

INFLUENCE OF GROWING MEDIUM ON MEAN NUMBER OF LEAVES
BY WEEK IN THE SPRING AND SUMMER CROPS

	Week 2		Week 4		Week 6	
	Spring [y] $LSD_{.05} = 0.47$	Summer $LSD_{.05} = 0.39$	Spring $LSD_{.05} = 0.52$	Summer $LSD_{.05} = 0.39$	Spring $LSD_{.05} = 1.12$	Summer $LSD_{.05} = 0.39$
P-V	5.34^{ab}	4.91^{b}	7.02^{a}	6.08^{c}	11.59^{a}	6.86^{c}
P-P	5.23^{ab}	4.19^{a}	6.92^{a}	5.17^{a}	11.42^{a}	6.00^{a}
P-S	5.03^{a}	4.80^{b}	7.00^{a}	5.95^{bc}	11.67^{a}	6.88^{c}
P-V-P	5.13^{a}	4.53^{ab}	6.67^{a}	5.58^{b}	11.14^{a}	6.44^{b}
P-V-T	5.63^{b}	4.61^{b}	6.97^{a}	5.63^{b}	11.33^{a}	6.44^{b}
	Week 8		**Week 10**		**Week 12**	
	Spring $LSD_{.05} = 1.59$	Summer $LSD_{.05} = 0.42$	Spring $LSD_{.05} = 2.03$	Summer $LSD_{.05} = 0.54$	Spring $LSD_{.05} = 3.13$	Summer $LSD_{.05} = 0.62$
P-V	17.16^{a}	8.11^{c}	25.34^{a}	8.95^{b}	35.36^{b}	10.50^{c}
P-P	17.19^{a}	7.08^{a}	23.64^{a}	8.05^{a}	33.13^{ab}	9.13^{a}
P-S	17.27^{a}	7.98^{c}	23.95^{a}	8.77^{b}	31.27^{a}	9.95^{bc}
P-V-P	16.89^{a}	7.77^{bc}	24.34^{a}	8.56^{ab}	33.25^{ab}	9.70^{ab}
P-V-T	17.09^{a}	7.39^{ab}	24.38^{a}	8.09^{a}	33.38^{ab}	9.09^{a}

TABLE III (continued)

	Week 14		Week 16	
	Spring	Summer $LSD_{.05} = 0.73$	Spring	Summer $LSD_{.05} = 0.98$
P-V	-	11.58[b]	-	13.34[c]
P-P	-	10.09[a]	-	11.22[b]
P-S	-	10.20[a]	-	10.56[ab]
P-V-P	-	10.97[b]	-	12.50[c]
P-V-T	-	9.61[a]	-	10.19[a]

[y]Means within a given column (top-to-bottom) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing various means within a particular column is given in the heading of that column.

But at Week 12 (termination), significant differences appeared with plants in P-S (31.2) having significantly fewer leaves than P-V (35.3) and the remaining media treatments being intermediate in response.

The summer crop showed significant differences in leaf number due to the influence of growing media at all reporting periods (Table III). The general trend for Week 2 through 8 was that P-P gave the fewest leaves, P-V-P and P-V-T were intermediate and P-V and P-S gave the greatest number of leaves. The latter half of the experimental period showed a somewhat different trend with P-P and P-V-T exhibiting the fewest leaves, P-S being intermediate, and P-V and P-V-P resulting in the highest leaf counts.

Influence of Growing Media on Stem Height

Spring Crop. There were significant differences in stem height due to growing media at all reporting periods (Table IV).

For Weeks 4 through 10, P-V-T gave decidedly shorter plants with P-S and occasionally P-V resulting in the tallest plants.

At Week 12 (termination) however, P-S suddenly resulted in the shortest plants (68.2 mm.) with P-P being the tallest (72.9 mm.).

Summer Crop. As in the spring, this crop also showed significant differences at all reporting periods (Table IV).

Through the first 12 weeks, there was a strong tendency for P-P and P-V-T to result in shorter plants while P-V, P-S, and P-V-P gave taller specimens. There were no definite intermediate treatments.

At Weeks 14 and 16 however, the pattern changed somewhat. P-P and P-V-T remained very definitely at the shorter end of the range but

TABLE IV

INFLUENCE OF GROWING MEDIUM ON MEAN STEM HEIGHT (mm.) BY WEEK IN THE SPRING AND SUMMER CROPS

	Week 2		Week 4		Week 6	
	Spring	Summer y $LSD_{.05}$ = 1.09	Spring $LSD_{.05}$ = 1.39	Summer $LSD_{.05}$ = 1.97	Spring $LSD_{.05}$ = 1.67	Summer $LSD_{.05}$ = 2.72
P-V	-	10.42^{b}	16.75^{ab}	17.16^{bc}	25.95^{b}	25.50^{b}
P-P	-	8.47^{a}	15.91^{ab}	13.31^{a}	24.84^{ab}	19.70^{a}
P-S	-	10.36^{b}	17.17^{b}	18.56^{c}	26.38^{b}	27.41^{b}
P-V-P	-	8.80^{a}	16.41^{ab}	16.38^{b}	25.28^{ab}	25.58^{b}
P-V-T	-	9.44^{ab}	15.70^{a}	14.32^{a}	23.77^{a}	19.85^{a}

	Week 8		Week 10		Week 12	
	Spring $LSD_{.05}$ = 2.62	Summer $LSD_{.05}$ = 3.65	Spring $LSD_{.05}$ = 3.36	Summer $LSD_{.05}$ = 4.42	Spring $LSD_{.05}$ = 4.53	Summer $LSD_{.05}$ = 5.29
P-V	38.27^{ab}	38.88^{b}	53.83^{b}	50.44^{b}	72.66^{ab}	66.98^{b}
P-P	39.13^{b}	29.72^{a}	52.77^{ab}	38.72^{a}	72.89^{b}	49.53^{a}
P-S	39.61^{b}	39.78^{b}	53.95^{b}	52.31^{b}	68.23^{a}	66.42^{b}
P-V-P	38.00^{ab}	37.59^{b}	52.33^{ab}	48.88^{b}	72.44^{ab}	63.30^{b}
P-V-T	36.08^{a}	30.20^{a}	49.97^{a}	37.35^{a}	69.36^{ab}	47.93^{a}

TABLE IV (continued)

	Week 14		Week 16	
	Spring	Summer $LSD_{.05} = 6.10$	Spring	Summer $LSD_{.05} = 7.37$
P-V	-	82.69[c]	-	94.42[c]
P-P	-	63.25[a]	-	74.64[a]
P-S	-	76.47[b]	-	82.48[b]
P-V-P	-	78.52[bc]	-	92.19[c]
P-V-T	-	57.28[a]	-	68.08[a]

[y]Means within a given column (top-to-bottom) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing various means within a particular column is given in the heading of that column.

with P-S then giving intermediate readings. Plants in P-V and P-V-P were the tallest plants at the conclusion of the experiment.

When comparing the influence of growing media on stem height during both seasons, the following trends emerge: P-V-T gave consistently low readings; P-S resulted in taller plants until the latter weeks of the two experimental periods; and P-V was at or near the upper range of plant heights throughout.

Influence of Fertilizer Rate on Number of Leaves

Spring Crop. Except for Week 6, there was no significant difference in leaf number due to fertilizer rate (Table V).

Summer Crop. From Week 2 to 10, there was a tendency for the 15 pound rate to result in fewer leaves, while the 5 and 10 pound rates often resulted in higher leaf counts (Table V).

During the last six weeks of the growing period, there were no longer any significant differences in leaf number between fertilizer treatments. This abrupt change was quite interesting in view of the fact that fertilizer rate continued to result in significant differences in stem height during the same reporting period.

Influence of Fertilizer Rate on Stem Height

Spring Crop. At the fourth and tenth weeks, there were no significant differences in stem height due to fertilizer rate (Table VI).

During the remaining weeks, however, 15 pounds and 20 pounds resulted in shorter plants, 5 pounds and 10 pounds the taller plants (except during the last reporting period when five pounds dropped to the shorter category as well).

TABLE V

INFLUENCE OF FERTILIZER RATE ON MEAN NUMBER OF LEAVES BY WEEK IN THE SPRING AND SUMMER CROPS

	Week 2		Week 4		Week 6	
	Spring[y] $LSD_{.05} = 0.42$	Summer $LSD_{.05} = 0.34$	Spring $LSD_{.05} = 0.47$	Summer $LSD_{.05} = 0.35$	Spring $LSD_{.05} = 1.00$	Summer $LSD_{.05} = 0.35$
5#	5.21^{a}	4.80^{b}	7.16^{a}	5.81^{bc}	11.93^{b}	6.70^{b}
10#	5.34^{a}	4.68^{ab}	6.99^{a}	5.95^{c}	11.76^{ab}	6.64^{ab}
15#	5.33^{a}	4.43^{a}	6.83^{a}	5.40^{a}	11.18^{ab}	6.31^{a}
20#	5.21^{a}	4.53^{ab}	6.69^{a}	5.56^{ab}	10.86^{a}	6.44^{ab}

	Week 8		Week 10		Week 12	
	Spring $LSD_{.05} = 1.42$	Summer $LSD_{.05} = 0.37$	Spring $LSD_{.05} = 1.82$	Summer $LSD_{.05} = 0.48$	Spring $LSD_{.05} = 2.80$	Summer $LSD_{.05} = 0.56$
5#	17.53^{a}	7.88^{b}	24.48^{a}	8.60^{ab}	32.20^{a}	9.60^{a}
10#	17.53^{a}	7.76^{ab}	24.85^{a}	8.75^{b}	34.43^{a}	9.95^{a}
15#	16.89^{a}	7.39^{a}	24.13^{a}	8.23^{a}	33.90^{a}	9.48^{a}
20#	16.54^{a}	7.64^{ab}	23.88^{a}	8.36^{ab}	32.58^{a}	9.68^{a}

TABLE V (continued)

	Week 14		Week 16	
	Spring	Summer $LSD_{.05} = 0.65$	Spring	Summer $LSD_{.05} = 0.88$
5#	-	10.39[a]	-	11.25[a]
10#	-	10.78[a]	-	11.98[a]
15#	-	10.33[a]	-	11.51[a]
20#	-	10.48[a]	-	11.51[a]

[y]Means within a given column (top-to-bottom) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing various means within a particular column is given in the heading of that column.

TABLE VI

INFLUENCE OF FERTILIZER RATE ON MEAN STEM HEIGHT (mm.)
BY WEEK IN THE SPRING AND SUMMER CROPS

	Week 2		Week 4		Week 6	
	Spring[y]	Summer $LSD_{.05} = 0.97$	Spring $LSD_{.05} = 1.25$	Summer $LSD_{.05} = 1.76$	Spring $LSD_{.05} = 1.50$	Summer $LSD_{.05} = 2.44$
5#	-	9.76^{ab}	16.70^{a}	16.23^{ab}	26.65^{b}	24.01^{ab}
10#	-	10.08^{b}	16.78^{a}	17.32^{b}	25.59^{ab}	25.90^{b}
15#	-	9.04^{a}	16.04^{a}	15.28^{a}	24.40^{a}	22.41^{a}
20#	-	9.11^{ab}	16.04^{a}	14.96^{a}	24.34^{a}	22.11^{a}

	Week 8		Week 10		Week 12	
	Spring $LSD_{.05} = 2.34$	Summer $LSD_{.05} = 3.27$	Spring $LSD_{.05} = 3.00$	Summer $LSD_{.05} = 3.95$	Spring $LSD_{.05} = 4.05$	Summer $LSD_{.05} = 4.73$
5#	39.21^{b}	34.76^{a}	53.24^{a}	44.34^{a}	70.06^{a}	56.68^{a}
10#	39.50^{b}	38.20^{b}	54.05^{a}	48.76^{b}	75.69^{b}	63.60^{b}
15#	36.08^{a}	34.14^{a}	51.35^{a}	44.86^{ab}	69.94^{a}	56.94^{a}
20#	38.08^{ab}	33.84^{a}	51.64^{a}	44.20^{a}	68.78^{a}	58.13^{a}

TABLE VI (continued)

	Week 14		Week 16	
	Spring	Summer $LSD_{.05} = 5.46$	Spring	Summer $LSD_{.05} = 6.59$
5#	-	67.79^{a}	-	76.15^{a}
10#	-	77.42^{b}	-	87.45^{b}
15#	-	70.88^{a}	-	83.43^{b}
20#	-	70.48^{a}	-	82.43^{ab}

[y]Means within a given column (top-to-bottom) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing various means within a particular column is given in the heading of that column.

Figure 4. Appearance of Philodendron hastatum on Capillary Matting on the Forty-second Day from Transplanting

Summer Crop. For week two through six, 15 and 20 pounds gave shorter plants, while 10 pounds resulted in the tallest plants (Table VI). Weeks 8 through 14, 5 pounds had joined 15 and 20 pounds in the shorter category with 10 pounds again giving greater height. At termination, Week 16, five pounds was low (76.2), 20 pounds intermediate (82.4), with 10 and 15 pounds (87.5 and 83.4 respectively) resulting in the taller plants.

A general comparison of fertilizer influence on stem height during both crops shows the 10 pound rate gave rise to taller plants with other treatments giving intermediate results.

General Comparison: Spring Versus Summer Crop

As shown in Table VII and Figure 5, the summer crop had significantly fewer leaves throughout the comparative test period (Weeks 2-12) than did the spring crop. Through the first four weeks, the two crops, while significantly different, were at least in approximately the same range. From the sixth week on however, the spring crop often exhibited two or three times the total number of leaves of the summer crop. For example, from Week 6 to Week 12, the mean number of leaves for the summer crop only increased from 6.52 to 9.67 while that of the spring crop jumped from 11.43 to 33.28.

Much of this difference may have been genetic as a typical spring plant exhibited a rather surprising flush of many small leaves in the basal area while a typical summer plant was characterized by having fewer but larger leaves. It is possible that the seed for the spring crop came from a different seed lot than that used for the summer crop.

TABLE VII

MEAN NUMBER OF LEAVES AND STEM HEIGHT (mm.) BY WEEK IN THE SPRING AND SUMMER CROPS[y]

	No. of Leaves			Stem Height		
Week	Spring	Summer	$LSD_{.05}$	Spring	Summer	$LSD_{.05}$
2	5.27b[z]	4.61[a]	0.27	-	9.50	-
4	6.92[b]	5.68[a]	0.29	16.39[a]	15.94[a]	1.08
6	11.43[b]	6.52[a]	0.53	25.24[b]	23.61[a]	1.43
8	17.12[b]	7.67[a]	0.73	38.22[b]	35.23[a]	2.01
10	24.33[b]	8.48[a]	0.94	52.57[b]	45.54[a]	2.48
12	33.28[b]	9.67[a]	1.43	71.12[b]	58.83[a]	3.12
14	-	10.49	-	-	71.64	-
16	-	11.56	-	-	82.36	-

[y]Figures listed are overall means (media and fertilizer combined) from each reporting period.

[z]Means across rows (left-to-right within a given category) followed by different letters are significantly different at the five percent level.

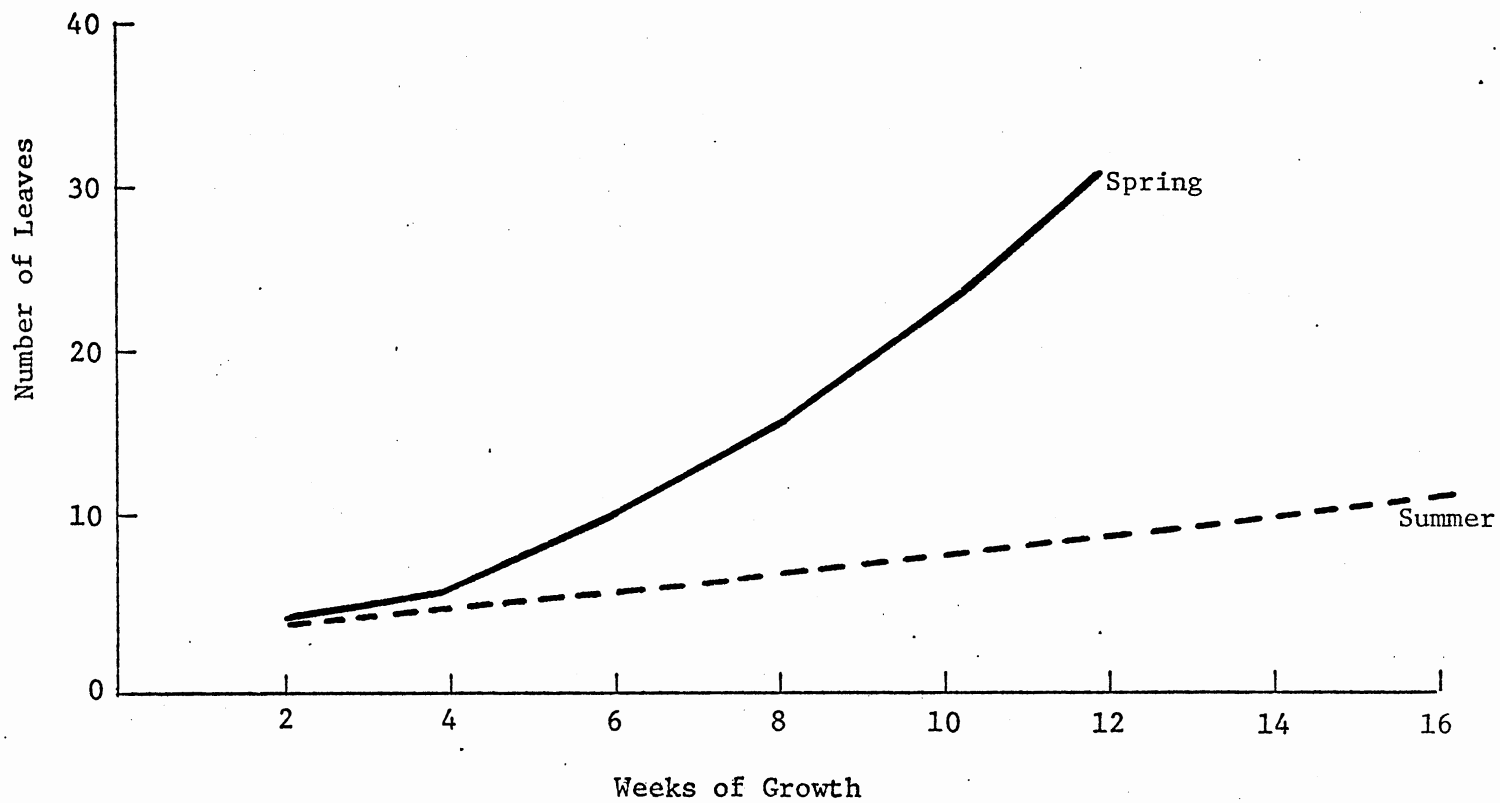

Figure 5. Overall Leaf Number (Media and Fertilizer Means Combined) by Week in the Spring and Summer Crops

In the area of stem height, the measurements of the spring plants were again significantly greater than those of the summer although the differences were not as striking as with leaf number (Table VII, Figure 6). It is important to note that there was no significant difference in stem height at four weeks (there was insufficient data for a comparison at two weeks) but significantly different heights were recorded for all remaining weeks. Although significant, the height differences at Weeks 6 through 10 were not extraordinary. At Week 12, however, the spring crop began to show a rather dramatic height increase.

The genetic makeup of the two crops of philodendron appeared somewhat similar in stem height but different in number of leaves.

Final Measurements

Top Grade

Spring Crop. The various growing media seemed to exert more of an influence on top grade at the low fertilizer rates, 5 and 10 pounds, than they did at the higher rates (Table VIII, Figure 7). At the five pound rate, P-P gave the best top grade (2.63) while P-S resulted in the poorest (1.25). P-V, P-V-P, and P-V-T gave intermediate results. When 10 pounds of fertilizer was incorporated, the differences were less striking but still significant with P-V-P now giving the best top grade of the entire crop at 2.81. At this rate, P-V-T was lowest with a result of only 1.94. As the level of fertility increased, the influence of the various growing media diminished greatly with no significant differences recorded at 15 pounds and only one, P-S, at 20 pounds. The better-aerated media, P-P for example, encouraged such superior root systems (Table X), that it is assumed their roots were able to reach out further, to contact more of what limited fertilizer was present at the low rate.

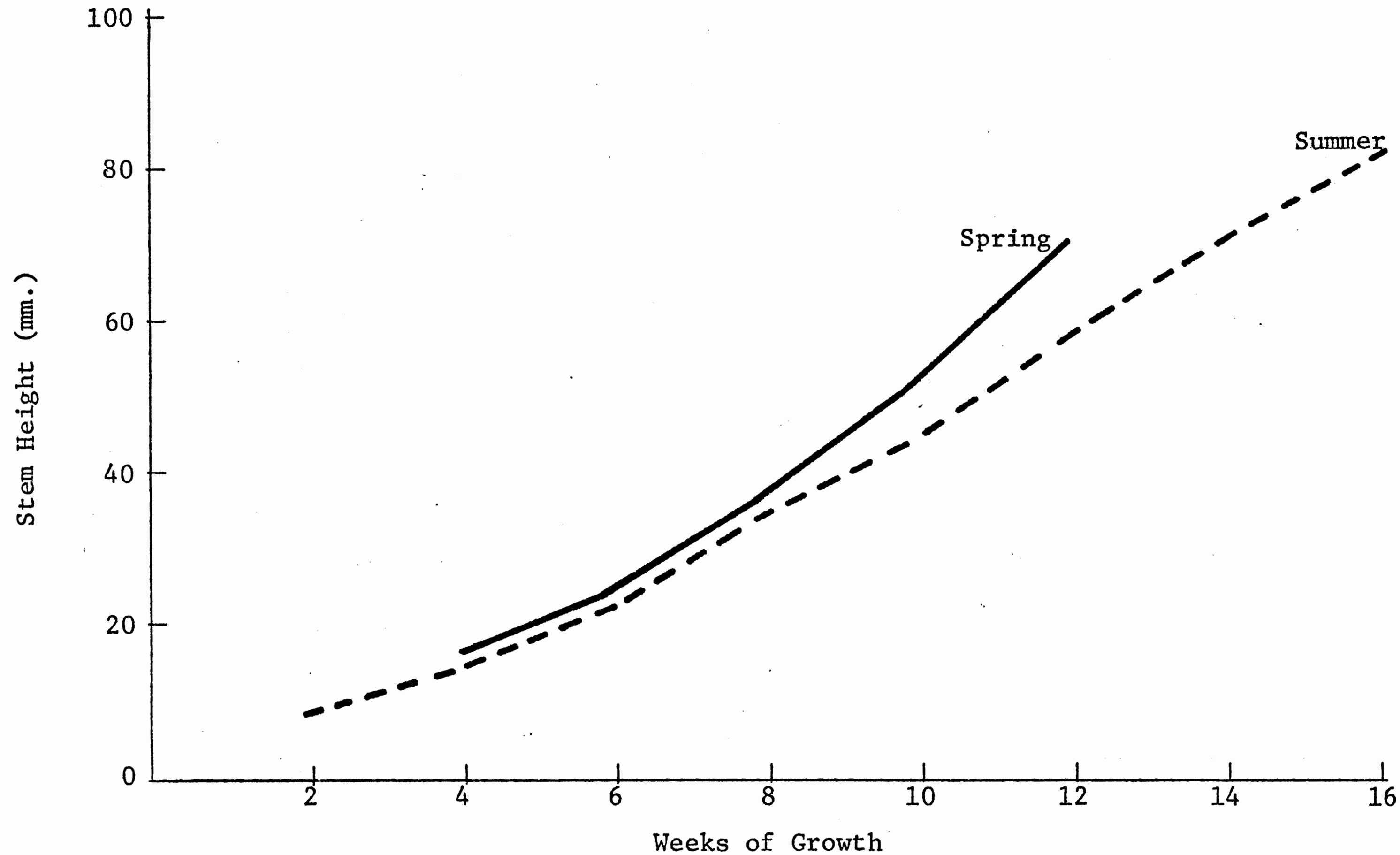

Figure 6. Overall Stem Height (Media and Fertilizer Means Combined) by week in the Spring and Summer Crops

TABLE VIII

ANALYSIS OF TOP GRADE[x] IN RELATION TO RATE OF FERTILIZER AND TYPE OF GROWING MEDIUM IN THE SPRING CROP[w]

Rate of Osmocote 14-14-14 (lbs./cu.yd.)	Growing Media PV	PP	PS	PVP	PVT
5	[y]1.94^{b}	2.63^{c}	[z]1.25$^{a}_{m}$	[y]1.94$^{b}_{m}$	2.06^{b}
10	2.38^{abc}	2.25^{ab}	2.63$^{bc}_{n}$	2.81$^{c}_{n}$	1.94^{a}
15	2.25^{a}	2.50^{a}	2.31$^{a}_{n}$	2.00$^{a}_{m}$	2.38^{a}
20	2.50^{ab}	2.13^{a}	2.69$^{b}_{n}$	2.06$^{a}_{m}$	2.00^{a}

[w]Significance of main effects, trends, and interactions:

	PV	PP	PS	PVP	PVT
Fertilizer Rate	0.002				
Linear	.058	.12	.0001	.59	.75
Quadratic	.60	1.00	.007	.02	.49
Cubic	.25	.12	.004	.002	.09
Growing Media	0.28				
Media x Fertilizer	0.0001				

[x]Top Grade: Subjective rating, on a scale of 1-4 (1 = poor, 4 = excellent), of overall plant quality.

[y]Means across rows (left-to-right) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing media means within the same rate = 0.51.

[z]Means within a given medium (top-to-bottom) followed by different subscripts are significantly different at the five percent level. $LSD_{.05}$ for comparing fertilizer means within the same medium = 0.51.

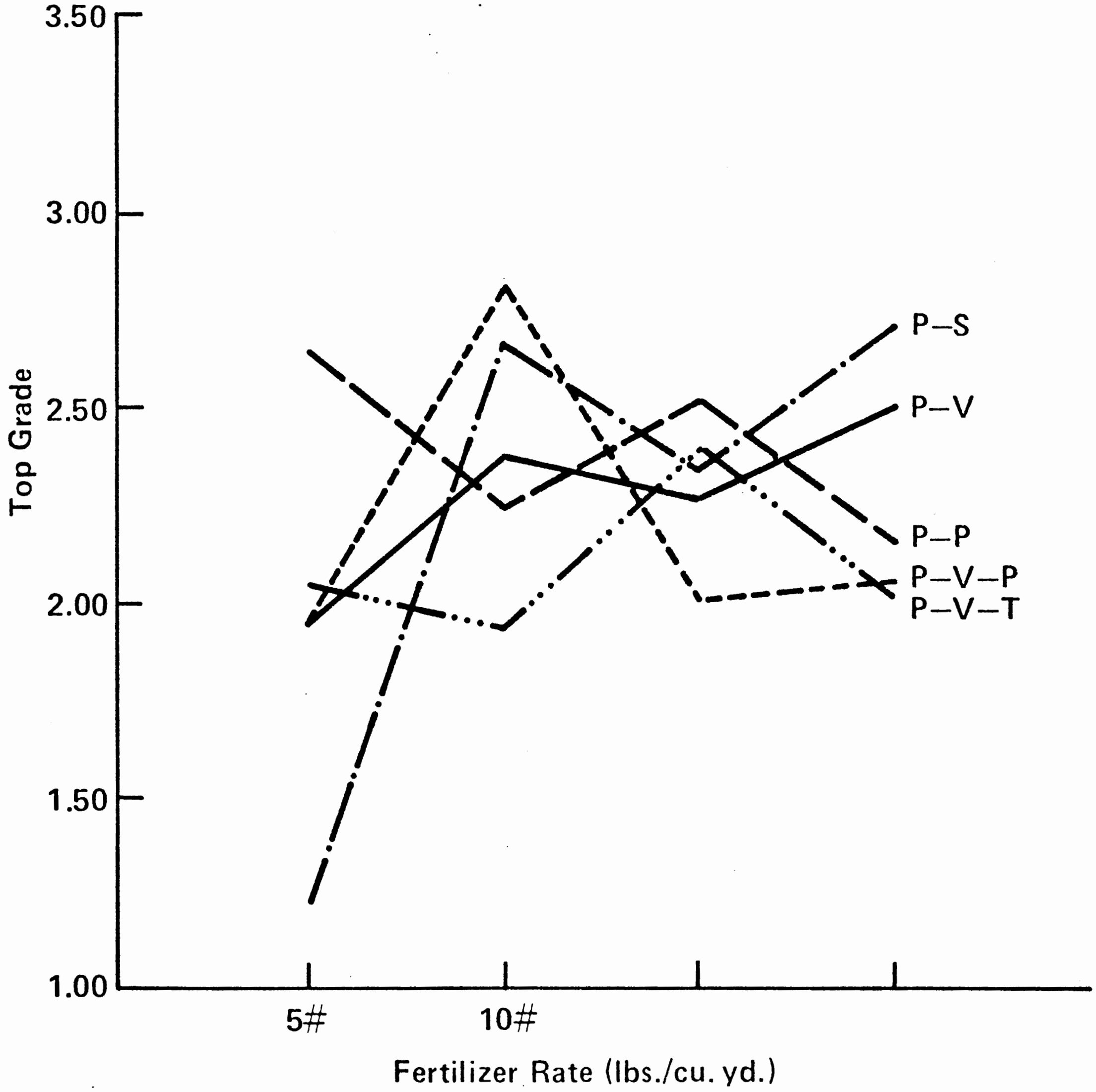

Figure 7. The Influence of Rate of Fertilizer and Type of Growing Medium on Top Grade in the Spring

As fertilizer rate increased, even the sparse roots in more poorly aerated media were able to contact sufficient nutrients to sustain adequate growth.

As shown in Table VIII, fertilizer rate was highly significant as was media x fertilizer interaction. As evidenced in the trend analysis, fertilizer rate had no significant effect on top grade with P-V, P-P, and P-V-T.

When more than one trend was significant, as seen in the trend analysis for P-S and P-V-P, this indicated that no single pattern accurately described the quality response. In this instance, the technique of least significant difference (LSD) was employed in conjunction with actual media means to better understand the trends (see subscripts in Table VIII). This method of data presentation was also used in Tables XII and XIV. For P-S, top grade was significantly lower at five pounds (1.25), from which it rose to 2.63 at 10 pounds, and then continued at a statistically similar level through the 15 and 20 pound rates. For P-V-P, the 5, 15, and 20 pound rates were statistically similar (1.94, 2.00, and 2.06 respectively) with the 10 pound rate being clearly and statistically greater (2.81).

<u>Summer Crop</u>. As with the spring crop, the influence of growing media was most dramatic at the lower fertility levels and gradually diminished as rates increased (Table IX, Figure 9).

Again as in the spring, the better-aerated media, P-V-P, P-V, and P-P, gave superior readings at the five pound rate. Those readings increased rather impressively at the 10 pound rate with P-V and P-V-P giving the highest readings of the season at 3.25 and 3.13 respectively.

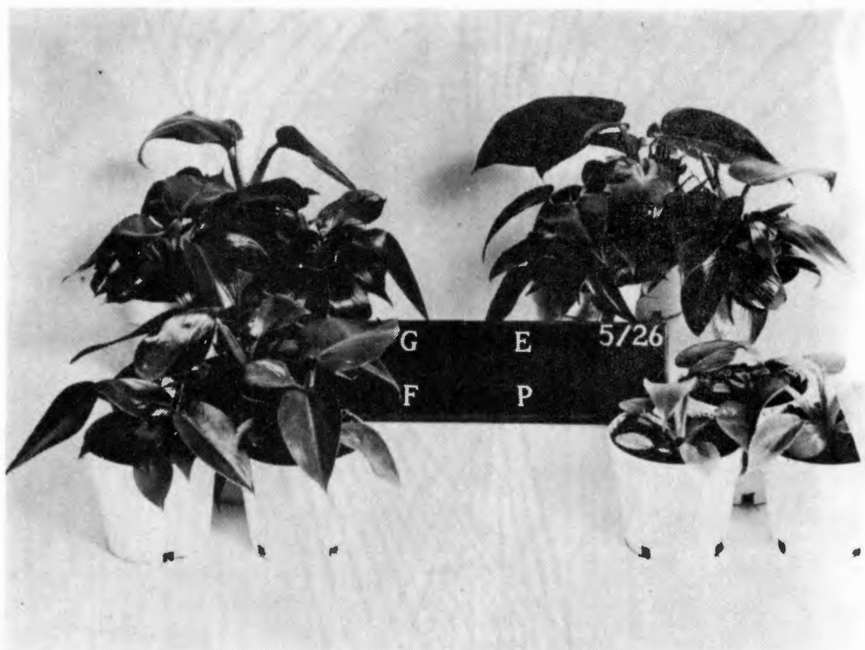

Figure 8. A Visual Comparison of Top Grade Categories for the Spring Crop at Termination (12 Weeks from Transplanting)--(E) Excellent, (G) Good, (F) Fair, (P) Poor

TABLE IX

ANALYSIS OF TOP GRADE[y] IN RELATION TO RATE OF FERTILIZER AND TYPE OF GROWING MEDIUM IN THE SUMMER CROP[w]

Rate of Osmocote 14-14-14 (lbs./cu.yd.)	Growing Media				
	PV	PP	PS	PVP	PVT
5	2.38[b] [z]	2.00[b]	1.19[a]	2.50[b]	1.31[a]
10	3.25[c]	2.50[b]	1.50[a]	3.13[c]	1.50[a]
15	2.88[c]	1.81[a]	2.06[ab]	2.63[bc]	1.63[a]
20	2.44[a]	1.88[a]	2.13[a]	2.13[a]	2.31[a]

[w]Significance of main effects, trends, and interactions:

Fertilizer Rate	0.0058				
	PV	PP	PS	PVP	PVT
Linear	.89	.46	.02	.26	.03
Quadratic	.04	.50	.70	.08	.44
Cubic	.41	.18	.60	.44	.66
Growing Media	0.0001				
Media x Fertilizer	0.0013				

[y]Top Grade: subjective rating, on a scale of 1-4 (1 = poor, 4 = excellent), of overall plant quality.

[z]Means across rows (left-to-right) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing media means within the same rate = 0.61.

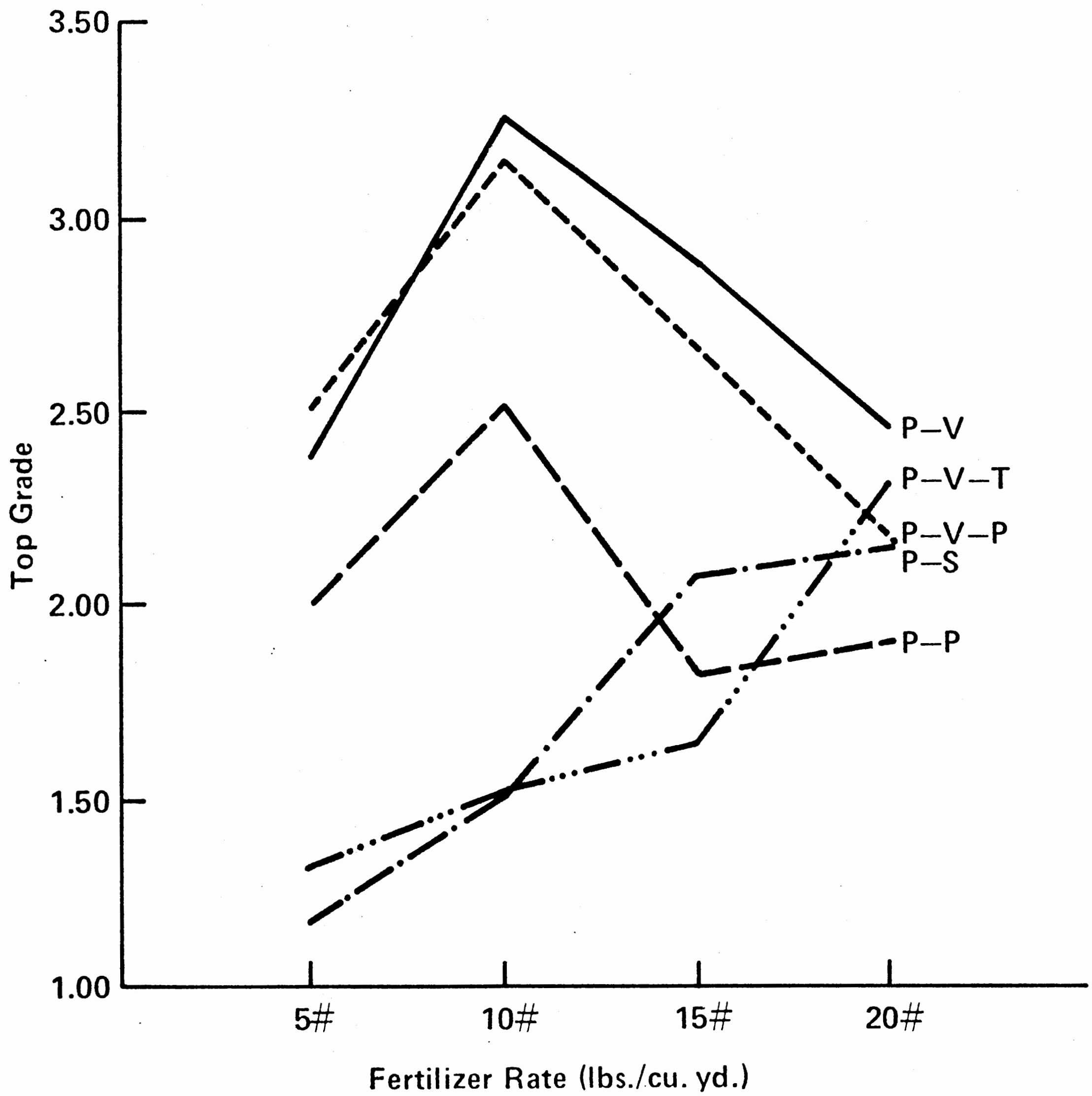

Figure 9. The Influence of Rate of Fertilizer and Type of Growing Medium on Top Grade in the Summer

P-P was intermediate at 10 pounds with P-S and P-V-T being significantly lower. P-V and P-V-P maintained their superiority at 15 pounds with the 20 pound rate showing no significant differences in top grade due to media influence.

Table IX indicates that the main effects of fertilizer rate and growing media plus media x fertilizer interaction were all highly significant.

The various trend analyses for the different media indicated the following: P-V described a quadratic function with the 10 pound rate being highest, fertilizer rate had no significant effect on top grade with P-P and P-V-P. P-S as well as P-V-T followed an increasing linear function in response to fertilizer application.

Root Grade

Spring Crop. As Table X and Figure 10 so clearly illustrate, growing media exerted considerable influence on root grade. This influence seemed to be linked to percent air space of the various media--the better aerated media encouraged healthier and more extensive root systems.

Generally speaking, P-P, P-V, and P-V-P, 23.5, 14.0, 13.3 percent air space respectively, gave the highest root grades throughout the life of the crop with P-P giving significantly higher readings at five pounds and 15 pounds. Conversely, P-V-T and P-S, 4.7 and 5.0 percent air space respectively, resulted in the poorest root growth (except P-V-T at 15 pounds) with a typical root system consisting of only a few roots, dark brown in color and lacking proper root hair development.

It was interesting to note that the root grade ranking of the various media at the five pound level conformed very closely to the percent air space readings recorded above.

TABLE X

ANALYSIS OF ROOT GRADE[y] IN RELATION TO RATE OF FERTILIZER AND TYPE OF GROWING MEDIUM IN THE SPRING CROP[w]

Rate of Osmocote 14-14-14 (lbs./cu.yd.)	Growing Media				
	PV	PP	PS	PVP	PVT
5	2.69[b][z]	3.19[c]	1.63[a]	2.69[b]	1.81[a]
10	2.56[b]	2.81[b]	1.75[a]	2.94[b]	1.69[a]
15	2.19[b]	3.25[c]	1.06[a]	2.38[b]	2.19[b]
20	2.19[b]	2.44[b]	1.38[a]	2.06[b]	1.44[a]

[w]Significance of main effects, trends, and interactions:

	PV	PP	PS	PVP	PVT
Fertilizer Rate	0.0002				
Linear	.22	.24	.35	.11	.68
Quadratic	.85	.52	.78	.41	.36
Cubic	.68	.18	.24	.49	.22
Growing Media	0.0001				
Media x Fertilizer	0.0082				

[y]Root Grade: Subjective rating, on a scale of 1-4 (1 = poor, 4 = excellent) of overall root quality.

[z]Means across rows (left-to-right) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing media means within the same rate = 0.47.

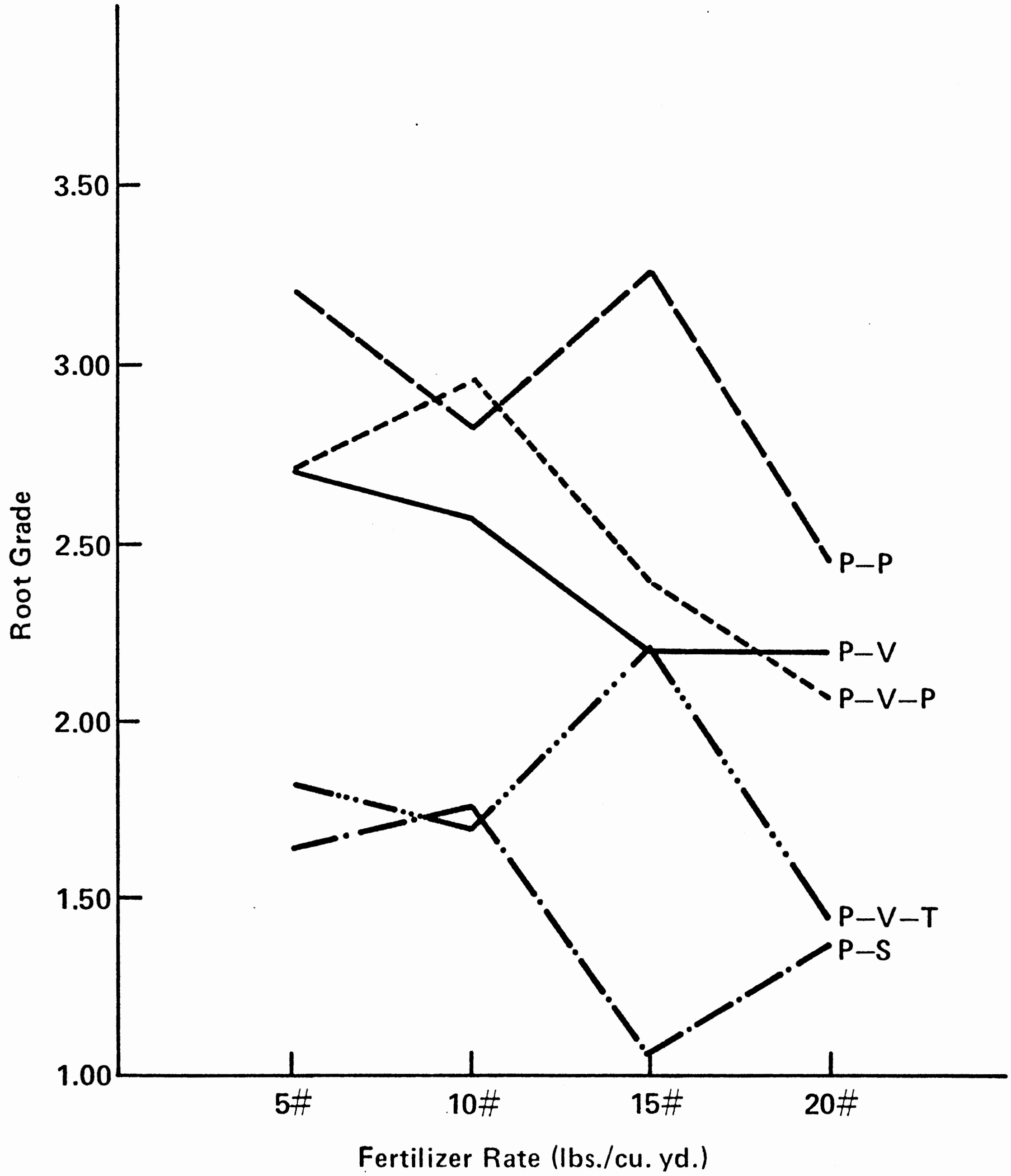

Figure 10. The Influence of Rate of Fertilizer and Type of Growing Medium on Root Grade in the Spring

While it was possible that this very striking difference in root grade might not have greatly influenced plant growth during the course of the experiment due to the constant availability of moisture, it probably would become very important when the plants were subjected to the low humidity conditions of the average home or office environment.

The trend analyses listed in Table X clearly illustrated one important point--fertilizer rate had no significant effect on root grade.

The fact that both the main effects of fertilizer and growing media as well as the media x fertilizer interaction were highly significant statistically was quite puzzling. Thorough study of the entire collection of root grade data would lead one to logically expect only the main effect of growing media to be statistically significant.

Summer Crop. As with the spring crop, the better-aerated media, P-V-P, P-V, and P-P gave consistently higher root grade rankings than did the less well-drained media, P-V-T and P-S (Table XI, Figure 11). For example, at the five pound level, P-V-P, P-V, and P-P gave readings of 3.1, 2.9, and 2.7 respectively while P-V-T recorded only 1.9 and P-S only 1.8.

Again in similarity to the spring study, the trend analyses in Table XI showed that fertilizer rate had no significant effect on root grade.

And as logic would indicate, only the main effect of growing media was statistically significant.

Dry Weight

Spring Crop. As illustrated in Table XII and Figure 12, the effect

TABLE XI

ANALYSIS OF ROOT GRADE[y] IN RELATION TO RATE OF FERTILIZER AND TYPE OF GROWING MEDIUM IN THE SUMMER CROP[w]

Rate of Osmocote 14-14-14 (lbs./cu.yd.)	Growing Media				
	PV	PP	PS	PVP	PVT
5	2.94	2.69	1.75	3.13	1.88
10	3.25	3.13	1.56	3.13	2.13
15	3.00	2.69	1.81	3.13	1.94
20	2.94	2.63	1.75	2.50	2.19
Pooled Means[z]	3.03[c]	2.78[c]	1.72[a]	2.97[c]	2.03[b]

[w]Significance of main effects, trends, and interactions:

Fertilizer Rate	0.25				
	PV	PP	PS	PVP	PVT
Linear	.87	.69	.87	.24	.63
Quadratic	.59	.48	.86	.38	1.00
Cubic	.63	.43	.63	.69	.58
Growing Media	0.0001				
Media x Fertilizer	0.36				

[y]Root Grade: Subjective rating, on a scale of 1-4 (1 = poor, 4 = excellent) of overall root quality.

[z]Means within this row (left-to-right) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing media means = 0.27. All Osmocote rates are pooled.

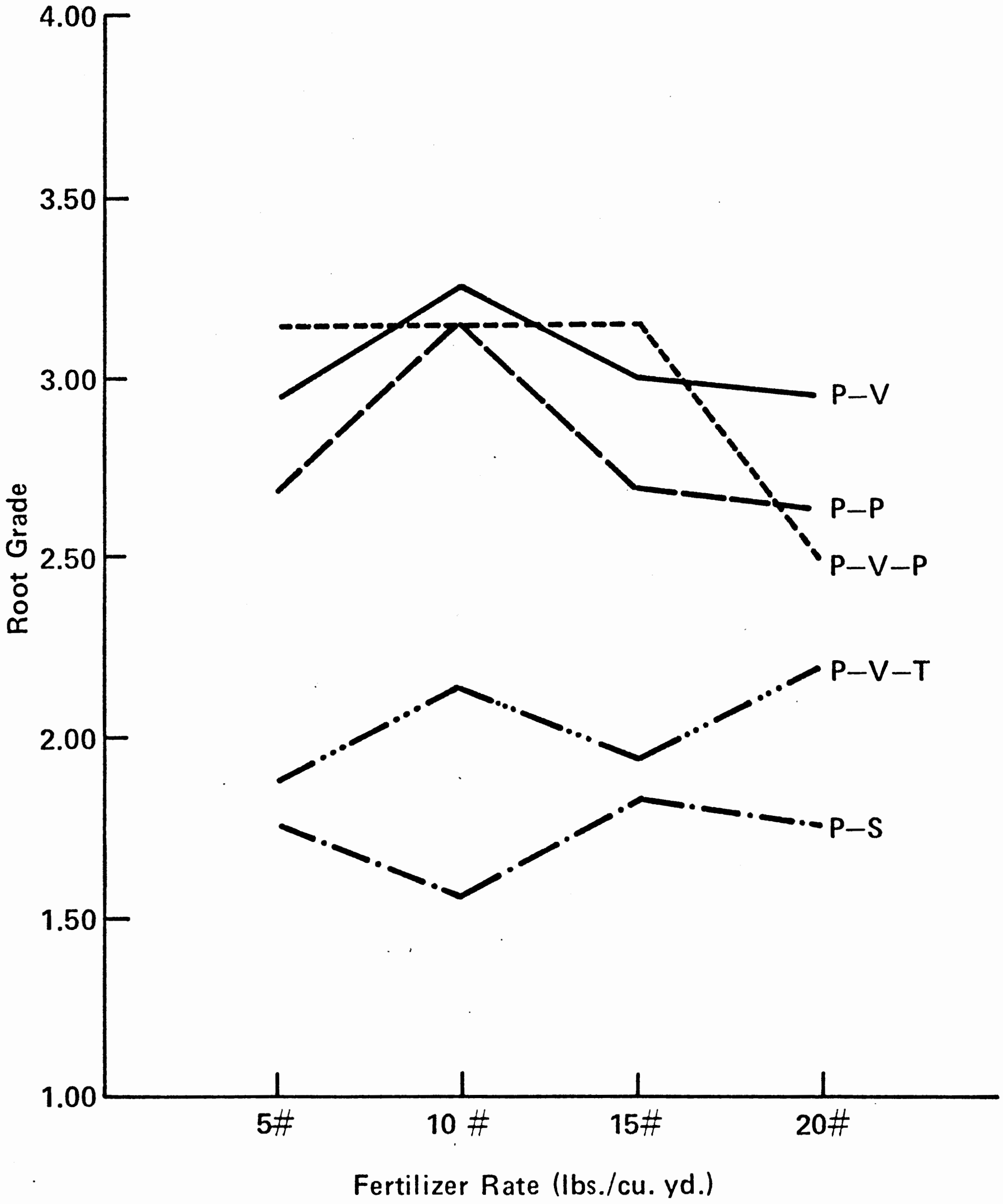

Figure 11. The Influence of Rate of Fertilizer and Type of Growing Medium on Root Grade in the Summer

TABLE XII

ANALYSIS OF DRY WEIGHT(g) IN RELATION TO RATE OF FERTILIZER AND TYPE OF GROWING MEDIUM IN THE SPRING CROP[w]

Rate of Osmocote 14-14-14 (lbs./cu.yd.)	Growing Media				
	PV	PP	PS	PVP	PVT
5	[z]1.85[ab]	[y]1.98^{b}_{n}	1.51[a]	1.88^{ab}_{no}	1.70[ab]
10	2.00[ab]	1.64^{a}_{mn}	1.98[ab]	2.19^{b}_{o}	1.74[a]
15	1.75[ab]	1.89^{b}_{n}	1.60[ab]	1.44^{a}_{m}	1.85[b]
20	1.71[ab]	1.35^{a}_{m}	1.87[b]	1.51^{ab}_{mn}	1.52[ab]

[w]Significance of main effects, trends, and interactions:

Fertilizer Rate	0.0047				
	PV	PP	PS	PVP	PVT
Linear	.26	.007	.24	.002	.47
Quadratic	.46	.46	.46	.36	.17
Cubic	.31	.02	.01	.002	.40
Growing Media	NS (0.71)				
Media x Fertilizer	0.0066				

[z]Means across rows (left-to-right) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing media means within the same rate = 0.39.

[y]Means within a given medium (top-to-bottom) followed by different subscripts are significantly different at the five percent level. $LSD_{.05}$ for comparing fertilizer means within the same medium = 0.39.

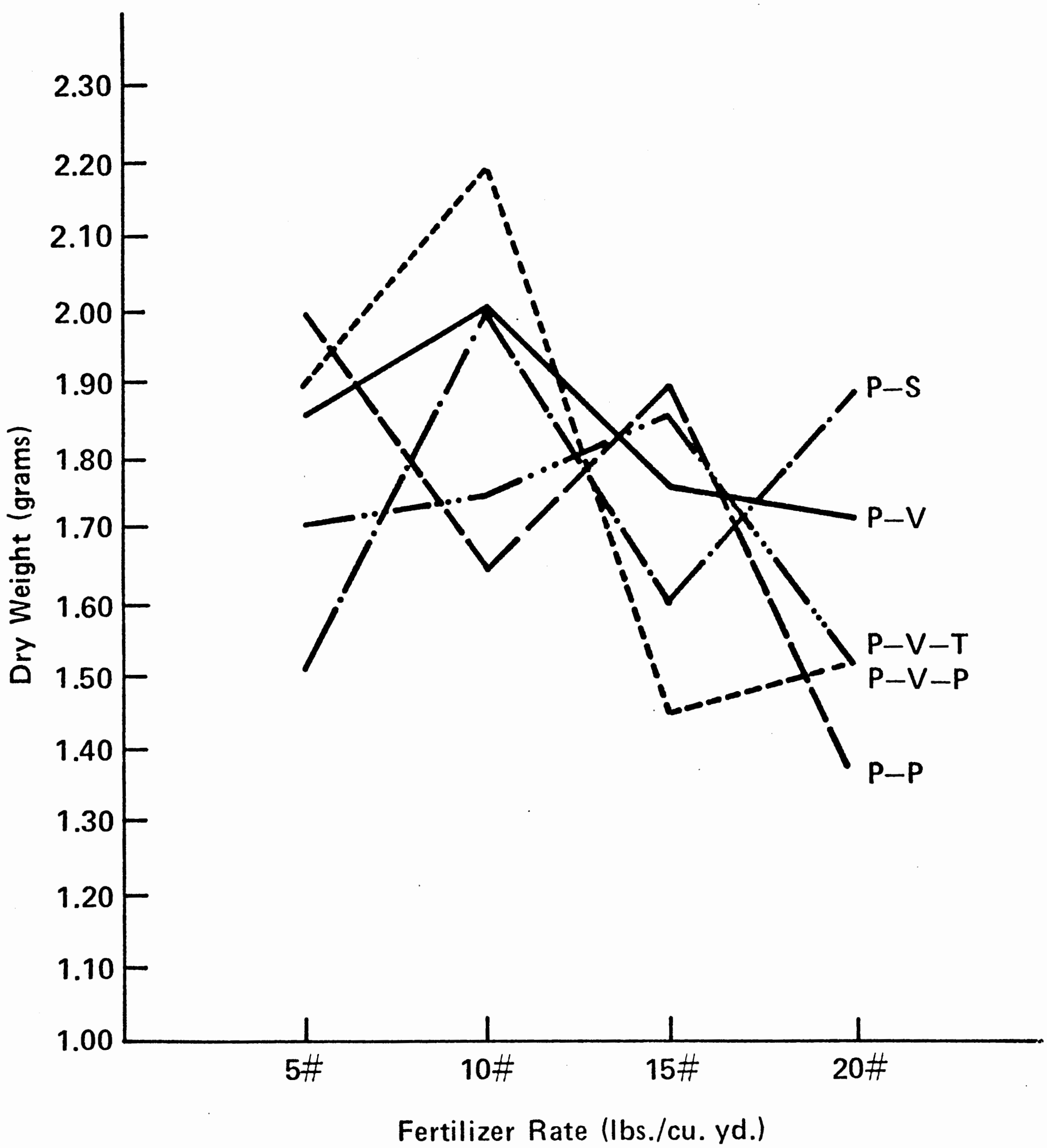

Figure 12. The Influence of Rate of Fertilizer and Type of Growing Medium on Dry Weight in the Spring

of growth media on plant dry weight was varied and no discernable pattern of influence was evident.

Study of the various means showed P-V-P at 10 pounds to result in the greatest mean dry weight (2.19 g.) while P-P at 20 pounds gave the lightest plants (1.35 g.).

Study of the main effects and interaction revealed that both fertilizer rate and media x fertilizer were highly significant (0.0047 and 0.0066 respectively), while that of growing media was clearly non-significant (0.71).

The trend analysis data in Table XII revealed several interesting facts. First, fertilizer rate had no significant effect on dry weight with the media P-V and P-V-T. Secondly, both P-S and P-V-P plants described cubic trends with the 10 pound rate resulting in the greatest dry weight for both media (1.98 g. and 2.19 g. respectively). Lastly, plants in P-P showed no statistical difference in response to 5, 10, or 15 pounds of fertilizer but did exhibit a reduction in dry weight at the 20 pound rate.

<u>Summer Crop</u>. As with top grade, the influence of growing media on dry weight was greatest at the lower fertility levels but was gradually reduced as increasing levels of nutrients were added (Table XIII, Figure 15).

P-V and P-V-P resulted in the heaviest plants at both 5 and 10 pound levels, 2.40 and 2.28 plus 2.64 and 2.71 grams respectively, while P-P and P-S rose from the lower category at five pounds to the intermediate category at the 10 pound level. P-V-T yielded the lightest plants at all fertilizer rates except 20 pounds.

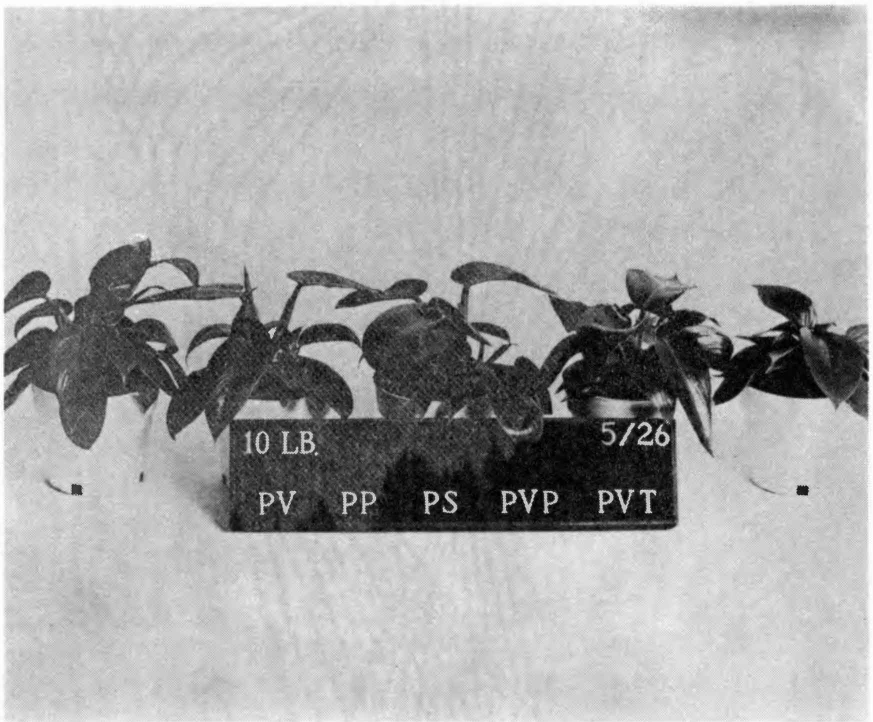

Figure 13. The Influence of Growing Media on the Spring Crop of Philodendron hastatum at the 10 Pound Fertilizer Rate (Plants Shown at Termination--12 Weeks from Transplanting)

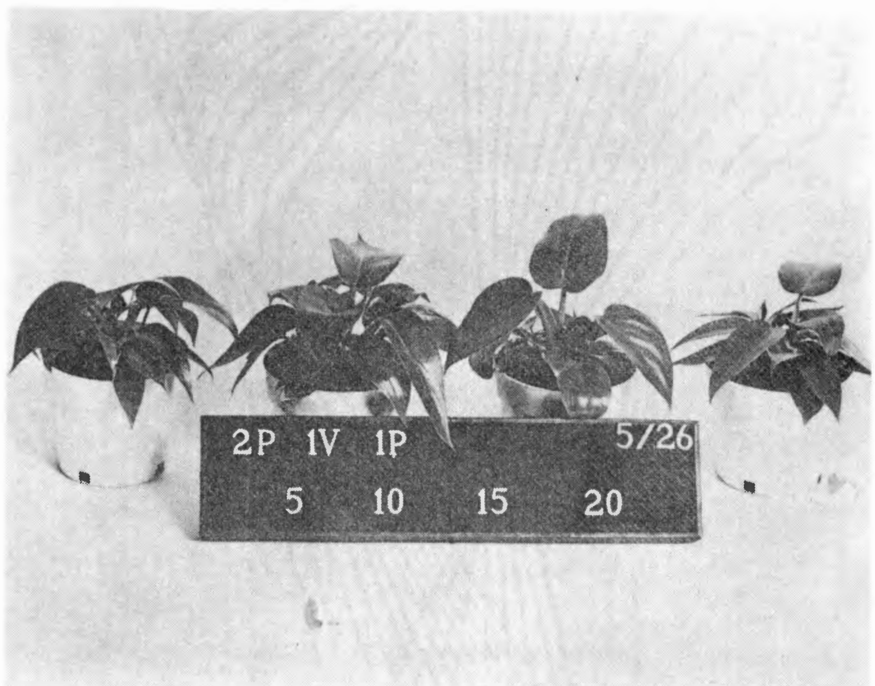

Figure 14. The Influence of Fertilizer Rate on the P-V-P Treatment of <u>Philodendron hastatum</u> in the Spring Crop (Plants Shown at Termination--12 Weeks from transplanting)

TABLE XIII

ANALYSIS OF DRY WEIGHT (g) IN RELATION TO RATE OF FERTILIZER AND TYPE OF GROWING MEDIUM IN THE SUMMER CROP[w]

Rate of Osmocote 14-14-14 (lbs./cu.yd.)	Growing Media				
	PV	PP	PS	PVP	PVT
5	2.40b[z]	1.42[a]	1.34[a]	2.28[b]	0.95[a]
10	2.64[c]	1.80[b]	2.15[bc]	2.71[c]	1.14[a]
15	2.48[b]	1.24[a]	2.15[b]	1.96[b]	1.20[a]
20	2.13[b]	1.09[a]	2.14[b]	1.60[ab]	1.93[b]

[w]Significance of main effects, trends, and interactions:

	PV	PP	PS	PVP	PVT
Fertilizer Rate	0.0387				
Linear	.52	.30	.11	.06	.04
Quadratic	.37	.41	.21	.23	.42
Cubic	.89	.37	.58	.28	.59
Growing Media	0.0001				
Media x Fertilizer	0.0078				

[z]Means across rows (left-to-right) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing media means within the same rate = 0.65.

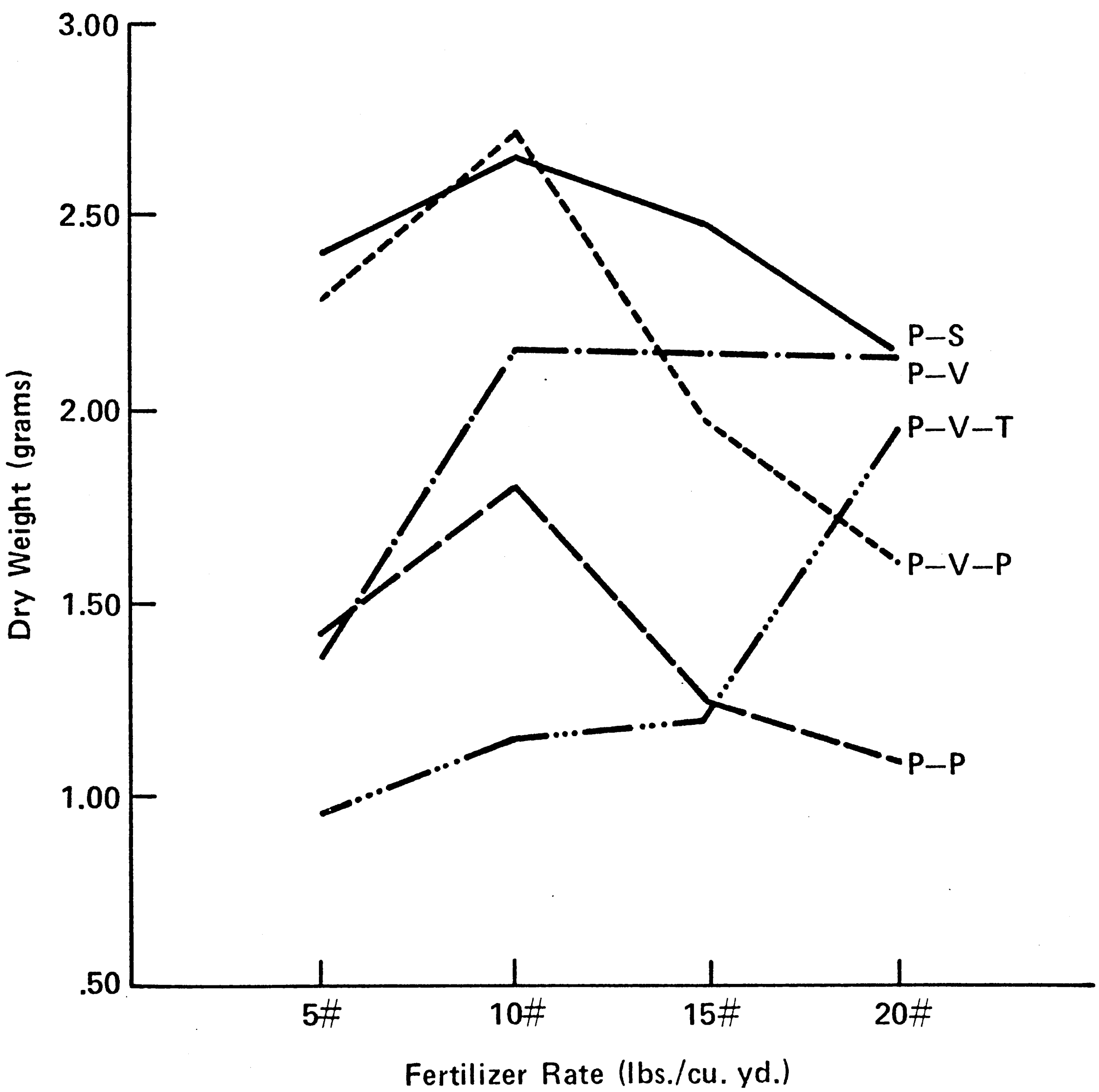

Figure 15. The Influence of Rate of Fertilizer and Type of Growing Medium on Dry Weight in the Summer

There was little difference between media at the 20 pound rate except P-P which was significantly lower with a mean dry weight of only 1.09 grams.

Table XIII indicated that the main effects of fertilizer rate and growing media were significant as was the media x fertilizer interaction.

Study of the trend analysis data in this table showed that fertilizer rate had no significant effect on mean dry weight of plants grown in P-V, P-P, P-S, or P-V-P. Examination of the actual mean dry weights showed that the 10 pound rate yielded the heaviest plants in these particular media, however.

An increasing linear trend was apparent for P-V-T with the greatest plant dry weights in this media (1.93 grams) occurring at the 20 pound rate.

Nitrogen Content

Spring Crop. As with top grade and dry weight (summer crop), there were striking differences in media influence on nitrogen content at lower fertilizer rates, but few if any differences at the highest rates (Table XIV, Figure 16).

At the five pound rate, P-P, which exhibited the highest root grade at this particular rate, also resulted in the greatest nitrogen content (4.15). P-S, conversely, had the poorest root grade and the lowest nitrogen content (2.17) while plants in P-V-T, P-V-P, and P-V gave intermediate results. A similar trend was evident at the 10 pound rate as well.

As the level of fertility rose to 15 and 20 pounds however, there were no longer any significant differences in nitrogen content due to the various media.

TABLE XIV

ANALYSIS OF NITROGEN CONTENT OF PLANT TISSUE IN RELATION TO RATE OF FERTILIZER AND TYPE OF GROWING MEDIUM IN THE SPRING CROP[w]

Rate of Osmocote 14-14-14 (lbs./cu.yd.)	Growing Media				
	PV	PP	PS	PVP	PVT
5	3.20b[z]	4.15[c]	[y]2.17$^{a}_{m}$	3.36[b]	3.43[b]
10	4.06[ab]	4.54[b]	3.80$^{a}_{n}$	4.18[ab]	4.30[ab]
15	4.30[a]	4.56[a]	4.49$^{a}_{o}$	4.33[a]	4.54[a]
20	4.59[a]	4.52[a]	4.72$^{a}_{o}$	4.72[a]	4.60[a]

[w]Significance of main effects, trends, and interactions:

Fertilizer Rate	0.0001				
	PV	PP	PS	PVP	PVT
Linear	.0001	.29	.0001	.0002	.0008
Quadratic	.23	.37	.005	.37	.10
Cubic	.52	.79	.64	.40	.67
Growing Media	0.0019				
Media x Fertilizer	0.0048				

[z]Means across rows (left-to-right) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing media means within the same rate = 0.60.

[y]Means within a given medium (top-to-bottom) followed by different subscripts are significantly different at the five percent level. $LSD_{.05}$ for comparing fertilizer means within the same medium = 0.60.

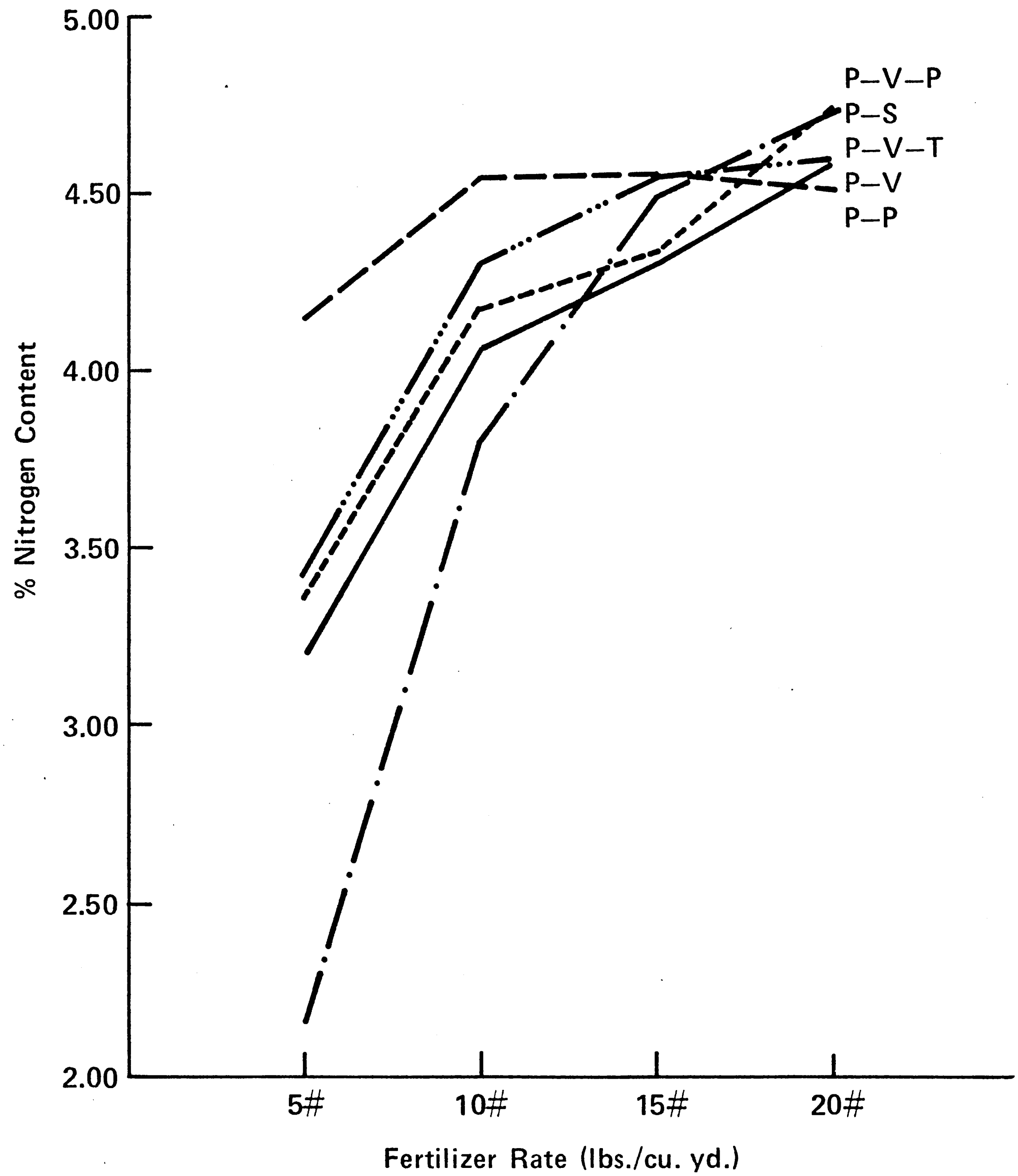

Figure 16. Influence of Rate of Fertilizer and Type of Growing Medium on Nitrogen Content in the Spring

One possible explanation for the general trend of dramatic differences between media at lower fertilizer rates with few if any differences at higher rates could be based on the aeration of the various media and its effect on root development. At lower fertilizer rates, the more extensive, better developed root systems in the well-aerated media such as P-P could physically contact and absorb more of the limited nutrients. As more and more fertilizer was added, plant nutrients flooded the system in a manner of speaking and even the poorly-developed root system in the media with low aeration could then absorb enough nutrients for adequate growth.

Both the main effects of fertilizer rate and growing media as well as media x fertilizer interaction were highly significant as to their effect on tissue nitrogen content.

The trend analysis data revealed several interesting facts. First, as fertility increased, the nitrogen content of plants grown in P-V, P-V-P, and P-V-T described a linear increase. Using the least significant difference technique as an interpretive aid, it was shown that the nitrogen content of plants grown in P-S rose as fertility increased to the 15 pound rate from which point it remained relatively steady through the 20 pound rate. Lastly, the trend analysis indicated lack of a significant fertilizer response for those plants produced in P-P (Table XIV).

Summer Crop. As in the spring crop, differences in nitrogen content due to growing media were more striking at the lower fertility rates (Table XV, Figure 17).

At the five pound rate, plants grown in P-V-P, P-P, and P-V (the better aerated media) gave significantly higher readings, 4.49, 4.29,

TABLE XV

ANALYSIS OF NITROGEN CONTENT OF PLANT TISSUE IN RELATION TO RATE OF FERTILIZER AND TYPE OF GROWING MEDIUM IN THE SUMMER CROP[w]

Rate of Osmocote 14-14-14 (lbs./cu.yd.)	Growing Media				
	PV	PP	PS	PVP	PVT
5	3.92[z]	4.29[b]	1.87[a]	4.49[b]	2.44[a]
10	4.59[c]	4.32[c]	2.01[a]	4.57[c]	3.24[b]
15	4.16[b]	4.65[b]	3.00[a]	4.26[b]	4.03[b]
20	4.72[b]	4.96[b]	3.29[a]	4.29[b]	4.44[b]

[w]Significance of main effects, trends, interactions:

Fertilizer Rate	0.0001				
	PV	PP	PS	PVP	PVT
Linear	.39	.30	.02	.69	.004
Quadratic	.92	.78	.88	.95	.70
Cubic	.36	.88	.49	.75	.87
Growing Media	0.0001				
Media x Fertilizer	0.01				

[z]Means across rows (left-to-right) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing media means within the same rate = 0.80.

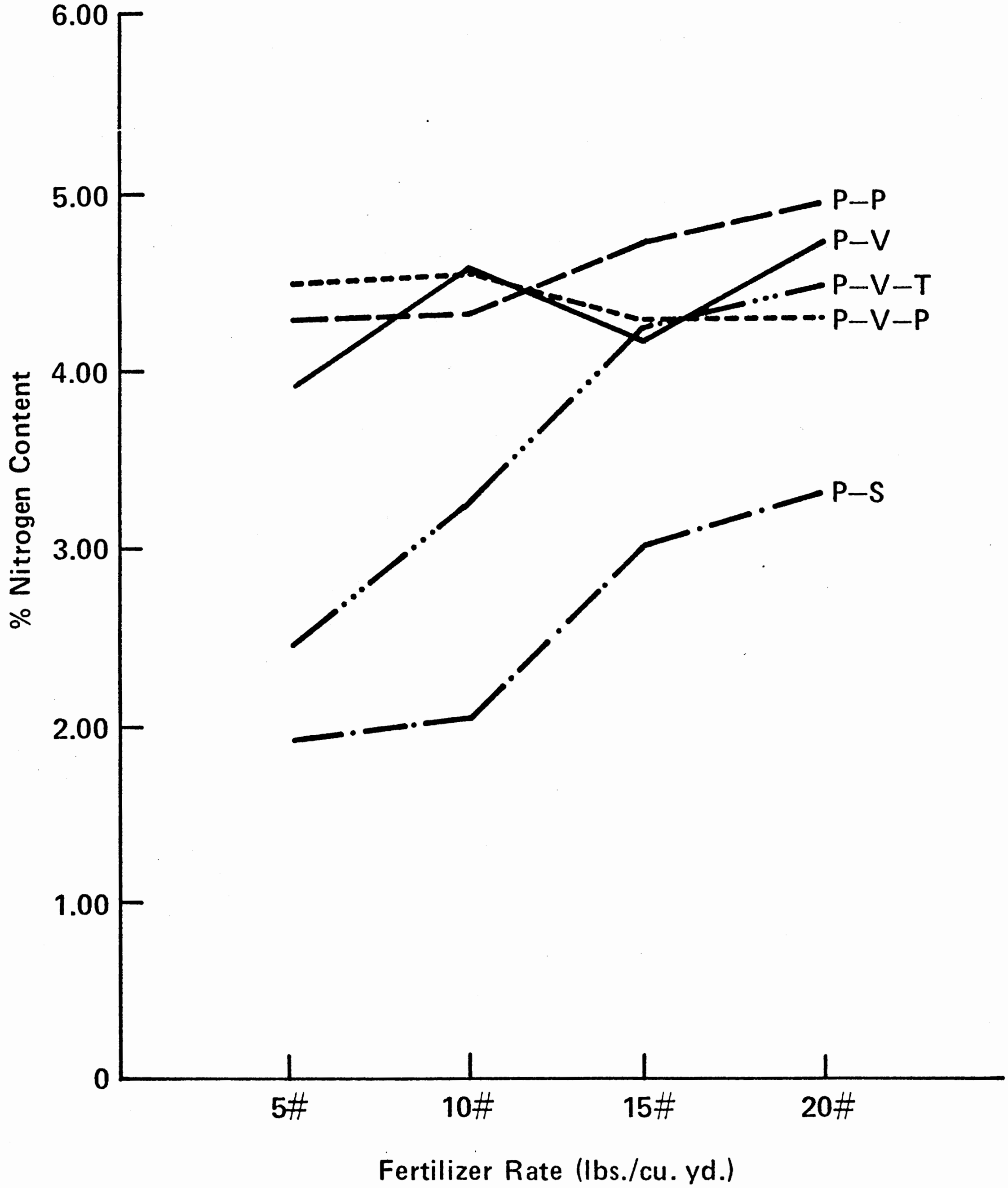

Figure 17. Influence of Rate of Fertilizer and Type of Growing Medium on Nitrogen Content in the Summer

and 3.92 percent respectively, than did those in the poorly-aerated media of P-V-T and P-S (readings of 2.44 and 1.87)(Table XV).

A similar trend was apparent at the 10 pound rate with the only change being that the philodendrons in P-V-T then gave a significantly higher reading (3.24) than did those in P-S (2.01).

At the 15 and 20 pound rates, the effect of growing media on nitrogen content was very similar except with P-S which lagged behind at both rates.

As was expected, the main effects and interaction were all significant, but the trend analyses highlighted an interesting fact. The only media which showed an increase in tissue nitrogen content with increasing fertility levels were P-S and P-V-T--the two poorly-aerated media. The nitrogen content of plants grown in media with greater aeration, P-V, P-P, P-V-P, showed no significant response to fertility levels.

pH

Summer Crop. In direct contrast to the results in several other growth or quality categories, the influence of media on pH was greater at the higher fertility levels (Table XVI, Figure 18).

Another change was the fact that the more poorly-aerated media were characterized by higher pH readings. The media could be ranked from highest to lowest pH as follows: P-S, P-V-T, P-V, P-V-P, and P-P (with pooled means of 6.76, 6.48, 6.38, 6.20, and 6.03 respectively). An inverse relationship seemed to exist between pH and percent air space of the various media.

Another facet of media influence on pH concerned the possibility of increased alkalinity due to the presence of sand and turface.

TABLE XVI

ANALYSIS OF pH IN RELATION TO RATE OF FERTILIZER AND TYPE OF GROWING MEDIUM IN THE SUMMER CROP[w]

Rate of Osmocote 14-14-14 (lbs./cu.yd.)	Growing Media					Arithmetic Means of Fert. Rates[y]
	PV	PP	PS	PVP	PVT	
5	6.65	6.55	6.98	6.43	6.93	6.71[c]
10	6.38	5.98	6.80	6.25	6.55	6.39[b]
15	6.38	6.20	6.65	6.43	6.33	6.40[b]
20	6.10	5.38	6.60	5.70	6.10	5.98[a]
Pooled Arithmetic Means[z]	6.38[bc]	6.03[a]	6.76[d]	6.20[ab]	6.48[c]	

[w]Significance of main effects, trends, and interaction:

	PV	PP	PS	PVP	PVT
Fertilizer Rate	0.0001				
Linear	.05	.0003	.13	.02	.002
Quadratic	1.00	.51	.74	.15	.69
Cubic	.51	.03	.92	.14	.86
Growing Media	0.0001				
Media x Fertilizer	0.09				

[z]Means within row (left to right) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing media means = 0.18. Means thus displayed are arithmetic means of logarithmic functions. All Osmocote rates are pooled.

[y]Means within this column (top-to-bottom) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing fertilizer means = 0.17. Means thus displayed are arithmetic means of logarithmic functions.

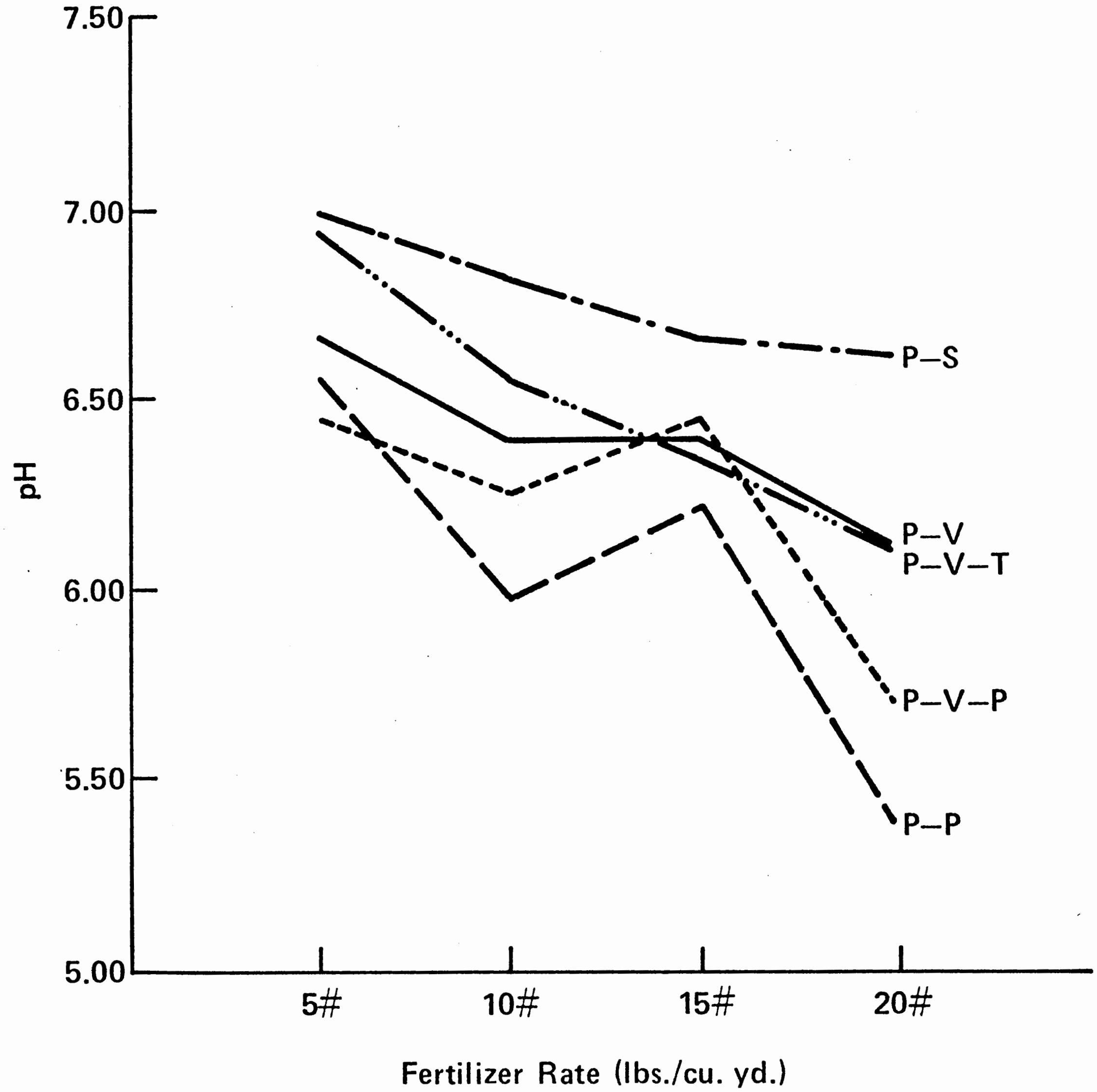

Figure 18. Influence of Rate of Fertilizer and Type of Growing Medium on pH in the Summer

As indicated in Table XVI, the main effects of fertilizer rate and growing media were highly significant while media x fertilizer interaction was not statistically significant.

Close examination of the pooled fertilizer rate means revealed an inverse relationship between fertility level and media pH, that is, as more fertilizer was added the media became more acid. The five pound fertilizer rate resulted in the highest pH reading (6.71) while the 20 pound rate gave the lowest (5.98). There was no significant difference in pH between the 10 and 15 pound treatments (6.39 and 6.40 respectively).

Total Soluble Salts

Summer Crop. With the exception of P-V-P at the 15 pound rate, there was no significant difference in total soluble salt content of P-V, P-P, P-V-P, and P-V-T at any of the various fertility levels (Table XVII, Figure 19). P-S, however, contained dramatically lesser amounts of total soluble salts at the majority of fertility levels. An average of the pooled means of P-V, P-P, P-V-P, and P-V-T (individual pooled means of 56.44, 53.88, 50.50, and 55.94) equalled 54.19 compared to only 17.94 for P-S.

A combination of factors could explain the reduced salt levels in P-S. First, P-S showed a very high leval of water retention (89.2 percent compared to 78 percent for P-V and P-V-P and 63.4 percent for P-P) which would tend to dilute any salts present. Furthermore, sand is known for its low nutrient retention against leaching influence and observation of initial algal growth on the mats indicated that at least some leaching was taking place in the capillary mat system. Following

TABLE XVII

ANALYSIS OF TOTAL SOLUBLE SALTS (MHOS X 10^{-5}--1:5 DILUTION) IN RELATION TO RATE OF FERTILIZER AND TYPE OF GROWING MEDIUM IN THE SUMMER CROP[w]

Rate of Osmocote 14-14-14 (lbs./cu.yd.)	Growing Media PV	PP	PS	PVP	PVT	Means of Fert.Rates[y]
5	47.25	37.25	17.75	41.25	32.00	35.10[a]
10	52.50	49.50	13.50	53.00	53.00	44.30[ab]
15	62.25	55.50	21.00	38.25	74.25	50.25[bc]
20	63.75	73.25	19.50	69.50	64.50	58.10[c]
Pooled Means[z]	56.44[b]	53.88[b]	17.94[a]	50.50[b]	55.94[b]	

[w]Significance of main effects and interaction:

Fertilizer Rate	0.0014				
	PV	PP	PS	PVP	PVT
Linear	.27	.03	.81	.19	.02
Quadratic	.87	.81	.90	.41	.20
Cubic	.81	.73	.69	.17	.56
Growing Media	0.0001				
Media x Fertilizer	0.33				

[z]Means within row (left-to-right) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing media means = 12.46. All Osmocote rates are pooled.

[y]Means within this column (top-to-bottom) followed by different letters are significantly different at the five percent level. $LSD_{.05}$ for comparing fertilizer means = 11.11.

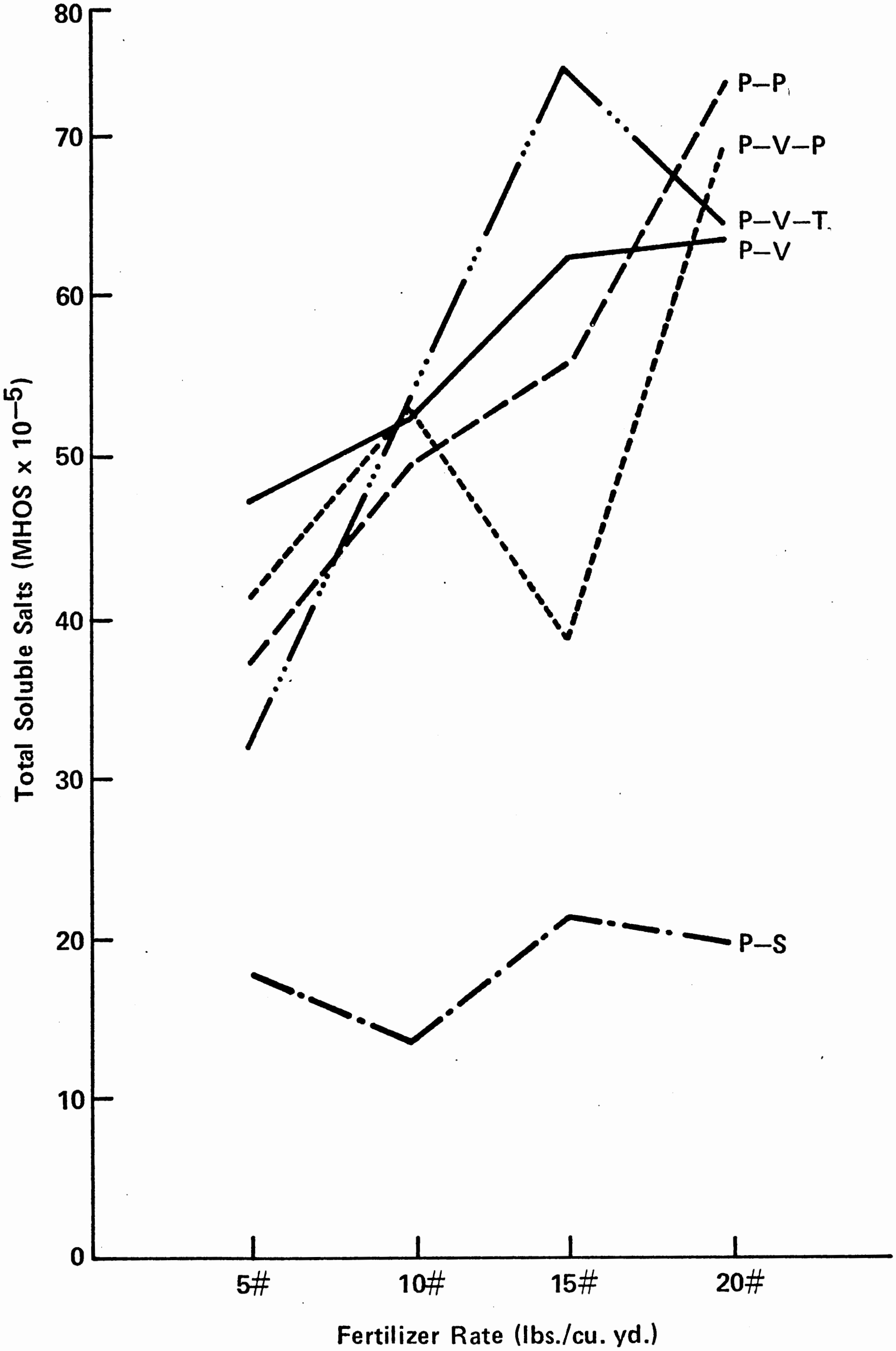

Figure 19. Influence of Rate of Fertilizer and Type of Growing Medium on Total Soluble Salts in the Summer

the dilution line of reasoning, one would expect P-V-T (92.4 percent water retention) to also exhibit reduced salt levels but such was not the case. However, it must be remembered that calcined clay has a tremendous amount of both internal and external surface area and it was thought that this increased surface area captured many of the dissolved salts thus preventing their loss through leaching.

As with pH, the main effects of fertilizer rate and growing media were highly significant while the media x fertilizer interaction was clearly non-significant.

The pooled means of the various fertilizer rates showed a positive linear trend of 35.10, 44.30, 50.25, and 58.10 MHOS x 10-5 for 5, 10, 15, and 20 pound fertilizer rates respectively (Table XVII).

Total Soluble Salts and pH Levels of Root Balls Separated Into Thirds

In an attempt to determine if and where in the root ball appreciable amounts of fertilizer salts were collecting, eight root balls were separated into thirds--top, middle, and bottom, with each third then being analyzed for total soluble salt and pH levels.

As shown in Table XVIII and Figure 20, very significant differences did exist. The top layer of media showed a dramatic increase in total soluble salts (average of 52 MHOS x 10-5) as compared to the bottom and middle layers (13.88 and 9.88 MHOS x 10-5 respectively). These results indicated that fertilizer salts were indeed being concentrated in the upper regions of the root zone, presumably through capillary action and evaporation.

TABLE XVIII

MEAN SOLUBLE SALT AND pH LEVELS OF ROOT BALLS SEPARATED INTO THIRDS

Treatment	Block and Pot No.	A Total Soluble Salts (MHOS x 10^{-5})			B Media pH		
		Top	Middle	Bottom	Top	Middle	Bottom
P-S 10#	1-38	22	07	01	6.5	7.1	7.1
P-S 10#	2-38	23	00	10	6.4	7.0	7.2
P-S 10#	3-38	27	02	10	6.4	6.9	7.1
P-S 10#	4-40	23	01	01	6.5	7.0	7.2
P-V-P 10#	1-53	161	34	25	5.4	6.6	6.8
P-V-P 10#	2-56	50	08	22	5.8	6.9	6.9
P-V-P 10#	3-53	35	13	24	6.1	7.2	7.2
P-V-P 10#	4-56	75	14	18	5.7	7.1	7.3
Mean Values		[y]52b	9.88a	13.88a	[z]6.10a	6.98b	7.10b

[y]Means across row (left-to-right) followed by different letters are significantly different at the five percent level. LSD$_{.05}$ = 29.97.

[z]Means across row (left-to-right) followed by different letters are significantly different at the five percent level. LSD$_{.05}$ = 0.29. Means thus displayed are arithmetic means of logarithmic functions.

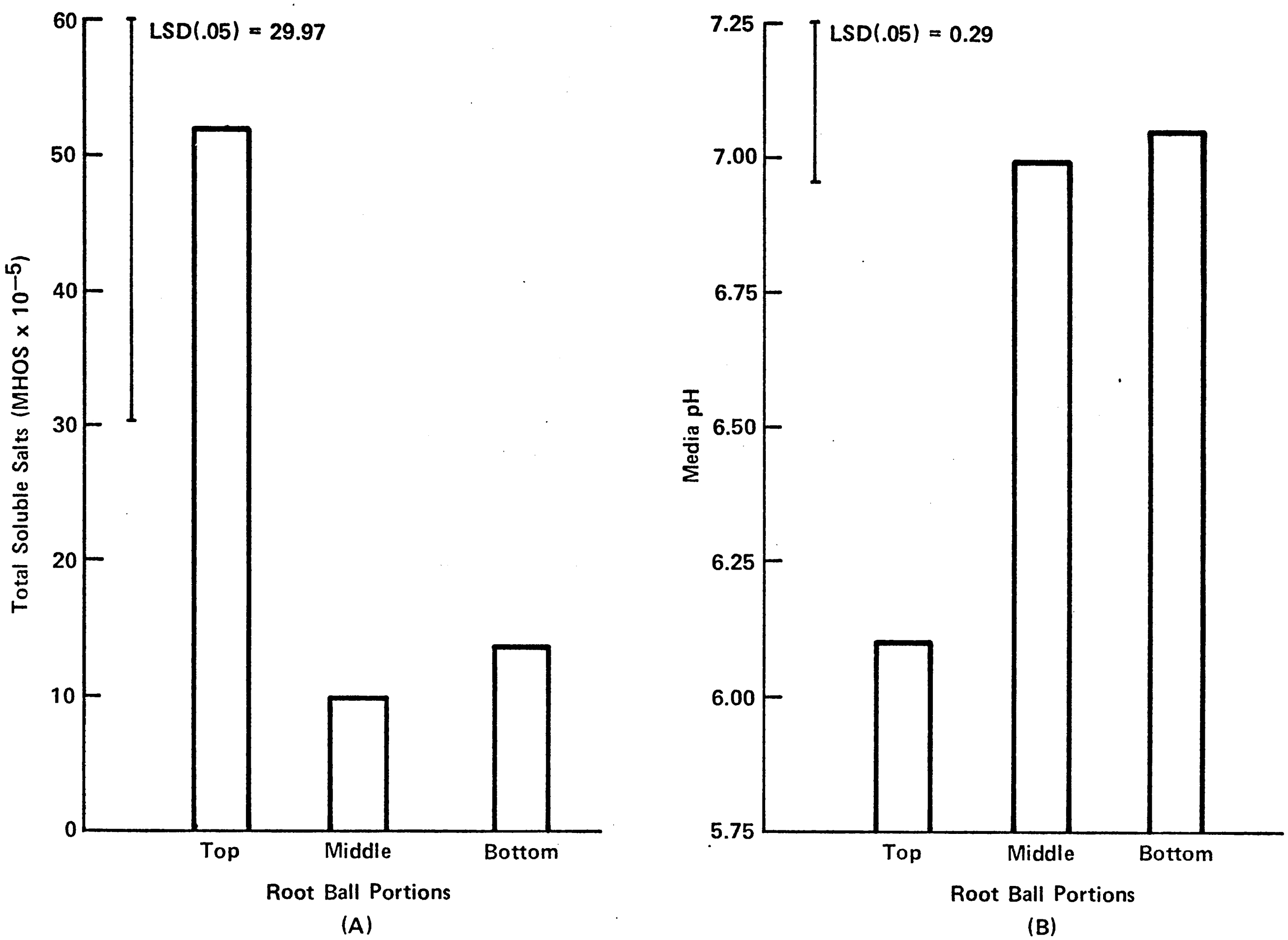

Figure 20. A Comparison of Mean Soluble Salt and pH Levels of Root Balls Separated Into Thirds--(A) Mean Soluble Salt Levels, (B) Mean pH Levels (arithmetic means of logarithmic functions)

The significantly reduced pH of the top layer also supports this deduction as earlier data (Table XVI) illustrated the inverse relationship between fertilizer rate and pH.

CHAPTER IV

PRINCIPAL CONCLUSIONS

In an attempt to more concisely summarize the information gleaned from this study, the principal conclusions will be listed in a condensed form.

Percent Air Space of Growth Media

P-P was the most highly aerated (23.47 percent) with P-V and P-V-P possessing very adequate amounts of air space at 14.11 and 13.28 percent respectively. P-S and P-V-T, however, were relatively poorly aerated (5.03 and 4.68 percent).

Biweekly Growth Measurements

The effect of growth media on number of leaves was quite variable between the spring and summer crops. However, P-V seemed to result in consistently higher leaf counts in both crops. When the influence of growth media on stem height was analyzed for both crops, P-V-T often resulted in shorter plants while P-S gave rise to taller plants until the latter weeks of the study. P-V gave plant heights at or near the top range during both seasons.

When significant differences in leaf counts due to fertilizer rate did occur, the lower rates, 5 and 10 pounds, resulted in more leaves while 15 and 20 pounds gave low to intermediate leaf counts. Fertilizer rate had a very significant effect upon stem height, with both crops showing taller plants with the 10 pound rate, shorter plants with the 15 and 20 pound rates.

Final Growth and Quality Results

Top Grade

The differences in top grade due to growth media were most apparent at the lower fertilizer rates, then seemed to diminish at higher rates. Furthermore, it was the better-aerated media, such as P-P in spring and P-V, P-P, and P-V-P during the summer, which resulted in higher quality ratings at the low to medium rates of fertilizer. One possible explanation for this general trend was that the better-aerated media, such as P-V-P and P-P, encouraged such superior root systems (Tables X and XI, Figures 10 and 11) that their roots were able to reach out further to contact more of what limited fertilizer was present at the lower rates. As the fertilizer rate increased, however, even the sparse roots in the more poorly aerated media, such as P-S, were able to contact sufficient nutrients to sustain adequate growth.

The best top grades recorded were with P-V-P at 10 pounds in spring (2.81) and P-V and P-V-P at 10 pounds in summer (3.25 and 3.13). The poorest top grades for both crops occurred in P-S at five pounds (1.25 and 1.19 respectively).

The influence of fertilizer rate on top grade was variable with several media showing no significant response. For those media which did respond, the 10 pound rate often gave top grades as high or higher than those of other rates. An exception was P-S and P-V-T, two poorly aerated media, which showed an increasing linear response to fertilization during the summer crop.

It is important to note that those plants receiving the higher top grade rankings were very impressive in terms of foliage development, foliage color and overall eye appeal.

Root Grade

In both the spring and summer crops, growing media exerted considerable influence on root grade with this influence strongly linked to the aeration levels of the various media.

For example, P-P, P-V, and P-V-P, the better aerated media (23.5, 14.0, and 13.3 percent air space respectively) resulted in the highest root grade readings for both crops. P-V-T (4.7 percent air space), however, gave low to intermediate readings while P-S (5.0 percent air space) resulted in consistently low readings throughout the experimental periods.

The importance of a healthy, well-developed root system to optimum plant performance during the production phase is a basic tenet of horticultural science. An interesting example of this principle in these studies was the fact that the more extensive root systems in the better aerated media could more effectively utilize reduced rates of fertilizer. This advantage looms large in the face of current petroleum shortages. Well-developed root systems would also be extremely important to plant performance in the low humidity conditions of the average home environment and thus a major factor in customer satisfaction.

One very striking discovery of the root grade studies was the fact that fertilizer rate had no significant effect on root grade in any of the growing media.

Dry Weight

While growing media had little effect on dry weight in the spring, P-V and P-V-P often resulted in heavier plants during the summer crop, especially at the lower rates of fertility.

Fertility levels seemed to vary in their impact between the two crops but a study of the raw data indicated the 10 pound rate often resulted in the heaviest plants in most media. The two treatments giving the greatest dry weights in both seasons were P-V-P and P-V at the 10 pound rate.

Nitrogen Content of Plant Tissue

As with top grade and dry weight (summer crop), there were dramatic differences in the influence of growing media on nitrogen content at lower fertilizer rates, 5 and 10 pounds, but little or no difference at the higher rates (except P-S in summer which was consistently low at all rates).

In general, the better-aerated media, P-V, P-P, and P-V-P, gave the greatest nitrogen levels at the lower rates, with P-V-T being low to intermediate and P-S consistently low. As with top grade, perhaps the more extensive root systems present in the better aerated media could more effectively collect and utilize nutrients at lower fertilizer rates while at higher rates, nitrogen "flooded" the system to the extent that even poorly developed root systems could garner needed nutrients.

Study of fertilization's influence on nitrogen content showed a linear increase for the majority of the media in the spring crop while only the poorly-aerated media, P-S and P-V-T, gave such a response, or indeed any response, during the summer season.

pH of Growing Media

pH levels of the various growing media exhibited somewhat different patterns than those present in other growth or quality categories.

First, the influence of media on pH was greater at higher fertility levels. Secondly, the more poorly-aerated media were characterized by higher pH readings.

Examination of the pooled fertilizer means revealed an inverse relationship between fertilizer rate and media pH, that is, as more fertilizer was added the media became more acid (6.71 pH at 5 pound rate, 5.98 pH at 20 pound rate).

Total Soluble Salts

There was little difference between the various media in their influence on soluble salt levels except for P-S which gave consistently low salt readings. The dilution factor associated with a high level of water retention plus a low cation exchange capacity could account for the reduced salt levels present in P-S.

As indicated by pooled fertilizer means, there was a direct relationship between fertility level and total soluble salt levels.

pH and Total Soluble Salts of Root Balls Separated Into Thirds

These tests indicated conclusively that fertilizer salts were being concentrated in the upper third of the root ball, presumably through capillary action and evaporation. This would necessitate thorough leaching prior to shipment to preclude salt injury to roots.

Considering all factors of growth and quality, it appears that peat-vermiculite-perlite with the 10 pound rate of 14-14-14 Osmocote resulted in the best plant performance using this particular growth and irrigation system. Peat-vermiculute, 10 pounds, also gave outstanding results.

In general, this particular growing system performed quite well. The capillary mats proved capable of producing good quality, very salable P. hastatum with reduced labor and absence of foliar disease. The slow-release fertilizer provided adequate plant nutrition for three to four months.

In fact, once the system was assembled and in operation, its most striking feature was its production of quality plants with virtually no maintenance other than periodic pest control.

Thus, this system holds great potential for those growers lacking personnel experienced in the subtleties of proper watering and growers wishing to reduce labor costs. It is also ideally suited to the simultaneous production of plants in different size containers on the same bench and to the production of plants intolerant of cold water on their foliage, such as African violets.

There were problems encountered during the study--the most important of which was the accumulation of algae on the mats. This accumulation did not hinder operation of the mats; the major complaints concerned its unsightly appearance and its tendency to harbor fungus gnats. It is possible that the application of a fungicide to the mat itself would be helpful in controlling this algae. Secondly, while no salt injury was evident, it would be prudent to thoroughly leach the containers monthly during the production cycle and immediately prior to shipment to avoid even a remote possibility of salt injury.

Further study is definitely needed to specifically tailor media-fertilizer combinations to the production of other plant species on capillary matting.

LITERATURE CITED

1. Adam, Shivaun M. Influence of Rate and Placement of Slow-Release Fertilizer on Growth and Quality of Saintpaulia ionantha Wend. Pot Plants Grown with Capillary Mat Watering. (Unpublished Master's thesis, Oklahoma State University, 1977.)

2. Ball, Vic, ed. 1972. The Ball Red Book. 12th ed. Geo. J. Ball, Inc., West Chicago, Illinois.

3. Ball, Vic, ed. 1974. Mat Irrigation. Grower Talks, 38 (7):1-11.

4. Ball, Vic, ed. 1976. Cornell Research Day. Grower Talks, 39(12): 11-15.

5. Ball, Vic, ed. 1976. Ohio '76-Research Projects. Grower Talks, 39(11):1-26.

6. Barron, Hollis M. 1974. The Use of Slow-Release Fertilizers for Ornamental Crops. International Plant Propagators Soc. Proc., 24:221-229.

7. Barron, Hollis M. 1976. Controlled Release Fertilizer and Its Use in Hot Climates. Oklahoma Greenhouse Growers Newsletter. 43 (November-December):6-17.

8. Clark, David E., ed. 1959. Gardening in Containers. Lane Pub. Co., California.

9. Conover, C. A. 1972. Fertilization Practices for Foliage Plant Stock Production. Florida Foliage Grower, 9(3):6-7.

10. Conover, C. A., R. T. Poole, and R. W. Henley. 1973. Influence of Fertilizer-Amended Peat Used for Propagation of Selected Foliage Plants. Florida Foliage Grower, 10(6):1-3.

11. Conover, Charles A. and R. T. Poole. 1974. Foliage Plants for the Bedding Plant Grower. Grower Talks, 38(8):1-10.

12. Crockett, James Underwood. 1972. Foliage House Plants. Time-Life Books, New York.

13. Dickey, R. D. and J. N. Joiner. 1966. Identifying Deficiencies in Foliage Plants. Southern Florist and Nurseryman, 79(20): 38, 42-43.

14. Elstrodt, Charles J. and Daniel C. Milbocker. 1975. Root Development as Affected by Particle Sizes in Container Media. Southern Nurserymen's Assoc. Research Conf. 20th Annual Report (Sept.):36.

15. Everett, T. H., ed. 1973. New Illustrated Encyclopedia of Gardening. Greystone Press, New York, New York.

16. Furuta, Tok. 1976. Nitrogen Fertilization of Container-Grown Ornamentals. American Nurseryman, 142(12):14, 106-109.

17. Grimmer, W. W. 1975. Greenhouse Cost Accounting. Gateway Technical Institute, Wisconsin.

18. Hammer, P. A. and J. W. Boodley. 1968. Capillary Bench Watering of Pot Plants. (Abstract) N.Y. St. Flower Growers Bulletin, 275:1, 3-8.

19. Hasek, R. F. and R. H. Sciaroni. 1970. The Use of Osmocote Formulations in Commercial Potted Lily Production. Florists Review, 146:45, 84-88.

20. Henley, R. W. 1974. A Review of Fluoride Research on Tropical Foliage Plants. Florida Foliage Grower, 11(7):1-4.

21. Henley, R. W. 1975. Back to Basics--Soluble Salts. Florida Foliage Grower, 12(3):1-4.

22. Hogan, LeMoyne and James B. Shanks. 1966. Nutritional Studies on Philodendron cordatum. Amer. Soc. Hort. Sci., 86:662-671.

23. Johnson, C. R. and G. D. Warden. 1975. Influence of Rate and Placement of Osmocote on Growth of Container Grown Celosia argentia. Southern Nurserymen's Assoc. Research Conf. 20th Annual Report (Sept.):23.

24. Joiner, Jasper N. and R. D. Dickey. 1961. Effects of Nitrogen, Potassium and Magnesium Levels on Growth and Chemical Composition of the Lychee (Litchi Chinesis, Sonn.) Grown in Sand Culture. Amer. Soc. Hort. Sci., 77:270-277.

25. Kiplinger, D. C., Harry Tayama, and Hugh Poole. 1975. Pointers on Subirrigation of Potted Plants. Ohio Florists' Assn., Bulletin No. 551 (Sept.):5-7.

26. Klingman, G. L. 1975. Evaluation of Container Mediums. Southern Nurserymen's Assoc. Research Conf. 20th Annual Report (Sept.): 19.

27. Koths, Jay S. and Roy W. Judd, Jr. 1976. Capillary Watering. Connecticut Greenhouse Newsletter, 69:1-4.

28. Kramer, Paul J. 1963. Water Stress and Plant Growth. Agronomy Journal, 55:31-35.

29. Laiche, Adolph J., Jr. 1975. Growth of Container Woody Ornamental Plants Produces With a Slow Release Fertilizer and N Treated Composted Pine Bark and Supplemental K. Southern Nurserymen's Assoc. Research Conf. 20th Annual Report (Sept.):30.

30. Larson, Roy A. and Bobby G. Hilliard. 1976. Mat Irrigation Comparisons. Grower Talks, 39(12):16-23.

31. Lindstrom, Richard. 1975. A Comparison of Growth Rates Between Container Grown Azaleas Using Selected Medias With and Without a Slow Release Fertilizer. Southern Nurserymen's Assoc. Research Conf. 20th Annual Report (Sept.):38-39.

32. Milbocker, Dan and Charles J. Elstrodt. 1975. The Value of Graded Amendments in Container Media. Southern Nurserymen's Assoc. Research Conf. 20th Annual Report (Sept.):36.

33. Patel, S. I. and J. H. Tinga. 1974. Growth of Azalea and Wax Myrtle as Affected by Capillary Watering, Media Type and Depth. J. Amer. Soc. Hort. Sci., 99(2):180-182.

34. Paul, J. L. and C. I. Lee. 1976. Relation Between Growth of Chrysanthemums and Aeration of Various Container Media. J. Amer. Soc. Hort. Sci., 101(5):500-503.

35. Pierce, John H. 1975. Instant Solution-Capillary Watering. Plants Alive, 3(7):26-27.

36. Poole, R. T. and C. A. Conover. 1974. Media and Watering Effects on Aechmea fasciata. Florida Foliage Grower, 11(12):1-3.

37. Poole, R. T. and C. A. Conover. 1974. Nutritional Studies of Three Foliage Plants. Southern Nurserymen's Assoc. Research Journal 1(11):17-26.

38. Poole, R. T. and C. A. Conover. 1975. Current Research-Capillary Irrigation. Florida Foliage Grower, 12(8):4.

39. Poole, R. T., C. A. Conover, and D. B. McConnell. 1974. Fertilization of Philodendron selloum. Southern Nurserymen's Assoc. Research Journal 1(1):7-12.

40. Poole, R. E. and W. E. Waters. 1972. Media For Potted Plants. Florida Foliage Grower, 9(6):6-7.

41. Poole, R. T. and W. E. Waters. 1972. Production of Container-Grown Azaleas Under Slat Shade Using Osmocote Slow Release Fertilizer. Florida Foliage Grower, 9(2):1-2.

42. Post, Kenneth. 1949. Florist Crop Production and Marketing. New York: Orange Judd Publishing Co., Inc., 181-206.

43. Scarborough, E. F. and Jan Welch. 1974. Marketing Trends in Potted Foliage Plants. Florida Foliage Grower, 11(7):4-5.

44. Seeley, John G. 1948. Automatic Watering of Potted Plants. Amer. Soc. Hort. Sci., 51:596-604.

45. Self, R. L. 1975. Comparisons of Cedar, Mahogany, and Pine Shavings in Azalea Potting Mixtures. Soutern Nurserymen's Assoc. Research Conf. 20th Annual Report (Sept.):14.

46. Self, R. L. 1975. Fungicide Incorporation in Potting Soil. Southern Nurserymen's Assoc. Research Conf. 20th Annual Report (Sept.):56-57.

47. Sierra Chemical Company. Commercial Grower's Crop Sheet: Osmocote for Greenhouse Cut Flower Production of Chrysanthemums. Newark, California, 1971.

48. Sierra Chemical Company. Commercial Grower's Crop Sheet: Osmocote for Pot Plants. Newark, California, 1971.

49. Stephens, J. A. and E. C. Volz. 1951. The Growth of Stocks and China Asters on Four Iowa Soils with Constant-Level Subirrigation. Amer. Soc. Hort. Sci. Proc., 48:605-609.

50. VanLoon, G. J. and R. L. Cook. 1950. The Effect of Three Methods of Watering on the Production of Carnations in Several Soils and Soil Mixtures. Amer. Soc. Hort. Sci., 56:415-422.

51. Waters, W. E. and William Llewellyn. 1968. Effects of Coated Slow-Release Fertilizer on Growth Responses, Chemical Composition and Soil Salinity Levels for Philodendron oxycardium. Florida Foliage Grower 5(11):1-5.

52. Whitcomb, Carl E. 1975. Developing a Long-Term, Slow-Release Fertilizer for Container Production. Southern Nurserymen's Assoc. Research Conf. 20th Annual Report (Sept.):30-31.

53. Whitcomb, Carl E. 1975. Response of Ilex cornuta 'Burford' to Osmocote, Micronutrients, and Container Size. Southern Nurserymen's Assoc. Research Conf. 20th Annual Report (Sept.): 32-33.

54. Whitcomb, Carl E. 1976. Personal Communication. Dept. of Horticulture, Oklahoma State University, Stillwater, Oklahoma.

55. Wilfret, Gary J. and James L. Green. 1975. Mini-pot Garden Mums. Southern Nurserymen's Assoc. Research Conf. 20th Annual Report (Sept.):23-24.

VITA

Steven Wylie George

Candidate for the Degree of

Master of Science

Thesis: EFFECTS OF GROWING MEDIUM AND SLOW-RELEASE FERTILIZER ON DEVELOPMENT OF PHILODENDRON HASTATUM HORT. POT PLANTS GROWN WITH CAPILLARY MAT WATERING

Major Field: Horticulture

Biographical:

Personal Data: Born in Stillwater, Oklahoma, July 7, 1948, the son of Mr. and Mrs. Walter Skaggs.

Education: Graduated from Harrah High School, Harrah, Oklahoma, in 1966; received Bachelor of Science degree in Zoology from Oklahoma State University in 1970; completed the requirements for a Master of Science degree in Horticulture at Oklahoma State University in May, 1980.

Professional Experience: Graduate Teaching Assistant, Department of Horticulture, Oklahoma State University, 1977; County Extension Horticulturist, Kansas State University, 1977-1979; County Extension Horticulturist, Texas A & M University, 1979-present.