DETERMINATION OF AN ECONOMIC OPTIMUM FERTILITY AND CONTAINER VOLUME COMBINATION FOR SIX WOODY ORNAMENTAL SPECIES

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PREFACE

This study is concerned with cost and return comparisons for six common nursery species as influenced by changes in container volume or fertility. The primary objective is to determine the combination of slow-release fertilizer (18-6-12 Osmocote) and container volume which will return the highest profit for each species at the end of the growing cycle. An economic analysis system is developed and employed in translating empirical results of plant growth response to treatment into profit comparisons.

The author applauds the effort and patience expended by Dr. Carl E. Whitcomb in the pursuit of this study as his guidance was most essential in the completion of this manuscript. Appreciation is also expressed to Dr. Wayne Huffine and Steve Ownby who ably assisted as members of the graduate committee, and to Dr. Grant Vest who expedited completion of the final draft.

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CHAPTER I

INTRODUCTION

Within the framework of woody ornamental plant production, there exists a myriad of possible resource inputs and cultural techniques. In recent years, several researchers have concluded that many management systems will produce plants of equal quality. The challenge is to combine the most effective materials with a minimum of time, labor, and risk without sacrificing desirable plant appearance at the end of the growing cycle.

The container-grown woody ornamental industry is a vital economic force in many areas of the United States and Europe. In this country, refinement has been hindered by a demand which has exceeded supply since 1949, especially in the period from 1962 to the present (74). This phenomenon allowed commercial producers to disregard costs of operation, to a certain extent, as total production could be increased from year to year to offset losses on a per-unit basis (3, 4, 14, 37, 59). It has also allowed nurserymen to sell less than superior plant material, and become complacent toward production technique changes beneficial to his profits, plant quality, and the well being of the entire industry.

To reduce cost of production and increase profits, a nursery operator must have knowledge of present costs, ability to determine value of the finished product, and information on alternative cultural methods (3, 5, 57). Studies have shown that many growers are uninformed as to cost computation from records and thus base their selling price on competitor valuation or "hunch" (8, 48, 60). This practice dismisses the importance of cost differences between producers and provides a built-in penalty for those who do not or will not exercise cost control.

A further addition to the production dilemma is the lack of uniformity in assessment of the most important criterion in determination of plant value--quality. Researchers do not agree on the measurement of this parameter as experimental results are reported in terms of top growth, root growth, visual grade, growth index, fresh weight, dry weight, height, caliper, and spread. Growers feel that size is the most important factor, but caliper and visual appearance also influence salability (27). For the most universal understanding, results of any study must be presented in terms of as many qualitative and quantitative parameters as possible, regardless of personal preference.

A commercial grower has more control over variable cost than fixed cost. He cannot set wages below a minimum level or control taxes, insurance, and other non-production rates to benefit his profit structure. He can decide on which combinations of resources are optimum for production of the most profitable species.

By manipulating two of the crop-oriented cost variables, the intent of this study is to determine:

(1) the combination of slow-release fertilizer and container volume required to produce high quality plants of several species,

(2) the difference in response between species to changes in volume and slow-release fertilizer,

(3) a method to evaluate the economic advantage of one container size/fertility combination over another, for each of several species, using five physiological measurements to determine quality difference.

The main objective of any enterprise is to combine raw materials in the most economical fashion to produce a desirable finished commodity. If this objective "maximum economic growth" (6) is attained, maximum profit is achieved for that product within a particular pricing structure. Managers of container ornamental nurseries who do not face this basic fact will soon experience failure in an industry that becomes more competitive every year (57).

CHAPTER II

REVIEW OF LITERATURE

Nutrition

Research on container-grown woody ornamentals often deals with plant nutrition. The problem has been determining the rate, proportion, and form of fertilizer materials most beneficial to plant growth (11, 17, 32, 35, 39, 40, 41, 42, 43, 45, 46, 51, 54, 56, 68).

Studies have concluded that form and rate of nitrogen affects plant growth more than form and rate of any other nutrient element (7, 9, 17, 21, 22, 34, 40, 42, 53, 62, 63, 76). However, disagreement exists as to which source or nitrogen level is optimum. In a review of nutrition research, Dirr (27) noted that no concrete recommendations could be made as to best levels for production.

A lack of uniformity in culture between researchers has created some of the confusion. While some have reported superiority of one growing system over the others, Carter (15) and others (36, 42, 49, 64), observed that many systems exist which will produce plants of similar quality. As early as 1955, Matkin (49) found it neceesary to alter the rate of nitrogen to achieve equal plant quality when components of the growing medium were changed. Since then, others have observed that to maintain plant quality it is necessary to modify some facet of culture, generally nutrition, when a change is made in another (30, 31, 33, 61, 64, 71, 78).

Inconsistency in fertility research has also been attributed to response differences between species. Whitcomb (80, 81) and others (16, 26, 32, 39, 41, 43, 63, 70) observed the nutrition level for optimum growth was not the same for all species when other cultural factors were equal.

Therefore, it is apparent that specific recommendations on level or source of plant nutrients must not be generalized over all growing conditions and species.

Container Volume

Effects of container volume (size) on growth response have not been intensively investigated, although response to increase in volume of growing medium has been reported in propagation and production phases by some researchers.

Bisher and Whitcomb (10) observed better overall growth of viburnum cuttings under mist in 3½-inch square pots than in 2¼-inch square pots. Davis and Whitcomb (18) found 2½-inch square pots superior to 1½ or 2-inch square pots for Japanese black pine, Chinese pistache, and western soapberry seedlings during initial growth after germination. Funk (30) noted better top and root weight of black walnut seedings as volume increased. Brown (12) observed a suppression of later growth for azalea and ligustrum cuttings held too long in 2½-inch square pots, while Japanese and dwarf Burford holly and camellia liners were not affected.

In the production phase, research seems to indicate response to container size is dependent on the level of fertility. A change in container size will influence growth only after the basic nutritional requirements of the plant are met. Laiche (44) found no difference in growth indices or plant color of photinia or azalea grown in three or five gallon containers and amended with 7.5 to 12 lbs 18-6-12 Osmocote per cubic yard. In a two-year study, Dickey (19, 20) and Dickey and Poole (2) found significant increase in growth index for podocarpus, ligustrum, and azalea as volume increased form one quart to two gallons. However, fertility was calculated on a rate per acre basis, and not all container sizes received the same absolute amount of nitrogen, phosphorus or potassium from liquid feeding. All species responded in a similar manner.

In further research by Dickey and Poole (24, 25), after nine months, ligustrum and azalea growth was best at 540 lb N/acre/yr in a two-gallon container. After eighteen months, ligustrum was largest in two-gallon containers with 360 or 540 lb N/acre/yr while azalea showed no difference between one or two-gallon containers with 540 lb N/acre/yr. The low rates of all nutrients supplied to these plants restricted growth severely, thus limiting the validity of the container comparison.

In a series of experiments, Whitcomb (77, 78, 79, 80) found an overall increase in dwarf Burford holly growth as container volume increased to 680 cubic inches of growing medium and fertilization reached 2000 lb N/acre/yr, while juniper growth increased with volume to 680 cubic inches and 3500 lb N/acre/yr as supplied by 18-6-12 Osmocote.

Whitcomb and Hathaway (81) found an increase in growth of Hetzi juniper as container volume increased to 380 cubic inches, while evergreen euonymus increased in size to only 207 cubic inches. The response to fertility failed to increase for juniper beyond 15 grams

18-6-12 Osmocote per container while response continued up to 24 grams for euonymus.

Each of the above studies was conducted in containers which varied in depth as volume increased. This increase in depth may have been as important in subsequent plant response as the larger volume of growing medium. Studies by Matkin (50), Green (36), and many others (13, 28, 29, 31, 33, 47, 58, 73, 75, 82) determined that a decrease in container depth will decrease the amount of growing medium in which moisture and oxygen dispersal is favorable for root growth. In contrast, Hathaway and Whitcomb (38) observed no difference in top growth or root growth response of Shumard oak seedlings as container depth decreased from 11 inches to 5½ inches with a constant container surface area.

Differences seem to exist between species as to requirements for volume of medium and rate of fertilization. Nutrition seems the most important factor of the two, although research indicates a response from some species to larger volumes when basic fertility requirements have been satisfied.

Growth and Economics

Studies on cost and return of container-grown ornamentals are generally restricted to reviewing trends over a period of time (1, 2, 3, 4, 14, 37, 59, 74) or determining where costs are incurred and how to reduce them. Several researchers (6, 29, 55, 57, 60) have observed that no universal cost of production or return exists in the nursery industry. This lack of uniformity restricts the application of one set of production costs to another set of circumstances.

Alysworth and Gartner (6) and Cake (14) state that cost of production depends on labor, type and quantity of fertilizer, and efficient use of all resource inputs. Perkins (59) and McGuire (52) observed that the amount of profit returned by a plant for a given period of time for a standard area will allow a grower to determine which species are most profitable.

Padgett and Frazier (57) noted that while time required (and thus risk) to produce quality plants has changed; many wholesale growers fail as a result of inability to adapt to changes in culture which allow for cost reduction. Shugert (72) stated that cost analysis of crops from propagation to sale will give the grower an accurate basis for intelligent pricing.

The grower's goal should be to produce a plant of acceptable quality with the lowest input of cost in the shortest possible time within his production scheme. The 18-6-12 formulation of Osmocote has been reported to be highly efficient in delivering a high percentage of nutrients to the plant with little loss to leaching (9). It has also been reported to save time in application (69) and thus reduces cost of labor. Although investment in nutrients is higher with Osmocote, no expensive delivery equipment is necessary (41) and slow-release of the elements allows uniform fertilization with little chance of error (9).

A reduction in container volume required to grow salable plants will reduce investment considerably, as smaller containers are less expensive and the amount of growing medium required would be reduced. Rackley and Whitcomb (65) and Whitcomb and Hathaway (81) noted the economy of reducing container volume if salability is not affected.

CHAPTER III

METHODS AND MATERIALS

Containers

The effects of container size on plant response could not be studied in commercial containers as most increase in depth with an increase in diameter thus confounding results by allowing a taller drainage column. Therefore, bottomless containers of four different diameters, all eight inches deep, were constructed.

A total of 576 containers was fabricated from one-eighth inch smooth sheet fiberglass, cut to dimension, and pop-riveted into 144 cylinders each of five, six, seven, and eight inch diameter. All finished containers were dipped in white acrylic enamel paint to retard light infiltration.

The lack of drainage on the periphery of the container base prevented placement on the polyethylene-covered container bed. To overcome this problem, elevation platforms were constructed prior to the initiation of the study. Thirty-six platforms, three feet by six feet and four inches tall were constructed on one-inch rough cedar. Welded wire one inch by two inch-mesh was stapled to the top surface of each frame for uniform container support. The finished platforms were placed on the production bed in six groups of six frames each to provide for separation of species. Heavy paper was placed on each frame to provide restriction until growing medium stabilized.

Four containers of each size were placed randomly on each frame and filled to a seven inch depth with a 2:1:1, by volume, mixture of pine bark, peat, and sand (Table I). Actual volume in each container was 137, 198, 269, or 352 cubic inches, and each occupied one square foot of production space.

Propagation and Planting

Six common commercial species, differing in cultural requirements, were chosen for the study (Table II). Terminal cuttings, four to six inches in length, were obtained between November 1 and December 15, 1975, and rooted in two and one-quarter inch multipot trays. Rooting medium was an unamended, 1:1 by volume, mixture of peat moss and perlite. All cuttings were placed under intermittent mist until rooting was completed. Once adequate roots had formed, misting was terminated and rooted cuttings were maintained in the propagation greenhouse until weather permitted planting on the production bed.

From April 19 to 21, 1976, 96 liners of each species were removed from the greenhouse and planted. Each group of six support frames, with 16 containers per frame, constituted the growing area for one species. One liner was planted in each container, and each species then treated as a separate experiment.

Fertility

Four rates of 18-6-12 Osmocote (manufactured by Sierra Chemical Company, Miltpas, California) were selected to determine the range of response to fertility. Past experience with many species in six-inch

TABLE I

RATE AND COST OF BASIC GROWING MEDIUM COMPONENTS

Component	Rate/yd^3 Medium[y]	Cost/Unit	Cost/yd^3 Medium
Ground Pine Bark	15 ft^3	\$ 7.60/yd^3	\$ 4.50
Canadian Sphagnum Peat Moss	10 ft^3	7.80/10 ft^3	7.80
Coarse Builders Sand	8 ft^3	4.00/yd^3	1.18
Dolomite	8 lb	1.40/100 lb	.11
Single Superphosphate (0-20-0)	4 lb	.90/100 lb	.14
Perk[z] Micronutrient	4 lb	10.00/50 lb	.80
		Total Cost/yd^3	14.55
		Cost/in^3	.03

[y]A 20% shrinkage of bark, peat, and sand components results in a final volume of 27.2 ft^3.

[z]Perk is a micronutrient blend manufactured by Kerr McGee Chemical Corporation, Jacksonville, Florida.

TABLE II

SCIENTIFIC AND COMMON NAME INDEX FOR SPECIES EVALUATED IN STUDY

Scientific	
Aucuba japonica	Aucuba or Gold Dust Tree
Berberis julianae	Wintergreen Barberry
Ilex cornuta 'Burford nana'	Dwarf Burford Holly
Juniperus chinensis 'Hetzi'	Hetzi Juniper
Pyracantha coccinea 'Wyatti'	Wyatt's Pyracantha
Elaeagnus macrophylla	Fragrant Elaeagnus

containers provided a guide for levels to use in this volume, but target ranges were not known for the five, seven, and eight-inch pots. To compensate for the large range in volumes, equal increments of 600 lb N/acre/yr (approximately .6 lb N/cu yd) were added to a base value of 2200 lb N/acre/yr (1.1 lb N/cu yd). This base rate has been reported as an optimum level of nitrogen, using 18-6-12 Osmocote for growth of many species in six-inch containers with the same basic growing medium (78, 80, 81). Once rates of nitrogen to be used were determined on a per acre basis, the amount of Osmocote equivalent per container was calculated by the following formula:

$$N/acre/yr \div 43{,}560 = N/ft^2/yr \times ft^2/container = N/container/yr$$

$$N/container/yr \div .18 = 18\text{-}6\text{-}12\ Osmocote/container/yr$$

These rates were then used as the four levels of nutrition for each container size. The 18-6-12 formulation was chosen as a fertilizer source for its long term, uniform release properties and its acceptable balance of nitrogen, phosphorus, and potassium. The small labor requirement of Osmocote fertilization was considered to be an added benefit. Amounts of Osmocote applied, coversion to nitrogen (N), phosphorus (P), and potassium (K) equivalents, and expression of rates per acre or volume for each container size are presented in Table III.

All species were fertilized on April 22, 1976, and August 19, 1976. One-half of each Osmocote treatment was applied on each date to gain the highest efficiency.

When nutrition was supplied, six separate experiments--one for each species--were conducted. Each experiment was a four by four

TABLE III

BULK WEIGHT; N, P, AND K WEIGHTS; AND CONVERSION TO COMMON AREA AND VOLUME MEASUREMENTS OF ALL OSMOCOTE LEVELS AT EACH CONTAINER VOLUME

Osm. Level	Bulk Wt		N Wt		P Wt		K Wt	
	oz	gm	oz	gm	oz	gm	oz	gm
1	.40	11.4	.07	2.1	.01	.30	.04	1.1
2	.64	18.2	.12	3.3	.02	.50	.06	1.8
3	.88	25.0	.16	4.5	.03	.80	.09	2.5
4	1.12	31.8	.20	5.7	.04	1.00	.11	3.2

Osm. Lev	Cont Dia	lb/Acre			kg/Hectare			lb/yd^3			kg/M^3		
		N	P	K	N	P	K	N	P	K	N	P	K
1	5"	1445	240	805	1620	270	905	1.5	.23	.85	.52	.08	.29
2	5	2310	385	1285	2590	430	1440	2.5	.38	1.40	.86	.13	.48
3	5	3170	530	1760	3550	595	1975	3.4	.51	1.90	1.17	.18	.66
4	5	4035	675	2240	4525	755	2515	4.3	.65	2.40	1.48	.22	.83
1	6"	1000	165	555	1120	185	625	1.1	.16	.61	.38	.06	.21
2	6	1600	265	890	1795	295	1000	1.7	.25	.94	.59	.09	.32
3	6	2200	365	1225	2490	410	1375	2.3	.35	1.28	.79	.12	.44
4	6	2800	465	1560	3140	520	1750	3.0	.45	1.67	1.04	.16	.58
1	7"	735	125	410	825	140	460	.8	.12	.44	.28	.04	.15
2	7	1175	195	655	1320	220	735	1.3	.19	.72	.45	.07	.25
3	7	1615	270	895	1810	305	1005	1.7	.25	.94	.59	.09	.32
4	7	2055	340	1140	2305	380	1280	2.2	.33	1.22	.76	.11	.42
1	8"	565	95	315	635	105	355	.6	.09	.33	.21	.03	.11
2	8	900	150	500	1010	170	560	1.0	.15	.55	.35	.05	.19
3	8	1235	205	685	1385	230	770	1.3	.19	.72	.45	.07	.25
4	8	1570	260	875	1760	290	980	1.7	.25	.94	.59	.09	.32

factorial arrangement of treatments with six randomized complete blocks.

Additional Cultural Considerations

Partial shade was provided for aucuba, Burford holly, and barberry by one-half inch steel mesh fastened to three-foot wooden uprights. Response of these species from April 22 to June 30 indicated an insufficient reduction of light. On July 8, at 3:30 P.M., light meter readings showed a reduction of only 17 percent under cover. An additional layer of mesh increased the shade to 28 percent, and subsequent plant response did not warrant further modification.

All plants were watered with approximately one inch of overhead irrigation every 36-48 hours from April 22 to November 15.

Containers were hand-weeded at weekly intervals to avoid competition or herbicide effects.

Initial Data Observations

Between July 19 and 22, preliminary data was collected to determine treatment differences after two months. All new growing terminals (bud breaks) were tallied for each plant in the barberry, Burford holly, and elaeagnus experiments. Many shoots of less than one inch length were developing into juvenile thorns on pyracantha; consequently, only breaks longer than one inch were counted. No terminal counts were taken for aucuba or juniper, as no visual differences could be detected between treatments.

A random marginal burn and leaf necrosis on aucuba prompted development of a leaf damage index to determine treatment correlation. Comparison was made between treatments on the basis of percent of leaves affected.

All data was subjected to analysis of variance and "F" value significance testing. Where significance existed, Duncan's New Multiple Range Test was used to separate treatment means. These results were used to gauge the progress of each experiment, but final measurements were more helpful in evaluating the objectives of the study.

Final Data Observations

Between December 6 and 22, 1976, all plants were removed from the container bed and evaluated as follows:

Growth Index

Each plant was measured for height (H), maximum width (WD MAX), and width perpendicular to maximum (WD 90). Growth index (GI) was calculated by multiplying the height by the average of the two width measurements:

$$GI = (WD\ MAX + WD\ 90)/2 \times H$$

Top Weight/Root Weight

Fresh top weight was obtained by severing the stem(s) at the soil line in the container and weighing. After top weight had been determined for one replication of each species, containers were emptied and growing medium removed from the roots before weighing.

Visual Grade

On November 11, all species were evaluated for visual appearance by three qualified raters. Plants were graded on a ten-point scale with ten rating most attractive and one rating least attractive. The average score from three independent ratings was recorded for each plant.

All growth response measurements were subjected to statistical analysis by the S.A.S. computer program.

Economic Evaluation

When analysis of growth response was completed, a cost-price evaluation was initiated to determine profitability of each treatment combination.

Cost Analysis

Variable. Each input cost which varied with changes in container size or amount of Osmocote was calculated as follows:

(1) The cost of growing medium was obtained by adding the component costs for one cubic yard and calculating the subsequent cost for each container size based on volume (Tables I and IV).

(2) Container cost was derived by averaging actual wholesale values for containers of comparable volume and composition. Parameters used in selection of commercial containers for comparison were:

a) that total container volume would not exceed test volume by more than ten inches, and

b) that container composition must be some form of rigid plastic comparable to test containers.

Using cost quotation for lots of 1000, at least six values were obtained from wholesale supply catalogs for each volume variable. These

TABLE IV

LINE COST SUMMARY FOR EACH VOLUME AND FERTILITY COMBINATION

Osm. Level	Cont. Dia.	Variable Costs ($) Medium	Pot	Osm.	Total	Fixed Costs ($) Liner	Over-head	10% Mort. ($)	Total Cost ($)
1	5"	.04	.11	.01	.16	.25	.31	.07	.79
2	5	.04	.11	.02	.17	.25	.31	.07	.80
3	5	.04	.11	.03	.18	.25	.31	.07	.81
4	5	.04	.11	.04	.19	.25	.31	.08	.83
1	6"	.06	.14	.01	.21	.25	.31	.08	.85
2	6	.05	.14	.02	.22	.25	.31	.08	.86
3	6	.06	.14	.03	.23	.25	.31	.08	.87
4	6	.06	.14	.04	.24	.25	.31	.08	.88
1	7"	.08	.19	.01	.28	.25	.31	.08	.92
2	7	.08	.19	.02	.29	.25	.31	.09	.94
3	7	.08	.19	.03	.30	.25	.31	.09	.95
4	7	.08	.19	.04	.31	.25	.31	.09	.96
1	8"	.11	.23	.01	.35	.25	.31	.09	1.00
2	8	.11	.23	.02	.36	.25	.31	.09	1.01
3	8	.11	.23	.03	.37	.25	.31	.09	1.02
4	8	.11	.23	.04	.38	.25	.31	.09	1.03

values were averaged by size, and means entered in Table IV as the cost attributable to container.

(3) The final variable cost item, fertilizer, was computed from invoice. Actual cost per gram, approximately .11¢ for 18-16-12 Osmocote, was calculated by dividing invoice cost for one 50-pound bag ($25.00) by the number of grams it held (22,700). This figure was then multiplied by the number of grams at each treatment rate to determine cost per fertility level (Table IV). Costs of other nutrient additives were extremely small on a container basis. These costs were added to growing medium cost (Tables I and IV) as they were amended at the mixing phase, and monetary differences could not be detected between container sizes.

Fixed. Input costs which did not vary by treatment were considered fixed. Depreciation, taxes, interest, insurance, labor, and intangible expenses were grouped in this category. Each of these costs can be determined on a yearly total basis, and apportioned over the prodiction area to obtain a cost per unit area per year, although labor is not normally computed in this manner. The allowance of one square foot of growing space for each unit in the study equalizes production and non-production labor costs for all treatments. The column labeled "overhead" in Table IV represents a reasonable, although conservative, estimate of the cost per square foot per year incurred by the above items.

The cost of purchased liners was added under fixed cost to achieve a realistic estimate of total cost. An average of wholesale price quotations from several commercial catalogs for similar liners was used as the liner cost for all species (Table IV).

The uniformity of fixed cost for all species and treatments allowed for economic comparison by variable cost alone without forfeiting the use of retail values in the return analysis.

Mortality Deferral and Total Cost. A 10 percent mortality deferral, based on the sum of fixed and variable costs, was computed for each treatment to reflect the increase in cost per unit which would occur if only 90 percent of the plants in a treatment were salable (Tables IV and VI). Separate cost items were added together to derive total cost for each fertility/volume combination (Tables IV and VI).

Return Analysis

To complete the economic evaluation, a system was devised to determine the profitability of each combination. As some sort of visual grade is most often used to determine value, the ten point grading scale was broken into four value classes (Table V). The arbitrary nature of this breakdown was unavoidable, and the objective was to detect dollar value differences if they existed.

A selling price was assigned to each class by obtaining values from current wholesale catalogs published by several large nurseries which grew the same species as used in the study. These returns were combined with total cost to determine profit comparisons between treatments for each species.

One-Year Comparison. All four container sizes were compared in the one-year evaluation (Table V). Total cost was subtracted from expected return, and resulting net profit plotted for each species.

TABLE V

FIRST YEAR RETURN AND PROFIT DETERMINATION FOR ALL SPECIES WITH EACH OF THE TREATMENT COMBINATIONS

Osm. Level	Cont. Dia	Cost ($)	Pyracantha Return ($)	Pyracantha Profit ($)	Juniper Return ($)	Juniper Profit ($)	Holly Return ($)	Holly Profit ($)
1	5"	.79	(3)[z] .00	- .79	(3) .00	- .79	(6) 1.35	.56
2	5	.80	(4) 1.00	.20	(6) 1.40	.60	(4) 1.00	.20
3	5	.81	(6) 1.35	.54	(7) 1.40	.59	(6) 1.35	.54
4	5	.83	(7) 1.35	.52	(7) 1.40	.57	(6) 1.35	.52
1	6"	.85	(3) .00	- .85	(4) 1.00	.15	(7) 1.35	.50
2	6	.86	(5) 1.00	.14	(7) 1.40	.54	(5) 1.00	.06
3	6	.87	(8) 1.45	.58	(7) 1.40	.53	(6) 1.35	.48
4	6	.88	(7) 1.35	.47	(9) 1.50	.62	(6) 1.35	.47
1	7"	.92	(5) 1.00	.08	(4) 1.00	.08	(6) 1.35	.43
2	7	.94	(6) 1.35	.41	(7) 1.40	.46	(5) 1.00	.06
3	7	.95	(8) 1.45	.50	(7) 1.40	.45	(7) 1.35	.40
4	7	.96	(9) 1.45	.49	(8) 1.50	.54	(7) 1.35	.39
1	8"	1.00	(4) 1.00	.00	(4) 1.00	.00	(4) 1.00	.00
2	8	1.01	(7) 1.35	.34	(5) 1.00	- .01	(4) 1.00	- .01
3	8	1.02	(9) 1.45	.43	(9) 1.50	.48	(6) 1.35	.33
4	8	1.03	(9) 1.45	.42	(9) 1.50	.47	(8) 1.45	.42
			Elaeagnus		Barberry		Aucuba	
1	5"	.79	(2) .00	- .79	(5) 1.00	.21	(4) 1.00	.21
2	5	.80	(6) 1.35	.55	(6) 1.60	.80	(6) 1.35	.55
3	5	.81	(7) 1.35	.54	(7) 1.60	.79	(6) 1.35	.54
4	5	.83	(6) 1.35	.52	(8) 1.70	.87	(5) 1.00	.17

TABLE V (Continued)

Osm. Level	Cont. Dia.	Cost ($)	Elaeagnus Return ($)	Elaeagnus Profit ($)	Barberry Return ($)	Barberry Profit ($)	Aucuba Return ($)	Aucuba Profit ($)
1	6"	.85	(2) .00	- .85	(4) 1.00	.15	(3) .00	- .85
2	6	.86	(5) 1.00	.14	(6) 1.60	.74	(5) 1.00	.14
3	6	.87	(6) 1.35	.48	(9) 1.70	.83	(8) 1.45	.58
4	6	.88	(8) 1.45	.57	(8) 1.70	.82	(4) 1.00	.12
1	7"	.92	(3) .00	- .92	(4) 1.00	.08	(5) 1.00	.08
2	7	.94	(5) 1.00	.06	(5) 1.00	.06	(5) 1.00	.06
3	7	.95	(8) 1.45	.50	(7) 1.60	.65	(7) 1.35	.40
4	7	.96	(9) 1.45	.49	(7) 1.60	.64	(8) 1.45	.49
1	8"	1.00	(2) .00	- 1.00	(3) .00	- 1.00	(4) 1.00	.00
2	8	1.01	(7) 1.35	.34	(5) 1.00	- .01	(6) 1.35	.34
3	8	1.02	(9) 1.45	.43	(6) 1.60	.58	(7) 1.35	.33
4	8	1.03	(9) 1.45	.42	(9) 1.70	.67	(8) 1.45	.42

[z]Figure in parentheses is average visual grade used to determine return as follows:

8-10 - excellent quality, 10¢ premium over average price
6- 7 - acceptable quality, sold as an average plant
4- 5 - not of acceptable quality, usually sold as culls for about $1.00
0- 3 - not salable. Plants represent a total loss of investment.

TABLE VI

SECOND YEAR COST, RETURN, AND PROFIT PROJECTIONS FOR SEVEN-INCH AND EIGHT-INCH DIAMETER CONTAINERS

Osmocote Level	Container Diameter	First Year Cost ($)	Second Year Cost ($)	Total Two-Year Cost (+ 10% Mort.) ($)
		Cost Summary		
1	7"	.84	.63	1.62
2	7	.85	.64	1.64
3	7	.86	.65	1.66
4	7	.87	.66	1.68
1	8"	.91	.63	1.69
2	8	.92	.64	1.72
3	8	.93	.65	1.74
4	8	.94	.66	1.76

Return Summary

Species	Anticipated Return ($)[x]	Adjusted Return ($)[y]	Losses[z]
Pyracantha	3.35	1.45	Variable
Juniper	3.50	1.40	Variable
Holly	3.00	1.45	Variable
Elaeagnus	3.00	1.45	Variable
Barberry	3.70	1.60	Variable
Aucuba	3.35	1.45	Variable

TABLE VI (Continued)

Osm. Level	Cont. Dia.	Total Cost ($)	Profit Summary Return ($)	Profit ($)	Return ($)	Profit ($)	Return ($)	Profit ($)
			Pyracantha		Juniper		Holly	
1	7"	1.62	1.45	- .17	1.40	- .22	3.00	1.38
2	7	1.64	3.35	1.71	3.50	1.86	1.45	- .19
3	7	1.66	3.35	1.69	3.50	1.84	3.00	1.34
4	7	1.68	3.35	1.67	3.50	1.82	3.00	1.32
1	8"	1.69	1.45	- .24	1.40	- .29	1.45	- .25
2	8	1.72	3.35	1.63	1.40	- .32	1.45	- .27
3	8	1.74	3.35	1.61	3.50	1.76	3.00	1.26
4	8	1.76	3.35	1.59	3.50	1.74	3.00	1.24
			Elaeagnus		Barberry		Aucuba	
1	7"	1.62	.00	- 1.62	1.60	- .02	1.45	- .17
2	7	1.64	1.45	- .19	1.60	- .04	1.45	- .19
3	7	1.66	3.00	1.34	3.70	2.04	3.35	1.69
4	7	1.68	3.00	1.32	3.70	2.02	3.35	1.67
1	8"	1.69	.00	- 1.69	.00	- 1.69	1.45	- .24
2	8	1.72	3.00	1.28	1.60	- .12	3.35	1.63
3	8	1.74	3.00	1.26	3.70	1.96	3.35	1.61
4	8	1.76	3.00	1.24	3.70	1.94	3.35	1.59

[x]Plants which achieved at least average growth in one year, appraised at the average market value for a two-gallon plant.

[y]Plants which were culls after one year; value at end of second year would be similar to that of an average one-year old plant.

[z]Plants not salable after one year; appraised as a total loss of investment.

Two-Year Comparison. Containers of seven and eight-inch diameters only were compared in the two-year evaluation. Experience with five and six-inch containers suggested a volume restriction which would result in poor growth response, regardless of fertility, for plants held more than one year in these sizes.

Average yearly return (Table VI) was computed for plants grown for two years in the two larger container volumes to determine any economic advantage in holding plants for an additional season. The assumptions made are:

(1) that a salable plant can be grown in two years in a two-gallon container,

(2) that growth response differences observed after one year would be evident after the second year,

(3) cost of nutrition for each treatment would be the same for the second growing season, and

(4) twice as much space would be required for each container in the second growing season.

Under these assumptions, overhead costs for the second year would be twice as much as the first, and nutrition cost the same (Table VI).

Valuation of plants was based on first year visual grade and wholesale price listings for containers of this volume. All plants in the projected study were assumed to have a uniform price if they attained the minimum salable quality. Plants which received a cull rating after one year were assumed to be worth as much after two years as a high quality one year old. Plants determined to be of no value after one year's growth were also considered as a total loss after the second year. The average yearly return was obtained by adding first and second year costs, subtracting the total from the expected return, and dividing by two:

$$\text{Average yearly return} = \text{expected return} - \left(\text{cost}^{\text{yr }1} + \text{cost}^{\text{yr }2}\right)/2$$

This return was plotted by species with the one year net profit values to compare monetary advantage of one over the other if it existed.

CHAPTER IV

RESULTS AND DISCUSSION

Growth Response

Elaeagnus

As fertilizer application increased, top and root weight (Table VII and Figure 1) and growth index increased significantly. Height growth (Table VII) increased only with added fertilizer from 18.2 to 25 grams.

An interaction between fertility and volume was significant for visual grade (Table IX and Figure 2). As rate of fertility increased to 25 grams, response to all volumes increased significantly. Response to fertility beyond 25 grams increased for all container sizes except the five-inch (137 cubic inch) container, where a visual grade suppression was noted. Other response to volume indicated that no consistent increase could be expected in appearance with an increase in the volume of growing medium.

All measured responses increased with fertility up to 25 grams Osmocote/container/year. This pattern has been noted by many researchers using different fertilizer sources on many different species (10, 11, 16, 54, 62, 65, 66, 69, 83, 87). The visual difference observed between applications of 25 and 31.8 grams of fertilizer to a five-inch container indicated an excessive fertility for elaeagnus at the 31.8

TABLE VII

EFFECTS OF FERTILITY ON SIX WOODY ORNAMENTAL NURSERY SPECIES

Species	Osm. Rate (g)	Top Wt (g)	Root Wt (g)	Ht (in)	Growth Index	Visual Grade
Elaeagnus	11.4	11.4[a][x]	11.1[a]	7.1[a]	37.4[a]	INT[y]
	18.2	24.9[b]	19.1[b]	8.0[a]	63.4[b]	
	25.0	37.3[c]	27.4[c]	9.6[b]	89.2[c]	
	31.8	46.5[d]	32.5[d]	10.5[b]	106.9[d]	
Barberry	11.4	15.5[a]	13.6[a]	NS[z]	44.1[a]	4.0[a]
	18.2	20.7[b]	16.4[a]		54.4[a]	5.7[b]
	25.0	29.4[c]	22.2[b]		74.5[b]	7.4[c]
	31.8	32.1[d]	24.6[b]		86.7[b]	8.1[c]
Hetzi Juniper	11.4	INT	INT	11.0[a]	INT	INT
	18.2			11.3[a]		
	25.0			12.9[b]		
	31.8			13.2[b]		
Dwarf Burford Holly	11.4	INT	INT	NS	INT	INT
	18.1					
	25.0					
	31.8					
Pyracantha	11.4	51.2[a]	48.9[a]	14.6[a]	255.0[a]	3.6[a]
	18.2	65.3[b]	58.7[b]	16.6[b]	317.2[b]	5.7[b]
	25.0	73.0[c]	62.7[b]	17.0[b]	346.4[bc]	7.7[c]
	31.8	77.8[c]	58.6[b]	17.1[b]	355.7[c]	8.1[c]
Aucuba	11.4	17.0[a]	NS	NS	32.7[a]	4.2[a]
	18.2	21.8[ab]			41.9[ab]	5.5[b]
	25.0	27.6[b]			48.8[b]	6.8[c]
	31.8	24.4[b]			46.0[ab]	6.6[c]

[x]For each species, means within a column which are followed by the same letter are not significantly different at the .05 level.

INT[y]Signifies interaction between main factors.

NS[z]No significant differences at the .05 level

TABLE VIII

EFFECTS OF CONTAINER VOLUME ON SIX WOODY ORNAMENTAL NURSERY SPECIES

Species	Cont. Vol. (in^3)	Top Wt (g)	Root Wt (g)	Ht (in)	Growth Index	Visual Grade
Elaeagnus	137 198 269 352	NS[x]	NS	NS	NS	INT[y]
Barberry	137 198 269 352	26.8[b][z] 27.1[b] 22.9[ab] 21.1[a]	NS	NS	NS	NS
Hetzi Juniper	137 198 269 352	INT	INT	11.0[a] 11.4[a] 13.2[b] 12.8[b]	INT	INT
Dwarf Burford Holly	137 198 269 352	INT	INT	NS	INT	INT
Pyracantha	137 198 269 352	47.1[a] 56.1[b] 74.0[c] 89.0[d]	43.6[a] 52.8[b] 59.8[c] 72.0[d]	14.4[a] 15.6[ab] 17.3[bc] 17.9[c]	254.8[a] 289.6[ab] 343.4[b] 382.7[c]	4.8[a] 5.8[b] 7.0[c] 7.4[c]
Aucuba	137 198 269 352	NS	NS	NS	NS	NS

[x]No significant differences at the .05 level.

[y]Signifies interaction between main factors.

[z]For each species means within a column which are followed by the same letter are not significantly different at the .05 level.

TABLE IX

EFFECTS OF A VOLUME AND FERTILITY INTERACTION ON ELAEAGNUS VISUAL GRADE

Container Volume (in^3)	Osmocote Rate (g) 11.4	18.2	25.0	31.8
137 (5")	$2.3^{a\,z}$	5.7^{bc}	7.3^{de}	6.3^{cd}
198 (6")	1.8^{a}	4.5^{b}	6.2^{cd}	8.3^{ef}
269 (7")	2.5^{a}	5.2^{bc}	7.7^{def}	8.7^{ef}
352 (8")	1.7^{a}	6.5^{cd}	9.0^{f}	9.2^{f}

[z]Means followed by the same letter are not significantly different at the .05 level.

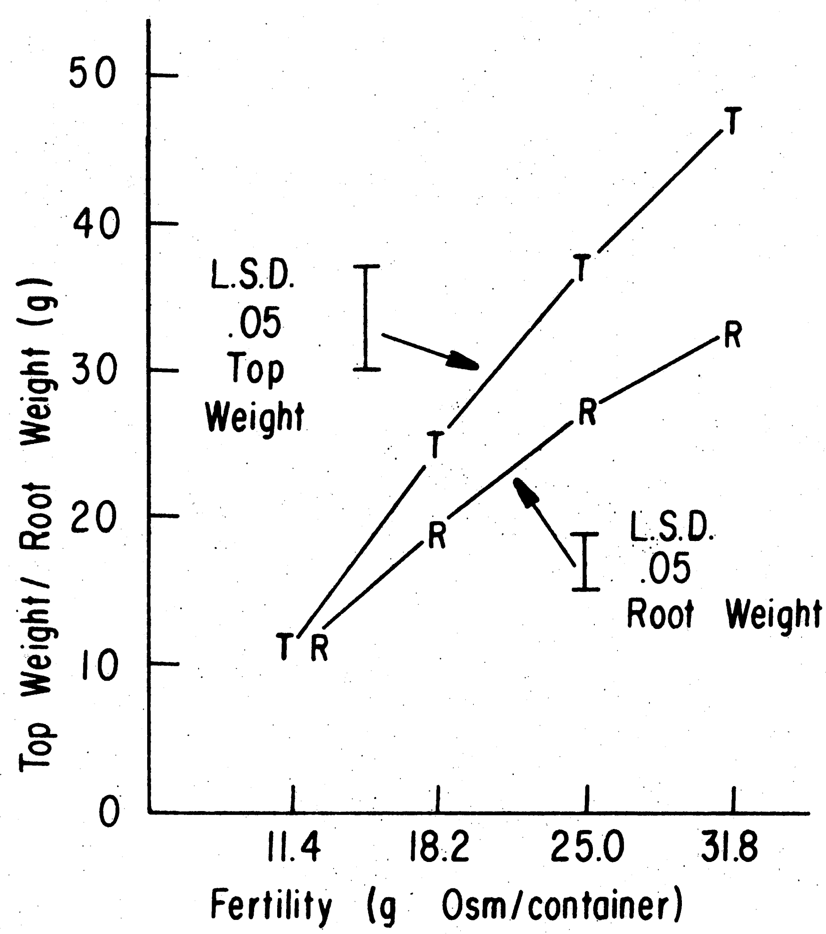

Figure 1. Effects of Fertility on Elaeagnus Top and Root Weight

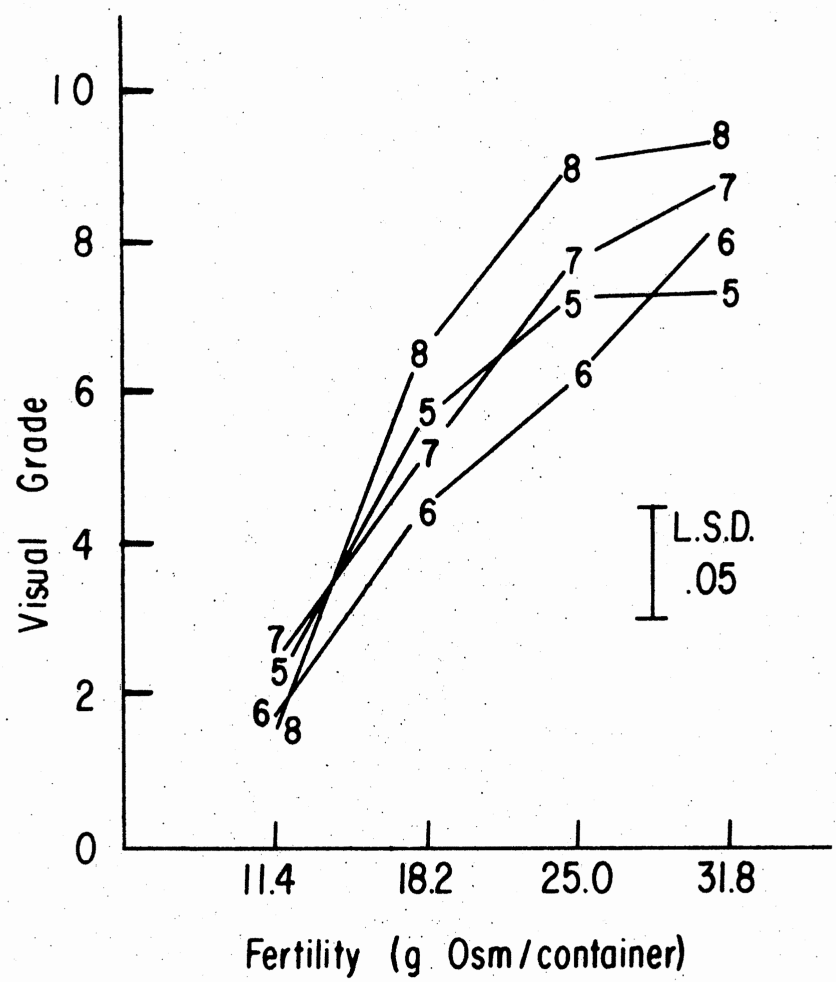

Figure 2. Interaction of Volume and Fertility on Elaeagnus Visual Grade

gram level in a small volume of medium. Self (67) noted mortality of Hinodigiri azaleas which he attributed to excess nitrogen from high rates of 18-6-12 Osmocote. Goin and Link (34) reported poorer growth and decreased potassium uptake with excessive nitrogen application.

Other than the visual grade interaction, no significant differences were observed between container sizes.

Barberry

Top weight increased with each increase in fertilizer, and decreased as container size increased from five to eight inches (352 cubic inches) in diameter (Tables VII, VIII, and Figures 3 and 4).

Root weight, growth index, and visual grade increased significantly with an increase of fertilizer up to 25 grams/container/year (Table VII and Figures 3 and 5).

No significant height growth was stimulated by an increase in fertility or volume.

These results indicate a definite advantage in application of 25 grams of fertilizer over any other rate tested on barberry, and a lack of influence (root weight, visual grade, height, and growth index) or inhibition of growth (top weight) with increased volume. A similar inhibition was observed by Dickey and Poole (24) on azalea and ligustrum grown in one-quart, one-gallon, and two-gallon containers.

Hetzi Juniper

All measured responses, except height, indicated an interaction between fertility and volume (Table X). While top weight increased in all container sizes with an increase in fertilizer to 25 grams, the

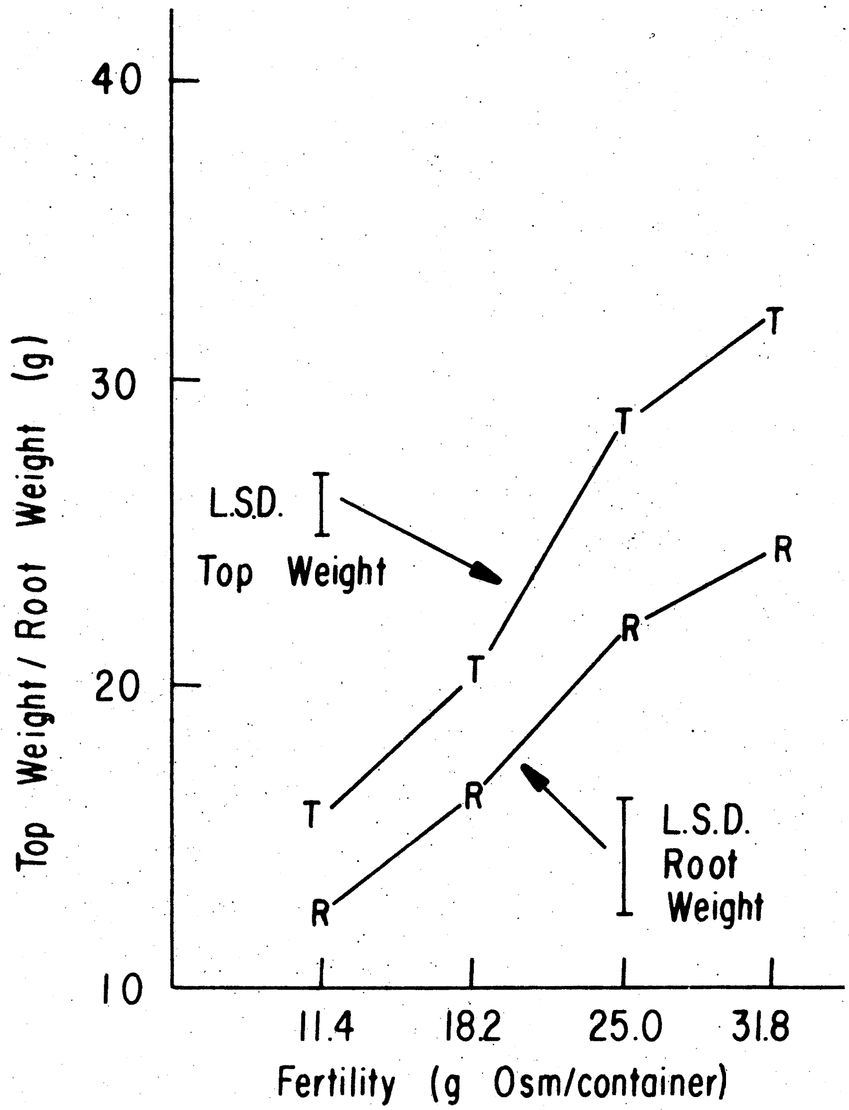

Figure 3. Effects of Fertility on Top and Root Weight of Barberry

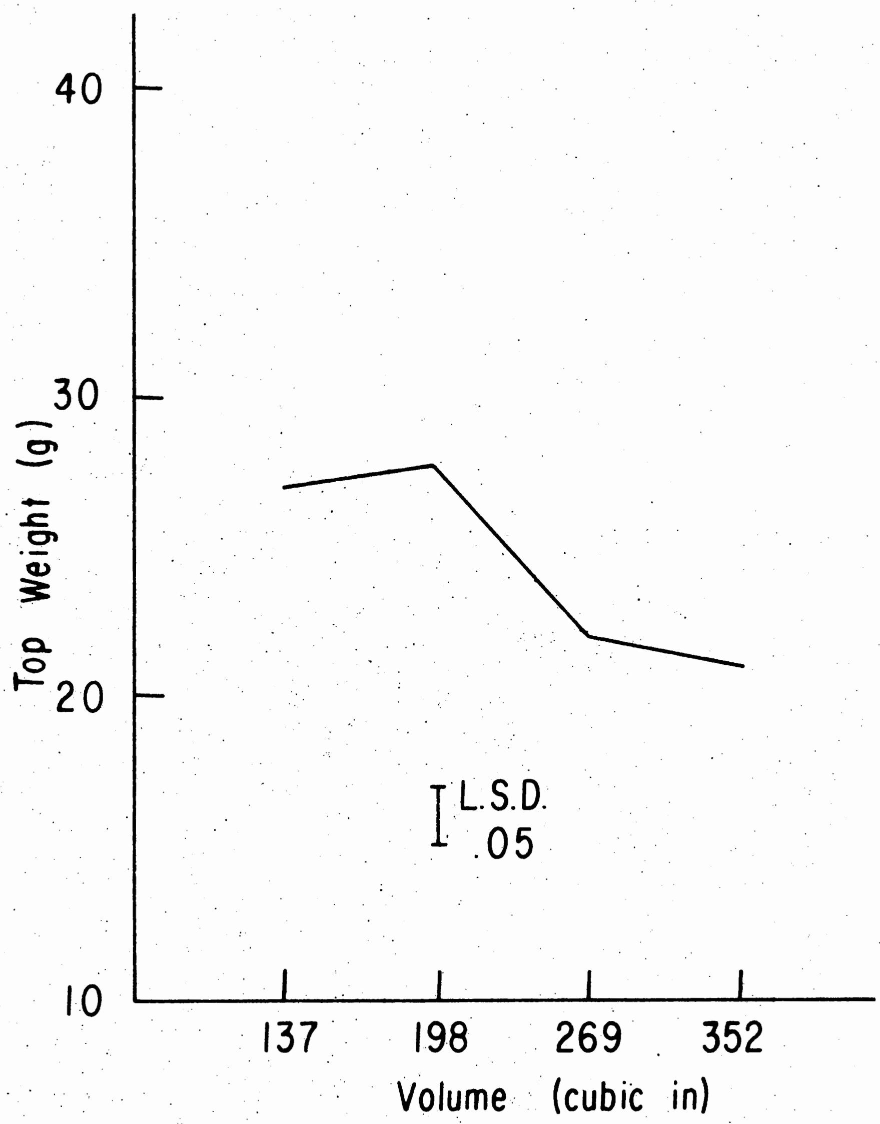

Figure 4. Effects of Container Volume on Top Weight of Barberry

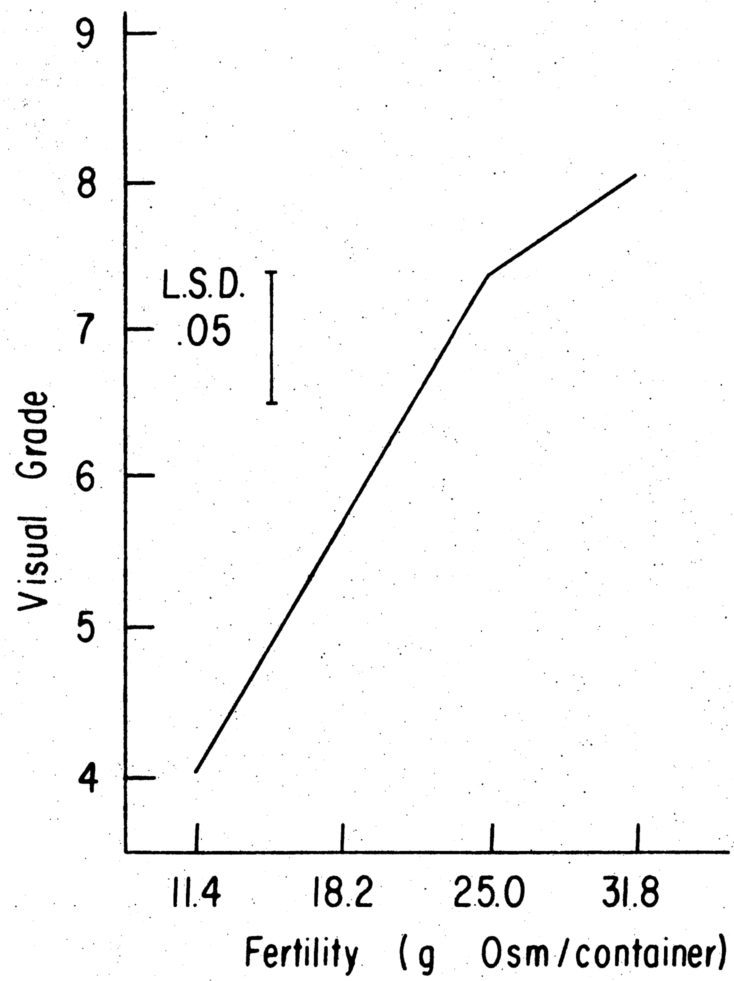

Figure 5. Effects of Fertility on Visual Grade of Barberry

TABLE X

EFFECTS OF VOLUME AND FERTILITY INTERACTION ON HETZI JUNIPER TOP WEIGHT, ROOT WEIGHT, GROWTH INDEX, AND VISUAL GRADE

Container Volume (in^3)	Osmocote Rate (g) 11.4	18.2	25.0	31.8
		Top Weight		
137 (5")	39.6^{az}	62.5^{cd}	76.8^{ef}	70.0^{de}
198 (6")	43.0^{ab}	65.3^{cd}	75.3^{def}	77.8^{ef}
269 (7")	45.7^{ab}	69.0^{de}	86.3^{f}	83.7^{f}
352 (8")	44.3^{ab}	55.5^{bc}	85.0^{f}	101.2^{g}
		Root Weight		
137	18.8^{a}	23.5^{abc}	25.5^{bcde}	25.7^{cde}
198	18.5^{a}	27.2^{cde}	29.0^{cdef}	28.7^{cdef}
269	19.0^{ab}	26.5^{cde}	35.0^{fg}	29.7^{def}
352	18.3^{a}	23.0^{abc}	31.2^{efg}	38.2^{g}
		Growth Index		
137	115.6^{a}	169.2^{bcd}	203.5^{de}	180.4^{cd}
198	142.4^{abc}	170.2^{bcd}	209.6^{def}	208.0^{def}
269	139.0^{abc}	211.2^{def}	249.6^{fg}	246.0^{efg}
352	131.3^{ab}	139.4^{abc}	228.7^{ef}	291.9^{g}
		Visual Grade		
137	3.2^{a}	6.3^{c}	7.3^{cde}	7.2^{cde}
198	3.8^{a}	6.5^{cd}	7.3^{cde}	8.5^{f}
269	3.7^{a}	6.7^{cd}	7.5^{def}	8.0^{ef}
352	4.0^{a}	5.2^{b}	8.5^{ef}	9.7^{g}

[z]Means within a response group which are followed by the same letter are not significantly different at the .05 level.

application of 31.8 grams to an eight-inch container produced plants which were significantly better than any others in this experiment (Figure 6).

An increase in fertilizer beyond 18.2 grams did not increase root weight in five or six-inch (198 cubic inch) containers, while a significant response was noted up to 25 grams in seven-inch (269 cubic inch) and eight-inch containers (Table X and Figure 7). No significant increase in root weight occurred beyond the 25 gram rate in the seven-inch container, and no inhibition was noted with an increase to 31.8 grams of fertilizer or to the eight-inch container.

Growth index did not increase significantly beyond 25 grams of Osmocote/container for the five, six, and seven-inch containers, but did increase in the eight-inch container as fertility was increased from 18.2 to 31.8 grams (Table X). As was observed with root weight, no significant response occurred in growith index beyond the 25 gram Osmocote /seven-inch container combination.

For juniper, an increase in visual grade was dependent on the rate of fertilizer supplied and the size of container (Table X and Figure 8). Appearance did not improve in five-inch containers beyond 18.2 grams of fertilizer, while an increase from 18.2 to 31.8 grams stimulated increases in the six and seven-inch containers. Each added increment of fertilizer enhanced visual grade of plants grown in eight-inch containers.

Although height was affected independently by either fertility or volume, significant differences were noted only as container size increased to seven inches and fertility reached 25 grams/year (Tables VII and VIII).

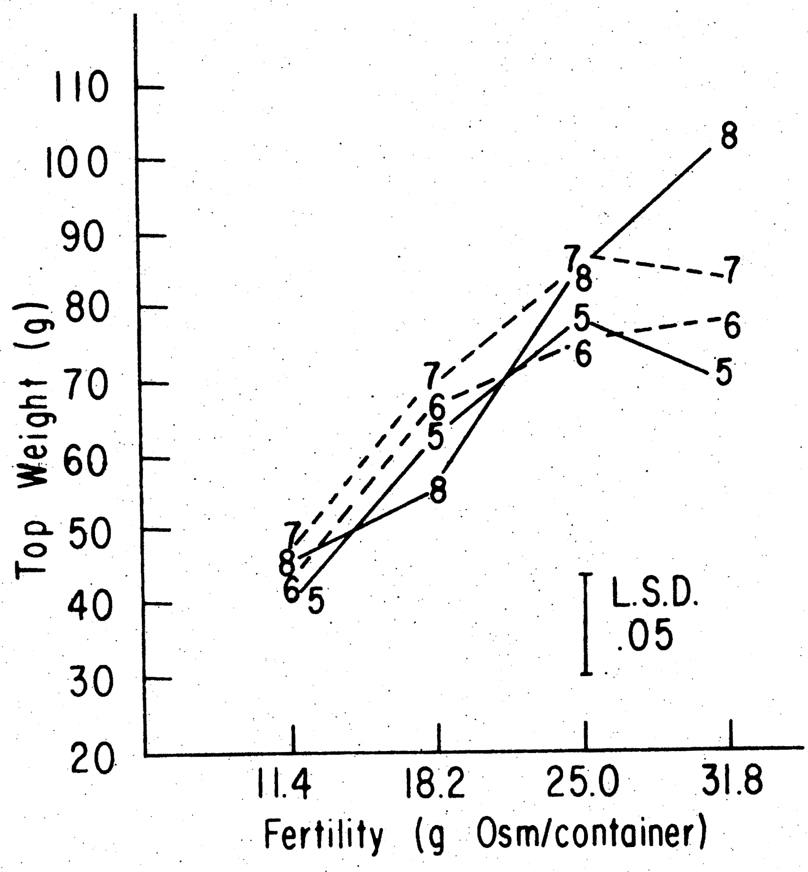

Figure 6. Interaction of Volume and Fertility on Juniper Top Weight

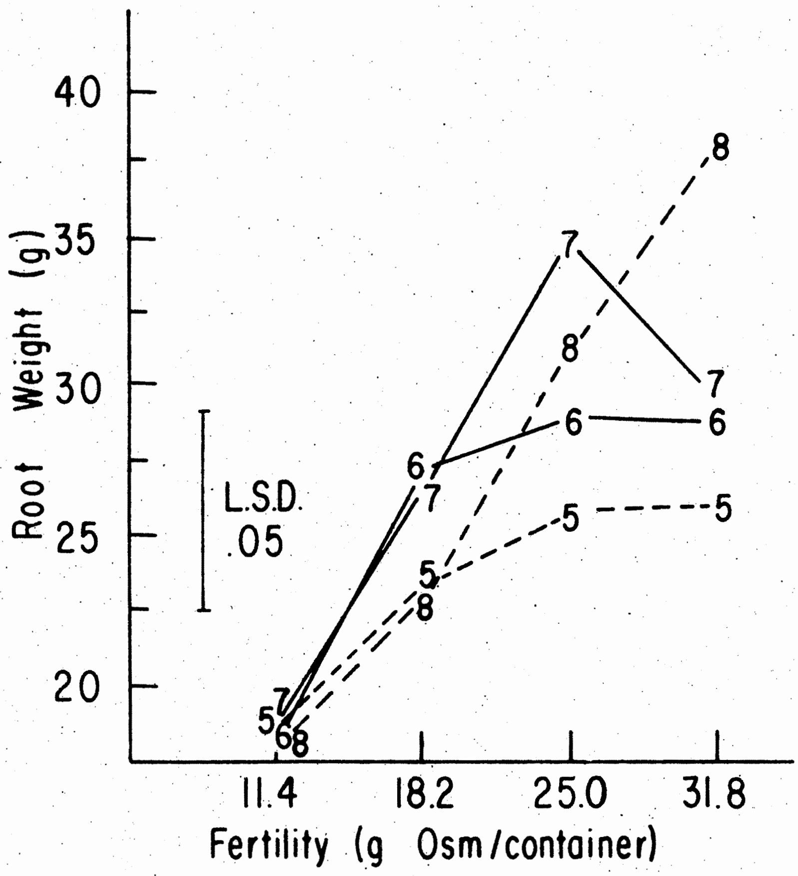

Figure 7. Interaction of Volume and Fertility on Juniper Root Weight

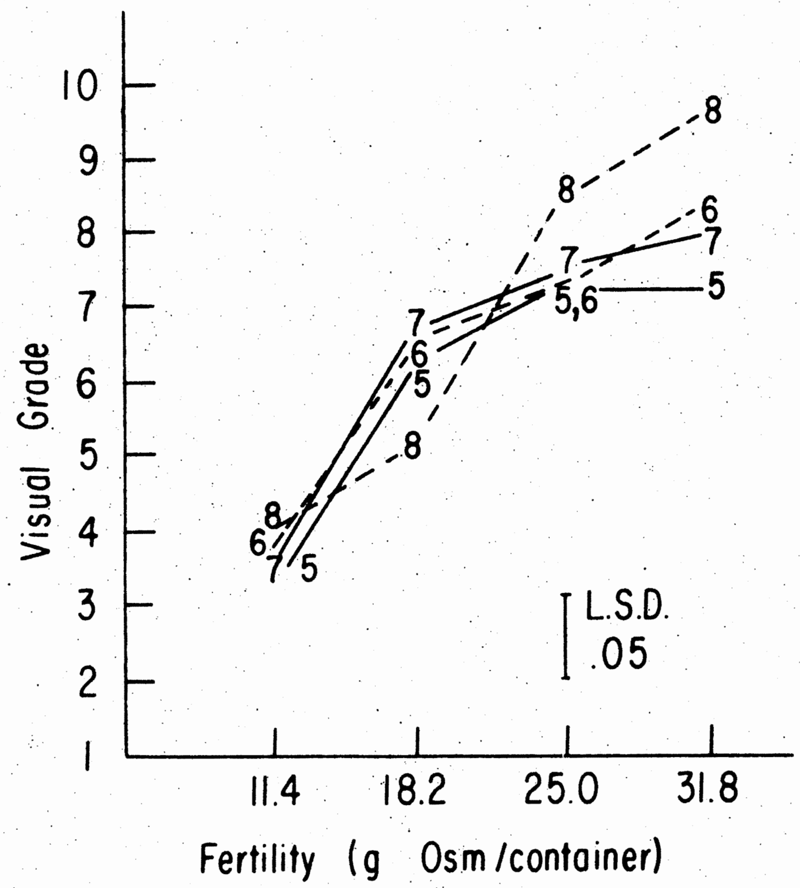

Figure 8. Interaction of Volume and Fertility on Juniper Visual Grade

For all container sizes, top and root weight, visual grade, growth index, and height increased as the amount of fertilizer applied increased to 25 grams/container. Significant increases in growth were noted up to 31.8 grams for plants grown in eight-inch containers. As fertility increased, growth responses were enhanced by an increase in container volume. The best overall growth of juniper occurred when 31.8 grams of Osmocote were applied to an eight-inch container.

Whitcomb and Hathaway (81) noted a linear increase in growth response of Hetzi juniper as container volume increased from 137 to 380 cubic inches, and little response beyond 15 grams 18-6-12 Osmocote per container. In later studies, Whitcomb (79, 80) found growth of Hetzi juniper to be better at higher nitrogen levels in larger containers.

Burford Holly

An interaction was noted between container volume and fertility for all measured responses except height (Table XI). Inspection of the data suggests that growth response to increased fertility in eight-inch containers was mainly responsible for the declared significance. While no other increases were observed on any parameter with changes in fertility or volume, overall growth improved with each increase in fertility in the eight-inch container (Figures 9, 10, 11). However, the maximum growth attained in the eight-inch container (at 31.8 grams Osmocote) was not better than growth in five-inch containers at the 11.4 gram rate.

These results are inconsistent with findings of Whitcomb (77, 79, 80) in two-year studies of Burford holly. He reported an increase in growth with similar increase in 18-6-12 Osmocote rate, and with container

TABLE XI

EFFECTS OF VOLUME AND FERTILITY INTERACTION ON DWARF BURFORD HOLLY TOP WEIGHT, ROOT WEIGHT, GROWTH INDEX, AND VISUAL GRADE

Container Volume (in^3)	Osmocote Rate (g) 11.4	18.2	25.0	31.8
		Top Weight		
137 (5")	27.5^{cd}[z]	24.3^{cd}	26.7^{cd}	28.8^{d}
198 (6")	24.2^{cd}	26.2^{cd}	23.7^{bcd}	250^{cd}
269 (7")	23.2^{bcd}	22.0^{bc}	27.7^{cd}	29.3^{d}
352 (8")	16.2^{a}	17.3^{ab}	29.8^{d}	26.0^{cd}
		Root Weight		
137	19.0^{abc}	18.5^{abc}	24.8^{cde}	20.0^{bc}
198	17.0^{ab}	19.8^{bc}	19.2^{abc}	21.0^{bc}
269	17.7^{abc}	19.8^{bc}	24.5^{cd}	32.0^{e}
352	12.5^{a}	15.8^{ab}	28.3^{de}	24.8^{cde}
		Growth Index		
137	55.6^{cd}	42.1^{abc}	42.2^{abc}	48.7^{abcd}
198	44.3^{abc}	46.8^{abcd}	35.2^{ab}	38.1^{abc}
269	46.2^{abcd}	41.2^{abc}	46.2^{abcd}	55.8^{cd}
352	30.5^{a}	36.7^{ab}	63.8^{d}	52.5^{bd}
		Visual Grade		
137	6.0^{cde}	4.7^{abc}	5.7^{bcd}	5.8^{bcde}
198	6.8^{de}	5.8^{bcde}	5.5^{abcd}	5.8^{bcde}
269	5.8^{bcde}	4.8^{abcd}	6.5^{cde}	6.7^{cde}
352	3.5^{a}	3.8^{ab}	6.3^{cde}	7.8^{e}

[z]Means within a response group which are followed by the same letter are not significantly different at the .05 level.

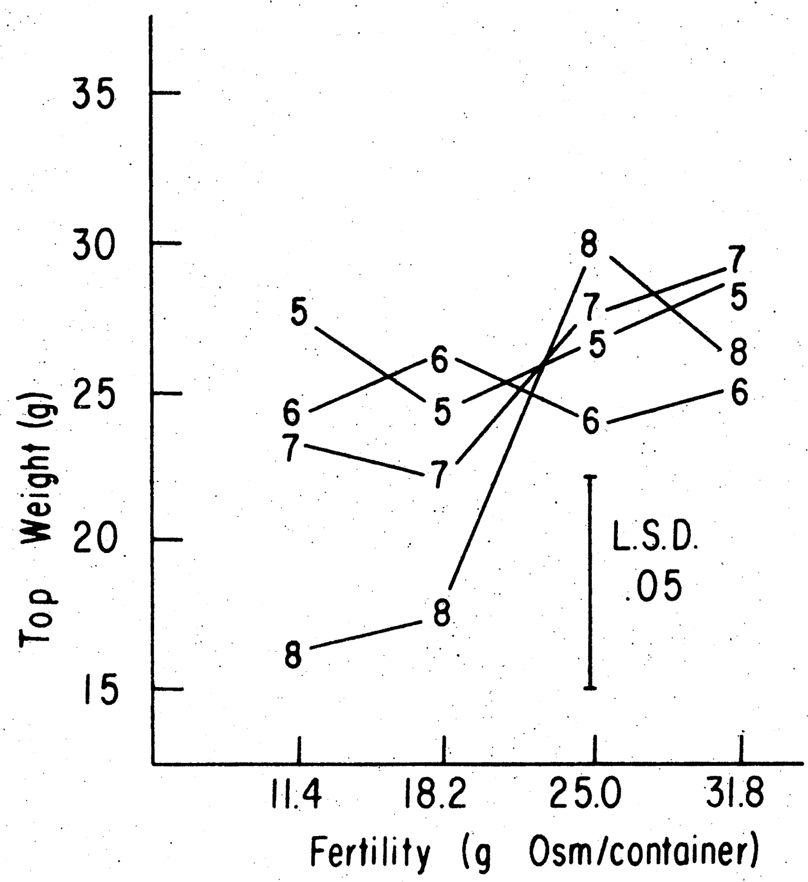

Figure 9. Interaction of Volume and Fertility on Top Weight of Burford Holly

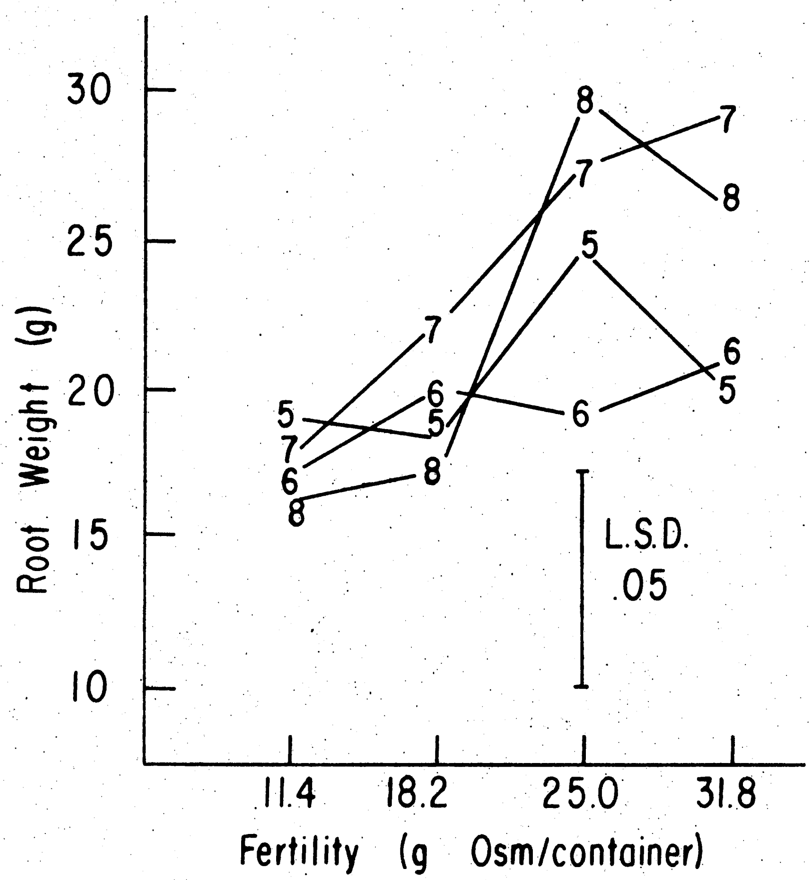

Figure 10. Interaction of Volume and Fertility on Root Weight of Burford Holly

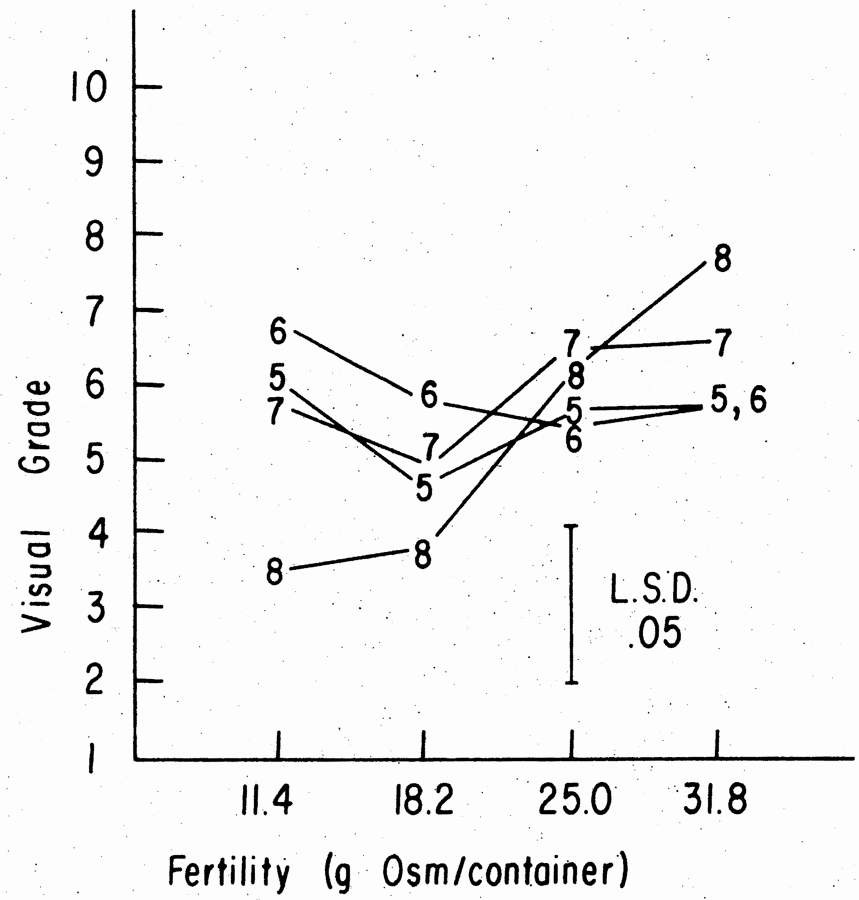

Figure 11. Interaction of Volume and Fertility on Visual Grade of Burford Holly

size increase up to 680 cubic inches.

Poole and Dickey (25) noted the same lack of response to container size increase with azalea, although some fertility response was noted in their study.

Pyracantha

All five parameters measured showed significant increases with an increase in fertility or volume (Tables VII and VIII). Top root weight increased with each volume increase, while response to fertility increased to the 25 gram level for tops and the 18.2 gram level for roots (Figures 12 and 13).

Height and visual grade increased with an increase in volume up to the seven-inch container size while the greatest increase in growth index occurred between the five and eight-inch containers. An increase in fertilizer up to 25 grams/container enhanced visual grade and growth index, but height failed to increase beyond 18.2 grams (Table VII and Figure 14).

Results indicate that response to fertility does not increase when the rate of Osmocote exceeds 25 grams/container/year. An increase in both top and root weights with increased container volume, and a top weight increase only with added nutrition, indicates a greater efficiency of nutrient utilization as container volume increased to the seven-inch size.

Aucuba

Aucuba top weight, growth index, and visual grade improved significantly with increase in fertilizer to 25 grams/container (Table VII

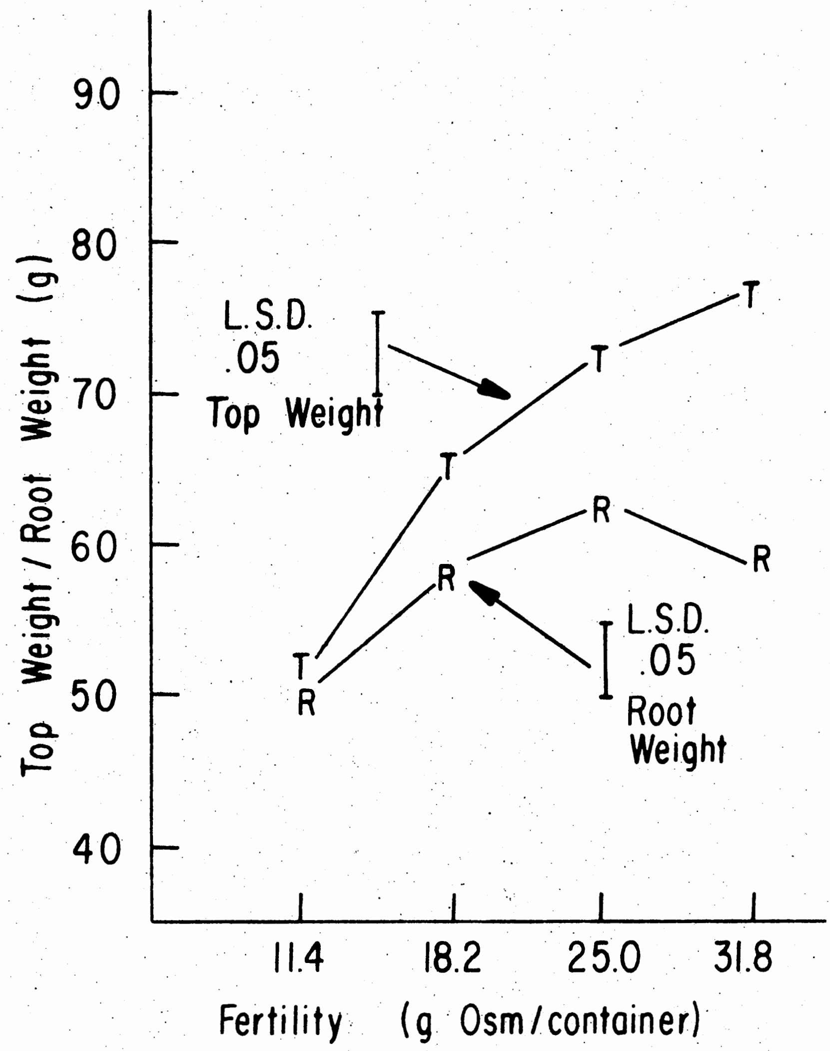

Figure 12. Effects of Fertility on Top and Root Weights of Pyracantha

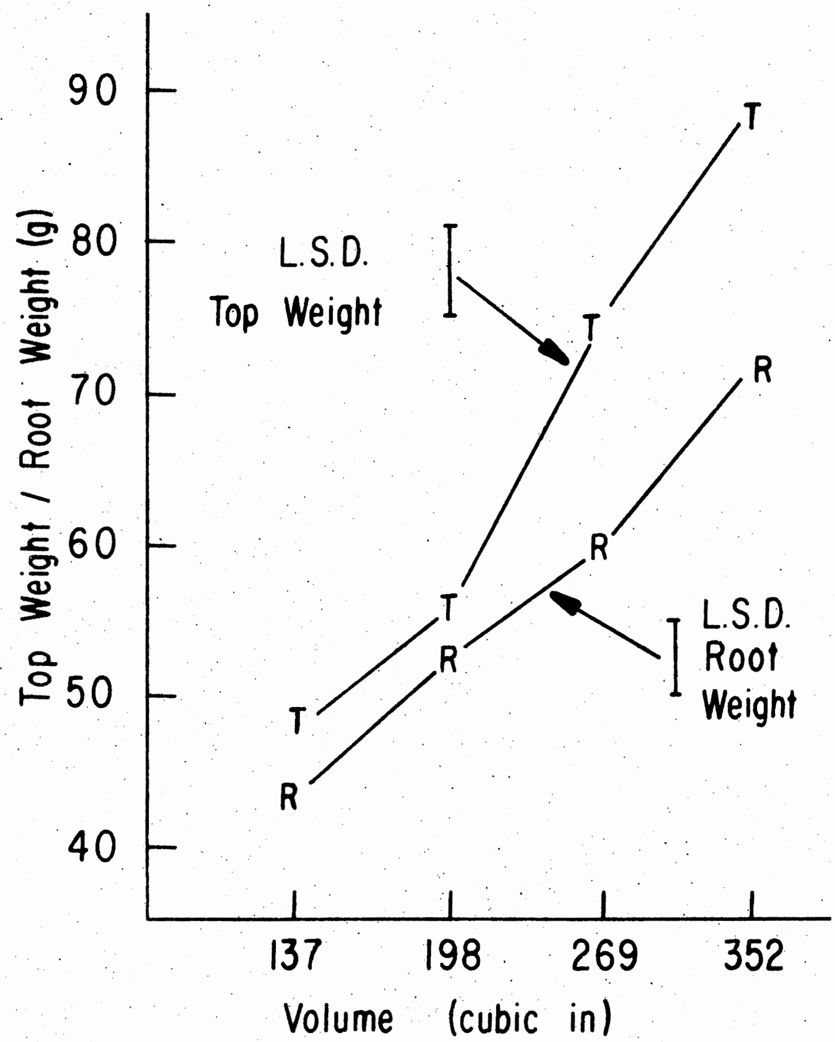

Figure 13. Effects of Container Volume on Top and Root Weights of Pyracantha

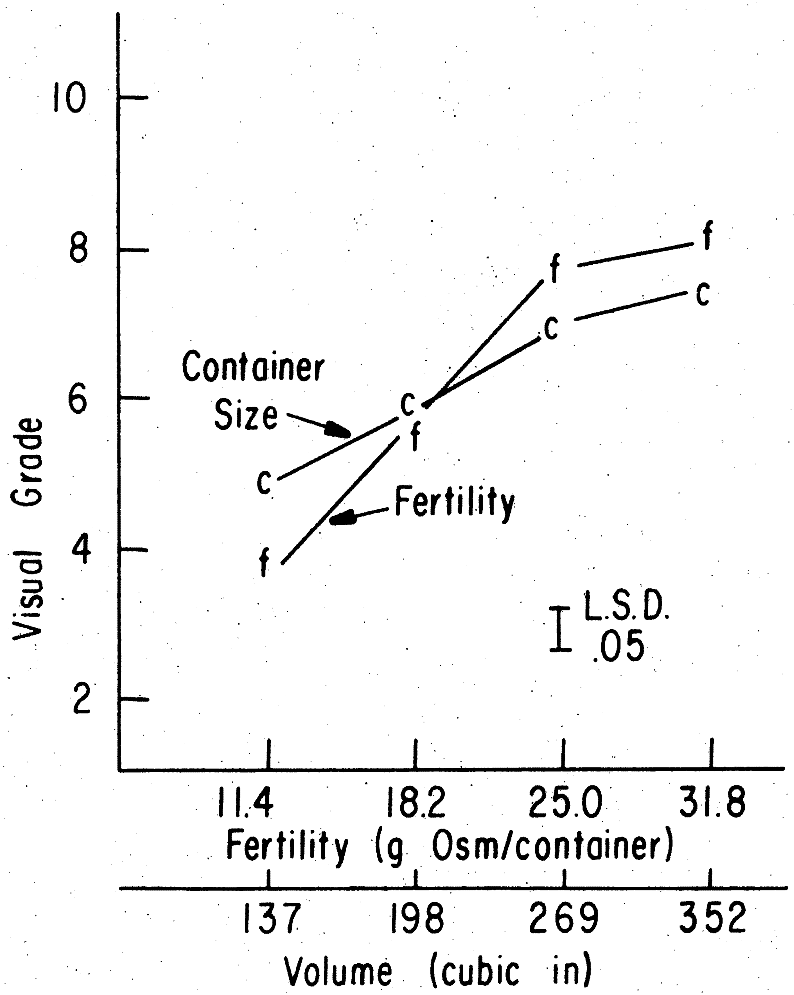

Figure 14. Effects of Container Volume and Fertility on Visual Grade of Pyracantha

and Figures 15 and 16. Evaluation of treatment differences on aucuba was difficult as damage incurred by high light intensity in the early stages of the experiment was still evident at termination.

Economic Analysis

If visual grade has been determined without bias, it becomes a composite measurement of all growth parameters. Each individual response is reflected in the overall appearance of the plant. Measurement of height growth of shrub species or growth index of trees reflects a response which may not be valid in determination of superiority between experimental variables. Top and root weights give an indication of relative size, but not salability or appearance of plants being evaluated. However, any deviation from the normal response to experimental treatment, for any species, is detected by visual grade in terms of plant quality. Dirr (27) observed the universal acceptance of quality as a guide in the determination of economic differences when evaluating all species of plants.

Results of the analysis outlined in Chapter III are a reflection of differences in visual grade in terms of dollars and cents.

One-Year Analysis

Based on average visual grade for each treatment, the greatest net return for Burford holly was in five-inch (167 cubic inch) containers with 11.4 grams Osmocote applied yearly (Figure 17).

Pyracantha and aucuba were most economically grown in six-inch (198 cubic inch) containers at 25 grams of Osmocote per year (Figures 18 and 19).

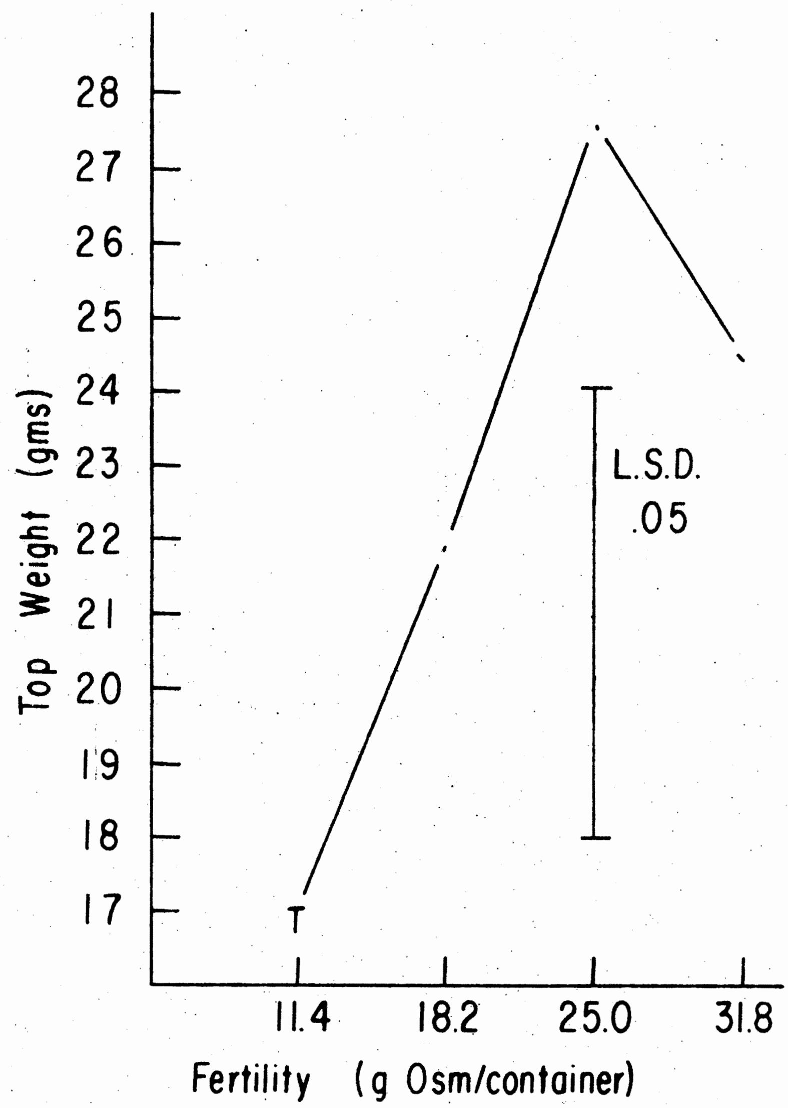

Figure 15. Effects of Fertility on Aucuba Top Weight

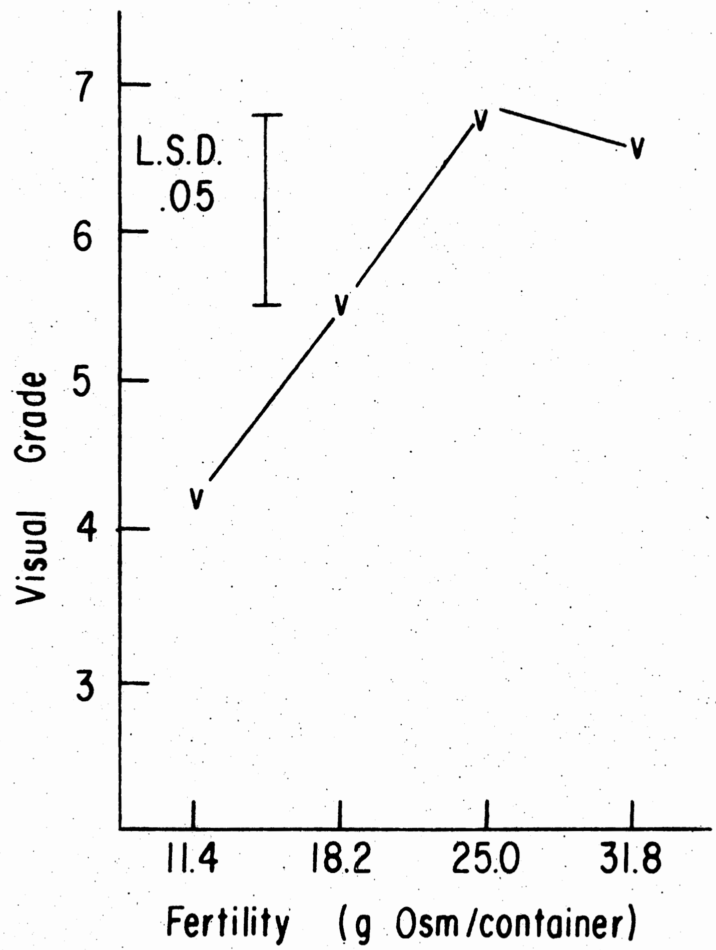

Figure 16. Effects of Fertility on Aucuba Visual Grade

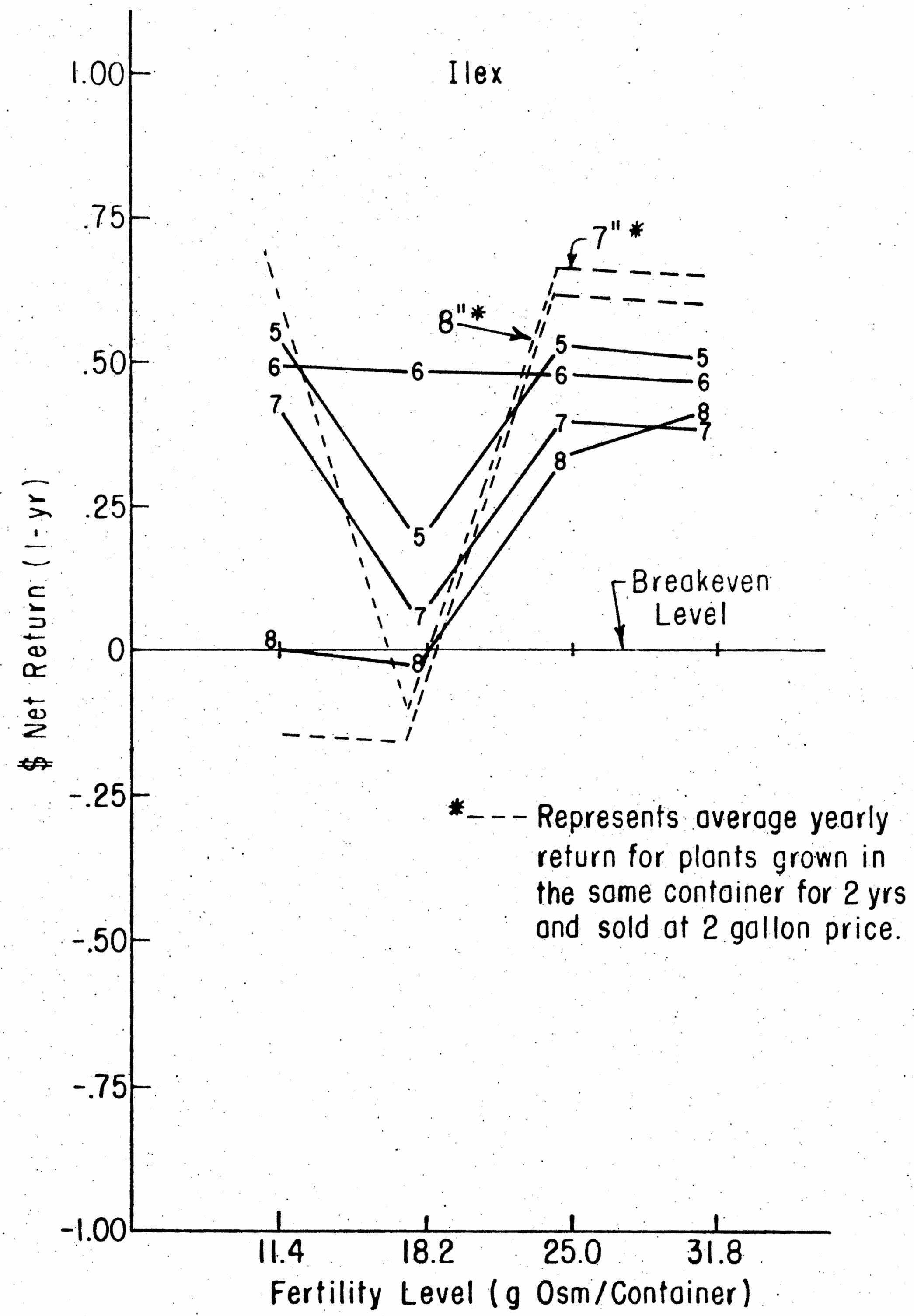

Figure 17. Influence of Volume and Fertility on Net Return for Burford Holly

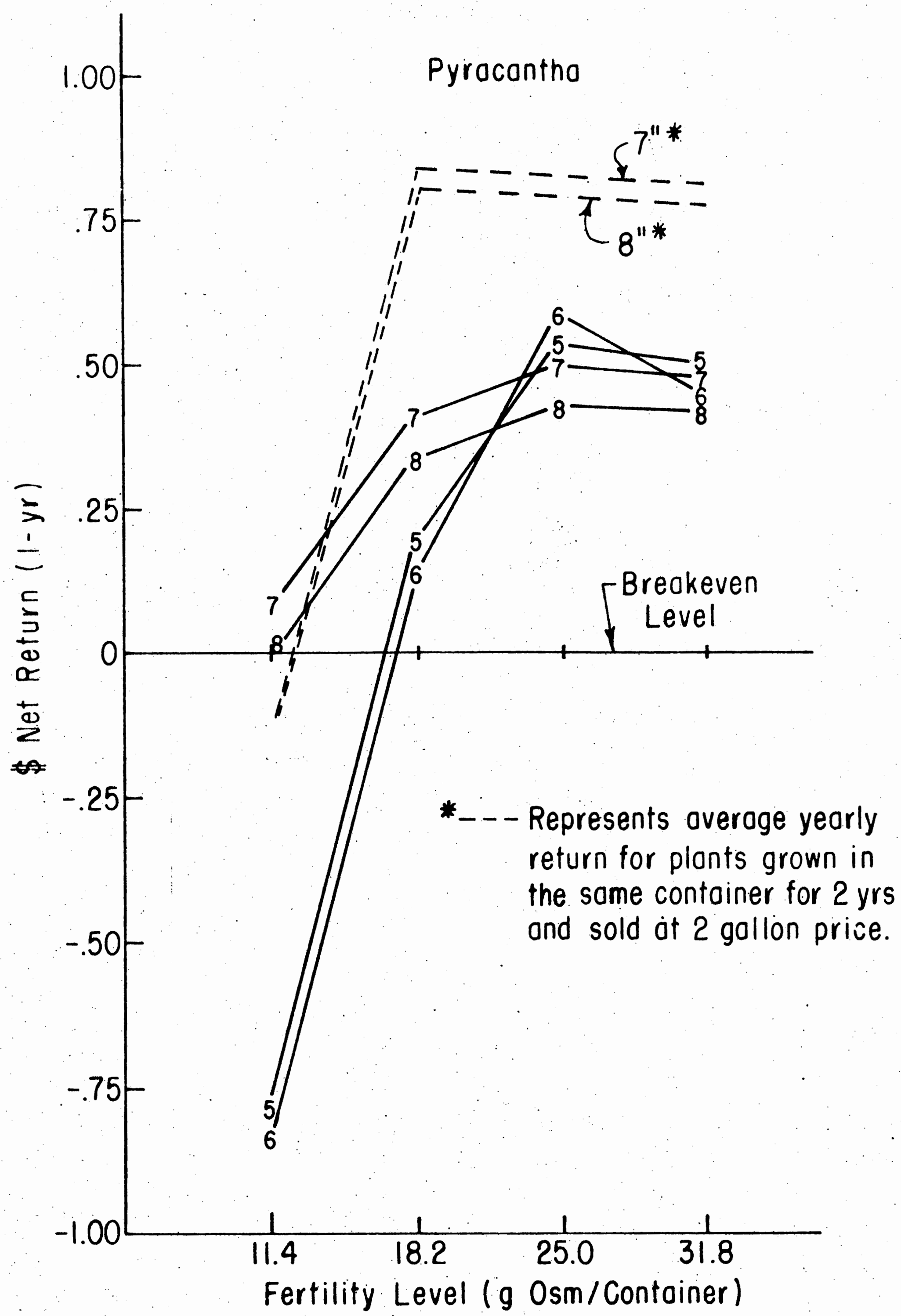

Figure 18. Influence of Volume and Fertility on Net Return for Pyracantha

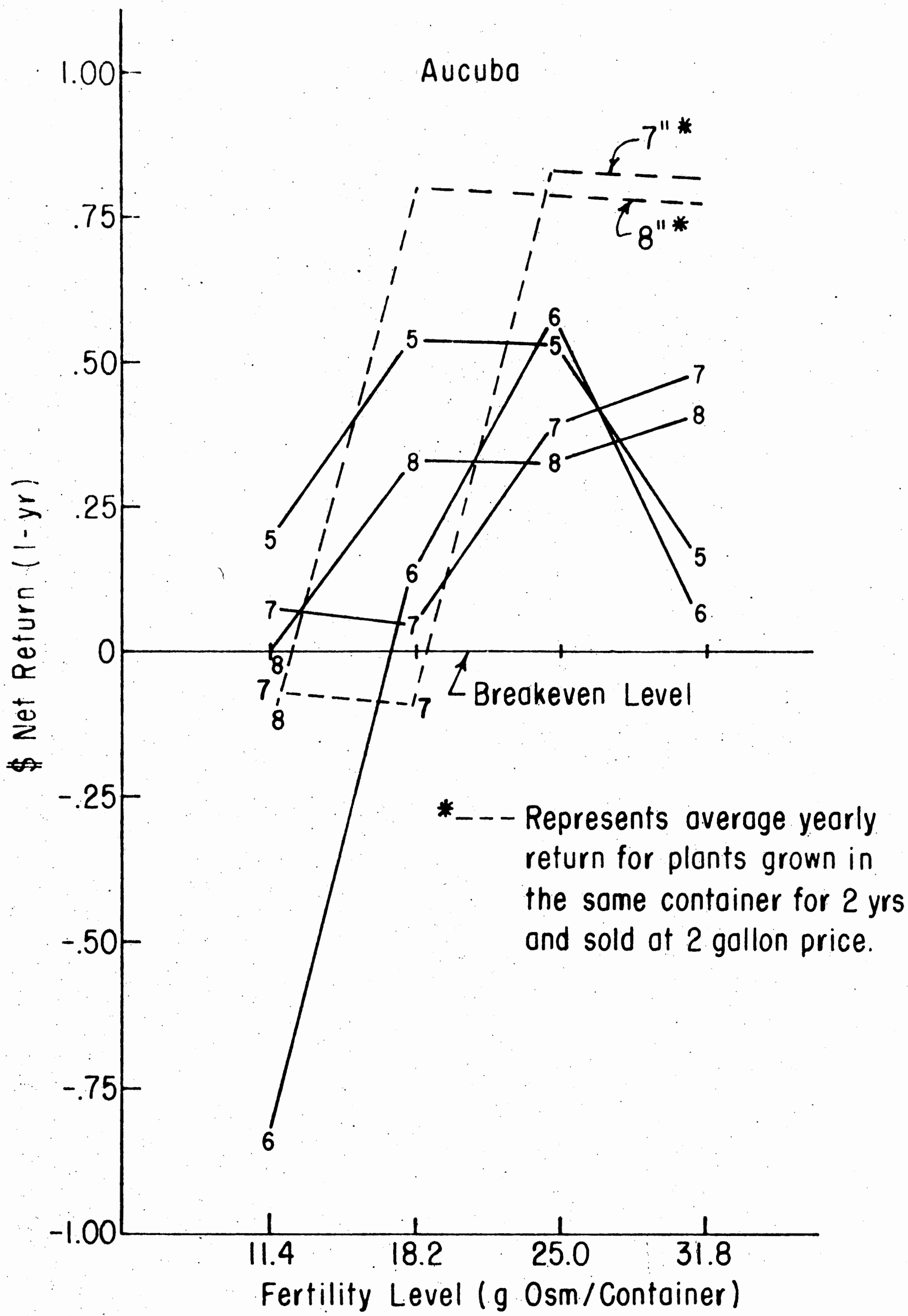

Figure 19. Influence of Volume and Fertility on Net Return for Aucuba

Barberry proved most profitable when grown in five-inch containers and 31.8 grams Osmocote (Figure 20), while juniper and elaeagnus returns were maximized with 31.8 grams in a six-inch container (Figures 21 and 22).

Two-Year Analysis

When growth responses were projected to the end of the second growing season (Chapter III), all species tested achieved highest profit in seven-inch containers. This comparison was based on response in the first year and present pricing and marketing procedures.

Aucuba, barberry, and elaeagnus required 25 grams of fertilizer to produce highest returns (Figures 19, 20, and 22), while pyracantha and Juniper (Figures 18 and 21) needed 18.2 grams and holly only 11.4 grams (Figure 17). All species showed highest profit when grown for two years in either seven or eight-inch containers as compared to profit in any container size/fertility combination after just one year.

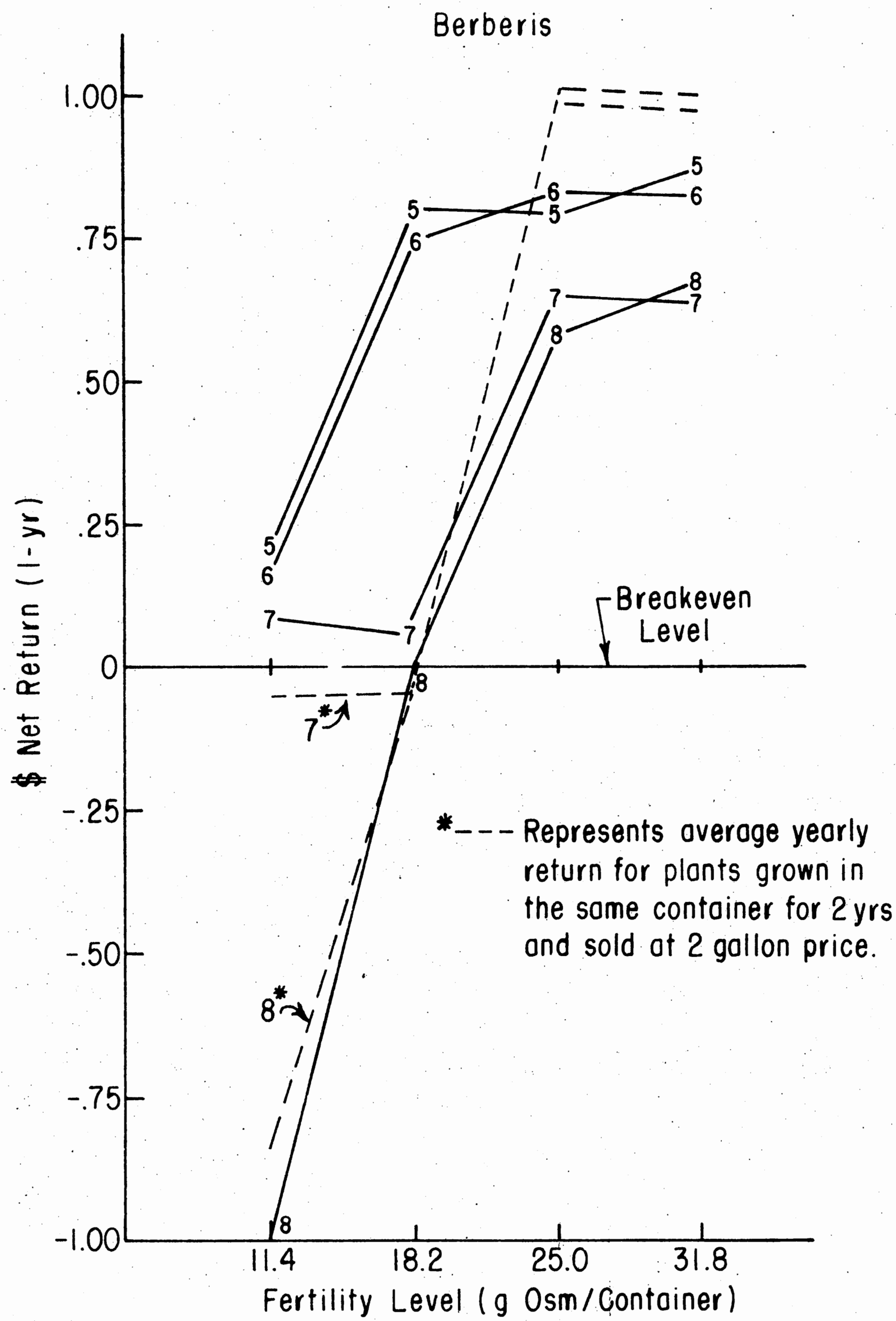

Figure 20. Influence of Volume and Fertility on Net Return for Barberry

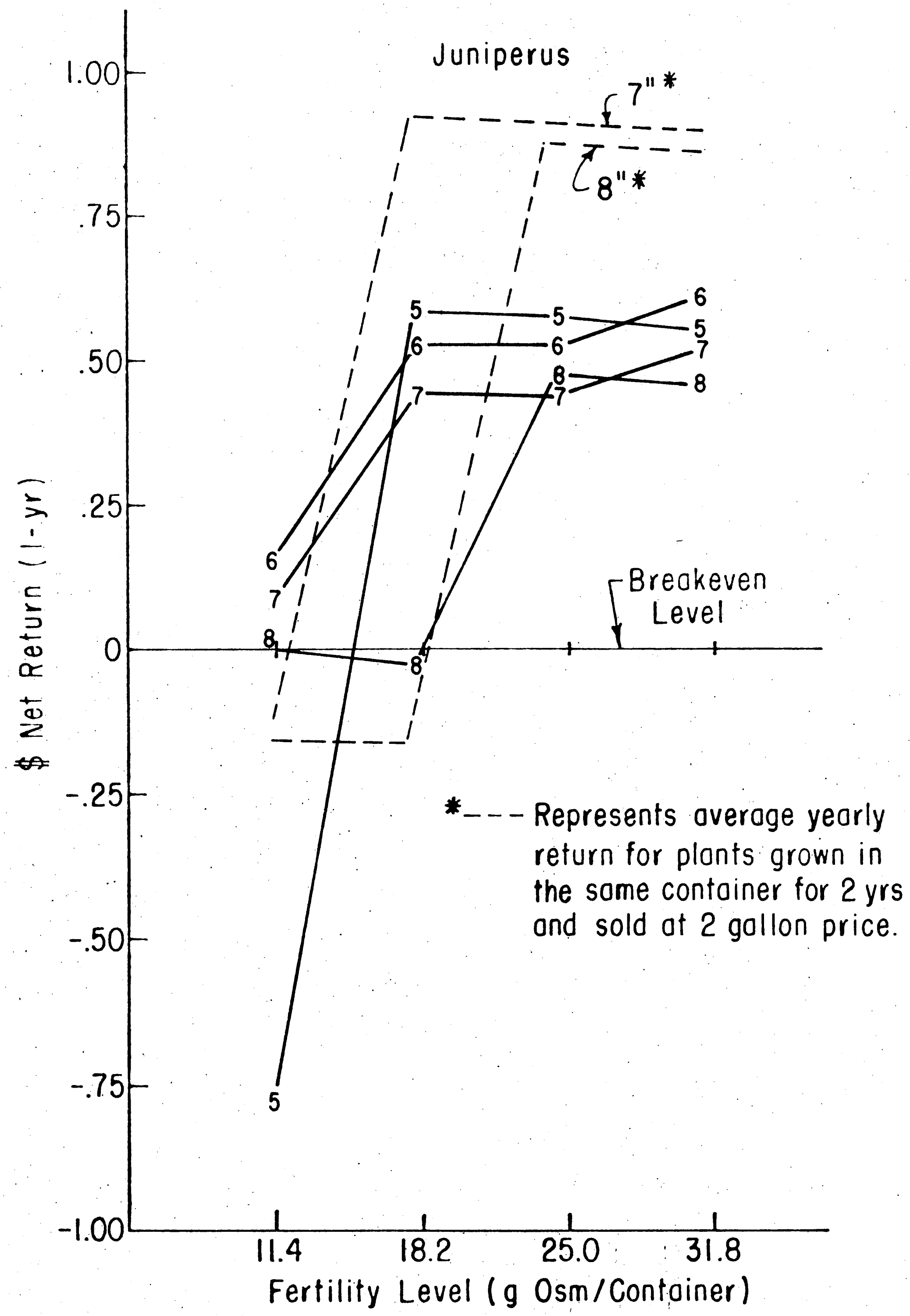

Figure 21. Influence of Volume and Fertility on Net Return for Hetzi Juniper

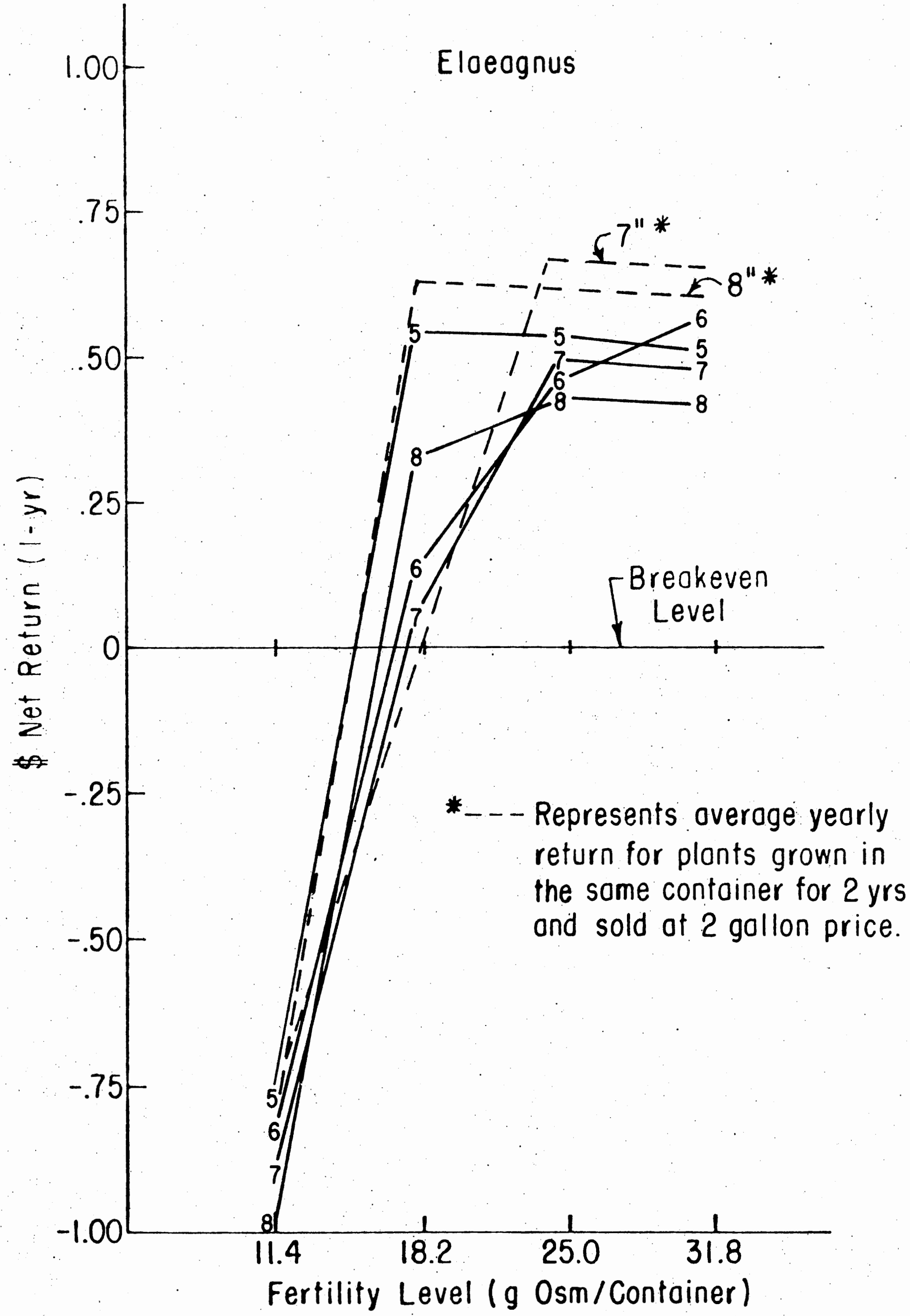

Figure 22. Influence of Volume and Fertility on Net Return for Elaeagnus

CHAPTER V

SUMMARY AND CONCLUSIONS

The results of growth response and economic comparison of treatments indicates (Table XII):

(1) no standard fertility or container size will maximize growth or return for all species.

(2) except for species like Burford holly which do not respond to higher fertility or container volume, greatest growth and highest profit do not occur at the same volume/fertility combination.

(3) species which will achieve better growth and quality with higher levels of fertility or with greater volume (juniper, elaeagnus, and pyracantha) are still most economically grown in small containers with lower fertility if grown in a one-year production cycle. Market compensation for extra growth and quality is not enough to justify the added expense.

(4) a greater profit can be obtained by holding all of the species tested for two years if container volume is sufficient to support additional plant growth in the second year.

(5) with species similar to barberry, an increase in fertility beyond the level determined to be statistically optimum for plant growth can still be profitable.

(6) with species similar to aucuba, an increase in container volume beyond the level determined to be statistically optimum for

plant can still be profitable.

Measurement of growth response to the treatments did not provide an accurate assessment of profitability, nor did the economic analysis provide any insight as to the combinations which produced plants of high quality. Significant increases in growth did not correlate with significant increases in profit due to a market pricing system which does not sense subtle differences in plant quality. At the present time, market pricing does not accommodate large differences in plant quality either, and does not provide enough incentive for growing the best plant possible, regardless of species or duration of production cycle. However, the combination of economic and growth information derived together will allow a manager to assess his present profit structure and make intelligent changes in his production system if the market requires or rewards higher quality plants.

TABLE XII

SUMMARY OF GROWTH AND ECONOMIC EVALUATIONS FOR SIX WOODY ORNAMENTAL SPECIES

Species	Best Growth		Best Return (1 yr)		Best Return (2 yr)	
	Cont. Volume (in^3)	Osm. Rate (g)	Cont. Volume (in^3)	Osm. Rate (g)	Cont. Volume (in^3)	Osm. Rate (g)
Dwarf Burford Holly	137	11.4	137	11.4	269	25.0
Barberry	137	25.0	137	31.8	269	25.0
Aucuba	198	25.0	137	25.0	269	25.0
Pyracantha	269	25.0	198	25.0	269	18.2
Hetzi Juniper	352	25.0	198	31.8	269	18.2
Elaeagnus	269	25.0	198	31.8	269	25.0

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VITA 2

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