RESPONSE OF 3 WOODY ORNAMENTALS TO THE DIBBLE METHOD OF OSMOCOTE[R] PLACEMENT WHEN TRANSPLANTING LINERS INTO GALLON CONTAINERS

by

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ABSTRACT

The growth response of 3 landscape plants of varying salinity tolerances was tested when Osmocote^{R} 17-7-12 was placed directly beneath the liner at transplanting. This mode of fertilizer placement is referred to as the Dibble Method.

Species used include Bougainvillea x 'Barbara Karst', highly salt tolerant; Pyracantha fortuneana 'Graberi', moderately salt tolerant; and Trachelospermum jasminoides, salt sensitive.

Four Osmocote application rates were used (21, 30, 38, and 48 g/container), based on manufacturer recommendations for use, plus one level 25% greater than the highest suggested rate.

There was no significant difference in growth for Bougainvillea x 'Barbara Karst' or Pyracantha fortuneana 'Graberi' between the four Osmocote rates. Trachelospermum jasminoides showed significantly less growth at all Osmocote rates above 21 g/container.

Soil leachate conductivities from Trachelospermum jasminoides reached levels above the estimated tolerance level for Star Jasmine, although plants showed no sign of phytotoxicity.

Soil leachate conductivities from Bougainvillea x 'Barbara Karst' and Pyracantha fortuneana 'Graberi' were within their estimated tolerance level.

INTRODUCTION

Growing woody ornamental plants in containers has become a valuable and integral part of the nursery industry. In some parts of the country container production has replaced field culture as the primary method of growing nursery stock. Some of the advantages of container production include greater uniformity of plants because of increased control of environmental and cultural factors, more efficient use of production and sales areas, extension of planting and sales seasons, greater ease in transport, and the production of attractive cash and carry sales items. Aside from these advantages there are certain problems in container growing not encountered in a field production system. Two major considerations are plant nutrition and irrigation. The small volume of soil in containers provides only a limited nutrient and water reservoir. Frequent fertilization and irrigation are necessary. Loss of plant nutrients by leaching presents problems in maintaining optimum fertilizer levels. This is especially significant since periods of highest water use often occur at the time of high nutrient requirements. In addition, the light weight soil mixes used for ease in handling generally have a low cation exchange capacity.

For optimum plant growth, a fairly uniform and continuous supply of fertilizer is necessary. During periods of active growth, optimum fertilizer levels could be somewhat higher than at other times. How to supply optimum dosages of nutrients to thousands of containers

is of vital concern in nursery management. With today's rising cost of labor, equipment, and fertilizer, and a concern for environmentally sound practices, the nurseryman must evaluate his management systems more closely.

Liquid fertilizer applied through irrigation systems, application of dry fertilizer to each pot, or the use of slow release fertilizer materials, are the basic methods of supplying the nutrient requirements of container stock. Repeated application of dry fertilizer to individual pots is labor intensive and uniform application is very difficult. Although liquid fertilizer applications are easily distributed and automated not all fertilizer materials can be applied in this manner and special pumping or proportioning equipment is required. The other approach to fertilization is the use of slow release fertilizers which release nutrients over an extended period. Application can be made at planting time and this one application may be sufficient for an entire crop cycle for short term plants. The slow release of nutrients reduces the chance of burn from heavy application, prevents excessive leaching losses, and reduces luxury absorption of nitrogen (Heilman, Thomas, and Namken, 1966).

Osmocote^{R} is a resin coated slow release fertilizer manufactured by the Sierra Chemical Co., Milpitas, California. It consists of a water soluble fertilizer prill with multiple plastic polymer coatings. Today Osmocote has been used successfully in the production of many horticultural crops, including herbaceous and woody ornamentals, turfgrass, fruits, nuts and vegetables.

When Osmocote is incorporated into soil mix and stored for a week or more significant amounts of fertilizer salts can be released. Unless the soil is leached prior to planting, phytotoxicity may occur. Leaching may prevent plant injury, but this wastes fertilizer and is a more potential pollution concern. Rather than incorporating Osmocote into soil that is to be stored, it may be better to apply it at the time of planting. Application should not interfere with transplanting practices, increase production costs, or result in damage or stress to the nursery stock.

Osmocote manufacturers have suggested another mode of application which they term the Dibble method. In this method of Osmocote application the fertilizer is placed directly beneath the plant at transplanting. This is a fast efficient alternative to soil incorporation, but there is the need to assess its safety to plants and its benefits in terms of improved growth.

The purpose of this research is to determine the growth response of landscape plants of varying soluble salt tolerances to the Dibble Method placement of four rates of Osmocote^{R} 17-7-12 at the time of transplanting nursery liners to gallon containers.

LITERATURE REVIEW

The slow release of fertilizer nutrients over an extended period of time has been achieved by the use of nitrification inhibitors, low solubility compounds, nitrogenous compounds mineralized slowly by microbial action, treated organic materials requiring microbial action for nutrient release, and by coating or encapsulating soluble fertilizer (Hauck and Koshino, 1971; Lunt, 1971; Maynard and Lorenz, 1979). Detailed reviews on the theory, practice, and chemical reactions of slow release fertilizers have been prepared by Allen and Mays (1974), Hauck (1972), Hauck and Koshino (1971), and Prasad, Rajale, and Kakhdive (1971). Reviews of slow release fertilizer from a horticultural standpoint are provided by Barron (1974), Kofranek and Lunt (1966), Lunt (1971), Maynard and Lorenz (1979), and Sharma (1979). Patent and manufacturing details are covered by Araten (1968), Powell (1968), and Slack (1968). Market potential of slow release fertilizer is periodically evaluated in the Chemical Economics Handbook (Merritt, 1976).

The focus of this study is in the use of Osmocote^{R}, a resin coated soluble fertilizer developed by Archer Daniels-Midland Co. and patented in 1965: U.S. patent no. 3,223,518. The license for Osmocote^{R} is now held by Sierra Chemical Co., Milpitas, California. The resin coating is applied over the fertilizer prill in several layers of different composition. The main constituent of these layers is a copolymer of dicyclopentadiene with a glycerol ester (Powell, 1968). The nutrient

release period can be controlled by the selection of coating type, thickness, and fertilizer source (Barron, 1974; Oertili and Lunt, 1962). Some of the Osmocote^{R} formulations (N-P-K) and dissolution rates currently available include 14-14-14 (3 to 4 month), 19-16-12 (3 to 4 month), 13-13-13 (8 to 9 month), 18-6-12 (8 to 9 month), and 17-7-12 (12 to 14 month).

Nutrients are released from the coated prill by diffusion. Under moist conditions, water vapor diffuses through the coating, dissolves the soluble core, and the nutrients in solution move out through the membrane into the soil. The deterioration of the coating is not a factor in release, there is no evidence of coating degradation during the release period. Rate of nutrient release is influenced by temperature, an increase from 10° C to 20° C almost doubles the release rate, and at temperatures below freezing release ceases (Barron, 1974a & b, 1977; Brown, Luebs, and Pratt, 1966; Oertli and Lunt, 1862). Release rate is not affected by soil pH, microbial activity, or soil moisture levels between the permanent wilting point and field capacity (Ahmed et al., 1963; Barron, 1974a, 1977; Lunt and Oertli, 1962; Lunt, Oertli and Kofranek, 1962).

Soil incorporation of Osmocote will increase release rate whereas the intermittent drying of a surface application slows release due to lack of continuous moisture (Barron, 1974; Lunt and Oertli, 1962; Waters, 1963, 1965).

Release curves have been characterized by Oertli and Lunt (1962), Patel and Sharma (1977), and Prasad and Woods (1971).

The literature provides numerous reports on nutritional studies of woody plants which relate slow release fertilizer sources and/or rates to growth and appearance. Although some discrepancies among experimental results are apparent it appears that under many circumstances Osmocote^{R} produces growth and plant quality equal to or better than other fertilizer sources (Furuta, 1976; Hathaway and Whitcomb, 1975; Mcfadden and Conover, 1970; Marie and Bronson, 1977; Orton and Flannery, 1976; Whitcomb, 1975). Chadwick (1977) compared the growth of Viburnum plicatum 'Tomentosa', using Osmocote (8 to 9 month dissolution rate) to periodic liquid fertilization. He found the plant growth to be equivalent from the two fertilizer sources, although 41% more nitrogen was applied to each plant in the liquid fertilizer treatments. In another study, soil incorporated Osmocote (8 to 9 month dissolution rate) was compared to continuous liquid fertilization, via irrigation, for the growth of Pyracantha x 'Loboy', Ilex crenuta 'Helleri', Juniperus horizontalis 'Douglasi', Weigela florida, and Prunus laurocerasus in 1 gallon containers (Gouin and Link, 1973). Plants grown with the Osmocote produced top growth equal to plants grown with continuous liquid fertilization. Prunus laurocerasus showed significantly greater stem length with Osmocote.

In some cases, superior performance of soluble liquid fertilizers over Osmocote and other slow release fertilizers has been observed (Dickey, 1969; Istas, 1976; Sanderson and Martin, 1974).

Effectiveness of single applications of slow release fertilizer over limited periods has been shown (Coultas, 1966; Dickey and Poole, 1966; Dickey, 1969). In one such study, soil incorporated and surface

applied Osmocote (8 to 9 month dissolution rate) were compared with periodic liquid fertilization of container grown 'Coccinea Major' and 'Gloria' azaleas (Poole and Waters, 1972). Appearance and plant growth with one application of Osmocote, regardless of application method, was superior to liquid fertilization.

In personal communication, Sierra Chemical Co. discussed the problem of incorporated Osmocote in soil stored one week or longer. In these soil/fertilizer mixes, the fertilizer salts build up and can reach levels toxic to plants. This soil must be leached before use to avoid possible plant injury. As an alternative to preplant soil incorporation of Osmocote, they suggest the placement of the fertilizer in the container just beneath the plant during the transplant process. They refer to this mode of fertilizer application as the Dibble Method. In this method of Osmocote application, the proximity of fertilizer to the plant roots poses the potential danger of salt injury. Plant species and varieties vary considerably in their tolerance to soluble soil salts. When plants are subjected to soluble salts exceeding their tolerance level, a number of symptoms can occur (Kelly, 1960; Dickey et al., 1978). Many woody ornamental plants can suffer a reduction in top growth without any visible symptoms where soil conductivities (Ec x 10^3) are between 2-4 mmho/cm.

MATERIALS AND METHODS

Representative species from three ranges of soluble salt sensitivity were selected based on information published by the United States Salinity Laboratory, Riverside CA. (Francois, 1980), and from work done on salt tolerance of landscape plants by Bernstein, Francois, and Clark (1972) and Ferguson (1952). Species used were as follows:

Very Poor Salt Tolerance (tolerates soil salinity no greater than 2mmho/cm)

Star Jasmine — Trachelospermum jasminoides (Lindl.) Lem

Moderate Salt Tolerance (tolerates soil salinity no greater than 5 to 6 mmho/cm)

Pyracantha — Pyracantha fortuneana 'Graberi'

High Salt Tolerance (tolerates soil salinity no greater than 10 mmho/cm)

Bougainvillea — Bougainvillea x 'Barbara Karst'

Uniform plants, approximately 6 inches (15.25 cm) tall, in 2¼ inch (5.72) cm containers, were purchased from a commercial nursery. Plant height was nearly equal for all three species.

The potting media consisted of a 1:1:1 ratio, by volume, of shredded pine bark, Canadian spagnum moss peat, and medium grade washed builders sand. One gallon (approximately 0.15 cu. ft. or 4.25 l volume), black, plastic nursery containers were used.

The fertilizer, Osmocote^{R} 17-7-12, with an estimated 12 to 14

month release period, was supplied by the product manufacturer, Sierra Chemical Co., Milpitas, CA. Rates of application were based on manufacturer recommendations for commercial use, plus one level 25% greater than the highest suggested rate.

Table 1. Rates of Osmocote^{R} 17-7-12 used in a study of the effectiveness of the Dibble Method of application on growth of woody ornamentals

Manufacturer Recommended Rates For Incorporation of Osmocote per cubic foot of soil mix.	Amount of Osmocote Applied Per Container
Low (salt sensitive plants) 5 oz	0.75 oz (21 g)
Medium (standard nursery stock) 7 oz	1.04 oz (30 g)
High (greenhouse or nursery stock) 9 oz	1.35 oz (38 g)
High +25% 11.25 oz	1.68 oz (48 g)

Containers were filled nearly 3/4 full with moist media. A depression about 2 inches (5 cm) deep and 2 inches (5 cm) in diameter was made in the media in the center of the container. Osmocote^{R} 17-7-12 was placed in the hole at one of the four rates shown in Table 1. The plant was then placed directly on top of the Osmocote and the transplanting completed.

Plants were potted in September, 1981, and placed under 50% shade cover for 10 days. The plants were then transferred to the nursery yard at the University of Arizona Campbell Avenue Research Farm. A

randomized complete block design was used, with 10 replications, and one plant per experimental unit.

Plants were watered manually, to saturation and beyond, as needed. Temperatures in the nursery yard ranged from an average maximum of 95 F (35° C) and an average minimum of 54° F (12° C).

In November, the plants were moved into a greenhouse in order to maintain active growth. Greenhouse temperatures ranged from 100° F (38°C) to 40° F(4° C).

Soluble salt readings were taken weekly from soil leachates for the first three months of the experiment, and subsequently at two week intervals. All pots were watered, if needed, the day before leachates were collected. At each reading three complete replications were selected. Pots were placed on large funnels held in plastic containers. Two hundred millileters of water of known conductivity was applied to each pot, and leachates were collected after about 5 minutes. A Hach Portable Water Analysis Instrumentation Conductivity Meter was used for conductivity readings.

In March, 1982, growth measurements, including length of longest branch, number of branches, and number of nodes, were taken. Three complete replications of each species were randomly selected and ranked for purchase preference. Judges were asked to rank the plants within each replicate as to which they would select to buy first, second, third, and fourth, assuming all plants of each species were the same price. All plants were then harvested, fresh weights of top growth taken, and roots observed. The harvested plant material was dried at 150°F (66°C)

for seven days, and dry weights taken.

An analysis of variance was determined, by species, for each growth parameter. Treatment means for growth parameters were compared for significance by the Student-Newman-Kuels' test, at the 5% level.

A linear regression line and coefficient of correlation (r) value was generated, by species, to show the relationship between the dry weight of individual plants and their corresponding average leachate conductivity.

Results from the purchase preference ranking of plants were analyzed for each species by the Freidman test.

RESULTS AND DISCUSSION

The Dibble Method of Osmocote[R] 17-7-12 application did not cause salt damage when used at manufacturer recommended rates under the conditions of this study. There appears to be a wide range of application rates at which Osmocote[R] 17-7-12 can be used with equal success in terms of growth responses. Statistical analysis of the growth parameters of Bougainvillea x 'Barbara Karst' and Pyracantha fortuneana 'Graberi' revealed no significant differences in plant fresh weight, dry weight, number of nodes, number of branches, and length of longest branch, between the four rates of Osmocote application (Tables 2 and 3). Healthy, vigorous plants of both bougainvillea and pyracantha were produced at each Osmocote application rate. There was no visible difference in foliage color between fertilizer levels for each species. Plants grown without Osmocote were found to be inferior in all growth parameters to those plants grown with Osmocote.

Observation of the roots of Bougainvillea x 'Barbara Karst' revealed that the most dense and well established root systems were produced at Osmocote rates of 38 g and 48 g per container. The 38 g level produced the largest root systems with many fine fibrous roots. Plants grown at the 48 g level also had large roots sytems, but roots were generally less fibrous and of larger diameter. There did not appear to be a significant difference in the root systems produced at the 21 g and 30 g per container rates. The control plants had somewhat smaller root systems, but appeared healthy.

Table 2. Growth of Bougainvillea x 'Barbara Karst' in 1 gallon containers with varying levels of Osmocote[R] 17-7-12 applied directly beneath the plant at transplanting.[z]

Fertilizer Rate (g Osmocote per container)	Fresh wt (g)	Dry Wt (g)	No. Nodes	No. Branches	Length of longest branch (cm)
0	2b[y]	1.06b	24.00b	2.30b	18.68b
21	43a	13.33a	85.30a	6.20a	48.49a
30	39a	12.75a	95.30a	5.60a	45.44a
38	42a	13.68a	98.50a	6.20a	44.28a
48	45a	13.43a	90.30a	5.90a	44.82a

z
All values given are the average of 10 plants unless otherwise indicated.

y
Mean separation in columns by Student-Newman-Keul's test, 5% level.

Table 3. Growth of Pyracantha fortuneana 'Graberi' in 1 gallon containers with varying levels of Osmocote[R] 17-7-12 applied directly beneath the plant at transplanting.[z]

Fertilizer rate (g Osmocote per container)	Fresh wt (g)	Dry wt (g)	No. Nodes	No. Branches	Length of longest branch (cm)
0	5b[y]	3.17b	39.00b	4.67a	23.11b
21	62a	27.07a	265.89a	22.67a	62.37a
30	58a	24.34a	257.60a	25.20a	58.18a
38	67a	27.62a	269.40a	31.40a	62.92a
48	60a	22.24a	268.50a	28.70a	54.26a

[z] All values are the average of 10 plants unless otherwise indicated.

[y] Mean separation in columns by Student-Newman-Keul's test, 5% level.

Pyracantha fortuneana 'Graberi' produced healthy root systems at all 4 Osmocote application levels. The densest root systems were observed at the 30 g and 38 g per container levels. The 48 g/container rate generally produced a larger root system, but not as dense as those produced at the 30 g and 38 g levels. Roots from plants grown at the 21 g/container level appeared well developed and healthy. Control plants had smaller root systems than those grown with Osmocote, but appeared healthy.

Trachelospermum jasminoides exhibited a different response to the four Osmocote application rates. Statistical analysis showed the only significant difference in growth between treatments occured at the lowest applicaton rate, 21 g/container (Table 4). The plants grown at this fertilizer level produced greater fresh weight, dry weight, and number of nodes. Plants grown at the higher fertilizer rates displayed healthy foliage and new growth at the time of harvest. There was no visible evidence of phytotoxicity. Plants grown without Osmocote were stunted and chlorotic.

Star jasmine plants produced healthy roots at all Osmocote application rates. Plants grown at the 21 g/container level generally had the densest root systems.

For each species, the average leachate conductivity was determined per container and compared to the dry weight of that particular plant. The relationship was found to be significant at the .05 level for both bougainvillea and pyracantha. Although the coefficient of determination (r^2) for both species showed that only 25% of the variation in dry

Table 4. Growth of Trachelospermum jasminoides in 1 gallon containers with varying levels of Osmocote^{R} 17-7-12 applied directly beneath the plant at transplanting.[z]

Fertilizer rate (g Osmocote per container)	Fresh wt (g)	Dry wt (g)	No. Nodes	No. Branches	Length of longest branch (cm)
0	5a[x]	2.25b	32.70a	5.90b	19.24a
21	22c	5.91a	68.80c	12.40a	39.35b
30	12b	3.47b	62.60b	12.00a	33.40ab
38	10ab	3.10b	61.00ab	11.10a	23.03a
48	11ab[y]	3.23b[y]	66.29ab[y]	13.00a[y]	20.08[y]

z
All values given are the average of 10 plants unless otherwise indicated.

y
Average of 7 plants

x
Mean separation in columns by Student-Newman-Keul's test, 5% level.

weight could be attributed to variation in conductivity (Figures 1 and 2). The coefficient of correlation (r) determined for the relationship between conductivity and dry weight for star jasmine showed a high negative correlation when the control values were excluded (Figure 3). When control values were included the coefficient of correlation dropped by 1/2 but was still significant at the .05 level.

The highest application rate of Osmocote^{R} 17-7-12 used in this experiment did not create soluble salt levels high enough to inhibit the growth of either Bougainvillea x 'Barbara Karst' or Pyracantha fortuneana 'Graberi'. Bougainvillea has been found to be highly tolerant of soluble soil salts, showing little or no damage at soil conductivities of 8mmho/cm (Bernstein, Francois, and Clark, 1972; Ferguson, 1952; Francois, 1980). The conductivity of the bougainvillea leachates at any of the treatments was not found to exceed an average of 4.4 mmho/cm at any time throughout the study (Figure 4).

Pyracantha has been shown to be moderately salt tolerant, showing a 25% reduction in top growth where soil conductivities are between 5 to 6 mmho/cm (Bernstein, Francois, and Clark, 1972; Ferguson, 1952; Francois, 1980). In this study, conductivities taken from Pyracantha soil leachates reached an average maximum of 5.2 mmho/cm at the 48g/container level at one reading, but conductivities generally ranged at a maximum of 3 to 4 mmho/cm (Figure 5).

Unlike bougainvillea and pyracantha, star jasmine is an extremely salt sensitive plant, showing a 25% reduction of top growth at soil conductivities as low as 2 mmho/cm (Bernstein, Francois, and Clark, 1972; Francois, 1980). Soil leachates taken from Trachelospermum jasminoides

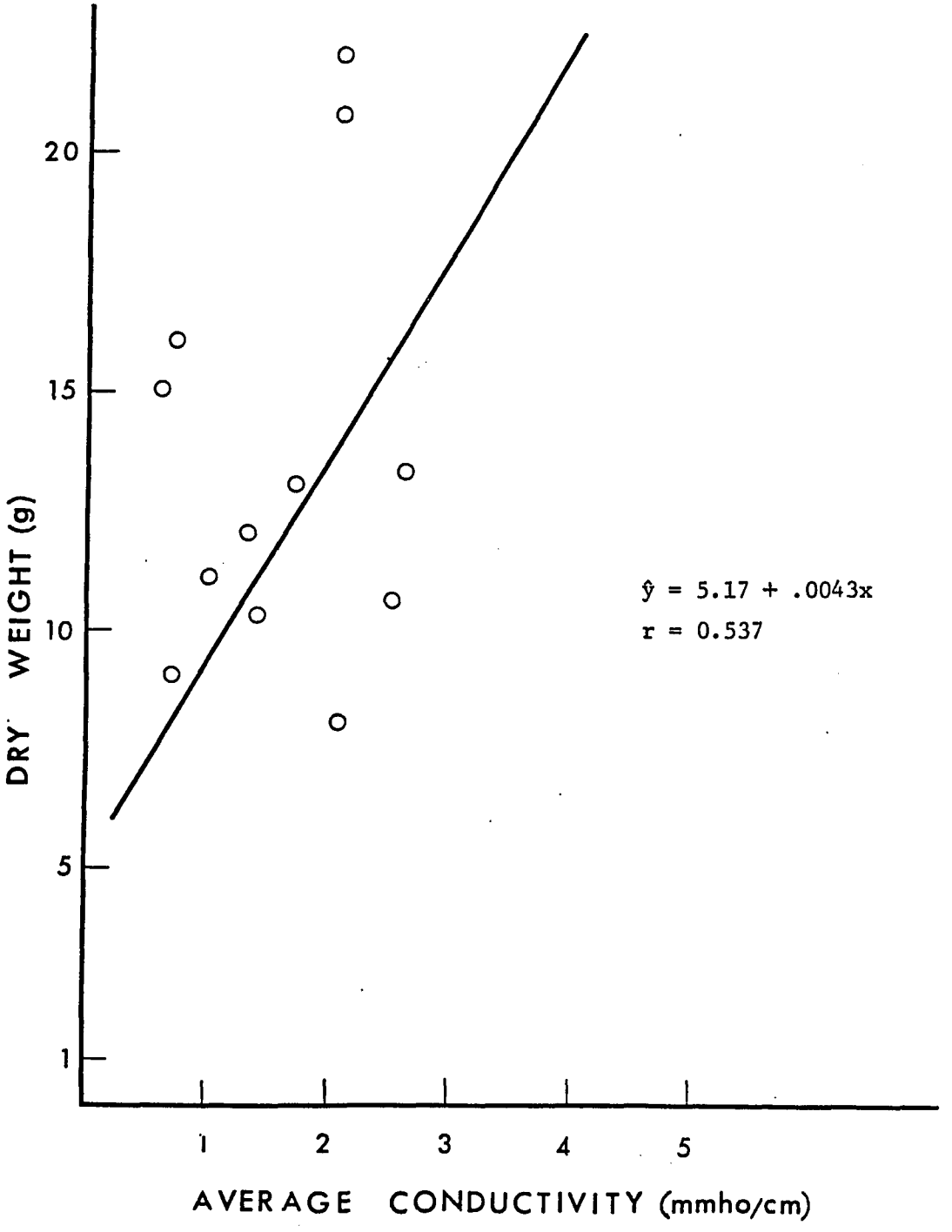

Figure 1. Relationship between the Dry Weight of individual Bougainvillea x 'Barbara Karst' plants and their average leachate conductivity.

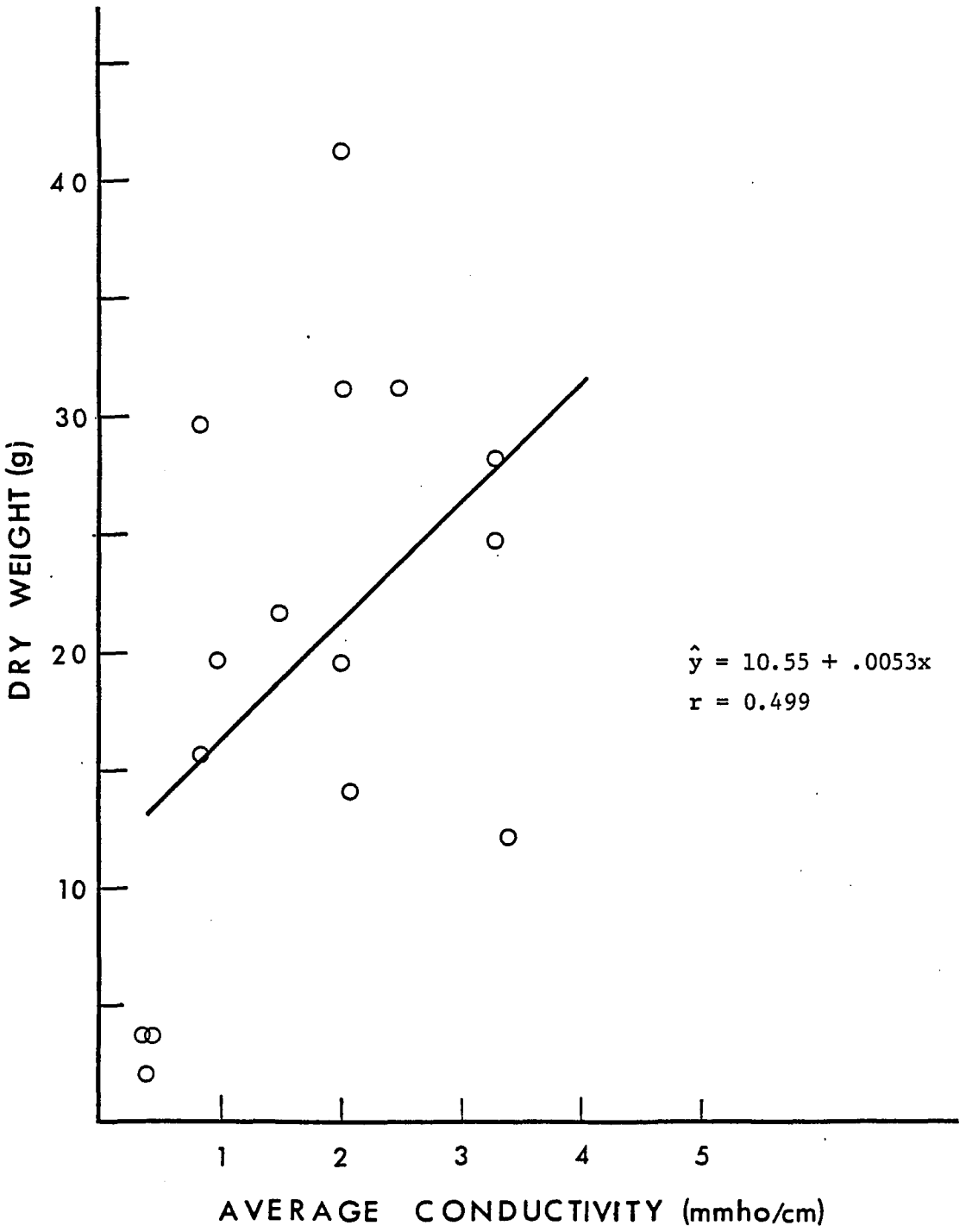

Figure 2. Relationship between the Dry Weight of Individual Pyracantha fortuneana 'Graberi' plants and their average leachate conductivity.

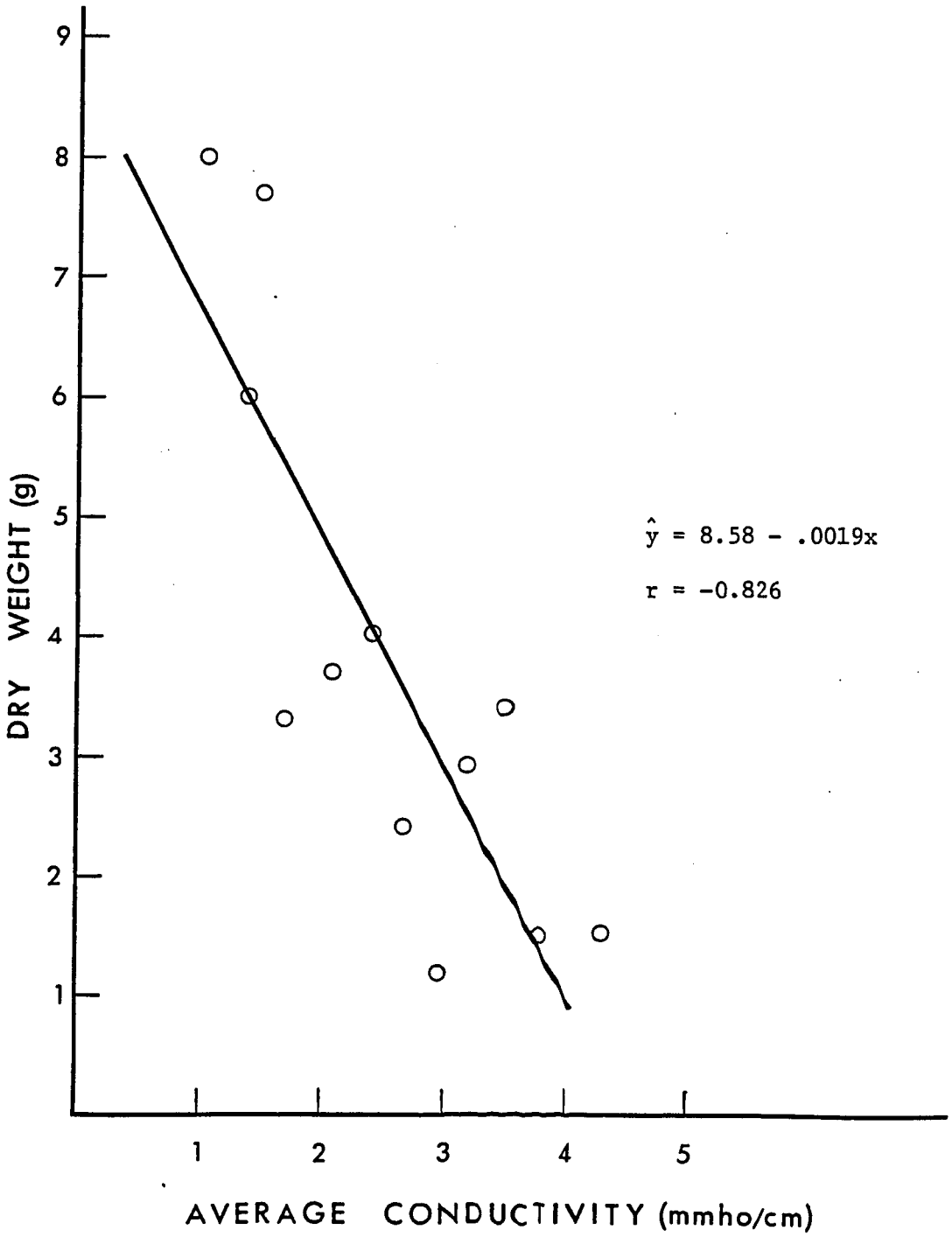

Figure 3. Relationship between the Dry Weight of individual Trachelospermum jasminoides plants and their average leachate conductivity.

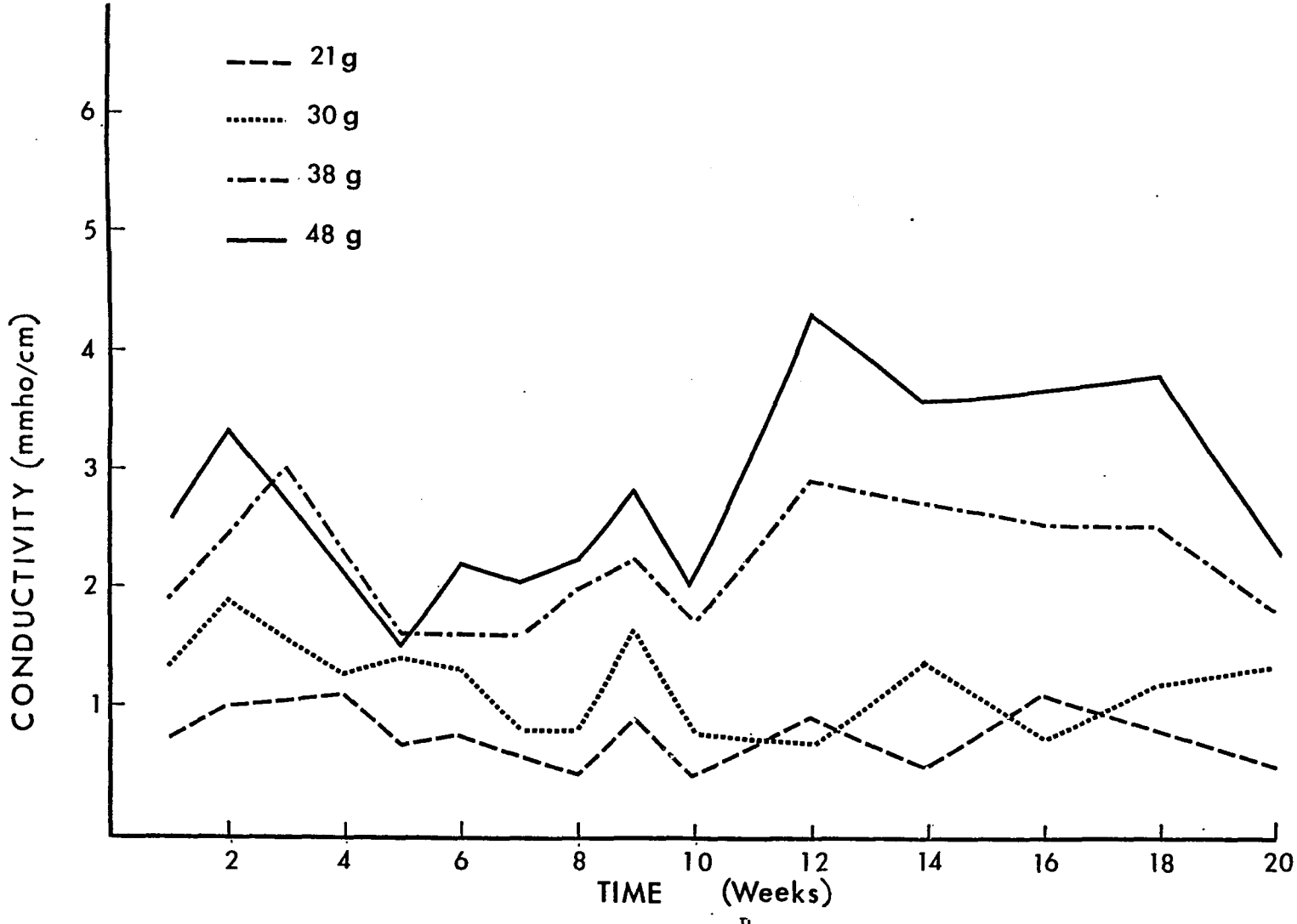

Figure 4. Leachate conductivity of 4 rates of Osmocote[R] 17-7-12 applied in the Dibble Method for the production of Bougainvillea x 'Barbara Karst' in 1 gallon containers.

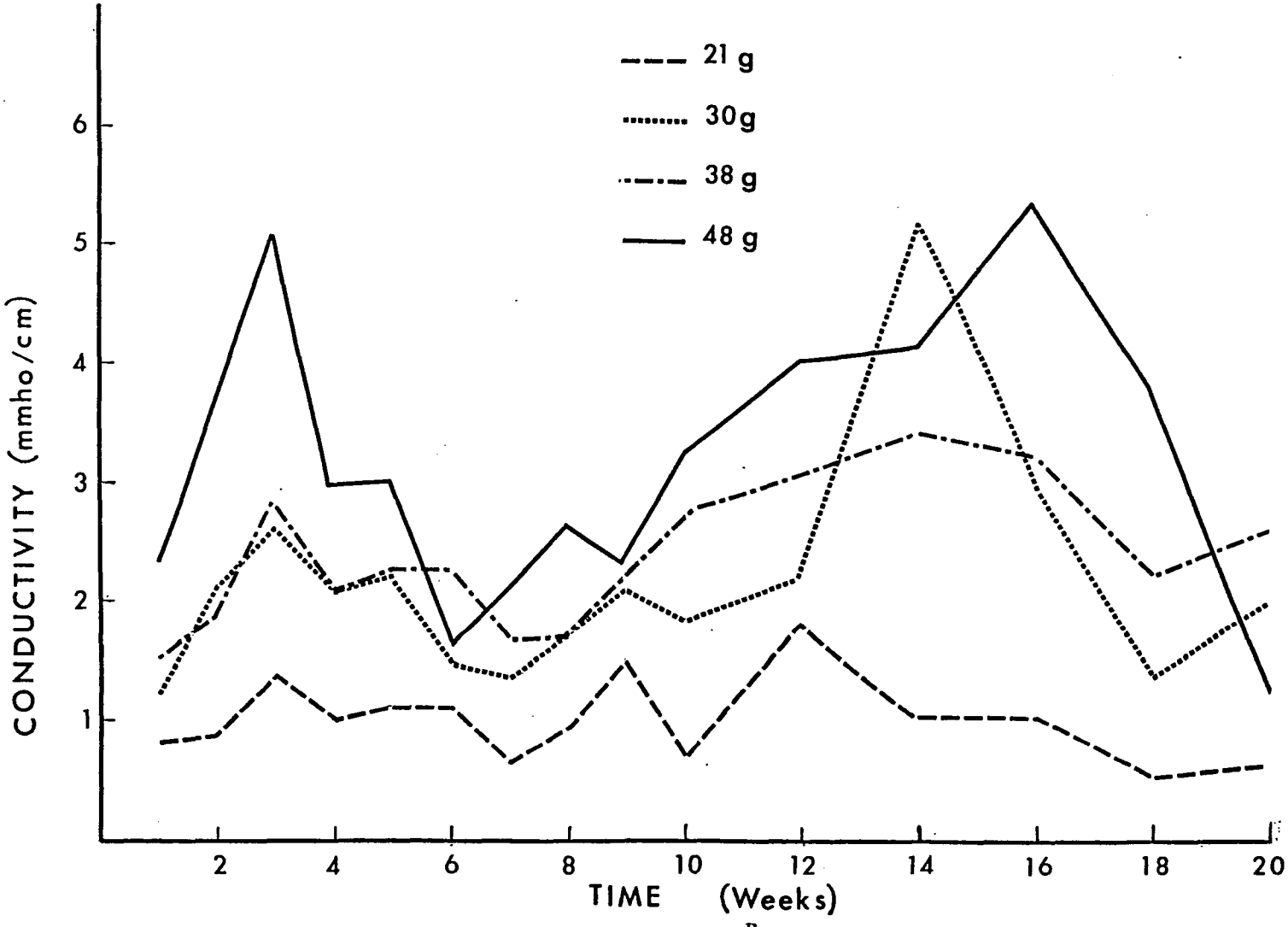

Figure 5. Leachate conductivity of 4 rates of Osmocote[R] 17-7-12 applied in the Dibble Method for the production of Pyracantha fortuneana 'Graberi' in 1 gallon containers.

at the 21 g/container level never reached 2 mmho/cm throughout the study (Figure 6). The highest conductivity at this treatment level was 1.9 mmho/cm, but values generally ranged between 0.9 to 1.7 mmho/cm. Average leachate conductivities from the other treatment levels ranged between 1.5 to 4.3 mmho/cm at the 30 g/container level; 1.5 to 5.1 mmho/cm at the 38 g level; and between 1.6 to 6 mmho/cm at the 48 g level. All but the lowest fertilizer rate created soluble soil salt conditions well above that tolerated by star jasmine.

Results of the ranking test for purchase preference showed no significant pattern for the choice of plants by fertilizer level (Table 5). Certain plants did receive significant preference, or non-preference, but this appeared to be a result of the characteristics of the specific plant and not a reflection of the treatment level. These results support the insignificance of increased Osmocote rates on the growth of Bougainvillea x 'Barbara Karst' and Pyracantha fortuneana 'Graberi'. It also shows that even though the lowest level of Osmocote produced the most growth in Trachelospermum jasminoides, these plants did not exhibit a significant increase in market value.

The results of this study show that Osmocote^{R} 17-7-12, applied in the Dibble Method, can safely be used in the production of ornamental woody plants in late summer and fall. Plants known to be highly sensitive to soil salts should receive the lowest recommended commercial application rate, or less. Other plants which are known to have higher tolerance to soil salts could receive higher rates of Osmocote. However, an increase in fertilizer above the 21 g level did not produce a

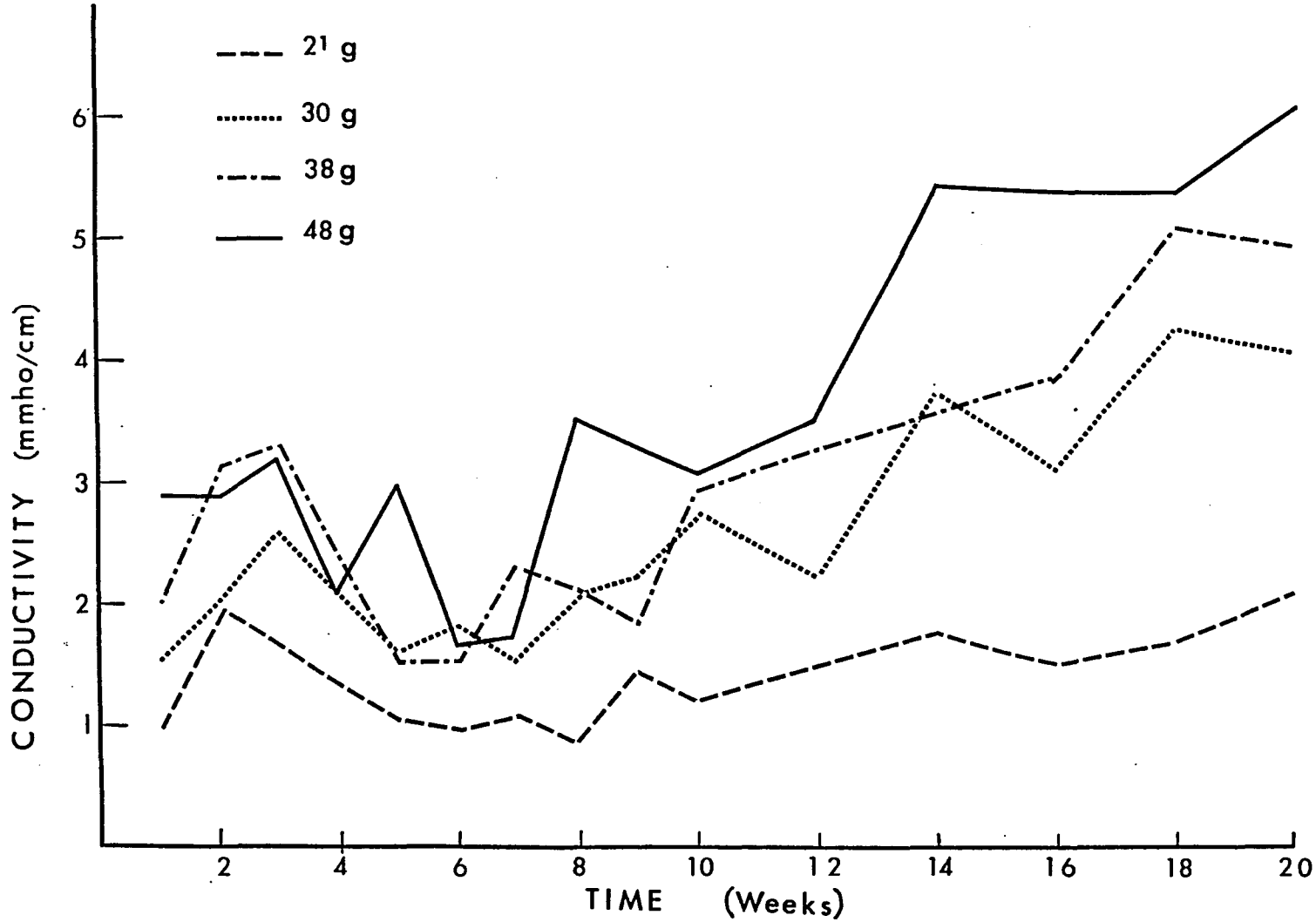

Figure 6. Leachate conductivity of 4 rates of Osmocote[R] 17-7-12 applied in the Dibble Method for the production of Trachelospermum jasminoides in 1 gallon containers.

Table 5. Mean results from the ranking test for purchase preference. Species were ranked within each replication, from 1 (first choice) to 4 (last choice).[z]

Species	Fertilizer rates (g Osmocote® 17-7-12 per container)											
	REP 1				REP 2				REP 3			
	21	30	38	48	21	30	38	48	21	30	38	48
Bougainvillea 'Barbara Karst'	2.5b[y]	3.3bc	1.5a	2.7b	3.6c	2.8b	1.7a	1.8a	2.7b	3.5c	2.3b	1.3a
Pyracantha fortuneana 'Graberi'	2.7b	3.7c	1.5a	2.1ab	2.2a	3.5b	2.0a	2.3a	2.1ab	3.8c	1.8a	2.3b
Trachleospermum jasminoides	1.1a	2.9c	2.1b	3.8d	3.9c	2.5b	2.1b	1.5b	2.6a	2.5b	3.8c	1.1a

z
All values given are the average ranking of 15 judges.

y
Mean separation in rows by Friedman's Test for multiple comparison, t .975 and 42 d.f.

significant increase in plant growth under the conditions that existed in this experiment.

The stunted, lighter green control plants reinforce the importance of fertilizer in plant production. In this study, the minimum rate of Osmocote required to influence plant growth was not identified. The use of Osmocote application levels below the lowest recommended rate should be tested in order to identify this minimum rate. Also, the lower rate may be safer to use in the production of salt sensitive plants in a hot climate.

This research was conducted through the fall and winter, during shorter days and cooler temperatures. Although plant growth continued throughout the study, it probably was not as vigorous as it would be in the spring. Also, the plants were grown primarily in a greenhouse where light intensity is reduced and temperature modified. These conditions do not accurately reflect the true environmental conditions encountered by nurserymen in southern Arizona.

Further testing of the use of the Dibble Method of Osmocote application in the production of woody ornamental plants in desert climates should be conducted in a nursery yard from late winter through late fall.

It has been shown that nutrient release from Osmocote is influenced by temperature. As temperatures increase nutrients are released more rapidly. It would be interesting to generate the nutrient release curve when daytime temperatures reach 100°F (38° C), a common occurance in southern Arizona from June to September.

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