ROOT AND SHOOT GROWTH OF SEEDLING GERANIUMS (*PELARGONIUM X HORTORUM* L. H. BAILEY) AS INFLUENCED BY CONTAINER TYPE.

309

by

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B. S., Kansas State University, 1976

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1980

Approved by:

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LITERATURE REVIEW

Bedding plants are the leading floricultural crop in terms of dollar value in the United States (2). In 1978, the wholesale value of bedding plants was estimated at $250 million (14). Bedding plants provide an inexpensive, effective way to introduce color and beauty to the landscape. Increased interest in flower gardens and container growing of flowering plants are two reasons why the wholesale value of bedding plants increased 37% from 1959 to 1970 (2).

Up until the early 1960s, bedding plants were produced by planting approximately 100 plants per flat. Plants were dug and wrapped for the customer at the time of the sale. This method of digging plants from a 8.6 or 9.4 cm flat led to many injured plants (2,11). To avoid damage to the root system, production was shifted to use of smaller containers (11). Plants are now produced in peat, plastic, clay, and many other types of containers. Recent trends are toward individually potted plants rather than production in multicelled paks (2).

Clay pots have provided years of customer satisfaction. The porous nature of clay helps to prevent overwatering since moisture can move out of the soil mass through the pot walls. Clay pots, however, are heavy, breakable, costly, and require more frequent waterings (2).

One of the most popular peat containers is the "Jiffy" pot.

The Jiffy pot, first marketed in 1954 by George J. Ball, Inc., is composed of 70% European peat, 30% wood fiber, and a soluble fertilizer.

Peat pots allow the gardener to plant both the plant and the biodegradable container. Problems can be encountered with peat pots. For example, they tear easily when wet. Also, it is desirable to remove the upper edge of the pot when planting, as the pot rim acts as a wick by drawing moisture out of the root mass when left exposed above the soil surface (2).

Plastic pots are another option in bedding plant production. They are attractive, light weight, can be molded into a variety of shapes, and are low to moderate in cost. Overwatering may be a problem when plants are grown in plastic, since no water escapes through the pot walls (2). Some customers are critical of plastic containers because they feel plastic pots allow the plants to "heat up too much" while in the sales area, resulting in unsatisfactory transplants (10).

The Todd planter flat, a registered trademark product of the Speedling Corporation, is a molded styrofoam flat with an inverted pyramidal root cell. Each cell has a small opening at the bottom. By suspending the Todd flat over wire benches or metal runners, air circulation beneath the flats allows air movement into the flat. This "air pruning" causes root growth to become more branched. The combination of "air pruning" and inverted pyramidal cells cuts down on transplant shock (1).

Currently the Todd flat is used for production of vegetable transplants, woody plants, and foliage plants. It is also used

for production of seed geranium plants that are grown in Florida for shipment to northern states. The Todd flat provides an option for institutions such as parks, gardens, arboreta, etc., that produce their own bedding plants yearly, and could benefit monetarily from the use of recyclable containers.

Balmer (3) has reported on the use of styrofoam flats for the production of forest tree seedlings ("plugs"). However, few studies have been directed toward bedding plant production.

Biermann (4) reported Pelargonium cv. Konigin Wilhelmine rooted better in clay and plastic pots than in Jiffy pots. Shoot development was best for geraniums grown in Jiffy pots. Vandemark and Splittstoesser (15) found tomatoe, cabbage, and pepper grown in peat pots weighed less than plants grown in plastic or clay pots. Pepper plants were more compact when grown in clay pots as compared to plastic and peat pots.

Container volume influences plant growth. Vandemark and Splittstoesser (15) found that tomatoes grew larger in 6.4 cm diameter clay pots and 10 cm plastic containers than plants in peat containers. In the 10 cm containers cabbage grew larger in clay pots. Vik (16) found onions raised in peat pots yielded as well as plants grown in two types of paper pots even though the paper pots had larger volumes.

The geranium (Pelargonium X hortorum L. H. Bailey) is the sixth most popular flower crop in the United States, and is even more popular in some areas within the United States (2). Bedding geraniums comprised 14.7% of the 1970 United States bedding plant flower value (17). "Geraniums, a native of South Africa, are known and loved by more people than any other flower in the world."

according to James Underwood Crockett (7). Geraniums are popular because of their colorful flowers and adaptation to a wide variety of environmental conditions and uses (2).

The first commercial variety of geranium to come true from seed was 'Nittany Lion Red'. An inbred line, it was introduced by the Pennsylvania State University in 1964 for use as a bedding plant. Originally introduced as green or non-blooming bedding plants, years of breeding have developed seed geraniums that are marketed with colorful blooms (13). By 1979 it was estimated that 60 million plants of seed geraniums are produced annually in the United States (5).

A major advantage in seed geraniums over vegetatively propagated geraniums is freedom from viruses, which enables the grower to start with a disease free plant (13). The need for stock plants or purchased cuttings is also eliminated. Seed geraniums are vigorous, free-blooming plants available in a variety of colors. They are especially noted for their late summer flowering.

A disadvantage in seed geraniums is the cost involved in hand labor needed to produce F_1 hybrids. Seed geraniums also require strict adherence to production schedules to produce flowering plants for early sales (2).

One of the more popular series of seed geraniums is the Sooner series. 'Sooner Red' is a red flowering cultivar of the series. In a study of 36 cultivars the mean day from sowing until two-thirds of the plants flowered was 109.6 days. 'Sooner Red' flowered earlier, at 101 days (5).

Plant studies involve not only vegetative growth and flowering, but root development. Since it is advantageous to be able to observe

the rooting patterns in addition to taking weight measurements of the root system, many plant scientists have used root observation boxes. In an 1888 New York Agricultural Experiment Station Bulletin, Comstock (6) reported on studies of soil insects at Cornell University. His root cage consisted of a box with two plate glass sides used for viewing. The box was filled with soil and planted with the plant to be studied.

The root cage or root observation box was modified by Dean (8), who also used glass sides with wooden shutters to keep out light. Muzick and Whitworth (12) used root boxes with glass on only one side for periodic observation of root systems. They also discussed the use of vermiculite or sand as media in substitution for soil. Vermiculite was superior because it was light and sterile.

Hurd (9) used root boxes with sloping sides in his wheat studies. The sloping sides encourage roots to come in contact with the pane of glass and follow the glass as they grow. A wax pencil was used to mark growth made from one observation to the next.

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MANUSCRIPT

This manuscript is written in the style of and for publication in HortScience.

Root and Shoot Growth of Seedling Geraniums (Pelargonium X hortorum L. H. Bailey) as Influenced by Container Type.[1]

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Additional index words. F_1 hybrid geranium, Todd® planter flat, styrofoam containers, peat pots, plastic pots, clay pots, 'Sooner Red'.

Abstract. Seed geraniums (Pelargonium X hortorum) cv. Sooner Red were grown in 4 types of transplant containers--clay, peat, and plastic pots, and a molded styrofoam flat, all having diameters approximately 5.1 cm. Plants were studied under field and greenhouse conditions after transplanting from the treatment containers. Plants grown in plastic and peat pots were initially taller, flowered sooner in the field, and had more root development than plants from clay or styrofoam containers. After 12 weeks in the field, survival rates, shoot dry weights, root dry weights, and bloom numbers per plant were similar regardless of the container type.

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Bedding plants are the leading dollar value floriculture crop in the United States (1), with a wholesale value of $250 million in 1978 (5). Until the early 1960s, bedding plants were produced 100 plants per flat. Plants were dug and wrapped for the customer at the time of sale, which resulted in many injuries (1,4). To avoid damage to the root system, smaller containers such as peat, plastic, clay and others, were used in production (4). A recent trend has been toward individually potted plants rather than paks of several plants (1).

The Todd planter flat[3] is constructed from molded styrofoam with inverted pyramidal root cells, each having a bottom drainage hole. Air contact prunes the roots, encouraging a more branched root system. "Air pruning" in conjunction with the inverted pyramidal cell cuts down on transplant shock. Also, the Todd flat provides an option of recyclable containers.

Balmer (2) has reported on the successful use of styrofoam flats for the production of forest tree seedlings ("plugs"). However, limited research information is available on use of styrofoam flats for bedding plant production.

Biermann (3) reported clay and plastic pots were more satisfactory than Jiffy pots for rooting of Pelargonium cv. Konigin Wilhelmine

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[3]The Todd planter flat is a registered trademark product of the Speedling Corporation, Sun City, Florida.

cuttings, however, shoot development was best for plants grown in Jiffy pots. Vandemark and Splittstoesser (6) reported tomatoes, cabbages, and peppers weighed less when grown in peat pots when compared to plants grown in plastic or clay pots.

The purpose of this study was to determine the effect of 4 bedding plant containers on the initial growth and development of seed geraniums and the field growth response following transplanting, and to study the influence of containers on root development after transplanting in a controlled environment.

The investigation was conducted in 3 phases a) a field study to measure growth and development, survival, and blooming response, b) a greenhouse study to measure initial root development following transplanting, and c) a root observation box study to observe root development following transplanting. Containers used as treatments were clay, square plastic, square peat, and Todd planter flats each approximately 5.1 cm in diameter. Container volumes were 90.3 cm^3 (clay), 130.3 cm^3 (peat), 168.3 cm^3 (plastic), and 76.3 cm^3 (Todd flat).

Geraniums (Pelargonium X hortorum cv. Sooner Red) were seeded February 24, 1979, and transplanted on March 24 into the 4 treatment containers in a peatlite artificial mix, containing shredded sphagnum peat, horticultural grade vermiculite with 0.38 kg N, 0.93 kg P, and 0.14 kg K fertilizer per m^3. Fertilizer was injected into the watering system during transplant growth using a solution of 20% N, 8.6% P, and 8.3% K fertilizer at a rate of 100 ppm. On May 17 the plants were set in a Sarpy fine sandy loam soil at the KSU Ashland Horticulture Farm and watered with a starter fertilizer. Fertilizer at the rate of 0.48 kg N per 100 m^2 and 0.32 kg P per 100 m^2 was

broadcast and incorporated prior to planting. Eight plants per experimantal unit were randomized within 3 replications. Conventional growing procedures, cultivation, and irrigation practices were used during the 12 week growth period.

Plant height and bloom counts were determined at weekly intervals. By the end of the 12th week plant heights and bloom numbers were similar regardless of the treatment container. Shoot weight and root weights (two plants of each unit) were determined at the termination of the study on August 8.

For the greenhouse phase, 'Sooner Red' geraniums were seeded on August 27 and transferred September 17 to the 4 treatment containers. Two growing media were used; peatlite and a mix of one part each soil, peat, and vermiculite. On November 30 the geraniums were transplanted into 15.3 cm diameter plastic pots containing 2 parts soil, 1 part peat, and 1 part vermiculite. Four replications of 2 plants per experimental unit were arranged in a randomized complete block design. At weekly intervals, plant height was measured from the soil level and roots removed in 3 cm increments were dried and weighed. On December 21 the study was terminated.

On November 26, 24 geraniums were transplanted from the treatment containers into root view boxes containing 2 parts soil, 1 part peat, and 1 part vermiculite. Each box was 61 cm wide, 30 cm deep, by 8.5 cm wide at the upper surface. Glass 0.65 cm thick was set at a 15° slant on one side of the box. Three replications were used, with each box containing 1 plant of each of the 4 treatments. The glass surface was kept dark except when measurements were taken. Shoot heights were measured each week. Exposed roots along the glass

surface were traced weekly with a wax pencil. Final total length of all visable roots was calculated on December 24.

All data were analyzed with a SAS ANOVA program with means separated by Duncan's Multiple Range Test at the 5% level.

In the field study as shown in Table 1, survival rates and shoot and root dry weights were similar with all types of containers. At the beginning of the field study, the tallest plants were those grown in the plastic and peat pots; the smallest plants were recorded in clay pots. Shoot growth was similar over the course of the study. Similar geranium heights were recorded at the end of the 12 week study, regardless of container type.

Flowering followed a similar trend. Although plastic pot plants flowered about 2 weeks earlier than other plants, by the termination date bloom numbers per plant were consistent for all container types (Figure 1).

In the greenhouse study root development after transplanting followed a nearly linear increase over time (Table 2). Media nor container treatment alone significantly influenced root weights, however, certain container-media interactions did affect the root weights taken the final week of the study (Table 3, Figure 3). With the peatlite medium plants grown in peat pots had the greatest root weights in the bottom two layers of the media (6.1-12 cm).

In the soil media, plants in plastic containers exhibited the greatest root weight. Root weights were greatest in the upper two layers (0-6 cm). Todd flat plants grown in the soil mix had less extensive root systems in the 0-6 cm zone than the plastic potted plants. However, the overall root weights of the Todd and

plastic container plants were not significantly different (Figure 3). For both peat and plastic pots, significant differences were seen with the two types of media. Peatlite was best when peat pots were used, however, the soil mix yielded greater root weights in the plastic pots (Table 3). Although the data do not indicate a specific reason for this, the "lighter" media resulted in greater root growth in porous containers while the "heavier" media in the nonporous containers had greater root growth.

Although diameter measurements of the 4 treatment containers were similar, container volumes varied, as did container surface area. The root growth of geraniums grown in clay, peat, and Todd containers were related to surface area and volume (Figure 4). Actual geranium root weights in plastic pots were less than the anticipated root weights for the given surface area and container volume. Because of the relationship between container volume and root weight, differences in growth of plants in clay, peat, and Todd containers should be studied with containers of equal volumes. The results of this study compliment findings of previous work. Vandemark and Splittstoesser (6) found that container volume as well as composition influenced plant growth. Vik (7), found onions raised in Jiffystrips yielded as well as plants grown in two types of paper pots even though the paper pots had larger volumes.

Root growth during the first week in the root boxes was greater in plastic pots than in clay pots (Table 4). The third week plastic and peat pot plants initiated more new root growth than plants grown in clay or Todd containers. The second and fourth weeks root growth

was similar for all container types. Growth during the third week was depressed, possibly due to reduced light intensity during the period. Media differences observed at the end of the root study basically confirm the findings of the greenhouse study, with some data indicating peatlite media root lengths were greater than soil mix.

For containers with approximate diameters of 5.1 cm, plastic or peat pots were better than clay pots or Todd flats when growing 'Sooner Red' geraniums. Although shoot heights and bloom numbers per plant were similar after 12 weeks in the field, initially greater heights were noted for plants grown in plastic and peat pots. Earlier flowering was exhibited with the plastic pots, an advantage because of the late flowering tendency of seed geraniums. Root weights of plants grown in the greenhouse and root box studies were greatest when peat and plastic pots were used. Root growth responses depended upon the container and media combinations.

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Table 1. Influence of container type on initial plant height, final plant height, final number of blooms per plant, dry shoot weight, dry root weight, and percent survival of 'Sooner Red' geraniums during a 12 week field study.[z]

CONTAINER	INITIAL PLANT HEIGHT (cm)	FINAL PLANT HEIGHT (cm)	FINAL NUMBER OF BLOOMS PER PLANT	DRY SHOOT WEIGHT (g)	DRY ROOT WEIGHT (g)	SURVIVAL (%)
Clay	(24)[y] 3.3 c	(22) 20.0 a	(22) 10.9 a	(22) 36.8 a	(6) 4.0 a	(24) 92 a
Peat	(24) 5.4 ab	(23) 20.4 a	(23) 9.8 a	(23) 38.3 a	(6) 4.2 a	(24) 96 a
Plastic	(24) 6.3 a	(23) 20.2 a	(23) 10.4 a	(23) 43.3 a	(6) 3.9 a	(24) 96 a
Todd	(24) 4.6 b	(20) 20.6 a	(20) 13.4 a	(20) 44.4 a	(6) 3.6 a	(24) 83 a

[z]Means separated within columns by Duncan's Multiple Range Test, 5% level.

[y]Number of observations in each mean.

Table 2. Mean dry root weights (g) of 'Sooner Red' geraniums taken at 3 cm layers over a 4 week period.[z]

Depth (cm)	WEEK 1		2		3		4	
0-3	(15)[y]	0.06 a	(16)	0.08 a	(16)	0.12 a	(16)	0.14 a
3.1-6	(15)	0.03 b	(16)	0.08 a	(16)	0.16 a	(16)	0.18 a
6.1-9	(15)	0.00 c	(16)	0.02 b	(16)	0.10 a	(16)	0.09 b
9.1-12	(15)	0.00 c	(16)	0.01 b	(16)	0.04 b	(16)	0.05 b

[z]Means separated within columns by Duncan's Multiple Range Test, 5% level.

[y]Number of observations in each mean.

Table 3. Final mean root weights (g) of 'Sooner Red' geraniums grown in 4 types of transplant containers.[z]

MEDIA	CONTAINER				
	CLAY	PEAT	PLASTIC	TODD	MEAN[y]
PEATLITE	(2)[x] 0.44 bc	(2) 0.81 a	(2) 0.35 c	(2) 0.24 c	(8) 0.46 a
SOIL MIX	(2) 0.31 c	(2) 0.32 c	(2) 0.70 ab	(2) 0.47 bc	(8) 0.45 a
MEAN[y]	(4) 0.37 a	(4) 0.57 a	(4) 0.53 a	(4) 0.36 a	

[z]All means separated by Duncan's Multiple Range Test, 5% level.

[y]Main effect means are separated independently from interaction means.

[x]Number of observations in each mean.

Table 4. Influence of 4 transplant containers on mean root growth (cm) of 'Sooner Red' geraniums grown in root view boxes.[z] (Data indicates the weekly non-cumulative root lengths observed on the glass surface.)

WEEK	CONTAINER			
	CLAY	PEAT	PLASTIC	TODD
1	4.8 b[y]	8.8 ab	12.3 a	7.8 ab
2	34.7 a	50.3 a	62.2 a	39.7 a
3	18.5 b	36.8 a	38.0 a	19.5 b
4	52.2 a	67.8 a	53.5 a	63.3 a

[z]Means separated by Duncan's Multiple Range Test, 5% level.

[y]Six observations in each mean.

Figure 1. Influence of container type on shoot heights of 'Sooner Red' geraniums during a 12 week field study.

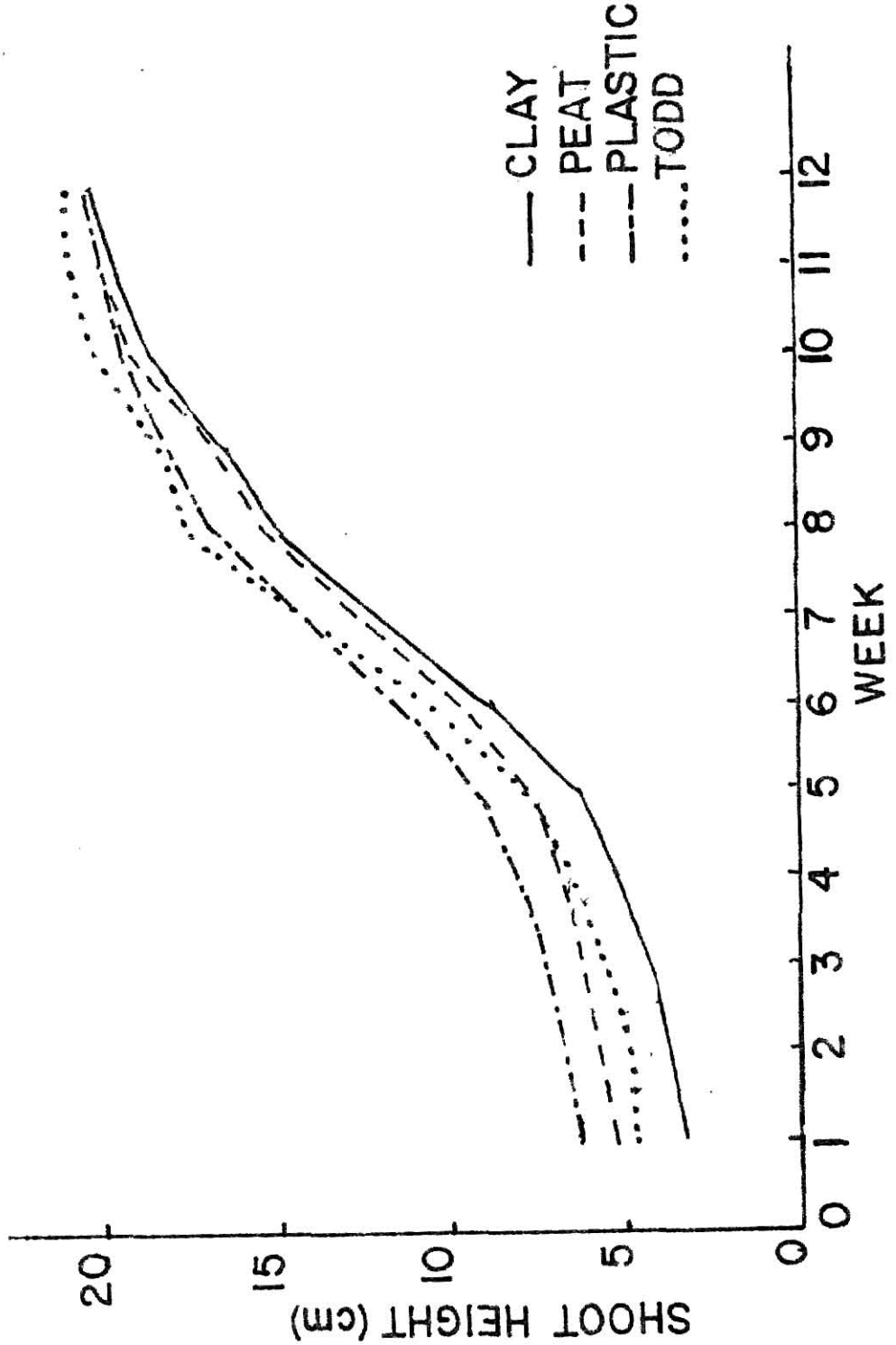

CLAY
PEAT
PLASTIC
TODD
SHOOT HEIGHT (cm)
0
5
10
15
20
WEEK
0
1
2
3
4
5
6
7
8
9
10
11
12

Figure 2. Effect of transplant container on bloom number per plant of 'Sooner Red' geraniums during a 12 week field study.

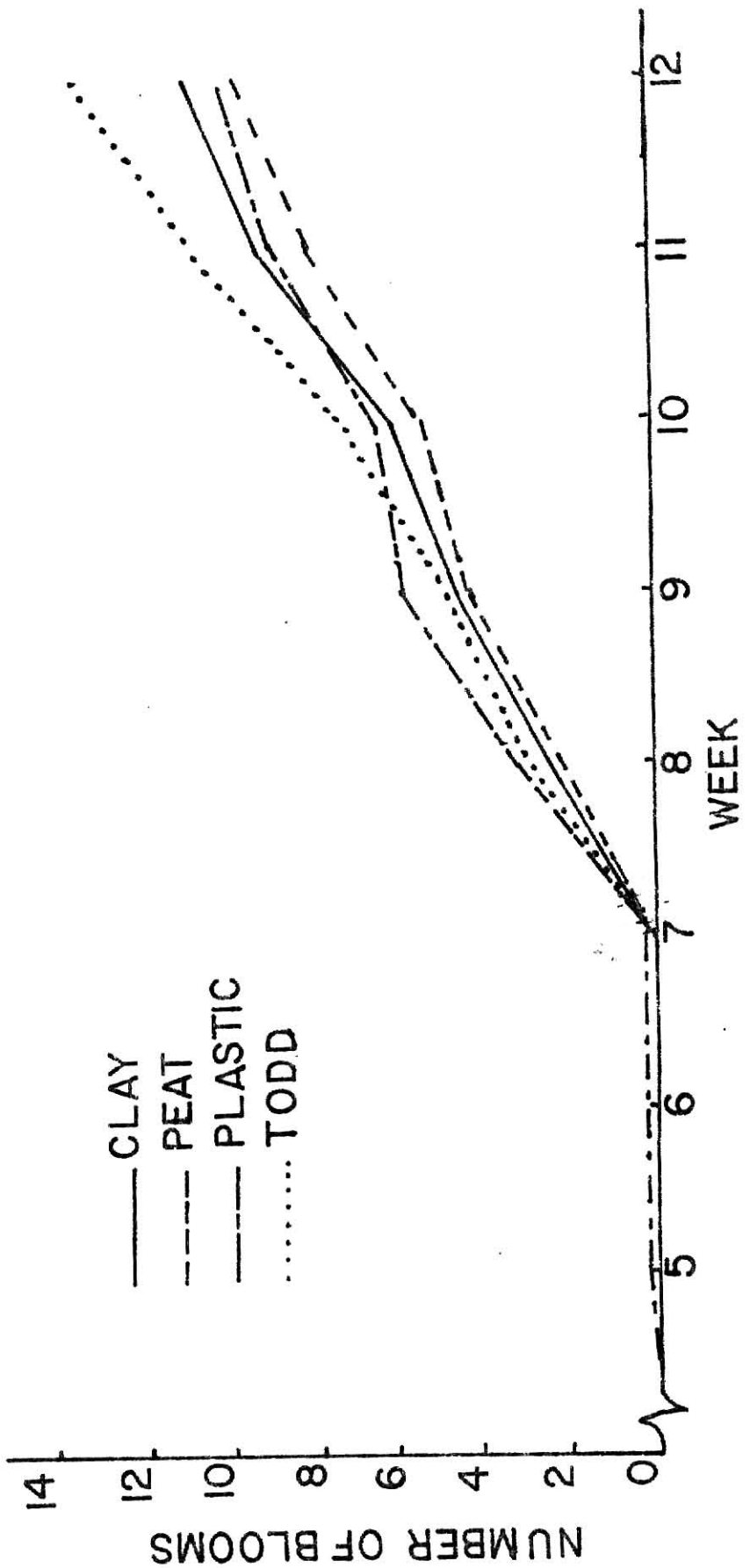

NUMBER OF BLOOMS
0
2
4
6
8
10
12
14
WEEK
5
6
7
8
9
10
11
12
CLAY
PEAT
PLASTIC
TODD

Figure 3. Final mean root weight (g) taken at 4 depths as influenced by container type and medium.

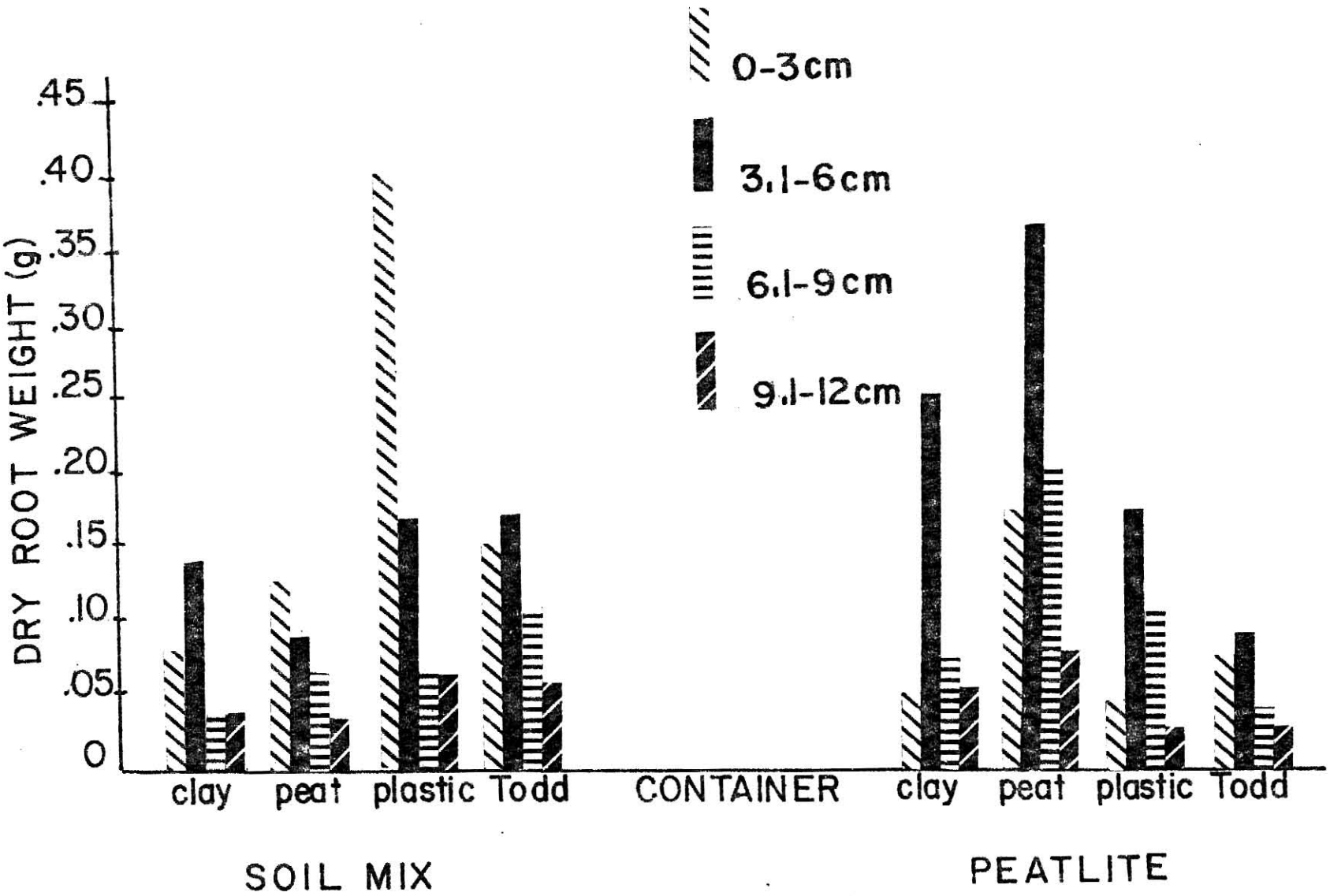
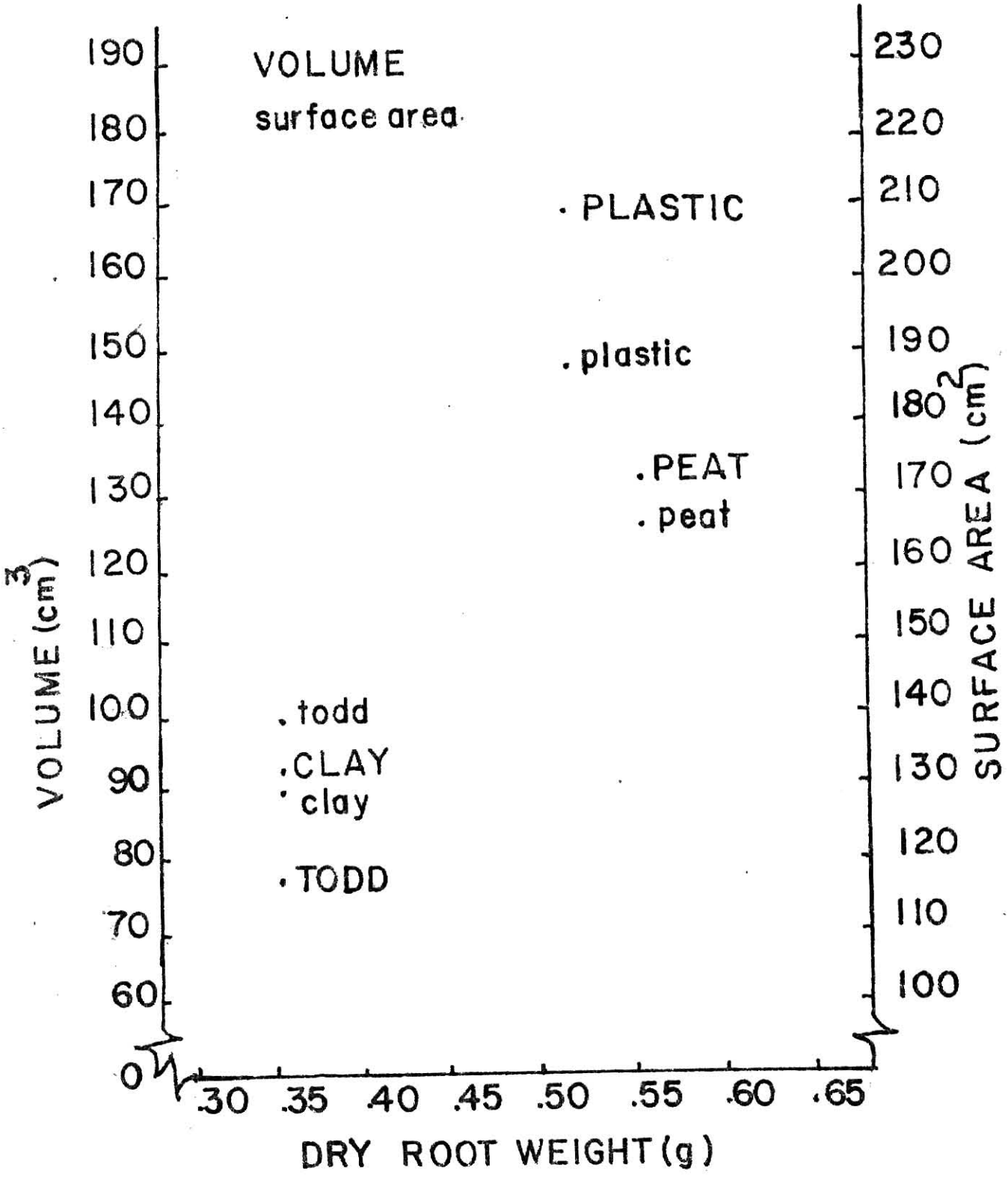

0-3cm
3.1-6cm
6.1-9cm
9.1-12cm
DRY ROOT WEIGHT (g)
.45
.40
.35
.30
.25
.20
.15
.10
.05
0
clay
peat
plastic
Todd
CONTAINER
clay
peat
plastic
Todd
SOIL MIX
PEATLITE

Figure 4. Final dry root weight of 'Sooner Red' geraniums in relation to container volume (cm^3) and surface area (cm^2).


VOLUME
surface area
. PLASTIC
. plastic
. PEAT
. peat
. todd
. CLAY
. clay
. TODD
VOLUME (cm3)
SURFACE AREA (cm2)
190
180
170
160
150
140
130
120
110
100
90
80
70
60
0
230
220
210
200
190
180
170
160
150
140
130
120
110
100
.30
.35
.40
.45
.50
.55
.60
.65
DRY ROOT WEIGHT (g)

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation and indebtedness to my major professor, Dr. Charles Marr, for his patience, guidance, and encouragement throughout my graduate program.

I extend my appreciation to the other members of my committee, Dr. Richard Mattson and Dr. Fred Schwenck, and to Dr. George Milliken of the Department of Statistics, for their advice and help.

I wish to acknowledge the financial support provided by the Department of Horticulture.

I would like to thank my friends and fellow students for all their assistance throughout the course of my project, and for their emotional support and encouragement.

Finally, I would like to thank my parents and my fiance, whose encouragement and sacrifice made my graduate studies possible.

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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

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MASTER OF SCIENCE

Department of Horticulture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1980

Seed geraniums (Pelargonium X hortorum L. H. Bailey) cv. Sooner Red were grown in 4 types of transplant containers--clay, peat, and plastic pots, and a molded styrofoam flat. All container diameters were approximately 5.1 cm. Plants were studied under field and greenhouse conditions, and in root view boxes. Plants grown in plastic and peat pots were initially taller than clay or styrofoam container plants. Plastic pot plants flowered sooner than other similar plants grown in clay, peat, or styrofoam containers. At the end of a 12 week field study, survival rates, shoot dry weights, root dry weights, and bloom numbers per plant were similar regardless of the container type. Four weeks after being shifted to 15.3 cm diameter plastic pots, peat pot transplants that had been grown in peatlite mix, and plastic and styrofoam container plants grown in a soil mix had the largest root dry weights. Root view boxes indicated plastic pot plants initiated more roots during the first week after transplanting than did clay pot plants. The third week peat and plastic pot plants had more new roots than plants grown in clay or styrofoam containers.