AN ANALYSIS OF POT CHRYSANTHEMUM PRODUCTION METHODS, DIRECT COSTS AND SPACE USE

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AN ANALYSIS OF POT CHRYSANTHEMUM PRODUCTION

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PREFACE

No single phase of horticulture can be ascribed a predominate role above all others. However, one that permeates most other phases and dramatically affects our daily lives is the commercial production of horticultural products.

This thesis is concerned with four interrelated factors in the greenhouse production of horticultural crops: cultural methods, product quality, direct costs and space use. The means for accomplishing this study has been the production of pot chrysanthemums through three production cycles. Methods employed to measure results were: the classification of product quality, the analysis of direct costs and the comparison of greenhouse space use.

During the three repetitive cycles in the spring, summer and fall, the data resulting from the five production methods were accumulated and studied. The schedules and conditions in each cycle were held as rigidly similar as the capabilities of the facilities permitted. The results of this study have been reported in terms of product quality achieved, direct costs incurred and effectiveness of space use. In addition a major effort in the study resulted in identifying direct cost elements and space use needs that are in general applicable to all pot mum crops.

I should like to express my sincere appreciation to Dr. Richard N. Payne not only for making a wealth of material and facilities available to me for this study, but also, and most important, for his generous assistance and wise counsel without which the goals of this study could not have been reached. My gratitude is also extended to Professor W. R. Kays for his sincere interest, guidance and encouragement. I am indebted as well to Dr. J. Q. Lynd for taking time from his extensive research endeavors in the Agronomy Department to participate on this committee.

Certainly I would be remiss if I did not recognize the very real help my wife and family have given by their enduring patience, their confidence, and their encouragement. I should also like to thank Mrs. Clara Yeck for her fine editing and typing.

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CHAPTER I

INTRODUCTION

Purpose

The purpose of this study was to investigate those aspects of commercial greenhouse pot chrysanthemum production which would disclose facts leading to improved efficiency and profitability. The immediate objectives consisted of analyzing production methods, analyzing the effectiveness of greenhouse space use, deriving direct cost data for specific greenhouse production operations, and evaluating levels of product quality obtained from various production methods. The original statement of these objectives is as follows:

> The objective relating to production methods is limited to investigating methods that will assure efficient and economical operation. Effective space use will be analyzed in evaluating bench space requirements for pot mum growth and the efficient use of total greenhouse space during a production cycle.
>
> The direct costs of production will provide useful data to identify economical operation in terms of efficient use of labor and materials as compared among production methods used in the study. The objective will be to clearly identify these costs and an economical level for them.
>
> In the final analysis, standards of product quality constitute the true measure of production efficiency. It is not the objective of this study to propose product standards but to identify statistically the level of pot mum quality resulting from varied production methods.

Background

The commercial grower of greenhouse crops in Oklahoma is faced with the dilemma of selling prices of products moving up more slowly than the rising labor and material costs. The result is a lower real income for the grower.

The most obvious prospects for alleviating this problem are reduced labor costs through increased mechanization and automation and other cost reduction techniques such as the improved use of space and the reduced length of crop production cycles. Many growers and wholesalers are merely setting higher selling prices. Some are resorting to modifying their volume of production in an attempt to move prices up or to increase gross income at the same cost level (1).

The floral industry is more than ever before moving toward the more sophisticated production and marketing practices which are commonly used throughout industry. Certainly one of the more notable practices of industry that has set the stage for much industrial growth is sound financial practices based upon accurate cost accounting and cost analysis (2). Cost control in the flower growing business for the most part still lacks this elementary tool (3). Efficient production control in industry consists of cost control, market analysis, and procurement planning as well as striving for maximum use of facilities for a desired level of output through detailed planning and production scheduling. Even though much attention is being given by growers to crop scheduling and space use, implementation of these management practices is moving slowly (3, 4).

With wider use being made of direct sales arrangements between growers and wholesalers, rather than consignment contracts, an accurate knowledge of costs is more essential than ever to the grower. For he now takes full responsibility in setting selling prices (6). It is also important in the face of the increased vertical integration in the floral industry (7). Cost data make each element of the business stand on its own in the matter of contribution to the total profitableness of the business. Sound business practice demands that production decisions be based on their profitableness to the business. In the absence of accurate cost information, such decisions are often made by falling back on personal biases and preferences for certain crops (8).

The floral industry is also faced with dramatic shifts in production. Regional areas are no longer isolated from outside competition even in pot plant production (9, 10). Some production efficiency on the part of northern growers is reflected in decreased production space accompanied by increases in production. Growers in the South are rapidly expanding production to meet increased demands (9). However, their implementation of production efficiency is not in keeping with this growth. Thus, growers are not realizing the profitableness that should be theirs.

Certainly, more studies which cope with this problem of production efficiency in the floral industry are in order not only from the standpoint of the grower but from that of the consumer as well. It is the consumer who in the long run stands to benefit the most in both higher product quality and lower prices. It is with this viewpoint in mind that this study of flower crop production was undertaken.

In this study four significant aspects of production were examined: production methods, production costs, space use, and product quality. These aspects come to grips with such major production problems as crop spacing, cost of labor and materials for specific operations, and production planning (3). No defense is given for narrowing the study to these four aspects. For, as a minimum, the study has disclosed information fruitful for further investigation by both the grower and the researcher. Progressive producers may find such facts as are disclosed in effective space management and in accumulating production cost data to be directly applicable to their operation.

CHAPTER II

LITERATURE REVIEW

Production Methods

Recommended methods for producing quality pot mums are quite similar in such matters as temperature control, watering methods, fertilizing practices, photoperiod control, pinching and disbudding practices, and height control (4, 5). Yet, there are still two major procedures about which a wide diversity of opinion exists. One is starting procedures, and the other is pot space requirements.

Standard procedures for starting pot mums at Pennsylvania State University by the "Fast Crop" method (1), Cornell and Ohio State methods (4, 5), and commercial practices (12) have been to place them directly on the growing bench at the time of potting. Hand misting or overhead misting have often been provided when temperature and humidity conditions require. Under the "Yoder Three Climate System" and certain other commercial practices a polyethylene plastic humidity chamber is recommended in the early stages for conditioning the young plants (13, 14).

Recommendations regarding space requirements for pot mums universally promote wide spacing to assure proper growth and prevent lower leaf deterioration. Recommendations vary from "give plenty of space" to specific measurements of 15" X 15" or 16" X 16" spacing throughout the growing period. Some procedures call for varying of spacing from an initial close spacing of 7" X 7" to wider spacings as the plants grow larger (13). Basically, all recommendations suggest a wide spacing of over 200 square inches during some part of the growing period (4, 5, 11, 12, 13).

Considerable interest has been shown recently by Ohio State University researchers in effects resulting from closer spacing of various florist crops (15, 16). Their results indicated some discrepancy may exist in the wide spacing recommendations for pot mums. Commercial use of closer spacing if proven feasible would certainly be more economical (17).

Procedures employed in this study closely adhere to the standard practices of the previously cited authorities. The spacing and starting variables, however, were compared in the five production methods used to identify whether significant differences might occur in production results, i.e., product quality, costs, and space use.

Production Costs

All authorities are in agreement that little or nothing concrete is known, or has been published, about the costs of production of floral crops. All agree, however, that this is the single most essential item of information now needed in order to get at improved efficiency in production (3, 18). A common statement made is that it is impossible to identify production costs for a specific crop (3). Another is that the cost of an accounting system is prohibitive (8). Still another often noted comment is that finding the cost of production is so involved that it is usually avoided (19).

These statements point to more than mere excuses for avoiding distasteful work. They strongly indicate that much must soon be done to acquire urgently needed knowledge about cost control methods for greenhouse operations. Methods to implement thorough and conventional cost accounting practices apparently have not been developed because of at least one factor, the paucity of information about cost elements.

A number of approaches have been suggested to circumvent the requirement for cost accounting records. One such practice is to cost out a crop at 7 or 8 cents a week per square foot, plus the cost of cuttings or seedlings, potting labor, and the cost of pots (20). Another method recommended is to identify costs by specific operations regardless of crop (3). Neither of these methods is acceptable as standard cost accounting practice, but they do provide useful methods for roughly estimating costs to be used in production planning or budgeting.

One group of costs which should not be difficult to accumulate is the overhead cost (indirect cost) since it does not depend on the performance of a specific crop, but refers to the entire production effort. Such costs are heating, taxes, depreciation, building repair, equipment maintenance, insurance, administration, interest, and supervision. These costs are related to all crops in proportion to the amount of space and for the length of time that the crop occupies the production unit (21).

Costs which are directly applicable to specific crops on any other basis should be assigned to the crops to which they apply. Such costs as labor on crops, rooted cuttings, bulbs, seeds, seedlings, soil, fertilizer, water and other directly used materials should be assigned to crops as they are consumed. Separating these costs after the fact is what is next to impossible about cost determination. Direct costs of specific operations are known when they occur and should be assigned routinely on labor and materials cost slips for crop and production units. Indirect costs can be readily allocated to crops by using the results of periodic crop space inventories, or better, on the basis of actual space use data (19).

This discussion has been an attempt to clarify the distinction between direct and indirect costs and point out acceptable cost accounting practice for assigning these costs to a specific crop. To achieve accurate cost control, however, personnel must be trained to record cost information accurately, and the actual space used by a crop must be converted to a time-space factor suitable for allocating overhead (22). Also, some hard decisions must be made relative to the relation of selling costs to production costs and the relation of transportation costs to both of these.

Because indirect cost elements (overhead) are allocated to crops periodically and without reference to specific day to day operations, it was not considered essential in this study to accumulate such data daily to determine its applicability to the crop. Overhead for a producer will vary greatly according to the size of his operation, the extent of depreciation he takes, the amount of local taxes, interest and insurance he pays, and his heating and cooling costs. All of these indirect cost items are readily discernible in total. Since they can be allocated to production on a space time factor they should not be difficult to arrive at on an individual crop basis.

In the case of direct costs, these are variables not related to space or time and can only be known by accumulating them for each crop activity as the work is performed. It was deemed necessary in this study to examine these costs and use them as a basis of comparison between production methods, as would also be appropriate for any commercial concern. They are costs that can be varied to affect only a single crop whereas the variation of indirect costs affects all crops and are not manageable on an individual crop basis.

Space Use

Two aspects of space were included in this study. One concerned the spacing of pots to provide a suitable habitat for plant growth. The other aspect was related to the maximum use of bench space by efficient space layout and tight production scheduling.

Concerning the first aspect, pot spacing, there is a strong belief in the trade that space for individual plants must be plentiful to provide optimum light, humidity, and other atmospheric conditions (12). As has been noted, some serious study has been made to determine minimum spacing needs for such crops as pot mums, lilies, and geraniums (5, 15, 16). From a strictly cost point of view, the closer the spacing the larger will be the output per unit of space (17).

The second aspect, total square feet of greenhouse space occupied by a crop, has many ramifications in production efficiency. What is the optimum per cent of bench space that should be available in a greenhouse and still permit labor to move about efficiently in the care and management of the crops? Of the total land space covered by a greenhouse range, how much space on the average is actually occupied by growing crops? After arriving at the ideal efficiency in these measurements one may ask how much bench space one can afford to have vacant and for how long. Computations such as these are essential to the producer in order to make decisions about crop scheduling and quantities of supplies to order (23, 24). There is, as previously noted, a direct relationship between indirect costs and space. Thus, there is also a close relationship between unoccupied space and the many indirect costs experienced in greenhouse operations. Within a floral business every square foot of land, whether it has a greenhouse or plastic film house on it or just an open drive, constitutes a space that must be assessed to some crop. Even though there is no bench or plant on the bench, it does not eliminate the need to assign such unoccupied space with its share of the cost of production. It is a cost which will have to be assigned to a crop being produced (25).

Product Quality

Grading standards for pot mums have not as yet been formally established. However, many tests and research studies which have compared the results of producing pot mums under various conditions have consistently used certain measures to indicate the quality of the plants produced. These measures have been dry weights (26), number of flowering breaks, and plant height (26, 27, 28). Realizing, of course, that the true value of a plant is more closely related to its aesthetic value, these quantitative measures were used in this study only as an expedient to enhance statistical comparisons.

CHAPTER III

METHODS AND MATERIALS

Approach to the Problem

Data on all four facets of the problem, production methods, direct production costs, space use and product quality, were accumulated simultaneously. This provided a maximum of interaction to support the findings on production method efficiency and profitableness, and at the same time permitted close examination of each separate aspect.

Facilities, Materials, and Practices

A major portion of a 32' X 100' greenhouse structure was used for the conduct of the experiment (see Figures 1 and 2). This structure provided steam heat with poly-tube and exhaust fan ventilation. Summer cooling was provided by means of evaporative cooling pads and exhaust fans. Plants were grown in pots on 50 inch wide redwood benches without sides. Each bench was equipped with a Chapin irrigating system containing a 3/4" central header line and individual pot tubes. A GEWA fertilizer injector system was connected into the line providing 200 ppm each of N, P_2O_5 and K_2O, using 20-20-20 soluble fertilizer with each watering. Daylight duration was reduced, when required, with a manually drawn sateen black cloth shade (64 X 104 mesh). A climate control bench, polyethylene covered and enclosing a mist line, provided the high temperature and humidity control for designated

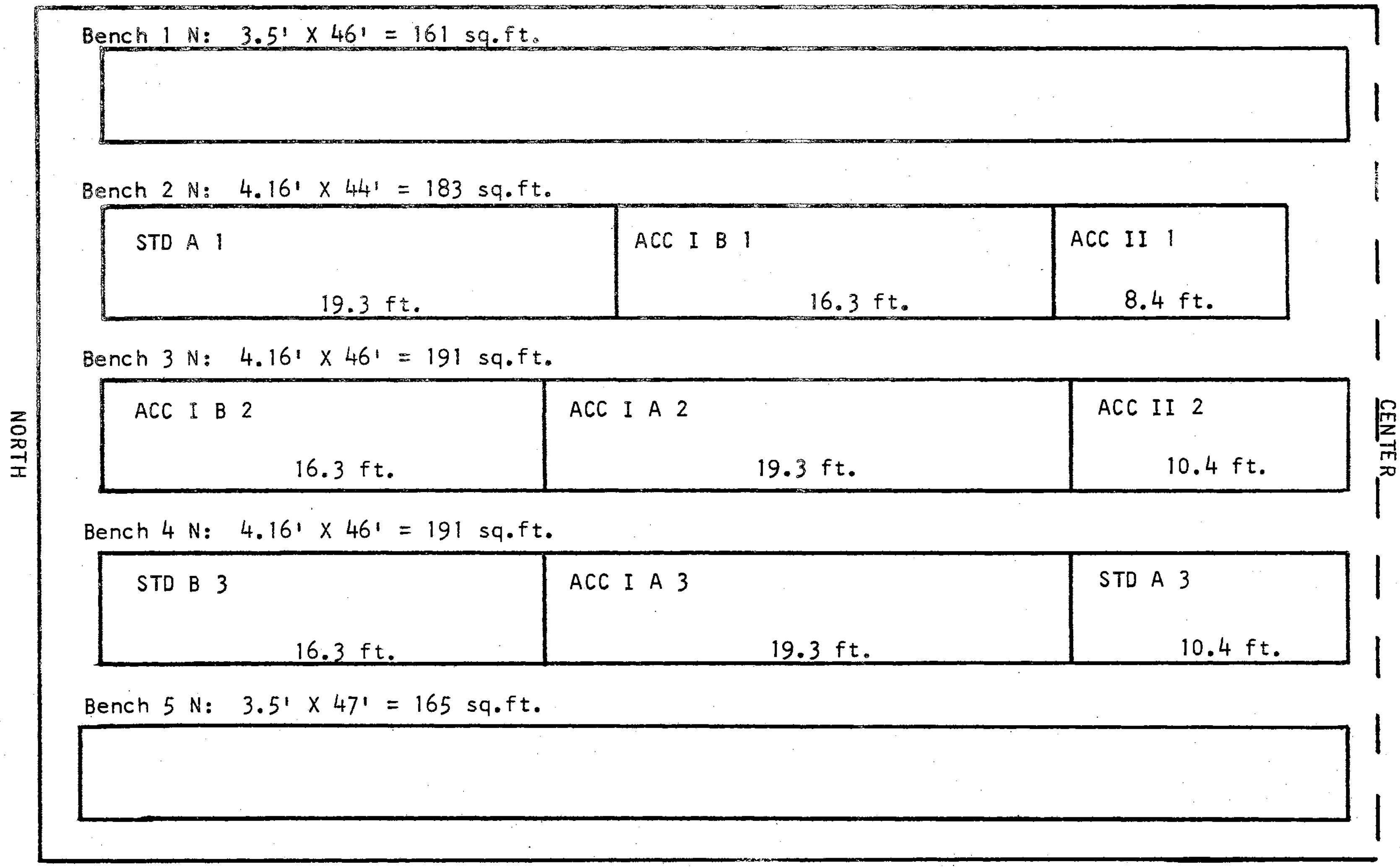

Figure 1. Space Layout for the North Half of the Greenhouse.

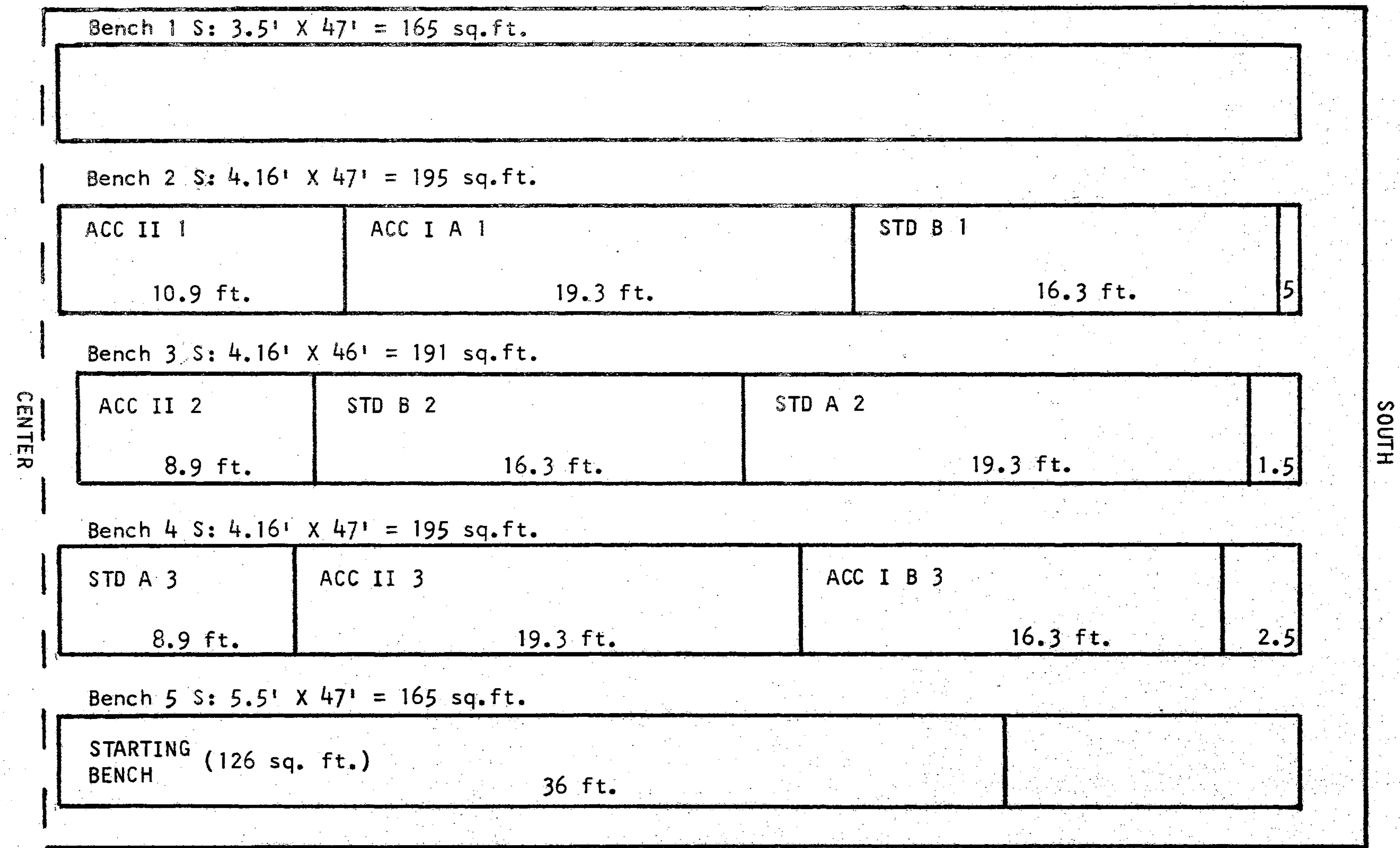

Figure 2. Space Layout for the South Half of the Greenhouse.

production methods (see Table I). The growth retardant Alar[1] was used for growth control on all tall treatment varieties. Standard preventive practices for disease and insect control were followed using sprays, fumigants, and dusts as needed.

Production Methods

Although five separate production methods were examined, they actually constituted a variation of the two common commercial methods: First, providing long days with a climate control start prior to starting short days and second, placing pots directly on the growing bench without climate control or initial long day treatment. An additional two methods were derived from the two common methods by a pot spacing variation of 13" X 13" in place of 15" x 15". The fifth method was a variation of the climate control method with climate control provided after the start of short days. The test was run on three separate cycles. Each cycle, the growing period for a particular crop, consisted of the five production methods in three randomized replications. Each replication consisted of two cultivars with the only variable between replications being greenhouse location (see Figure 3). There were a total of 30 plants of each cultivar in each of three replications for a total of 180 plants in each method. The five methods thus totaled 900 plants for each cycle, or 2700 plants for the total test. The first cycle was started on March 11 and continued through May 20. The second cycle started on May 27 and continued through August 12. The third and final cycle started on September 10 and ended on November 20. The use

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[1]Uni-Royal 85% WP formulation of succinic acid 2,2-dimethyl hydrazide.

TABLE I

PRODUCTION METHODS

Method	Starting Procedure	Spacing		Pinching
		Start	Finish	
Standard A	*7 Long Days, Mist, 65°F plus	7" X 7" 1-7th day	15" X 15"	Tall: **SD + 7 Short: Start SD No Alar
Standard B	*7 Long Days Mist, 65°F plus	7" X 7" 1-7th day	13" X 13"	Tall: SD + 7 Short: Start SD No Alar
Accelerated 1 A	No Long Days, No Mist, 62°F	15" X 15"	15" X 15"	Tall: SD + 7 Short: SD + 3 No Alar
Accelerated 1 B	No Long Days, No Mist, 62°F	13" X 13"	13" X 13"	Tall: SD + 7 Short: SD + 3 No Alar
Accelerated II	No Long Days Mist, 65°F plus	7" X 7" 1-7th day	15" X 15"	Tall: SD + 7 Short: SD + 3 No Alar

*A climate control of increased temperatures, high humidity and additional daylength were provided Standard A and Standard B production methods as indicated.

**SD = short days.

Plot A (Bench 2)

Standard A	Accelerated I B	Accelerated II	Accelerated I A	Standard B
15" X 15"	13" X 13"	15" X 15"	15" X 15"	13" X 13"
Replication 1	Replication 10	Replication 13	Replication 7	Replication 4

Plot B (Bench 3)

Accelerated I B	Accelerated I A	Accelerated II	Standard B	Standard A
13" X 13"	15" X 15"	15" X 15"	13" X 13"	15" X 15"
Replication 11	Replication 8	Replication 14	Replication 5	Replication 2

Plot C (Bench 4)

Standard B	Accelerated I A	Standard A	Accelerated II	Accelerated I B
13" X 13"	15" X 15"	15" X 15"	15" X 15"	13" X 13"
Replication 6	Replication 9	Replication 3	Replication 15	Replication 12

Figure 3. Randomized Replications.

of three cycles introduced a wide range of climate differences into the test to further validate results.

The five methods were identified as Standard A, Standard B, Accelerated I A, Accelerated I B and Accelerated II. These methods with the variables in each are summarized in Table I. The standard method used the seven long days starting period within a polyethylene climate control tent. The only difference between Standard A and Standard B methods was the pot spacing. Spacing for pots in Standard A was 15" X 15", and 13" X 13" for Standard B. The accelerated method was a variation which excluded the long day starting period. The difference between Accelerated I and Accelerated II was the seven short days of climate control given to Accelerated II immediately after potting. Accelerated I was placed directly on the bench without the seven short days of climate control after potting. Accelerated I A was spaced with pot centers at 15" X 15" and Accelerated I B at 13" X 13". Figures 4 and 5 illustrate the spacing arrangement employed in both A and B production methods. The three replications of each method varied only in greenhouse location. The location of replications is shown in Figure 3. The two cultivars used in the spring and fall cycles were 'Bright Golden Anne' and 'Mandalay'. In the summar they were 'Snow Ridge' and 'Yellow Delaware'. Thus, for each cycle there was a tall growing cultivar and a short growing cultivar. All plants consisted of five rooted cuttings in a 5½" pot.[2]

The tall cultivars were given a tall treatment which consisted of a manual pinch one week after the start of short days and a growth

[2]Cuttings, courtesy Yoder Bros., Inc., Barberton, Ohio.

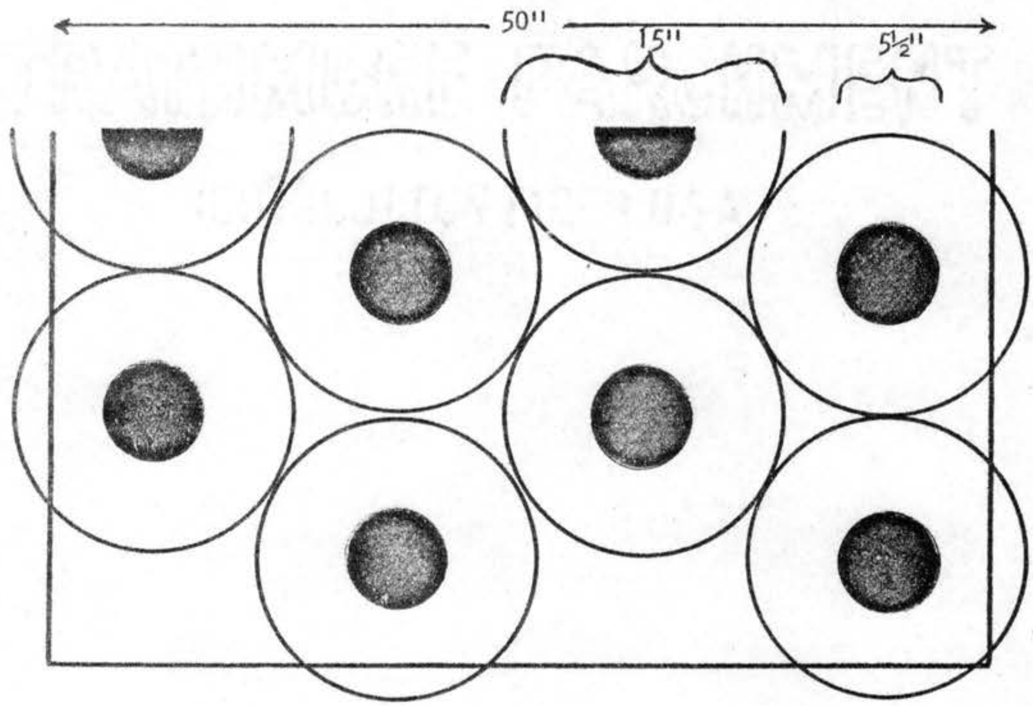


Figure 4. 15" X 15" Pot Spacing Patterns.

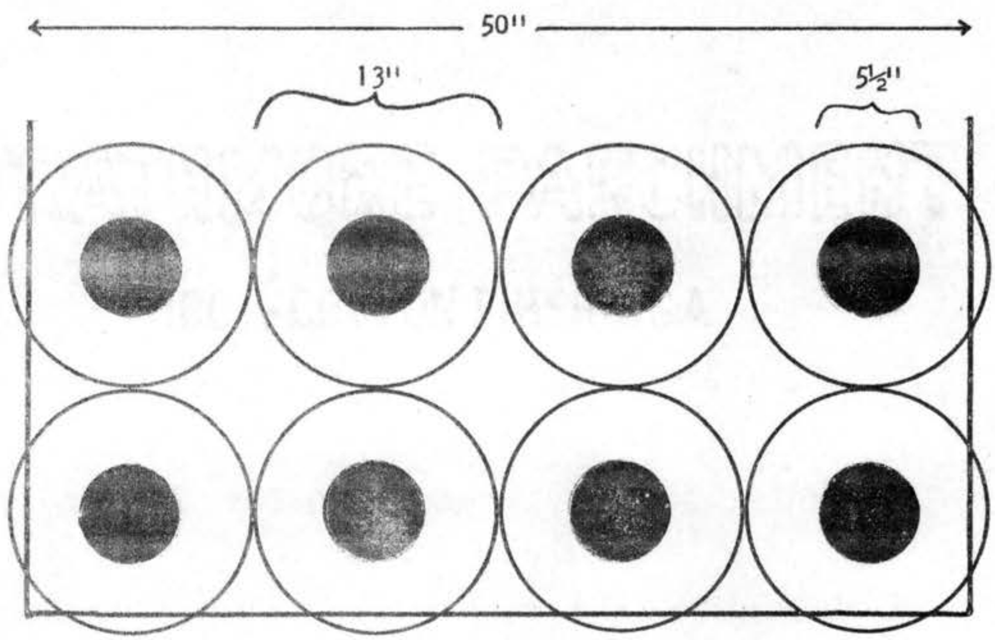


Figure 5. 13" X 13" Pot Spacing Patterns.

control treatment of .25% Alar foliar spray two weeks after the pinch (29). In the summer cycle a .50% spray of Alar was used. The short cultivars were actually given a modified medium treatment with pinching done on the third day after the start of short days (29). No Alar applications were made on the short cultivars.

As already noted, a fertilizer application of 20-20-20 soluble fertilizer was injected at every watering. On the third day after potting, a 500 ppm starter solution of 20-20-20 fertilizer was applied with manual watering. Plants were irrigated as weather and soil moisture conditions permitted. After an initial phasing-in requiring some "spot watering" of individual pots, all plants received the same rate of watering application of 10 ounces at each watering.

Additional cultural practices concerning temperature, light, black cloth shading, and soil followed the generally accepted commercial practice in this area. Throughout each cycle, night temperatures were held to 62°F when possible. During the last two weeks of each cycle the night temperature was reduced as close to 58°F as possible. The day temperature was held at 70° to 75°F on normal days and 65°F on cloudy days. Lighting was provided for the standard methods during long day treatments for four hours, from 10 p.m. until 2 a.m. each night at the start of the spring and fall cycles. The black cloth shading was used for daylength control from March 1 until October 1. It was drawn at 5 p.m. during the spring and fall and at 7 p.m. during the summer, remaining on until 8 a.m. each morning. The soil mixture consisted of one part clay loam, one part peat, and one part perlite. Hydrated lime was added at the rate of 2.7# per cubic yard of soil mix. In the potting operation rooted cuttings were carefully planted shallow and leaning outward at the pot perimeter. A production method schedule is included in Table II.

Accumulating Direct Production Costs

This study, for reasons previously presented and as discussed below, was restricted to direct material and direct labor inputs. Overhead (indirect) costs were excluded because they are prorated to all production areas after being accumulated centrally without reference to specific crops. There is nothing novel about isolating indirect costs in regard to a single crop because they are then simply proportional to space use and they are not controllable by any single crop.

The identification of direct cost inputs is useful. The level of such costs is fairly uniform from one firm to another within wide regional areas, assuming the same or quite similar production methods. In this test the direct cost data were accumulated for each production method. Whenever a cost was not directly associated with a production method, it was prorated uniformly to all production methods.

Each crop cycle in this test was produced as a single lot with all plants in a lot scheduled to be finished on the same date regardless of production method. It, therefore, was appropriate to use the simplified form of job order cost accounting. Costs for materials were recorded daily on "Materials Used Slips" at the time supplies were drawn for use. Each slip contained a slip number, user's name, date, production method on which it was used, item, quantity, and price. The format is shown in Figure 6.

A single slip was prepared for each item or for each group of items when several were applicable to a single operation. The materials used slips were accumulated for each week and at the end of the week they

TABLE II

PRODUCTION CYCLE SCHEDULE

Activity	Production Method*		
	Standard	Accelerated I	Accelerated II
Potting	1	8	8
Long Days	1	8	8
Conc. Feed	4	10	10
Short Days	8	8	8
Humidity and Temp. Control	1 to 8	none	8 to 14
Pinch: Short Cultivar	10	10	10
Tall Cultivar	16	16	16
Alar	30	30	30
Disbudding	48	48	48
Quality Measure	72	72	72
Flowering Date: Schedule	78	78	78
From Potting	78	70	70
Dry Weight Test	79	79	79
Data Summary	72 - 75	72 - 75	72 - 75

*The number given is the sequence number of the day within the production schedule.

MATERIALS USED SLIP

Slip No. ______________________ Treatment __________

User __________________________ Date __________

Mat Cat	Qty	Item	Price	Total	Ck Pd

Figure 6. Materials Used Slip.

were posted to a materials consumption list (Figure 7). All material was identified by production method whenever possible. Such procedures as fumigation, Alar applications, and irrigation were uniform for all methods and were prorated to each method equally. Care was taken to include all materials costs. Water through the irrigation system was prorated to each production method each week by the rate of 1/5th of 69 gallons, the total quantity distributed at each watering. Such materials as cleaning and painting supplies or building repair materials were not included under direct costs of production.

Prices for computing costs of materials were obtained from invoices or suppliers' catalogs. All costs were accumulated on the materials consumption list by the materials categories:

	Category	Explanation
1.	Soil	Components and additives at the time of potting.
2.	Pots and labels	Pots, labels, drainage, stakes, and ties.
3.	Fertilizer	Both soluble fertilizer and other special purpose fertilizer.
4.	Insecticides, etc.	Insecticides, fungicides, and other chemicals for control of diseases and disorders, including spreaders.
5.	Water	All water, both through injector and manual.
6.	Chemicals	For special chemical treatments such as Alar.
7.	Equipment repair	Parts, supplies, and materials used in equipment set up, maintenance, and repair.
8.	Other	Clearly identified.

Materials Consumption List

Slip No.	Materials Category								Production Method					
	Soil	Pots Labels	Fert. Water	Insect-icide	Manual Water	Chem-icals	Equip. Repair	Other	Std A	Std B	Acc I A	Acc I B	Acc II	Not Dist.

Figure 7. Materials Consumption List.

After summarizing each material category on the materials consumption list, it was posted to the production cost sheet for the production cycle.

All labor attributable to the test was recorded at the time performed on a "Daily Time Slip" (Figure 8) by the individual performing the work. A separate slip was prepared by each individual for each day he performed work. All labor time that could be identified with a specific production method such as manual misting of a particular replication was recorded for that method. Where it was not possible or was impractical to so identify the labor cost, i.e., pulling black cloth, irrigating, or potting, the costs were prorated evenly to all methods. Daily time slips contained the name of the worker, inclusive times in which the work was performed, the date, and the production method.

Daily time slips were accumulated each week and recorded individually on the Labor Time Data Sheet (Figure 9). Undistributed direct labor was prorated evenly to each production method. All labor performed was recorded at the current federal minimum wage of $1.60 per hour. Such tasks as building maintenance or heating system repair, even though performed in the project area, were not included as direct costs. (These costs would normally be accumulated as indirect costs by a commercial producer.) All work performed was recorded as one of the sixteen types of tasks:

Task Area	Explanation
1. Soil preparation	Hauling, mixing, sterilizing.
2. Potting	Setting up the potting bench, potting, placing pots on bench.
3. Moving pots	Re-spacing and spacing out.

DAILY TIME SLIP

Date ____________

Name ________________________

Hour	Time (min)	Treat-ment	Job Done	Rate	Total	Ck Pd
a.m. 7:00						
8:00						
9:00						
10:00						
11:00						
p.m. 12:00						
1:00						
2:00						
3:00						
4:00						
5:00						

Other (specify)

Figure 8. Daily Time Slip.

Labor Time Sheet

Task Area														Production Method							
Time Slip No.	Soil Prep.	Potting	Moving Pots	Watering	Fert. Prep.	Spray & Fum.	Pinch	Disbud	Black Cloth	Manual Water	Special Fert.	Equip. Repair	Misc.	Std A	Std B	Acc I A	Acc I B	Acc II	Not Dist.	Inspection	Research Data

Figure 9. Labor Time Sheet Summary Data.

4.	Watering	Normal daily proportioner applications.
5.	Fertilizer preparation	Preparing fertilizer for GEWA injector.
6.	Spraying and fumigating	All preventive insect and disease treatment and specific treatments, including the proportionate share of equipment set-up and clean-up.
7.	Pinching	Stem apices removal as well as clean-up.
8.	Disbudding	Initial disbudding, clean-up, and later rechecks.
9.	Black cloth shading	Pulling and removing black cloth.
10.	Manual watering	Miscellaneous watering and syringing tasks but not washing of walks.
11.	Special fertilizer	Applications other than routine.
12.	Inspections	Reserved for Project Advisor superintendent.
13.	Equipment repair	Should include such tasks as adjusting watering lines, rearranging equipment, repairing black cloth, and hanging lights and reflectors, as related directly to this crop.
14.	Research data	Labor time used to measure plant quality, light intensity, and other experimental procedures. Also, time recording data was entered here.
15.	Lost time	Time arising from labor waiting or coffee break or resulting from delays such as equipment breakdown or conference on crop.
16.	Miscellaneous	That which is not identified elsewhere, such as cleaning benches, washing down walks, and moving out finished pots.

The data summarized by type of task were posted each week in summary form to the production cost sheet (see Figure 10) for the production cycle.

PRODUCTION COST SHEET

From ______ To ______

Task or Category	Week											Total
	1	2	3	4	5	6	7	8	9	10	11	
Comments:												

Figure 10. Production Cost Sheet.

As indicated above, the production cost sheet (Figure 10) was used to summarize both materials and labor costs each week during the entire period of the cycle. Actual costs and prorated costs accumulated by type of task or material category were also summarized each week on the production cost sheet by production method. This provided a weekly cost level for each production method for each style. The production cost sheet thus gave complete direct cost information for each week. Individual cost elements (categories and tasks) were summed to give totals for the cycle and for the entire test period.

Identifying Space Use Efficiency

At the present state of the art, the most significant characteristic of greenhouse bench space in production management is its two dimensional quality. Although attempts have been made and continue to be made to use available cubic space by employing shelves, tier benches, and racks (30), greenhouse bench space remains for all practical purposes a single plane dimension.

In order to study space it was necessary to break it down into its component elements and to deal with each separately. The following discussion describes terms used to identify space components for this study. It is suggested that these terms and the components they represent could be seriously considered as a management tool in greenhouse production control. They represent a basic approach which has been accepted and successfully used by industrial and marketing firms (31).

For the total greenhouse range structure and land in the immediate vicinity, the term Total Gross Range Space was used. This component was essentially a total of all other components. It included land, surrounding the greenhouses, that was used for roads, walks and idle space between greenhouse units as well as the greenhouse space itself. Also included were such structures as hotbeds, coldframes, headhouses and boiler rooms. It did not include land devoted to separate field production.

A major component of the total gross range space was the ground space actually occupied by the greenhouse production units. The term given to this component was Gross Greenhouse Production Space. It included all bench space, aisles, walks, equipment space, and space obstructed by structural features such as purlin posts, doors, and pipelines.

Space outside of production units was identified as Space in Support of Production. This space included the headhouse, potting sheds, grading and packing areas, office areas, cold storage facilities, boiler rooms, rest rooms, as well as cold frames, hotbeds and seedbeds that are used in activities directly related to greenhouse production.

The greenhouse production space was further divided into a component represented by the term Usable Bench Space. It was very similar to the commonly used term in the trade, bench space. This component constituted actual ground bench space or raised bench space, including shelves and potential bench space not in use.

Bench space (Usable Bench Space) actually occupied by crops is called Occupied Bench Space. This space component when compared with the gross greenhouse production space provided an overall measure of efficiency in space management. It was described as the Per Cent of Gross Space Used.

Empty bench space, usable bench space not used for crops, was identified as Vacant Bench Space. When the vacant bench space was compared with the usable bench space it provided a measure of the efficiency by which actual space available was being managed. It was called the Per Cent of Usable Space Loss.

Within the scope of the above defined terms, space use data were recorded during the period and analyzed. The unused space was identified and comparisons were made with gross space and usable space to arrive at a useful description of space effectiveness.

Each unit of space was measured in terms of the possible number of days it was usable and the numberof square feet it constituted. This measure was developed in "square foot-days", meaning that in an average month each square foot of usable bench space would be thirty "square feet-days". A bench with one hundred square feet would have available 3000 square foot-days per month.

By comparing gross greenhouse production space, measured in square foot-days, with the occupied bench space, also measured in square foot-days, a per cent space used figure was readily derived which accurately described the efficiency with which space was being managed. It considered both space available and time available factors. As an example, in the test the total gross greenhouse production space/time for one month was 96,000 square foot days. If the total usable bench space was fully occupied during this same period, the occupied bench space time would be 54,060 square foot-days (refer to Table III). Thus the per cent of gross space used would have been 56 per cent. This efficiency figure, assuming optimum pot spacing, constitutes the best use that could have been made of the greenhouse space under the present space layout. It is conceivable that other layout arrangements such as peninsular benches might increase space use efficiency, however, the

TABLE III

USABLE BENCH SPACE

Bench	Dimensions	*Net Usable Total	Bench Space Project
1 North	3.5' X 46'	161	-
1 South	3.5' X 47'	165	-
2 North	4.16' X 44'	183	183
2 South	4.16' X 47'	195	195
3 North	4.16' X 46'	191	191
3 South	4.16' X 46'	191	191
4 North	4.16' X 46'	191	191
4 South	4.16' X 47'	195	195
5 North	3.5' X 47'	165	-
5 South	3.5' X 47'	165	126
Total		1802	

*Square feet.

present arrangement limited efficiency to a maximum of 56 percent. Any unused space (the difference between usable bench space and occupied bench space) decreases efficiency so that when operating figures are compared with 56 per cent they will provide a gauge of efficiency in space management including both space use and layout planning.

The other space management efficiency figure, Per Cent Usable Space Loss, concerned the usable bench space/time that was available during the period and how the occupied bench space/time compared with this figure. If during a month on various days space was not used that amounted to 1500 square foot-days (or an average of 50 square feet per day out of the 1802 available), the per cent usable space loss would have been 2.2%.

In addition to space advantages through complete and continuous occupancy, certain space advantages can be derived by the minimum spacing of pots. A stigma is placed on generous pot spacing and rightfully so. As has been shown in the space layout charts, Figures 1 and 2, and Table IV, 60 plants spaced at 15" X 15" occupy approximately 80 square feet, while 60 plants spaced 13" X 13" only take up 68 square feet, a savings of 12 square feet, or fifteen per cent.

TABLE IV

SPACE REQUIREMENTS FOR 60 PLANTS

Spacing	No. Plants	Bench Length (feet)	Bench Width (feet)	*Space Requirement
15" X 15"	60	19.3	4.16	80.3
13" X 13"	60	16.3	4.16	67.8

*Bench length times bench width.

Evaluating Product Quality

For the purpose of this test uniform measurable standards were essential for statistically comparing the output of production methods. The measures, grams of dry weight, number of flowering breaks, stem height, and plant diameter used successfully in many previous studies of pot mum production were employed in this study. It should be noted, with reference to the raw data, that aesthetic comparisons made during the test at the same time as the taking of other measures showed close agreement with the more definitive measurement standards.

The justification for using product quality as a measure for comparison appears too obvious to require amplification. In the final analysis, results achieved in any flower crop test of the commercial production become valid only when the product is marketed.

One half of all plants in each replication, the two inner rows, were measured for height, diameter, and number of flowering breaks. Each plant so measured was also evaluated as to its overall appearance. Quality points were awarded to each plant from the results of these measures. One point was given for each inch in height up to eighteen inches. At eighteen inches and above one point was deducted. One point was also given for each inch of growth in diameter. For plants averaging over 24" in diameter, one point was deducted for each extra inch. The evaluation of overall appearance was visually classified from poor to superior. Points were awarded as follows:

Evaluation	Points
Superior	8
Excellent	6
Good	4
Fair	2
Poor	0

From the group of measured plants five were selected from each replication for dry weight measure. Great care was taken to select average plants. If extremes existed, they were not selected. Only plants that measured average for the replication and appeared average were selected. The flowers and foliage were cut off at the pot rims of the five plants from each replication and were packaged separately by replication. These two groups of packages, flowers, and stems were oven dried for a minimum of 76 hours and then weighed to the nearest gram.

After completion of all measurements, statistical tests were run to determine differences between production methods. As a quick check of the raw data in Appendix A will show, height and diameter differences showed no trend that could be associated only with the production method. (Differences in replications of the same method seemed to have been associated with greenhouse location, which was not a factor in this study.) The factor of stem weight did not vary by production method.

The number of flowering breaks and the gram weight of the flowers did show a mean difference between the five production methods, and other statistical test trials indicated these measures to be the truest test of variance between production methods. The statistical test used in the analysis of variance was the t - test. A result of .05 per cent or less was considered significant. Larger values were explained.

CHAPTER IV

EXPERIMENTAL RESULTS

General Statement of Production Observations

During the test every effort was made to maintain commercial practices as closely as possible in all tasks undertaken during each production cycle. Actual performance of tasks as scheduled was achieved on the dates established except for such practices as pinching. In this case a one day delay was permitted in the tall cultivar during the second and third cycles to gain advantages in improved development (32). This same advantage was sought in the three day pinching delay for short treatment cultivars. The effects of these modified procedures were not evaluated in the test. However, it is believed that the commercial practice would be to follow similar procedures.

Aside from the watering problem in cycle I during the starting phase of the Accelerated I method and the excessive growth of foliage on the 'Snow Ridge' and 'Yellow Delaware' cultivars during the summer cycle, there were no unusual cultural problems to be solved. Periodic soil tests showed that desired nutrient levels were maintained. Insect and disease control practices prevented injury to the plants. No diseases were noted. The foliage of all plants was examined at the end of each production cycle and for the most part the lower leaves and stems showed the same rich green lustre as did the upper leaves.

In a number of cases during the second cycle, where crown buds formed before the pinching of the tall cultivar, no imbalance in the final conformation of the plant was observed. The lateral bud break that occurred was apparently only a few days ahead of the normally pinched plants and growth subsequently evened out.

Watering and fertilizing were readily controlled by the irrigating system and the GEWA injector. A supervisor could assure proper water control by removing irrigating tubes to prevent additional watering until he replaced the tubes. When a nutrient build up was apparent during cloudy weather, particularly during the third cycle, the injector was shut down so that only water was provided for plant needs and for leaching.

Comparisons by Product Quality Measures

An examination of the differences in mean dry weight and quality measures was made for the five production methods by tall and short cultivars for all three of the cycles. The results of these computations are shown in Tables V and VI. Only two measures, flower dry dry weight and number of flowering breaks, demonstrated a consistent difference among production methods. These differences were consistent among the tall cultivar replications but were not among the short cultivar replications. Among the three variations in production method (excluding spacing comparison methods) flower dry weight for the tall cultivars was over four grams heavier for the standard production method than for the accelerated methods. The difference was two and one-half grams for the short cultivars. For the count of the number of flowering breaks, the standard method for tall cultivars produced approximately four more breaks than did the accelerated methods. For short cultivars this difference was approximately one.

TABLE V

DIFFERENCE IN MEAN DRY WEIGHTS BETWEEN THREE PRODUCTION METHODS*

Production Method	Stem Dry Weight		Flower Dry Weight	
	Tall Cultivars	Short Cultivars	Tall Cultivars	Short Cultivars
Standard A	36.6	36.8	22.3	23.0
Accelerated I A	36.8	38.5	18.0	20.3
Accelerated II	35.9	35.0	18.1	20.4

*A mean of all three cycles in grams.

TABLE VI

DIFFERENCE IN MEAN QUALITY MEASURES BETWEEN THREE PRODUCTION METHODS*

Production Method	Height		Diameter		Breaks	
	Tall Cultivars	Short Cultivars	Tall Cultivars	Short Cultivars	Tall Cultivars	Short Cultivars
Standard A	14.0	12.9	20.7	21.2	23.4	24.1
Accelerated I A	13.6	12.8	20.7	21.3	19.7	23.4
Accelerated II	13.7	12.8	20.6	21.5	18.9	21.8

*This is a mean of all three production cycles. Height and diameter are given in inches. Breaks are the number of individual flowers per pot.

During the summer test period (cycle II) the plants in the accelerated production methods produced generally heavier stem weights and lighter flower weights than did the comparable standard method. The data supporting these observations are shown in Table VII.

TABLE VII

DIFFERENCES IN MEAN WEIGHTS BETWEEN PRODUCTION METHODS BY CYCLE

Production Method	*Stem Weight		*Flower Weight	
	Tall Cultivars	Short Cultivars	Tall Cultivars	Short Cultivars
Cycle I				
Standard A	35.5	32.7	28.7	27.8
Accelerated I A	31.2	30.2	25.7	25.1
Accelerated II	30.6	29.2	24.9	24.1
Cycle II				
Standard A	51.0	55.4	20.7	24.2
Accelerated I A	55.7	61.1	11.7	18.4
Accelerated II	54.8	53.7	12.8	20.8
Cycle III				
Standard A	23.3	22.2	17.1	17.1
Accelerated I A	23.3	24.1	16.7	17.4
Accelerated II	22.3	22.2	16.5	16.4

*In grams.

Once a consistent relationship among production methods was established by both flower dry weight and flowering breaks, a study of the statistical significance of the difference between the sample means of production methods was made. The criterion for accepting a difference as significant was a P value equal to .05 or less. In most cases a statistical difference was established at the .05 level. The data accumulated for all cycles (Appendix A) showed a significant difference to exist between the standard method and the accelerated method, as illustrated in Table VIII. No significant difference was demonstrated between Standard A and Standard B, indicating the two methods produced comparable results. A statistical difference between the standard and accelerated methods was not as clearly established in the short cultivar replications as in the tall cultivar replications.

Similar statistical studies made of the other plant measurements, height and diameter mean differences, did not demonstrate any significant differences among production methods. However, a study of the visual evaluation measures showed a difference in means which supports the observations made of flower dry weight and flowering break differences (see Table IX).

Aside from the noticeable visual differences in cycle II, there were few readily observable differences among the production methods. The more observable differences were among replications in a particular method caused by variations in greenhouse humidity, temperature, and light conditions. Cycle II differences were apparently the result of less heat delay associated with the standard method than with the accelerated methods during the summer period. They, also, probably resulted from the strong tendency of both 'Yellow Delaware' and 'Snow Ridge' to be heavy foliage producers.

Pot spacing comparisons by visual observation showed no noticeable differences between 15" X 15" spacing and the closer 13" X 13" spacing. The pictures displayed in Figure 11 show no visible differences in the flower or foliage composition between the two production methods, Standard A and Standard B.

TABLE VIII

SIGNIFICANCE OF DIFFERENCE BETWEEN SAMPLE MEANS OF PRODUCTION METHOD BY FLOWER DRY WEIGHT AND FLOWERING BREAKS

Production Method Comparison	Flower Dry Weight (grams)		Flowering Breaks (number)	
	Tall Cultivars	Short Cultivars	Tall Cultivars	Short Cultivars
Standard A	22.3	23.0	23.4	24.1
versus				
Standard B	21.7	21.6	22.7	23.4
Accelerated I A	18.0[a]	20.3[c]	19.7[a]	23.4
Accelerated II	18.1[a]	20.4[b]	18.9[a]	21.8[c]

Significance of Difference:

[a] = P value of .01 or less; considered highly significant.

[b] = P value of .05 or less; considered significant.

[c] = P value of .10 or less but greater than .05; considered close to significant.

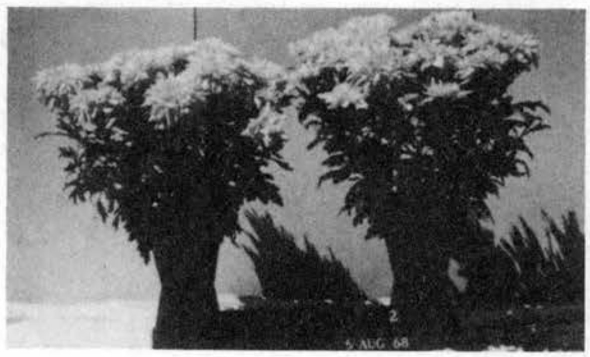
TABLE IX

DIFFERENCE IN MEANS OF VISUAL EVALUATION MEASURES FOR ALL THREE CYCLES

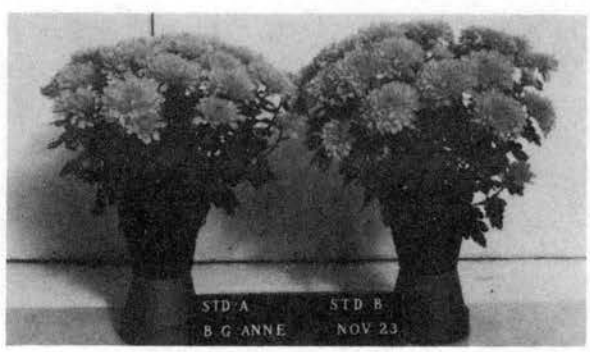
Production Method	*Tall cultivars	*Short cultivars
Standard A	7.1	7.0
Standard B	7.0	6.9
Accelerated I A	6.2	6.7
Accelerated II	6.3	6.5

*Means of quality points assigned to all measured plants. 8 points equals superior quality.

Cycle I, 'Mandalay'



Cycle II, 'Snow Ridge'



Cycle III, 'Bright Golden Anne'

Figure 11. Standard A and Standard B Methods Compared.

Composition of Direct Production Costs

Generally, the direct production costs when compared among the three production cycles, were highly uniform (see Table X). Deviations from the average cost levels occurred in Cycle I for potting, moving pots, manual watering, equipment repair, and other labor. For Cycle II, deviations were noted in irrigating and disbudding. For Cycle III, deviations occurred in black cloth shading, fertilizer costs and insecticide costs. Each of these cost deviations is explained below. For the most part they represent differences which occurred because of a change of season or would normally have accumulated over a period of longer than one production cycle.

Deviation	Explanation
Cycle I	
Potting	The initial learning period for the workers resulted in slower performance than for potting in later cycles.
Moving Pots	The first layout of pots in proper locations for each replication took a longer period of time than in later cycles, when it was better understood.
Manual Watering	Establishing the plants for irrigating took one week longer than in the following cycles when the technique was better understood.
Equipment Repair	Fewer adjustments and repairs in equipment were required during the first cycle than were required later.
Other Labor	Additional temperature and humidity checks were made in the climate control chamber during the first cycle to evaluate performance.
Cycle II	
Irrigating	The increased irrigating during the summer cycle was normal for the high light and high temperature conditions.

Cycle II (Cont'd)

Disbudding	The vigorous foliage producing cultivars used for this cycle and heat delay resulted in increased disbudding work.

Cycle III

Black Cloth Shading	Black cloth daylength control was required for only the first ten days of this cycle.
Fertilizer Cost	Less than a full tank was required for each cycle. As a result only half of a tank was required for the final cycle.
Insecticide Cost	A persistent white fly infestation resulted in additional fumigation control measures above that of the first two cycles.

With further reference to Table X it will be noted that relatively few of the cost elements constituted a significant cost on an average per pot basis. As would be expected, of the total labor cost (39.50 cents), disbudding (18.36 cents), potting (6.47 cents), and black cloth pulling (5.26 cents) were the largest. The labor cost of irrigating was minor (1.65 cents), even less than the small amount of manual watering and misting required (2.64 cents). Materials costs were minor elements except for cuttings (35.76 cents) and pots (9.00 cents) which together constituted almost one-half of the total direct cost of the plants (92.77 cents) and about 85 per cent of the total materials cost (53.27 cents). Such costs as labor for moving pots, watering, spraying and pinching, previously thought to be expensive tasks, were less important in the overall costs. Materials costs, such as high priced soluble fertilizer, insecticides and water, likewise were found to be minor expenses.

Production method total direct costs were uniformly the same

TABLE X

DIRECT COST BY TASK OR CATEGORY FOR EACH CYCLE

Task or Category	Cycle III	Cycle II	Cycle I	Average	Cost per pot
Labor*					
Soil preparation	$ 2.54	4.54	3.07	3.38	.0038
Potting	51.20	54.40	69.06	58.22	.0647
Moving pots	6.94	4.26	18.40	9.87	.0109
Watering	11.61	19.51	13.37	14.83	.0165
Fertilizer prep.	.94	1.20	.53	.89	.0009
Spraying	3.21	5.60	6.79	5.20	.0057
Pinching	8.01	9.60	9.87	9.16	.0101
Disbudding	174.15	198.79	122.35	165.09	.1836
Black Cloth	16.72	69.47	55.64	47.28	.0526
Manual water	20.72	21.20	29.20	23.71	.0264
Special fert.	1.21	1.59	2.14	1.65	.0018
Equipment repair	10.27	17.23	4.92	10.84	.0120
Other	1.87	4.80	9.61	5.43	.0060
Total	309.39	412.29	344.95	355.54	.3950
Materials					
Soil	12.65	11.90	11.30	11.95	.0132
Pots and labels	81.00	81.00	81.00	81.00	.0900
Fertilizer	8.69	17.32	17.29	14.43	.0160
Insecticide	7.08	3.72	1.94	4.25	.0047
Water	2.24	2.98	3.02	2.75	.0031
Chemicals	.10	.24	.46	.27	.0003
Equipment repair					
Other:					
Cuttings	324.00	317.25	324.00	321.75	.3576
Materials	43.02	43.02	43.02	43.02	.0478
Total	478.78	477.43	482.03	479.41	.5327
TOTAL LABOR AND MATERIALS	788.17	889.72	826.98	834.96	.9277

*Manhours used in each cycle for each task can be computed by dividing the cost of each task by the Federal minimum wage of $1.60 per hour, i.e., the average cycle potting labor equals 36.5 hours, $58.22 ÷ $1.60.

throughout the test period (see Table XI). Close examination of the total per pot costs show that the Accelerated I method cost one-half cent less than the Standard method and the Accelerated II method one cent less than the Standard method.

TABLE XI

DIRECT COST BY PRODUCTION METHOD AND BY PRODUCTION CYCLE

Production Method	Production Cycle I	Production Cycle II	Production Cycle III	Avg. Cost Per Pot
Standard A	$ 164.57	179.50	159.24	0.9321
Standard B	164.55	179.52	159.23	0.9320
Accelerated I A	165.81	176.89	157.64	0.9265
Accelerated I B	165.84	176.92	157.63	0.9266
Accelerated II	166.21	176.89	154.43	0.9213
Average				0.9277

The direct production costs during each cycle peaked during the first two weeks and again during the seventh and eighth weeks. This is illustrated for the three cycles in the graph in Figure 12. The total direct labor labor and material costs by cycle and the average for all cycles are given in Table XII. These material and labor costs as graphically illustrated in Figure 13 were not parallel throughout the production cycle. After the second week of production, the material costs for a cycle were very low. Labor costs were high during the first two weeks, then declined until the seventh and eighth weeks when the labor cost for disbudding was incurred. Following disbudding, labor costs again declined for the remainder of the cycle.

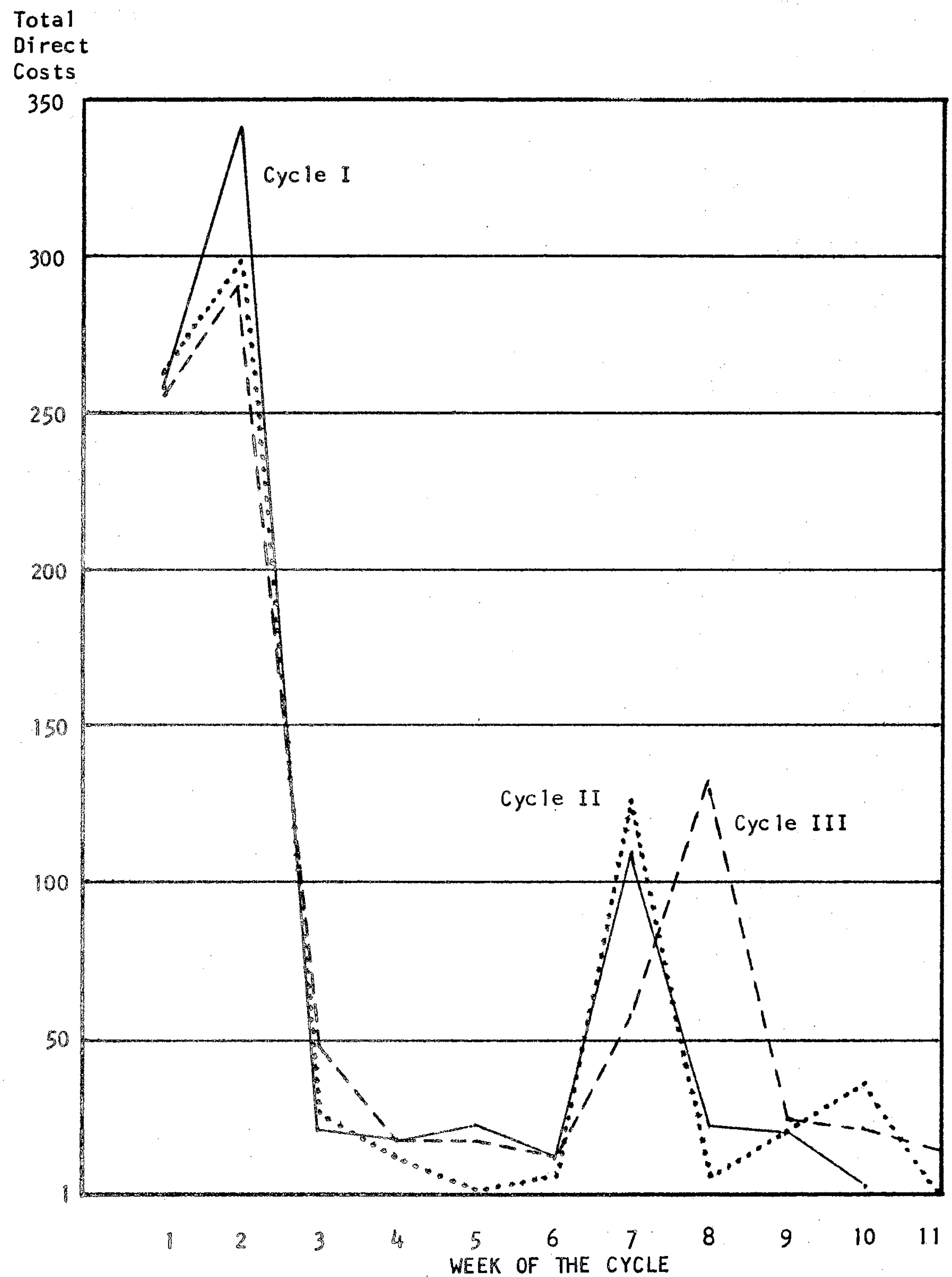


Figure 12. Comparison of Direct Costs Incurred by Week by Cycle.

TABLE XII

WEEKLY LABOR AND MATERIALS DIRECT COSTS AS COMPILED FOR EACH PRODUCTION CYCLE

Production Cycle	Cost for the week of:											Total
	1	2	3	4	5	6	7	8	9	10	11	
Cycle I												
Labor	31.60	90.10	23.16	16.88	20.23	12.53	108.08	20.32	19.89	2.16		344.95
Materials	226.85	250.28	.39	.83	1.16	.62	.57	.80	.25	.28		482.03
Total	258.45	340.38	23.55	17.71	21.39	13.39	108.65	21.12	20.14	2.44		826.98
Cycle II												
Labor	35.48	58.11	32.11	16.37	16.26	11.99	55.20	130.55	22.68	20.44	13.10	412.29
Materials	221.04	233.37	17.64	.80	.34	.25	.98	1.85	.32	.42	.42	477.43
Total	256.52	291.48	49.75	17.17	16.60	12.24	56.18	132.40	23.09	20.86	13.52	889.72
Cycle III												
Labor	32.55	59.63	20.74	9.25	1.35	3.63	124.83	5.36	19.75	31.49	.81	309.39
Materials	233.69	238.20	8.05	2.34	.18	1.93	.21	.71	.18	3.18	.11	478.78
Total	256.24	297.83	28.79	11.59	1.53	5.56	125.04	6.07	19.93	34.67	.92	788.17
Average												
Labor	33.21	69.28	25.33	14.16	12.61	9.38	96.04	52.08	20.79	18.03	4.63	355.54
Materials	263.87	240.62	8.69	1.32	.56	.93	.59	1.12	.25	1.29	.17	479.41
Total	257.08	309.90	34.02	15.48	13.17	10.31	96.63	53.20	21.04	19.32	4.80	834.95

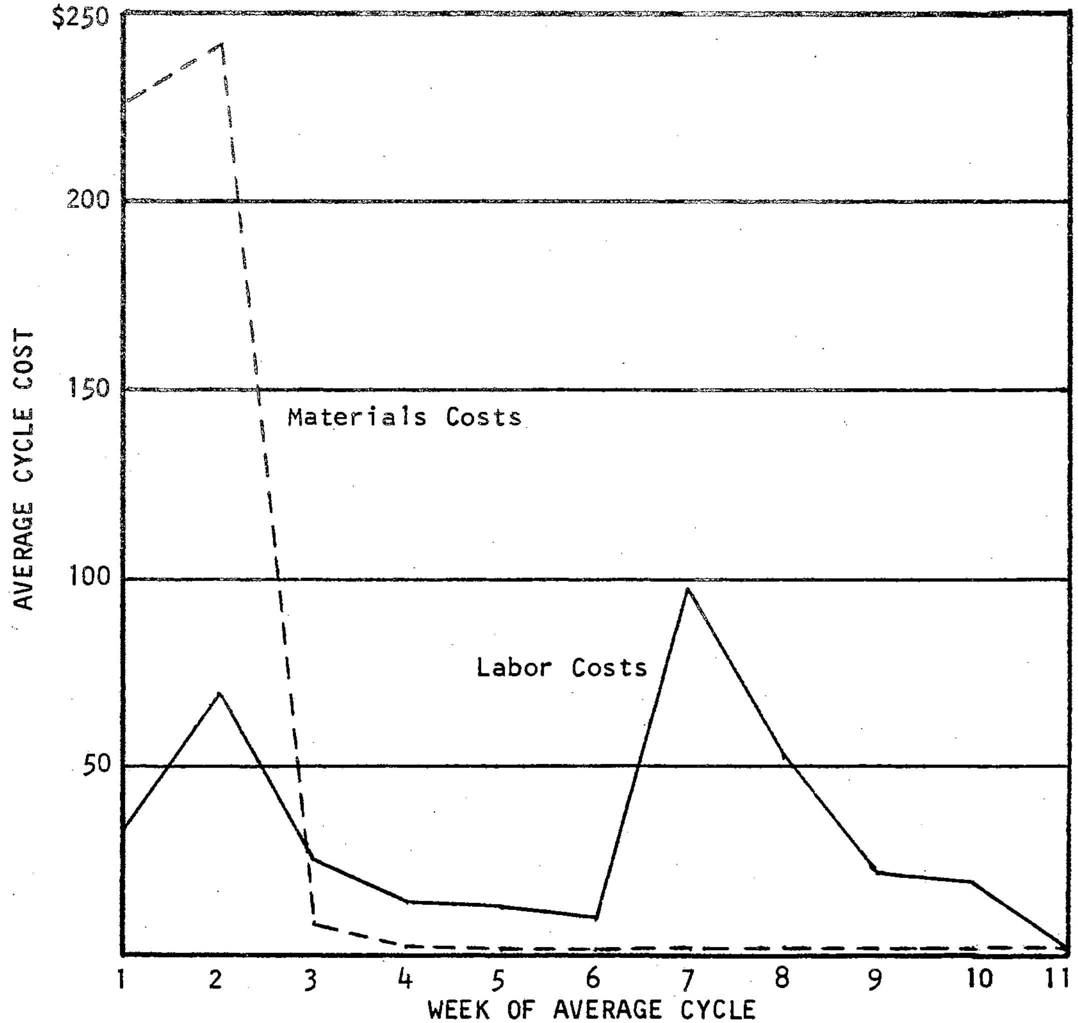


Figure 13. Average Production Cycle Costs for Materials and Labor.

Indirect production costs, as was previously discussed, vary considerably with each individual firm and with the region in which pot mums are grown. For many firms it may run 25 per cent of the total production cost, for others it may be higher. If it were 25 per cent, then, the major cost elements would appear somewhat as follows, provided the selling price per plant was $1.85 (21).

Production Costs:

Direct Costs	$ .9277
Overhead (Indirect) Costs	.3092
Total Production Cost	$ 1.2369
Selling Costs and Profit	.6131
Selling Price	$ 1.8500

Space Use Efficiency Data

The accumulated space use data for the test is summarized in Appendix B for each week within each production cycle. The square foot-days space requirement for each week and each cycle is listed in Table XIII. The space used during each cycle was quite uniform. The average space used was 121,332 square foot-days. Cycle I was 1.7 per cent below this at 118,945 square foot-days, Cycle II 4.5 per cent above the average at 126,541, and Cycle III 1.6 per cent below the average at 119,261 square foot-days. The cause of the increased space use during Cycle II was the increased bench time required to finish the crop resulting from some heat delay, particularly in the accelerated production methods and the longer growing period (11 weeks) for the 'Snow Ridge' cultivar.

The important space management data figures for this test were compiled from the summarized space use data in Appendix B as follows:

TABLE XIII

SPACE USE DURING THE ENTIRE STUDY PERIOD*

	**Week											
Cycle	1	2	3	4	5	6	7	8	9	10	11	Total
I	4,592	9,860	12,185	12,488	12,488	12,488	12,488	12,488	12,488	12,488	12,488	118,945
II	4,592	9,860	12,185	12,488	12,488	12,488	12,488	12,488	12,488	12,488	12,488	126,541
III	4,466	9,542	12,185	12,488	12,488	12,488	12,488	12,488	12,488	12,488	12,488	119,261
Total	13,650	29,262	36,555	37,464	37,464	37,464	37,464	37,464	37,464	37,464	22,432	
Average	4,550	9,754	12,185	12,488	12,488	12,488	12,488	12,488	12,488	12,488	7,477	121,332

*Space used for 900 plants plus occupied bench space for other projects.
**Square foot days.

Item	Square Foot-Days
Gross Greenhouse Production Space	768,000
Usable Bench Space	432,480
Occupied Bench Space	377,407
Vacant Bench Space	55,073

These data were used to compute the space management efficiency measures, Per Cent Gross Space Use at 49.14%, and Per Cent Usable Space Loss at 12.7%, as shown in Table XIV. These figures would represent a relatively low space use efficiency for a commercial operation, but are probably quite high for a research greenhouse. These figures do not include a period of two weeks during which the project was closed down at the end of the second cycle.

TABLE XIV

SPACE MANAGEMENT EFFICIENCY COMPUTED

Occupied Bench Space	÷	Gross Greenhouse Space	=	Per Cent Space Use
377,407	÷	768,000	=	49.14%
Vacant Bench Space	÷	Usable Bench Space	=	Per Cent Space Loss
55,073	÷	432,480	=	12.7%

Each firm, in managing space, must evaluate space use efficiency at an occupancy level which maximizes the use of space for its peculiar structures and facilities. Whereas 49% may usually be quite low, 59% may be abnormally high. But, if an increase of 10 per cent were possible, the cost of space could be reduced considerably, as shown in

Table XV. This cost evaluation is derived from the indirect costs that would be distributed to production units on a square foot/time use basis. The indirect costs for this illustration were computed at 25 per cent of total production costs. As shown in Table XV, the space cost for a gross space use of 49% is 2.2 cents per square foot per week. For a 59% of gross space use, it is reduced 23% to 1.7 cents per square foot per week.

TABLE XV

COMPUTING INDIRECT COST OF SPACE USE

Steps	Occupancy Level 49%	Occupancy Level 59%
1. Indirect Cost (for 2700 plants at 25% of Total Costs)	$273,336	329,073
2. Occupied Bench Space in Square Foot-Days (2700 plants)	$834.95	$834.95
3. Indirect Cost Per Square Foot-Day	$ .31	$ .25
4. Indirect Cost Per Square Foot Per Week	X 7 days 2.2 cents	X 7 days 1.7 cents

When one looks at space management efficiency in regard to space available for use, the per cent space loss becomes a valuable gauge. The value of lost space is measured by the income that could have been received by the firm had the space been used. One way of computing lost space value is to price it at the selling price of the product which could have been grown in the space lost; another would be to distribute the increased income that could have been received over total output. Since one amounts to the same as the other, the sales value of additional output which is arrived at more directly is used in Table XVI. Had the plants been spaced at 13" X 13", the value of the lost space for this test would have been $369.08.

TABLE XVI

COMPUTING VALUE LOST IN VACANT SPACE*

Steps	Computation
1. Vacant Space (square foot days from data in this study)	55,073
2. Square foot-days per plant (240 days X 1.15 sq. ft.)	÷ 276
3. Lost production (number of plants)	199.5
4. Selling price, per plant	X $ 1.85
5. Space loss value (lost production X selling price)	$ 369.08

*Assuming a 13" X 13" pot spacing.

Under the section "Identifying Space Use Efficiency" in Methods and Materials, the cost advantages of minimum spacing were pointed out. Using space data from this test, a clear illustration of this advantage is shown in Table XVII. The same level of space use efficiency, 49%, was used to compute the income which could be derived from an average cycle if the entire space had been used solely for the production of pot mums. The gain from the decreased pot spacing would be a gross income of $667.85 for this average cycle. Table VIII shows that there was no difference in quality between the Standard A and B methods.

TABLE XVII

COMPUTING THE GAIN IN GROSS INCOME BY MINIMUM POT SPACING (AVERAGE CYCLE)

Steps	Computation
1. Occupied Bench Space (at 49% space use)	125,802 sq. ft.-days
2. Square foot-days per plant	
13" X 13" (1.15 sq.ft. X 80 days)	(1) ÷ 92 sq.ft.-days
15" X 15" (1.56 sq.ft. X 80 days)	(2) ÷ 125 sq.ft.-days
3. Output per cycle	
13" X 13" pot spacing	(1) 1367 plants
15" X 15" pot spacing	(2) 1006 plants
4. Selling price per plant	X $1.85
5. Gross income	
13" X 13" pot spacing	(1) $ 2,528.95
15" X 15" pot spacing	(2) - 1,861.10
6. Minimum pot spacing gross income gain	$ 667,85

(1) Computation at 13" X 13" pot spacing.
(2) Computation at 15" X 15" pot spacing.

The income advantage derived from a minimum pot spacing when converted to gross greenhouse production space would be 1.89 cents per week which is the difference between a return of 5.29 cents a square foot per week from a 15" X 15" pot spacing and a return of 7.18 cents a square foot per week from a 13" X 13" pot spacing. (See Table XVIII).

TABLE XVIII

WEEKLY GAIN IN GROSS INCOME PER SQUARE FOOT FROM MINIMUM POT SPACING

Pot Spacing	*Gross Income	÷	Gross Space	Cycle Return	Weekly Return (÷ 11 weeks)
13" X 13"	$ 2528.95		3200 sq.ft.	79.03 cents	7.18 cents
15" X 15"	1861.10		3200 sq.ft.	58.16 cents	5.29 cents
Gain in Gross Income:				20.87 cents	1.89 cents

*See gross income figures in Table XVII.

CHAPTER V

DISCUSSION AND CONCLUSIONS

Significance of Pot Mum Production Results

The three main aspects of the pot mum production methods studied in this test, the cultural practice, the direct costs of production, and pot spacing, each produced results providing a clearer understanding of production efficiency.

Of the three basic methods of production used, the long day start with climate control, the standard method, proved conclusively to be the better producer of quality plants for tall treatment cultivars. The data in Table VI show that more flowers were produced per plant in the standard method. This evidence is also supported by a higher flower weight per plant. In addition, plants of this standard method were evaluated to be slightly higher in overall visual appearance than those of accelerated methods. In the case of the short growing cultivars under the medium treatment, differences did exist among production methods, but these were not statistically significant in all cases, particularly in the count of flowering breaks.

The high significance attained in difference between standard and accelerated methods for tall treatment cultivars (Table VIII) was probably due to the additional establishment time provided by seven long days prior to the start of short days as well as the effects on flower bud formation that the later tall treatment pinching causes.

The standard method proved superior in all three cycles of the test (Table VIII). This limited the significance of cultivar and seasonal differences, such as the response of the 'Snow Ridge' cultivar to the standard method during the summer period (Cycle II) with uniform flowering. Under the accelerated method it produced excessive vegetation and less uniform flowering and, also, proved difficult to disbud. It would be difficult to conclude that the standard method was more effective for tall treatment than for short treatment cultivars until tested with a wider range of both short and tall cultivars. However it should be remembered for future reference that the short treatment cultivars did obtain improved quality in the standard method not obtained in the accelerated methods, particularly the Accelerated II method.

It is reasonably conclusive for this test that flowering breaks and flower dry weights did vary significantly with production method. The other commonly used quality measurements, stem weight, plant height above pot rim and diameter of plant, showed no pattern related to methods of production (Table VI). In this test the number of flowering breaks and flower dry weights were good indicators of pot mum quality. Because of the strong counter indications of stem dry weights, during the high light and high temperature conditions, it is probable that stem dry weights are unsuitable as a quality measure. Height and diameter measures may so strongly reflect chemical growth control and pinching treatment that they also are not relevant measures for pot mum quality. It is by this argument that the number of flowering breaks and the flower dry weight evidence is accepted as a conclusive measure of quality for this test.

Again, looking at Table VIII concerning the significance of difference, there is little possibility that any real difference exists between Standard A spaced at 15" X 15" between pot centers and Standard B at 13" X 13", even though the 15" X 15" spacing provided almost 0.39 square feet more space per pot. Visual comparison of plants grown under the Standard A method and the Standard B method also showed them to be equal in quality appearance. This strongly supports the results of the statistical test. This evidence points convincingly to the fact that high quality pot mums can be produced in a 169 square inch space in this regional area from early spring to late fall. Since light intensities in this area generally continue at acceptable levels through the winter months, it can be reasonably speculated that the winter months would produce similar results.

Returning to Table VIII, the comparison of flower dry weights between Standard A and Accelerated I A methods for the short cultivars should be clarified. The significance is only .03 above the criterion established as a minimum for acceptance. This significance is so close, that it demands further proof before it can be denied that Standard A was a superior method. The same comparison between Standard A and Accelerated II meets the criterion established for acceptance of significance. Thus, there is a degree of certainty that for short treatment cultivars, the standard method was superior to the accelerated methods.

As has already been pointed out, the superiority of the standard treatment method must be closely related to its high flower bud initiation. This condition was associated with both an improved vigor resulting from the seven long days prior to the start of short days and with a more appropriate time of pinching. For all other conditions the production methods were either the same or were highly similar. Thus, for efficient pot mum production, starting procedure and pinching are key factors to a successful crop. Apparently a crop is "made" within the first three weeks of the production cycle.

In addition to closely evaluating the product quality differences, a detailed study of direct costs was performed to identify cost differences among production methods. As has been seen, there was little difference in costs when comparing them as cost per plant. This was a one-half to one cent difference (see Table XI). It amounted to an advantage of from fifty cents to one dollar for each one hundred plants produced by the accelerated method. When this difference is compared with the highly significant quality differences shown in Table XVIX, it can be seen that the cost of flowers per pot was actually one cent higher per flower for the accelerated method than for the standard method.

TABLE XVIX

DIRECT COST OF FLOWERING BREAKS BY PRODUCTION METHOD, AVERAGE ALL THREE CYCLES

Production Method	Direct Cost Per Pot	No. Flowering Breaks Per Pot	Cost Per Flowering Break
Standard A	$ .9339	23.4	3.9 ¢
Accelerated I A	.9284	19.7	4.7
Accelerated II	.9232	18.9	4.9

As illustrated in Table XVII, the gain in gross income from a 3200 square foot greenhouse of pot mums spaced 13" X 13" would approximate $650 per cycle over a 15" X 15" spaced crop. This almost equals

$3,000 annually for this modest sized greenhouse and at only 49% space use. A comparison of the income disparity between the common 15" X 15" spacing and several closer spacing arrangements is made in Table XX. These data clearly illustrate that pot spacing should be a major consideration for the commercial grower. Even with the one inch decrease in pot spacing, from 15" to 14", there would be an increase in gross annual income of over $1,200.

TABLE XX

ANNUAL INCOME GAIN FROM VARIOUS POT SPACINGS
IN A 3200 SQ. FT. GREENHOUSE
(49% OCCUPIED)

Pot Spacing	*No. Plants (5½" pot)	Annual Gross Income	Annual Income Gain over 15" X 15" Pot Spacing
15" X 15"	4527	$ 8,374.95	-
14" X 14"	5193	9,607.05	$ 1,232.10
13" X 13"	6152	11,380.50	3,005.55
12" X 12"	7065	13,070.25	4,695.30

*Computed at 4.5 cycles per year. See Table XVII for number of plants per cycle.

In hand with increased gross income from closer pot spacing is the decreased indirect cost (computed the same as in Table XVII) per pot resulting from the same closer spacing as shown in Table XXI. Reducing pot spacing from 15" X 15" to 13" X 13" would decrease indirect cost, according to this example, by ten cents per pot, from 39 cents to 29 cents.

TABLE XXI

DECREASE IN INDIRECT COSTS PER POT RESULTING FROM CLOSER POT SPACING (49% SPACE USE)

Pot Spacing	*Annual Indirect Cost	**Annual Production	Indirect Cost Per Pot
15" X 15"	$ 1,787.52	4527	$ 0.39
14" X 14"	1,787.52	5193	0.34
13" X 13"	1,787.52	6152	0.29
12" X 12"	1,787.52	7065	0.25

*See cost at 49% space use in Table XV.
**Computed at 4.5 cycles per year. See Table XVII for number of plants per cycle.

Analysis of Direct Costs of Production

By a cursory scanning of direct cost elements in Table X, a few costs are quickly identified which are much higher than all others and also a number of costs which are of minor significance when compared to the total direct costs. For the largest cost savings, concentrating on the few high cost elements would certainly produce the most substantial cost reductions. Conversely, any amount of effort to accumulate cost data on most minor cost elements could hardly be expected to pay for the effort involved.

The approach to effective cost control of pot mum production is clearly seen in the five major cost elements (see Table XXII). Together these costs amounted to over 80% of the total direct costs of a 32' x 100' greenhouse production unit. Obviously, then, the labor costs of potting, disbudding, and black cloth shading should be closely monitored, even to the point of time and motion studies, to determine where time and effort can be reduced. Materials costs of pots and cuttings also should receive careful purchasing studies to assure the lowest price for the desired quality and to obtain the most favorable discount and freight advantages.

Much cost accounting effort can be reduced by eliminating the separate recording of less significant labor cost data such as: soil preparation time, fertilizer injector filling time, special fertilizer application time, insecticide and other spraying, and equipment repair. Materials costs such as insecticides, water, growth retardant, and other chemicals were also of little importance to the total direct cost structure. In Table XXIII these eight minor cost elements are shown as a per cent of annual direct costs for a 32' x 100' greenhouse production unit producing pot mums.

TABLE XXII

MAJOR DIRECT COST ELEMENTS

Element	*Annual Direct Cost	% of Total Direct Cost
Labor		
Potting	$ 398.03	7.0
Disbudding	1,129.51	19.8
Black Cloth	323.59	5.7
Materials		
Pots	553.68	9.7
Cuttings	2,199.95	38.6
Total Major Costs	4,604.76	80.8
Total Direct Costs	5,718.28	100.0

*Computed from cost per pot Table X and annual production at 13" X 13" pot spacing, Table XXI. Production levels are for a 32' X 100' greenhouse unit.

It will be noted that the total of all of these costs is less than any one of the major costs shown in Table XXII. Since they all are constituent costs of most pot plant production, it would seem appropriate to accumulate such costs in a miscellaneous category and allocate them to all crops as with the indirect costs of production when arriving at total production costs.

TABLE XXIII

MINOR DIRECT COST ELEMENTS

Element	*Annual Direct Cost	% of Total Annual Direct Cost
Labor		
Soil preparation	$ 23.38	.41
Fertilizer preparation	5.54	.10
Spraying	35.07	.62
Special fertilizer	11.07	.19
Equipment repair	73.82	1.29
Materials		
Insecticide	28.91	.51
Water	19.07	.33
Chemicals	1.85	.03
Total Minor Direct Costs	$ 198.71	3.48
Total Direct Costs	$ 5,718.28	100.00

*Computed from cost per pot, Table X, and annual production at 13" X 13" pot spacing, Table XVII. Production levels are for a 32' X 100' greenhouse unit.

Another aspect of effective cost control is the reduction of high labor costs by using more efficient methods, particularly mechanical and automatic methods. For potting, mechanical potting devices and motorized conveyor systems could very probably pay for themselves in less than two years for a moderate sized greenhouse range. Extending the figures in Table XXII to a 20,000 square foot range (X 6.25) producing only pot mums, a system costing $5,000 would be less than the two year cost of manually potting and placing on the bench.

The expense of disbudding is undoubtedly the most disputable of all expenses to justify in this day of extensive crop research. Certainly with this highest of all labor costs, chemical and genetic approaches to solving the problem should be carefully researched to find a low labor input solution. Cultivars that require no disbudding or the use of an inexpensive chemical disbudding agent would eliminate over $6,500 in labor costs for the same 20,000 square foot range cited above. Generous support by commercial growers of extensive research on this problem certainly makes good business sense.

A common cost reduction technique employed by many firms is mechanically operated black cloth shading curtains. Here again the savings experienced over two years in a 20,000 square foot range, approximately $3,000, would go a long way toward paying the costs of installing many of the currently used systems.

The cost of purchased cuttings is an exceedingly high expense. For a large firm, the possibility of the reduced cost in propagating locally would require careful study. A suitable propagating facility should be entirely possible at the two year cost of over $26,000, the approximate amount expended for rooted cuttings by a firm containing a 20,000 square foot range devoted entirely to pot mum production.

A simplified accounting system such as employed in this test, with the extraneous cost accumulations eliminated, provides valuable benefits when it comes to making management decisions of the type discussed above. It is true that the illustrations cited are the more dramatic examples of production planning. In a similar fashion, the more routine activities, just as certainly, require careful cost analysis to accompany any sound decision making. Any firm, even of the moderate sized 20,000 square foot facility used in the above examples, has a sufficiently high production cost to afford some sort of cost accounting procedure. With an annual production of about 38,000 plants the 20,000 square foot size firm would expend close to $50,000 in production costs. Or, would it? The answer must be based on rather vague judgements unless there are cost accounts to which one can refer.

Attaining Efficiency in Space Use

During the test period, no particular effort was made to assure maximum space use. Production scheduling was planned to permit the proper finishing of one crop before another would require the space. Existing greenhouse bench layout was used. This, of course has made possible an analysis of space management efficiency under conditions characteristic of those to be found in an undeveloped plan.

As has been observed under Experimental Results, the level of efficiency attained was not high. Production scheduling permitted a lag of several days between the finished date for the crop and the date that the next crop was placed on the bench. If the gap in lag time was closed between the production cycles, the per cent usable space loss would have been reduced from 12.7% to 7.6% of usable bench space, a 40% decrease in space loss.

Another deficiency in space management was the 18 square feet of space loss permitted even during the period of maximum space occupancy. In addition, there was a one week loss of 63 square feet in the climate control bench at the start of each cycle. These two minor losses alone increased space loss by 1% from 11.7% to 12.7%.

The one method by which space management efficiency could have been improved most was in the greenhouse space layout plan. With usable space occupied to a maximum, the per cent gross space use could not have exceeded 56%, or 1802 square feet-days per day. A layout of five foot wide peninsular benches with two foot access aisles and a main aisle of four feet, permitting two-way traffic, would make 1960 square foot-days of net usable bench space available per day, or a maximum gross space use of up to 61%. In the present state of greenhouse layout and mechanization, such a space use is high indeed. But with the introduction of truly mechanized systems to include overhead personnel conveyors (locating people in the usable space above plants) and detachable mobile pallet benches put in place with powered lift trucks, aisles for many crops would become superfluous and a gross space use of 90% or above would become possible. As expensive as land is for the producer, especially those near large urban centers, a 61% gross space use should be the starting point rather than the peak of efficiency.

To improve the use of greenhouse space, much more could have been done for the test than improving the layout or by mechanizing. Structures such as purlin posts, pipe lines, and water outlets occupying space interfering with the placement of benches or the use of benches could have been relocated. Entrances could have been relocated to aisles instead of at the end of benches thus adding bench space to areas now used for personnel and equipment access. Procedures which reduced the amount of required personnel access to plants, such as tube irrigating, fumigating, and fertilizer injecting, were used and could have made fewer aisles necessary and wider benches possible. The outside placement of cooling pads at the south end of the greenhouse provided potential bench space that could have been used. The location of the GEWA injector inside the greenhouse unit occupied several square feet of growing space. Heating elements occupied wall space over which benches could not be placed because they would have interfered with an adequate air circulation. Placing of heating elements above and under benches would have permitted use of this additional space.

The previous discussion points to the fact that efficient space management is a concern for many facets of greenhouse production from the crop planning and scheduling stages, through the growing cycle (affected by many procedures used) and even by the harvesting, movement, and replacement of the crop. Even though, as illustrated above, the greatest savings come from original space planning, much space can be saved by efficient management of space use throughout the production cycle.

Referring to the experimental results in Table XV, the indirect cost of .31 of a cent per square foot-day and a 49% space use, could have been reduced to .24 of a cent at a 61% space use had a peninsular bench arrangement described previously been installed. Thus, the per pot total production cost would have been $1.21, a reduction of 2.7 cents from the total production costs of approximately $1.24 per pot.

The increased production made possible by the peninsular bench layout (91,000 square foot-days) would have been 989 plants at a 13" X 13" pot spacing. The increase in profit from the sale of these additional plants would actually be the amount of the reduced indirect cost

(989 X \$.3098), \$306.39, plus some transportation and selling cost reduction per pot resulting from larger lot distribution. The gross income from these added plants would be \$1829.65. It should be remembered that in this example only one 3200 square foot greenhouse unit is involved. A range of 20,000 square feet would have increased production by about 6200 plants and the gross income would have been almost \$12,000, and the net profit would be \$2,000 above the average profit realized on this number of plants.

Conclusions

Long Day with Climate Control Best. Of the three basic production methods tested the seven long-days method with climate control, standard method, exceeded the other two methods in quality and in economy of production. To obtain the highest quality in this region it is necessary to start pot mums immediately after potting with at least one week of long days, a high humidity, and above average temperatures (65°F to 72°F). This was proven by a statistical test of the significance of the differences between sample means at the .05 level (Table VIII). For tall treatment cultivars, a significance at the .01 level was attained between the standard method and the accelerated method. As for economy advantages, the standard method in this test produced flowering breaks at one cent less per flowering break than the other methods, proving it to be not only a high quality method but a most economical one as well.

Closer Pot Spacing Equal in Quality and More Economical. By statistical test of significance of difference between sample means, no significance exists between the 15" X 15" pot spacing and the 13" X 13" pot spacing in the standard method (Table VIII). The test showed that there was no real quality difference between plants produced between the two methods. Since the closer pot spacing produces more plants at a reduced indirect cost, it is far more economical, and this at the same quality level as the wider spaced plants.

Concentrate on Reducing High Cost Elements. The detailed analysis of pot mum direct production costs revealed that many costs were so low as to be capable of little contribution to any cost reduction endeavor. However, the labor costs of potting, disbudding, and manual black cloth shading as well as materials costs of pots and cuttings were of such magnitude, 80% of total direct production costs, as to be lucrative sources for cost cutting. Even small reductions in these direct costs would result in considerable savings. A number of minor direct costs in pot mum production should be accumulated in a general category and periodically allocated to production.

Labor Savings Essential to Cost Reduction. Since potting, disbudding, and manual black cloth shading constituted over seventy-five per cent of the total labor costs, they require a vigorous innovative attack to develop labor savings devices and techniques that will produce substantial cost reductions. Such facilities as mechanical potting equipment and motorized roller and overhead conveyors increase vastly the product handling capacity of each worker, often to the extent that they pay for themselves with the payroll reduction resulting from a few production cycles. In like measure, the continuation of the expanding use of mechanized black cloth shading equipment is an effective approach to cost reduction. Disbudding, the highest labor cost element, exceeding 45 per cent of the total direct labor cost, requires the most urgent attention of the entire cost control program. Although the possibilities of developing non-disbudded cultivars or chemical disbudding substances seem distant, an extensive research effort supported heavily by commercial producers is certainly practical considering the vast cost reduction gains to be achieved.

Cost of Cuttings and Pots is High. The 5½" clay pot costs about one-sixth of the total materials cost of the plant in this study. This high level of cost for pots makes it most advantageous for the producer to expend considerable time in searching for the cheapest suitable container as well as experimenting with various promising container materials. Efforts should always be made in purchasing to obtain the highest quality and trade discounts. It is in the cost of cuttings that the highest production cost is experienced, exceeding two-thirds of the total materials cost. For most growers the question of "to buy or to propagate" is a real one, and should be given the most thorough study. With cuttings for 10,000 plants costing over $3,500, there possibly are adequate funds for skillful producers to produce their own cuttings. In any case the producer is justified in obtaining the cheapest possible cutting that will give reliable results for the relatively short bench time that it must survive.

Cost Data Are Essential for Sound Management Decisions. Today, no business manager can afford to avoid any of the tasks in sound business practice. With the development of extensive interregional competition between producers of ornamentals and with the use of "recipe growing", every producer has the time and must use that time to improve his performance as a business manager. His most urgent need now is business facts of which a prime group is cost data. It is largely on data accurately accumulated in cost accounting records that the successful manager will depend when making major production decisions. Cost accounting records, as illustrated in this test, need not be a cumbersome or a mysterious activity. They can be readily adapted to normal skilled bookkeeping practices that go on in any management office.

Space is a Major Resource. The entire physical plant of a greenhouse range has as its singular purpose the maintenance of a suitable environmentally controlled space for the growing of crops. Bench space is the basic resource without which all other factors of production are impotent. A knowledge of acreage or gross space under glass can hardly be sufficient for a true production expert. He must also know how much space can be used for production (usable bench space) and how it can be increased. To maximize production, he must know where all available space is on a daily basis, and keep it full (occupied bench space). By testing he should determine the closest pot or plant spacing possible that is consistent with the desired quality. A considerable loss in production is possible unless plant spacing is properly controlled.

Space Management is a Continuing Task. All space analysis finally gets back to how completely the gross space under glass is being used and how much usable space is being lost by leaving it empty or sparsely occupied. Measures of efficiency in the use of space must consider both the amount of space involved and the length of time the space is available. Ten square feet of empty bench space for 100 days is the same loss as 100 square feet for ten days. A yardstick of efficiency for determining the amount of space that should be available for growing plants in the greenhouse unit is a function of maximum bench space and minimum aisle and structural loss space. Perhaps a 60% gross space use approximates the highest level attainable by most firms under present day production methods. The total elimination of space loss eludes realization because of the many factors involved in planning, scheduling, and managing production. Each manager must confine space loss to the lowest possible level. Space loss probably should not exceed a figure of 5% for a period such as one month. Basic tools for efficient space are: a detailed space plan for one or more years, a planograph reflecting the space status for the current week, a space data record showing continuing space use, and a maximum pot spacing allowance record that each crop must not exceed.

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APPENDIX A

TABLE XXIV

DRY WEIGHT MEASURES FOR POT MUM STEMS AND FLOWERS BY PRODUCTION METHOD FOR ALL THREE CYCLES*

Production Method		Cycle I			Cycle II			Cycle III			Total All Cycles		
		Stems	Flowers	Total	Stems	Flowers	Total	Stems	Flowers	Total	Stems	Flowers	Total
1. Standard A-Tall													
	(1)	533	430	963	765	311	1076	350	265	615	1648	1006	2654
	(2)	35.5	28.7	64.2	51.0	20.7	71.7	23.3	17.7	41.0	36.6	22.3	58.9
2. Standard A-Short													
	(1)	491	417	908	831	363	1194	334	256	590	1656	1036	2692
	(2)	32.7	27.8	60.5	55.4	24.2	79.6	22.2	17.1	39.3	36.8	23.0	59.8
3. Standard B-Tall													
	(1)	550	428	978	732	299	1031	344	249	593	1626	976	2602
	(2)	36.7	28.5	65.2	48.8	19.9	68.7	22.9	16.6	39.5	36.2	21.6	57.8
4. Standard B-Short													
	(1)	492	384	876	815	343	1158	344	246	590	1651	973	2624
	(2)	32.8	25.6	58.4	54.3	22.9	77.2	22.9	16.4	39.3	36.7	21.6	58.3
5. Accelerated I A-Tall													
	(1)	468	385	853	836	176	1012	350	250	600	1654	811	2465
	(2)	31.2	25.7	56.9	55.7	11.7	67.4	23.3	16.7	40.0	36.8	18.0	54.8
6. Accelerated I A-Short													
	(1)	453	376	829	916	276	1192	362	261	623	1731	913	2644
	(2)	30.2	25.1	55.3	61.1	18.4	79.5	24.1	17.4	41.5	38.5	20.3	58.8
7. Accelerated I B-Tall													
	(1)	465	378	843	837	167	1004	356	235	591	1658	780	2438
	(2)	31.0	25.2	56.2	55.8	11.1	66.9	23.7	15.7	39.4	36.8	17.3	54.1
8. Accelerated I B-Short													
	(1)	472	376	848	926	234	1160	372	251	623	1770	861	2631
	(2)	31.5	25.1	56.6	61.7	15.6	77.3	24.8	16.7	41.5	39.3	19.1	58.4

TABLE XXIV (Continued)

Production Method	Cycle I			Cycle II			Cycle III			Total All Cycles		
	Stems	Flowers	Total	Stems	Flowers	Total	Stems	Flowers	Total	Stems	Flowers	Total
9. Accelerated II-Tall												
(1)	459	374	833	822	192	1014	335	247	582	1616	813	2429
(2)	30.6	24.9	55.5	54.8	12.8	67.6	22.3	16.5	38.8	35.9	18.1	54.0
10. Accelerated II-Short												
(1)	438	362	800	805	312	1117	333	246	578	1576	920	2496
(2)	29.2	24.1	53.3	53.7	20.8	74.5	22.2	16.4	38.6	35.0	20.4	55.4
Total - Tall (1)										8202	4386	12,588
(2)										36.5	19.5	55.9
Total - Short (1)										8384	4703	13,087
(2)										37.3	20.9	58.2

(1) Production method and total weights.
(2) Mean weights by replication and cycle.
* Fifteen plants per production method.

TABLE XXV

QUALITY MEASURES BY PRODUCTION METHOD AND CYCLE*

Production Method	Cycle I				Cycle II				Cycle III				Replication Grand Totals
	1**	2	3	Total	1	2	3	Total	1	2	3	Total	
1. Std. A-Tall													
(1)	997.5	1074.5	1053.0	3125.0	901.0	841.0	875.5	2617.5	1024.0	1025.0	1047.0	3096.0	8838.5
(2)	66.5	71.6	70.2	69.4	60.1	56.1	58.3	58.2	68.3	68.3	69.8	68.8	65.5
2. Std. A-Short													
(1)	989.0	1030.5	1032.0	3051.5	931.0	968.0	1001.0	2900.0	946.0	938.0	969.0	2853.0	8804.5
(2)	65.9	68.7	68.8	67.8	62.1	64.5	66.7	64.4	63.1	62.5	64.6	63.4	65.2
3. Std. B-Tall													
(1)	1036.0	1008.0	964.5	3008.5	861.5	973.5	853.0	2688.0	1028.5	980.5	994.5	3003.5	8700.0
(2)	69.1	67.2	64.3	66.8	57.4	64.9	56.8	59.7	68.5	65.4	66.3	66.7	64.4
4. Std. B-Short													
(1)	997.0	1027.5	945.0	2969.5	975.0	909.5	952.0	2836.5	960.5	934.5	957.0	2852.0	8658.0
(2)	66.5	68.5	63.0	65.9	65.0	60.6	63.5	63.0	64.0	62.3	63.8	63.4	64.1
5. Acc. IA-Tall													
(1)	967.5	991.0	969.5	2928.0	832.5	758.5	782.0	2373.0	953.0	935.0	946.5	2834.5	8135.5
(2)	64.5	66.1	64.6	65.1	55.5	50.5	52.1	52.7	63.5	62.3	63.1	63.0	60.3
6. Acc. IA-Short													
(1)	986.5	985.0	891.0	2862.5	920.5	882.0	918.5	2721.0	1030.0	1037.0	1025.0	3092.0	8675.5
(2)	65.7	65.7	59.4	63.6	61.4	58.8	61.2	60.5	68.7	69.1	68.3	68.7	64.3
7. Acc. IB-Tall													
(1)	945.0	894.5	1072.0	2911.5	732.0	698.5	824.0	2254.5	893.5	948.5	929.0	2771.0	7937.0
(2)	63.0	59.6	71.5	64.7	48.8	46.5	54.9	50.1	59.5	63.2	61.9	61.6	58.8
8. Acc. IB-Short													
(1)	965.0	960.5	997.0	2922.5	892.0	825.0	973.0	2690.0	1027.0	1044.5	1037.0	3108.5	8721.0
(2)	64.3	64.0	66.5	64.9	59.5	55.0	64.9	59.8	68.5	69.6	69.1	69.1	64.6

TABLE XXV (Continued)

Production Method	Cycle I				Cycle II				Cycle III				Replication Grand Totals
	1**	2	3	Total	1	2	3	Total	1	2	3	Total	
9. Acc. II-Tall													
(1)	916.5	928.0	987.0	2831.5	796.0	777.5	825.0	2398.5	935.0	916.5	945.0	2796.5	8026.5
(2)	61.1	61.9	65.8	62.9	53.1	51.8	55.0	53.3	62.3	61.1	63.0	62.1	59.5
10. Acc. II-Short													
(1)	949.0	900.0	994.0	2843.0	882.0	906.5	903.0	2691.5	1010.0	935.5	975.0	2920.5	8455.0
(2)	63.3	60.0	66.3	63.2	58.8	60.4	60.2	59.8	67.3	62.4	65.0	64.9	62.6
Grant Total				29453.5				26170.5				29325.0	84951.5
Mean				65.5				58.2				65.2	62.5

(1) Replication and cycle totals.
(2) Replication and cycle mean.
* 15 plants per replication.
** Replication.

TABLE XXVI

NUMBER OF FLOWERING BREAKS PER REPLICATION BY PRODUCTION METHOD FOR EACH CYCLE

		Production Method									
		Std. A Cultivars		Std. B Cultivars		Acc. IA Cultivars		Acc. IB Cultivars		Acc. II Cultivars	
Replications		Tall	Short	Tall	Short	Tall	Short	Tall	Short	Tall	Short
I	1	374.0	414.0	416.0	434.0	391.0	414.0	361.0	383.0	340.0	383.0
	2	419.0	431.0	361.0	412.0	381.0	388.0	360.0	389.0	331.0	312.0
	3	396.0	434.0	353.0	385.0	386.0	365.0	440.0	411.0	381.0	382.0
II	1	263.0	260.0	286.0	332.0	236.0	279.0	139.0	229.0	190.0	249.0
	2	285.0	317.0	298.0	267.0	168.0	244.0	133.0	172.0	191.0	257.0
	3	271.0	352.0	237.0	277.0	187.0	265.0	255.0	314.0	237.0	254.0
III	1	373.0	336.0	407.0	381.0	319.0	410.0	270.0	386.0	293.0	389.0
	2	404.0	361.0	361.0	344.0	298.0	404.0	300.0	392.0	276.0	347.0
	3	389.0	348.0	347.0	325.0	302.0	394.0	313.0	421.0	310.0	372.0
Total		3174	3253	3066	3157	2668	3163	2571.0	3097	2549	2945
Mean		352.7	361.4	340.7	350.8	296.4	351.4	285.7	344.1	283.2	327.2

APPENDIX B

TABLE XXVII

CHRONOLOGICAL RECORD OF SPACE USE DATA

Dates	Number of Days	Usable Bench Space	Occupied Bench Space	Sq. Ft. Days Usable	Sq. Ft. Days Occupied
Cycle I					
March 11-17	7	1802	656	12,614	4,592
18	1	1802	974	1,802	974
19-24	6	1802	1481	10,812	8,886
25	1	1802	1481	1,802	1,481
26-31	6	1802	1784	10,812	10,704
April 1-7	7	1802	1784	12,614	12,488
8-14	7	1802	1784	12,614	12,488
15-21	7	1802	1784	12,614	12,488
22-28	7	1802	1784	12,614	12,488
April 29-May 5	7	1802	1784	12,614	12,488
May 6-12	7	1802	1784	12,614	12,488
13-19	7	1802	1784	12,614	12,488
20-26	7	1802	656	12,614	4,492
Total	77	23,426	19,520	138,754	118,545
Cycle II					
May 27-June 2	7	1802	656	12,614	4,592
June 3	1	1802	974	1,802	974
4-9	6	1802	1481	10,812	8,886
10	1	1802	1481	1,802	1,481
11-16	6	1802	1784	10,812	10.704
17-23	7	1802	1784	12,614	12,488
24-30	7	1802	1784	12,614	12,488
July 1-7	7	1802	1784	12,614	12,488
8-14	7	1802	1784	12,614	12,488
15-21	7	1802	1784	12,614	12,488
22-28	7	1802	1784	12,614	12,488
July 29-August 4	7	1802	1784	12,614	12,488
August 5-11	7	1802	1784	12,614	12,488
12-18	7	1802	1340	12,614	9,380
19-23	5	1802	670	9,010	3,350
Total	89	27,030	22,658	160,378	139,271

TABLE XXVII (Continued)

Dates	Number of Days	Usable Bench Space	Occupied Bench Space	Sq. Ft. Days Usable	Sq. Ft. Days Occupied
Cycle III					
Sept. 8-9	2	1802	530	3,604	1,060
10-15	6	1802	656	10,812	3,936
16	1	1802	656	1,802	656
17-22	6	1802	1481	10,812	8,886
23	1	1802	1481	1,802	1,481
24-29	6	1802	1784	10,812	10,704
Sept. 30-Oct. 6	7	1802	1784	12,614	12,488
Oct. 7-13	7	1802	1784	12,614	12,488
14-20	7	1802	1784	12,614	12,488
21-27	7	1802	1784	12,614	12,488
Oct. 28-Nov. 3	7	1802	1784	12,614	12,488
Nov. 4-10	7	1802	1784	12,614	12,488
11-17	7	1802	1784	12,614	12,488
18-20	3	1802	1784	5,406	5,352
Total	74	25,228	20,860	133,348	119,491
Grand Total	240			432,480	377,407

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