An Analysis of Pot Chrysanthemum Production Methods, Direct Costs And Space Use

H. V. Griffith
R. N. Payne

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Introduction and Background

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 certain production methods and effectiveness of greenhouse space use, deriving direct cost data for specific production operations and evaluating levels of plant quality obtained from various production methods.

The commercial grower of greenhouse crops is faced with the dilemma of selling prices moving up more slowly than the rising labor and material costs. The result can be 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 also setting slightly 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. One of the more notable practices setting the stage for industrial growth is sound financial practices based upon accurate cost accounting and cost analysis (2). 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.

Efficient production control in industry consists of cost control, market analysis and procurement planning. Striving for maximum use of facilities for a desired level of output through detailed planning and

* Former Graduate Assistant and Associate Professor, Dept. of Horticulture. Research reported herein was done under Station Project 1411.

production scheduling is also a must. 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).

A number of approaches have been suggested to circumvent the requirement for production cost records for individual crops. One such practice is to cost out a crop at 7 or 8 cents a week per square foot of bench space, plus the cost of cuttings or seedlings, potting labor and the cost of pots (5). Another method is to identify costs by specific operations regardless of crop (3). Neither of these methods is acceptable as a standard cost accounting practice, but they do provide useful methods for estimating costs to be used in production planning or budgeting.

Overhead cost (indirect cost) should not be too difficult to accumulate 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 (6).

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 a crop, 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 next to impossible. Direct costs of specific operations with a given crop are known when they occur and should be assigned routinely on labor and materials cost slips (Figures 1 and 3). 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 (7).

A review of literature reveals that 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, 8). 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, 8), and commercial practices (9) have been to place them directly in the growing bench at the time of potting. Intermittent automatic mist or hand misting have often been recommended when temperature and humidity conditions require. Under the "Yoder three climate system" and certain other practices a polyethylene plastic humidity chamber is recommended in the early stages for establishment of the young plants (10, 11).

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 approximately 7″ x 7″ to wider spacings as the plants grow larger (10). Basically, all recommendations suggest a wide spacing of 200 square inches or more per 5½ or 6″ pot during some part of the growing period. It has also been pointed out (15) that different chrysanthemum cultivars may require different spacings.

Considerable interest has been shown recently by Ohio researchers in effects resulting from closer spacing of various florist crops (12, 13). Their results indicated some discrepancy may exist in the wide spacing recommendations for pot mums. Commercial use of closer spacing, if proven feasible by quality of plants produced, would certainly be more economical (14).

Maximum use of greenhouse space by efficient space layout and tight production scheduling is becoming recognized as a major factor in assuring profitable operations (15, 16). Since indirect costs are closely related to space use, a continuous evaluation of space needs and the careful analysis of causes of space loss are procedures clearly essential to minimizing production costs.

In the study reported herein, four significant aspects of production were examined: production methods, direct production costs, space use and product quality. Procedures employed closely adhere to 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 results of quality, costs and space use.

Methods and Procedures

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 covered with one year old fiberglass was used for the experiment. 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 clay pots on existing 50 inch wide redwood benches without sides. No attempt was made to increase total bench space. 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 production methods (see Table 1). Growth retardant[1] was used for growth control on all tall treatment varieties only. Standard preventive practices for disease and insect control were followed using sprays and fumigants as needed.

Production Methods

Although five separate production methods were examined, they actually constituted a variation of 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 va-

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

Table 1—Production Methods

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

*A *climate control* of increased temperature, high humidity and additional daylength were provided Standard A and Standard B production methods as indicated.
**SD = short days.

riation 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. 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 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 1. 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″.

The three replications of each method varied only in greenhouse location. The cultivars used in the spring and fall cycles were 'Bright Golden Anne' and 'Mandalay'. In the summer 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 control treatment of .25 percent succinic acid 2.2-dimethyl-hydrazide foliar spray two weeks after the pinch (29). In the summer cycle a .50 percent spray was used. The short cultivars were given a medium treatment with pinching done at the start of short days (standard A & B) or given a modified medium treatment (accelerated IA, B and II) with pinching done on the third day after the start of short days (29). No growth retardant applications were made on the short cultivars.

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

As already noted, a fertilizer application of 20-20-20 soluble fertilizer was injected at every watering. On the third day afer 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 acecpted 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 when possible. 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 pounds per cubic yard of soil mix. In the potting operation rooted cuttings were carefully planted shallow and leaning outward at the pot perimeter.

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 1.

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 were posted to a materials consumption list (Figure 2). All material was identified by production method whenever possible. Such procedures as fumigation, chemical 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.

MATERIALS USED SLIP

Slip No.__________ Treatment__________

User__________ Date__________

Mat Cat	Qty	Item	Price	Total	Ck Pd

Figure 1. Materials used slip.

MATERIALS CONSUMPTION LIST

Slip No.	Materials Category								Production Method					
	Soil	Pot 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 2. Materials consumption list.

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, and drainage.
3. Fertilizer	Both soluble fertilizer and other special purpose fertilizer.
4. Insecticides, etc.	Insecticides, fungicides, and other chemicals for control of diseases and pests, including spreaders.
5. Water	All water, both through injector and manual.
6. Chemicals	For special chemical treatments such as growth retardants.
7. Equipment repair	Parts, supplies, and materials used in equipment set up, maintenance, and repair.
8. Other	Clearly identified.

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 3. Daily time slip.

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 3) 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 Sheet (Figure 4). Undistributed direct labor was prorated evenly to each production method. All labor perform-

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 IA	Acc IB	Acc II	Not Dist.

Figure 4. Labor time sheet summary data.

ed 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.
4. Watering	Normal daily proportioner applications.
5. Fertilizer preparation	Preparing fertilizer for GEWA injector.

6. Spraying and fumigating	All preventive insect and disease treatments, 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. Equipment repair	Such tasks as adjusting water lines, rearranging equipment, repairing black cloth, and hanging lights and reflectors, as related directly to this crop.
13. Miscellaneous	Those tasks 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 5) for the production cycle.

As indicated above, the production cost sheet (Figure 5) 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 cycle. 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

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 maangement tool in greenhouse production control.

PRODUCTION COST SHEET

FROM _____ TO _____

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

Figure 5. Production cost sheet.

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 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 was called **Occupied Bench Space.** This space component when compared with the gross greenhouse production space provided an overall measure of efficiency in greenhouse space management. It was described as the **Percent of Usable Space Loss.**

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 **Percent of Gross Space Used.**

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 number of 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, the **percent of gross space used** 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 had been fully occupied during this same period, the occupied bench space time would have been 54,060 square foot-days or 1802 square feet per day. Thus, the percent of gross space used would have been 56 percent. 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.

The other space management efficiency figure, **Percent 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 on various days during a month, 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 percent usable space loss would have been 2.75 percent.

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 over-generous pot spacing and rightfully so. As has been shown in Table 2, 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 percent.

Table 2—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. 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 dry 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 producion methods. The statistical test used in the analysis of variance was the t-test. A result of .05 percent or less was considered significant. Larger values were explained.

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 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 a watering problem in cycle I during the starting phase of the Accelerated I method and 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 3 and 4. Only two measures, flower 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 3—Difference In Mean Dry Weight 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 4—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 5.

Table 5—Differences In Mean Dry 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 showed a significant difference to exist between the standard method and the accelerated method, as illustrated in Table 6. 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 7).

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 probably also resulted from

Table 6—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 7—Difference in Means of Visual Evaluation Measures for All 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.

the strong tendency of both 'Yellow Delaware' and 'Snow Ridge' to be heavy foliage producers at this season of the year.

Pot spacing comparisons by visual observation showed no noticeable differences between 15″ x 15″ spacing and the closer 13″ x 13″ spacing. The picture displayed in Figure 6A shows no visible differences in the flower and foliage composition or stem strength between the two production methods, Standard A (15″ x 15″) and Standard B (13″ x 13″).

Composition of Direct Production Costs

Generally, the direct production costs when compared among the three production cycles, were highly uniform (see Table 8). Deviations from the average cost levels occurred in Cycle I for potting, moving pots,

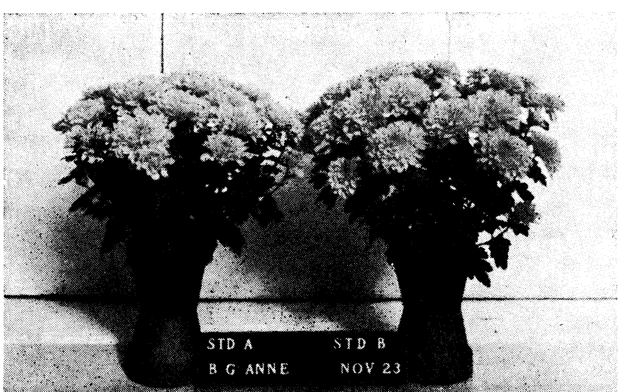

Figure 6A 'Bright Golden Anne.' 15 x 15 inch spacing (StdA) and 13 x 13 inch spacing (StdB). No noticeable differences in growth or flowering were observed at the two pot spacings in a bright, fiberglass greenhouse.

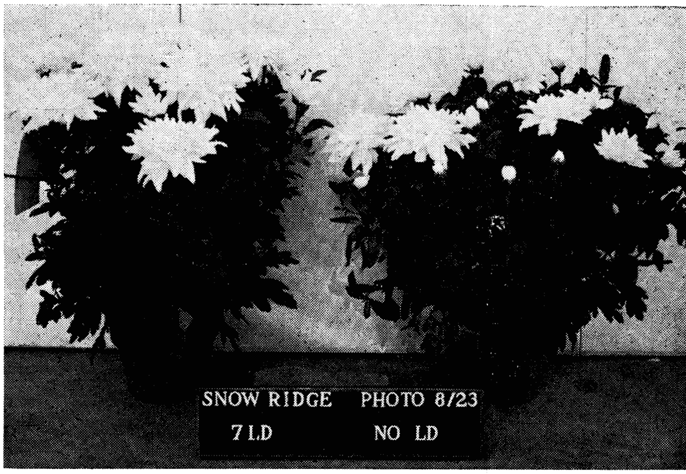

Figure 6B 'Snow Ridge,' summer crop. Plants receiving 7 long days (7LD-Standard Method) flowered more evenly and were easier to disbud than plants receiving no long days (No LD-Accelerated method).

Figure 6C A 32 x 100 foot fiberglass greenhouse was used for the experiment. Tobacco cloth shading was used as shown to reduce light intensity during the summer crop cycle. Black cloth was pulled over each bench individually to obtain short days.

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. These cost deviations represent differences which occurred because of a change of season or which would normally have accumulated over a period of longer than one production cycle.

With further reference to Table 8 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 watering 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 ex-

Table 8—Direct Cost by Task or Category for Each Cycle (900 Pots per 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	300.39	412.29	344.95	355.55	.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.

cept 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 percent 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. The disbudding cost would have been lower if only a "single pass" at disbudding each plant had been possible. Workers had to return a second time on many plants, especially the 'Snow Ridge' plants in the summer. This is reflected in the high disbudding cost for Cycle II. 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 throughout the test period (see Table 9). 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.

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 7. The total direct labor and material costs by cycle and the average for all cycles are given in Table 10. These material and labor costs as graphically illustrated in Figure 8 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.

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 percent of the total production

Table 9—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

Table 10—Weekly Labor and Materials Direct Costs as Complied for Each Production Cycle

Production Cycle	Cost for the week of: 1	2	3	4	5	6	7	8	9	10	11	Total
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	31.39	.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

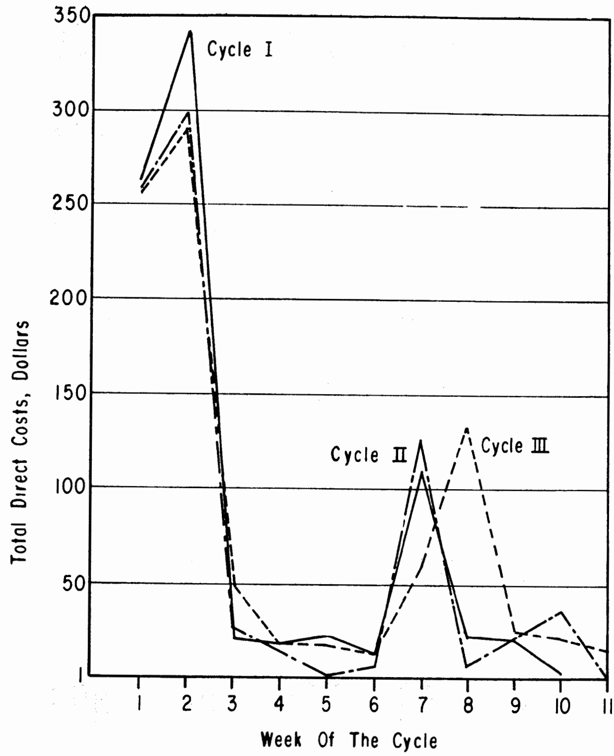

Figure 7. Comparison of Direct Costs Incurred by Week by Cycle.

cost, for others it may be higher. If it were 25 percent, then, the major cost elements would appear somewhat as follows, provided the selling price per plant was $1.85.

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

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, **Percent Gross Space Used** at 49.14 percent, and **Percent Usable Space Loss** at 12.7 percent, as shown in Table 11. These figures would represent a relatively low space use efficiency for a commercial operation, but are probably quite high for a research greenhouse.

Table 11—Space Management Efficiency Computed.

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

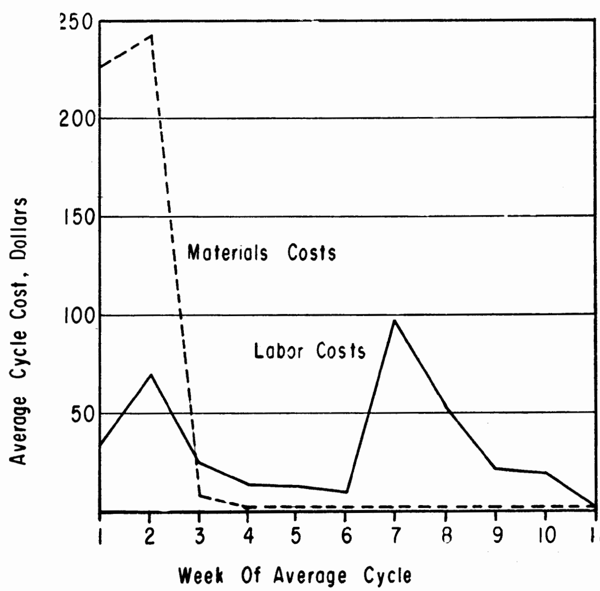

Figure 8. Average production cycle costs for materials and labor.

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 percent may usually be quite low, 59 percent may be above normal. If an increase of 10 percent were possible, the cost of space could be reduced considerably, as shown in Table 12. This cost computation is derived from indirect costs that would be distributed to the production unit on a square foot/time use basis. (The indirect costs for this illustration were computed at 25 percent of total production costs.) As shown in Table 12, the space cost for a gross space use of 49 percent is 2.2 cents per square foot per week. For a 59 percent of gross space use, it is reduced 23 percent to 1.7 cents per square foot per week.

When one looks at space management efficiency in regard to space available for use, the percent space loss becomes a valuable guage. The value of lost space is measured by the income that could have been received by the firm had the space been used. Had the plants been spaced at 13" x 13", the value of the lost space for this test would have been $369.08. (Table 13).

Table 12—Computing Indirect Cost of Space Use.

	Occupancy Level	
Steps	49 Percent	59 Percent
1. Indirect Cost (for 2700 plants at 25% of Total Costs)	$834.95	$834.95
2. Occupied Bench Space in Square Foot-Days (2700 plants)	÷ 273,336	329,073
3. Indirect Cost Per Square Foot-Day	$ .0031	$ .0025
4. Indirect Cost Per Square	X 7 days	X 7 days
Foot Per Week	2.2 cents	1.7 cents

Table 13—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 lost value	$369.08

*Assuming a 13" X 13" 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 14).

Table 14—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

* Output multiplied by a selling price of $1.85.

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 4 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 6) 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 6). This limited the 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 more 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 6). 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 6 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. It should be recognized, however, that these results were obtained under relatively new fiberglass.

Returning to Table 6, 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 good branching and 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 9). 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 15, 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.

A comparison of the income disparity between the common 15″ x 15″ spacing and two closer spacing arrangements is made in Table 16. 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 could be an increase in gross annual income of over $1,200.

Table 15—Direct Costs 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

Table 16—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

*Computed at 4.5 cycles per year.

In hand with increased gross income from closer pot spacing is the decreased indirect cost per pot resulting from the same closer spacing as shown in Table 17. 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 17—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

* Computed at 4.5 cycles per year in a 32' x 100' greenhouse.

Analysis of Direct Costs of Production

By a cursory scanning of direct cost elements in Table 8, 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 18). Together these costs amounted to over 80 percent 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 19 these eight minor cost elements are shown as a percent of annual direct costs for a 32′ x 100′ greenhouse production unit producing pot mums.

It will be noted that the total of all of these costs is less than any one of the major costs shown in Table 18. 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.

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

Table 18—Major Direct Cost Elements.

Element	*Annual Direct Cost	Percent 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 8 and annual production of 6152 pots at 13" X 13" pot spacing. Production levels are for a 32' X 100' greenhouse unit, 49% occupied, and 4.5 crops per year.

Table 19—Minor Direct Cost Elements.

Element	*Annual Direct Cost	Percent 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 7, and annual production of 6152 pots at 13" X 13" pot spacing. Production levels are for a 32' X 100' greenhouse unit, 49% occupied, and 4.5 crops per year.

in Table 12 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 high labor cost, chemical and genetic approaches to solving the problem should be carefully researched to find a low labor input solution. In accumulating cost figures for disbudding, growers should be sure to count labor used in all the "passes" required to remove buds and shoots not reached in the initial disbudding. 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 at the disbudding cost rate found in this study. 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 a high expense. For a large firm, the possibility of reduced cost in propagating locally would require careful study. A suitable propagating facility should be 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 justify 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

As has been stated earlier, the level of space use 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 percent usable space loss would have been reduced from 12.7 to 7.6 percent of usable bench space, a 40 percent 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 from 11.7 to 12.7 percent.

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 percent gross space use could not have exceeded 56 percent, 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 percent. 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 percent or above would become possible. As expensive as land is for the producer, especially those near large urban centers, a 61 percent gross space use should be the starting point rather than the peak of efficiency.

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, preferably with 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 6). 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 existed between the 15″ x 15″ pot spacing and the 13″ x 13″ pot spacing in the standard method (Table 6). 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 more economical, and this at the same quality level as the wider spaced plants. Growers should be cautious in using the closer spacing. Each grower is advised to use small scale trials initially to assure that their glazing material permits a light penetration of sufficiently high intensity.

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 percent 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 percent 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 may 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, exceeding 45 percent of the total direct labor cost in this experiment, 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 quantity 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 (5 cuttings per pot) 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 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 maanger. 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, a grower 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 percent 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 percent for a period such as one month.

Basic tools for efficient space use 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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