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ABSTRACT

PROFIT MAXIMIZATION IN COMMERCIAL GREENHOUSE FLORICULTURE UNDER NORTHERN UNITED STATES PRODUCTION AND MARKETING CONDITIONS: A LINEAR PROGRAMMING APPROACH

By

Carl Frank Gortzig

Managers of commercial greenhouse flower production businesses in the northern United States operate in a rapidly changing business environment. Technological developments in transportation and crop production favor distant producers and enhance their ability to compete effectively in northern markets. Operating costs for greenhouses in the industrial north increase substantially each year. Greenhouse managers experience difficulty in recruiting and retaining permanent employees given the competition from larger, generally unionized employers.

Given this situation, the purpose of this study is to determine greenhouse crop production profit maximizing combinations under northern United States production and marketing conditions. Linear programming, an operations research technique, is used. The method enables managers to identify optimal combinations of crop enterprises which will return maximum profit to their fixed resources. Greenhouse production area and permanent employee complement are considered fixed resources in the study.

To obtain essential cost and return data and estimates of coefficients for production inputs of greenhouse production space and labor of the nine crops included, data were collected from greenhouse firms in Michigan and supplemented with data from two out-of-state firms. With these data, linear programming models are developed for these production schemes: (1) specialization (monocropping) in each of these crops -

Carl Frank Gortzig

carnations, standard chrysanthemums, snapdragons, potted chrysanthemums, geraniums, poinsettias, (2) a diversified crops program offering opportunity to combine monocrop options with roses for cut flowers, bedding plants and Easter lilies, (3) a potted plant specialization, (4) a cut flower specialization, (5) a bedding plant and geranium specialization, and (6) a program of bedding plant specialization January through May followed by a diversified crop operation in the remainder of the year.

The optimal mixes of crops which emerge in the analyses using each of these models identify a series of guidelines useful to the manager in the development of efficient production programs. The diversified crops program is shown to be the most profitable in terms of net return to specified levels of the fixed resources of greenhouse production space and permanent employee labor. Analysis with the potted crop specialization model shows the combination of crops to be second most profitable. Cut flower specialization emerges third in profitability. Other models yield generally unprofitable results primarily because inadequate levels of permanent labor prevent full use of the production space resource. Analysis of the results of studies using the models yields numerous production guidelines for each of the crop specializations and the diversified crop programs.

Finally, a model is devised to study the use of temporary employees to supplement the permanent employee resource at peak labor periods in the diversified crops program. Given unlimited temporary labor and three possible hourly wages, \$2.00, \$3.50 and \$5.00, analysis of the optimal crop mix yielded by the model provides labor management guidelines.

PROFIT MAXIMIZATION IN COMMERCIAL GREENHOUSE
FLORICULTURE UNDER NORTHERN UNITED STATES
PRODUCTION AND MARKETING CONDITIONS:
A LINEAR PROGRAMMING APPROACH

By

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CHAPTER I

INTRODUCTION

In the dynamic business environment of the 1970's, managers of northern United States greenhouse flower production firms need to increase their effectiveness as management decision-makers. They must apply sophisticated management tools and techniques to the analysis of their operations, and to the study of enterprise combinations for the most profitable use of production resources.

Among the situations about which operators of floriculture production firms need to be able to make decisions are (1) combinations and rotations of crop enterprises and crop production options which are most profitable for their specific production and marketing situations, (2) adjustments in fixed resource levels, and (3) the impact of limitations imposed by the manager on the quantities of fixed resources to be made available, the nature of crop enterprises, and the flexibility of resource organization.

The Objective

The general objective of this study is to determine greenhouse crop production profit maximizing combinations of florist crop enterprises under northern United States greenhouse production and marketing conditions.

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Methodology

Linear programming is used in the study. This operations research technique as used here enables one to establish guidelines for general use by northern producers to analyze their businesses from the standpoint of optimum combination of enterprises which will return maximum profit to fixed resource levels. A major advantage of the method is that normative solutions to enterprise combination and resource use problems are generated for a rather specific level of production resources.

Historical Perspective and Current Situation

A brief examination of the historical development and the current situation of northern United States floriculture provides an essential base for understanding the industry's need for the adoption of modern and effective management decision-making methods.

The commercial production of florist crops occurs with varying degrees of intensity in all regions of the United States. The products of the industry include cut flowers, potted flowering and foliage plants and garden bedding plants.

Nationally, the current value at wholesale of the flower producers' output is conservatively estimated by industry economists to be in excess of \$500,000,000 (12). At retail, floriculture goods and services are currently valued at above \$2 billion annually. Available data indicate that retail florist shops account for about two-thirds of the volume with non-florist outlets accounting for the remainder (12). Some industry men indicate that the latter outlets

account for as much as one-half of the total volume, and that their share is increasing steadily.

In the northern United States, florist crop production occurs primarily in the highly controlled environment of the glass or plastic greenhouse. The industry of this region has its roots in the nineteenth century greenhouse firms which served emerging urban areas. The perishable nature of their product, the limitations of the available transportation of the time, and the lack of wholesale flower producers combined to require the florist firm to locate near to its consumers and to produce its own flowers and plants to be assured of a year-round supply.

In the tradition of the times and of their agricultural beginnings, early floriculture firms tended to be family-owned and operated (16). There has been a strong tendency for businesses to be transferred from one generation to the next, and at present, it is usual for a business to have been started by the present owner's grandfather or even his great grandfather.

As the demand for flowers grew, family operations added more greenhouses. They soon found simultaneous crop production and retail selling in the greenhouse and work shed to be increasingly incompatible (36). The retail grower's shop, a facility designed specifically for selling, soon began to appear as an attachment to the greenhouse. Division of labor set in, often with the florist's wife assuming considerable responsibility for the retail operation.

The retail flower shop as a business unit separate and distinct from crop production began to appear in large cities in the early

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1860's. These shops were at first retail outlets opened by the producer as a direct sales channel to the large numbers of consumers in the growing cities. But soon, other persons not affiliated with the industry saw the retail florist shop as a business opportunity and the first stores without production facilities appeared.

With the development of the city stores, growers peddled flowers and plants from store to store. At about the same time, increasing diversity of flower species and varieties began to be grown, and as a grower developed a reputation for a given product, say roses, his returns increased and the demand for more of his roses developed. As a logical next step, we find these growers specializing increasingly in one or two crops (26).

Specialization and the increasing numbers of retail stores soon led to the need for central market facilities where the retailer could procure a broad selection of flowers, and where the grower could perform the marketing function with a minimum of time loss from his production operation. The wholesale commission florist emerged to meet these needs. He became the growers' marketing agent and the retailers' purchasing agent; he received flowers and plants from the grower, usually on consignment, and assumed full responsibility for the wholesale marketing, handling, delivery, credit and accounting functions. Growers were more than content to devote full time to crop production (36). This functionally specialized system grew and worked well through World War II. But the post-war years brought dramatic and rapid change. Significant growth in population and in disposable income brought increased demand for the products of floriculture. The advent of the

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mass-market system of retailing geared to serve all of the consumer's needs in one store challenged the specialty nature of the retail florist shop. Developments in air and truck transportation opened northern markets to the production of distant regions (6). Post-war floricultural research gave the grower a new body of technology which introduced an unprecedented level of precision into crop production schedules and increased both quality and quantity of output.

These developments have combined to give the American floriculture industry as it enters the 1970's dimensions very unlike those of just 20 years ago. The northern grower now shares his markets with the product of the distant shipper. The latter producers usually with newer facilities are often more sophisticated in their production and marketing techniques and so provide increasingly effective competition. And, both the northern grower and the southern and western United States shippers alike eye with uneasiness the growing volume of imported cut flowers reaching American markets. Among foreign areas shipping cut flowers are Australia, Africa, Ecuador and Columbia in South America, and certain European nations. In 1960, cut flower importations were valued at \$136,000 (31). By 1966, the volume was \$1,250,000 (11); in 1970, \$2,250,000 (31). The United States exports \$1,500,000 - \$2,000,000 worth of florist crops annually, mainly to Canada. Higher labor costs in the United States coupled with current unfavorable tariff rate provisions make it unlikely that the export market for American-grown florist crops will increase very greatly. Recent research in the post-harvest handling of cut flowers provides both foreign and distant United States producers with still more

opportunity to reduce shipping costs while placing a higher quality product on the market.

Like growing, the retailing of florist crops has come in for its share of change in the early 1970's. By tradition, the retail florist is a merchant who provides the consumer with cut flowers, potted plants, and appropriate accessories. But among the retail florist's most significant functions may well be the provision of the services of advice, design, credit and delivery as they pertain to the use of flowers for numerous social, sentimental and emotional occasions. Historically, there has been little interest or effort on the part of the retail florist to satisfy consumer demand for low-service, therefore lower priced, flowers for regular use in the home and the environment. Consequently, it is not surprising to find that mass merchandising of flowers and plants in supermarkets and variety stores has been steadily increasing since its inception just prior to World War II. Fisher Foods, Inc. of Cleveland, and Krogers, both supermarket chains, report that flower and plant sales represent one of the most profitable non-food departments in their operation (43). Alpha Beta, Sentry Foods and Acme Markets sell flowers on a regular basis (25). In a recent study (34), innovators across the floriculture industry nationally were asked to identify major trends occurring in commercial floriculture. The trend identified most frequently, and twice as often as the second-place trend, is that of increase in mass marketing of flowers. Research shows that sales through mass merchandisers are mostly sales in addition to those made by retail florists (2). They are sales of florist products with

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relatively few, if any, of the services traditionally added by the retail florist; they are sales of plants and flowers for daily use in the home, office or other environment.

Fossum (10) reports that of the \$1.5 billion dollars in consumer expenditures for the goods and services of commercial floriculture in 1967, one-third of these sales were through non-florist outlets. Bachman estimates that such sales utilize one-half of the total United States production of potted crops and cut flowers (37). He predicts that by 1980 two-thirds of all florist crops sold will reach the consumer through outlets other than the retail florist shop.

Offerings by the mass marketers have been heavily oriented to potted crops, and emphasis has been on sales for holidays and occasions. But supermarket and discount department store managers are increasingly interested in offering both cut flowers and potted plants on a continuous basis throughout the year (37). Berninger predicts that the supermarkets are trending toward becoming major distributors of cut flowers (4).

With these significant trends in the florist crop retailing apparently already well established, the decade of the 1970's is likely to produce profound changes in the type of product demanded from the producer. A dichotomous marketing structure appears to be emerging. The traditional retail florist shop likely will continue to meet the need for the highly serviced floral products required for social occasions and for the personal and business gift trade. The demand for flowers for daily use in home and office will be served by the volume merchandiser in one manner or another. The florist crop producer likely will need to grow two grades of floral products to

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meet the need of these different types of outlet. Furthermore, the producer may have a considerable role to play in selecting and developing new species for the emerging mass markets.

The northern wholesale grower's response to the changing situation has been vigorous especially in the last 15 years. With the influx into his markets of cut flowers from distant production areas, one of his major responses has been to switch his production efforts to potted foliage and flowering crops and bedding plants.

The northern wholesale producer is adjusting in other ways as well. Mechanization of crop irrigation, fertilization, temperature control, cut flower grading and other production tasks is occurring in a majority of operations. Remodeling and reconstruction of physical plants to make more efficient use of light, heat and labor is occurring. Application of new technology is making for more precise production schedules and elimination of labor-consuming production tasks. And, expansion of greenhouse production facilities to take advantage of the economies of scale is increasingly apparent.

The impact of rising costs of production inputs in face of relatively slower increases in market returns is intensified for northern growers by virtue of their location in heavily industrial and urban areas. Increases in real estate and school taxes, and in other property costs, are considerable in such areas. Concurrently, the surge of national interest in environmental protection requires the manager to decide between investment in noise, smoke and other nuisance abatement measures and such major alternatives as relocation or withdrawal from business.

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As an agricultural production industry, commercial floriculture has been generally exempt from much of the basic labor legislation of this country. For the same reason, it has been relatively untouched by unionization. Consequently, during these times when the industrial worker has received considerable legislated and union-negotiated improvements in his compensation in terms of wages, fringe benefits and working conditions, floriculture has not, until very recently, had the same legal and union-engendered compulsions to offer similar improvements to its employees. Consequently, the industry finds it increasingly difficult to recruit and retain a quality employee force in the highly industrialized northern metropolitan areas. Complicating this current dilemma is the fact that northern growers' physical production facilities are often 50 to 75 years old.

Facing increased costs of production, and increasingly severe competition in the labor market as well as in the flower market, the northern producer must examine ways in which he may improve his competitive position. Expansion or contraction, modernization or greater investment in a more effective work force - these are his dilemmas. Appropriate responses in any of the areas have potential for improving his competitive position. Individually and in combination, all offer feasible bases for managers to begin to solve the problems and pursue the opportunities inherent in the present industry situation.

Among these opportunities is the emerging potential for market expansion through flowers and plants in smaller sizes and quantities for daily home and business use. Development of new crops and of new production schedules for traditional ones is needed. Innovative

packaging to serve the needs of mass outlet sales is overdue. Review and reorganization of the grower-wholesaler-retailer relationship may yield opportunities for effective vertical as well as horizontal integration of the present trifunctional industry distribution system. Greater coordination of production and marketing could result. In this matter, already one sees the development of plant shops in areas of high customer traffic offering little or no service, retail florists specializing primarily in one or more selected services, the return of strong combination production-retail operations, and the addition to retail florist shops of greenhouses for displaying plants.

But perhaps more than any other, the application of modern management practices to the operation of northern production firms represents an opportunity with great potential for aiding in the successful adjustment to the business environment. New methods of management planning and decision-making or operations research techniques are ideally suited to the study of the complex production input-output relationships and the numerous alternatives for resource use.

Review of the Literature and Previous Research

There is a dearth of information available on floricultural production economics and management decision-making. Lacking is the basic data which other agricultural commodities have gleaned from long-term farm cost-account studies done by the United States Department of Agriculture and land grant colleges. Fossum (9) delineates the reasons for the lack of these data.

There are no data available concerning the relationships between resource use and production. These data represent the basis for the development of production functions, "the tools by means of which the problems of production or resource use can be analyzed" (19). Kearl (23) points out that with such data, producers would be able to analyze efficiency of production as measured in input-output relationships and in dollar costs and returns. He indicates that they could also measure the progress of their operation as well as compare their firm's operations with those of competitors. He cites these data as necessary basis for development of standards of reference useful in industry research and education programs.

Some cost-of-production data began to emerge in the post-World War II period as the industry began to sense the need for better understanding of resource use in an increasingly competitive market. The primary source was records information presented by managers usually at university florist short courses or in the trade press. P.A. Washburn (35), a flower producer in Bloomington, Illinois, was among the first to describe his rather complete system of records which yielded data on the costs and returns for each of his crops. His figures became the basis for numerous grower discussions during the 1950's and provided growers with guidelines for considering and comparing data from their own records.

The 1960's saw the emergence of several formal approaches to the study of resource use in flower crop production. Besemer and Holley (5) in 1965 and 1966 conducted a study of wholesale carnation growers in the seven major producing regions of the United States. They were able to determine the percent of total production costs accounted

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for by 10 major categories of production inputs. They found that the major input categories followed a fairly consistent relationship one to the other when expressed as percentages. Labor and management costs represented 55-60% of total costs for all areas except Massachusetts, where it was 40-45%. Fuel costs were 7.3-10.7% of total costs with the exception of California where fuel accounted for 3.0-3.6%.

Plants and supplies represented the next major categories with utilities, taxes, interest and insurance registering as relatively minor cost categories. Besemer and Holley (5) stressed the need for carnation producers to recognize that management problems have replaced cultural problems as the factor which determines successful operation in the modern business environment. They called for managers to keep better records of investments, costs, returns, crop yields, and cultural practices, and to make greater use of these data in constant reappraisal, projection of trends, and in the evaluation of alternative courses of action.

Jarvesco and deGraaf (22), also concerned with carnation production, studied the productivity of resources used in greenhouse carnation production in Massachusetts. Their primary purpose was to determine the production function for Massachusetts greenhouse firms specializing in carnation production. A Cobb-Douglas production function was fitted to input data, and was used to estimate the marginal productivities of five input categories: a square foot of greenhouse bench area in a year, a man-month of labor, one dollar spent on soil additions, one dollar of general operating expenses, one dollar of capital costs. The authors' most significant observation gleaned from their study was that on an

average, Massachusetts carnation growers over-used labor and used too little capital to achieve optimum economic results. They suggested that net returns from resource use could be improved by adjustments which increase capital inputs, particularly those which reduce labor requirements and increase carnation flower yields.

With the objective of obtaining descriptive and financial information for a group of New York State flower production operations, Goodrich (14) collected and analyzed appropriate cost and returns in 16 such operations for the 12 months of 1965. He identified from the data certain relationships between costs and returns and such other factors as crop enterprises, and the size and location of the production firm. He provided a dollar as well as a percentage break-down of production and marketing expenses for the major input categories.

In a similar study, Fisher (8) determined production costs and returns for 10 Ontario, Canada, flower producers for the period July 1, 1968 to June 30, 1969. He categorized inputs in essentially the same manner as Goodrich and provided dollar and percentage data for each.

While the 1960's saw the beginning of research into costs and returns in commercial floriculture, such studies have tended to be descriptive and general in nature. Still needed is the design of a system for annual collection of representative cost and return data which can provide a basis for the continuing analysis of such data, and development from it of standards of reference for use by floriculture managers.

The need for the on-going assembly of these data becomes even more emphatic when one views the developments in the field of operations research and management decision-making during the last quarter century. One such development, linear programming, is one of the more

important optimization techniques which has emerged (29).

Spawned by World War II as a method for decision-making concerning optimum use of the Allies' limited transportation facilities, and for allocating the scarce resources available for the production of war goods, the technique was sophisticated in the post-war period and applied in industry, business and research (21). A fuller definition and description of linear programming as an operations analysis technique is provided in Chapter II.

Heady (20), in 1954, was the first to apply linear programming in the field of farm management and agricultural economics. Barker (3) reviewed the application of linear programming to the solution of problems of individual farm managers through 1964. He stated that while "almost every college department of agricultural economics in the country has at least one member trained in this technique (3)", the results of their linear programming studies had reached extension channels only indirectly. But, he foresaw the application of linear programming as a management consultation tool by extension staff as being on the threshold of considerable expansion. In the late 1960's and early 1970's this expansion did indeed occur.

Today, linear programming service is offered to farm managers by Cooperative Extension in a number of states. These programs are designed to provide aid in management decision-making where a number of alternatives and production factors must be considered and where the complexity of the problems is considerable. The Pennsylvania State University Cooperative Extension Service (38), in their leaflet describing the linear programming service they offer farmers, cites

the following uses by the farm manager for the technique: "profit maximizing, cost minimizing, problems of organization, questions of labor profits, determining a least-cost (animal feed) ration, problems of additional capital, land addition considerations, other management decisions."

In 1974, the Michigan State University Teleplan System, utilizing linear programming as well as other operations research techniques, was used by Michigan and out-of-state extension and teaching personnel to do nearly 14,000 agribusiness and farm business analyses. The same system was utilized for only about 2,400 analyses in 1970 (17).

Linear programming has been more extensively applied in general agriculture than it has in commercial floriculture management. While Pennsylvania's Cooperative Extension Service specifically cites the development of maximum profit plans for greenhouse managers as a very appropriate use of the technique, there has been little use made of it by the industry in the 10 years the program has been offered (41). European researchers and extension workers have given some attention to the use of linear programming in operational analysis of greenhouse businesses but their major emphasis has been on glasshouse vegetable production.

Dorling (7) studied the appropriateness of applying linear programming to various aspects of planning greenhouse vegetable production in Britain. Specifically, he demonstrated the use of linear programming to determine the most profitable combination of individual glasshouse vegetable crops and crop sequences. He also included cut chrysanthemums as a crop alternative. The constraints were area of glasshouse production, area incorporating various heating regimes, and

hours of available labor. He also applied the technique to the problem of planning for investment in new greenhouse construction, and more specifically, in the types of construction used, e.g. mobile, cold temperature regimes, heated regimes.

Dorling (7) also identified the problem of reconciling the greenhouse production area for a given crop enterprise which the optimum solution calls for with the constructional and temperature limitations imposed in the real-world situation. He noted that a greenhouse range is composed of a series of structures of various sizes. Variable temperature and other cultural requirements of the different crops may make it impossible to produce them in the same house. Dorling (7) presented a budgeting method which provides for revision of the optimum plan generated by linear programming to conform with the limitations imposed by the physical plant and yet which minimizes the loss of profit as a result of deviation from the optimal solution.

Meijaard (28) applied linear programming techniques to the study of a series of management decisions concerning alternative cropping patterns, labor resource availability and the expansion of glasshouse holdings in the Netherlands glasshouse vegetable industry. His initial matrix included 54 activities and 82 restrictions. The activities included 16 tomato crops, 14 lettuce crops and provisions for the availability of casual labor during different periods. The author described the optimal solutions for the problem but refrained from detailed discussion of them because his purpose was to illustrate the application of linear programming as a method of research on certain management aspects of glasshouse vegetable production.

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Lloyd and Perkins (27) used linear programming to analyze varying resource combinations to determine profitable greenhouse cropping plans under British production conditions. They stated:

Glasshouse production is perhaps better suited to analysis by sophisticated management technique than are other types of agriculture, for, with the possible exception of the amount of light received by crops, the glasshouse operator has a high degree of control over the physical environment in which his crops are produced. The performance of crops under glass is therefore more predictable from season to season and given a reasonable level of technical competence crop yields exhibit less variability than in other spheres of agriculture.

Hales (15) described the use of linear programming in horticultural advisory work in Great Britain. He cited an increasing interest in and application of the technique among horticultural advisory workers and concludes:

factors which have made this possible are: an increasing number of advisers in the National Agricultural Advisory Service (NAAS) have been trained in its use, some management consultants are basing their advice on LP, and more grower/managers are entering the industry with management training. Interaction between these factors is bound to promote an awareness of its value, added to which, LP has an undeniable attraction to a generation to whom the computer is becoming familiar.

Hales (15) considered linear programming "to be of particular value in horticultural crop production management because of the very nature of many horticultural businesses; namely the large number of enterprises, double cropping and the resulting complex labour and marketing organization". He pointed out that linear matrices for horticultural firms are generally somewhat simpler than for their agricultural counterparts citing the existence of fewer enterprise complexities than are present in animal-oriented enterprises. He granted, however, that matrices for horticultural firms are generally much larger than for other agricultural

firms. He attributed this greater size to the variations in planting and harvesting dates (15).

While Hales (15) work appears to have been primarily with vegetable products both in the open and in glasshouses, he cited one programming effort in which he worked with the carnation enterprise:

Profit maximization from an apparent mono-crop such as the carnation also lends itself to LP where there is a choice of planting times, variable length of cropping period, and several glasshouses.

While stating that he has worked with a chrysanthemum production problem, Hales (15) grimly concluded that "in spite of much thought and effort, (it) remains unsolved, and at the present it is not certain whether the problem is capable of solution by LP".

In the United States, there has been relatively little application of linear programming to floriculture production management. Few greenhouse operators have availed themselves of the university-offered programs because they do not have the record data inputs required. The bedding plant crop is the main one studied with the Pennsylvania State University's program to date. This work has been mainly with vegetable growers who grow a crop of bedding plants in their vegetable plant-growing structures each spring. Some work is underway with geraniums and budget data have been collected for carnations (24).

Stevens (36) at the University of Maryland has developed an economic model for flower production for use in his extension teaching programs. However, while he has developed activity budgets for a number of flower crops using general cost and return data, he has not applied linear programming to the analysis of crop alternatives.

Extensive review of the literature identifies only one published work which applies linear programming to commercial greenhouse floriculture under United States conditions. Vaut, Christenson, Slane and Smiarowski (33) simulated a small (10,000 ft² of production area and 90 hours per week of unpaid family labor), family-operated, diversified retail-wholesale flower production operation. Using data for process budgets collected by Cooperative Extension agents in Massachusetts, they applied linear programming to analyze a number of floriculture crop enterprise alternatives as a basis for certain production management decisions.

CHAPTER II

THE LINEAR PROGRAMMING MODEL

Background

The background of linear programming as an operations research tool is reviewed in Chapter I. Hazell (18) relates the technique to agricultural management when he states: "linear programming is widely recognized today as a method of determining a profit maximizing combination of farm enterprises that is feasible with respect to linear fixed farm constraints". Heady and Candler (21) describe linear programming as

a procedure which provides normative answers to problems so formulated. By normative we refer to the course of action which ought to be taken by an individual business unit, area, or other economic sector when (a) the end or objective takes a particular form and (b) the conditions and restraints surrounding the action or choice are of a particular form. Hence, a problem may be defined in terms of the end or objective of profit maximization by an individual farmer.

A linear programming model is a conceptual and mathematical account of the phenomena involved in the problem under study. Heady and Candler (21) provide this definition:

A model is a functional account of relationships between relevant variables which will be given cardinal values in the empirical phase of the study. It is an abstraction, describing and duplicating the situation under investigation. It is used to isolate those parts of a problem or situation most important for analysis or solution. Perhaps as much as any other tool, linear programming forces the investigator to set down a systematic model. He does so as he defines resource restrictions, production possibility equations, profit functions, etc. A simplex table involves a fairly systematic model. However, it is not so much the

ability to formulate these relationships in algebraic or tabular fashion which makes linear programming successful; it more nearly is the ability to represent real world opportunities as restrictions and obtain accurate data to feed into the model.

It is essential that the linear programming model employed in a study be as consistent as possible with the actualities of the situation under study. Heady and Candler (21) indicate that a model is consistent with the real situation when the technical coefficients, commodity prices and physical or other constraints are realistic to the problem. They further emphasize the point: "Consistency with the real world can be attained only with sufficient acquaintance and experience with the agricultural or marketing sectors to be analyzed (21)." Such analyses are ideally suited to the joint efforts of the commodity technologist and the agricultural economist.

Hazell (18) provides a generalized mathematical statement of the linear programming model applied to production management problems of agricultural firms:

For a given farm situation the linear programming model requires specification of:

- a) The feasible farm activities, their unit of measurement, resource requirements and specific constraints.
- b) The fixed resource constraints.
- c) The forecasted activity returns net of variable costs, hereafter called gross margins.

The linear programming model can then be formulated in primal form as:

$$(2.1) \text{ Maximize } \sum_{j=1}^n f_j x_j$$

$$(2.2) \text{ such that } \sum_{j=1}^n a_{ij} x_j \leq b_i \quad (i=1, \dots, m)$$

$$(2.3) \text{ and } x_j \geq 0, \quad (j=1, \dots, n)$$

where,

x_j = the level of the j^{th} activity, ($j=1, \dots, n$);

f_j = the forecasted gross margin of the j^{th} activity,

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($j=1, \dots, n$);

a_{ij} = the quantity of the i th resource (or activity
constraint) required by one unit of the j th
activity, ($i=1, \dots, m; j=1, \dots, n$);

b_i = the i th resource or activity constraint level,
($i=1, \dots, m$).

Application of linear programming to the study of floricultural production management is essentially the same in all respects as the use of the technique in agricultural management. The commercial flower producer's production management concerns possess the characteristic and necessary components for the linear programming analysis, namely:

1. The desire on the part of the manager to maximize something, generally profit,
2. The existence of constraints in terms of fixed amounts of resources available for his use,
3. Existence of numerous alternatives for the use of these limited resources.

Assumptions Inherent in Linear Programming

The use of the linear programming model for analysis of production management situations must be consistent with the assumptions which underlie the technique (13, 21, 18).

Maximization or Minimization

The maximization of profit, or predicted total gross returns, is assumed to be an appropriate basis for decision-making, as is minimization of costs of inputs and other resources.

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Divisibility

The assumption is that the production input factors can be used, and the resultant output of commodities can be produced, in quantities which are fractional units.

Fixedness

It is assumed that one or more of the factors of production are fixed in quantity available for use in the production process for the planning period involved. In other words, there is always at least one constraint which must be considered in making the management decision.

Finiteness

A limit is assumed to exist to the number of alternative activities and resource constraints of the situation.

Certainty

It is assumed that resource supplies, input-output coefficients, and commodity prices are known with certainty. That is, all f_j , a_{ij} and b_i coefficients, ($i=1, \dots, m$; $j=1, \dots, n$), in the linear programming model are assumed to be known constants.

Homogeneity

All units of resources and of commodity output are assumed to be identical.

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Additivity and Linearity

The assumption is that the total amount of resources used and the total product output of several enterprises must be equal to the sum of the resources used and the product yield of each individual enterprise. That is, it is assumed that no interaction between the several enterprises in the amount of resources required per unit of activity are assumed to be constant at all levels of employment of the activity.

While the assumptions underlying linear programming may seem highly restrictive, many of these assumptions may be relaxed sufficiently to allow their application to the realities of the actual floriculture enterprises and constraints (13, 18). Hazell (18) summarizes the many ingenious methods devised to increase the flexibility of the basic linear programming model.

Advantages and Disadvantages of Linear Programming

Linear programming was selected as the technique for use in the project because of its capability to compare the relative probability of large numbers of production activities within the framework of limited resources and other production constraints. The commercial flower producer has available not only a staggering number of crop enterprises from which to develop his production schedules, but he also has numerous options internal to each crop enterprise. Some of these options are:

1. The choice of market target date for production of the crop,
2. Selection of cultivars from among a wide range of colors, flower types, growth habit, and other characteristics, for use in production programs,

3. For potted crops, selection from a wide range of pot sizes, which in turn influence resource inputs used and the type of product yielded,
4. For cut flowers, a decision as to whether to grow the single-stemmed or pinched, thereby determining spacing and affecting final commodity grade potential,
5. For potted crops, selection from among a number of production regimes each with different space, labor and other resource inputs and each yielding a different form of the product with varying acceptability in the usual market channels,
6. For bedding plants, container size, number of plants per container, and related factors.

Linear programming has additional advantages over conventional farm management budgeting techniques. In addition to providing an optimal production plan for the owner/manager, the solution also yields for each of the scarce resources or constraints in the problem situation, the cost in terms of increase or decrease in gross margin of the optimal solution caused by an increase or decrease of one unit of the scarce resource available for input purposes. Shadow prices, as these values are termed by the economist, are of use to the manager because they indicate possible gains in return to be derived from acquisition of additional units of constraining resources (24). For activities which do not come into the optimal production plan, information is obtained on the cost to the owner/manager in terms of reduction in gross margins, and hence profit, for forcing into the solution one or more units of

an activity which did not come into solution, at the expense of some number of units of an activity which did come into the optimal solution (21). These values are termed opportunity costs.

Some disadvantages are inherent in the linear programming technique. Perhaps the greatest is the requirement for extensive amounts of detailed production management data. Needed are technical coefficients for all activities, prices of commodities marketed and quantities of limiting resources. Managers of agricultural firms often do not record information in this detail. Consequently, the programmer must often resort to intensive and prolonged interview procedures to generate the essential data.

Hazell (18) cites an additional disadvantage of linear programming especially when used in direct management consultation work with producers:

Linear programming models must generally be solved on computer facilities for problems of sufficient complexity to justify use of the technique. This may limit its application in some parts of the world, but may also tend to create a communication gap between the farmer and programmer. A farmer may place considerable confidence in a farm plan derived with his participation by intuitive procedures, but may have little faith in a plan produced by some backstage and omniscient computer.

However, Hales (15) describes in detail an effective technique used by the British National Agricultural Advisory Service both in communicating with producers concerning the possibilities linear programming may hold for their firms as well as in interpreting solutions to managers during consultation sessions.

Finally, a possible disadvantage is that the assumptions fundamental to linear programming are not always easily handled in the

analysis of certain agricultural situations. Hazell (18) reviews methods of increasing the flexibility of the basic model.

General Procedure

The first procedural phase was to identify representative production firms for the purpose of obtaining cost and return data and estimates of coefficients for the inputs of greenhouse production area and labor for the nine crops and their respective options. The managers of these firms also were queried to determine whether they had production and business records adequate to provide the basic data required, and whether they could accurately estimate necessary data not available in their records. A series of firms was identified through discussion with floriculture faculty and Cooperative Extension agents of Michigan State University. Each of the firms identified was visited and the manager interviewed to determine whether the firm qualified for inclusion in the study. Primary criteria for qualification follow.

The firm is a full-time commercial production operation with the capability of engaging in the growing of the nine crop enterprises and their internal production and marketing options. The firm realizes a gross annual income from flower crop production of at least \$100,000 (wholesale value of crops sold), thus qualifying as a commercial operation. The firm's business objective is basically that of maximization of profit, and the operation is not primarily oriented to or influenced by other objectives, e.g. family-oriented goals, real estate appreciation and speculation.

The firm employs a level of technology in production and marketing

which reflects the application of the majority of practices current in the industry and/or recommended or endorsed by the Cooperative Extension Service of its' state for operations of the same general type and size.

The firm is located in the northern United States at, or generally near, 42 degrees 30 minutes north latitude, a geographical area which includes Grand Rapids, Kalamazoo, Lansing and the Detroit metropolitan area. In actuality, this belt contains the majority of commercial flower crop production firms in Michigan. Production and marketing conditions in this area may be considered typical of those of the northern United States.

Based on the interviews, 14 Michigan firms were selected for study. One firm in New York State and one firm in Pennsylvania also were selected to provide additional data for snapdragons and carnations when it was determined that it was not possible to obtain sufficient data on these crops from the Michigan producers.

Data were then collected in the following categories from the 16 producers:

1. The manager's description of his objective for his business and his general philosophy and approach to their achievement,
2. Costs and returns for production and marketing of the crops they produced,
3. Greenhouse production space coefficients for crops produced,
4. Tasks involved in the production of crops grown and labor coefficients for each of the tasks.

Detailed production cost and return records beyond those required

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for income tax and other legal accounting purposes were not available from most of the managers. This is generally true in the floriculture industry. Consequently, interviews in depth were necessary to obtain data in sufficient detail for project purposes.

The second phase in the procedure was to use these data to build a linear programming research model for use in pursuing the objective of the study. The data collected were used to compute estimates of labor and greenhouse space coefficients for the nine crop enterprises and their internal options.

The Model

The linear programming model is essentially an abstraction which describes and reflects the real situation under study. Accordingly, the model developed for this study is assumed to have the characteristics of commercial status, level of operation and geographic location delimited earlier in this chapter for the representative firms from which data were drawn.

Other characteristics of the model as developed from study of the representative firms follow.

Production and Marketing Cycle

The cycle is established as a 52-week year. The 12 months of the year were each assigned a number of weeks as shown in Table 1. Easter Sunday, a major holiday for the flower producer, is a variable holiday and may range from the last Sunday in March to the second-last Sunday of April. For purposes of this study, Easter Sunday is assumed

to be fixed on the second Sunday of April.

Table 1. Weeks assigned to each calendar month in the model.

Month	Number of weeks
January	5
February	3
March	5
April	4
May	5
June	4
July	4
August	5
September	4
October	4
November	5
December	4

Characteristics of the Owner/manager

The owner/manager of the model firm is assumed to keep abreast of new developments and to apply innovations within a reasonably short period after they are recommended. He is considered sufficiently competent in managerial technology and skill to be able to efficiently manage an operation of this size and complexity.

Mechanization

The model firm is assumed to have at least the operations listed below mechanized. In industry, production operations of this size are generally mechanized to this extent.

1. Thermostically controlled heat and ventilation,
2. Automatic watering controls,
3. Fertilization of crops done mechanically at each watering with proportioners,
4. Systemic insecticides and fungicidal soil drenches applied through the automatic watering system, or in granular form,
5. Bench soils steam-sterilized following each crop,
6. Potting operations set up and operated in assembly-line fashion with conveyor track and fork-lift equipment used to the extent possible,
7. Fork-lift trucks and front-end loading tractor equipment used to handle all materials possible,
8. Transfer of potted crops and bedding plants from greenhouse to loading area achieved with roller conveyors, carts and fork-lift trucks to the extent possible.

Greenhouse Heating

The greenhouse plant is assumed to be heated by a central boiler plant fully maintained for maximum efficiency. The fuel is natural gas.

Market

A market is assumed to exist for all of the crop enterprises and internal options available to the manager except in those enterprises

and options for which market quotas have been imposed in the program. These quotas are specified later in this chapter.

Point of Sale and Delivery Practices

It is assumed that no delivery service is provided by the model firm; retail merchants pick up potted crops and bedding plants at the greenhouse, and that cut flowers are either picked up at the greenhouse by the retail merchant or are shipped to the wholesale florist by common carrier. This simplifying assumption is necessary in that both sales and delivery methods vary so greatly that it would be unrealistic to designate a 'typical' method. Delivery techniques found in use are:

1. Retail merchant picks up potted and cut crops and bedding plants at the greenhouse,
2. Wholesale florist picks up cut flowers at the greenhouse,
3. Growers deliver potted plants, cut flowers and bedding plants to retail merchants,
4. Growers deliver crops to wholesale florists,
5. Growers operate truck route selling his crops to retailers,
6. Truck, bus, air shipment of crops to retailers and wholesalers,
7. Others.

Enterprises and Internal Options

Nine crop enterprises and numerous internal options in terms of production technique, final form of commodity produced, and marketing alternatives, are available to the manager. The crop enterprises are:

1. Cut flower crop enterprises
 - a.) Carnations

- b.) Chrysanthemums (standard)
- c.) Roses
- d.) Snapdragons (single-stem)

2. Potted crop enterprises

- a.) Chrysanthemums
- b.) Easter Lilies
- c.) Poinsettias
- d.) Geraniums

3. Bedding Plants.

The production options internal to each crop are described in detail in Chapter III in the discussion of the optimal solutions for the monocrops and the various multicrop programs.

The Objective Function of the Model

The model is designed to produce a global optimum solution which maximizes the objective function, i.e. the gross margin net of crop-specific variable costs, within the constraints of fixed greenhouse production area and fixed permanent employee complement, and within the alternative activities for the use of these fixed resources offered by the nine crop enterprises and their internal production and marketing options. The objective function represents gross market returns in dollars less the cost of crop-specific variables used in the production and marketing of the crop. It is the return to the fixed resources of greenhouse production area and permanent employee force in terms of gross margin in dollars after crop-specific variable costs are deducted. The cost of fixed resources (overhead costs to provide a square foot of production area per week and the cost of the permanent labor force per

hour) are deducted from the gross profit to determine net profit. The manager's labor contribution and time spent in doing management tasks is included in the 600 hours per week of permanent employee complement in the amount of 60 hours per week.

Residual profit then is the net profit which remains after all costs, i.e. crop specific variable costs and fixed costs, are deducted. It is return to fixed resources, and may be considered income which the owner/manager receives beyond his salary compensation for his management skill. Net profit also includes returns to capital investment in the firm.

The Constraints in the Model

The constraints have been identified as greenhouse crop production area and permanent employee complement. Specification of these fixed production resources follows.

Greenhouse Crop Production Area

The model has 107,000 square feet of area under the cover of glass greenhouses. The greenhouses are of modern aluminum frame construction with wide-span glass. The structures are fully maintained. Production areas within the greenhouses are assumed to be laid out efficiently so that 70% of the area under glass, or 75,000 ft², is available for crop production activity. It is generally assumed in the floriculture industry that 65 to 70% of the area covered by glass converts to useable production area if careful attention is given to bench layout. The remainder is devoted to walks and work areas.

Storages are a usual component of the flower grower's facility. They are essential for pre-marketing post-harvest treatments of cut flowers as well as for bulb, seed, cutting and plant storage. Such an ancillary facility is provided in the 125,000 ft² of temperature-controlled storage area in the model firm. Among the crop enterprises, storage facilities are required only by certain options of the Easter lily crop. So as not to have available storage space impose an undesirable constraint on these lily options the amount of storage area in the model is that required to allow the entire greenhouse production area to be programmed to Easter lilies should such be an optimum solution. Storage facilities typically are shelved to provide maximum use of space. Therefore, storage area square footage does not equal floor area.

Permanent Employee Component

A total permanent labor resource of 600 hours per week is available in the model and may be characterized as follows:

1. An owner/manager who contributes 60 hours per week including his time devoted to management as well as that considered to be production, marketing and other non-management tasks,
2. Eleven permanent employees who each work 48 hours per week for an available total of 528 hours per week,
3. The owner/manager's wife and family at 12 hours per week total.

The permanent employees are assumed to be skilled and trained in the performance of the majority of production tasks essential to

the programming of the nine crop enterprises and their options. Permanent employees are considered to be sufficiently skilled and trained to do all of the production activities studied.

Market Quotas

Another set of constraints was applied in the form of market quotas for some enterprises and options. Market quotas are specified later in this chapter. These constraints conform to the actual limitations imposed by the market situation, particularly at holidays, under industry conditions.

The Estimates of Values for Constraints,

Prices of Inputs and Outputs, and Coefficients

A researcher utilizing a linear programming model to study typical production firms usually obtains his estimates of input and output prices, constraints and technical coefficients from a traditional set of data sources including census reports and cost of production and other studies done by governmental agencies and land-grant universities. He supplements these resources with discussion and interviews with producers, extension workers and commodity production and marketing specialists. But a researcher finds a dearth of census and costs-and-returns data for commercial floriculture as a result of the traditional lack of attention to such studies in this commodity by the usual agencies. This problem was discussed in depth in Chapter I. Furthermore, records kept by flower producers are the minimum necessary for tax and legal purposes.

Consequently, most of the estimates for the various factors required for the linear programming model used in this study are derived from interviews with managers and key employees. However, some coefficients were derived from the few recent floriculture cost-of-production studies which have been done (14)(8). Detailed producer records where available also provide additional information. Data from all sources are further tailored on the basis of the researcher's experience and observations as an extension adviser to floriculture industry managers for more than 15 years.

Determination of Levels of Constraints

Greenhouse production area (75,000 ft²) and its ancillary temperature-controlled plant storage (125,000 ft²) and permanent employee complement (600 hours per week) are the fixed resources considered to constrain production in the model.

The model's greenhouse area under glass and production area are derived from data collected from the firms in the study. Area under glass ranges from 25,000 to 300,000 ft², and production area from 23,000 to 204,000 ft². See Table 2. The mean area covered by glass and plastic for the 14 Michigan firms is 95,570 ft², and for all 16 firms, 92,570 ft². The mean production area per operation for the Michigan producers is 70,430 ft², and for all 16 firms, 67,000 ft². The values of 107,000 ft² under glass, and 75,000 ft² production area assigned the model are considered representative of the firms studied. Approximately 72% efficiency in conversion of area under glass to crop production area is reflected here. An operation of this size is

Table 2. Area under glass and plastic for 14 Michigan and 2 out-of-state firms, 1970.

Firm Number	Area under glass (1,000 ft ²)	Production area (1,000 ft ²)	Conversion of area under glass to production area (%)
Michigan			
102	173	110	64
108	300 ^a / ₁	204	68
116	161	130	81
122	100	89	89
128	62	43	69
134	78	60	77
140	75	53	70
146	110	74	69
152	25 ^a / ₁	23	92
158	45	37	83
164	65	39	60
170	80	54	68
176	45	43	96
182	39	27	70
$\bar{x}$	97.00	70.43	75.43
Out-of-state			
188	42	26	61
194	100	60	60
$\bar{x}$	71	43	60.5
All firms			
$\bar{x}$	93.75	67.00	73.56

^a/ Firm 152 is considerably smaller than the other firms, and Firm 108 is somewhat larger. They are selected primarily because they produce crop options for which data are not available from other growers in the study or because they have complete records information.

considered to be fully commercial in character because it will generally be beyond the scope of a simple family business thus insuring that the firm's objectives are profit oriented.

The rationale for the assignment of 125,000 ft² of temperature-controlled storage area to the model firm is described earlier in this chapter. The availability of this much storage area could be considered unrealistic when one considers that the facility would be used only for purposes of producing certain Easter lily crop options, the storage of plants, cuttings, bulbs and seeds prior to planting, and the pre-marketing treatment of cut flowers and certain potted crops. However, in a real industry situation, a producer would likely grow crops other than lilies which would require storage facilities, e.g. bulb crops, azaleas, hydrangeas. These crops are not included in the alternative enterprises available in the model simply because of the need to keep the number of enterprises manageable within the scope and purposes of the study.

Levels for the permanent complement constraint are defined earlier in this chapter and established on the basis of data obtained from producers interviewed. The average number of permanent employees per 1,000 ft² of area under cover for 13 of the firms is .095 with a range of .037 to .187. See Table 3. The model firm is considered to have 107,000 ft² of area under glass and on the basis of the firms surveyed would typically employ 9.88 employees including managerial staff. A total of one manager and 11 permanent employees are assigned the model. The number is increased by two employees because managers interviewed had considerable difficulty specifying the amount of managerial time, unpaid family labor, and part-time labor utilized during

Table 3. Composition of employee complement in firms studied.

Area under		Number of Employees			Employees		
Firm Number	Glass (1000 ft ²)	Management	Supervisory	Skilled	Unskilled Total	per 1000 ft ²	
Michigan Firms:							
102	173	2	3	11	3	19	.187
108	300	3	3	15	2	23	.076
122	100	3		3		6	.060
128	62	2		4		6	.096
140	75	5		4		9	.120
146	110	1	3	6		10	.091
152	25	2				2	.080
158	45	3		1		4	.090
164	65	1		4		5	.077
170	80	1		2		3	.037
182	39	2		5		7	.180
Mean, Michigan Firms							.099
Out-of-state Firms:							
188	42	1		2		3	.071
194	100	2	2	2	1	7	.070
Mean, out-of-state Firms							.071
Mean, all firms							.095

the year. While all interviewees made estimates, they were perhaps least sure of their figures in these areas. Managerial time beyond 60 hours per week is not accounted for in the model. There is considerable indication on the part of managers that they devote more time than this to their operations.

Further, there are indications that wives and children contribute considerable amounts of unpaid labor to the operation. In some cases, younger children are paid an allowance for doing chores in the greenhouse. Similarly there are indications that part-time labor may have been understated by managers. With these observations, it is considered that a 12-man permanent complement including the manager may provide a more realistic estimate of the usual permanent labor complement available to the manager of a range the size used in the model.

It must be noted also that the permanent labor complement should vary among the businesses studied on the basis of:

1. Crop enterprises in the annual production rotation, i.e., certain enterprises require less labor on a day-to-day basis than others, but may have periodic peaks of labor requirement, e.g. bedding plants, holiday-oriented crops.
2. The specific cultural practices used to produce crops, e.g. one participant manager waters all crops automatically with the exception of poinsettias which he feels must be hand-watered. Other poinsettia producers studied water poinsettias automatically.
3. The efficiency of layout of the greenhouse range. Assumptions about the layout of the greenhouses in the model are specified

earlier in the chapter. The model is laid out likely more efficiently than the average firm studied.

4. The managerial approach to organization and implementation of the use of the labor resource, e.g. several producers organize the potting of certain crops in an extremely efficient assembly line which minimizes steps and motions. Others give less thought to such organization thereby requiring more employees to accomplish the task.
5. Of course, the level of mechanization influences substantially the labor complement required. As noted earlier, the greenhouse operations included in the study are mechanized essentially to the extent prescribed for the model. Some are mechanized beyond this level thereby reducing the number of employees required.

Pricing Greenhouse Production Area

The production area constraint is established in units of square feet of production area available for cropping per week. The basic pricing unit is the cost to provide one square foot of production area per week. This cost includes the costs of these fixed, non-crop-specific factors:

1. Non-capital costs associated with providing the physical greenhouse, heating plant and allied facilities including property taxes, depreciation on buildings and installed equipment, interest on capital, maintenance and repairs, rents paid to provide facilities, insurance and related costs.

2. Costs associated with providing non-installed equipment including motor vehicles, office equipment, greenhouse equipment and non-installed storage equipment, e.g. portable refrigeration equipment. Also included are associated depreciation, insurance and interest costs, maintenance and repairs, and fuel for operation of the equipment.
3. Cost of natural gas fuel required to maintain greenhouse night and day temperatures at 40°F year-round. This portion of the heating cost is assigned as a part of the cost of providing greenhouse production area because greenhouses must be maintained at this minimum temperature to prevent collapse in periods of snow and ice, and to prevent damage to the heating system (42). Fuel costs to heat the greenhouse from 40°F to the temperature required for a specific crop enterprise are assigned to that enterprise in that the temperature requirement varies not only by crop enterprise but by stage of production of each crop. The method used to calculate heating requirements and costs is discussed later in this chapter.
4. Cost of utilities including water, sewer, and electricity except in those crops where artificial lengthening of the day is required for control of certain photoperiodic responses. In these cases, cost of electricity for photoperiod control is assigned as a crop-specific cost to the enterprise requiring it.
5. General administrative and marketing expenses including legal, tax and accounting services, corporate taxes, telephone, administrative and office supplies, contributions, freight,

express and postage, advertising and promotion of a general nature, selling, travel and entertainment, life insurance premiums on the owner/manager's life, and dues and subscriptions.

To calculate the cost to provide a square foot of production area, the cost per unit of greenhouse production area is determined for the Michigan firms studied in this project. Data from nine of the firms are used in calculating the mean cost of production. Data from two of the 12 firms studied are omitted because they operate less than 12 months per year, and cost data for one firm are not available. Table 4 specifies average total costs of production, costs per square foot of production area, and percentages of operating costs.

In Table 5, cost of production data generated by Goodrich in his study of 16 New York State producers, and Fisher in his study of 10 Ontario, Canada, flower production firms are presented. Cost of production per square foot of production area as determined in each of these studies is detailed in Table 7. These data are not directly comparable because of variations in handling of certain costs.

Fisher (8) notes that while \$3.61 per ft² of production area is the average production cost for all operations studied, the average cost for producers of cut flowers only was \$3.69 per ft² of production area. The average cost for producers who grew both cut flowers and potted plants in the same operation is \$3.52 per ft² of production area.

A fixed cost per unit (ft²) of greenhouse production area for use in the model is determined based on data from these three studies. However, many of the costs usually included in the total fixed cost/ft² of production area are accounted for in crop-specific costs

Table 4. Flower crop production receipts and expenses, 9 northern United States firms, 1970.

Item	Average receipts & expenses per firm		Per cent item is of total operating cost
	Total	Per ft ² production area	
<u>Receipts</u>	\$317,329	\$3.55	
<u>Operating expenses:</u>			
Labor:			
Wages	87,779	.98	30.53
Salary	28,088	.31	9.66
Benefits	2,974	.03	.93
Production supplies	38,641	.43	13.40
Marketing expenses:			
Commissions	32,561	.36	11.21
Delivery costs	1,261	.01	.31
Fuel	25,209	.28	8.72
Maintenance and operation of buildings, equipment and vehicles	17,587	.20	6.23
Depreciation	12,851	.14	4.36
Taxes	12,486	.15	4.52
Insurance	7,695	.09	2.80
Utilities	6,060	.07	2.18
Packing, shipping and office supplies	3,702	.04	1.25
Public relations	2,590	.03	.93
Interest	2,306	.03	.93
Freight, express, postage	1,725	.02	.62
Legal, accounting and tax service	1,864	.02	.62
Miscellaneous	2,290	.03	.93
Total operating expenses	\$287,679	\$3.22 ^{a/}	100.00
Net operating income	\$ 29,650	\$0.34	

^{a/} equals \$0.62/ft²/week

Table 5. Flower crop production and marketing expenses; data from 3 studies.

Item	(1965) <u>a/</u>	(1968-69) <u>b/</u>	(1970) <u>c/</u>
Labor:			
Wages & salaries	37.5	39.0	40.2
Benefits	1.7		.9
Production supplies	15.2	18.1	13.4
Marketing expenses:			
Commissions	14.4	6.2	11.2
Delivery expenses			.3
Fuel	9.9	12.2	8.7
Maintenance and operation	4.4	6.5	6.2
Depreciation	4.0	4.0	4.4
Taxes	3.8	1.9	4.5
Insurance	2.5	.8	2.8
Utilities	2.4	2.2	2.2
Packing, shipping, office supplies	1.6	.5	1.3
Freight, express, postage		2.8	.6
Public relations	1.1		.9
Interest		2.6	.9
Other	1.5	3.2	1.5
Total operating expense	100.0	100.0	100.0

a/ Goodrich, Dana C., Jr. 1968. Selected costs and returns in flower production and marketing.

b/ Agr. Econ. Res. Rpt. 271, Dept. of Agr. Econ., Cornell University, October.

c/ Fisher, G. A. 1971. Greenhouse flower production in Ontario: Production costs, returns and management practices, 1966 and 1968-69, Ontario Dept. of Agr. and Food, Toronto, Ontario, Canada, March.

c/ This study.

Table 6. Basis for fixed costs of greenhouse production area in model firm.

Item	Cost per ft ²
Production supplies	
Plants, pots, soil, labels, fertilizer, pesticides, growth regulators, etc.	\$0.15
Commissions	0.40
Fuel	
To heat total square footage under glass and service buildings to 40°F	0.10
Maintenance and operation	0.20
Depreciation	0.14
Taxes	0.15
Insurance	0.09
Utilities ^{a/}	0.07
Packing, shipping and office supplies	0.04
Freight, express, postage	0.02
Public relations	0.03
Interest	0.03
Other	0.03
Total fixed cost of greenhouse space per ft ² production area per year	\$1.45

^{a/} Expense for photoperiodic lighting is assigned in crop-specific costs.

Table 7. Cost of production per ft² of production area under glass as determined in 3 studies.

	(1965) ^{a/}		(1968-69) ^{b/}		(1970) ^{c/}	
	\$/ft ² /yr	\$/ft ² /wk	\$/ft ² /yr	\$/ft ² /wk	\$/ft ² /yr	\$/ft ² /wk
Cost per ft ² of production area	\$2.89	0.055	3.61	0.069	3.22	0.062

a/ Goodrich, Dana C., Jr. 1968. Selected costs and returns in flower production and marketing. Agr. Econ. Res. Rpt. 271, Dept. of Agr. Econ., Cornell University, October.

b/ Fisher, G. A. 1971. Greenhouse flower production in Ontario: Production costs, returns and management practices, 1966 and 1968-69, Ontario Dept. of Agr. and Food, Toronto, Ontario, Canada, March.

c/ This study.

Table 8. Salary and wage rates paid, 10 northern United States greenhouse firms, 1970.

Firm Number	Average hourly rate			
	Supervisory employees	Skilled employees	Semi-skilled employees	Unskilled employees
102	\$3.00	\$2.90	\$2.50	\$2.00
108	4.00	3.00	--	2.60
122	--	2.75	--	--
140	--	2.95	--	--
146	3.00	3.00	2.50	2.00
164	--	3.75	--	--
170	--	1.80	1.80	--
182	3.10	2.25	2.05	--
188	--	1.60 ^{a/}	--	--
194	2.63	2.00	1.65	2.00
Mean all firms	\$3.73	\$2.56	\$2.10	\$2.00
Range all firms	\$2.63-4.00	\$1.60-3.75	\$1.65-2.50	\$2.00
				\$1.50-2.75

^{a/} plus a home on the premises

1

1

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be

programmed in the model. Therefore, the total fixed cost per ft^2 used in the model is determined by reducing the total fixed cost per ft^2 of production area by the amount attributable to crop-specific costs. Components of fixed costs used in this calculation are listed in Table 6. On this basis, the total fixed cost of providing greenhouse production area in the model is established at \$1.45 per ft^2 of production area per year.

Pricing Fixed Cost for Permanent Employee Complement

The basis for pricing the permanent employee complement as an input are data for calendar year 1970 from 10 floriculture firms in the study. These data are summarized in Table 8. As thus calculated, salary and wage rates used in the model are as specified in Table 9.

Table 9. Salary and wage rates used in the model firm.

Level of employee	Number	Hours per week	Salary or wage rate(\$)
Manager	1	60	\$25,000/year
Supervisor	2	54	\$4.00/hour
Skilled laborer	7	48	\$2.50/hour
Semi-skilled laborer	2	48	\$2.00/hour

On these bases, the fixed cost of one hour of salary and wages including benefits is set at \$3.31.

An option to hire temporary labor is programmed. It restricts the model to 400 hours per week of permanent employee complement but gives the manager the option to employ unlimited hours of temporary labor once total permanent employee hours are fully committed. In this option, temporary employees may be hired at one of three hourly wage rates: \$2.00, \$3.50 or \$5.00. In any given use of the option, however, only one of these wage rates may be used for all temporary hours paid.

Estimating Crop-Specific Variable Costs

Crop specific variable costs are those non-fixed expenses associated with production and marketing of a specific crop enterprise or one of its internal options. Specific expenses vary from crop to crop depending on the production process and the final form in which the product is marketed. These variable input costs are included in the estimates:

1. Costs of purchasing stock plants, cuttings, started plants, seeds and bulbs with which to initiate a crop. These costs are determined from 1970 suppliers' catalog listings, price quotations in 1970 issues of trade magazines, and discussions with salesmen and producers. Prices are verified to be within the usual range paid as identified by producer participants in the study. The usual quantity and early-order discounts, as well as appropriate premiums and royalties, are included where appropriate.
2. Costs of ingredients for soil mixtures including soil, peat moss, perlite, fertilizers and other soil amendments. The soil mixture used in the model is a mixture of one-third field

soil, one-third Canadian sphagnum peat moss and one-third perlite by volume. This mix, with minor variations, is a standard recommendation for the crops produced in the model (40). Basic amendments of ground limestone for soil pH adjustment, and of superphosphate to provide basic phosphorus nutrition are also assumed. The cost of the soil mixture, \$12.00 per cubic yard, is determined on the basis of price quotations from Michigan suppliers of the ingredients as verified in interviews with project participants. These costs are detailed in Table 10.

Table 10. Costs of ingredients in soil mixture used in model.

Ingredient	Price per cubic yard (\$)
Field soil	3.00
Canadian sphagnum peat moss	15.75
Perlite	17.40
1:1:1 mixture of soil, peat moss, perlite	12.05

In the model, a soil mix charge is applied to potted crops and bedding plants because the soil is sold with the crop. No soil charge is assigned to the crop-specific variable costs for cut flower crops because the soil mix remains permanently in the bench and is sterilized between crops. Only periodic addition of amendments is made and these costs are considered minor enough to be absorbed in the general supplies cost category.

3. Costs for containers in which to produce potted crops and bedding plants, e.g. clay and peat pots of various sizes, plastic flats and packs, BR-8 blocks. Prices used for containers of various types are from suppliers' catalogs and verified in interviews with producers. The usual trade and quantity discounts are considered in assigning container costs to crop options. It is assumed that a manager will purchase his container supplies on an annual basis for all planned crop production and thereby qualify for quantity discounts.
4. Costs of natural gas fuel to heat the greenhouses from the basic 40°F included in the fixed cost of greenhouse production area to the temperature required for the crop enterprise or option. Heating requirements and costs are calculated using Aldrich's (1) procedure.

$$F = \frac{H(HDD)24}{E(\Delta_t)C}$$

where:

F is the fuel required,

H is the estimated heat loss in Btu/hr,

HDD is the heating degree days for the time period,

E is the efficiency assumed for the boiler,

C is the heating value of the fuel,

Δ_t is the temperature difference for which the heating unit was designed.

$$M = F \times P$$

where:

M is the fuel cost,

F is the fuel required,

P is the price per unit of fuel.

Heating-degree data used in calculations are based on those for Corry, Pennsylvania (32). Aldrich (42) recommends these as sufficiently representative for purposes of the geography of the model. Natural gas rates used in the heating calculations are those charged by Consumer Power Company, Jackson, Michigan under their "commercial and industrial service contract rate C (39)." Interviews with producers indicate that a majority are on this rate. Project participants in western Michigan are in the territory served by Michigan Consolidated Gas Company. Rates of the two firms are roughly comparable. In calculating the cost to heat production area occupied by a unit of a crop enterprise or option, the production area is increased by a factor of one-third. In this way, the cost of heating the 30% non-productive area in the greenhouse is prorated across each unit of crop enterprise or option.

5. Costs of providing photoperiod control equipment, e.g. light fixtures, bulbs, black cloth, and the cost of providing electricity for photoperiodic lighting purposes. Photoperiodic control equipment is used for successive chrysanthemum crops over a period of years. Accordingly, depreciation schedules are established. A useful life of 10 years is assigned to

lighting fixtures and reflectors; a useful life of five years is assigned to black sateen cloth. The cost of these production inputs is pro-rated on the basis of number of crops produced per year for each of the years in the depreciation period. A photoperiodic expense factor is then assigned all crops requiring such treatment. Electricity expenses for photoperiodic lighting is considered a crop-specific expense for those crops requiring it.

6. Costs of labels and other miscellaneous supplies specific to crop enterprises and options. Identification of each market unit of bedding plants with a label containing a color photograph of the cultivar is essential. The cost of labels is included in crop-specific variable costs for this enterprise. Label costs are based on current suppliers' prices and are adjusted for appropriate quantity discounts.

In all crop-specific variable costs, producers participating in the program indicate that prices used in the model are in general agreement with prices paid by them for similar items.

Establishing Market Returns for Products Sold

The market for florist crops has heavy seasonal and holiday orientations. Perhaps the best examples of seasonally oriented crops are bedding plants and geraniums. Both are grown primarily for sale during April through June when the consumer is planting his garden and making other outdoor uses of flowering plants. Adverse weather conditions during this period can affect total sales. But, specialists in

these crops generally cover a wide enough geographical market area to be able to plan production with considerable certainty.

Nearly all potted plants and cut flower crops at some time in the production year are timed to serve the consumers' demands for holiday decorations for home and business, and for holiday gifts. Two crops, Easter lilies and poinsettias, are grown almost exclusively for the Easter and Christmas holidays respectively. However, potted chrysanthemums and the major cut flower crops - roses, carnations, chrysanthemums, snapdragons - are produced on year-round schedules with production peaks timed for the holiday and occasion markets when prices tend higher.

Producers of cut flowers generally market their crops through wholesale commission florists and pay a commission of 20-25% for the service. These producers generally do not set the price of their commodity but leave it to the judgment of the wholesaler based on market supply and demand for a given day. However, many producers do work closely with their wholesalers to establish a price range in which sales are to be made.

Potted crops on the other hand are generally sold directly by the grower to the retailer. The grower usually sets his price in advance and often issues a price list for major holidays. Accordingly, he exercises considerably more control over the pricing and sales of these crops. In estimating market returns for specific crops and internal options, price data from project participants serve as the primary basis. These values are verified by comparison with prices quoted in market reports and price quotations listed in trade paper reports and advertisements. Two

assumptions concerning marketing and pricing are made in the model:

1. Prices are assumed to remain constant throughout the period required to sell the entire crop, i.e. the last unit sold of a specific crop enterprise or option is assumed to bring the same price as the first and all other units sold.
2. The market is assumed to have the capacity to absorb the entire production of the model with the exception of crop enterprises and options listed in Table 11 for which market quotas are established. These quotas are set on the basis of discussions with managers who participated in the project.

For the longer run, it is assumed that once the manager has the optimum solution produced by the linear program as a planning guide:

1. As a part of the change from one production program to the other, the manager will carry out appropriate market development activities to ensure that the new product mix and quantities will be saleable at least at the market price used in the linear program model.
2. If a manager applies the optimum solution indicated he can change the crops grown and the production options and schedules used only over the period of one or more years, i.e. he will phase out of his present production programs and into the new program.

Prices used for crop enterprises and options are specified in Table 12.

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Table 11. Crop options with market quota.

Crop and option	Market quota (production units)
Bedding plants	
Potted petunias, Mother's Day	50.00
Potted marigolds, direct sown,	
Mother's Day	25.00
Memorial Day	25.00
Potted marigolds, transplanted,	
Mother's Day	25.00
Memorial Day	25.00
Potted impatiens, Memorial Day	12.00
Potted fibrous-rooted begonias, Memorial Day	12.00
Carnations, controlled holiday cropping	
Christmas	5.00
Valentine's Day	4.00
Easter	5.00
Mother's Day	6.00
Easter lilies	
Sell started plants, Feb 2, grades:	
10/11	3.00
9/10	3.00
8/9	6.00
7/8	3.00
Buy started plants, Feb 2, grades:	
10/11	5.00
9/10	5.00
8/9	10.00
7/8	5.00
Sell started plants, Mar 2, grades:	
10/11	3.00
9/10	3.00
8/9	6.00
7/8	3.00
Buy started plants, Mar 2, grades:	
10/11	5.00
9/10	5.00
8/9	10.00
7/8	5.00
Sell finished plants, Apr 2, grades:	
10/11	10.00
9/10	20.00
8/9	45.00
7/8	45.00

Table 11. (Cont'd).

Crop and option	Market quota (production units)
Geraniums, 40/1 program	
Sell started 12 inch stock plants, early Mar	1.00
Sell started 12 inch stock plants, mid Mar	2.00
Sell started 5 inch stock plants, mid Mar	1.00
Sell started 5 inch stock plants, late Mar	2.00
Sell started 7 inch stock plants, mid Mar	1.00
Sell started 12 inch stock plants, mid Dec	2.00
Sell started 12 inch stock plants, mid Jan	2.00
Sell started 12 inch stock plants, mid Feb	2.00
Sell finished 12 inch pots, Mother's Day	1.00
Sell started 7 inch stock plants, mid Feb	2.00
Sell started 7 inch stock plants, late Nov	2.00
Sell started 5 inch stock plants, late Feb	2.00
Sell finished 4 inch stock plants, Easter	2.00
Sell finished 4 inch stock plants, Mother's Day	12.00
Sell finished 4 inch stock plants, Garden sales	200.00
Sell finished 5 inch stock plants, Garden sales	200.00
Sell finished 7 inch stock plants, Garden sales	0.50
Sell finished 12 inch stock plants, Garden sales	0.25
12/1 program	
Sell finished 7 inch plants, Garden sales	0.50
Sell started 7 inch plants, mid Mar	1.00
Sell started 7 inch plants, late Dec	8.00
Sell started 7 inch plants, mid Feb	8.00
Sell finished 4 inch plants, Easter	2.00
Sell finished 4 inch plants, Mother's Day	4.00
Sell finished 7 inch plants, Mother's Day	2.00
Tree program	
Sell finished geranium trees, Mother's Day	1.00
Sell finished geranium trees, Garden sales	1.00
Sell finished 4 inch plants, Mother's Day	4.00
Poinsettias	
See figure 30.	
Potted chrysanthemums	
Crops which bloom in:	
August	6.00
September	6.00
October	6.00
Early November	6.00
Thanksgiving	8.00
Late November	5.00
Christmas	2.00

Table 11. (Cont'd).

Crop and option	Market quota (production units)
Potted chrysanthemums (cont'd)	
December	6.00
February	6.00
Valentine's Day	6.00
Early March	2.00
Late March	4.00
Easter	15.00
Late April (1)	4.00
Late April (2)	4.00
Mother's Day	25.00
Late May	4.00
Memorial Day	none
June	5.00
July	6.00
Roses	none
Snapdragons	none

Table 12. Wholesale market prices assigned crop options in the model.

Crop option		\$/each	\$/unit
Bedding plants:			
3 inch pot:			
petunia, Mother's Day		0.30	300.00/1,000 pots
marigold:			
Mother's Day		0.25	250.00/1,000 pots
Memorial Day		0.20	200.00/1,000 pots
impatiens, Memorial Day		0.30	300.00/1,000 pots
fibrous-rooted begonia,			
Memorial Day		0.30	300.00/1,000 pots
plants in trays, garden sales		2.30	460.00/200 trays
Carnations:			
standards:			
single-pinch program	Extra fancy	0.18	
multiple-pinch program	Fancy	0.15	2,050/400 ft ²
controlled holiday crops:	Standard	0.12	2,250/400 ft ²
Christmas	Design	0.06	
Valentine's Day	Miscellaneous	0.30	1,800/400 ft ²
Mother's Day			1,800/400 ft ²
Easter			1,800/400 ft ²
			1,450/400 ft ²
miniatures		1.89/bunch	2,800/400 ft ²
Easter lilies, 6 inch pots:			
less than 3 buds		1.25	1,250/1,000 pots
3 buds		1.75	1,750/1,000 pots
4-5 buds		2.25	2,250/1,000 pots
6-7 buds		2.50	2,500/1,000 pots
8-9 buds		2.75	2,750/1,000 pots
Geraniums			
(See Table 28.)			
Poinsettias			
(See Table 35.)			
Potted chrysanthemums, 6 inch pot		2.25	2,250/1,000 pots
Roses			
Hybrid teas		0.27/flower	3,240/400 ft ²
Floribundas		0.225/flower	2,700/400 ft ²

Table 12. (Continued.)

Crop option	\$/each	\$/unit
Snapdragons, single-stem		
November-March	1.60/doz	640/400 ft ²
April-October	1.32/doz	528/400 ft ²
Christmas, Easter, Mother's Day	1.80/doz	720/400 ft ²
Standard chrysanthemums		
pinched crops:		
July-November	4.25/doz	871/400 ft ²
June	4.50/doz	810/400 ft ²
December-May	5.00/doz	900/400 ft ²
Holidays	5.50/doz	1,100/400 ft ²
single-stem crops:		
July-November	4.25/doz	850/400 ft ²
June	4.50/doz	810/400 ft ²
December-May	5.00/doz	800/400 ft ²
Holidays	5.50/doz	880/400 ft ²

Estimates of Greenhouse Production Area and

Labor Coefficients for Crop Enterprises and Options

The production program for the crop enterprises and their internal options are selected as enterprise alternatives for use in the model on the basis of several factors. First, the programs reflect the most modern approaches recommended by Cooperative Extension and other trade advisory groups on the basis of availability of precision technology and equipment for the process. Second, those systems which utilize the latest tested and industry-accepted crop cultivars are given priority. Finally, only production processes which have been adopted by a substantial number of industry managers are included. All programs are in use by two or more producers in the 16-firm group from which estimates were drawn. Greenhouse production area coefficients are generally easy for interviewees to specify in that they are familiar with pot sizes, cut crop and pot spacings, frequency and dates of planting, and spacing adjustments made in potted plants as these crops grow and develop. The standard units of crops used in the model are:

For Potted Crops. The production area required by 1,000 pots of a crop, regardless of pot size used, at a given spacing is considered to equal one unit of greenhouse production area for potted crop enterprises or options. Production area coefficients are established in multiples of one week, i.e. a potted crop is assumed to be grown at a given space requirement for a minimum of one week and for periods of longer duration, in multiples of the one-week time unit. This standard

for determining production space required is selected in that no other meaningful standard adequately recognizes differences imposed by the use of various pot sizes and of different spacings of pots during specific time components of the production program for a given crop. Also, the differences in time components among the various crop enterprises and options are adequately treated by use of this standard.

For Cut Flower Crops. A production bench unit 100 feet long and 4 feet wide or 400 ft² per week is considered a production unit for cut flower purposes in the model. As for potted crops an enterprise or option is required to occupy the bench space in multiples of one-week time periods. This 400 ft² unit is selected primarily because these dimensions represent typical bench units in cut flower firms. Of course, spacing of the plants in the bench units varies with the enterprise or option.

For Bedding Plants. Two hundred standard 11"x22" plastic trays each containing 12 plastic packs per tray and spaced tray-to-tray are considered a greenhouse production area unit for this crop enterprise. This unit represents 340 ft² per week and may occupy space only in multiples of one week. This tray/pack combination is the one typically used by Michigan bedding plants producers. Number of plants per pack varies by species of bedding plant; the number again is based on general practice among firms studied. Potted bedding plant options are specified in the same units used for potted crops in general.

Coefficients for permanent employee complement are estimated in units of manhours per week. The production program for each crop enterprise or option is analyzed in terms of major crop-specific tasks which

must be performed. Managers specify or estimate the number of manhours required in their firm to perform the task. These data are then interpreted into manhours per greenhouse production area unit of the enterprise or option and provide the basis for manhour per week estimates of labor coefficients for each of the crop alternatives.

An additional labor-use factor is considered in determining the final labor coefficients. Two manhours per week are added to the coefficient determined in the manner just described for each greenhouse production area unit of the enterprise. The rationale is that non-crop specific labor and managerial tasks essential to the production and operation of the firm are performed by the permanent employee complement and must be pro-rated across all units of production. Included in the two-hour per week per unit factor are the time the manager and his family spend in the performance of such tasks as production and business planning and control, general supervision, purchasing, marketing, customer and community relations, accounting and other office work, and similar activities. Both managerial and labor force input into non-crop specific tasks are included, i.e. maintenance of greenhouses and related facilities, non-mechanized watering and fertilization when necessary, pest management, hand-ventilation when required, general clean-up, heating plant operation, general pick-up and delivery activities, and numerous other minor non-crop specific tasks. Vacation and sick days are also accounted for in the two hour per week factor as are part-time employees utilized for general tasks, e.g. students employed in the summer to perform greenhouse and other facility maintenance.

There is a tendency for the managers of the firms studied to estimate a somewhat lower manhour per week per production unit value for this non-crop specific labor use. They eliminate from consideration much of the time devoted to these tasks, and especially to the management function, on the basis that it is work done by the manager after hours, on weekends and during other "free time" and should not be charged against the crop enterprises.

Input-output coefficients for each of the crop enterprises and options are developed from estimates made by managers participating in the study. Rarely, does the person interviewed have data recorded on which to base these estimates. Rather, the coefficients must be developed in intensive interview sessions in which managers estimate coefficients based on their first-hand knowledge of the practices, tasks and procedures involved in each crop production program.

Estimates from two or more firms producing each crop enterprise or option are carefully compared. Where one or more firms vary substantially from the other firms in their estimates, a basis for the differences is sought initially by careful review of the production process to determine ways in which the deviant firm performed differently. Where no reasons for the variation can be determined, the producer is contacted either by telephone or a second visit and re-interviewed. In most cases, a rationale for extreme differences in coefficients estimates is determined.

CHAPTER III

ANALYSES MADE WITH THE MODEL

The model firm is used as a vehicle to analyze and compare the several modes of enterprise specialization and combination generally used by floriculture producers. These include: (1) specialization by crop or monocropping, (2) specialization by a combination of potted crops and bedding plants or by cut flower crops, (3) diversification with the production of a wide range of crops. Table 13 summarizes these modes.

Crop Specialization

Specialization by crop or monocropping is a common production alternative chosen by many flower growers. To examine this approach, production options within a number of major crops are analyzed using the fixed resources of the model firm. Crops studied include standard chrysanthemums for cut flowers, carnations, snapdragons, poinsettias, potted chrysanthemums and geraniums. Discussion of the results of these analyses follows. All analyses are discussed in terms of one calendar-fiscal year constituted of 52 weeks.

Comparison of Production Options for Carnations

Two types of carnations are produced for the cut flower market-standards and miniatures. Standard carnations are large-flowered types disbudded to allow only the terminal bud to develop. Miniatures are

Table 13. Descriptive summary of models used in study.

Model	Internal options
Carnation specialization	standard carnations: single-pinch production program multiple-pinch production program miniature carnations controlled holiday cropping for: Christmas Valentine's Day Easter Mother's Day
Standard chrysanthemum specialization	pinched crops to produce one crop per month single-stem crops to produce one crop per month
Snapdragon specialization	single-stem crops to produce one crop per month; option to: produce own seedlings purchase seedlings
Potted chrysanthemum specialization	one crop per month and for Christmas, Valentine's Day, Easter and Mother's Day
Poinsettia specialization	stock plant program to produce for sale unrooted and rooted cuttings, started plants in 2 1/4 inch and 4 inch pots, and finished pinched and single stem blooming plants in 4, 5, 6, 7, 8, and 12 inch pots, and finished stock plants in bloom finished pinched and single stem blooming plants in 4, 5, 6, 7, 8 and 12 inch pots from purchased propagation material
Potted geranium specialization	options for production for sale of unrooted and rooted cuttings, started plants in 2 1/4 inch and 4 inch pots, started stock plants in 5, 7 and 12 inch pots, and finished crops in 4, 5, 7 and 12 inch pots for Easter, Mother's Day, garden sales and Memorial Day. Programs in which these options occur are: 40/1, 25/1, 12/1, 8/1, 5/1, 2.5/1 and the tree geranium program.
Diversified crops program	all specialization program options plus: roses for cut flowers: hybrid teas floribundas bedding plants: potted petunias and marigolds for Mother's Day and garden sales: - direct-sown option - transplanted option potted impatiens and fibrous-rooted begonias for garden sales petunias, marigolds, impatiens, fibrous-rooted begonias, tomatoes in packs and trays for garden sale: - direct sown option - transplanted option Easter lilies: controlled temperature forcing program home case-cooled or non-pre-cooled program case-cooled or pre-cooled program (for all three programs, opportunity is offered to buy and/or sell started plants at two points in the production program)

Table 13. (Continued).

Model	Internal options
Potted plant specialization	all potted options listed in above programs: potted chrysanthemums poinsettias geraniums Easter lilies bedding plants
Cut flower specialization	all cut flower options in above programs: carnations standard chrysanthemums snapdragons roses
Bedding plant specialization January-May; diversified crops program June-December	all options in bedding plant specialization for January-May period; other crops June-December including all options of poinsettias, and those options of carnations, snapdragons, standard chrysanthemums, potted chrysanthemums and gerani- ums which can be produced within the limits of this period.
Bedding plant and geranium specialization	all options of bedding plants and geraniums
Employment of temporary labor	with fixed resources of 75,000 ft ² greenhouse production area and 400 hours per week of per- manent employee labor, the model provides the options to hire temporary hourly employees at \$2.00, \$3.50 and \$5.00 per hour.

smaller-flowered cultivars in which all flower buds are allowed to develop to produce a spray of small flowers on a stem. The terminal bloom is removed because it flowers earlier than laterals and is usually fading when the spray is marketable.

Carnations are a long-term crop when compared with most other cut flowers. Standard chrysanthemums and snapdragons may be produced in 3-4 months whereas the usual carnation production options occupy bench space for 1-3 years depending on crop vigor, freedom from disease, and grower preference. Carnations are in greatest demand during winter and spring, but also find acceptable markets at other times of the year.

Carnation cropping is determined by time of pinching of the crop. The new growth which develops following pinching generally produces a peak of bloom in 4-6 months depending on the season of year. Major carnation holidays are Easter, Mother's Day, Christmas and Valentine's Day. Red carnations are in primary demand for the latter two holidays.

Two major cropping programs are currently used by standard carnation producers. And, there is considerable discussion among them as to which system or combination of systems are most productive and profitable. The systems are described as follows:

Single or terminal-pinch system

Under this regime, plants receive only an initial terminal pinch approximately 4 weeks after planting. The crop generally responds with two complete crops during the next 40-45 week period. This system tends to allow more accurate timing of crops for peak markets.

Multiple or pinch-and-a-half system

All plants receive an initial pinch as in the single pinch system. About 6 weeks later the most vigorous shoots are pinched again. Cropping

is spread over a longer period of time, and the initial peak of bloom occurs 5-6 weeks later than plants grown in the single-pinch system. Proponents of this system suggest that this delay peaks the crop in late fall and early winter when demand and prices are generally better.

In recent years, "controlled holiday cropping", a short-term production program, has been introduced as a means of supplementing standard carnation production for peak markets. Some producers also use it to ensure consistency of grade during less optimum growing periods for the long-term plantings. Under this program, cuttings are planted and single-pinch to time them for a specific period of bloom. Two to three blooms per plant are produced simultaneously. The plants usually are discarded after initial bloom. Because plants are in the bench for only 24 to 30 weeks, they are spaced 4 by 6 inches rather than the usual 6 by 8 inches used for long-term options. Of course, the tighter spacing also bolsters yield per square foot.

The production program for miniature carnations uses a single pinch or with some cultivars no pinch at all. Plants are spaced 4 by 6 inches. Otherwise the production program is essentially that used for standards except that temperatures 3-5F higher are used.

Carnation options included in the model

The model greenhouse firm is utilized to study the profitability of the three systems of standard carnation production as well as the miniature carnation option. The manager has available the options described in Table 14. The following information supplements that in the table:

Table 1ha. Carnations: production options available in the model.

Production option	Yield 400 ft ² production unit (stems)	Spacing inches	ft ² /plant	Week planted	Week plants removed	Time in bench (weeks)	Photoperiodic treatments L = lights
<u>Carnations</u>							
<u>Standard:</u>							
Single-pinch	16,000	6 x 8	.33	Jun 1	May 5	52	None
Multiple-pinch	16,000	6 x 8	.33	Mar 4	Mar 3	52	None
Miniature	16,000	4 x 6	.17	1/3 Mar 1	Oct 3 ^a /	52	None
				1/3 Jun 1	Oct 3 ^a /	52	None
				1/3 Aug 1	Oct 3 ^a /	52	None
<u>Controlled holiday cropping:</u>							
Christmas	6,000	4 x 6	.17	Jul 2	Dec 3-4	24	L
Valentine's Day	6,000	4 x 6	.17	Aug 2	Feb 2	27	L
Easter	6,000	4 x 6	.17	Oct 1	Apr 3	29	L
Mother's Day	6,000	4 x 6	.17	Nov 2	May 2	26	L

^a/ of next production year

Table 14b. Carnations: summary of optimal crop mix.

Production Option	Market returns \$/bloom	Market returns \$/400 ft ² unit	Market quota (400 ft ²)	Optimal crop mix (400 ft ² production units)	Total return to fixed costs (\$/production unit)	Marginal return (Shadow price) (\$/400 ft ² unit)	Opportunity costs (\$/400 ft ² unit)
Carnations							
Standard:							
Single-pinch	a/	2,050		38.18	78,269.00		631.65
Multiple-pinch	a/	2,250		0	0		
Miniature							
	2.00/bunch ^{b/}	2,800		18.92	52,976.00		
Controlled holiday cropping:							
Christmas	0.30	1,800	5.00	5.00	9,000.00	1,442.83	
Valentine's Day	0.30	1,800	4.00	4.00	7,200.00	1,406.79	
Easter	0.25	1,450	5.00	1.75	7,250.00		
Mother's Day	0.30	1,800	6.00	4.80	8,640.00		

^{a/} Market returns based on assumptions of following grades and prices:

	% in grade	Price/bloom (\$)
Extra fancy	9	0.18
Fancy	30	0.15
Standard	52	0.12
Design	5	0.06
Miscellaneous	4	0.03

^{b/} bunch = about 10 stems

Single-pinch standard carnation option

Cuttings are planted directly in the bench in the first week of June and the plants removed one year later in the fifth week of May. This option occupies production area for 52 weeks.

Multiple-pinch standard carnations

Carnation producers plant cuttings for the multiple-pinch standard carnation option in peat pots 10-12 weeks prior to benching. This practice presumes that benching of a well-developed plant will favorably affect subsequent growth and flower production. To account for this practice in the model, 104 ft² of additional production area is assigned to each 400 ft² production unit for the weeks March 4 through June 1. Hence, greenhouse production area assigned this option for this period includes 104 ft² for the potted cuttings, and 400 ft² for the crop currently in production. Additional heat, pots and other input costs for the potted phase are included in the variable costs for this option.

Miniature carnation option

As indicated in Table 14 one-third of this option is planted at each of three times in the production year for the purpose of providing more uniform levels of production throughout the year. Further, the option requires continuation of each of these plantings through the third week of October of the second year to take advantage of a favorable early fall market. Thus, the planting made in the first week of March is in the bench 86 weeks, the June planting 72 weeks, and the August planting 64 weeks. Fixed resources of greenhouse production area and labor, variable inputs specific to each option, and market returns for each option reflect these multi-year aspects.

The optimal crop mix

Table 15 summarizes carnation options in the optimal crop mix.

Table 15. Carnation options and number of units of each in optimal crop mix.

Production option	Number of units in mix	Market limits (units)
Standard carnations single pinch	38.18	none
Standard carnations multiple pinch	none	none
Miniature carnations	18.92	none
Controlled holiday cropping:		
Valentine's Day	4.00	4.00
Easter	1.75	5.00
Mother's Day	4.00	6.00
Christmas	5.00	5.00

The multiple-pinch system of producing standard carnations is the only option which does not appear in the optimal crop mix. The solution indicates that total returns net of variable costs will be reduced by \$631.65 for each unit of this practice which is used in place of more profitable options. In other words, for each unit of multiple-pinch system carnations, an option not in the optimal mix, which is produced in place of other carnation programs which are identified in the optimal mix, returns to the fixed costs will be reduced by \$631.65.

Controlled holiday cropping options for standard carnations are assigned market limits. The Valentine's Day and Christmas options are produced to meet these limits. The Mother's Day option falls only 1.2 units short of the allowable 6.0 units. Only 30 percent of the

allowable 5.0 units of the Easter option come into the optimal mix.

Nearly 19 units of miniature carnations occur in the optimal mix.

The greenhouse production area fixed resource was used in the range of 34 to 45% capacity by the optimal carnation crop mix. The long-term nature of the major carnation options couples with market limitations on the short-term controlled holiday cropping options to provide relatively little flexibility in combining activities for maximum use of production area. Figure 1 depicts greenhouse production area useage through the year. Weeks in the year when the labor resource is limiting are indicated.

The pattern of labor use for long-term carnation options including the miniature option is characterized by a relatively low but regular weekly input of labor into harvest. Unlike chrysanthemums and snapdragons where harvest occurs in the final 1 or 2 weeks of the production cycle, long-term carnation options are harvested during most of the last 9 months of their production cycle. The harvest operation though requiring a low weekly input by virtue of its continuation over a 9 month period easily accounts for the majority of total labor input. Bench preparation / planting operations and final crop removal account for major peaks in the cycle. Disbudding coincides with and continues as long as the harvest operation and accounts for a steady labor input through the latter three-fourths of the production cycle. Because of the program objectives, controlled holiday cropping is not characterized by continuous harvest. Rather, the option incurs two major labor peaks, one at bench preparation/planting and one at harvest.

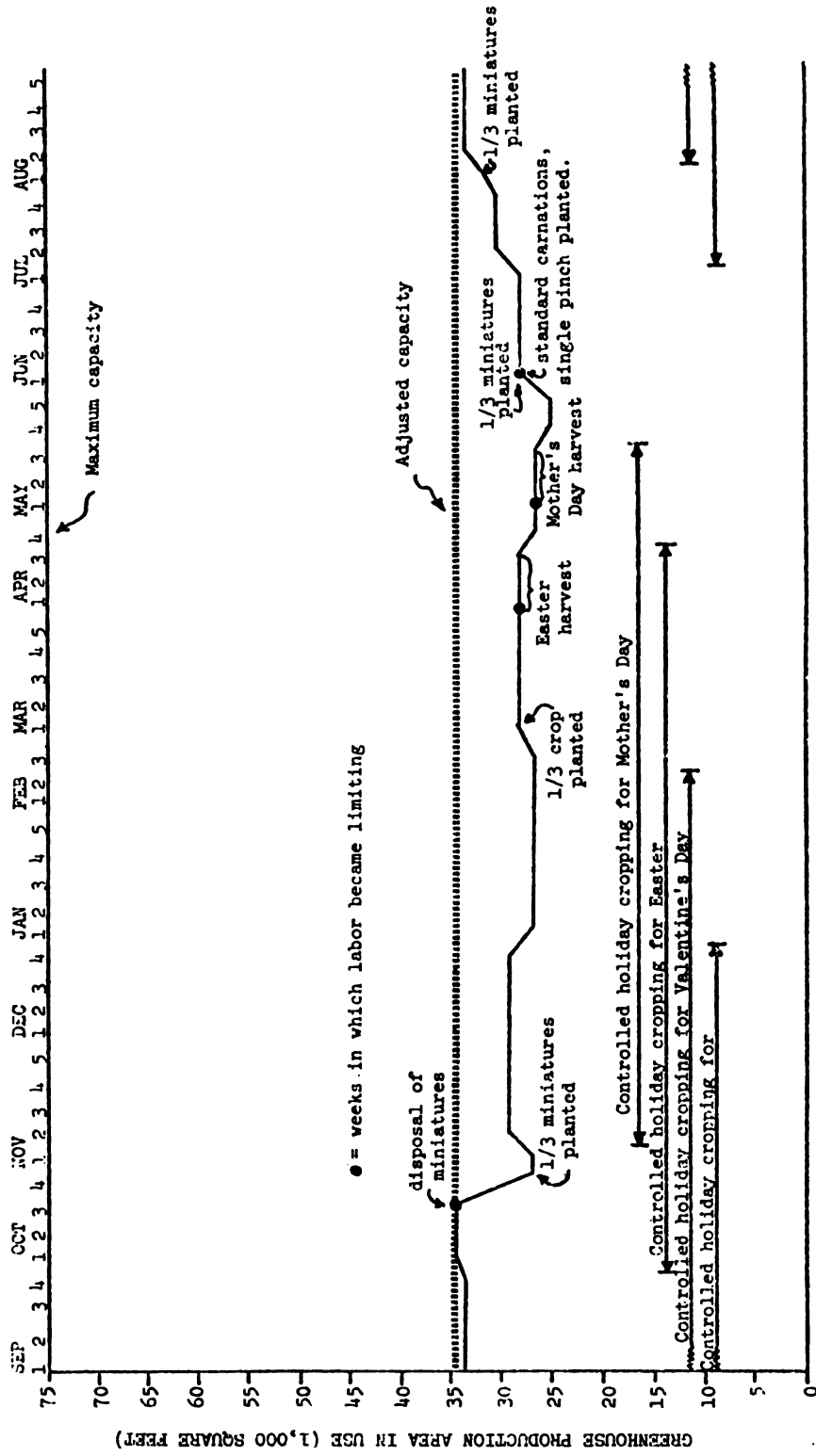


Figure 1. Carnation: greenhouse production area used in optimal crop mix.

In 4 weeks of the 52-week production year, the level of labor resource limits further use of greenhouse production area. Marginal returns, i.e. the amount by which return to fixed resources would be increased if one more unit of labor were available, for each of these periods, are given in Table 16. Table 17 and Figure 2 summarize labor resource use.

Table 16. Carnations: production periods in which labor is limiting; marginal returns for labor in those periods.

Production week	Marginal return per hour of labor (\$)
October 3	45.00
April 1	127.00
May 1	26.91
June 1	11.52

Table 17. Carnations: summary of use of 600 hours/week of permanent employee resource.

Excess labor capacity (hours)	Number of weeks in year with excess labor capacity
0	4
1-50	5
51-100	1
101-200	11
201-300	14
301-400	14
401-450	3
451-600	0
	52

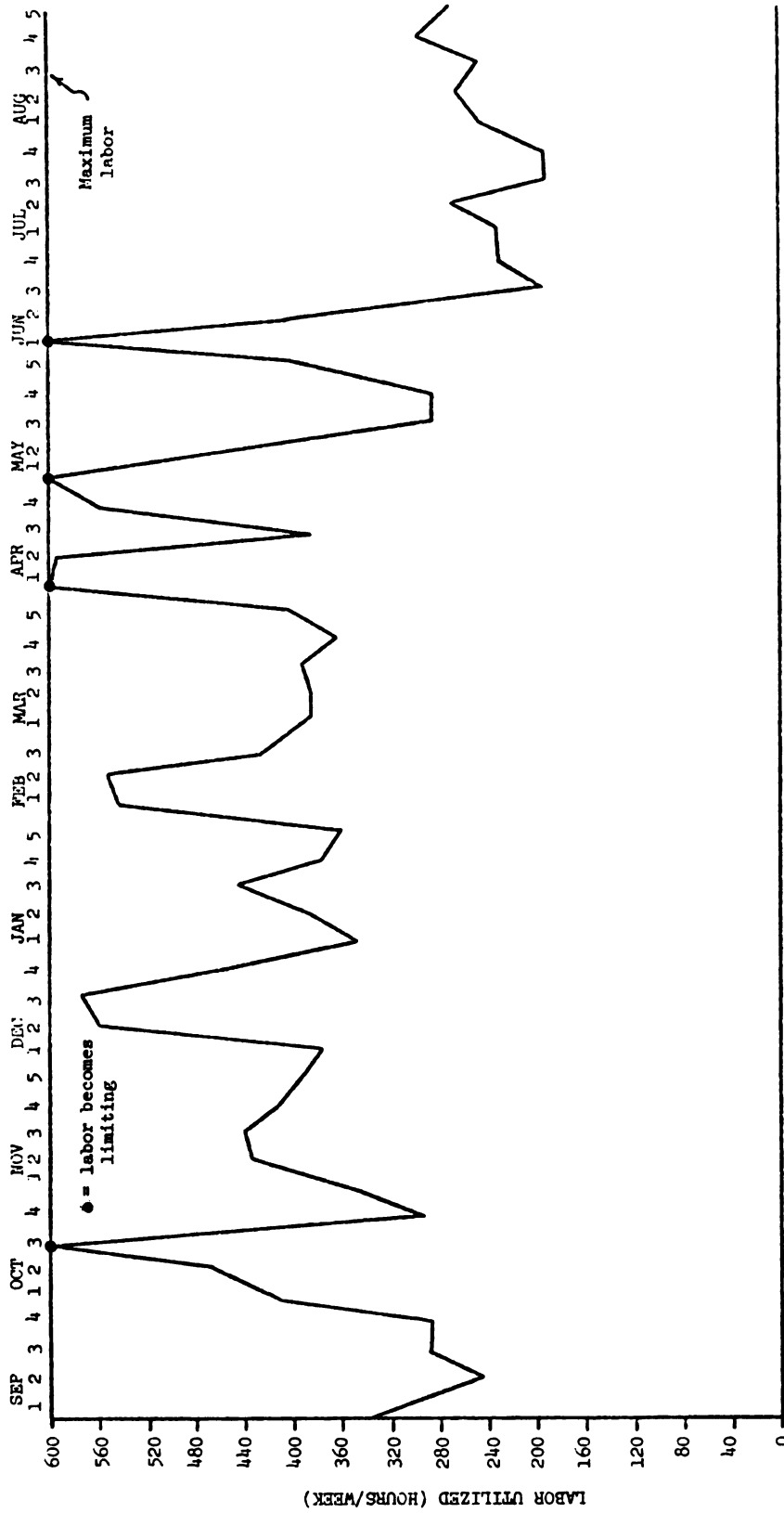


Figure 2. Carnation: permanent employee resource use in optimal crop mix.

Market limits are imposed on controlled holiday options based on the nature of demand for carnations at these periods. The optimal crop mix contains full production quotas for only the Valentine's Day and Christmas options. Shadow prices (marginal returns), the amount by which total returns to fixed resources are reduced for not producing an additional unit of the option, are \$1406.79 and 1422.83 respectively for these options. The other options are not produced to the limits imposed.

The carnation optimal mix generates \$139,000 total return to fixed costs per year, or \$1.87 per ft² of total production area. This mix yields net return (loss) to fixed costs, i.e. returns after fixed costs incurred to provide 75,000 ft² of greenhouse production area and 600 hours of labor are deducted, of -\$73,074.00 or -\$0.97 per ft².

However, if the carnation program is charged the fixed cost for only the greenhouse production area actually used to produce the amount of the crop in the optimal mix, e.g. about 35,000 ft² and for all 600 hours per week per year of permanent employee complement, then total return (loss) to fixed resources is -\$15,022 or -\$0.43 per ft² per year.

On the other hand, if proportionately more hours of labor are provided to fill the 75,000 ft² of production area with the carnation optimal mix, total return (loss) to fixed resources is -\$32,096 or -\$0.43 per ft².

Production guidelines which emerge from analysis of optimal crop mix

A number of production guidelines emerge based on analysis of the optimal crop mix:

1. The single-pinch system of producing standard carnations is a more efficient program than the multiple-pinch approach. While the multiple-pinch option returns \$200 more per unit of

production than the single-pinch option it also requires additional labor and 104 ft^2 more production area per unit for the 10-week pre-benching, potted phase of production. Further, more labor is required for the additional pinching operation. Essentially, the single-pinch and multiple-pinch programs are identical except for these differences in inputs and returns. Where the labor and space resources available are fixed, and market returns for the product are the same, the program requiring the least of each of these resources should likely emerge in the optimal crop mix.

2. The level of permanent labor resource limited further use of production area at four points in the year. In two of these weeks, June 1 and October 3, major crop planting operations and major crop removal activities respectively accounted for exhaustion of the labor resource. With the exception of the peak labor needs generated by annual planting and removal of crops and by harvest peaks at holiday times, the labor requirement for long-term carnation options is relatively uniform throughout the year. The short-term controlled holiday cropping system imposes additional peak labor requirements primarily at holidays when harvest requirements of long-term options are swelled by this supplemental production. The other two weeks in the year in which labor is limiting are April 1 and May 1, weeks in which harvest occurs for the peak Easter and Mother's Day markets respectively. Marginal returns for labor in the April 1 week are highest at \$127.00 per hours. This demand

for labor is influenced not only by the Easter harvest of both single-pinch program and Easter controlled holiday option, but also by the demand for labor in this week for disbudding Mother's Day crops to be harvested 4 weeks later. Similar competition for the labor resource does not occur with other controlled holiday options because of the greater time period between their harvest dates. These situations exemplify the need for the carnation operation manager to consider carefully how the major labor-requiring tasks of planting, disbudding, harvesting and crop-plant disposal mesh among the production schedules for the options. Where conflict in these operations indicates labor resource limitations, selection of alternative production options, or employment of temporary labor for peak periods become necessary considerations.

3. By their occurrence in the optimal crop mix, controlled holiday cropping options are shown to be economically valid for supplementing long-term production programs for peak holiday markets. While each of these options occupies production area for about one-half the time required for the long-term options, and yet yields only one-third to one-half the number of flowers per production unit, grade is generally better and peak harvest occurs at holidays when prices are considerably higher. There are fewer operations requiring labor input because pinching and plant maintenance practices essential for long-term options are unnecessary.

4. Miniature carnations emerge as the second major component in the optimal crop mix. This option occupies a greater amount of bench area per production unit over a longer period of time because of the nature of the cropping system. Labor input is somewhat greater per unit but returns to fixed resources also are greater. However, the greater returns apparently are countered by the option's greater use of the fixed resources of space and labor.
5. The optimal crop mix favors those options which make most efficient use of fixed resources. Given available precision production technology, it is questionable whether production systems which require additional labor and space inputs ostensibly for the purpose of building more vigorous plants, e.g. the standard carnation multiple-pinch system, should be carefully evaluated for validity before being implemented by the modern floriculture firm.

Before concluding discussion of the carnation options, it is important to note that long-term programs do not lend themselves well to analysis within the 52-week production year of the model. The standard carnation multiple-pinch and the miniature carnation options require more than a year to complete and would be more accurately analyzed within a two-year time frame. Some compromise with the actual industry situation has been made through the various assumptions necessary to fit these options into an annual model. The optimal mix and its analysis should be considered with this in mind.

Comparison of Production Options for Standard

Chrysanthemums for Cut Flowers

Standard chrysanthemums for cut flowers are grown year-round. Specialists in this crop produce three to four crops annually. Growers of diversified crops produce chrysanthemums only at times selected to mesh with their markets and production timetable for other crops.

The chrysanthemum blossoms in response to temperature and photoperiod. At 60F night temperatures, and under long-day conditions, the plant is vegetative; given short days at this temperature, flowers initiate and develop. The chrysanthemum flowers naturally in the fall in the northern United States. Through the use of lights and/or black shade cloth, the crop may be manipulated to flower in any week of the year. Precise schedules for year-round flowering of specific cultivars are provided by major chrysanthemum propagators.

The chrysanthemum grower has the options of producing a single-stemmed crop, or of pinching the plant and allowing two blooms to develop. Pinched crops are given about twice the spacing as single-stemmed crops and so require about half the number of plants. Spacing for both options is further influenced by grade of cut flower desired and the light intensity as it varies from season to season, i.e. greater spacing fall and winter, closer spacing spring through summer. The major production input difference between the pinched and the single-stemmed production option is that the latter requires about twice the number of rooted cuttings with which to start the crop. Single-stemmed crops generally require two to three weeks less production time and do not require the pinching labor input, 2 hours per unit of production

area (400 ft²).

Other variations in production inputs apply to both pinched and single-stemmed crops alike and stem from differences in heating costs and photoperiodic requirements as determined by season of production. The costs of photoperiodic manipulation include those of lighting equipment, electricity and/or black shade cloth, and the labor to daily cover and uncover the crop with cloth during the required shading period.

Standard chrysanthemum options included in the model

The manager of the model greenhouse operation has the option of producing pinched or single-stemmed crops timed to bloom at least once per month and for the major holidays of Easter, Mother's Day, Thanksgiving and Christmas. The options are specified in Table 18a. Market quotas are established only for the four major holiday crops.

Yield per 400 ft² unit of production area ranges between 160 and 205 dozen blooms depending on seasonal spacing. Also, the yield for pinched crops is slightly favored by use in the model of the grower practice of allowing three stems per plant to develop on outside rows of the bench. Pinched crops occupy bench space for two to three weeks longer depending on season than do single-stemmed crops. Pinched crop time-in-bench ranges from 18 to 22 weeks ; single-stemmed crops from 15 to 19 weeks. Market returns vary with the crop based on seasonal and holiday price fluctuations. Hence, revenue from a 400 ft² production unit varies with seasonal production requirements in terms of plant spacing, heat, and photoperiodic requirements, and with market demand as reflected in price. The "Returns to fixed resources" column in

Table 18a. Standard chrysanthemums: production options available in the model.

Production options	Yield per 400 ft ² production unit (dozen)	Spacing		Week planted	Week harvested	Time in bench (weeks)	Photoperiod treatments B = blackcloth L = lights RL = blackcloth and lights
		inches	ft ² /plant.				
Pinched crops:							
October	205	6 x 8	0.33	Jun 2	Oct 2	18	B
November	205	6 x 8	0.33	Jul 1	Nov 2	19	B
November	205	7 x 8	0.39	Jul 3	Nov 4	19	BL
December	180	7 x 8	0.39	Aug 1	Dec 2	20	B
Christmas	205	7 x 8	0.39	Jul 4	Dec 3	22	BL
January	180	7 x 8	0.39	Aug 3	Jan 2	22	BL
January	180	7 x 8	0.39	Sep 4	Jan 2	22	L
March	180	7 x 8	0.39	Oct 3	Mar 2	21	L
Easter	180	7 x 8	0.39	Nov 3	Apr 2	22	L
Mother's Day	180	7 x 8	0.39	Dec 3	May 2	19	L
June	180	7 x 8	0.39	Feb 1	Jun 2	20	BL
July	200	6 x 8	0.33	Mar 3	Jul 2	19	BL
August	200	6 x 8	0.33	Apr 3	Aug 2	19	BL
August	200	6 x 8	0.33	Apr 3	Aug 5	18	B
Single stem crops:							
October	200	4 x 6	0.16	Jun 4	Oct 2	16	B
November	200	4 x 6	0.16	Jul 4	Nov 2	16	B
Thanksgiving	200	5 x 6	0.20	Aug 1	Nov 4	17	B
December	160	5 x 6	0.20	Aug 3	Dec 2	18	R
Christmas	200	5 x 6	0.20	Aug 3	Dec 3	19	BL
January	160	5 x 6	0.20	Sep 3	Jan 2	17	BL
February	160	5 x 6	0.20	Oct 2	Feb 2	18	BL
March	160	5 x 6	0.20	Nov 2	Mar 5	19	L
Easter	160	5 x 6	0.20	Dec 2	Apr 2	18	L
Mother's Day	160	5 x 6	0.20	Jan 2	May 2	18	L
June	160	5 x 6	0.20	Mar 1	Jun 1	16	BL
July	200	4 x 6	0.16	Apr 1	Jul 2	15	BL
August	200	4 x 6	0.16	May 2	Aug 2	13	BL
August	200	4 x 6	0.16	Jun 1	Aug 5	13	B

Table 18b. Standard chrysanthemums: summary of optimal crop mix.

Production options	Market returns \$/dozen	\$/400 ft ²	Market quota (400 ft ² units)	Total return to fixed costs (\$)	Optimal crop mix 400 ft ² production units	Opportunity cost (\$/400 ft ² unit)	Marginal return (Shadow price) (\$/400 ft ² unit)
Pinched crops:							
October	4.25	871		718.34	23.82		
November	4.25	871		710.66	7.29		
December	5.50	1128	10	952.76	10.00		194.55
Christmas	5.00	900		740.49	25.36		
January	5.50	1128	10	940.67	5.66		
February	5.00	900		718.72	6.49		
March	5.00	900		769.99	34.75		
Easter	5.00	900		749.36	41.10		
Mother's Day	5.50	990	12	835.53	12.00		262.75
June	5.50	990	10	841.66	10.00		369.79
July	4.50	810		633.95	36.81		
August	4.25	871		694.90	36.16		
August	4.25	871		706.40	9.62		
August	4.25	871		719.98	34.52		
Single stem crops:							
October	4.25	850		602.75	0	262.00	
November	4.25	850		593.43	8.97		
Thanksgiving	5.50	1100	10	839.39	6.50		
December	5.00	800		520.70	0	34.97	
Christmas	5.50	1100	10	817.72	10.00		60.60
January	5.00	800		569.35	0	230.96	
February	5.00	800		537.33	15.42		
March	5.00	800		575.25	10.48		
Easter	5.50	880	12	664.72	7.52		
Mother's Day	5.50	880	10	671.70	10.00		522.90
June	4.50	900		661.01	7.60		
July	4.25	850		585.74	0	25.46	
August	4.25	850		593.03	0	113.37	
August	4.25	850		604.42	0	401.96	

Table 18t reflects the revenue from each production option after the cost of production inputs specific to the option are deducted.

The optimal crop mix

Table 18b specifies the number of units of each production option in the optimal mix. Pinched options predominate with units of all 14 such options in the mix. Units of only eight of the 14 single-stemmed options occur in the mix. The holiday options for which highest prices are assigned are produced to the level of market limits imposed with the exception of the pinched Christmas crop and the single-stemmed Easter and Thanksgiving crops. In these latter three options, level of production is more than one-half the number of units allowed by the market limitation. Production options appear to come into the optimal mix generally on the basis of level of return to fixed resources. As expected, among the pinched options, number of weeks in the bench, i.e., the greater use of the fixed resource of greenhouse production area, influences selection with those options in the mix in greatest quantity requiring generally fewer weeks in the bench. This is not the case among the single-stemmed options where returns to fixed resources appear to be the primary basis for selection of the option.

The pattern of labor use in the chrysanthemum crop has major peaks at bench preparation/planting, disbudding and harvest. Additional labor inputs are required for installation of lights and manipulation of black cloth in those options which require one or both photoperiodic treatments.

The fixed labor resource becomes limiting in 17 of the 32 weeks

Table 19. Standard chrysanthemums: production periods in which labor is limiting and marginal returns for labor in those periods.

Production week	Marginal return per hour of labor (\$)
Sep 1	16.32
3	16.70
Oct 1	38.08
4	15.64
Nov 2	21.45
Dec 1	25.49
2	28.58
4	47.23
Feb 1	3.05
3	36.48
Mar 1	19.15
3	10.46
Jun 1	57.28
4	29.28
Jul 1	14.65
4	17.17
Aug 1	23.10

Table 20. Standard chrysanthemums: summary of use of 600 hours/week of permanent employee resource.

Excess labor capacity (hours)	Number of weeks in year with excess labor capacity
0	17
1-50	7
51-100	3
101-200	12
201-300	10
301-350	3
351-600	0
	52

as indicated in Table 19. The marginal return for an additional hour of labor at each of these periods is also given. These marginal returns suggest that the employment of temporary help in each of these 17 weeks will allow the manager to increase productivity of his fixed resources. A higher percentage of available greenhouse production area likely will be used, and the permanent employee complement will be more fully utilized. Table 20 summarizes the use of this latter resource. While greenhouse production area is not limiting in any period, it is nearly completely used during the period of the third week of October through the second week of November. The lowest level of usage occurs the third week in July when only about 50% of the production area is in use. The patterns of greenhouse space and labor use and those points at which the exhaustion of the labor resource occurs are shown in Figures 3 and 4. In those crops for which market limits are imposed, the marginal returns are listed in Table 21.

Table 21. Standard chrysanthemums: marginal returns for holiday crop options with market limits.

Holiday crop option	Market limit (production units)	Marginal returns (\$)
Pinched crops:		
Easter	12	262.75
Mother's Day	10	369.79
Thanksgiving	10	294.55
Christmas	10	limit not met
Single-stemmed crops:		
Easter	12	limit not met
Mother's Day	10	522.96
Thanksgiving	10	limit not met
Christmas	10	60.64

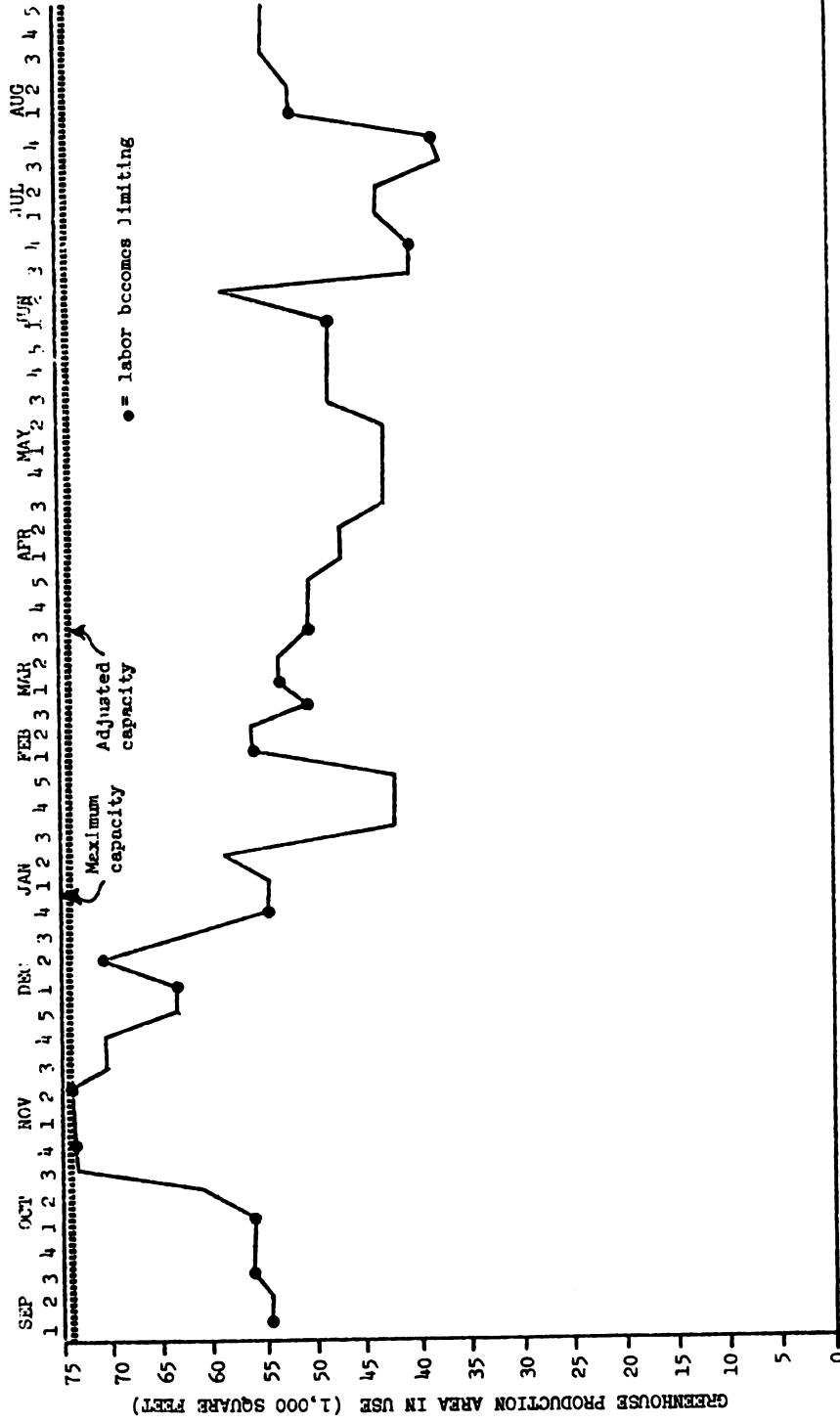


Figure 3. Standard chrysanthemums: greenhouse production area used in optimal crop mix.

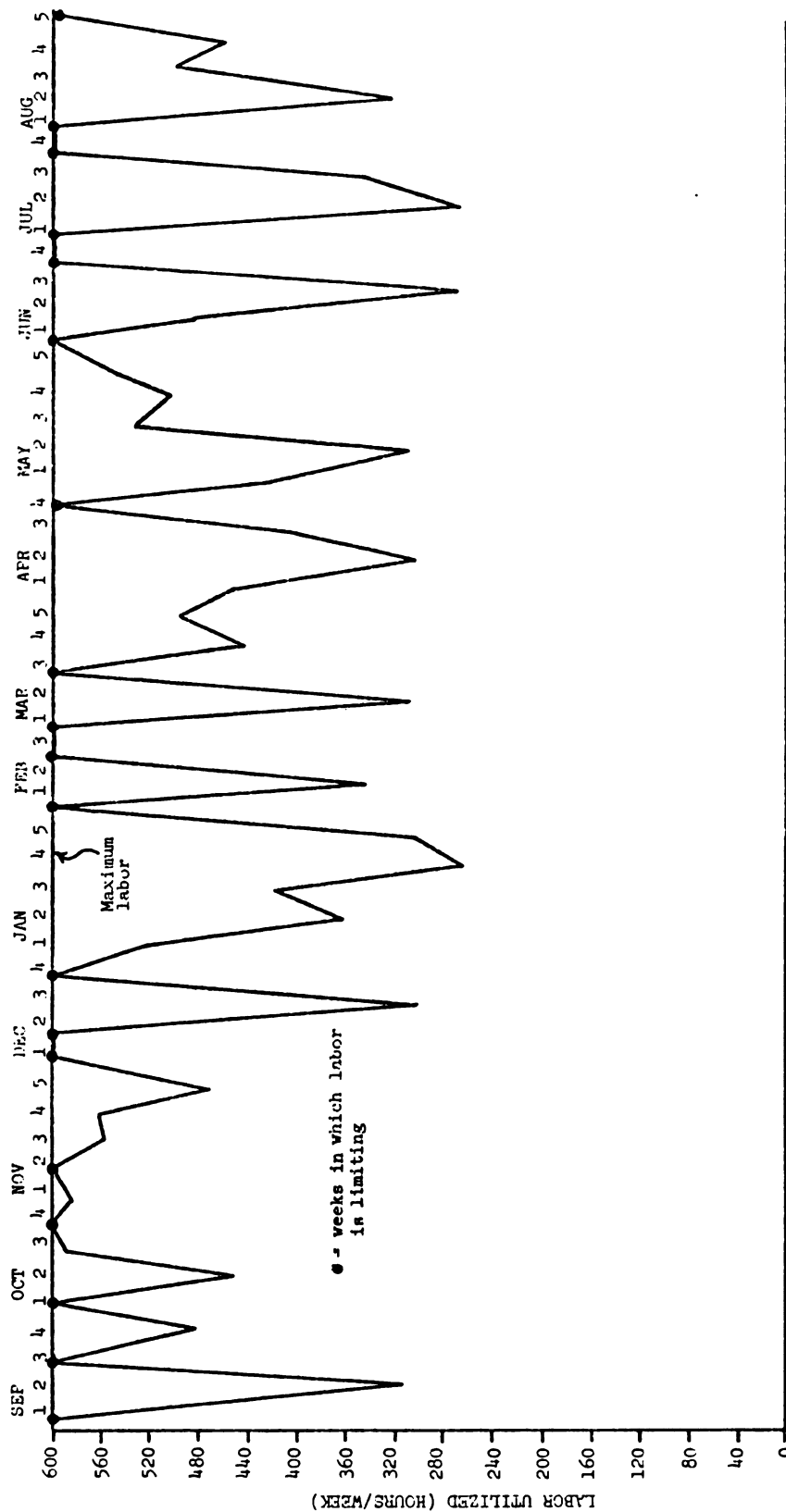


Figure 4. Standard chrysanthemum: permanent employee utilization in optimal crop mix.

Six single-stemmed production options do not appear in the optimal mix. These options are listed in Table 18b along with the costs in terms of reduction in total returns to fixed resources should the manager choose to produce these non-optimal enterprises. The standard chrysanthemum optimal mix generates \$266,710 total return to fixed costs per year, or \$3.56 per ft² of total production area. This mix yields net return (loss) to fixed costs, i.e. returns after fixed costs incurred to provide 75,000 ft² of greenhouse production area and 600 hours of labor are deducted, of \$54,688 or \$0.73 per ft². However, if the standard chrysanthemum program is charged the fixed cost for only the greenhouse production area actually used to produce the amount of the crop in the optimal mix, e.g. about 65,000 ft² and for all 600 hours per week per year of permanent employee complement, then total return to fixed resources is \$69,188 or \$1.06 per ft² per year. On the other hand, if proportionately more hours of labor are provided to fill the 75,000 ft² of production area with the standard chrysanthemum optimal mix, total return to fixed resources is \$80,170 or \$1.07 per ft².

Production guidelines which emerge from optimal crop mix

Production management guidelines may be identified for standard chrysanthemums grown for cut flowers on the basis of the analysis:

1. Pinched standard chrysanthemum production options provide greater net return to the use of the fixed resources of labor and greenhouse production area than do single-stemmed crops. The major factor which appears to give these options the advantage is the lower input cost for cuttings with which the crop is started. Because two blooms are produced per plant in

pinched options, and because plants are given about twice the spacing, cost of cuttings incurred per unit of production is about half even though essentially the same or somewhat higher yield is achieved. The assumption is made that a comparable grade of cut chrysanthemum will be produced under each option.

2. Among pinched options, those which come into the optimal mix generally tend to be the options with highest return to fixed resources. While this is not as generally true of single-stemmed options, the tendency is there. This is predictable in that labor input does not differ greatly among pinched and single-stemmed options. Most of it occurs during soil preparation, disbudding and harvest, all operations which require essentially the same input per stem regardless of whether the crop is grown pinched or single-stemmed. And, while there is considerable variation among options in numbers of weeks of greenhouse production area required, those options which require fewest weeks coincide in production with periods when market prices for their yield tend to be among the lowest of the year. Consequently, the production area advantage appears to be offset by the price disadvantage.

In summary, with relatively few differences in the required input of fixed resources of labor and greenhouse production area among the various options, returns to fixed resources from the options are closely tied to a combination of the levels of variable input costs incurred and market prices received. The most significant production input affecting the solution is cost of cuttings. As a result, pinched crops, which require about one-half the number of cuttings per unit as single-

stemmed options, and which yield slightly more than twice the blooms per production unit, predominate in the optimal crop mix. However, any change by the manager in his spacing or in the number of blooms which he grows per pinched plant, which in turn affects both crop yield and quality, will alter the optimal crop mix.

Comparison of Production Options for Single-stemmed Snapdragon Crops

Snapdragons for cut flowers are produced throughout the year. Specialist wholesale growers account for the majority of production although many retail producers also grow bench lots. In recent years, snapdragon production in the northern United States has declined because market returns have been inadequate to justify production. The snapdragon is a spike flower and is readily substituted for by the omnipresent gladiolus, readily available from Florida and other distant production areas for most of the year. Further, snapdragons do not ship well, and do not have long storage life.

Snapdragons crops are started from seed. Most growers propagate their own although seedlings are available from suppliers. Crops may be grown single-stem or pinched. In recent years wholesale growers have essentially abandoned pinched crops in favor of single-stem culture to assure better and more uniform quality, and more precision crop-timing. Unlike chrysanthemum cuttings, snapdragon seedlings represent a considerably lower input cost thereby allowing the better prices received for the higher quality single-stem crops to easily overcome the somewhat higher cost incurred by the use of greater numbers of seedlings in this option. Snapdragon specialists program production to supply

a continuous flow to market during most weeks of the year. The crop is grown at 50F nights thereby having a considerably lower heating cost input than most other major crops. The rate of development of the crop is readily influenced by temperature. This makes timing of the crop difficult. A period of bright light and/or warm weather can substantially speed development. Consequently, precise production management is essential to maintain marketing schedules.

The length of time required to produce a crop of snapdragons varies with the season. Crops harvested in mid to late summer are produced in as few as 11 weeks; mid to late winter-flowering crops may require 23 weeks of bench time. Table 22a specified other aspects of snapdragon production programs.

Snapdragon production options included in the model

The major objective of this portion of the study is to determine the profitability of specialization in snapdragons. The manager is given the options of producing snapdragons for major holidays and at least one crop in those months in which no holidays occur. In an actual industry situation, a grower would have much greater flexibility in scheduling, and a snapdragon specialist tends to program his operation to have some supply for market in all weeks of the year. Of course, greatest production is scheduled generally for peak market periods. In the model, only a monthly sampling of options, and holiday options are used in order to keep the problem of manageable proportions.

The manager also has the option of starting each crop from seed or purchasing seedlings from a supplier. The cost of variable inputs to produce seedlings is \$8.00 per 400 ft² unit of production option.

Table 22a. Snapdragons: production options available in the model.

Production options: single-stem crops to bloom	Production Seedlings	Production unit (ft ²) Crops	Yield per production unit (dozen)		Spacing for crop production inches ft ² /plant		Seedling production Week planted Week harvested		Crop production Week planted Week harvested		Time in bench (wks) Seedlings Crops	
			production unit (dozen)	unit	inches	ft ² /plant	Week planted	Week harvested	Week planted	Week harvested	Seedlings	Crops
January	10	400	400		3 x 4	0.08	Aug 2	Aug 5	Aug 5	Jan 2-3	3	21
February	10	400	400		3 x 4	0.08	Aug 5	Sep 3	Sep 3	Feb 2-3	3	23
March	10	400	400		3 x 4	0.08	Sep 3	Oct 2	Oct 2	Mar 2-3	3	23
April	10	400	400		3 x 4	0.08	Oct 3	Nov 2	Nov 2	Apr 1-2	3	22
May	10	400	400		3 x 4	0.08	Nov 4	Dec 3	Dec 3	Apr 4-May 1	3	20
June	10	400	400		3 x 4	0.08	Jan 4	Feb 3	Feb 3	Jun 3-4	3	19
July	10	400	400		3 x 4	0.08	Apr 3	May 2	May 2	Jul 3-4	3	12
August	10	400	400		3 x 4	0.08	Jun 3	Jul 1	Jul 1	Aug 3-4	3	12
September	10	400	400		3 x 4	0.08	Jun 3	Jul 2	Jul 2	Sep 2-3	3	11
October	10	400	400		3 x 4	0.08	Jul 3	Aug 3	Aug 3	Oct 2-3	3	15
November	10	400	400		3 x 4	0.08	Jul 4	Aug 3	Aug 3	Nov 3-4	3	15
December	10	400	400		3 x 4	0.08	Aug 1	Aug 4	Aug 4	Dec 2-3	3	18

Table 22b. Snapdragons: summary of optimal crop mix.

Production options: single-stem crops to bloom	Market return \$/dozen	Market return \$/400 ft ²	Optimal crop mix (400 ft ² production units)			Total return to fixed costs (\$/400 ft ²)	Opportunity cost (\$/400 ft ²)	
			purchase seedlings	grow seedlings	finished crops		purchase seedlings	grow seedlings
January	1.60	640	0	36.91	36.91	616.84	10.44	
February	1.60	640	4.59	0	4.59	609.34		11.33
March	1.60	640	0	35.73	35.73	605.51	10.04	
April	1.80	720	0	28.03	28.03	683.52	11.80	
May	1.80	720	0	4.43	4.43	691.40	11.64	
June	1.32	528	0	34.81	34.81	513.13	11.63	
July	1.32	528	0	44.20	44.20	525.03	11.85	
August	1.32	528	36.83	a/	36.83	525.03		
September	1.32	528	0	36.49	36.49	525.30	11.98	
October	1.32	528	0	0	0	523.86	124.14	112.16
November	1.60	640	0	2.09	2.09	632.52	11.98	
December	1.80	720	0	42.03	42.03	704.37	11.98	

a/ no option provided.

The total cost of purchased seedlings per unit is \$20.00. The former option requires labor and production area inputs; the latter does not. Market quotas were not established for any of the options.

Yield per 400 ft² of production area (one production unit) is set at 4,800 stems or 400 dozen based on a 3 by 4 inches spacing of plants. Market returns range from \$1.32 per dozen for summer crops to \$1.80 per dozen for holiday crops. The major variables in return to fixed costs are differences in market returns and in the heating input as it varies with season. Return to fixed costs for each option are specified in Table 22b.

The optimal crop mix

The optimal crop mix is specified in Table 22b. In that each option requires about the same major labor input, the factors which tend to influence whether an option occurs in the mix are the number of weeks in the bench and the returns to fixed costs. The latter, of course, reflects primarily differences among the options in market price and heating inputs.

Only the crop option scheduled for October bloom fails to occur in the mix. Total return to fixed resources would be reduced by \$112.14 per unit of this option produced instead of an optimal option. Review of the program for the October option reveals a minor coding error which resulted in adding 2 weeks to the production time for the crop. This error also places the planting period for this option in direct conflict with that for the September crop, an option which blooms 4 weeks earlier than the October crop, and for which return to fixed resources is slightly more than those for the October crop.

Under these circumstances, the September option should consistently be favored in the solution especially under conditions where the fixed labor resource is ultimately limiting.

All other options occur in the optimal crop mix in the range of 28 to 44 units each with the exception of those crops which bloom in February, late April and late November. These options occur in the optimal mix to the extent of 4.59, 4.43 and 2.09 units respectively. Analysis of production programs for these options indicates that each of them is competitive with another option for the labor resource during either peak planting or harvest periods. Consequently, the option which contributes most favorably to the optimum mix is programmed in a greater number of units.

Table 23. Snapdragons: Production periods in which labor is limiting, marginal returns for labor resource in these periods.

Week	Marginal return per hour of labor (\$)
Sep 2	20.64
Sep 3	3.71
Oct 2	28.90
Nov 2	42.65
Dec 3	51.96
Feb 3	29.78
May 2	34.04
Jun 1	39.66
Jul 2	14.54
Aug 4	3.08
Aug 5	25.96

Table 24. Snapdragons: use of 600 hours/week available permanent employee resource

Hours of excess labor capacity	Number of weeks in year with excess labor capacity
0	11
1-50	2
51-100	5
101-200	4
201-300	5
301-400	8
401-500	17
501-600	0
	52

In all cases except that of the February-blooming crop, production programs in the optimal crop mix are started from seed. For the February crop because the labor resource is limiting for 3 of the 4 weeks in the period required for seedling production, seedlings are purchased. For all purchase-seedling options, the reduction in total return to fixed costs is in the range of \$10-12 per production unit produced in place of one propagated from seed.

The pattern of labor use in the snapdragon crop is characterized by major peaks of input in the bench preparation/planting operation and at harvest. In a mechanized operation there is relatively little crop-specific labor expended in the period between these operations. Limitations in the availability of labor ultimately prevent the entire greenhouse from being programmed for production. The 4 weeks in which the labor resource is exhausted and the marginal returns for the resource in these weeks are shown in Table 23. In all cases, labor becomes limiting in weeks when planting and harvest operations occur. In that

these operations represent the only major labor inputs in the crop, this result is predictable. Marginal returns for the labor resource show the weeks of Dec 3, Nov 2, Jun 1, and May 2 to be the periods when one additional unit of labor resource would contribute most to the returns to fixed costs. Again, as would be expected with the labor input pattern for this crop, considerable excess labor is available in the weeks in which neither planting nor harvesting operations occur. Table 24 specifies these levels. In a real situation where the manager is cropping on a weekly or biweekly basis, instead of on a monthly basis as was necessary in the model, these amounts of excess labor would be considerably reduced as greater numbers of planting and harvesting operations came into the optimal crop mix.

The fixed resource of greenhouse production area does not become limiting at any point in the production year. Figures 5 and 6 depict the pattern of greenhouse and labor use, respectively. Points at which the available labor resource limits further use of greenhouse production area are also indicated.

The snapdragon optimal mix generates \$176,952 total return to fixed costs per year of \$2.36 per ft² of total production area. This mix yields net return (loss) to fixed costs, i.e. return after fixed costs incurred to provide 75,000 ft² of greenhouse production area and 600 hours of labor are deducted, of -\$35,122 or -\$0.47 per ft². However, if the snapdragon program is charged the fixed cost for only the greenhouse production area actually used to produce the amount of the crop in the optimal mix, e.g. about 60,000 ft² and for all 600 hours

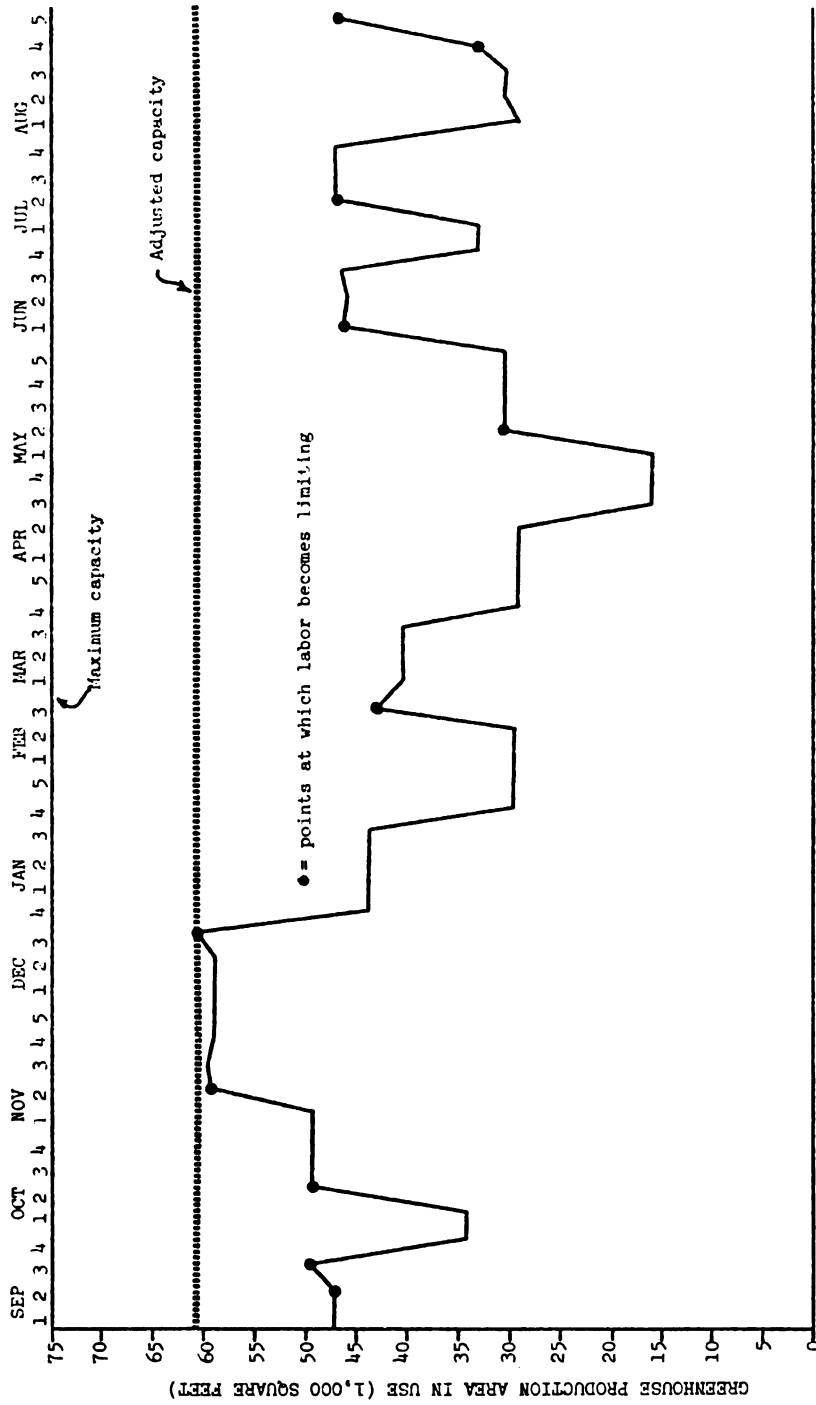


Figure 5. Snapdragon: greenhouse production area utilized in optimal crop mix

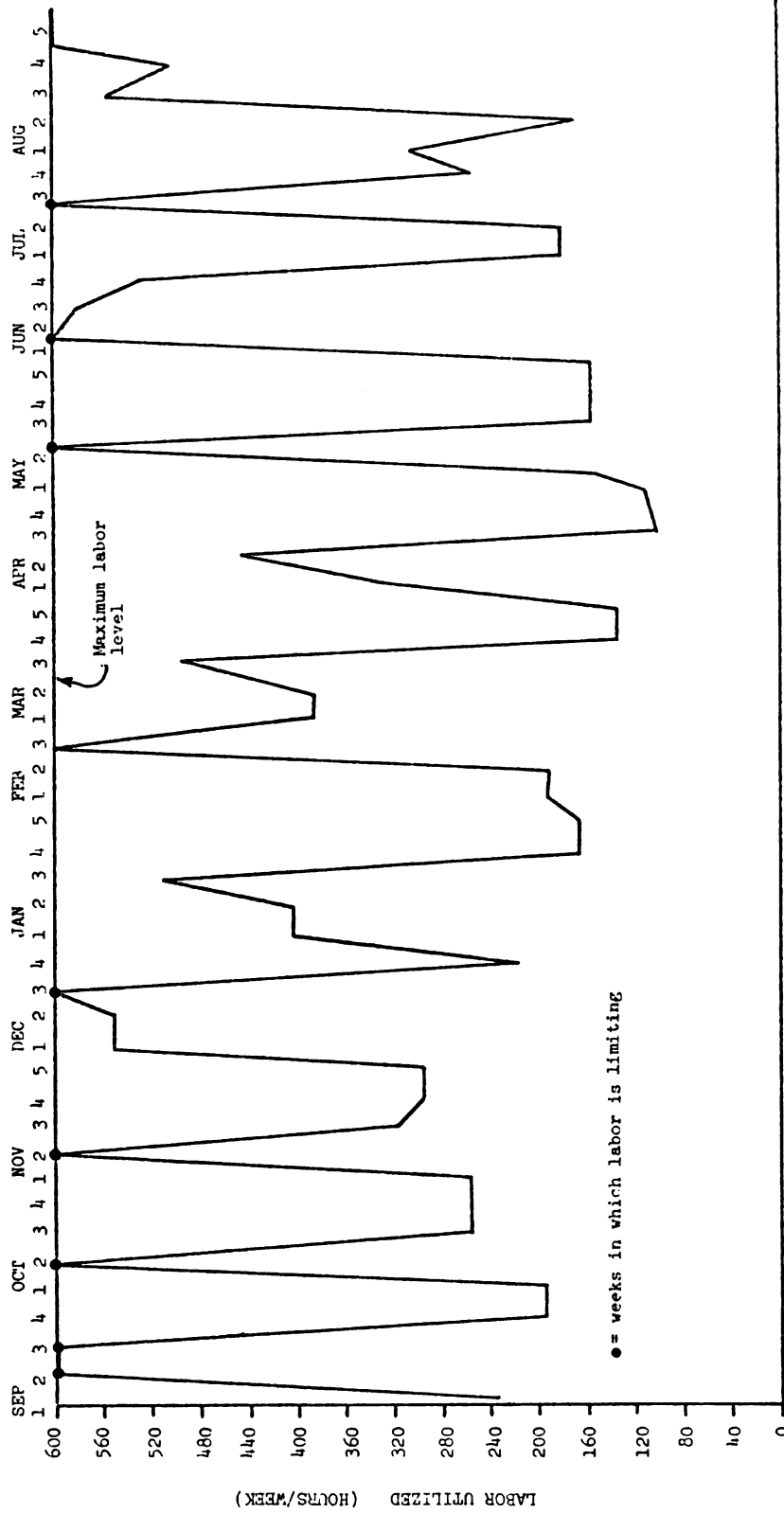


Figure 6. Snapdragon: permanent employee resource utilization in optimal crop mix.

per week per year of permanent employee complement, then total return (loss) to fixed resources is -\$13,320 or -\$0.22 per ft² per year.

On the other hand, if proportionately more hours of labor are provided to fill the 75,000 ft² of production area with the snapdragon optimal mix, total return (loss) to fixed resources is -\$16,590 or -\$0.22 per ft².

Production guidelines which emerge from analysis of the optimal crop mix

Production guidelines which may be identified based on the optimal mix follow:

1. As noted earlier, production options appear to come into the optimal crop mix primarily on the basis of number of weeks in the bench and returns net to fixed resources. Differences in the latter value among various options stem primarily from variations in market prices received and the cost of the heating input. Assuming at least a fair degree of labor efficiency, and knowing that heating costs are difficult to reduce, it would appear that increases in profitability in the snapdragon crop must come primarily from increased market returns.
2. Production of snapdragon seedlings with which to start the crop is the optimal alternative to buying seedlings from a propagator. The space and labor input are sufficiently small to make this practice economically favorable over the purchase option.
3. With the exception of the four crop options noted, all options are well represented in the optimal crop mix. The three

options which occur in lesser numbers of units, i.e. crops which bloom in February, late April and late November, could be rescheduled to avoid the present conflict with high labor inputs of other options. If this were done, one would predict that these options would be more heavily represented in this solution, thereby guaranteeing the desired uniform production pattern through the year.

4. In a real situation where a grower schedules to bring units into bloom on a weekly or biweekly basis rather than on a monthly basis as in the model, and given the labor use pattern for this crop, careful production planning to avoid conflicts in planting and harvest operations will result in considerably more efficient use of fixed labor resources.

Comparison of Production Options for Potted Chrysanthemums

Potted chrysanthemums are produced in every week of the year. Their diversity in color and form and their durability in the marketing process and in the consumer's home make them a highly acceptable product. They are produced with four to six plants per 5 inch or 6 inch pot. Increasingly, 4 inch pots containing one plant are finding acceptance particularly for mass market sales.

Potted chrysanthemums are grown from cuttings purchased from specialist propagators. Because chrysanthemums bloom in response to photoperiod, manipulation of day length with lights and black shading cloth make possible year-round production. Most chrysanthemum cultivars used

for potted crops are in the 10-week response group, that is, they require 10 weeks to bloom following the onset of short-day conditions. Total production time for a crop will vary between 11 weeks for summer crops to 12-15 weeks for crops produced other times of the year. Most growers are able to produce four crops per year per unit of production area. Of course, through proper scheduling, most specialists will have crops available every week of the year. Potted mums are grown for most major holidays with Thanksgiving, Easter and Mother's Day producing the greatest demand. Christmas and Valentine's Day represent minor demand peaks.

The usual production procedure for potted chrysanthemums is to place pots with five newly planted cuttings directly in a "nurse" area for a period of 1 to 3 weeks depending on the season of the year. In this area, warm temperature and high humidity are provided to initiate rapid establishment. Because mist facilities are required, plants are spaced pot to pot during this period. Thereafter, they are given increased spacing with some growers moving them directly to their final spacing.

Plants are pinched usually once and growth regulator sprays applied to control plant height and form. Most producers use automatic watering systems to irrigate and fertilize the crop. Potted chrysanthemums are grown at 60F night temperature.

Potted chrysanthemum options in the model

Most producers grow potted mums according to the procedures just outlined. The major point of decision for the manager lies in the scheduling of crops to meet the demands of the market at prices sufficiently

favorable to make the crop profitable. Production options available to the manager of the model firm are specified in Table 25, and include the opportunity to produce a crop at least once a month and for all major holidays.

The production unit is 1,000 6 inch pots, each containing five cuttings. This unit consumes 330 ft² of "nurse" area for 1 to 3 weeks, depending on the season. Pots are moved directly to final spacing from the "nurse" area. Photoperiodic treatments are provided as required.

As under present real market conditions, market return is set at a standard value for all crops including holiday options. In the model, this price is \$2.25 per 6 inch pot or \$2,250 per 1,000 pot production unit. Market quotas are established for all options except Memorial Day. Return to fixed costs in Table 25b specify revenue from the options after crop-specific variable costs are deducted but before fixed costs of greenhouse production area and labor are deducted.

The optimal crop mix

All production options come into the optimal crop mix to the limit of market quotas with the exception of the Easter crop and an option scheduled to bloom in the fourth week of December. The Easter crop is produced in 11.40 of the possible 15 units, and the December crop in 5.86 of the 6.00 unit quota. Table 25b specifies the number of units of all other options in solution.

Both level of return to fixed costs and weeks of bench time required are the primary factors influencing selection of crop options in the optimal mix. Marginal return is highest for the four options

Table 25a. Potted chrysanthemums: production options available in the model.

Production options: month of bloom	Production unit (number of 6 inch pots)	Spacing			Week planted	Week harvested	Time in bench (weeks)	Photoperiodic treatment B = blackcloth L = lights BL = blackcloth and lights
		Nursery area weeks	area (ft ²)	Production area weeks				
August	1000	1	330	10	Jun 1	Aug 3	11	B
September	1000	1	330	11	Jul 1	Sep 3	12	B
Late October	1000	2	330	11	Aug 1	Oct 4	13	L
Early November	1000	2	330	11	Aug 3	Nov 2	13	L
Thanksgiving	1000	2	330	12	Aug 3	Nov 3	14	L
Late November	1000	2	330	10	Sep 1	Nov 4	12	L
Christmas	1000	2	330	12	Sep 3	Dec 3	14	L
December	1000	2	330	11	Oct 1	Dec 4	13	L
February	1000	3	330	12	Nov 1	Feb 1	15	L
Valentine's Day	1000	3	330	12	Nov 2	Feb 2	15	L
Early March	1000	3	330	11	Dec 1	Mar 2	14	L
Late March	1000	2	330	11	Dec 4	Mar 4	13	L
Easter	1000	2	330	12	Jan 2	Apr 2	14	L
Late April (1)	1000	2	330	11	Jan 3	Apr 4	13	L
Late April (2)	1000	2	330	10	Feb 1	Apr 4	12	L
Mother's Day	1000	2	330	11	Feb 1	May 1	13	L
Late May	1000	1	330	11	Mar 1	May 3	12	BL
Memorial Day	1000	2	330	11	Mar 1	May 4	13	BL
June	1000	1	330	11	Apr 2	Jun 4	12	BL
July	1000	1	330	11	May 2	Jul 4	12	B

Table 25b. Potted chrysanthemums: summary of optimal crop mix.

Production options: month of bloom	Market return \$/pot	\$/1000 pots	Market quota (production units)	Optimal crop mix (production units)	Total return to fixed costs (\$/production unit)	Marginal return (Shadow price) (\$/production unit)
August	2.25	2,250.00	6.0	6.0	1703.87	1703.87
September	2.25	2,250.00	6.0	6.0	1700.88	1700.88
Late October	2.25	2,250.00	6.0	6.0	1706.23	1706.23
Early November	2.25	2,250.00	6.0	6.0	1690.07	694.47
Thanksgiving	2.25	2,250.00	8.0	8.0	1690.89	1590.38
Late November	2.25	2,250.00	5.0	5.0	1673.19	1537.42
Christmas	2.25	2,250.00	2.0	2.0	1633.76	49.84
December	2.25	2,250.00	6.0	5.86	1629.17	0
February	2.25	2,250.00	6.0	6.0	1598.27	1553.02
Valentine's Day	2.25	2,250.00	6.0	6.0	1609.05	477.68
Early March	2.25	2,250.00	2.0	2.0	1607.80	1555.75
Late March	2.25	2,250.00	4.0	4.0	1612.21	650.75
Easter	2.25	2,250.00	15.0	3.56	1609.41	0
Late April (1)	2.25	2,250.00	4.0	4.0	1620.55	11.14
Late April (2)	2.25	2,250.00	4.0	4.0	1644.08	1370.45
Mother's Day	2.25	2,250.00	25.0	12.37	1637.75	0
Late May	2.25	2,250.00	4.0	4.0	1625.77	779.95
Memorial Day	2.25	2,250.00	None	6.67	1633.15	0
June	2.25	2,250.00	5.0	5.0	1676.85	1080.56
July	2.25	2,250.00	6.0	6.0	1699.58	1699.58

which have the highest return to fixed costs per unit and which require relatively fewer weeks (11-13) of bench time, e.g. crops scheduled to bloom the fourth week in July, the third week in August, the third week in September, and on the fourth week in October. Market options are met first in these options. Table 25b specified marginal return (shadow price), weeks in bench, market quotas and units in the optimal mix for all options.

Beyond these four options, the quantity of an option in the optimal crop mix appears to be determined by one or more of these factors: (1) the degree to which it does not compete with the four most profitable options for the limiting labor resource, (2) number of weeks in the bench, and (3) returns to fixed costs. Input factors which determine returns to fixed resources include pots, soil, plants, heat and photoperiodic treatments. Only the latter two factors vary among the options.

The pattern of labor use in potted chrysanthemums is characterized by peak inputs at time of potting, at disbudding (6-8 weeks before harvest), and at harvest. Minor amounts of labor are used when pots are moved from the "nurse" area to final spacing, at pinching, and during the period black shade cloth is pulled over crops.

Labor is the fixed factor which limits further production. The supply is exhausted in four of the 52 weeks. Tables 26 and 27 summarize use of the labor resource and specify marginal return for weeks in which labor is limiting. These prices range from \$23.85 to \$45.25 per hour indicating that managerial action to alter availability of the

Table 26. Potted chrysanthemums: production periods in which labor is limiting and marginal returns for labor resource in those periods.

Production week	Marginal returns per hour of labor (\$)
Nov 2	42.25
Mar 1	26.03
Mar 4	41.34
Apr 2	23.85

Table 27. Potted chrysanthemums: summary of use of 600 hours/week of permanent employee resource.

Excess labor capacity (hours)	Number of weeks in year with excess labor capacity
0	4
1-50	2
51-100	0
101-200	2
201-300	4
301-400	15
401-500	19
501-600	6
Total weeks	52

labor resource or to reschedule periods of its peak use would increase considerably use of both greenhouse production area and permanent employee complement. Returns to the use of these fixed resources thereby would increase.

Greenhouse production area, the other fixed factor in the model, does not become limiting at any point. Range of use is from a maximum of 57,897 ft² during the third and fourth weeks in March to a minimum of 16,500 ft² during the fifth week of May. Pattern of space and labor use is shown in Figures 7 and 8, respectively.

The potted chrysanthemum optimal mix generates \$179,365 total return to fixed costs per year, or \$2.39 per ft² of total production area. This mix yields net return (loss) to fixed costs, i.e. returns after fixed costs incurred to provide 75,000 ft² of greenhouse production area and 600 hours of labor are deducted, of -\$32,709 or -\$0.43 per ft². However, if the potted chrysanthemum program is charged the fixed cost for only the greenhouse production area actually used to produce the amount of the crop in the optimal mix, e.g. about 58,000 ft² and for all 600 hours per week per year of permanent employee complement, then total return (loss) to fixed resources is -\$8,007 or -\$0.14 per ft² per year. On the other hand, if proportionately more hours of labor are provided to fill the 75,000 ft² of production area with the potted chrysanthemum optimal mix, total return (loss) to fixed resources is -\$4,849 or -\$0.06 per ft².

Production guidelines which emerge from analysis of the optimal crop mix

Within the range of the situation on which this problem is based, production guidelines for potted chrysanthemums may be offered. Static market returns through the year and relatively uniform patterns of labor

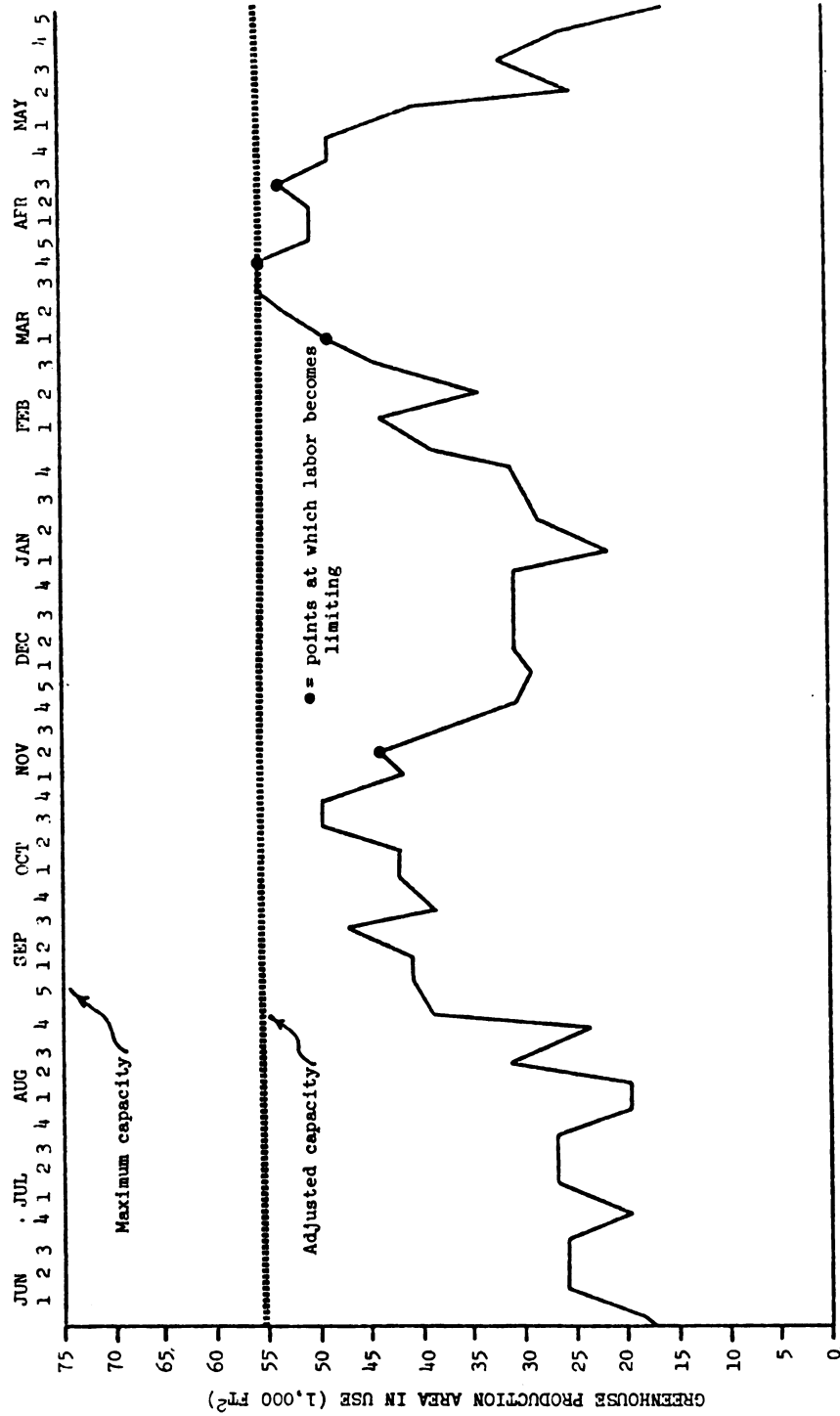


Figure 7. Potted chrysanthemum: greenhouse production area in optimal crop mix.

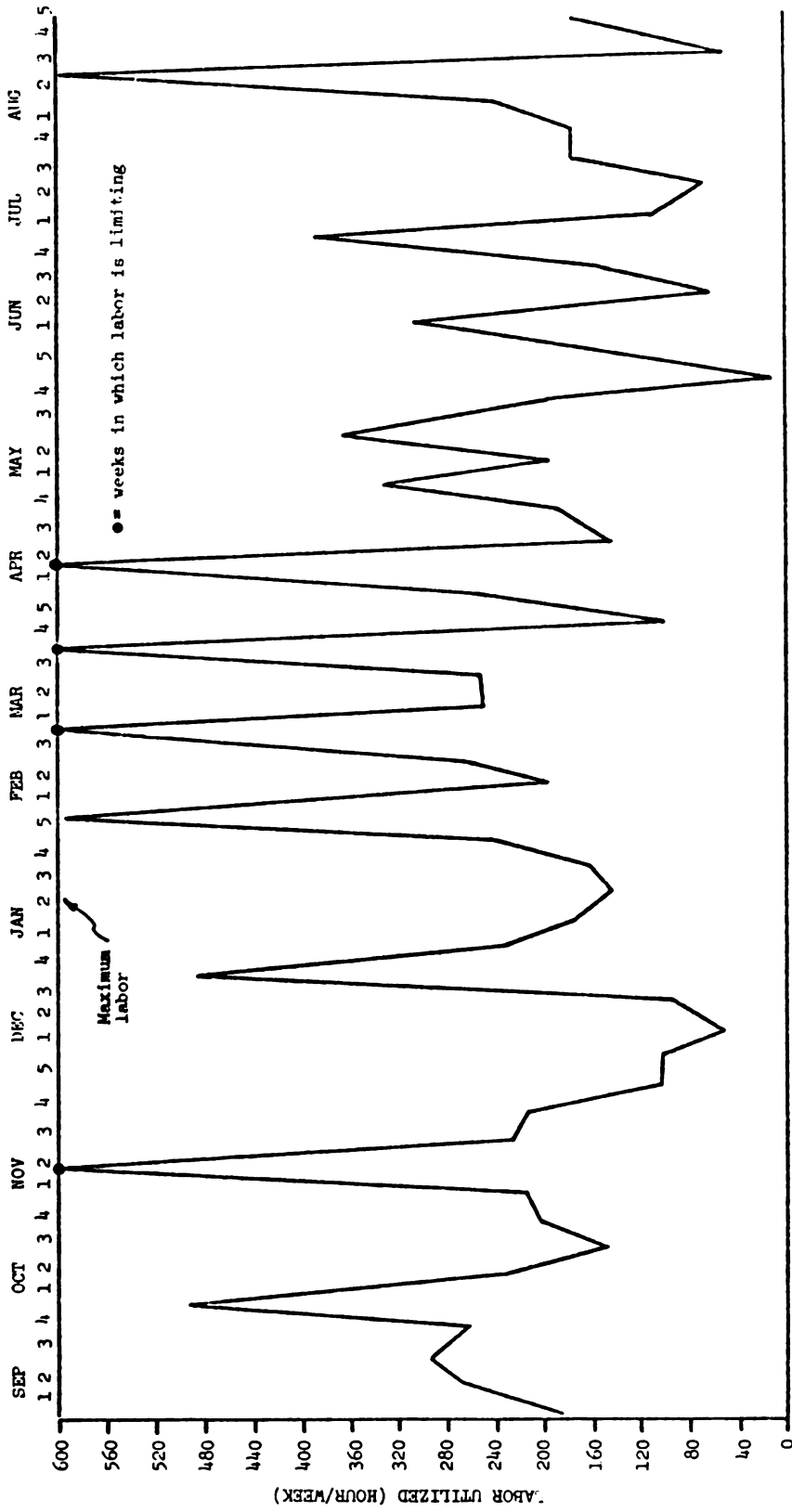


Figure 8. Potted chrysanthemums: permanent employee resource utilized in optimal crop mix.

and space usage among potted chrysanthemum production options points to the importance of the variable costs in determining profitability in this crop. The variable input cost which differs most among the option is greenhouse heating, with photoperiodic control costs the only other major variable cost which fluctuates. In both cases, costs vary with season of the year. Thus, profitability of a specific potted chrysanthemum option is essentially determined by season of the year in which it is produced. This suggests that an effective management approach to the year-round production of potted chrysanthemums is to plan some minimum level of production per week sufficient to maintain market position. Thereafter, an effort should be made to increase market demand for those production options which yield the greatest return to fixed costs. These options will tend to be those produced during periods of minimal heating costs and the least number of weeks in the bench. In the model, these conditions occur primarily in options planted in May, June, July and early August for bloom in late July, August, September, and October respectively.

Comparison of Production Options for Geraniums

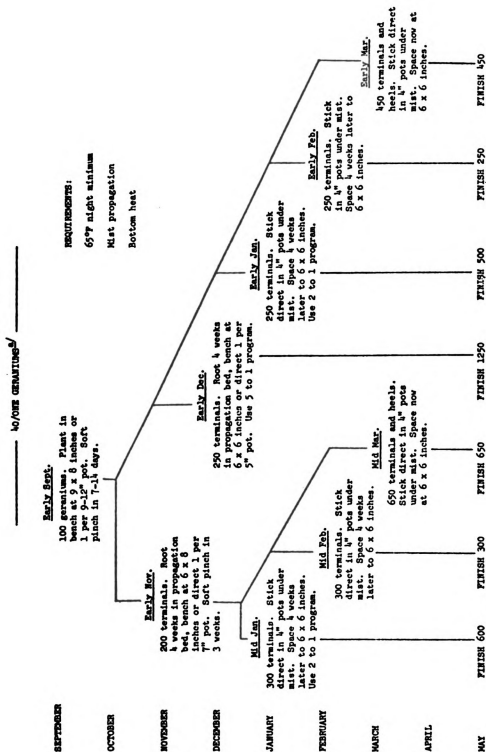
Geraniums are grown as potted plants for sale in May for garden and other outdoor uses. Some production is geared for sale at Easter and Mother's Day, with a major portion timed for mid-May and Memorial Day sales. While the crop is grown in a wide range of pot sizes, as well as in packs and tubs, the 4 inch pot is the most common container.

Geraniums are propagated from cuttings. Serious disease problems in recent years have led commercial geranium propagation specialists to

apply culture-indexing techniques to the crop. They are now able to offer the grower disease-free cuttings with which to initiate his crop. This development, coupled with new fast production techniques for the crop, has resulted in significant changes in the production schedules for geraniums. A grower may now produce spring-flowering geranium crops in numerous ways ranging from 10-month stock plant program as a basis for providing his own cuttings, to 6-8 week programs in which finished 4 inch potted geraniums are produced for spring sales from purchased cuttings. Further, there are opportunities for buying and selling cuttings and started plants at a number of points in the production year. Figures 9, 10, 11 and 12 show how one major commercial geranium propagator has diagrammed and named the numerous production programs available to the geranium grower. For purpose of this study, these programs have been modified and expanded to include numerous additional options as described below.

Geraniums options studied in the model

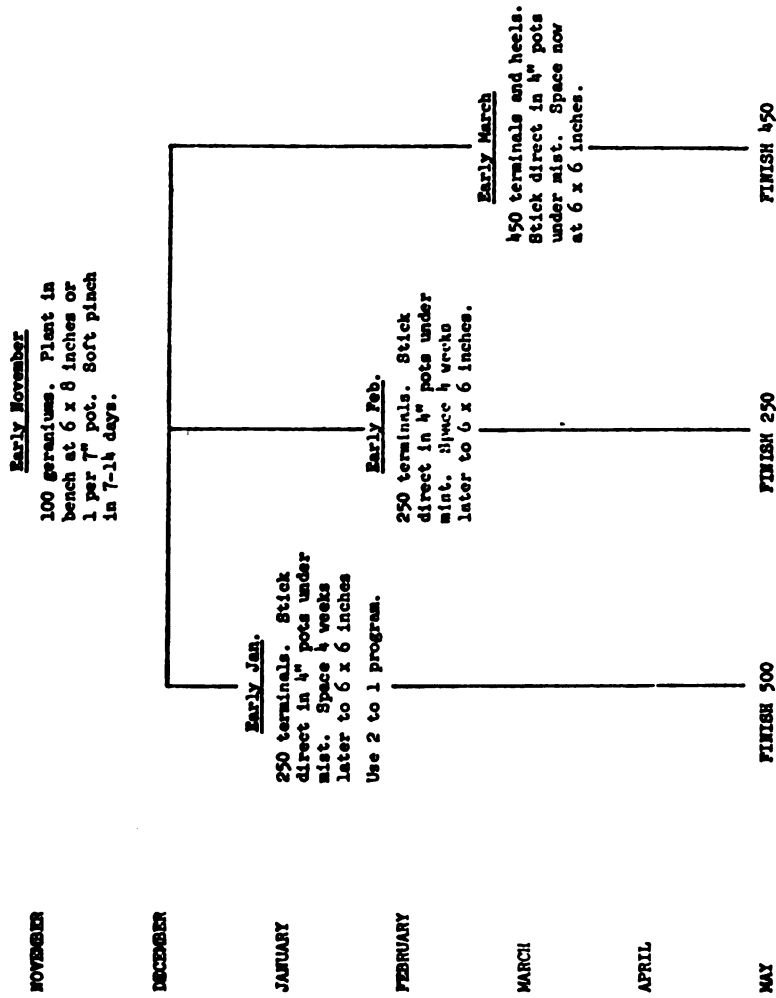
All geranium options included in Figures 9-12 are available to the manager of the model in the study. Further, a number of additional options are included. A 25/1 option is added which allows for initiation of a stock plant program in mid to late September rather than in August as for the 40/1 option. The opportunity is available to sell unrooted and rooted cuttings and started plants in 2½ inch and 4 inch pots at numerous points in the program. Further, started stock plants in 7 inch and 12 inch pots may be sold at several points early in the program. Stock plants kept late into the production program may be completely



5/ Adapted from Yoder Bros. Grover's Circle News 77, June 1969.

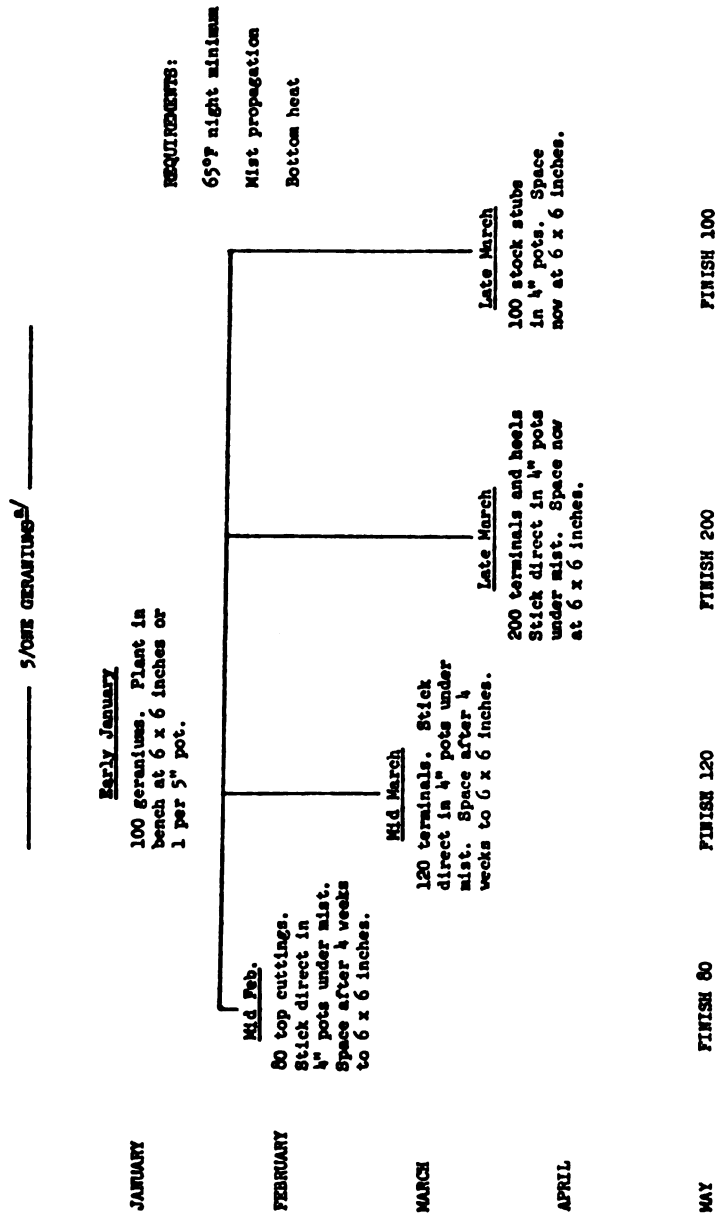
Figure 9. One commercial propagator's proposed 9-month geranium production program.

12/ONE GERANIUMS^{2/}



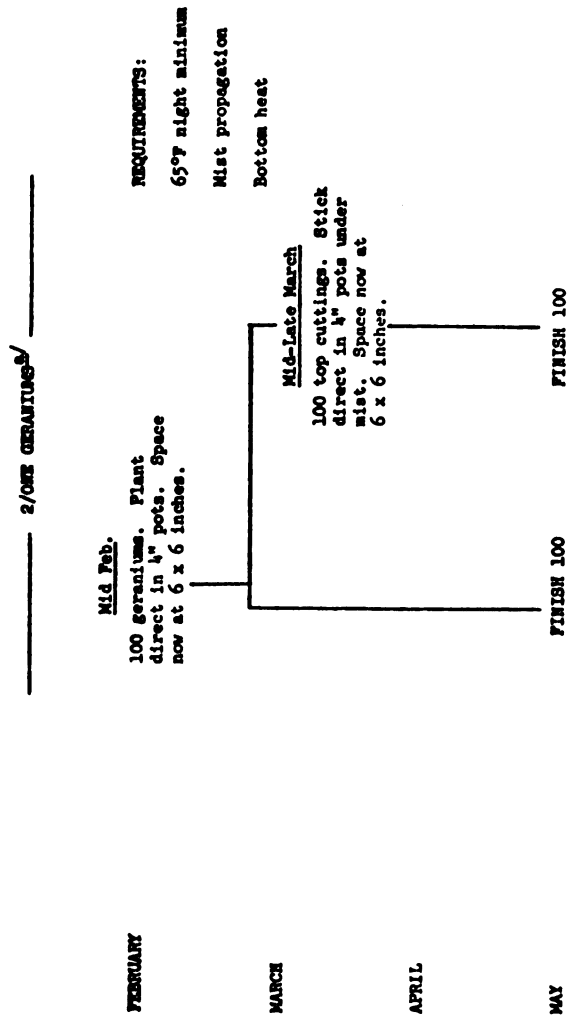
^{2/} Adapted from Yodar Bros. Grover's Circle News 77, June 1969

Figure 10. One commercial propagator's proposed 7-month geranium production program.



^{a/} Adapted from Yoder Bros. Grover's Circle News 77, June 1969.

Figure 11. One commercial propagator's proposed 5-month geranium production program.



^{a/} Adapted from Yoder Bros. Grover's Circle News 77, June 1969.

Figure 12. One commercial propagator's proposed 3 1/2-month geranium production program.

cut up as a final source of cuttings, or grown on to be sold in 7 inch and 12 inch pots for Mother's Day and garden sales, or dumped.

A "tree" geranium program is also available whereby stock plants are staked and grown in tree form. The purpose of this program is, through frequent pinching and growth regulator treatments, to develop and store large numbers of cuttings "in the vertical" on the stock plant until they are needed for finished production options. Stock trees used in this program are disposed of through sale as finished trees in May or are entirely cut up as a source of the final flush of cuttings.

Market quotas are set for nearly all of the holiday options, and for the finished stock plant and stock tree options.

The production unit assigned is 1,000 cuttings, started plants, finished plants, or stock plants. Prices assigned for the sale of each product are those current in the trade in 1970 and specified in Table 28. Terms used to define various categories of geranium plants and propagation material are defined here:

Stock plants may be initiated from unrooted or rooted cuttings or started plants in 2½ inch pots. The 40/1 and 25/1 options are potted directly in 12 inch clay pots. The 12/1 and 8/1 options are grown in 7 inch clay pots and the 5/1 option in 5 inch clay pots. Usual spacing commensurate with size of pot and stage of development is provided.

Finished crops are produced from unrooted cuttings stuck directly in 4 inch clay pots under mist. February propagation are spaced pot to pot at the outset and spread to a final 6 inches by 6 inches spacing 4 weeks later. Propagations made from March on are spaced immediately at 6 inches by 6 inches.

Table 28. Geraniums: market prices assumed in the model.

Type of plant material	Price per unit of 1,000 (\$)	Per each (\$)
Unrooted cuttings	60.00	0.06
Rooted cuttings	130.00	0.13
Started plants in 2½ inch pots	160.00	0.16
Started plants in 4 inch pots	300.00-400.00	0.30-0.40
Started stock plants in:		
5 inch pots	450.00	0.45
7 inch pots	700.00-2,000.00	0.70-2.00
12 inch pots	125.00-3,000.00	1.25-3.00
Finished 4 inch geraniums for:		
Easter	600.00	0.60
Mother's Day	550.00	0.55
Garden sales	500.00	0.50
Memorial Day	500.00	0.50
Finished stock plants:		
5 inch pots for:		
Garden sales	500.00*	0.50*
7 inch pots for:		
Mother's Day	2,000.00	2.00
Garden sales	2,000.00	2.00
Memorial Day	550.00*	0.55*
12 inch pots for:		
Garden sales	500.00*	0.50*
12 inch tree geraniums for:		
Mother's Day and Garden sales	12,000.00	12.00

*Prices for these options erroneously set at incorrect low prices.

Unrooted terminal cuttings are taken when 3 inches in length; heel cuttings are 2 inches long. Unrooted cuttings are sold immediately upon removal from the stock plant.

Rooted terminal cuttings have roots of at least $1/8$ inch in length and are sold bare root.

Started plants in $2\frac{1}{2}$ inch pots are produced by sticking an unrooted cutting directly in a $2\frac{1}{2}$ inch pot. The plant is sold 4 to 5 weeks later depending on season of the year.

Started plants in 4 inch pots are produced by rooting a cutting directly in a 4 inch plastic pot. The plant is sold 6 weeks after the cutting is stuck.

Started stock plants are stock plants which are generally grown on for 2 weeks after a given flush of cuttings is taken and then sold to another grower for stock plant purposes.

Cultural practices used may be summarized as follows. Finished 4 inch pot options are grown at 65F night temperatures. Bottom heat (75F) and mist are provided during rooting. Soil mixture, fertilization and irrigation programs are those generally recommended by suppliers and Cooperative Extension, and known to produce continuous quality growth.

Essentially, the manager contemplating geranium production is faced with decisions concerning sources of propagation material as well as the form in which he will market his product. The options are many and are strongly interrelated. Some require considerable inputs of greenhouse space and labor ; others require use of practically none of these resources. Hence, linear programming provides an effective means for analysis to determine an optimal combination of enterprises under a given set of constraints.

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The optimal crop mix

A total of 224 options are available in the program for producing plant material with which to initiate the crop, for production of the crop, and for form of product in which to market the crop. Eighty-five of the options occur in the optimal plan as listed in Tables 29-32.

The optimal mix is examined in terms of information it provides concerning several decision points in geranium production:

1. Should stock plants be produced, or should plant material be purchased when needed to start a crop?
2. If the decision is to produce stock plants, then in what form is the product to be sold: unrooted cuttings, rooted cuttings, started plants in 2½ inch pots, started plants in 4 inch pots, finished plants?
3. If the stock plant option is adopted, what will be the final disposition of the stock plants:
 - a) sold as started plants in 7 inch and 12 inch pots to other growers?
 - b) grown on to sell as large finished blooming plants?
 - c) completely cut up into terminal and heel cuttings at the last propagation and dumped?
4. If the decision is to not produce stock plants, then what type of plant material will be used to initiate production: unrooted cuttings, rooted cuttings, started plants in 2½ inch pots, started plants in 4 inch pots?
5. What mix of markets should be developed, i.e. what quantity of 4, 7 and 12 inch pots and tree geraniums should be grown for

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Easter, Mother's Day, garden sales and Memorial Day?

The optimal mix of geranium options provides the following information on these questions. Stock plant options come into production in the 25/1, 12/1, 8/1, 5/1 programs and in the geranium tree program. The 40/1 program does not come into the optimal mix. However, the 25/1 program, a sub-program of the 40/1 program which begins in mid-September rather than mid-August, and the 8/1 program another sub-program of the 40/1 program, do come into solution in 9.14 units and 3.0 units respectively. The 5/1 program which can be produced as a separate program started from cuttings or started plants in January, or as an integral part of the 40/1 and 25/1 programs, has only 2.67 units in the optimal mix. The 12/1 program contributes 18.25 units of stock to the mix. The stock tree program is represented by 0.81 units which, while seemingly small in number of units, contributes considerable quantities of cuttings.

All stock options except that for the tree program followed a consistent pattern in the mix. Immediately after the initial yield of cuttings was produced, a quantity of the stock plants, usually equal to the market quota for stock plant sales at this point, is sold. The unsold stock is transferred into the next production option. Following the next yield of cuttings, an amount of the stock plants again equal to the market quota is sold, and the remainder transferred into the next production option. In the 25/1 stock plant program, after following this pattern through the last stock plant sale option, 2.14 units (2,140 12 inch pots) of stock are dumped. This indicates

that for this option at least, sale of started stock plants is not the only purpose for production.

The majority of cuttings propagated from stock plants is sold through options other than finished 4 inch plants. In the optimal mix, only 35.27 units, or 17.8%, are produced from cuttings taken from stock plants produced in the model. Stock plant options then are programmed into the optimal mix primarily for the returns generated from the sale of propagative plant material, started stock plants and a relatively few units of finished product. Table 29 summarizes the sales of products from stock plant options. Sale of 134.87 units (45.7%) of unrooted cuttings represent the greatest quantity of any of the products sold from stock plant options. Rooted cuttings and started plants in 4 inch pots account for 35.7 (12.0%) units and started stock plants for 30.48 units. Started plants in 2½ inch pots account for the least with only 6.18 units sold.

The third decision point listed earlier deals with final disposition of stock plants grown in the program. In all options, with the exception of the 25/1 program, all units of stock plants in the mix are sold either as started stock plants or as finished flowering plants. As previously mentioned, the number of units was at or very near the market quota established for stock plant and finished plant sales options. In the 25/1 program, stock plants were sold to the limit of the market quotas and 2.14 units were ultimately dumped.

The preceding analysis shows that the majority (82.2%) of finished 4 inch potted geraniums are produced from plant material procured from other than stock plants grown in the model firm's greenhouses. Sources of plant material with which to initiate finished

Table 29. Products sold from geranium stock plant options in the optimal crop mix.

Stock plant program	Units of stock plants in optimal mix	Cuttings		Started plants in:		Total units propagated material sold	Finished 4" pots	Started Stock stock plants
		Unrooted	Rooted	2 1/4" pots	4" pots			
25/1	9.14	30.0	16.0	6.18	40.75	96.93	4.00	7.0
12/1	18.25	22.84	45.62	0.0	12.90	83.36	2.00	17.0
8/1	3.0	28.50	0.0	0.0	0.0	51.50	23.00	3.0
5/1	2.67	0.0	0.0	0.0	3.30	7.30	4.00	2.67
Tree program	.81	80.63	0.0	0.0	0.0	82.65	2.02	.81
Total all stock options	33.87	161.97	61.62	6.18	59.95	321.74	33.02	30.48
Per cent of total propagating units sold	---	50.34	19.15	1.92	17.70	100.00		

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4 inch potted geranium programs are primarily from purchase options and are shown in Table 30. Purchased unrooted cuttings account for the source of 56.97% of finished 4 inch geranium plants, purchased rooted cuttings 18.14%, purchased started plants in 2½ inch pots 7.15% and cuttings from stock plants grown by the firm 17.17%. The option to purchase started plants in 4 inch pots is not chosen.

In producing finished 4 inch pots of geraniums, the manager has the options of seeling the crops the first week in May for Mother's Day, or he may commit them to garden sales commencing the third week in May. Several early production programs also contain an Easter sales option, and some of the later programs a Memorial Day (fifth week of May) option. Table 31 summarizes the distribution of finished crops among these markets. Market quotas are placed on all Easter and Mother's Day options but no limits are placed on garden sales options. The Memorial Day option has a very high market quota of 200 units which is inserted as a programming precaution only. This limit is not met in that only 49.84 units are produced. The Easter and Mother's Day crop options are assigned a \$0.10 per pot and \$0.05 per pot price advantage respectively over the garden sales options. All Easter and Mother's Day 4 inch potted geraniums are produced to market quota with the exception of one option within the geranium tree program. The marginal return (shadow price), i.e. the addition to the total return to fixed costs to be realized for the next unit to be sold beyond the limit set by the market quota, for options with market quotas ranged from \$43.87 to \$151.90 per unit.

Table 30. Geraniums: units of finished 4 inch pots by source of plant material.

Total units finished 4 inch pots		Source of plant material									
		Purchased propagation materials									
		Cuttings				Started plants in					
		Unrooted		Rooted		2 1/2 inch pots		4 inch pots		Grover's stock plants	
		Units	%	Units	%	Units	%	Units	%		
197.49	100.0	112.51	56.97	35.83	18.14	14.13	7.15	0.0	0.0	35.02	17.17

Finished sales options in pot sizes larger than 4 inch are shown in Table 32. Market quotas are placed on all of these options. Only 7 inch potted geraniums for Mother's Day sales are produced up to quota. The only others of these options to occur in the optimal mix are 7 inch pots for garden sales and 12 inch finished tree geraniums for Mother's Day. Substantial marginal returns are reported for two 7 inch options.

Table 32. Geraniums: finished options other than in 4 inch pots in the optimal mix.

Option	Units (1,000 pots)	Market quota (units)	Marginal returns (\$)
5 inch pots for garden sales	0	200.00	
7 inch pots:	0	.50	
Mother's Day	2.00	2.00	1,237.95
Garden sales	.50	.50	935.29
12 inch pots:	0	.25	
Trees - Mother's Day	.81	1.00	
Trees - Garden sales	0	1.00	

The use of greenhouse production area and labor by the geranium production option is shown in Figures 13 and 14 respectively. Maximum area in production (68.5%) is the third week of April; minimum occupancy occurs for the period covering the months of June, July, August and the first week of September when space used ebbs to 0.42%. Labor supply limits further use of greenhouse production area. Weeks in which labor is exhausted are shown on Figure 14. Labor use is summarized in

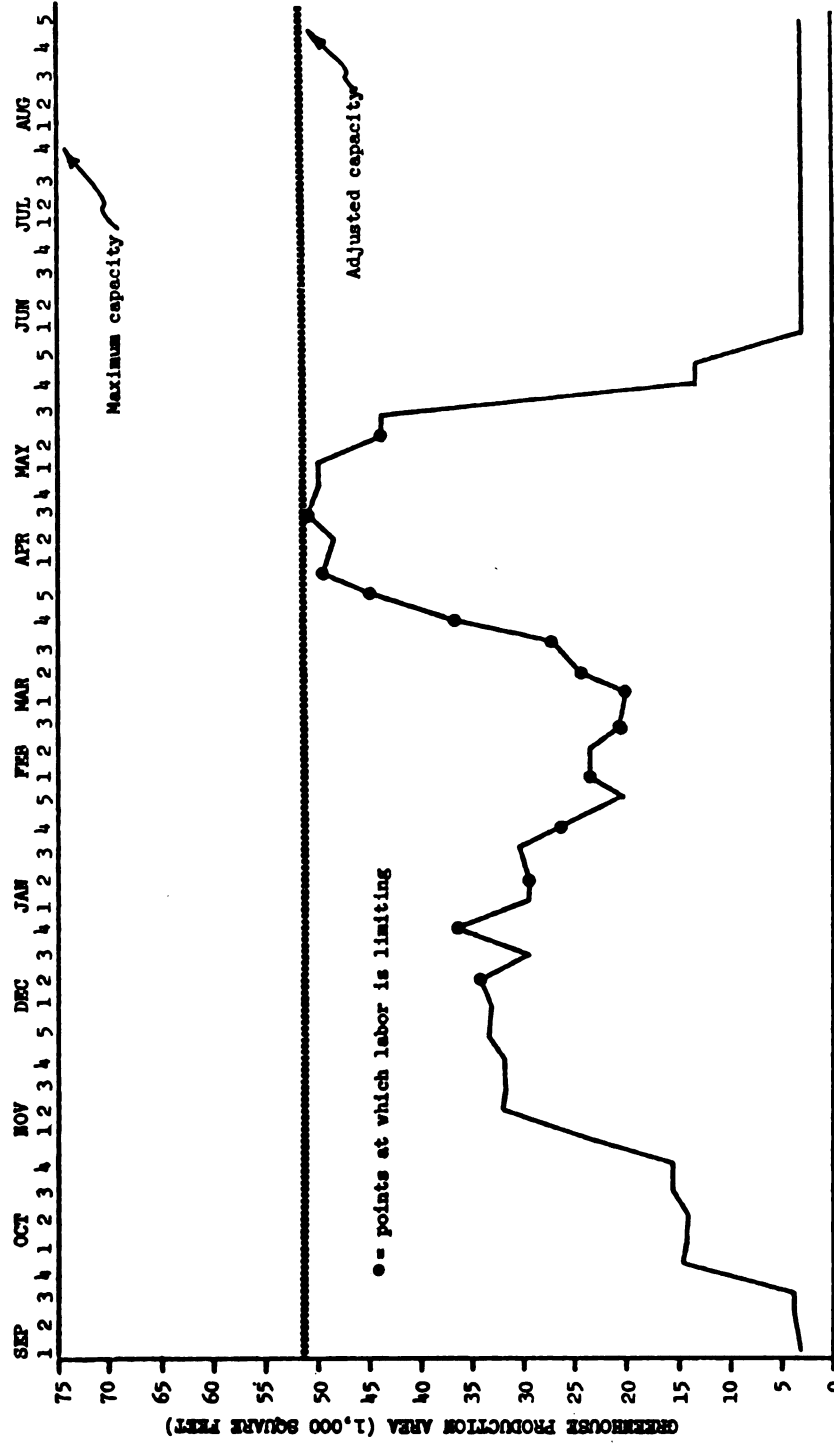


Figure 13. Geraniums: greenhouse production area in optimal crop mix.

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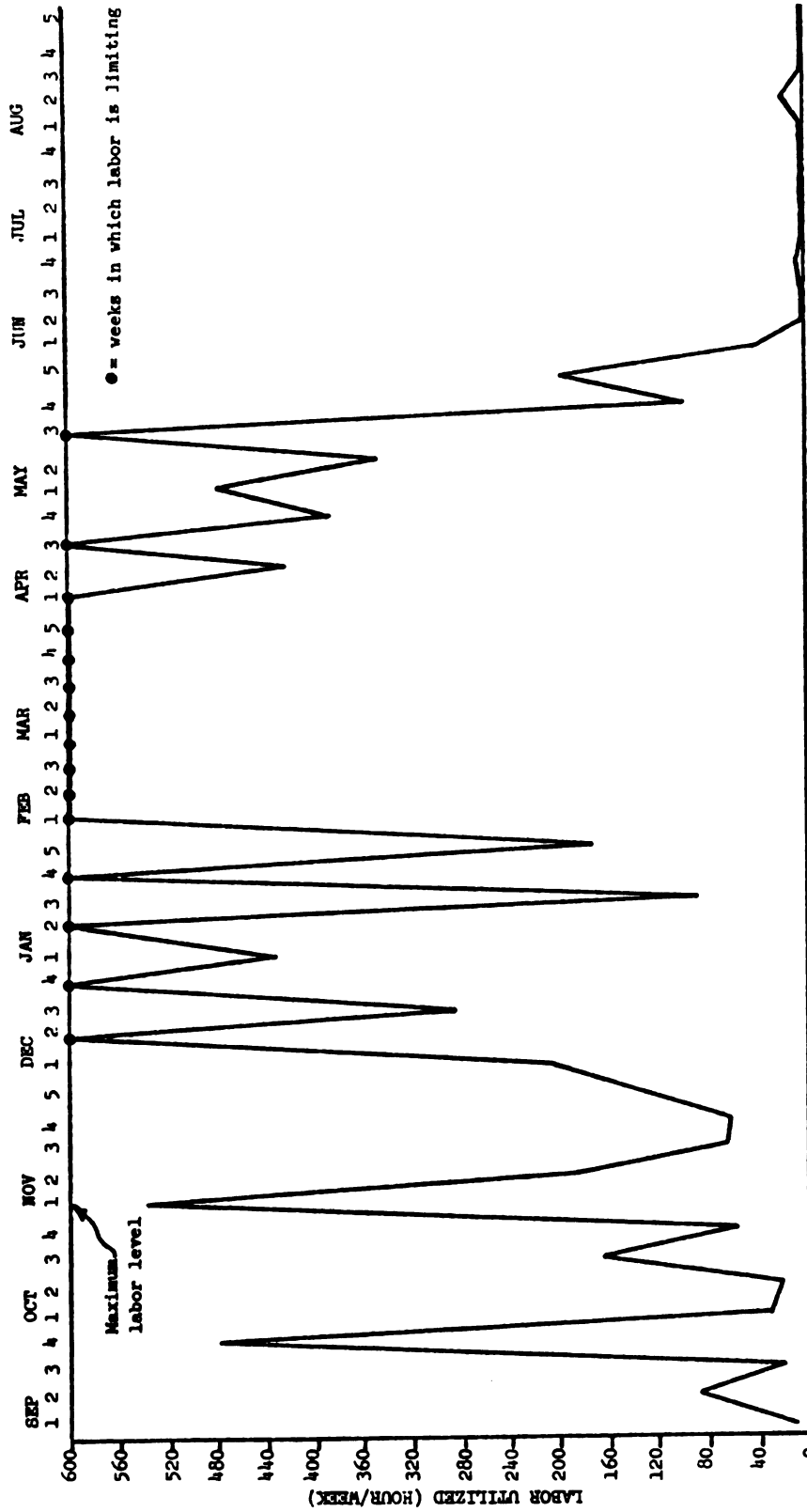


Figure 14. Geranium: permanent employee resource utilized in optimal crop mix.

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Tables 33a and 33b.

The pattern of labor use for geraniums is similar to that for most potted crops. Heavy labor input occurs in the propagation operation, at soil preparation and potting, in spacing pots, and in the sales operation at harvest. These are the operations in progress at those points in the production program when the labor supply becomes limiting.

Total returns to fix resources for the geranium operation are \$146,288.66 or \$1.95 per ft² of greenhouse production area. Net return to fixed resources in this situation after fixed costs of \$3.31 per hour for labor and \$1.45 per ft² for greenhouse production space are deducted is -\$65,785.34 or -\$0.88 per ft² of production area.

Table 33a. Geraniums: production periods in which labor is limiting and marginal returns for labor in these periods.

Production week	Marginal returns per hour of labor (\$)
Dec 2	7.92
4	8.87
Jan 2	9.02
4	25.66
Feb 1	14.34
3	2.54
Mar 1	11.50
2	5.71
3	15.13
4	19.68
5	18.75
Apr 1	14.83
3	13.08
May 3	25.01

Table 33b. Geraniums: summary of use of 600 hours/week of permanent employee resource.

Excess labor capacity	Number of weeks in year with excess labor capacity
0	14
1-50	1
51-100	0
101-200	4
201-300	2
301-400	3
401-500	6
501-600	22
Total	52

Production guidelines which emerge from analysis of the optimal crop mix

A number of production guidelines may be identified within the limits of the situation analyzed:

1. Long-term geranium options, i.e. those involving stock plant production, make most effective use of fixed resources when used to produce cuttings and started plants for sale to other producers.
2. Among the stock plant options in the mix, the 12/1 program which is started in early November is programmed in the greatest number of units and is the most productive of cuttings and started plants for sale. This option apparently utilizes the available fixed resources of labor and greenhouse space more productively than the longer-term though twice as productive 25/1 stock plant option. Similarly, the 25/1 option comes into production over the longer term 40/1 option which does not

appear in the optimal mix. This suggests that the long-term stock plant options while very productive of propagation material do not make as efficient use of fixed resources as the shorter-term 12/1 option. It is interesting to note that one of the main advantages suggested by suppliers for the long-term options is that a late summer start builds a stronger more productive stock plant. Apparently this valid cultural consideration is counterbalanced by the economic aspects of the shorter-term 12/1 program.

3. The relatively few finished plant options produced from programs which involve stock plant production are propagations made in mid-February and for the most part in March. The latter are the final flushes of cuttings before stock plants are sold or discarded. Further, two of the options propagated in February are for Easter and Mother's Day sales when a premium is applied to the sale price. Essentially, the tendency is for few finished options to be produced from stock plants, and when such options are programmed, they tend to be the final propagations as well as propagations for which price premiums exist.
4. The majority of finished 4 inch geranium options for Mother's Day, Memorial Day, and garden sales are produced in the 6-8 week options begun directly from purchased cuttings or started plants. This suggests that the grower whose primary geranium markets are for finished plants is best advised to use fast-crop options grown from plant material purchased for delivery

on or near the starting date of those crops. There seems to be little to be gained from the production of stock plants primarily as a source of propagation material for one's own finished geranium programs.

5. Geranium growers often advance the suggestion that starting material for finished crops should be purchased early enough to allow for the removal of one flush of cuttings from the crop thereby doubling the quantity produced from the purchased cuttings. Only one such option is programmed in the optimal mix. The preponderance of finished options is produced directly from purchased unrooted and rooted cuttings from which no cuttings are taken during the production process. Under conditions where the labor resource is limiting, as is the usual situation in floriculture firms, the choice of these latter options makes for a more labor-efficient operation. And, under this labor situation, savings in the cost of cuttings made possible by harvesting a flush of cuttings from the starting material apparently does not compensate for use of additional labor.
6. Direct potting of unrooted cuttings in $\frac{1}{4}$ inch pots appears to be the most efficient means of initiating finished $\frac{1}{4}$ inch geranium options. Rooted cuttings and the use of started plants in $2\frac{1}{4}$ inch pots are programmed in the optimal mix in considerably lower quantities. Started $\frac{1}{4}$ inch pots are not purchased as starting material for any option in the mix. These results indicate that the returns to the grower for

use of his labor and greenhouse space to produce geraniums from unrooted cuttings to the started 4 inch pot stage is greater than that which would accrue from the purchase of started 4 inch potted plants.

7. For the grower who engages in production for sale of propagating material, unrooted cuttings appear to represent the most favorable form in which to market his product. Thereafter, rooted cuttings and started 4 inch potted plants offer about the same advantage. Started plants in 2½ inch pots appear to be a relatively inefficient form in which to sell propagation material. This latter option requires labor inputs approaching those for the 4 inch potted option but returns substantially less income. While space requirements are considerably less, under a situation where labor is the limiting factor, the 4 inch potted option is likely to represent more productive use of the labor resource. Similarly, the sale of rooted cuttings requires almost as much labor input per unit as does the production of started plants in 2½ inch pots, but revenue from the latter is not substantially greater. Hence, rooted cuttings are programmed over the 2½ inch potted option in the optimal mix. The sale of unrooted cuttings requires use of no greenhouse production area and less labor than the other options. While revenue per unit is less than one-half that returned by other options, the relatively low demand of the program for fixed resources makes it an attractive option.
8. As expected, opportunities to sell started stock plants at

various points in the production regime contribute substantially to the manager's programming flexibility as well as to the profitability of the stock plant options. In industry, this is a rare practice. The solution would indicate that it is a marketing opportunity worth exploring for the manager interested in use of stock plant options for at least some portion of his geranium program

9. The geranium stock tree program as a means of producing propagation material for sale comes into the optimal mix in relatively substantial quantities. This is somewhat surprising when one considers the space and labor inputs required by the program. However, productivity of cuttings is substantial. It should be noted that it was possible to examine this program only in a somewhat more general manner than for the other geranium programs studied because so few producers use it thus making sources of data sparse. Further study of this program is merited.

Summary of production guidelines for geraniums

Several conclusions emerge from this analysis of geranium production options:

1. The production of geranium propagation material for sale to other growers of finished plants, and the production of finished flowering geraniums in 4 inch pots for spring sales emerge as essentially two separate production enterprises. The optimal mix indicates that when a grower engages in stock plant production, his primary revenue comes from the sale of

propagation materials. Relatively few units of finished 4 inch pots are sold in this program. On the other hand, the majority of finished 4 inch potted geraniums for spring sale programmed in the optimal mix are produced from purchased unrooted cuttings potted directly in the finishing pot.

2. Long-term stock plant production programs appear to be less efficient in producing propagation materials for sale than somewhat shorter range though less productive programs.
3. For the producer of propagation materials for sale to other growers, unrooted cuttings are the form of product which appears to be most efficient in use of fixed resources and most profitable. Sale of started plants in 2½ inch pots is least efficient.
4. The sale of started stock plants at various points in the production program offers the producer the opportunity to substantially increase his revenue from the use of fixed resources. In that this is not a common practice in the trade, there would appear to be market potential here. However, more detailed study of this option is warranted.

Comparison of Production Options for Poinsettias

The poinsettia is the traditional scarlet potted plant of the Christmas season. Finished plants are produced for sale beginning in early to mid-November and continuing through Christmas. The finished product takes many forms; the most common are individual single-stem and pinched plants grown one plant to a pot of the size range of 3 inch

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to 8 inch; 3-6 single-stem plants in 5, 6, 7 and 8 inch pots, and large specimen plants and trees in 10-12 inch pots and containers.

A poinsettia producer uses one or both of two basic production programs for the crop. One option is to grow the cuttings required to start his finished crop through a stock plant-propagation-finished plant program, herein after referred to as a stock plant program. The other option involves purchase of cuttings or started plants with which the finished crop is directly initiated, herein after referred to as the buy-plants program.

In the stock plant program, the producer purchases started plants from one of several national propagation firms at some point between March 1 and June 1 of the year in which he will market finished poinsettias. The started plants are rooted directly in 10 inch pots and grown as stock plants from which cuttings are taken in mid to late summer. The earliest cuttings may be used to establish sub-stock plant programs, or sold to other growers who wish to do so. An additional option is open to the producer on a stock plant program. He may operate sufficiently large stock plant program to allow him to sell cuttings and started plants to other producers of finished plants. Propagations for the Christmas finished crop are generally taken late August through mid to late September. Thereafter, the stock plants are discarded although some operators will carry a small portion of the plants through to Christmas bloom and sell them as large specimen plants and trees. However, there is a limited market for this product primarily because of size and price.

In the buy-plants program, the producer of finished plants simply

buys the required number of started plants in 2½ inch pots in the September week in which his finished plant programs commence. Planted directly in the container in which they will be sold, they are grown for the September-early December period at the end of which they are sold as finished plants.

Poinsettia options studied in the model

The manager in the model may use any of the production options shown in Figure 15. Included are a stock plant program initiated in the first week of June which yields cuttings which may be sold as rooted cuttings or used by the producer to initiate his own finished plant program in September. Most of the finished options are propagated directly in blocks of medium (BR-8 blocks) which are then planted directly into the pot in which the plant will be finished. One option is propagated by sticking an unrooted cutting directly from the stock plant into the 4 inch pot where it will root and develop into the finished plant for sale. This labor-saving technique is being used increasingly in the industry. At the conclusion of the stock plant program, the manager in the model may retain up to 0.25 units (250 plants) of stock to grow on for sale as finished plants for Christmas. The small stock plants used in the sub-stock plant program may be sold as started plants to other growers or grown on for sale as a finished 6-bloom pinched plants in a 6 inch pot. Numerous buy-plant options are also available to the manager in the model, all of which initiate finished plant programs during the first and second weeks of September. The finished plant options are described in Figure 15.

Pinched multi-bloom plants are a recent trend made possible by

Key to Figure 15.

Poinsettia production and marketing options.

Code	Description
A	Buy started plants in 2 1/4 inch pots; repot in 10 inch pots to initiate stock plant program
B	Take cuttings, root in peat blocks
C	Sell unrooted cuttings
D	Take cuttings
E	Sell started stock plants
F	Dump stock plants, retrieve containers
G	Buy started plants in 2 1/4 inch pots
H	Pot 1 started plant in a 6 inch pot
I	Take cuttings, stick direct in 4 inch pots
J	1 plant, 4 inch pot
K	2 plants, 5 inch pot
L	3 plants, 6 inch pot
M	4 plants, 7 inch pot
N	5 plants, 7 inch pot
O	6 plants, 8 inch pot
P	Pinched, 1 plant pot: 3-blooms, 4 inch pot
Q	4-blooms, 4 inch pot
R	5-blooms, 6 inch pot
S	6-blooms, 6 inch pot
T	heavy 6-bloom, 6 inch pot
U	Sell finished blooming stock plants in tubs

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new self-branching cultivars. The more traditional method of developing multiflowered poinsettia plants, i.e. planting of two or more plants in a 5, 6, 7, 8 inch or larger pot, is also available to the manager. In this approach, each unpinched plant produces one large flower; with several plants in the pot the "multibloom" is produced. Offering of both options to the manager in the model provides an opportunity for comparison of the two production techniques.

Wholesale market prices and market quotas for each of the finished plant options are detailed in Table 3⁴. The pinched finished plant options are assigned a lower market price than their counterpart multi-plant pots with comparable flower count. This reflects current practice in the industry.

Poinsettia options in the optimal mix

The poinsettia program which emerges as the optimal mix is shown in Figure 15. It contains both stock plant and buy-plant options. However, the ratio of number of units of finished plant options produced via the stock plant program to those grown from buy-plant options is about 3 to 1; the ratio based on dollar contribution to gross returns to fixed costs is 1.56:1.00. A total of 52.00 units, or 52,000 rooted cuttings, are sold from the stock plant program, as is the market quota of stock in the sub-stock plant program, i.e. 2.0 units or 2,000 plants are sold as started poinsettias in 6 inch pots in early September. The full quota of finished stock plants, i.e. 0.25 units or 250 plants are sold as finished plants at Christmas. The remaining units of stock plants are dumped and the large 10 inch pots in which they grow salvaged.

Table 34. Poinsettias, finished plants: wholesale market prices, market quotas and quantities sold.

Crop option	Plastic pot size (inches)	Wholesale Market Price		Market quota	Optimal mix (units of 1,000 6 inch pots)	Shadow price (\$)
		\$ per unit of 1,000	\$ per pot			
Flowering stock plants	1 wooden tub	12,000	12.00	0.25	0.25	10,916.16
Pinched, 1 plant per pot:						
heavy, 6-bloom	6	3,500	3.50	6.00	2.00	1,619.08
3-bloom	4	1,250	1.25	6.00	6.00	1,844.79
5-bloom	6	3,500	3.50	6.00	6.00	1,972.16
6-bloom	6	3,500	3.50	6.00	6.00	1,472.38
4-bloom	4	2,000	2.00	12.00	12.00	881.82
3-bloom	4	1,250	1.25	12.00	12.00	
Single stem:						
1 plant	4	750	0.75	none	0	
2 plants	5	1,500	1.50	6.00	0	
3 plants	6	2,500	2.50	12.00	8.00	
4 plants	7	3,750	3.75	3.00	3.00	2,033.01
5 plants	7	4,750	4.75	2.00	2.00	2,705.56
6 plants	8	6,000	6.00	1.00	1.00	3,876.86

The poinsettia optimal mix generates \$129,333 total return to fixed costs per year, or \$1.72 per ft² of total production area. This mix yields net return to fixed costs, i.e. return after fixed costs incurred to provide 75,000 ft² of greenhouse production area and 600 hours of labor for 30 weeks are deducted, of \$6,350 or \$0.08 per ft². However, if the poinsettia program is charge the fixed cost for only the greenhouse production area actually used to produce the amount of the crop in the optimal mix, e.g. about 56,000 ft², and for all 600 hours per week of permanent employee complement, for only the 30 week production period, then net return to fixed resources is \$22,909 or \$0.41 per ft² for the period. On the other hand, if proportionately more hours of labor are provided to fill the 75,000 ft² of production area with the poinsettia optimal mix, net return to fixed resources is \$30,676 or \$0.55.

Greenhouse production area is never limiting in the poinsettia situation. Available labor does limit further greenhouse space utilization in the first week of June when the stock plant potting operation is done, and again in the second week of September during the height of the finished plant propagation and potting operation, and the selling of started stock plants in 6 inch pots. Marginal return for the labor resource in these two weeks are \$37.71 and \$46.19 per hour respectively. Although it does not become limiting, labor supply approaches exhaustion in the third week of September for the same reasons as in the second week of this month. Figures 16a and 16b depict greenhouse production area and labor use respectively through the poinsettia cropping period.

Analysis of the Solution

The stock plant option enters the optimal program because of plentiful labor and space resources available June through August. The

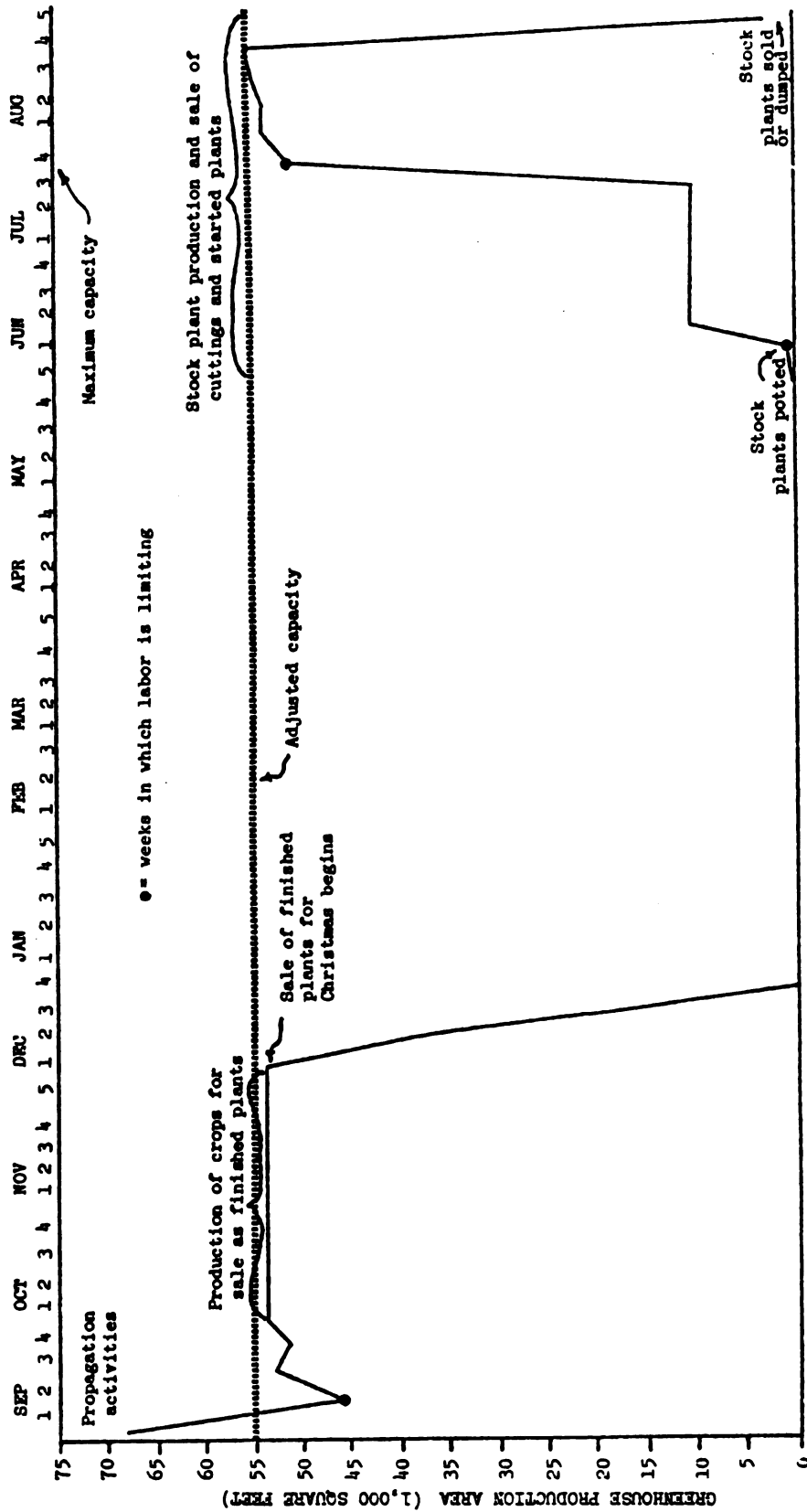


Figure 16a. Poinsettia: greenhouse production area used in optimal crop mix.

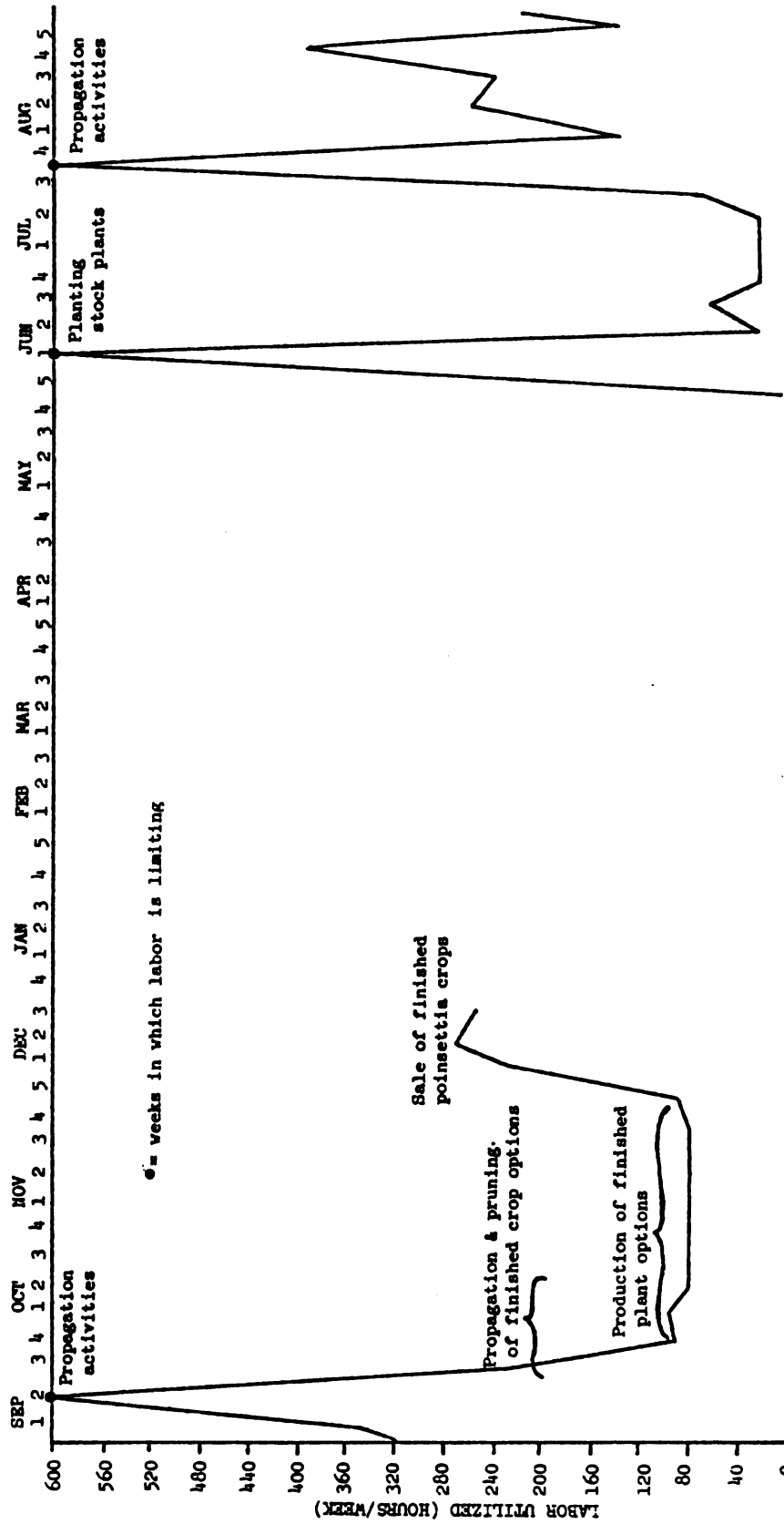


Figure 16b. Poinsettia: permanent employee resource utilized in optimal crop mix.

quantity of stock plants is determined by the availability of planting labor the first week of June. Once this limit is met, the abundant labor and space resources available in August are used to propagate those cuttings available from stock plants the third week of July and to grow them to saleable 2½ inch potted plants, rather than sell them as unrooted cuttings. However, cuttings available from the stock plants in the second, third and fourth weeks of August are for the most part used to produce finished plant options initiated in the first three weeks of September. The only portions of the propagations sold for other purposes are 15.13 units of those propagated in the fourth week of August which are sold as rooted cuttings in the third week of September. These likely are sold after the finished options available for initiation in third week of September are filled to market quota. Apparently, this propagation-to-sell option represents efficient use of space and of the small amount of labor still available during these weeks when labor is approaching the point of limiting further activity.

Finished plant options produced from cuttings taken from the stock plant program predominate in the optimal mix. These options include the 3, 4, 5, and 6 plant per pot options, and the 3 and 4 bloom pinched plants. Further, all options are produced to the limits of the market quotas except for the 3 plants per 6 inch pot option which is produced from the stock plant program in an amount just less than one-half of its quota. However, the quantity of this option produced is increased to about three-fourths of quota through the purchases of 12.51 units of started plants.

The pinched, multibloom, single-plant per pot options are all produced to market limit. The single-stem, multiplant per pot option

are produced only in the top three of the five grades available. The top two grades are grown to the limits of the market quotas. The middle grade, 3 plants in a 6 inch pot, is produced in about three-fourths of its market quota. The lowest two grades of the latter option are not in the optimal mix. The lowest grade, a 1-bloom plant in a 4 inch pot, is priced \$0.50 less per pot than is the 3-bloom, pinched plant counterpart. There is no 2-bloom pinched counterpart for the 1-bloom, 2 plants per 5 inch pot option, but it is priced \$0.25 higher per pot than is the 3 bloom, pinched plant in a 4 inch pot.

Started plants are purchased for finished plant options only in the second and third weeks of September. Slightly more than one-half of the finished crops so produced are of the 3-single-stem plants per 6 inch pot option. As mentioned earlier, the remainder of the market quota for this option is produced from cuttings propagated from the stock plant program. The 5 and 6 bloom pinched plants in 6 inch pots are produced to their market quota limits from purchased started plants. Started plants purchased in the third week of September are used to produce finished pinched 3-bloom plants in 4 inch plastic pots.

The pinched option which utilizes direct sticking of one cutting per 4 inch pot to produce a 3-bloom plant is produced to market quota. The market price assigned is equal to that for a comparable plant produced in the traditional manner. This option offers a relatively low labor requirement for initiation in the first week of September when labor is not taxed. Further, it eliminates the need for propagation space and for some of the labor associated with propagation.

Summary of production guidelines for poinsettias

These guidelines for poinsettia production emerge from the analysis.

1. Both the stock plant program and the buy plant option are profitable means of obtaining started plants for the production of finished poinsettias. The stock-plant program uses greenhouse production area and labor during the summer months when the supply of these fixed resources is relatively more available. Further, the stock plant program offers great flexibility through the numerous opportunities for the sale of unrooted and rooted cuttings and started plants in 2½ inch pots. Given a more abundant labor supply in key weeks of the summer months, returns from the stock plant program would likely increase significantly because the space resource is available. The buy-plant options on the other hand offer the opportunity for the manager to allow another firm to make labor inputs into the propagation phases during key periods in the summer months, and in the second and third weeks of September when his own labor resource is limiting. In this way, the manager is able to initiate programs to use labor and space which he has available in October through December.
2. Finished plant production appears to be somewhat more efficient in use of resources when initiated from cuttings produced from the stock plant program. These options occur in a 3:1 ratio of stock-plant-initiated options to buy-plant options, and in a 1.56:1.00 ratio on the basis of contribution to total return to fixed costs.

3. The continuation of stock plants for sale as large finished specimen plants at Christmas appears to be profitable within the limits of the market quota of 250 plants. The price for the next unit to be produced if the market quota did not exist is \$10,916.16, or about \$10.92 per 10 inch plant. This shows a return of nearly the full amount of the \$11.75 per 10 inch pot gross return to fixed costs possible. Given the necessary labor and space resources, production of at least another 1,000 plant unit would be profitable. However, market development would be necessary to expand the demand for these large plants.
4. The new technique of sticking unrooted cuttings directly into the pot in which they will develop into finished plants competes efficiently for fixed resources with the traditional propagation programs. The techniques were compared in the 3-bloom per pinched plant, 1 plant per 4 inch pot option. Both options carry the same market price and both had market quotas of 6 units. Shadow prices, i.e. the amount by which net return to fixed costs would be increased by production of the next unit beyond market quota for the direct-stick and traditional propagation techniques are \$1,619.08 or \$881.82 respectively. This indicates that the direct-stick program has considerable advantage over the traditional method. The lower labor and space requirements are its primary advantages.
5. Pinched, multibloom finished plant options appear to utilize labor and space more efficiently than do the single-stem

multiplant finished options, even though the latter are given a considerable market price premium. The requirement for two to six fewer starting plants per pot depending on the option, combines with the considerably lower labor requirement and the somewhat lessened space requirement to overcome the price disadvantage.

6. Within the finished plant options the top grades appear most profitable. The shadow prices for the options as shown in Table 34 indicate that the largest plants are the most profitable under this situation, and that contribution to profits declines as grade drops. However, it should be noted that market demand for the largest sizes is definitely limited.
7. The typical poinsettia crop, the one available in this situation, requires major labor inputs when planting stock plants, when propagating cuttings and started plants either for sale or use to initiate finished crops, and when initiating finished crop options. Crop harvest, the other major labor-requiring operation, does not present as great a demand upon the labor resource as do these operations.

The Diversified Crops Program

The diversified crops program study conducted using the model is designed to determine the most profitable combination of crop enterprises and of options internal to these enterprises from among the nine crops specified in Chapter II. The fixed resources of the model are as specified in Chapter II, e.g. 75,000 square feet of greenhouse production area per week and 600 hours per week of permanent employee labor. Limitations in the number of units of some crop options are imposed based on quantities the market will absorb. These market quotas are also specified in Chapter II.

The crop enterprises and options are detailed in Table 13. The production techniques and programs for the crops analyzed separately in the previous section of this chapter are the same as described there. Production techniques and programs used in the analysis of roses occur later in the chapter, while those for bedding plants and Easter lilies follow immediately.

Bedding Plants

In recent years demand for bedding plants has greatly expanded as increased concern for environmental quality has emerged. In this same period, production of bedding plants has become a specialized operation; many firms produce bedding plants January through May and no other crops during June through December. This is especially true of those growers who operate vegetable farms during the summer months. A usual rotation of activity for these operations is to

produce bedding plants January through May, grow outdoor vegetable crops April through October, and prepare plastic greenhouse and growing medium for the bedding plant operation September through December. Others, both vegetable farmers and florists, use a rotation of bedding plants followed by poinsettia production June through December. Some glasshouse operators combine only a few bedding plant options such as potted petunias, marigolds, impatiens, begonias and tomatoes in their regular florist crop rotations, while others employ both potted and flatted bedding plants as a major part of their rotation. Consequently, it is difficult to characterize the exact nature of this enterprise as readily as that for most other crops.

Both flower and vegetable plants are considered bedding plants by most producers. The crop is grown January through May for sale primarily in May for garden purposes. They are grown in plastic packs which in turn are carried in plastic trays. Some also are grown in pots both for sale in early May for Mother's Day as well as for later sales for garden purposes.

While bedding plants are produced in both glass and plastic greenhouses, the latter greenhouse covering annually accounts for an increasing percentage of the production area. The plants in trays are generally grown directly on the greenhouse floor with minimal aisles. The highly mechanized production operation eliminates the need for direct access to the flats. Potted bedding plants usually are grown on greenhouse benches although some producers grow them in flats on the floor at least during some stages of production.

Nearly all bedding plants are started from seed. Because of the high labor input required for transplanting seedlings from the tray

in which they are germinated to the packs and pots in which they are finished, producers are increasingly interested in perfecting methods for germinating seeds directly in the container in which the plants will be sold. Direct seeding is used successfully for some species including alyssum, marigold and tomato. Producers who use this technique generally grow extra plants with which to fill gaps in pots and packs where direct-planted seeds fail to germinate.

Bedding plant production options included in the model

There are literally hundreds of species of flower and vegetable plants which are grown as bedding plants. For purpose of this study, only a sampling of the major species is included because of time and program limitations. In the model, the bedding plant options described in Table 35a are available. During the majority of the production period, a unit of potted plants occupies 250 ft² of greenhouse production area; a unit of trays requires 340 ft². Some variation in spacing during the early periods of the options results from variable growth rates among the crops. Seedlings for use in transplanted options are germinated by the producer. In direct-seeded options, additional seedlings are germinated for use in filling gaps in pots and packs by transplanting.

Easter Lilies

Easter lilies production options

Easter lilies are produced as potted plants for the Easter season. The crop is initiated from bulbs grown on the west coast of the United States the summer before they are flowered in the greenhouse. The bulbs are dug in September and October and either stored by the supplier, or shipped to the greenhouse producer depending upon the production option he chooses.

Table 35a. Bedding plants: production options available in the model.

Production option	Yield per 400 ft ² production units		Spacing		Week planted	Week harvested	Time in bench (weeks)
	11" x 22" tray	3" clay pots	11" x 22" tray weeks - ft ²	3" clay pots weeks - ft ²			
Petunia, 1 plant per 3 inch clay pot, Mother's Day sale	1,000		4 - 70 8 - 250 1 - 125		Jan 3	May 1-2	17
Marigold, 1 plant direct sown into a 3 inch clay pot, Mother's Day sale	1,000		3 - 20 4 - 340 1 - 225 1 - 115		Mar 3	May 1-2	9
Marigold, 1 plant direct sown into a 3 inch clay pot, garden sales	1,000		4 - 72 5 - 250 1 - 125		Mar 4	May 3-4	10
Marigold, 1 plant transplanted into a 3 inch clay pot, Mother's Day sale	1,000		4 - 4 4 - 250 1 - 125		Mar 3	May 1-2	9
Marigold, 1 plant transplanted into a 3 inch clay pot, garden sales	1,000		4 - 4 5 - 250 1 - 125		Mar 4	May 3-4	10
Impatiens, 1 plant transplanted into a 3 inch clay pot, Mother's Day and Garden sales	1,000		4 - 4 4 - 70 7 - 250 1 - 200 1 - 125		Jan 4	May 1-4	18
Fibrous-rooted begonia, 1 plant transplanted into a 3 inch pot, Mother's Day and garden sales	1,000		1 - 1 4 - 4 8 - 70 5 - 250 1 - 200 1 - 125 1 - 50		Jan 2	May 1-4	19
Petunia, 6 plants per pack, 12 packs per 11 inch x 22 inch plastic tray for garden sales	200		7 - 20 6 - 340 6 - 250 1 - 125 1 - 115		Feb 2	May 2-4	13
Marigold, direct seeded, 6 plants per pack, 12 packs per 11 inch x 22 inch plastic tray for garden sales	200		4 - 342 3 - 340 1 - 225 1 - 115		Mar 5	May 2-4	9

Table 35a. (Continued).

Production option	Yield per 400 ft. ² production units		Spacing		Week planted	Week harvested	Time in bench (weeks)
	12 packs in an 11" x 22" tray	3" clay pots	11" x 22" tray	3" clay pots			
Marigold, transplanted, 6 plants per pack, 12 packs per 11 inch x 22 inch plastic tray for garden sales.	200		3 - 20 4 - 340 1 - 125 1 - 115		Mar 5	May 2-4	9
Tomato, 6 plants per pack, 12 packs for 11 inch x 22 inch plastic tray for garden sales	200		2 - 20 5 - 340 1 - 225 1 - 115		Mar 5	May 2-4	9
Impatiens, 3-4 plants per pack, 12 packs per 11 x 22 inch plastic tray for garden sales	200		4 - 20 6 - 340 1 - 225 1 - 115		Mar 2	May 2-4	12
Fibrous-rooted begonia, 3-4 plants per pack, 12 packs per 11 inch x 22 inch plastic tray for garden sales	200		7 - 20 10 - 340 1 - 225 1 - 115		Jan 3	May 2-4	19

Table 35b. Bedding plants: summary of optimal crop mix.

Production option	Market return		Market quota (units)	Optimal mix (units)	Total return to fixed costs (\$)	Shadow price (\$/unit)
	Trays \$/tray	Pots \$/pot				
Petunia, 1 plant per 3 inch clay pot, Mother's Day sale	2.30	.30	50.00	50.00	15,000	92.51
Marigold, 1 plant direct sown into a 3 inch clay pot, Mother's Day sale		.25	25.00	25.00	6,250	25.50
Marigold, 1 plant direct sown into a 3 inch clay pot, garden sales		.20	25.00	23.17	4,634	
Marigold, 1 plant transplanted into a 3 inch clay pot, Mother's Day sale		.25	25.00	25.00	6,250	49.69
Marigold, 1 plant transplanted into a 3 inch clay pot, garden sales		.20	25.00	25.00	5,000	8.20
Impatiens, 1 plant transplanted into a 3 inch clay pot, Mother's Day and garden sales		.30	12.00	12.00	3,600	36.87
Fibrous-rooted begonia, 1 plant transplanted into a 3 inch pot, Mother's Day and garden sales		.30	12.00	12.00	3,600	36.54
Petunia, 6 plants per pack, 12 packs per 11 inch x 22 inch plastic tray for garden sales	2.30	460.00	None	4.48	2,061	
Marigold, direct seeded, 6 plants per pack, 12 packs per 11 inch x 22 inch plastic tray for garden sales.	2.30	460.00	None	23.60	10,856	

Table 35b. (Continued)

Production option	Market return			Market quota (units)	Optimal mix (units)	Total return to fixed costs (\$)	Shadow price (\$/unit)
	\$/tray	\$/200 trays	\$/pot				
			Pots \$/1000 pots				
Marigold, transplanted, 6 plants per pack, 12 packs per 11 inch x 22 inch plastic tray for garden sales	2.30	460.00		None	0.0		
Tomato, 6 plants per pack, 12 packs for 11 inch x 22 inch plastic tray for garden sales	2.30	460.00		None	2.65	1,219	
Impatiens, 3-4 plants per pack, 12 packs per 11 inch x 22 inch plastic tray for garden sales	2.30	460.00		None	16.08	7,397	
Fibrous-rooted begonia, 3-4 plants per pack, 12 packs per 11 inch x 22 inch plastic tray for garden sales	2.30	460.00		None	27.64	12,714	

Controlled temperature forcing (CTF)

Bulbs are shipped directly from the field to the greenhouse operator who pots them the third week in September and places them in a 63-65°F bulb room for 3 weeks for root system development. Thereafter, the temperature is dropped to 35-45°F depending on the cultivar to provide the precooling or vernalization necessary for the plant to complete development to the point where it will respond to greenhouse production regimes. The CTF technique generally produces a sturdier plant with considerably higher bud count than bulbs given the vernalization treatment in the packing case.

Home case-cooled or non-pre-cooled method (NPC)

Bulbs are shipped directly from the field to the greenhouse producer; he places them, still in the cases, into refrigerated storage at 35-45°F depending on the cultivar for at least 6 weeks to achieve vernalization.

Commercial case-cooled or precooled method (PC)

The bulb supplier provides the 35-45°F storage in the cases prior to delivery to the greenhouse producer. Under this system, bulbs arrive at the producers having had vernalization treatment and ready to pot.

Another factor which determines quality, height and bud count of the finished lily plant is the size or grade of bulb. Lily grades are based on circumference of the bulb in inches, and the larger the bulb, the higher will be the bud count and the more vigorous the plant. The grades most commonly used in greenhouse programs are 7/8, i.e. bulbs 7-8 inches in circumference, 8/9, 9/10, 10/11. Larger and smaller

grades are available but not commonly used for the majority of a potted crop.

A typical potted Easter lily greenhouse production program commences in mid-December. Bulbs in the controlled temperature forcing (CTF) program are already potted and are moved directly into the greenhouse. The non-pre-cooled (NPC) and pre-cooled (PC) bulbs are brought from storage, potted and placed in the greenhouse. The crop is then grown for sale the week prior to Easter. Of course, the date of Easter Sunday varies annually between mid-March and late April. For purposes of this study, Easter is assumed to occur on the second Sunday in April, a relatively average Easter date.

There is a trend in industry for growers to purchase started lily plants from other growers at various points during production. This practice enables the initial producer to start more plants than he will be able to finish because of the need to give the crop greater space as they develop; the secondary producer has the advantage of not having to make the heavy labor input necessary to initially store, pot and move the crop to the greenhouse.

Lily options available in the model

Options available in the model are arrayed in Figure 17. The manager may choose among three bulb storage options: CTF, NPC, PC. The production program is divided into Phase I, the third week in December through the first week in February, Phase II, the second week in February through the first week in March, and Phase III the second week in March through the first week in April when finished plants are sold. At the beginning of each production phase, the manager has

Key to Figure 17.

Easter lily production options		Optimal crop mix				Market quota			
Code	Description	10/11	9/10	8/9	7/8	10/11	9/10	8/9	7/8
A	C.T.F. storage	16.00	10.15	0	0				
B	M.P.C. storage	0	0	0	0				
C	P.C. bulbs arrive	0	0	0	0				
D	Production phase I initiated:								
	- M.P.C. and P.C. bulbs potted - greenhouse	0	0	0	0				
	- C.T.F. bulbs, storage - greenhouse	16.00	10.15	0	0				
E	Sell started plants Feb week 1	3.00 ^{a/}	0	0	0	3.00			
F	Buy started plants, Feb week 2, P.C.	0	0	6.16	5.00 ^{a/}		10.00	5.00	
G	Production phase I	13.00	10.15	6.16	5.00				
H	Sell started plants Mar week 1, C.T.F.	3.00 ^{a/}	3.00 ^{a/}	0	0	3.00	3.00		
I	Buy started plants Mar week 2, P.C.	0	0	10.00 ^{a/}	5.00 ^{a/}		10.00	5.00	
J	Production phase III	10.00	7.15	16.16	10.00				
K	Sell finished plants in bloom, Apr week 1	10.00	7.15	16.16	10.00				

^{a/} Market quota achieved.

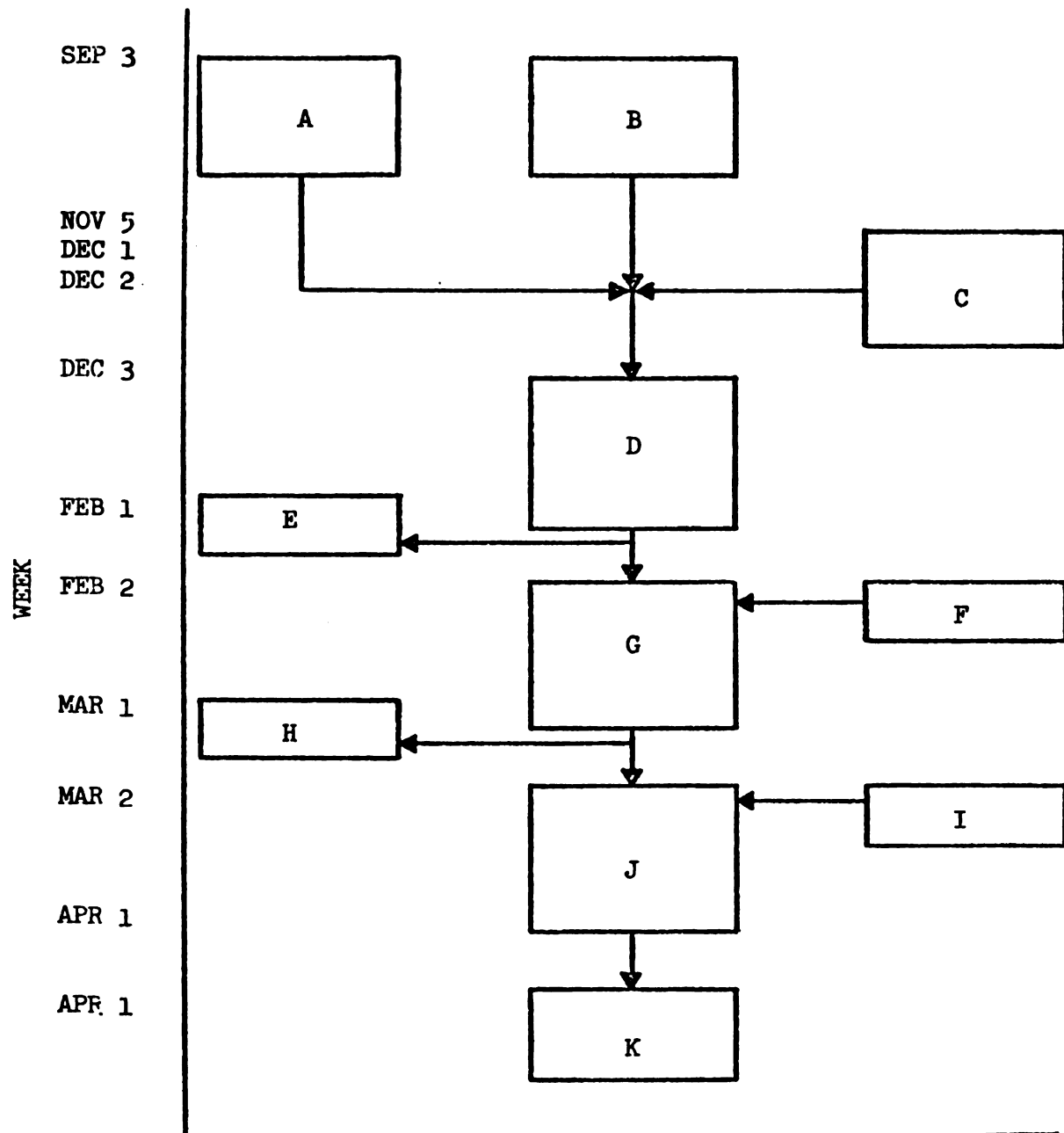


Figure 17. Diversified crops program: Easter lily production and marketing options available; options in optimal mix.

the options of keeping or selling some of all of his started plants and/or buying started plants. These alternatives make possible grower entry or exit from lily production at a number of points between the third week of September and the second week of March. Once he commits to produce in Phase III, the only remaining option is to sell finished plants for Easter.

The producer is also given the option of selecting among bulb grades 7/8, 8/9, 9/10, and 10/11 within any of the production options. Cost of bulbs and started plants, and selling price of the finished lilies vary with bulb grade as shown in Table 36. While CTF storage programs generally produce a plant with higher bud count and better general plant quality, a premium price is not assigned this option in the program so the direct comparison of the fixed resources requirement among the storage options can be made.

Table 36. Easter lilies: cost of bulbs and started plants, and whole prices for production options.

Bulb grade (cm)	Cost of bulbs (\$/1,000)	Cost of started plants (\$/1,000)		Wholesale market price for finished lilies	
		For Phase II	For Phase III	(\$/1,000)	(\$/pot)
7/8	406	750	1,025	1,750	1.75
8/9	535	1,250	1,525	2,250	2.25
9/10	614	1,525	1,775	2,500	2.50
10/11	670	1,775	2,025	2,750	2.75

Table 37. Diversified crops program: optimal crop mix.

Crop and options	Market quota (units)	Optimal crop mix (units)	\$/unit	Total returns to fixed resources total \$
<u>Snagdragons:</u>				
Single-stem grown from seed to bloom in				
Jul 4	None	19.35	533.18	10,317.03
Sep 3	None	0.18	533.32	96.00
Oct 3	None	22.07	531.88	11,738.59
Single-stem grown from purchased seedlings to bloom in				
Aug 4	None	12.81	545.03	6,981.83
Total				<u>29,133.45</u>
<u>Carnations:</u>				
Controlled holiday crops for				
Christmas (Dec 3)	5.00	2.84	1,512.85	4,296.49
Valentine's Day (Feb 2)	4.00	2.56	1,496.81	3,831.83
Total				<u>8,128.32</u>
<u>Standard Chrysanthemums for cut flowers</u>				
Pinched crops to flower				
Oct 2	4.00	4.00	718.34	2,873.36
Dec 2	10.00	10.00	740.49	7,404.90
Nov 4 (Thanksgiving)	10.00	10.00	952.76	9,527.60
Jul 2	4.00	4.00	694.90	2,779.60
Aug 2	4.00	4.00	706.40	2,879.92
Aug 5	4.00	4.00	719.98	2,825.60
Jan 2	9.98	10.00	769.99	7,172.82
Mar 2	10.00	10.00	749.36	7,493.60
May 2	9.44	10.00	841.66	7,945.27
Total				<u>50,902.67</u>

Table 37. Cont'd.

Crop and options	Market quota (units)	Optimal crop mix (units)	Total returns	
			to fixed resources \$/unit	total \$
Single-stem crops to flower				
Oct 2	4.00	3.54	602.75	2,133.74
Nov 4 (Thanksgiving)	10.00	10.00	839.39	8,393.90
Dec 3 (Christmas)	10.00	5.44	817.72	4,448.40
Sep 2	4.00	4.00	604.42	2,417.68
May 2	10.00	9.21	671.70	6,186.36
Total				23,580.08
Potted chrysanthemums:				
to flower				
Aug 3	6.00	6.00	1,703.87	10,223.22
Sep 3	6.00	5.57	1,700.88	9,473.90
Oct 4	6.00	2.03	1,706.23	3,463.65
Jun 4	5.00	5.00	1,776.85	8,384.25
Jul 4	6.00	6.00	1,699.58	10,197.48
Mar 2	2.00	2.00	1,607.80	3,215.60
Mar 4	4.00	4.00	1,612.21	6,448.84
Easter	15.00	3.12	1,620.55	5,056.12
Apr 4	5.00	1.72	1,644.08	2,872.82
Valentine's Day	6.00	5.54	1,609.05	8,914.14
Mother's Day	25.00	2.30	1,637.75	3,766.83
Memorial Day	None	6.00	1,633.15	9,798.90
Total				81,815.75
Poinsettias:				
Produce stock plants from started plants purchased Jun 1	None	2.93	- 961.92	- 2,818.43
Propagate Jul 1 to produce:				
started plants in 2 1/2 inch pots for sale Aug 4	None	6.79	243.86	1,655.81
sub-stock plant program, 1 plant per 6 inch pot	6.00	2.00	- 255.84	- 511.68

Table 37. Cont'd.

Crop and options	Market quota (units)	Optimal crop mix (units)	Total returns to fixed resources	
			\$/unit	total \$
Propagate Aug 5 from stub-stock plant program, stick cuttings direct in 4 inch pots to produce 1 3-bloom pinched plant for sale Dec 1-3	6.00	6.00	1,162.79	6,976.74
Sell sub-stock plant program 6 inch potted plants as started plants in Aug 5	6.00	2.00	3,500.00	7,000.00
Take cuttings from main stock plants Aug 3	None	8.8	259.00	2,276.6
produce finished, pinched 5-bloom plants in 6 inch plastic pots	6.00	2.79*	3,215.01	8,969.88
produce finished, pinched 6-bloom plants in 6 inch plastic pots	6.00	6.00	3,296.19	19,777.14
Buy started plants in 2 1/4 inch pots to produce finished, pinched 5-bloom plants in 6 inch plastic pots	6.00	3.21*	2,970.00	9,533.70
Take cuttings from main stock plants Aug 4	None	6.8	243.86	1,655.81
sell started plants in 2 1/4 inch pots in Sep 4	12.00	2.00	1,125.68	2,251.36
produce finished pinched, 3-bloom plants, one in a 4 inch plastic pot for sale Dec 3	None	2.68	403.00	1,080.04
Dump plants from main stock plant program	None			

*These options when combined yield the 6-unit market quota for finished, pinched, 6-bloom plants in 6 inch plastic pots.

Table 37. Cont'd.

Crop and options	Market quota (units)	Optimal crop mix (units)	Total returns to fixed resources	
			\$/unit	total \$
Sell finished blooming stock plants in tubs	0.25	0.25	11,734.00	2,933.50
Easter lilies:				
CTF program				
storage and production phase I:				
10/11 grade	None	16.00	- 820.76	-13,132.16
9/10 grade	None	10.15	- 755.62	- 7,669.54
sell started plants at end of phase I				
Feb 1				
10/11 grade	3.00	3.00	1,750.00	5,250.00
production phase II:				
10/11 grade	3.00	3.00	- 22.61	- 67.83
9/10 grade	3.00	3.00	- 14.24	- 42.72
sell started plants at end of phase				
II, Mar 1				
10/11 grade	3.00	3.00	2,000.00	6,000.00
9/10 grade	3.00	3.00	1,750.00	5,250.00
production phase III				
10/11 grade	10.00	10.00	- 32.72	- 327.72
9/10 grade	20.00	7.15	- 20.54	- 146.86
sell finished plants in bloom, Apr 1				
10/11 grade	10.00	10.00	2,750.00	27,500.00
9/10	20.00	7.15	2,500.00	17,875.00
Buy started plants				
beginning phase II, Feb 2				
8/9 grade	10.00	6.16	- 1,286.32	- 7,923.73
7/8 grade	10.00	5.00	- 784.78	- 3,923.90

Table 37. Cont'd.

Crop and options	Market quota (units)	Optimal crop mix (units)	Total returns to fixed resources \$/unit	Total returns total \$
beginning phase III, Mar 2				
8/9 grade	45.00	10.00	- 1,545.54	-15,455.40
7/8 grade	5.00	5.00	- 1,045.54	- 5,227.70
sell finished plants, Apr 1				
8/9	5.00	16.16	2,250.00	36,360.00
7/8	45.00	10.00	1,750.00	17,500.00
Total				<u>61,817.90</u>
Bedding plants:				
Marigolds transplanted into 3 inch pots for sale May 4	25.00	25.00	172.56	4,314.00
Total				<u>4,314.00</u>
Geraniums:				
25/1 program started from purchased cuttings:				
sell unrooted cuttings				
Dec 2	None	8.78	60.00	528.80
Feb 1	None	7.24	60.00	434.40
Mar 1	None	4.50	60.00	270.00
Mar 3	None	3.79	60.00	303.20
sell rooted cuttings				
Jan 2	None	0.47	128.00	60.16
sell started plants in 4 inch pots				
Mar 2	None	7.86	303.73	2,387.32
sell started stock plants in 5 inch pots				
Feb 3	2.00	2.00	347.12	694.24
Mar 5	1.00	0.93	323.00	300.39

Table 37. Cont'd.

Crop and options	Market quota (units)	Optimal crop mix (units)	Total returns to fixed resources \$/unit total \$	
sell started stock plants in 12 inch pots				
Jan 2	2.00	2.00	1,208.10	2,416.20
Feb 1	2.00	1.90	19.79	3,760.10
Mar 1	1.00	1.00	2,928.40	2,928.40
sell finished plants for:				
Mother's Day	2.00	2.00	495.55	991.70
Garden sales	None	5.00	453.94	2,269.75
Total				19,732.96
8/1 program started from purchased cuttings				
sell unrooted cuttings				
Feb 3	None	6.00	60.00	360.00
sell finished 4 inch pots				
May 1	4.00	4.00	504.14	2,016.56
sell started stock plants in 7 inch pots				
Jan 5	2.00	0.67	889.94	595.99
sell finished options grown from purchased cuttings:				
buy unrooted cuttings Feb 3, sell finished 4 inch, May 1	2.00	2.00	389.52	779.04
buy started plants in 2 1/2 inch pots				
Apr 1, sell finished 4 inch pots, May 1	2.00	2.00	245.20	494.40
Total				<u>4,245.99</u>
12/1 program started from purchased cuttings				
sell unrooted cuttings				
Dec 4	None	21.55	60.00	1,293.00
Feb 1	None	20.00	60.00	1,200.00

Table 37. Cont'd.

Crop and options	Market quota (units)	Optimal crop mix (units)	Total returns to fixed resources	
			\$/unit	total \$
sell rooted cuttings Jan 3	None	4.83	128.40	620.17
sell started stock plants in 7 inch pots Jan 1	8.00	5.09	1,293.64	6,584.63
Feb 1	8.00	8.00	1,977.74	15,821.92
sell finished 4 inch pots for Garden sales, May 3	None	22.19	1,346.78	9,959.79
finished options Crown from purchased cuttings and started plants: buy unrooted cuttings Mar 2, sell finished 4 inch plants May 1	2.00	0.68	441.35	300.12
buy started plants 2 1/2 inch Mar 5, sell finished 4 inch plants May 1		1.32	285.95	377.45
buy started plants 2 1/2 inch Mar 5, sell finished 4 inch plants May 3	None	4.83	343.38	1,648.22
buy rooted cuttings Apr 2, sell finished 4 inch plants May 3	None	16.22	243.98	3,957.36
Total				<u>41,762.66</u>
Tree program started from purchased cuttings				
sell unrooted cuttings Jan 4	None	42.81	60.00	2,568.60
Feb 3	None	0.43	-1,399.91	- 601.96
sell finished 4 inch pots May 1	2.00	0.38	1,032.54	392.37
sell finished tree geraniums in 12 inch pots May 1	1.00	0.43	11,880.00	5,108.40
Total				<u>8,671.33</u>
Total all geranium programs				<u>74,412.94</u>

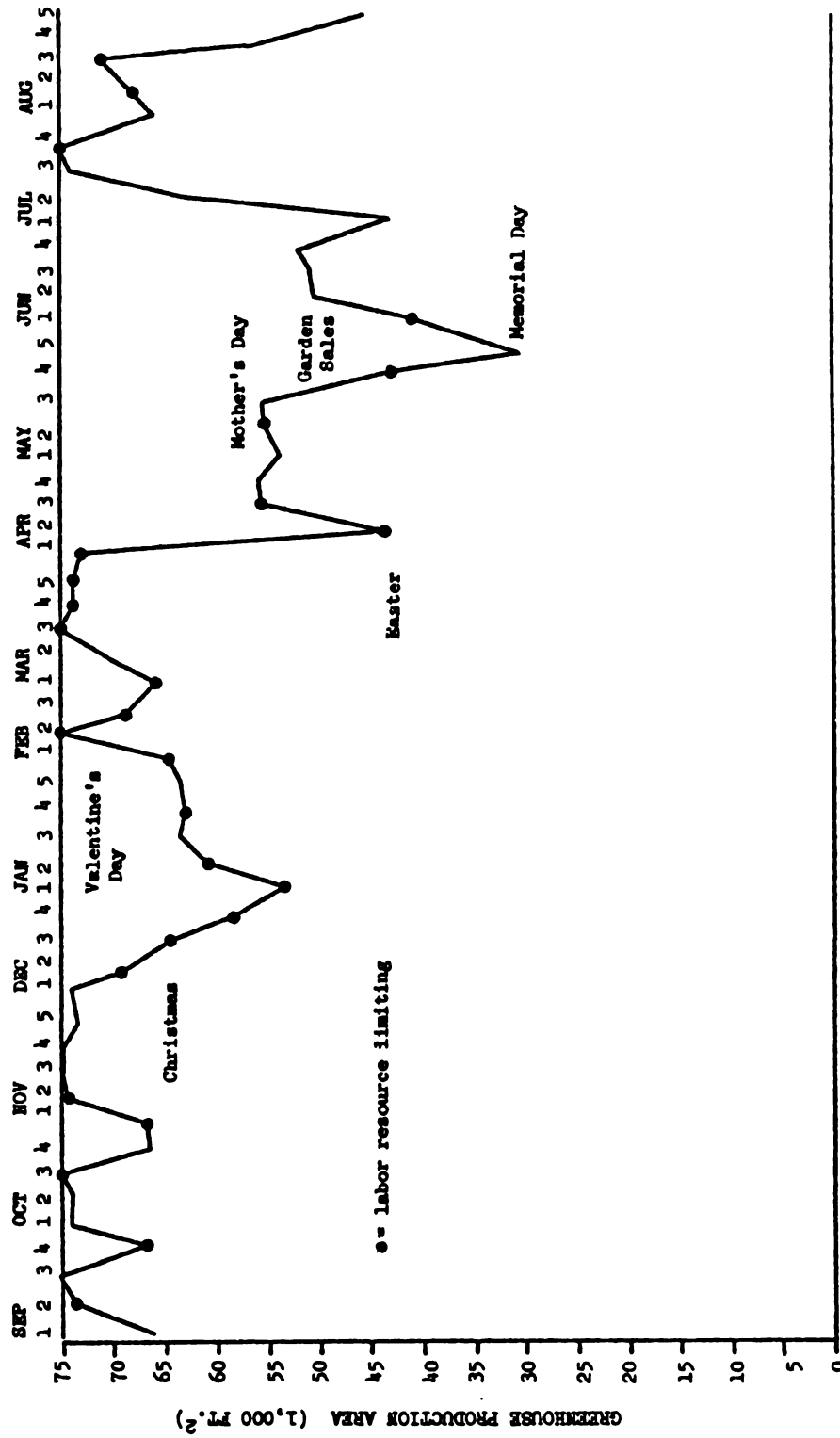


Figure 18. Diversified crops program: greenhouse production area utilized.

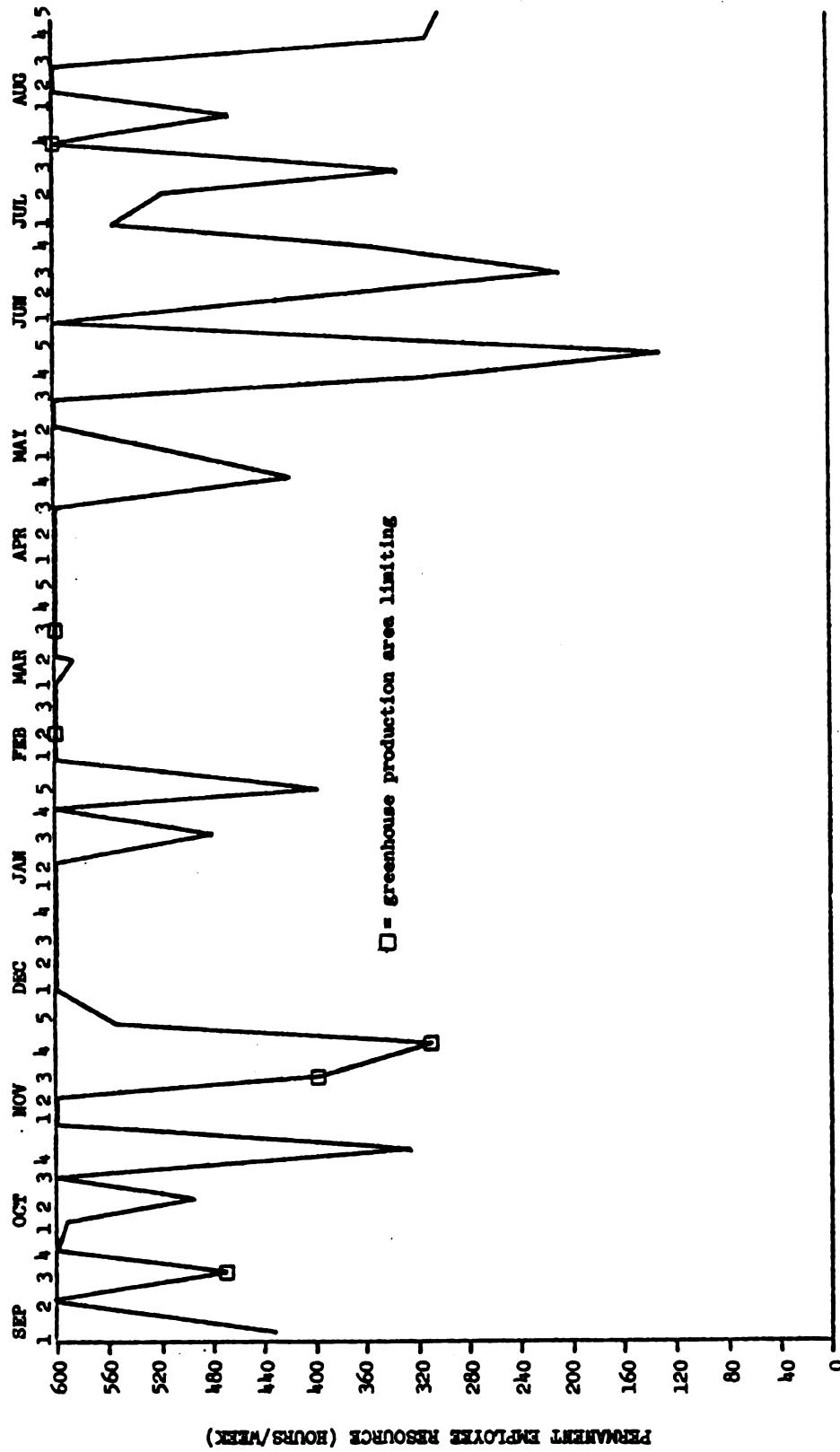


Figure 19. Diversified crops program: permanent employee resource.

Optimal Crop Mix for Diversified Crops Program

Table 37 specifies the optimal combination of enterprises and options for the diversified crops program. Number of units of each option in the combination as well as market limitations also are shown. Roses are the only crop not represented in the mix by at least one option. Bedding plants and carnations occur in relatively minor amounts. Most of the optimum combination is comprised of standard chrysanthemums, potted chrysanthemums, geraniums, Easter lilies, poinsettias and snapdragons. Analysis of crops and options in optimal mix occurs later in this chapter.

The fixed resources of greenhouse production area and permanent employee complement are used at or near full capacity for most of the period of mid-July through early April. Analysis of the patterns of use of each of these resources follows. Figure 18 shows the pattern of use of greenhouse production area; Figure 19 shows labor utilization.

Table 38 specifies weeks in which the greenhouse facility is at capacity and the amount by which the return to the firm would be increased if one additional unit of space (ft^2) were available in this week. Of the 7 weeks in which space is limiting, it is most constraining in the third week in September when the marginal return reaches \$0.82 per ft^2 . Labor is also limiting in this week. In this period, both poinsettia and geranium stock plants are in production. Both enterprises are grown in large containers requiring considerable space. Further, this is a week in which pinched poinsettia options are potted and placed at final spacing. Both the Christmas and Valentine's Day controlled holiday carnation crops are in the bench. A considerable planting of snapdragons is in production for October bloom as are a large number

of units of cut standard chrysanthemums. Essentially, this is a period when cut flower options which take advantage of low summer and early fall heating costs are in their final weeks. These options overlap the period when the finished poinsettia options are being initiated and the geranium stock plant program is commencing.

Table 38. Diversified crops program: weeks in which greenhouse production area is limiting, and marginal returns for a unit of space in these periods.

Production week	Marginal return (\$/ft ²)
Sep 3	0.82
Oct 3	0.04
Nov 3	0.15
Nov 4	0.00
Feb 2	0.08
Mar 3	0.12
Jul 4	0.02

The third weeks of November and March have the next highest marginal returns, e.g. \$0.15 and \$0.12 per ft² respectively. Labor is also limiting in the March week. In the third week in November, finished poinsettia options occupy maximum space, heavy production of standard chrysanthemums for Thanksgiving and December is underway, and the Christmas and Valentine's Day carnation programs continue. Heavy plantings of controlled temperature forcing Easter lilies and the 12/1 geranium stock plants have also entered production within several weeks

of this date. The third week in March represents a similar pre-holiday period when the greenhouse is filled to capacity with Easter, Mother's Day and garden sales crops. Heavy plantings of potted chrysanthemums for spring holiday sales are in production. Easter lilies now occupy maximum space and purchased started lilies are now in the bench. Many finished geranium options also are in production. Two major plantings of standard chrysanthemums for Mother's Day also occupy space. It should be noted that these two periods occur relatively close to major holiday periods and represent times when large quantities of holiday crops are finishing and space is also in demand for initiation or expansion of crops for subsequent sales periods.

For example, in the third week in November, the greenhouse is carrying peak crop loads for both Thanksgiving and Christmas. At the same time, Valentine's Day and Easter crops are already requiring space. In the third week of March, Easter and Mother's Day crops are at peak space and crops for spring sales are also demanding space.

The second week of February also finds the greenhouse at full capacity although the marginal return of $\text{\$}0.80^{\text{.08}}$ per ft^2 is somewhat lower than that for the two pre-holiday periods just discussed. Labor is also limiting in this week. Valentine's Day crops are in their final week of production in this week. Heavy plantings of potted mums are already underway for spring holidays and numerous geranium options are in production. All Easter lily options have now been expanded to final spacing and purchased started lily plants are now in place.

The periods of the third week in October and the fourth weeks in

November and July are the other times when space becomes limiting. However, as specified in Table 38, the marginal returns for these periods are relatively low, i.e. \$0.04, 0.02 and 0.0 per ft² respectively. The October period again represents a pre-holiday period when summer and early fall crops are maturing and Thanksgiving and Christmas crops are already well along. The fourth week in November is Thanksgiving week and similar to the second week in February, Valentine's Day week. This final week of the holiday crops finds these crops at full space capacity, and demand for space for subsequent crops increasing. The fourth week in July is a period more similar to the third week in September. Heavy plantings of summer and early fall snapdragon and standard chrysanthemums are in the bench. A number of potted chrysanthemum options are in production and the Christmas carnation crop is underway. Capacity is strained by the introduction of expanded poinsettia stock plant and propagation activity in this week.

Analysis of space use shows further that greenhouse capacity is very heavily utilized throughout the period of the fourth week in July through Christmas, and again February through Easter. In nearly all periods when the greenhouse is not used to capacity, labor resources limit further space utilization. In the period of Christmas through Valentine's Day lack of labor limits further space use in all but 2 weeks. During this period heavy labor inputs are required for the spacing of the lily crop, for planting, disbudding and marketing numerous potted chrysanthemum options, and the propagation, potting and spacing of geranium options.

Similarly, labor limits full use of space in 4 of the 7 weeks from the week after Easter through Memorial Day. Major labor inputs are made during this period in propagating, potting and selling geranium options, and initiating summer crops of snapdragons and standard chrysanthemums, and in initiating as well as selling several potted chrysanthemum options.

Analysis of the pattern of labor use in the model indicates that the 600 hours of permanent employee labor input likely would be sufficient to maintain this amount of greenhouse space at a high percentage of occupancy particularly if temporary employees were hired at the holiday and other peak labor input periods. Table 39 shows the weeks in which the labor supply is exhausted thereby limiting further production. Table 40 summarizes labor use in the program. Marginal return, the amount by which the return to the firm would be increased if an additional hour of labor were available in the period, for these weeks ranges from \$0.14 to \$66.85 per hours with a mean marginal return of \$16.09 per hour. Labor is of greatest value in Easter week when the marginal returns is \$66.85 per hour. It is second most valuable in Christmas week (the third week in December) at a price of \$47.56 per hour.

Peak labor use periods correspond with capacity use of greenhouse production area primarily (1) at major sales periods, i.e. Valentine's Day, Easter, Mother's Day and garden sales (mid-May), when the greenhouses are full with holiday crops and considerable labor is required to market them as well as to initiate subsequent crops, and (2) at periods when propagation, potting and planting activities are underway. These activities generally introduce production units which

occupy increased amounts of space, and which require considerable labor to accomplish.

The diversified crops program optimal mix generates \$384,135.64 total return to fixed costs per year, or \$5.12 per ft² of production area, or \$12.31 per hour of labor paid. This mix yields net return to fixed costs, i.e. returns after fixed costs incurred to provide 75,000 ft² of greenhouse production area and 600 hours of labor are deducted, of \$172,114.64 or \$2.29 per ft² or \$5.52 per hour of labor paid.

Table 39. Diversified crops program: weeks in which labor is limiting and marginal return for labor in these periods.

Production week	Marginal return (\$/hour)
Sep 2	8.03
Sep 4	8.91
Oct 3	4.52
Nov 1	17.10
Nov 2	22.66
Dec 2	3.18
Dec 3	47.56 (Christmas)
Dec 4	14.71
Jan 1	4.64
Jan 2	.14
Jan 4	14.77
Feb 1	24.71
Feb 2	16.97 (Valentine's Day)
Feb 3	5.97
Mar 1	12.74
Mar 3	9.74
Mar 4	9.54
Mar 5	3.09
Apr 1	66.85 (Easter)
Apr 2	18.96
Apr 3	11.46
May 2	27.24 (Mother's Day)
May 3	15.87 (Garden sales)
Jun 1	23.83
Jul 4	27.42
Aug 2	8.60
Aug 3	5.21

Table 40. Diversified crops program: summary of use of 600 hours/week of permanent employee resource.

Excess labor capacity (hours)	Number of weeks in year with excess labor capacity
0	27
1-50	1
51-100	4
101-200	10
201-300	7
301-400	2
401-500	1
501-600	0
	52

These returns for the optimum crop mix are more favorable than average returns for the nine northern United States greenhouse firms from which data were taken in this study. However they are lower than for the model used in the Massachusetts study (33). Table 41 lists the returns for these latter two situations. Returns to fixed costs are considerably greater in both models. This results partially because the models assume ideal conditions and, to some extent, because the

Table 41. Diversified crops program: comparison of net returns to fixed costs for nine northern United States firms with those generated in the model, and in the Massachusetts model.

	ft ²	Net return to fixed costs	
		Total (\$)	per ft ² (\$)
$\bar{x}_0$ firms	89,388	30,391.92	0.34
Model	75,000	172,061.64	2.29
Massachusetts model	10,000	37,977.50	3.80
a)			

a) Vaut, G.A., R.L. Christensen, T.C. Slane and J.F. Smiarowski. 1973. Greenhouse Linear Programming, Dept. of Agric. and Food Econ., Univ. of Mass., Public. no. 93.

crop mixes of the nine growers may be considerably non-optimal for their operations in terms of profit maximization.

Production guidelines which emerge from analysis of the optimal crop mix

The optimal crop combination programmed for the model contains 73% potted crops and 27% cut flowers based on contribution to total return to fixed costs. Potted plants offer a production programmer greater flexibility to enter and exit production because of the numerous and often short-term options, and the opportunities to buy and sell potted plant material in various stages of development. Conversely, once planted, cut flower crops represent a firm commitment of production area for a definite period of time.

Ninety per cent of the total return to fixed costs accrues from the production of five crops: potted chrysanthemums, standard chrysanthemums, geraniums, poinsettias, Easter lilies. In industry, these are the crops which tend to be found in production by the mixed crop grower, and, of course, with the exception of standard chrysanthemums, by the potted plant specialist. In industry, the crops which occur in the mix in relatively small amounts or not at all, e.g. snapdragons, carnations, bedding plants, roses, tend to be produced by specialists who have tailored both facilities and markets to these crops. These crops likely would yield more favorable contributions to total returns if the model were to be specified more closely to the characteristics of the specialist crop producer, as is done in a later section of this study.

Analysis of crop patterns in the optimal mix through the production year
September through Christmas

During the fall period with major holiday markets at Thanksgiving and Christmas, the production program is heavy in poinsettias for sale

as propagation material and finished plants, standard chrysanthemums for cut flowers, and geranium stock plant production. Very minor activity occurs in Easter lilies, potted chrysanthemums, controlled holiday cropping of carnations for Christmas and Valentine's Day, and snapdragons. Roses do not occur in the mix in this period. Bedding plant production is possible only in January through May.

Mid-December through Easter

The Valentine's Day and Easter markets occur in the winter period. The production schedule is heaviest in potted chrysanthemums, Easter lilies, geranium stock plants and geraniums for finished plant sales. Minor activity occurs with standard chrysanthemums, controlled holiday cropping of carnations for Valentine's Day, and bedding plants. There are no crops of snapdragons or roses, and poinsettia activity during this period is not possible.

Mid-April through August

This period embraces the major Mother's Day market, spring garden sales, and the relatively slow summer market period. Potted chrysanthemums predominate throughout the period. Finished geraniums are significant options in April and May. Snapdragons are a major component of the mix with nearly the entire production of this crop occurring during this period. Minor activities are standard chrysanthemums, poinsettia stock plant production and propagation activity, bedding plants and controlled holiday cropping of carnations for Christmas and Valentine's Day. Roses are not in production and Easter lilies cannot be programmed in this period.

Analysis of factors which appear to influence the entry of various crops into the optimal crop mix at various times of the year

Potted chrysanthemums

Potted chrysanthemums contribute nearly 21% of the total return to fixed resources. In our previous analysis of this enterprise under a situation where only potted mums are grown, the variable costs of heat and photoperiod control, and the length of time an option is in the bench, are cited as the apparent major factors which determine the occurrence of the option in the optimal mix. These factors again appear to be operative when potted chrysanthemums are studied in combination with other crops. Nearly all of the production or 31 of the total 43 units in the crop mix occurs in the first week of March through the end of August. During this period heating costs are among the lowest of the year, and a potted mum crop requires fewer weeks of bench time.

However, the competitive influence of other major crops may also influence the production pattern. For example, during the period of the first week of September through Christmas, only one potted chrysanthemum option occurs for any major period of time. And, this option is produced in only one-third of the allowable market quota, i.e. 2.00 of 6.00 units possible. This period coincides with that for production of finished poinsettia options. Also, approximately 25% of the production area is devoted to standard chrysanthemums. The combination of poinsettias and standard chrysanthemums in the fall months appears to offer greater profit potential than does potted chrysanthemum monocropping. In the specialized potted chrysanthemum program, this same period ranked near the top in number of units of potted chrysanthemums in production.

Easter lilies do not appear to compete with potted chrysanthemums for use of fixed resources as strongly as do poinsettias. In the period from mid-December through Easter, the major portion of the production period for 19 units of potted chrysanthemums occurs. This is also the period when heating costs are highest. Lilies and potted chrysanthemums are grown at essentially the same temperature. It is interesting to note that in the second week in February when the Valentine's Day potted chrysanthemum crop is sold, started Easter lilies are purchased in a quantity almost sufficient to fill space formerly occupied by the potted chrysanthemums.

During the first week of March through the end of May, the major portion of the production period of 15 units of potted chrysanthemums occurs. This is also a period of lower variable costs and shorter bench-time requirement for potted chrysanthemums. It also coincides with the time when the options for producing 6-8 week finished geraniums in 4 inch pots are available. Potted chrysanthemums appear to compete well for fixed resources with fast-crop geraniums. Standard chrysanthemums occupy about one-half as much of the production area during this period as do the potted chrysanthemum options.

In summary, the potted chrysanthemum crop in general uses fixed resources of space and labor efficiently within the parameters of this situation. It appears, however, that poinsettias and standard mums represent a more profitable combination for production during the period September through Christmas. Potted chrysanthemums appear to compete well with Easter lilies and finished non-stock geranium options, and seem to be most efficient during March through August. In the summer

months of June through September, potted mums, standard chrysanthemums, and snapdragons represent a profitable production combination.

Standard chrysanthemums - pinched and single-stem options

Standard chrysanthemums for cut flowers rank second in value in the optimal crop mix with total return to fixed costs of \$74,482.75. This represents nearly 19% of total returns. Earlier, when the standard chrysanthemum monocrops program was studied to determine the optimum combination of crop options for a grower specializing in the crop, the pinched options predominated in the mix. This pattern occurs again when the options are programmed along with those of the other eight crops. Pinched options comprise about 13% of the total return to fixed costs, about 68% of the revenue from standard chrysanthemums; single-stem crops are 6% of total revenue or 32% of standard chrysanthemum revenue. The lower input cost for cuttings, essentially one-half that of single-stemmed options, is apparently the basis for the greater profitability of the pinched options. After this major difference, the effect of the season on heating costs and length of bench time required for a crop appears to heavily influence the profitability of both the pinched and single-stemmed options.

The impact of these latter two factors is apparent when the cut chrysanthemum options compete with the other eight crops in the diversified crop program. Forty-six of the total 99 units of chrysanthemums in the mix are produced in the fall, i.e. September through Christmas, 29 units in winter, i.e. mid-December through Easter, and 24 units in mid-April through August. In the fall, heating costs and time in the bench are moderate. But the factor which likely brings so large a quantity of cut chrysanthemums into the mix in the period is the relatively

low labor requirement when compared to poinsettias, the other major enterprise in the mix at the time. More than one-half of the cut chrysanthemum crops (20 units) in this period are timed for Thanksgiving harvest, a period when relatively little labor is required for the companion crop of poinsettias. The Thanksgiving chrysanthemum crop is produced to the limit allowed by the market quota. Fifteen units are harvested in early to mid-December for the Christmas market. The remaining 11 units, while in production primarily in this fall period, bloom in the next time period in January. Premium prices are assigned to cut chrysanthemums sold in holiday markets with Thanksgiving and Christmas premiums the highest. Hence, standard mums are a good complementary crop for poinsettias.

The favorable effect of the lower labor input required for cut chrysanthemums is further illustrated by the relative absence in the fall mix of potted chrysanthemums, a relatively high labor consuming crop. Apparently, poinsettia and cut chrysanthemum operations mesh more favorably quantities and timing of labor input. Similarly, the several geranium stock plant options while perhaps operating under additional constraints, do require higher labor inputs than cut chrysanthemums and for this reason occur in the fall mix in relatively minor quantities.

During the winter period, 19 of the 29 units of standard mums in the mix are produced for the premium Mother's Day market. The remaining 10 units are an October-planted option which blooms in mid-March. In this period, cut chrysanthemums again appear to represent a low-labor-requiring complement to the higher-labor-requiring Easter

lilies, potted chrysanthemums, and geraniums which comprise the majority of production in the period.

Standard chrysanthemum production during the mid-April through August period is 24 units which is somewhat less than in the winter period but almost one-half that of fall production. With the exception of 8 units, standard chrysanthemums in production in this period bloom during the next period, fall. The 20 Mother's Day units are produced primarily in the winter period. During this period heating costs and time in the bench are both relatively low. Primary companion crops are potted chrysanthemums and snapdragons for cut flowers. Once again, the standard chrysanthemums are serving as a low-labor complement to the labor-consuming potted chrysanthemum which predominates in the schedule. However, snapdragons apparently now become competitive with standard chrysanthemums because of the extremely short production period required under spring and summer growing conditions, and because of the considerably lower, variable input costs for snapdragons. For example, snapdragon seedlings are far less expensive per production unit than are chrysanthemum cuttings. Consequently, a combination of cut chrysanthemums and snapdragons serve as the low-labor-requiring complement to the potted chrysanthemums, and to the geranium and poinsettia stock plants during the spring-summer period.

While snapdragons are a profitable option during at least the spring-summer-fall period, roses and carnations, with the exception of the Christmas and Valentine's Day controlled holiday options, apparently are not as efficient nor productive in their utilization of fixed resources as are standard chrysanthemums. And while two controlled

holiday options of carnations do occur in the mix, they are produced to only slightly more than one-half the market quota placed on them.

Roses for cut flowers

Commercial rose growers cycle their crop on a 4-year rotation. Once plants are benched, the grower is committed by his relatively high investment of about \$1.00 per plant to continue for a major portion of a 3- to 5-year period. A plant occupies one ft².

Because this study deals with only a one-year production period, all labor inputs are pro-rated on a 4-year basis. For example, the high labor input required for planting the crop is pro-rated across 4 years. Similarly, a labor factor for cutting and grading roses is pro-rated across the full 4-year production period to compensate for the fact that no cutting is done during the period of early plant development in the summer following planting. Annual production of cut flowers is similarly adjusted to reflect the 4-year regime.

As noted earlier, neither the hybrid tea rose option nor the floribunda rose option occur in the optimal crop mix. For each unit of hybrid teas a producer grows in the mix in place of an optimal component, the returns to fixed costs are reduced by \$50.53; and for floribunda roses by \$1,212.42. Floribunda roses require generally higher labor input than hybrid teas. They also yield fewer flowers per production unit and net somewhat lower market prices per flower. Further, growers report that they do not have the same opportunity to obtain premium holiday prices for this option as they do for the longer-stemmed hybrid tea roses. These differences are considered in the model and are likely the basis for the considerably greater reduction in return predicted

for the forced production of this option. In a situation where greenhouse production area and labor are both limiting, it is likely that roses or any other crop which requires commitment of considerable amounts of fixed resources for an entire production year are at a disadvantage when being evaluated against the many shorter-term crop options arrayed. Further, roses for the most part are produced by specialists rather than in combination with other crops.

Snapdragons - single-stem options

Ranking sixth in value in the optimal crop mix, single-stem snapdragons for cut flowers contribute \$28,541.10 or 7.18% to total return to fixed costs.

While 12 production options are available, enough to make continuous year-round production of snapdragons possible, only 4 options appear in the optimal mix. All are produced during May through October with crop harvest commencing as follows for each of the options: 19.35 units the third week of July, 0.18 units the third week in August, 22.07 units the third week in September, and 12.81 units the second week in October.

While market returns for snapdragons are usually the lowest of the year during the June through October period, the cost of producing snapdragons is similarly at its lowest in this period. Minimal costs stem from the near absence of heating expense and from considerable shortening of the time required to grow snapdragons under summer light and temperature conditions. Also, poinsettias and lilies, two high-profit options, are not available for production in this period. No market quotas are imposed on any snapdragon options.

During May through mid-October when snapdragons come into the

optimal mix, other crop options in the mix include potted chrysanthemums, standard chrysanthemums for cut flowers, and controlled cropped carnations. The early propagation stages of both poinsettias and geraniums also occur in the mix. Of course, poinsettias and geraniums for finished crops, bedding plants, and Easter lilies are not available for production programming in this period.

Analysis of the presence of snapdragons in considerable volume in the optimal mix in the May-October period, a time when the fixed resources of space and labor are both being utilized at near capacity, points to several characteristics of the crop. Snapdragons are a fast crop under summer conditions requiring only 11-12 weeks from benching to harvest. They also require relatively little labor. Standard chrysanthemums require one-third more time in the bench and considerably more production labor. Potted chrysanthemums may be produced in the same or slightly less bench time as snapdragons, but this potted crop has a much higher labor input. On the other hand, standard chrysanthemums and potted chrysanthemums both have a considerably higher total return to fixed costs per comparable unit of production. It is likely then that the snapdragon option by virtue of its relatively short production period under the growing conditions of the May through October period, and its characteristic low labor requirement, becomes a profitable filler crop which enables a producer to substantially increase his total return to fixed costs during this period with relatively minimal usage of fixed resources of greenhouse production area and labor. The other crop options available, roses and carnations, do not offer similar advantages, and the geranium and poinsettia propagation options represent only one of many alternative ways of initiating these crops for sale later in the

season.

Snapdragons do not occur in the optimal mix during the period bracketed by the fourth week of October and the first week of May. During this period, snapdragon market returns are greater per unit but so are the costs of production and the amount of bench time required per crop. Snapdragons also lose the time-in-the bench advantage which they hold over standard chrysanthemums in the early May through early October period. Total return to fixed costs also is reduced during the fall and winter period because the longer time in the bench increases total heating costs per crop. These factors couple with that of the availability of numerous poinsettia, geranium, Easter lily and bedding plant production options which are not available during the May through October period. Many of these compete favorably and to the disadvantage of snapdragon crops.

Finally, of the four snapdragon production options which occur in the final mix, all crops except the August option are produced from seed rather than from purchased seedlings. No grow-from-seed option is provided for the August crop because of adverse temperatures for snapdragon seed germination at this time. As reported for the specialized snapdragon program earlier, the use of the minimal labor and greenhouse area required for starting seedlings apparently is efficient enough to make purchase of seedlings, the alternative source of starting the crop, unprofitable.

Bedding plant options

Probably because the model does not portray the bedding plant option as accurately as it might, only one bedding plant option, marigolds transplanted into 3 inch pots and sold the fourth week in May, occurs in the optimal mix. The market quota of 25 units of 1,000 3 inch pots each, or 25,000 pots, are in the mix. Total return to fixed costs of \$4,314.00 or 1.09% of the total generated result from this option.

All bedding plant options occur only in the production period January through May. The potted marigold option in the optimal mix is seeded the fourth week in March and sold during the third and fourth weeks in May. This is the active garden plant and Memorial Day sales period. Market returns for this option are among the lowest of all the bedding plant options, e.g. \$200 per unit of 1,000 pots. An option which is essentially similar except that the potted marigolds are sold for Mother's Day, the first week in May, has a market return of \$250.00 per unit. Production costs per unit are essentially the same for both options as are greenhouse space and labor requirements.

The potted marigold option which appears in the mix likely does so primarily on the basis of a coincidence in periods of relatively excess greenhouse space and labor with those periods when the option requires space expansion and greatest labor inputs. The heavy transplanting requirement for this option coincides with the relatively excess labor period which occurs in the second week of April, immediately after heavy Easter sales. Similarly, marigolds upon being potted from the seed flat have a considerably expanded greenhouse space requirement. This option when in the seed flat seems to use efficiently the space vacated by Easter crops the week prior to the potting of the marigolds. Also, relatively little demand for labor is imposed by this option during the week of May when labor is limiting because of the heavy demand for this fixed resource for Mother's Day crop sales (first week). Further, there are relatively few other crop options available during this period which offer as short-term and as efficient a fit in their

use of the fixed resources.

The option is produced to market quota, e.g. 25 units. The relatively low marginal return for the option of \$2.31 implies that if the quota were lifted, relatively few additional units would enter the mix. In summary, while the potted marigold option which occurs in the optimal mix likely does so because it makes efficient use of fixed resources through its effective fit with available greenhouse space and labor, the marigold as a crop plant does offer considerable flexibility in production timing. Modification of production schedules one week forward or back in time would likely still allow for the production of a saleable crop for the target market. Hence, it should be recognized that certain other potted marigold options may be profitably fitted into the optimal mix with slight modification of the production schedule.

Easter lilies

Lily options in the optimal mix are shown in Figure 17. Contribution of these options to the total return to fixed costs are \$6,817.96 or 15.55%. In this respect, lilies rank fifth among the 9 options, but are within 1% of the fourth ranked crop, poinsettias, and within approximately 3% of the second and third ranked crops, standard chrysanthemums and geraniums. The dollar contribution of lilies is more than double the sixth ranked crop, snapdragons. The controlled temperature forcing program (CTF) is the only storage option utilized in the mix. Sixteen units of 10/11 grade bulbs and 10.15 units of 9/10 grade are placed in such storage. The non-pre-cooled (NPC) and pre-cooled (PC) storage options are not used. Of the 26.15 units which are initiated using CTF storage, 16.00 are of 10/11 grade and 10.15 of

9/10 grade. Of these units, 17.15 or 65.66% are grown to sale as finished Easter lilies in April. Three units of 10/11 grade are sold as started plants at the end of Phase I, and another 3 units of the same grade sold at the end of Phase II. The remaining 10 units are sold as finished plants for Easter at the end of Phase III. The 10.15 units of 9/10 grade bulbs are produced through the end of Phase II when 3 units are sold as started plants; the remaining 7.15 units are retained for finished plant sales. No additional units of 10/11 and 9/10 grade plants are purchased as started plants.

Conversely, the 8/9 and 7/8 grade options are not produced through storage options but are purchased during the production period. At the outset of Phase II, 6.16 units of 8/9 grade and 5 units of 7/8 grade are purchased. These are supplemented by purchase of 10 and 5 more units respectively at the beginning of Phase II. Ultimately, all 26.16 units of these two lower grades are sold as finished plants for Easter. None is sold as started plants earlier in the program.

Analysis of Easter lily units in the optimal mix indicates that while the CTF storage option adds the variable cost of heat during storage to the total cost of producing Easter lilies, it also offers the opportunity to make more efficient use of the labor resource. One can shift the major input of labor for the initial potting of the bulbs from the peak mid-December (Christmas) period required by the other storage options, a period when labor is limiting, to the first week in September when labor supply is not fully used even after the greenhouse production area is filled to capacity.

The occurrence in the optimal mix of the larger two grades for

production of nearly 66% of the units started from storage and grown to final sale indicates that even though bulb cost is greatest for these grades, their premium started-plant and finished-plant sales prices are sufficient to offset this higher variable cost. Also, the 10/11 grade option requires greater use of the greenhouse space resource because it is grown at wider spacing than are the other 3 grades during the latter half of Phase I and throughout Phases II and III. This greater spacing requirement, and the consequent effect on heating cost per unit particularly during Phase I (third week of December - first week of February), the costliest heating period, likely partially explain the sale of 3 units of 10/11 grade bulbs at the end of Phase I, and replacement through purchase of started plants of 6.16 units of 8/9 grade and 5 units of 7/8 grade options which produce more pots per unit of space occupied. And, because the 9/10 grade bulbs utilize the same space as the lower grades throughout production, and yet yield higher started-plant and finished-plant prices, it appears that sale of this option occurs only after sufficient units of 10/11 grade are sold to bring about the price/space balance referred to earlier. Hence, 9/10 grade are sold at the end of Phase II but not at the end of Phase I. However, the purchase of these quantities of 8/9 and 7/9 grade plants requires commitment to lilies of substantially more total greenhouse space during Phase II (7,030 square feet) than that released by sale of 10/11 plants (3,000 square feet). And, several major potted chrysanthemum options, and many of the spring geranium finished plant options, also are initiated or expanded in spacing in this critical week when the Valentine's Day crops are sold. Both fixed resources

of labor and greenhouse production area are at maximum use, and hence limiting in this period, and for most of the following 9 weeks through the week after Easter. It appears then that the lily options described above and the potted chrysanthemums and geranium finished plant options which enter the program in the second week of February represent an efficient and competitive combination of enterprises.

Essentially, the same transactions occur at the end of Phase II in the second week of March when 3 more units of 10/11 grade plants are sold as are 3 units of 9/10 grade. These sales release 4,890 ft² of production area. But, 10 units of 8/9 grade and 3 units of 7/8 grade are purchased as started plants and will require 9,450 ft² during Phase III. Other crops entering the optimal mix at or shortly after the second week in March are several potted chrysanthemum options, numerous spring finished geranium plant options, and the potted marigold program. Cut flower crops are not strong competitors for fixed resources during this period. The tendency toward replacement of some units of 10/11 grade plants in the final production phase indicates that the lower grades of bulbs are probably more efficient users of space than is the 10/11 grade plant, especially when greenhouse production area begins to become, or actually is, a limiting factor. Further, the premium price paid for the finished plant in the 10/11 grade apparently is not entirely sufficient to compensate for the added return to be obtained from some level of additional units of 7/8 and 8/9 grades produced in the comparable amount of space, and in the same time period. Further, the heating costs per finished pot during this period are greater for the 10/11 grade as a result of production of fewer pots per unit of greenhouse production area during Phase III.

On the other hand, 10 units of the 10/11 grade and 7.15 units of 9/10 grade are produced during Phase III indicating that the grades are profitable in the optimal mix. There appears to be a quantitative level at which the production of a greater number of units per ft² afforded by the lower grade plants, and the premium prices paid for both the 10/11 and 9/10 grades, combine to achieve the greatest return for the use of greenhouse space and labor. In this multicrop production situation, the number of units of the various grades of lilies produced to finished plants defines that optimum point for Phase III.

The following Easter lily production management guidelines emerge from the analysis:

1. Easter lilies appear to be a compatible and profitable series of options when used in a diversified greenhouse operation.
2. The CTF program offers the diversified producer a relief of pressure on the labor resource during the busy Christmas crop period by allowing the labor-consuming lily potting operation to occur in September. This advantage accrues to the CTF system even though additional heating costs are incurred during storage, and an additional labor cost occurs in the moving of the potted bulbs from potting operation into storage. Further, while not applied in the problem, in reality a premium price is obtained for CTF-grown lilies in some markets because of their greater bud count and more vigorous plant quality. If the market offers this premium, the advantages of the CTF system will be further enhanced.
3. The NPC and PC storage options may approach the profitability of CTF if the bulb potting operation were achieved in late

November when considerably more available labor exists.

However, in some markets, CTF plants will still command a price premium.

4. The sale of started plants at several points during the lily production program may be a profitable option, especially for managers who also produce potted chrysanthemums, finished geranium plants and bedding plants which must be initiated in February and March. This practice appears to be most profitable with the higher grades of bulb especially if sale occurs before or at the point of first spacing and sale price reflects bulb grade.
5. Purchase of started lily plants appears to be a viable means of initiating the crop. Advantages of this practice include the elimination of a considerable portion of the storage, potting, handling and spacing labor requirement and avoidance of losses stemming from poor bulbs and other maladies most prevalent during the early greenhouse production phase. This approach would offer greatest advantage to retail growers and other firms with limited labor resources.
6. A range of bulb grades appears to offer potential for achieving an optimum mix which uses greenhouse space and labor efficiently and achieves the greatest total return to fixed costs from the use of these resources. However, the optimum mix will be determined not only by the available lily options but also by the other crop options available for production.

Poinsettia options

Production of finished poinsettia crops from either or both stock plants and purchased started cuttings or plants is possible in the diversified crop program. Figure 15 depicts these options. A considerable number of units of each occur in the optimal solution indicating that both make efficient use of fixed resources in this production situation. Of the total \$65,549.83 return to fixed costs contributed by poinsettias, \$49,591.67 or 75.66% comes from stock plant programs, and \$15,958.16 or 24.34% from options which require the purchase of the initial cuttings or started plants. Poinsettias account for 16.49% of the total return to fixed costs and rank fourth after geraniums which account for 18.31%.

Options in the optimal mix are shown in Figure 15. Propagated options stem from a stock plant program which begins with the purchase of 2.93 units of started plants from a national supplier in the first week of June. The first units of cuttings are available on these stock plants in the fourth week of July. Of these, 8.79 units are propagated of which 6.79 units are sold as started plants in 2½ inch pots, and 2 units are potted in 6 inch pots for stock plants. Six units of cuttings are taken from these in the fifth week in August to produce 6 units of finished plants in 4 inch plastic pots pinched once to achieve 3 blooms per plant. The stock plants are grown on for sale as finished pinched, heavy 6-bloom plants in 6 inch plastic pots. The stock plants started in June are continued after the cuttings are taken in the fourth week in July. The next propagation occurs in the second through fourth weeks of August. Finished crop programs are initiated from these cuttings as shown in Table 42 and are produced to market quota. Also, 6.80 units of cuttings from this propagation are sold as started plants.

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Table 42. Diversified crops program: finished poinsettia options in the optimal crop mix.

Production option	Week Initiated	Optimal mix (1,000 pot units)	Market quota (1,000 pot units)	Marginal return (Shadow prices) (\$)
<u>Finished plants from stock plants</u>				
pinched plants:				
3-bloom, 4 inch plastic pot	Sep 3	2.00	2.00	23.66
5-bloom, 6 inch plastic pot	Sep 3	2.79	2.79	785.11
6-bloom, 6 inch plastic pot	Sep 3	6.00	6.00	874.32
<u>Finished plants from purchased cuttings and started plants</u>				
single-stem plants:				
5 plants in 7 inch pot	Sep 1	2.00	2.00	277.91
6 plants in 8 inch pot	Sep 1	1.00	1.00	820.04
pinched plants:				
5-bloom, 6 inch plastic pot	Sep 2	3.21	3.21	785.11
<u>Finished stock plants</u>	Jun 1	0.25	0.25	6,727.36

Thereafter, 0.25 units of the stock plants, the market quota, are grown on for sale at Christmas as large flowering poinsettias in a tub. The remaining 2.68 units of stock plants are dumped. Finished plants of poinsettias are produced from purchased 2½ inch potted plants to market quotas as shown in Table 42.

Analysis of poinsettia options in the optimal mix

The stock plant program initiated the first week in June requires considerable greenhouse production area during June through August, but is eliminated by September when pressure for space increases for the late fall and the Christmas holidays. Further, it provides an immediate

successor crop to the geranium and bedding plant crops which vacate space in late May. And, as with the geranium crop, the existence of numerous alternatives for the cuttings yielded by the stock plants offers considerable programming flexibility. In the model, the yield of the poinsettia stock plant program is channeled as follows: nearly 14 units of cuttings sold as rooted cuttings or started plants, and 17 units of cuttings go to produce finished crops. These summary figures include a sub-stock plant option initiated within the major program. All finished plant options initiated from cuttings of the stock plant program are produced to market quota.

The shadow prices for these finished crop options, in all of which market quotas are met, indicate that total return to fixed costs could be enhanced considerably by the production of the next unit of each option. However, the fact that other available finished options in the program are not produced indicates that factors other than the profitability of the finished plant options are responsible for limiting further production of the stock plant program

Among these factors are both greenhouse production area and labor which become limiting in the fourth week of July. Further, the labor resource is exhausted the first week in June, the period which requires considerable manhours to plant poinsettia stock plants. Labor also limits operations in the second and third weeks of August, a period when the major propagation operations are slated. Further, labor is limiting in the second week of September and greenhouse space is limiting in the third week in September and nearly so in the second week. The availability of numerous finished plant options which are not produced in the optimal mix indicates that other fall and Christmas

crops compete effectively for fixed resources with the finished poinsettia options.

Hence, the poinsettia stock plant program which occurs in the optimal mix is one which is limited by planting labor requirement in the first week in June, by space and labor requirements in late summer during peak propagation periods, and by the effective competition of other crop options for the fixed resources available both in the summer months during propagation, and in the latter third of the year when finished options compete with other crops.

It is interesting to note that the option whereby large stock plants initiated the first week in June are continued in production for sale as finished tubbed, blooming plants for Christmas is produced to the market limit of 250 plants. A shadow price of \$6,727.36 per unit of 1,000 plants indicates that the total return to fixed costs would be increased by this amount if the next unit could be produced. Unfortunately, the market quota is all too realistic for present markets. But, the apparent profitability of this option may merit efforts to expand the market for large-size poinsettia plants.

Production of a number of non-stock plant options in the optimal program likely reflects the limitations imposed by labor supply in key weeks in the summer. These finished plant options apparently utilize greenhouse space efficiently enough during September through Christmas sales to justify substitution of the higher initial started-plant cost for the scarce labor resource.

Options produced by the purchase of started plants in various weeks in September are for the most part the largest sizes of plants available for production. Further, they are all produced to market

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quota and they all have substantial shadow prices. Analysis of these options indicates that they return the highest market price because of plant size and number of blooms per plant. However, in the case of the 6-bloom and 5-bloom pinched single plants in 6 inch pots, there is no difference in space and labor requirements from those of a similar 4-bloom plant. In this situation, the options in which the plants carry a higher number of blooms, and hence a higher price, enter the optimal mix first, and to the limits of their market quotas. It is interesting to note, however, that the 4-bloom pinched single-plant per 6 inch pot option does not come into the mix, but the 3 blooms per single pinched plant in a 4 inch pot does, and to the limits of its market quota. Apparently, the greater yield of plants per ft² for this smaller size pot more than compensates for the lower price per finished pot. Also, the crop is in the bench for fewer weeks and requires somewhat less labor.

In the case of the single-stem, single-bloom per stem plants produced from the non-stock plant option, once again the plants with highest market value appear at full market quota. It appears that the higher market returns for this product more than offset the cost of additional cuttings and somewhat greater space and labor invested per unit. While the market demands a range of plant sizes and grades, and the market quotas reflect realistically the quantities of these higher grades which will be taken when offered, one ponders whether the grower is not sometimes enticed by the volume of crop which is demanded in plants of lower grade and smaller pot-size, and overlooks profitable opportunities latent in the production of the higher grades and larger

sizes.

In summary, when the poinsettia crop option is available for selection in a diversified crops program, both the stock plant and the non-stock plant options compete effectively for fixed resources. The mix in which they occur tends to contain a preponderance of the higher grades of the finished plant.

Geranium options

Geranium options in the optimal mix contribute \$72,768.36 or 18.31% of the total return to fixed costs. The crop ranks third in dollar value contributed, and is almost equal to the second ranked standard chrysanthemum crop. Further, both stock plant options for the production of propagation materials and started plants for sale, and those for production of finished crop options, are well represented in the mix. This indicates that both are profitable alternatives. Quantities of options in the diversified crops mix are shown in Table 37.

The long-term 40/1 production program is the only major option which does not occur in the mix. However, the 25/1 program, a shortened version of the 40/1 program initiated a month later in September from 2½ inch started plants, does occur. The program proceeds through the fall and winter months in much the same manner as was noted in the specialized geranium program, i.e. selling various forms of propagation material and at most opportunities, selling a portion of the stock plants. In the second week in December, the program initiates the 5/1 sub-program through which cuttings are sold at various points. Two units of 4 inch finished plants are produced for Mother's Day sales, 5 units of 4 inch finished plants are produced for May garden sales, and 5 similar units for Memorial Day sales.

An 8/1 program is initiated in the first week in November from purchased rooted cuttings. In the fifth week of January a program is propagated from these stock plants and yields 2 units of 4 inch finished plants for Mother's Day sales. The 8/1 program then phases out in the third week of February by sale of 6 units of unrooted cuttings produced at this time and the sale of started stock plants in 7 inch pots immediately thereafter.

A 12/1 program is begun in the third week in October by purchase of 13.09 units of unrooted cuttings with which to start stock plants. In the fourth week of December, the first propagation is taken from the stock plants, 21.55 units of which are sold as unrooted cuttings, 4.83 units as rooted cuttings, and 6.34 units used to initiate a 2.5/1 program. Immediately after this propagation (first week of January) 5.09 units of started 12/1 stock plants in 7 inch pots are sold. In the first week of February, 20 units of unrooted cuttings are sold, and the remaining 8 units of 12/1 stock plants are sold. The 2.5/1 program continues to completion producing 15.85 units of 4 inch finished plants for garden sales in the third week of May, and selling the 6.34 units of 4 inch stock plants from the program as finished plants in the third week of May. A market quota of 8 units applied to the sale of started stock plants in the first weeks of January and February is not met. No market quotas are applied to propagation material or finished plants for May garden sales. Finished plants produced through programs which did not involve stock plants occur in the optimal mix as shown in Table 43.

The geranium stock tree program also occurs in the optimal mix. It is initiated by purchase of 2½ inch started plants in the third week in February of the first year as a basis for initiating 0.43 units of

Table 43. Diversified crops program: finished geraniums produced from purchased propagation materials.

Propagation material purchased	Week purchased	Week finished plants in 4 inch pots sold	Number units sold (1,000 4 inch pots)	Market quota (1,000 pot units)	Shadow price (\$)
Unrooted cuttings	Feb 3	May 1	2.0	2.00	32.58
Unrooted cuttings	Mar 2	May 1	0.68		
Started plants in 2½ inch pots	Mar 5	May 1	1.32	2.00	44.50
Started plants in 2½ inch pots	Mar 5	May 3	4.80	none	
Rooted cuttings	Apr 2	May 3	16.22	none	
Started plants in 2½ inch pots	Apr 1	May 1	2.0	2.0	44.49

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stock trees. In the fourth week of January of the second year, 42.81 units of unrooted cuttings are sold, and 0.19 units of stock plants for a 2/1 program are initiated. The program concludes with sale of 0.38 units of finished 4 inch potted plants for Mother's Day. The original 0.43 units of stock trees are finished as flowering trees for Mother's Day sale. However, finished trees are produced in only one-fifth the quantity allowed by market quota, and the finished 4 inch plant options in only two-fifths of the allowable quantity.

As noted earlier, programs which produce propagation material and started plants for sale to other growers, and programs for the production of finished plants are both well represented in the optimal mix. Among the finished 4 inch plant options, plants grown from stock plant programs accounted for 36.57 of the total 57.59 units produced, or 63.50%; finished options produced from purchased cuttings or started plants contributed 21.02 units, or 36.50%. These results indicate that stock plant programs, e.g. 25/1, 8/1, 5/1, which produce for sale cuttings, started plants and finished plants use fixed labor and greenhouse space efficiently and are viable production options. Similarly, "quick-crop" geranium programs also have their place in a diversified production operation.

Further evidence of the profitability of the finished 4 inch geranium plant options comes from the fact that all finished 4 inch plant options grown for Mother's Day sales that occur in the solution, with the exception of those in the geranium tree program, are produced to market quota. Shadow prices for those options produced in non-stock plant programs range from \$32.58 to \$44.50 per unit indicating that

worthwhile revenue would be added to the total return to fixed costs by production of one more unit of each option. However, shadow prices for Mother's Day options produced from stock plant programs are \$62.09 and \$88.59, about double of those options which were started from purchased cuttings or started plants. These programs may be more profitable under the conditions of this situation than those which do not involve stock plants. Elimination of the cost of propagation material coupled with the revenue from the sale of cuttings, started plants and started stock plants yielded by the stock plant programs, likely serve to effect the greater heating costs and increased fixed resources utilization of the stock plant programs. Further, the many opportunities for entry and exit from the stock plant programs offers the production programmer considerable flexibility in his use of labor and greenhouse space. This flexibility is likely enhanced by the fact that many of the options in the stock-plant program require relatively short periods of time in the greenhouse bench.

Late May garden and Memorial Day sales options do not carry market quotas, and hence have no shadow prices for comparison with the Mother's Day options. However, the substantial quantity of each option that occurs in the optimal mix indicates that these programs likely are profitable.

The geranium tree program, because of its selected options being produced at considerably less than one-half the quantity of the market quotas, appears to be a less profitable geranium program than either the stock plant programs or the "quick-crop", non-stock plant programs.

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Geranium production options appear substantially productive in their use of fixed resources and compete effectively with other options for their use. The occurrence in the optimal mix essentially throughout the entire span of time for which geranium options are available for production further reinforces their potential. In summary, geranium options likely are profitable in a diversified crops production scheme because the numerous alternatives for starting the crop, i.e. unrooted cuttings, rooted cuttings, started plants in 2½ inch, 4 inch, 5 inch pots, and started stock plants in 5, 7 and 12 inch pots, provide the production manager with considerable flexibility in initiating his geranium program. In this way, he can mesh this program more effectively with other crops competing for the same fixed resources. Also, numerous entry and exit points are available within the production options which, when coupled with the relatively short-term nature of many of the sub-options, affords many opportunities for efficient use of fixed resources. Further, a number of the sub-options, e.g. production and sale of unrooted cuttings, require minimal greenhouse space. Production can occur even in periods of relatively full use of this resource. This is especially advantageous at times when greenhouse space is used to capacity but some labor resource remains available.

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The Potted Plant Specialization and
the Cut Flower Crop Specialization

Still another common practice among floriculture producers is to specialize either in cut flower crops or in potted crops. Often, bedding plants are included among the potted crop specialist's options. In order to examine the relative merits of specialization and diversification, a potted plant specialization model, and a cut flower specialization model are examined. Discussion of these studies follows.

The Potted Plant Specialization Model

Utilizing the same fixed resources of greenhouse production area and labor, and the same market quotas, a model is programmed as a potted plant specialist. Crop options included all potted options, i.e. potted mums, poinsettias, Easter lilies, geraniums, and bedding plants available in the diversified crop problem. Table 44 arrays the optimal mix for the potted plant specialist given these fixed resources and crop options.

Figures 20 and 21 show greenhouse production area and labor employed, respectively. Resources are used at or near full capacity during the periods September through the first week in December, and again from the second week in February through Easter. Fairly full use of resources occurs in the period between the third week in July and the fourth week in August. The inadequacy of the labor resource limits more complete utilization of greenhouse production area in the period of December through the first week of February, and from the second week in April through mid-May. During the two-month period of mid-May through mid-July both greenhouse production area and labor

Table 44. Potted plant specialization: optimal crop mix.

Crop and options	Market quota (units)	Optimal crop mix (units)	Return to fixed costs	
			\$/unit	total \$
<u>Potted chrysanthemums to bloom:</u>				
Aug 3	6.00	6.00	1,703.87	10,223.22
Sep 3	6.00	6.00	1,700.88	10,205.28
Oct 4	6.00	5.64	1,706.23	9,623.14
Nov 2	6.00	3.46	1,690.07	5,847.64
Nov 4	5.00	5.00	1,673.18	8,365.90
Dec 4	8.00	3.84	1,629.17	6,256.01
Thanksgiving	5.00	4.34	1,680.89	7,295.06
Jun 4	5.00	5.00	1,676.85	8,384.25
Jul 4	6.00	6.00	1,699.58	10,199.48
Mar 2	2.00	2.00	1,607.80	3,215.60
Mar 4	4.00	4.00	1,612.21	6,448.84
Apr 4 (1)	4.00	4.00	1,620.55	6,482.20
Apr 4 (2)	4.00	2.17	1,644.08	3,567.65
Valentine's Day	6.00	6.00	1,609.05	9,654.30
Easter	15.00	3.29	1,609.41	5,294.96
Mother's Day	25.00	5.61	1,637.75	9,187.78
Memorial Day	None	0.45	1,633.15	734.22
Total				<u>120,984.93</u>
<u>Poinsettias:</u>				
Produce stock plants from started plants purchased Jun 1	None	7.92	- 305.00 - 666.00	- 2,415.60 - 5,195.52
Propagate Jul 4 to produce: started plants in 2 1/2 inch pots for sale Aug 4	None	79.93	259.00	20,701.87
sub-stock plant program, 1 plant per 6 inch pot	6.00	2.00	- 255.84	- 511.68

Table 44. Cont'd.

Crop and option	Market quota (units)	Optimal crop mix (units)	Return to fixed costs	
			\$/unit	total \$
<u>Poinsettias (cont'd.):</u>				
Propagate Aug 5 from sub-stock program, stick cuttings direct in 4 inch pots to produce 1 3-bloom pinched plant for sale Dec 1-3	6.00	6.00	1,162.79	6,976.74
Sell sub-stock plant program 6 inch potted plants as started plants Aug 5	6.00	2.00	3,500.00	7,000.00
Take cuttings from main stock plants: in Aug 2	None	11.19	- 15.09	- 168.86
sell started plants in 2½ inch pots Sep 1	None	11.19	259.00	2,898.21
in Aug 3	None	12.00	- 15.12	- 181.44
sell finished pinched 5-bloom plant in 6 inch plastic pots Dec 1-3	6.00	6.00	3,230.13	19,380.78
sell finished pinched 6-bloom plant in 6 inch plastic pots Dec 1-3	6.00	6.00	3,311.31	19,867.86
in Aug 4	None	23.76	- 15.14	- 359.73
sell started plants in 2½ inch pots in Sep 3	None	17.76	259.00	4,599.84
sell finished pinched 4-bloom plant in 4 inch plastic pots in Dec 1-3	4.00	4.00	1,731.38	6,925.52
sell finished pinched 3-bloom plant in 4 inch plastic pots Dec 1-3	2.00	2.00	1,140.82	2,281.64
Sell finished blooming stock plants in tubs Dec 1-3	0.25	0.25	11,734.86	2,933.72
Dump stock plants Aug 5, reclaim containers	None	7.67	403.00	3,091.01
Total				87,815.76

Table 44. Cont'd.

Crop and options	Market quota (units)	Optimal crop mix (units)	Return to fixed costs	
			\$/unit	total \$
<u>Bedding plants:</u>				
Marigolds transplanted into 3 inch pots for sale May 4	25.00	24.87	223.21	5,551.23
Total				<u>5,551.23</u>
<u>Easter lilies:</u>				
GTP program				
Storage and production, Phase I				
10/11 grade	None	16.00	- 15.74	-
			- 805.02	-
			- 820.76	13,132.16
9/10 grade	None	14.62	- 15.74	-
			- 739.88	-
			- 755.62	-11,047.16
Sell started plants at end of Phase I, Feb 1				
10/11 grade	3.00	3.00	1,750.00	5,250.00
Buy started plants beginning of Phase II Feb 2				
9/10 grade	5.00	0.11	-1,525.00	- 167.75
8/9 grade	10.00	10.00	-1,250.00	-12,500.00
7/8 grade	5.00	5.00	- 750.00	3,750.00
Production Phase II				
10/11 grade	None	13.00	- 22.61	- 293.93
9/10 grade	None	14.72	- 14.24	- 209.61
8/9 grade	None	10.00	- 15.78	- 157.80
7/8 grade	None	5.00	- 14.24	- 71.20
Sell started plants at end of Phase II, Mar 1	3.00	3.00	2,000.00	6,000.00
			1,750.00	5,250.00

Table 44. Cont'd.

Crop and options	Market quota (units)	Optimal crop mix (units)	Return to fixed costs	
			\$/unit	total \$
<u>Easter lilies (cont'd.):</u>				
Buy started plants beginning of Phase III				
Mar 2				
8/9 grade	10.00	10.00	-1,525.00	-15,250.00
7/8 grade	5.00	0.55	-1,025.00	- 563.70
Production Phase III				
10/11 grade	None	10.00	- 32.72	- 327.20
9/10 grade	None	11.72	- 20.54	- 240.73
8/9 grade	None	20.00	- 20.54	- 410.80
7/8 grade	None	5.55	- 20.54	- 114.00
Sell finished lilies Apr 1				
10/11 grade	10.00	10.00	2,750.00	27,500.00
9/10 grade	20.00	11.72	2,500.00	25,000.00
8/9 grade	45.00	20.00	2,250.00	22,500.00
7/8 grade	45.00	5.55	1,750.00	17,500.00
Total				69,776.61
<u>Geraniums:</u>				
25/1 program started from purchased cuttings				
sell unrooted cuttings				
Dec 2	None	13.96	60.00	837.60
Feb 3	None	18.00	60.00	1,080.00
Mar 1	None	2.99	60.00	179.40
Mar 3	None	6.50	60.00	390.00
sell rooted cuttings, Jan 2				
sell started plants in 4 inch pots				
Mar 5	None	8.00	303.73	2,427.84

Table 44. Cont'd.

Crop and options	Market quota (units)	Optimal crop mix (units)	Return to fixed costs	
			\$/unit	total \$
<u>Geraniums (cont'd):</u>				
sell started stock plants in 5 inch pots.				
Feb 3	2.00	2.00	347.12	694.24
Mar 3	1.00	1.00	347.32	347.32
Mar 4	1.00	1.00	347.48	347.48
sell started stock plants in 7 inch pots				
Feb 3	2.00	2.00	889.54	1,779.08
sell finished plants in 4 inch pots for Mother's Day				
	2.00	2.00	504.14	1,008.28
	2.00	2.00	498.10	996.20
	2.00	2.00	498.56	997.12
	2.00	2.00	500.20	1,000.40
	2.00	2.00	504.14	1,008.28
	None	4.00	431.92	1,727.68
	None	4.00	452.29	1,809.16
	None	5.00	452.87	2,264.35
Garden sales				
Memorial Day				
12/1 program started from purchased rooted cuttings, Oct 4				
sell unrooted cuttings, Dec 4	None	31.75	60.00	1,905.00
sell unrooted cuttings, Feb 1	None	20.00	60.00	1,200.00
sell started stock plants in 7 inch pots				
Jan 1	8.00	8.00	1,293.64	10,349.12
Feb 1	8.00	8.00	1,993.64	15,949.12
Mar 3	1.00	1.00	893.92	893.92

Table 44. Cont'd.

Crop and options	Market quota (units)	Optimal crop mix (units)	\$/unit	total \$
<u>Geraniums (cont'd.):</u>				
sell finished plants in 4 inch pots				
Mother's Day	2.00	2.00	500.21	1,000.42
	2.00	2.00	1,976.69	3,953.38
Garden sales	0.50	0.50	1,974.19	987.10
	None	8.25	450.12	3,713.49
	None	66.28	455.41	30,184.58
<u>Geranium tree program</u>				
started from purchased started plants				
in 2 1/2 inch pots				
sell unrooted cuttings				
Jan 3	None	52.51	60.00	3,150.60
Mar 3	None	7.53	60.00	451.80
sell finished plants in 4 inch pots				
Mother's Day	0.10	2.00	536.35	53.64
	2.00	2.00	544.96	1,089.92
sell finished geranium trees in 10 inch pots	1.00	0.53	11,880.32	6,296.57
Total				<u>83,267.41</u>
Total for all crops in potted plant specialty				<u>370,267.09</u>

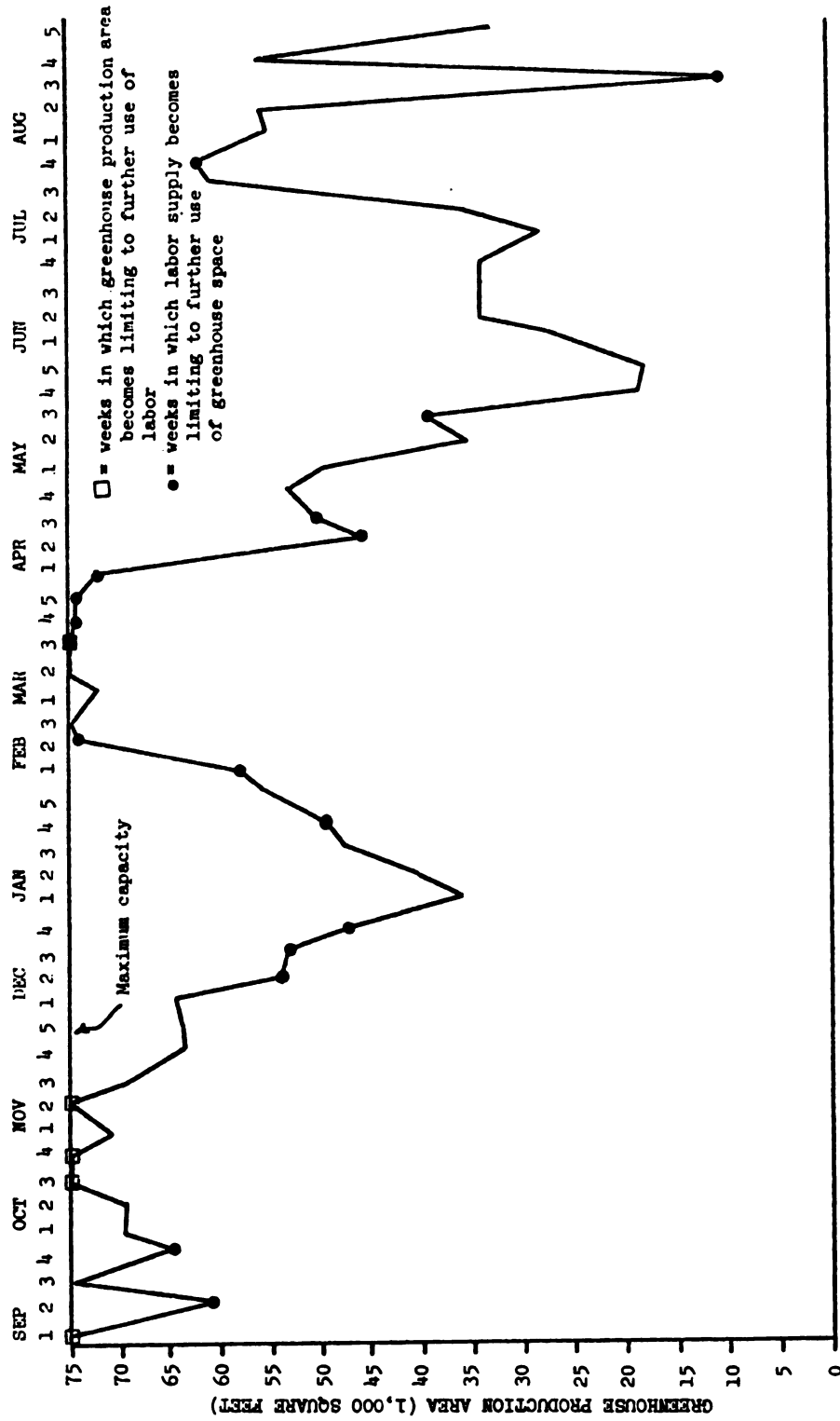


Figure 20. Potted plant specialization: greenhouse production area in optimal crop mix.

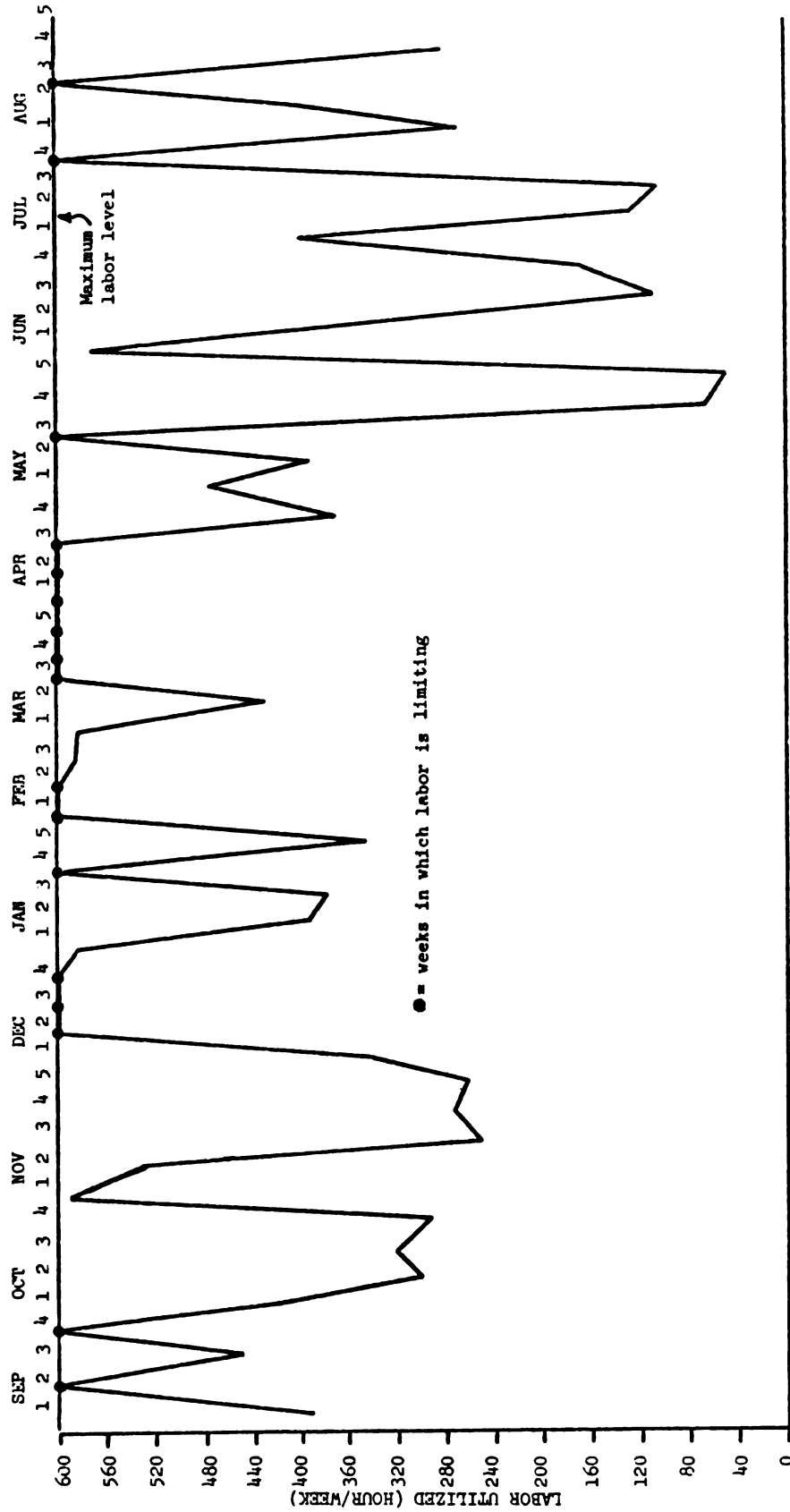


Figure 21. Potted plant specialization: permanent employee resource utilization in optimal crop mix.

are significantly under-utilized. Constraints imposed by the limited 2 month production period as well as the selection of profitable crop options which require labor and space primarily in other periods and only minimal space and labor during this period likely account for this summer hiatus. It is interesting to note that the typical potted crop specialist often runs at somewhat lower production capacity during summer months and utilize the available labor for greenhouse and equipment maintenance, soil preparation for fall and winter crops, and to cover for employee vacation time. Also, the market for all florist crops generally dips during the summer months for numerous reasons.

Comparison in crop options programmed and profitability of operation among several specialized production programs, as well as with the diversified program, is made later in the chapter.

The Cut Flower Specialization Model

Once again, as with the potted plant production specialization, the same set of fixed resources used in previous models are made available for cut flower programming. Crop options include standard chrysanthemums, snapdragons, carnations and roses. Table 45 shows the optimal mix yielded by the analysis.

Figures 22 and 23 plot the levels of the fixed resources of greenhouse production area and labor employed to operate this cropping program. During the period of the fifth week in August through the second week of January, greenhouse production area is used at levels generally between 60,000 and 66,000 ft². For much of this period, inadequate labor limits further space use. During the remainder of the year, production area is used in the range of 40,000-60,000 ft². Labor is limiting in

Table 45. Cut flower specialization: optimal crop mix.

Crop and options	Market		Optimal crop mix (units)	Return to fixed costs	
	quota (units)			\$/unit	total \$
<u>Roses:</u>					
Hybrid tea	None		19.24	3,026.00	58,220.24
<u>Snapdragons:</u>					
single-stem grown from seed to bloom					
Jan 2-3	None		21.92	608.82	13,345.33
Apr 1-2	None		.52	675.32	351.17
Jun 3-4	None		14.34	683.03	9,649.45
Sep 2-3	None		14.71	517.28	7,609.19
Oct 2-3	None		12.56	515.84	5,473.71
single-stem grown from purchased seedlings to bloom					
Apr 4, May 1	None		14.31	671.40	9,483.28
Jul 3-4	None		19.21	505.03	9,701.63
Aug 3-4	None		18.38	505.03	9,282.45
Total					63,485.01
<u>Carnations:</u>					
Controlled holiday options to bloom					
Christmas	5.00		5.00	1,512.85	7,564.25
Valentine's Day	4.00		4.00	1,496.81	5,987.24
Easter	5.00		5.00	1,487.43	7,435.15
Total					20,986.64
<u>Standard chrysanthemums, pinched crops to bloom</u>					
Oct 2	4.00		4.00	718.34	2,873.36
Nov 2	8.00		8.00	710.66	5,685.28
Dec 2	10.00		10.00	740.49	7,407.90
Thanksgiving	10.00		10.00	952.76	9,527.60
Christmas	10.00		10.00	940.67	9,406.70

Table 45. (Cont'd).

Crop and options	Market		Optimal crop mix (units)	Return to fixed costs	
	quota (units)			\$/unit	total \$
<u>Standard chrysanthemums, pinched crops</u> (cont'd)					
Jun 2	10.00		10.00	633.95	6,339.50
Jul 2	4.00		4.00	694.90	2,779.60
Aug 2	4.00		4.00	706.40	2,825.60
Jan 2	10.00		9.18	718.72	7,050.64
Jan 2	10.00		7.19	769.99	5,536.23
Mar 2	10.00		10.00	749.36	7,493.60
Easter	12.00		12.00	835.53	10,026.36
Mother's Day	10.00		9.83	841.66	8,273.52
					85,225.89
<u>Standard chrysanthemums, single-stem</u> to bloom					
Oct 2	4.00		4.00	602.75	2,411.00
Nov 2	8.00		2.39	593.43	1,419.06
Dec 2	10.00		1.16	520.70	604.01
Thanksgiving	10.00		10.00	839.39	8,393.90
Jun 2	10.00		10.00	661.01	6,610.10
Jul 2	4.00		4.00	505.74	2,342.96
Aug 2	4.00		4.00	593.03	2,372.12
Aug 5	4.00		4.00	604.42	2,417.68
Jan 2	10.00		10.00	569.35	5,693.50
Feb 2	10.00		8.92	537.33	4,792.98
Mar 5	10.00		10.00	575.25	5,752.50
Easter	12.00		2.24	664.72	1,488.97
Mother's Day	10.00		10.00	671.70	6,717.00
					51,015.78
					136,241.67

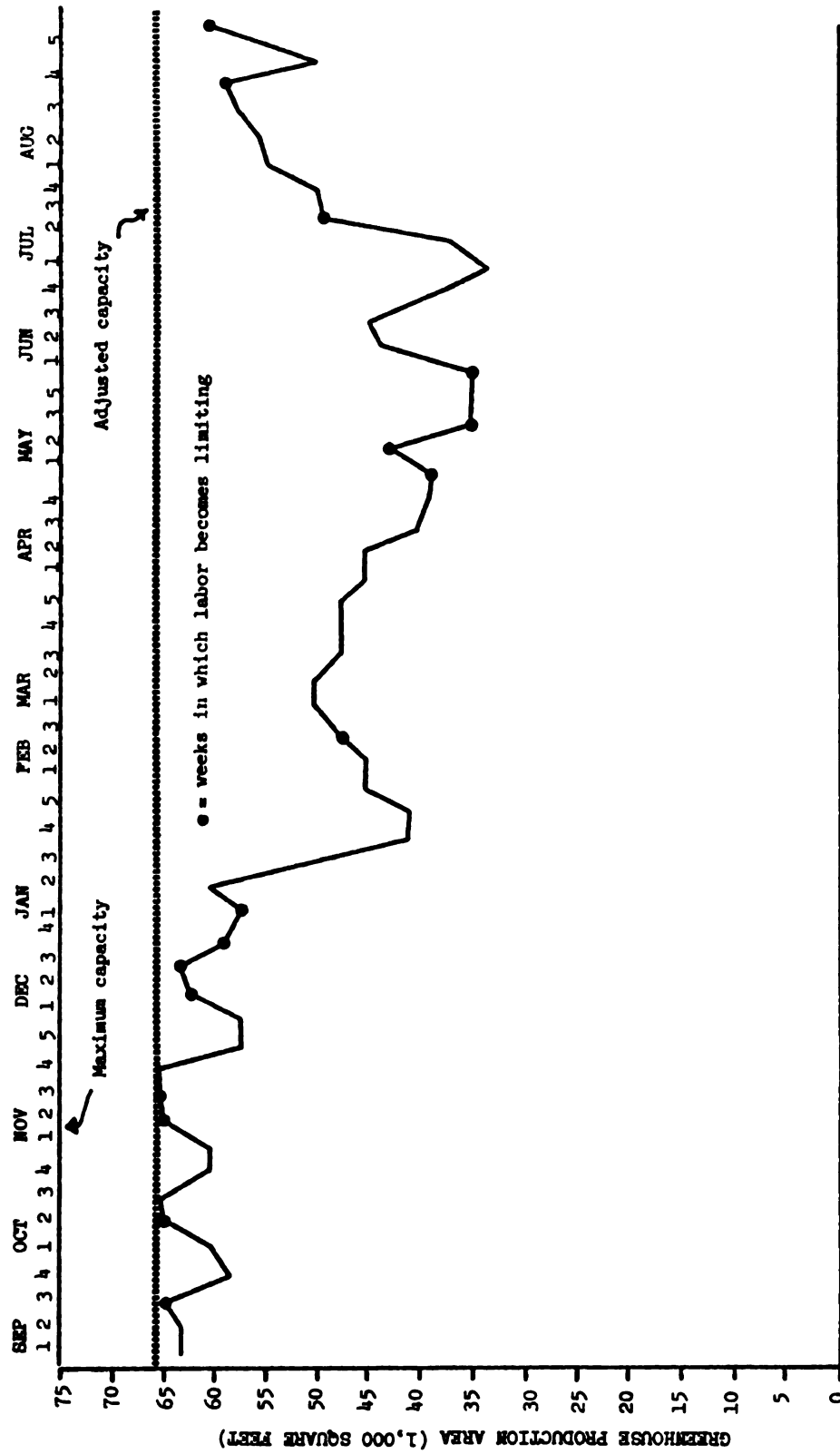


Figure 22. Cut flower specialization: greenhouse production area in optimal crop mix.

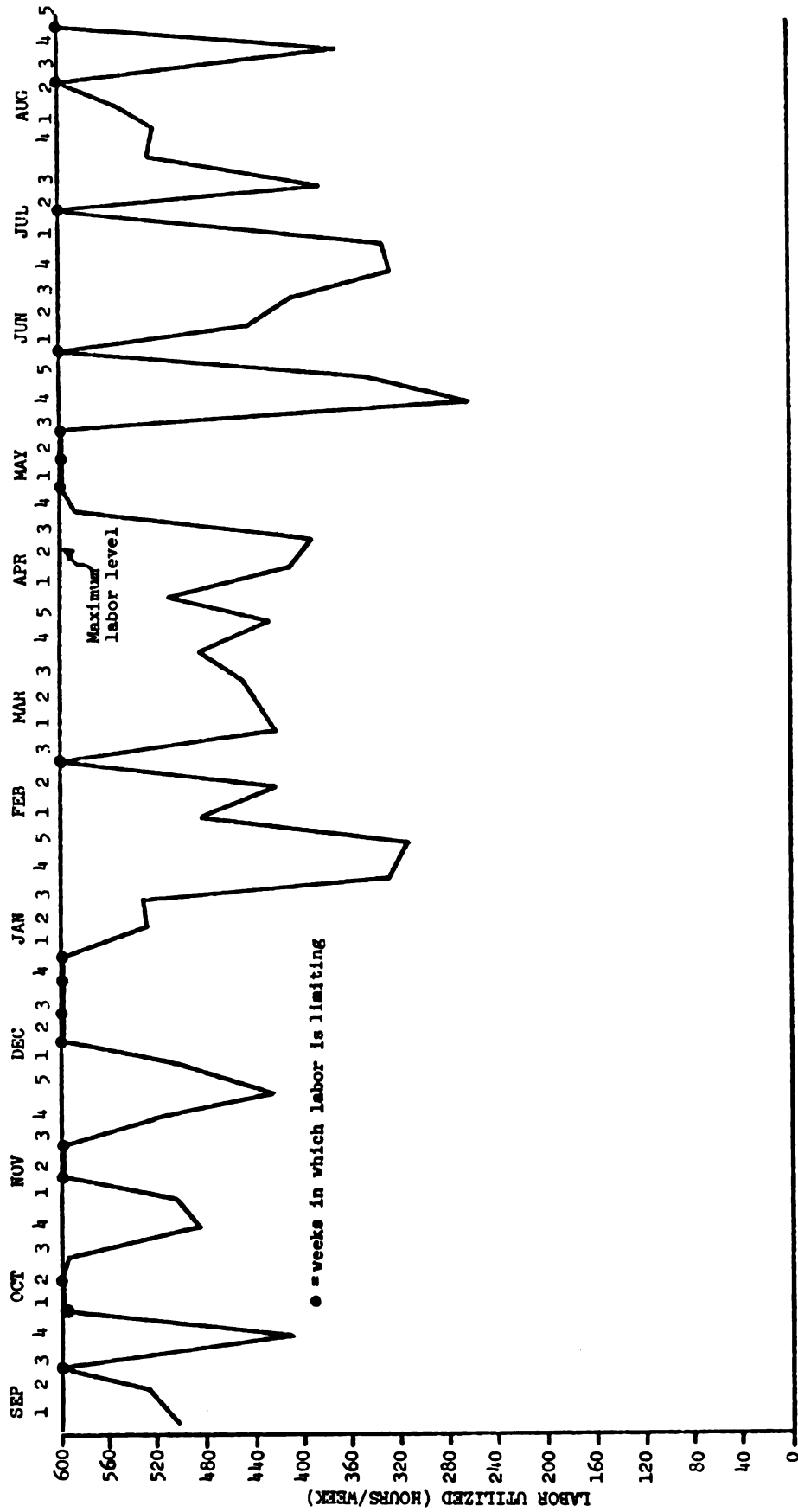


Figure 23. Cut flower specialization: permanent employee resource utilized in optimal crop mix.

only six of the weeks during this 36 week period. Figures 22 and 23 indicate that space and labor resources are employed more uniformly throughout the cut flower production year than they are in the specialized potted plant model. There is considerably more holiday market influence and seasonal impact on potted crop schedules than on those of cut flowers. Further, potted crops require generally more labor input per unit of crop than cut flowers. Both the potted crops program and the cut flowers regime use less greenhouse production area and less labor resources respectively than is used when both potted and cut crops are simultaneously available for cropping as in the diversified crops program. Table 46 compares space and labor used by each of the programs.

Table 46. Annual mean greenhouse production area and permanent employee resource used to produce the optimal crop mix in several diverse crop programs.

Program	Greenhouse production area (ft ² /week)	Permanent employee force (hours/week)
Diversified crops program	63,523	509
Potted plant specialization	54,819	429
Cut flower specialization	52,343	497

Comparison of Profitability and Crop Composition of the Several Diversified and Specialized Production Programs

The crop composition and profitability of the alternative cropping programs examined in this study are summarized in Tables 47 and 48 . Potted crop and bedding plant options account for 72.03 percent of total return to fixed costs yielded in the diversified crops program. Cut

Table 48. Return to fixed costs for diversified and specialized production programs.

Program	Total return to fixed costs (\$)			Net return to fixed costs (\$)		
	Total	per ft ² production area	per hour labor	Total	per ft ² production area	per hour labor
Diversified crops program	384,136	5.12	12.31	172,062	2.30	5.51
Potted plant specialization	370,914	4.95	11.89	158,904	2.12	5.09
Cut flower specialization	279,054	3.72	8.94	67,032	0.89	2.15
Bedding plants Jan-May, diversified crops Jun-Dec	250,969	3.35	8.04	38,947	0.52	1.25
Bedding plants plus geraniums	154,134	2.06	4.94	- 57,866	-0.77	-1.85
<u>Monocrop programs:</u>						
Potted mums	179,365	2.39	5.75	- 32,657	-0.44	-1.05
Geraniums:						
12-month base				- 65,734	-0.88	-2.10
10-month base		1.95	4.69	- 16,968	-0.23	-0.54
Poinsettias:						
12-month base	129,323	1.72	4.14	- 82,699	-1.10	-2.65
7-month base	NA			6,350	0.08	0.20
Easter lilies				NA		
Standard mums	266,710	3.56	8.55	54,688	0.73	1.75
Snapdragons	176,952	2.36	5.67	- 35,070	-0.47	-1.12
Carnations	139,000	1.85	4.46	- 73,022	-0.97	-2.34
Roses	NA			NA		
Mean, all monocrops	157,636					

flowers constitute the remaining 27.97%. Given the total array of crop options available in the diversified program, potted and bedding plants use fixed resources more profitably than do cut flower crops.

The potted crop specialization yields total returns to fixed costs of \$370,194.00, only \$13,222 short of the \$384,136 total returns for the diversified program, but \$91,860.00 greater than the \$279,054 revenues for the cut flower specialization program. Programs planned to test the profitability of a 5-month bedding plant production program coupled with an essentially year-round geranium program and of a 5-month bedding plant program supplemented by a 7-month summer and fall diversified crop program both prove less profitable than the cut flower specialty program. Total returns to fixed costs are \$154,134.00 and \$230,969.00 respectively. In both programs, unrealistically low utilization of greenhouse production area and labor resources occurs. See Figures 24-27.

Monocropping programs, that is, those situations in which the model is allowed to program production only from among the options of one crop enterprise, e.g. geraniums, are analyzed for all crops except roses for cut flowers, bedding plants, and Easter lilies. Total returns to fixed costs under monocropping are generally lower than for multicrop programs. Standard chrysanthemums for cut flowers is the only profitable monocrop program; it yields total return to fixed costs of \$266,710.00, only \$12,344.00 less than the multioption cut flower program. Net return to the fixed costs is \$34,688.00. All other monocropping programs yield positive total return to fixed costs, but negative return net of fixed costs. Carnations are the most unprofitable of the cut flower monocropping schemes in terms of total return to fixed costs with a loss of \$73,022.00. Poinsettias yield the highest

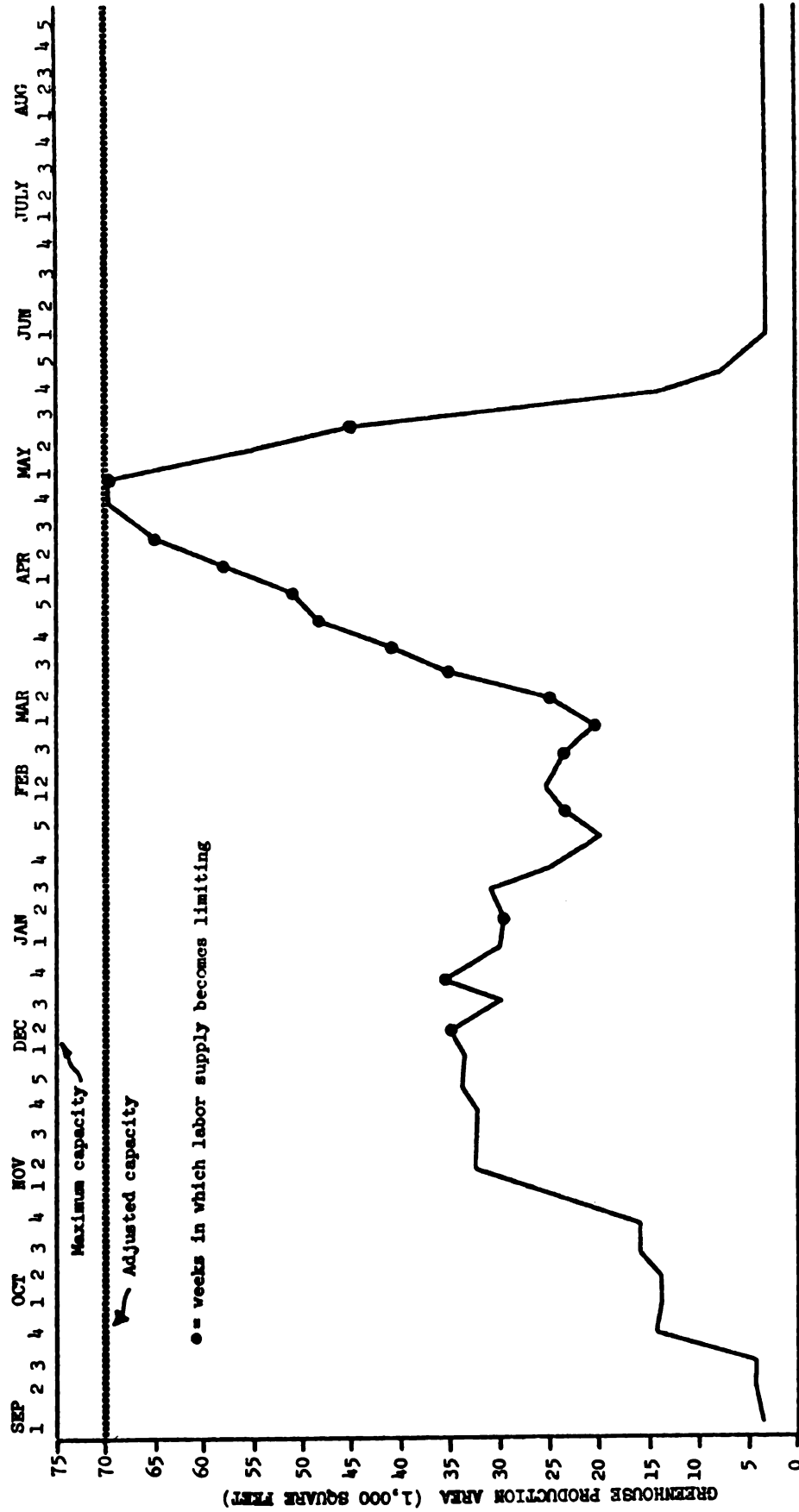
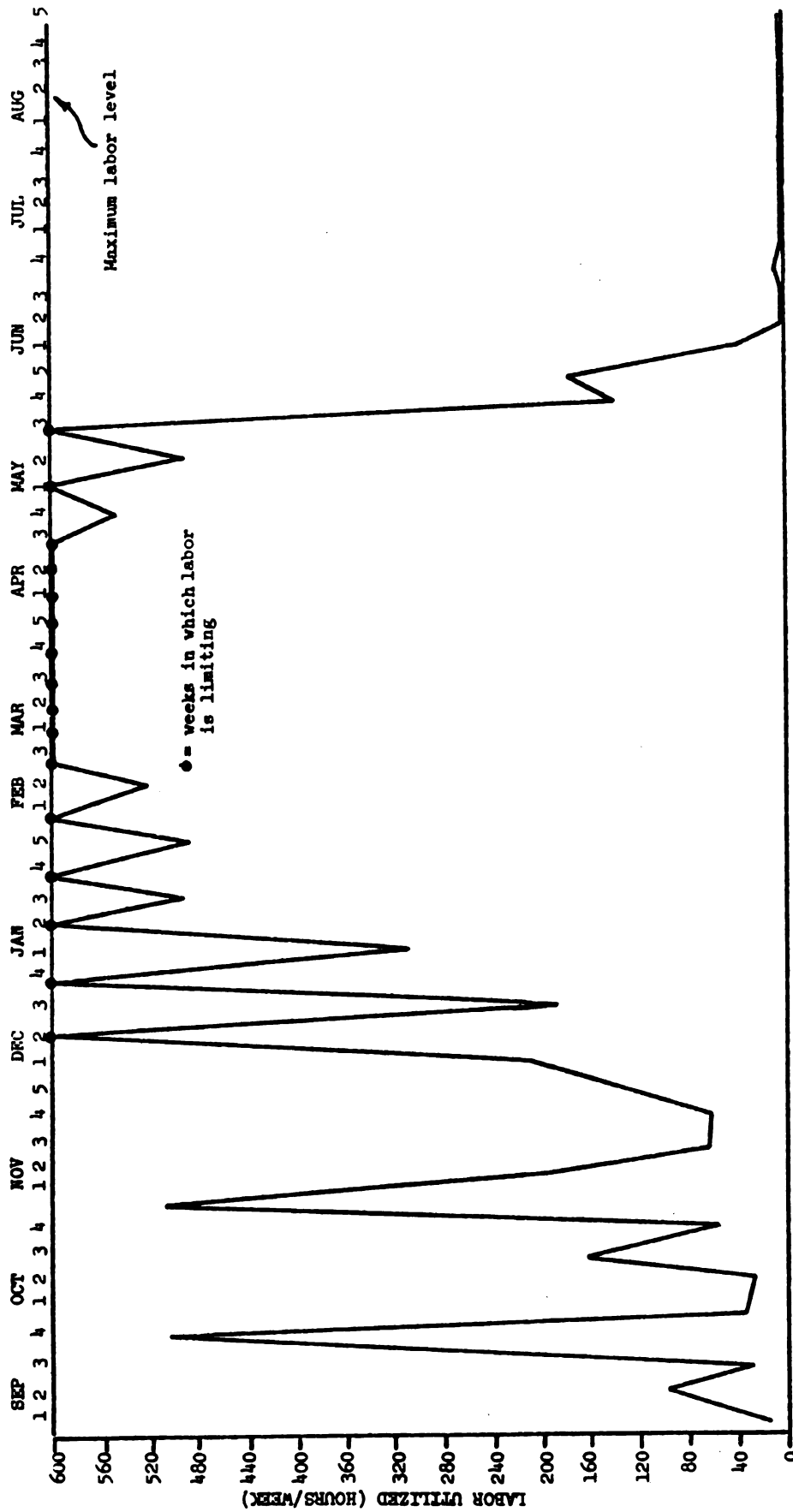


Figure 24. Bedding plant and geranium specialization: greenhouse production area in optimal crop mix.



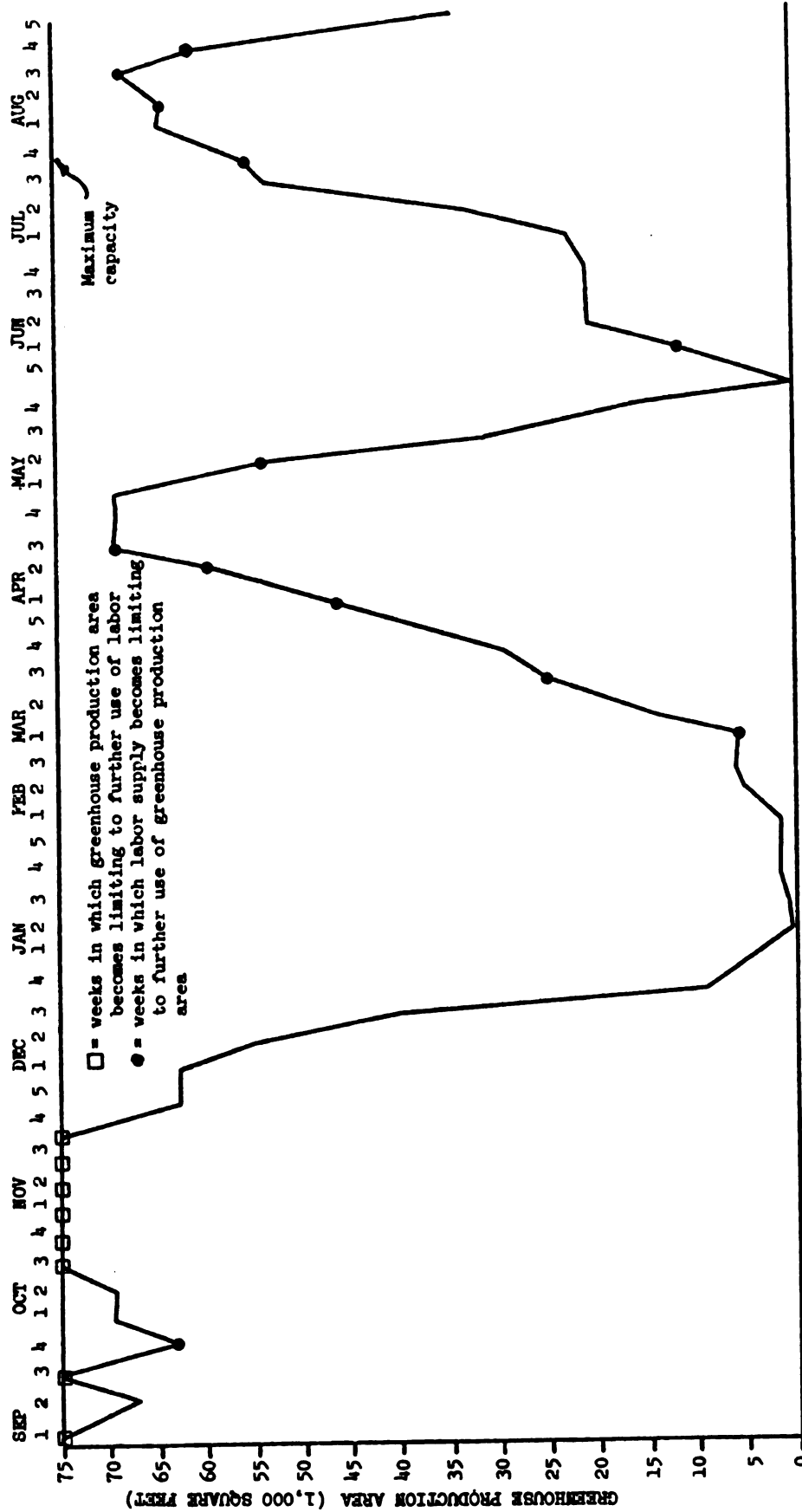


Figure 26. Bedding plants January through May, diversified crops June through December: greenhouse production in optimal crop mix.

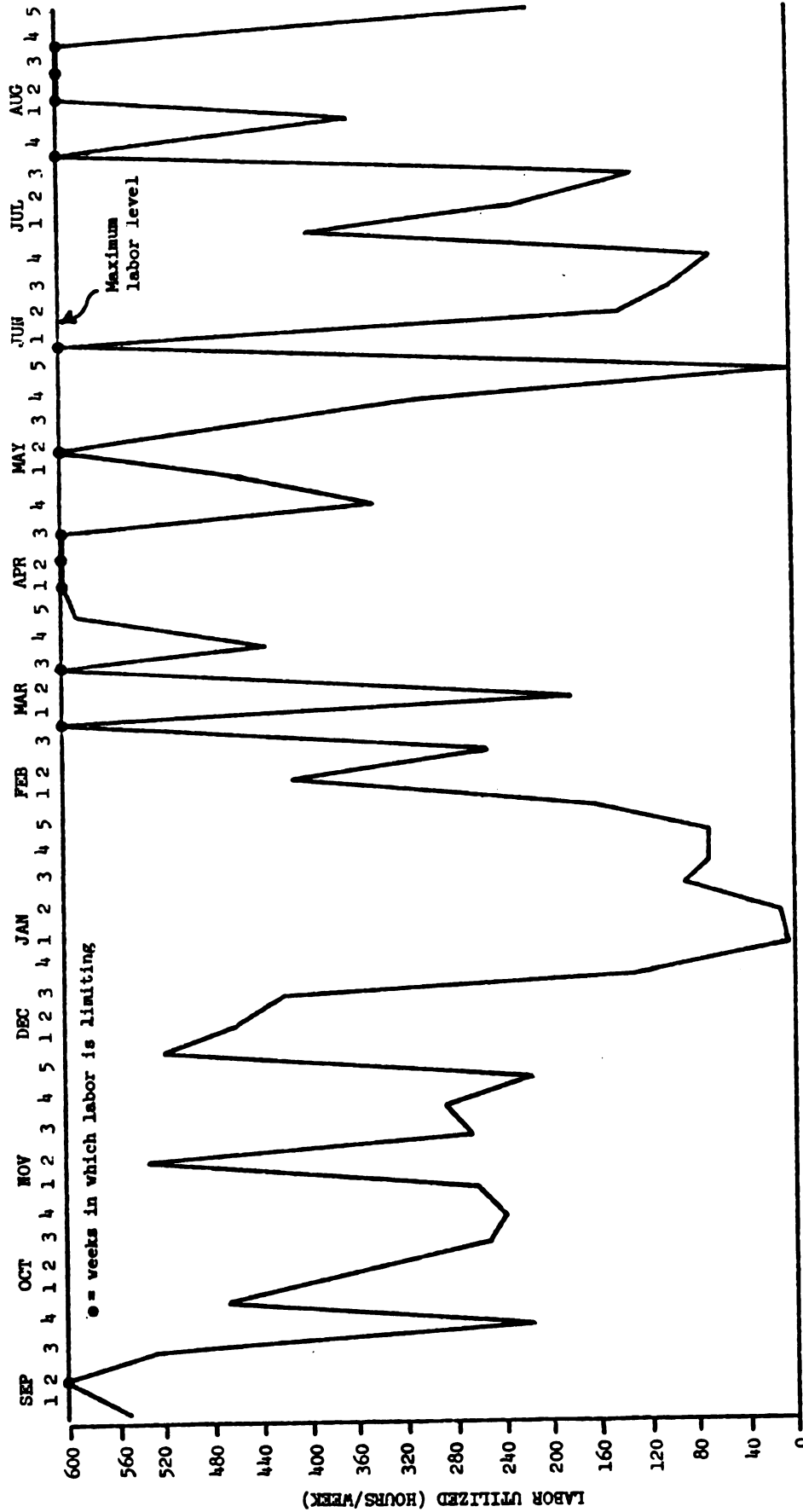


Figure 27. Bedding plants January through May, diversified crops June through December: permanent employee utilization in optimal crop mix.

loss among the potted crops, \$82,699.00. However, it is possible to schedule poinsettia production only during 7 months of the year so application of the fixed costs for the remaining 5 months is not realistic. If only 7 months of fixed costs are applied, total return to fixed costs is \$6,350.00. Bedding plants show a net loss of \$146,206.00. However, as with poinsettias, this crop can be programmed only during 5 months of the year. Using the rationale applied in poinsettia monocropping, bedding plants still reflect a loss of \$14,752.00 when only 5 months of fixed costs are applied. Monocropping net losses to fixed costs for the remaining crops are: carnations, -\$73,022.00; geraniums, -\$65,734.00 (-\$16,968.00 if fixed costs only for the weeks in which it is possible to program the crop are applied); snapdragons, -\$35,070.00; potted mums, -\$32,657.00. Total and net return to fixed costs per ft² of production area, and per hour of labor are specified in Table 48.

In the multicrop model wherein bedding plants are programmed exclusively during January through May with other crops available for production June through December, bedding plants contribute 26.22% of the total return to fixed costs. Among the crop options available for June through December production, poinsettias yield 37.06% of total return to fixed costs with potted chrysanthemums, cut chrysanthemums and snapdragons in descending magnitude of contribution respectively, e.g. 16.16, 10.70, 9.86% Figures 26 and 27 depict the use of greenhouse production area and labor in this program.

Clearly, this program offers a potentially more productive use of the fixed resources of greenhouse space and labor than does the bedding plant - geraniums program. With total return to fixed costs

of \$230,969.00, the program yields \$3.35 per ft² of production area or \$8.04 per hour of labor. Net return to fixed costs are \$38,947.00 or \$0.32 per ft², and \$1.25 per hour of labor. These projected returns rank the program as potentially more profitable than the bedding plant - geranium program but less than the diversified crops program and the potted plant and cut flower specialty programs.

As expected, the quantities of each of the crop options in the optimal mix increase as one moves from a diversified program in which nine crops and their options are available for production to potted plant or cut flower specialty programs wherein available options are more limited. Even greater incremental changes occur when one shifts from a diversified crops program containing potted plants and cut flower programs to a specialized monocrop program containing the options of only one crop. Table 47 identifies quantities of each crop in the optimal mixes of each of the programs.

Model for Employment of Temporary Labor

Flower production firms often utilize temporary labor, both on a full-time and part-time basis, to handle the work load for certain labor-intensive production activities. This is especially true of bedding plant growers, e.g. for the transplanting operation, and potted plant producers usually at peak marketing periods.

Analyses of crops and production options presented thus far in this study have used models which do not offer the opportunity to supplement permanent employee force with temporary labor. This is done to provide as realistic a labor situation as possible in that

many medium-size production firms increasingly attempt to operate within the limits of the time and abilities of their permanent employees. However, a limited examination of the impact of providing the opportunity to hire temporary employees is conducted and analyzed here.

The model for employment of temporary labor is described in Chapter II. Briefly summarized, the manager is provided with 400 hours per week of permanent employee time, instead of 600 hours as in other models used. But additionally, he has the option of employing unlimited temporary hourly employees. The program tests three temporary employee wage levels: \$2.00, \$3.50, and \$5.00 per hour. The same crops and crop options available to the manager in the diversified crop model are available here.

Table 49 summarizes the crops and options programmed. Figures 28 and 29 describe greenhouse space and permanent and temporary labor used for each week of the production year. Table 50 provides a comparison of total return to fixed costs and of net return to fixed costs for each of the temporary labor wage levels and for the 600-hour level of permanent employee labor without temporary employee availability.

With net return to fixed costs of \$23.17 per ft² at the \$2.00 wage level, \$18.47 per ft² at \$3.50 and \$13.95 per ft² at \$5.00, the temporary labor options are the most profitable of the programs studied. The diversified crops program returns only \$2.29 per ft². However, net return per hour of labor used are \$6.63 at the \$2.00 wage rate, \$5.37 at the \$3.50 rate, and \$4.33 at the \$5.00 rate. The diversified crops model using 600 hours of permanent employee time and no temporary employees, and with an average wage rate of \$3.31

Table 49. Total and net return to fixed costs for various levels of employee resource and wages.

Return (\$)	Utilizing 600 hours/week (1250 hours/week man equivalents) of available permanent employee time only		Utilizing temporary employees at several hourly wage rates plus 400 hours/week (850 hour/week man equivalents) of available permanent employee time		
	(average \$3.31/hour wage)		\$2.00	\$3.50	
Total hours	31,200	262,148	257,591	241,474	
50 hour work/week equivalent		92.86	91.07	84.87	
Total return to fixed costs	384,135.64	2,167,966.43	1,810,864.37	1,460,918.57	
Per hour of total labor used	12.31	8.27	7.03	6.05	
Per ft ² greenhouse production area/year	5.12	28.90	24.14	19.48	
Net return to fixed costs	172,114.64	1,737,750.00	1,385,250.00	1,046,250.00	
Per hour of total labor used	5.52	6.63	5.37	4.33	
Per ft ² greenhouse production area/year	2.29	23.17	18.47	13.95	

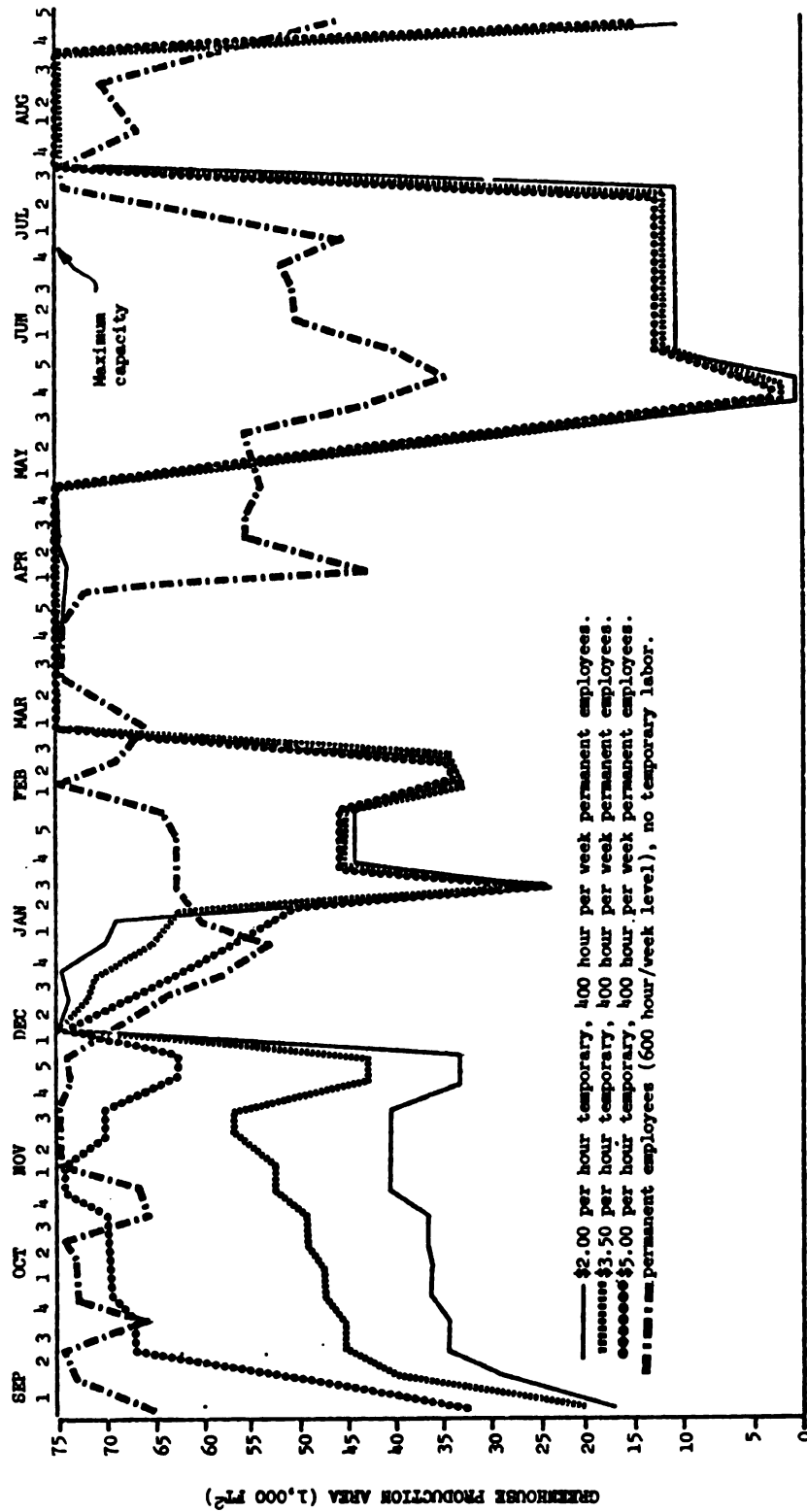


Figure 28. Model for employment of temporary labor: greenhouse production area utilized at various wage levels.

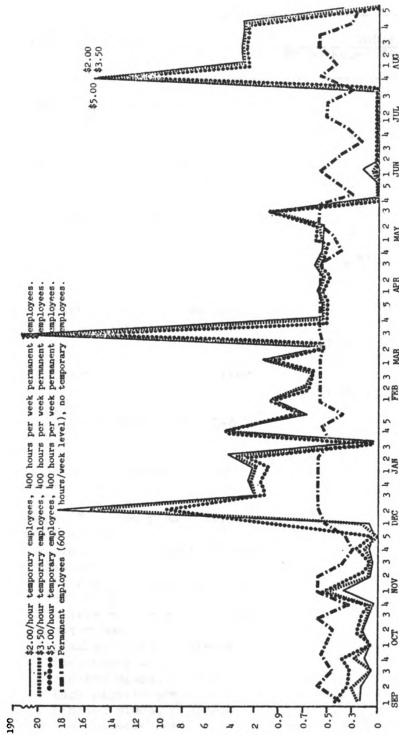


Figure 29. Model for employment of temporary labor: combined hours of permanent and temporary labor utilized at various wage levels.

Table 50. Model for employment of temporary labor: crops and options produced.

Crops and options	Units produced at:		
	\$2.00/hour	\$3.50/hour	\$5.00/hour
<u>Standard chrysanthemums:</u>			
Pinched, plant Sep 4, harvest Jan 2	0	0	10.00 ^{a)}
Single-stem, plant May 4, harvest Aug 2	0	1.25	2.34
<u>Potted chrysanthemums:</u>			
Plant Aug 3, harvest Nov 2	0	1.52	2.84
Plant Sep 1, harvest Nov 4	5.00 ^{a)}	5.00 ^{a)}	5.00 ^{a)}
<u>Poinsettias:</u>			
Buy started plants in 2½ inch pots to initiate stock plant program, Jun 1	1,053.92	1,045.59	1,039.45
Sell started plants in 2½ inch pots, July 4	3,159.00	3,134.76	3,116.36
Sell rooted cuttings in BR-8 blocks, Aug 2	2.00	2.00	2.00
Sell stock plants to another grower in Aug 5	2.00	2.00	2.00
Produce finished plants for Christmas sale:			
4 single-stem plants, 7 inch plastic pot	0	0	3.00 ^{a)}
5 single-stem plants, 7 inch plastic pot	0	0	2.00 ^{a)}
6 single-stem plants, 8 inch plastic pot	0	0	1.00 ^{a)}
1 pinched plant, 3 blooms, 4 inch plastic pot	6.00 ^{a)}	6.00 ^{a)}	6.00 ^{a)}
1 pinched plant, 5 blooms, 6 inch plastic pot	1.29	6.00 ^{a)}	6.00 ^{a)}
1 pinched plant, 6 blooms, 6 inch plastic pot	6.00 ^{a)}	6.00 ^{a)}	6.00 ^{a)}

a) market quota

Table 50. (Cont'd).

Crops and options	Unit produced at:		
	\$2.00/hour	\$3.50/hour	\$5.00/hour
<u>Poinsettias (cont'd):</u>			
1 pinched plant, 4 blooms 6 inch plastic pot	0	0	4.00 ^{a)}
1 pinched plant, 3 blooms, 6 inch plastic pot	0	0	2.00 ^{a)}
<u>Easter lilies:</u>			
Sell started plants Feb 1, CTF grades			
10/11	3.00 ^{a)}	3.00 ^{a)}	3.00 ^{a)}
9/10	3.00 ^{a)}	3.00 ^{a)}	3.00 ^{a)}
8/9	6.00 ^{a)}	6.00 ^{a)}	6.00 ^{a)}
7/8	0	3.00 ^{a)}	3.00 ^{a)}
Sell started plants Mar 2, CTF grade 9/10	0.56	0.54	0.54
Sell finished plants Apr 2, CTF grade 9/10	0	0.02	0.02
<u>Geraniums, 12/1 program:</u>			
Sell from 12/1 stock plant program started plants in 4 inch pots, Feb 1	31.38	40.00	40.00
started stock plants in 7 inch pots, Jan 1	4.55	8.00	8.00
unrooted cuttings from stock, Feb 1	20.00	20.00	20.00
started stock plants in 7 inch pots, Feb 1	8.00 ^{a)}	8.00 ^{a)}	8.00 ^{a)}
started stock plants in 7 inch pots, Mar 3	1.00 ^{a)}	1.00 ^{a)}	1.00 ^{a)}
<u>Geraniums, buy and sell program:</u>			
Sell finished plants in 4 inch pots for Easter (Apr 1) from unrooted cuttings purchased Feb 1	0.06	0	0
<u>Geranium tree program:</u>			
Sell from tree stock plant program			
unrooted cuttings, Mar 3	29,409.18	29,409.18	29,237.97
rooted cuttings, Apr 1	2.58	2.58	2.60
finished plants:			
4 inch pots, Mother's Day	2.00 ^{a)}	2.00 ^{a)}	2.00 ^{a)}
4 inch pots, garden sales	292.12	292.12	290.14
12 inch pots, Mother's Day (May 1)	0	0	0.44
dump stock plants, 12 inch pots, Jan 4	294.11	2.94	2.49

Table 50. (Cont'd).

Crops and options	Units produced at:		
	\$2.00/hour	\$3.50/hour	\$5.00/hour
<u>Roses</u>	none	none	none
<u>Bedding plants</u>	none	none	none
<u>Snapdragons</u>	none	none	none
<u>Carnations</u>	none	none	none

per hour, yields a return of \$5.52 per hour of labor used. Of course, total return for use of all fixed resources are substantially greater for the temporary labor programs than for the 600-hour permanent employee program.

Analysis of the crops and options programmed indicates that the additional labor available in the temporary employee model is applied for the most part to propagation options, that is, those which yield unrooted and rooted cuttings and started plants for sale to other producers. As a matter of fact, the model as programmed under all three temporary wage levels is essentially a geranium and poinsettia propagation specialty firm which also produces finished crops of each. The started Easter lily program and the potted and cut chrysanthemum options which appear in the program likely could be replaced with additional geranium and poinsettia options if relatively slight adjustments were to be made in scheduling of major poinsettia and geranium options to enable the use of production space available at non-peak periods. This is borne out by the marginal return for greenhouse production area in those weeks in which this input limits further production. These range from \$0.22 to \$8.56 per ft² in this model, that is, the total return to fixed costs would increase by this amount if one more unit of resource were available. Other crops and options programmed when an unlimited supply of temporary labor is made available at the three price levels are potted chrysanthemums, standard chrysanthemums for cut flowers, and Easter lilies grown under the controlled temperature storage (CTF) program for sale primarily as started plants to other growers. Roses, carnations and snapdragons - all cut flower crops - and bedding plants do not appear in the optimal program.

As Table 49 shows, the options and their quantities in the optimal program vary relatively slightly with the wage level for temporary labor. However, as the wage level increases from \$2.00 through \$3.50 to \$5.00, the following changes occur in the characteristics of the components of the optimal mix:

1. A decrease in the number of propagation activities and the quantities of each in the mix occurs. These activities are primary consumers of the labor resource and tax the greenhouse production area less than finished crop options.
2. An increase occurs in the number of, and in the quantities within each of, the finished crop options. For example, pinched three and four-bloom poinsettias in 4 inch pots and single-stem poinsettias with 4, 5 and 6 plants per 7 and 8 inch pot are not produced until the temporary labor wage level reached \$5.00 per hour. At this level, the latter are produced to the limits of market quotas whereas the former occur at one-third and one-sixth of market quotas respectively.
3. More greenhouse production area is used as the wage level of temporary help increases. At each of the temporary wage levels the mean production area in ft^2 per week utilized is 45,697 at \$2.00, 49,643 at \$3.50 and 54,560 at \$5.00.
4. Similarly, as temporary wage levels increase, hours per week of permanent employee complement utilized increase in those periods when permanent employee labor is not fully utilized. For example, during September through November, the mean

permanent employee hours per week consumed at the several wage rates is 260 hours at \$2.00, 265 hours at \$3.50 and 284 hours at \$5.00.

5. As temporary wages increase, the hours of temporary labor used decreases in those weeks when the permanent employee labor resource is used to the maximum, e.g. mean hours per week of temporary labor used at the several wage rates is 4,638 hours at \$2.00, 4,556 hours at \$3.50, and 4,361 hours at \$5.00.
6. As the temporary wage rate increases, the net return to fixed costs per ft² of greenhouse production area decreases, e.g. \$23.17 at the \$2.00 level, \$18.47 at \$3.50 per hour, and \$13.95 at \$5.00 per hour.

Analysis of Program Results

With unlimited availability of temporary labor at the wage levels indicated, greenhouse production area ultimately becomes the limiting factor to the further utilization of the resource. Hence, those crop production options which offer opportunities for producing income with a minimum requirement for greenhouse production area also offer the greatest potential for yielding maximum net return to fixed resources. Thus, poinsettias and geraniums with their numerous propagation and finished crop programs within the context of both stock plant and purchased starting plant material options emerge as components of the optimal programs. Similarly, the option to sell Easter lilies as started plants emerges. Thereafter, finished potted and cut chrysanthemum options which fit within the production space and timing

parameters appear.

However, as the cost of the temporary labor input increases, the high-labor-requirement propagation options in the optimal mix decline somewhat in favor of other crops and options which make greater utilization of the permanent employee force and the greenhouse production area. Hence, increased numbers and quantities of finished crop options, and of propagation options which require greater space per unit as well as more weeks of space per unit, appear in the mix. The 12/1 geranium stock plant program is an example. At the \$2.00 level of temporary employee wage, 12.55 units of stock plants are in production. At \$3.50 and \$5.00, the number of units of stock plants increases to 16.00; thereby making greater use of permanent employee time and greenhouse space during this period. At the same time, the cuttings yielded from the stock plants are sold as started 4 inch plants, and the additional units of stock are sold as started 7 inch plants, both options which utilize considerable quantities of the fixed labor resource and production area. On the other hand, production of unrooted geranium cuttings, an option requiring no greenhouse space and which can readily use temporary labor, decreases by 171 units. Similarly, as the temporary labor wage increases from \$3.50 to \$5.00, an additional 18 units of finished poinsettia options enter the mix.

Guidelines for Producers

Examination of the optimal results of this program wherein unlimited temporary labor is available yield these guidelines:

1. Propagation of started plants for sale to other growers in the form of unrooted and rooted cuttings, and partially developed

plants offer a promising alternative for producers with limited greenhouse production area and/or permanent employee complement, and with an available supply of temporary labor. Much of the labor required for such an operation could be accomplished by unskilled employees with minimal training.

2. Given an unlimited labor supply, potted crops appear to offer the most profitable alternatives for production given an existing market. A comparison of the reduced revenues which would result from growing one unit of bedding plants or cut flowers in place of a crop in the optimal mix reinforces this observation. Among the potted crops, poinsettias and geraniums as finished options and Easter lilies as started plants and finished options appear to be the most profitable. Potted mums in general appear relatively less profitable. Bedding plants and cut flowers are indicated to be considerably less profitable than any of the potted options.

Limitations of the Model for Employment of Temporary Labor

The return to fixed resources from the utilization of temporary employees at the wage level analyzed indicate this approach to be an extremely profitable one when compared to those programs which must operate within the constraints of the permanent employee force. A number of unrealities do exist, however, and should be considered as one contemplates possible expansion in the use of the temporary labor resource.

1. In this study, the model was examined under two labor resource situations: (a) 600 hours per week of permanent employees with

no option for hiring temporary employees, and (b) 400 hours per week of permanent employee work force with the opportunity to utilize unlimited quantities of temporary employees. Perhaps there is some level of permanent employee force between 400 and 600 hours per week which would be more realistic than either of these levels. Or, there may be more profitable opportunities given a different level of permanent employee force with the option to hire temporary employees only at known peak labor periods.

2. Several uncertainties were not accounted for in the temporary labor program. For example, does an unlimited temporary labor supply exist? And, if it does, would temporary employees with less training and experience be able to accomplish production tasks in the same time allotted in the program for permanent employees who are likely to be better trained, and more skilled and efficient in production operations? Further, with the use of large numbers of temporary employees, the time required of the manager and other permanent staff for recruitment, selection supervision and general records management apropos the temporary staff would represent a considerable manpower investment which, of course, would take involved permanent staff from other production activity. Thus, the efficiency of the permanent employee complement in the production phase might be markedly reduced. This factor was not adjusted for in this model.
3. Market quotas are imposed on nearly all of the finished crop options in the program. But there are no market limitations

for the propagation activities. Hence, this may favor these latter options as profitable alternatives, when in reality, unlimited markets for these products may not exist.

4. For a propagation-oriented production operation, such as the one which is indicated in this model to be able to market the large quantities of cuttings and started plants would require the development of a considerable market which in turn would require establishment of a marketing staff and a budget including advertising programs. Further, additional capital would need to be invested in storages and efficient propagation, plant-handling, and shipping equipment and techniques to support so large a propagation specialty firm. With major emphasis on geranium propagation, laboratory facilities for culture-indexing of stock would be desirable. The firm would be at a competitive disadvantage if it did not utilize this method to guarantee a disease-free product.

In summary, the temporary labor model offers significant insights into the potential for this alternate source of labor for the purposes of this study. However, considerable revision is needed to account for the above and other constraints, and for the added required resource inputs not programmed in this study. Perhaps, however, the temporary labor model does indicate an opportunity for the manager with well developed labor management skills.

CHAPTER IV

SUMMARY

The objective of this study is to determine optimal crop combinations which maximize profit in the production and marketing environment of the northern United States using linear programming.

In addition, characteristics of crops and options which contribute to their occurrence, or lack thereof, in the optimal mixes are studied. This analysis yields production management guidelines for each of the crops. These are useful planning aids to managers as they consider their unique set of fixed and other resources and as they do production management planning.

It is important to note that the data used in this study are for the calendar year 1970. As with any economic study, continuous change occurs in technology and practices, product prices and markets, input and output costs, and the other factors of production and marketing. These changes have been numerous since 1970 and often severe in their impact, i.e. the current energy crisis poses significant problems for producers. Fluctuations in fuel supplies and costs inject considerable uncertainty into long-range management planning.

Changes such as these impose some limitations on the validity of direct applications of these findings in current floriculture production programs. However, the operations analysis techniques remain valid, and their utilization in management studies such as this continue appropriate and relevant. Observation of the impact of these changes on the currency of such an analysis only reinforces the importance of frequent critical

evaluations of operative production programs. In this sense, the impact of the changing situation on the results of this study approaches reality characteristic of an actual industry situation.

In the future, wholesale cut flower and plant production and distribution patterns will continue to change dramatically. Managerially astute operators bound by few traditions and equipped with efficient physical plants rapidly are concentrating in favorable geographic areas. These floribusinessmen regularly seek and apply managerial methods to increase decision-making proficiency. They will not long neglect linear programming and other operations analysis methods as important adjuncts to their operations. In anticipation of this trend, there is need for continuing adaptive research in operations analysis applications to the management process in commercial floriculture.

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