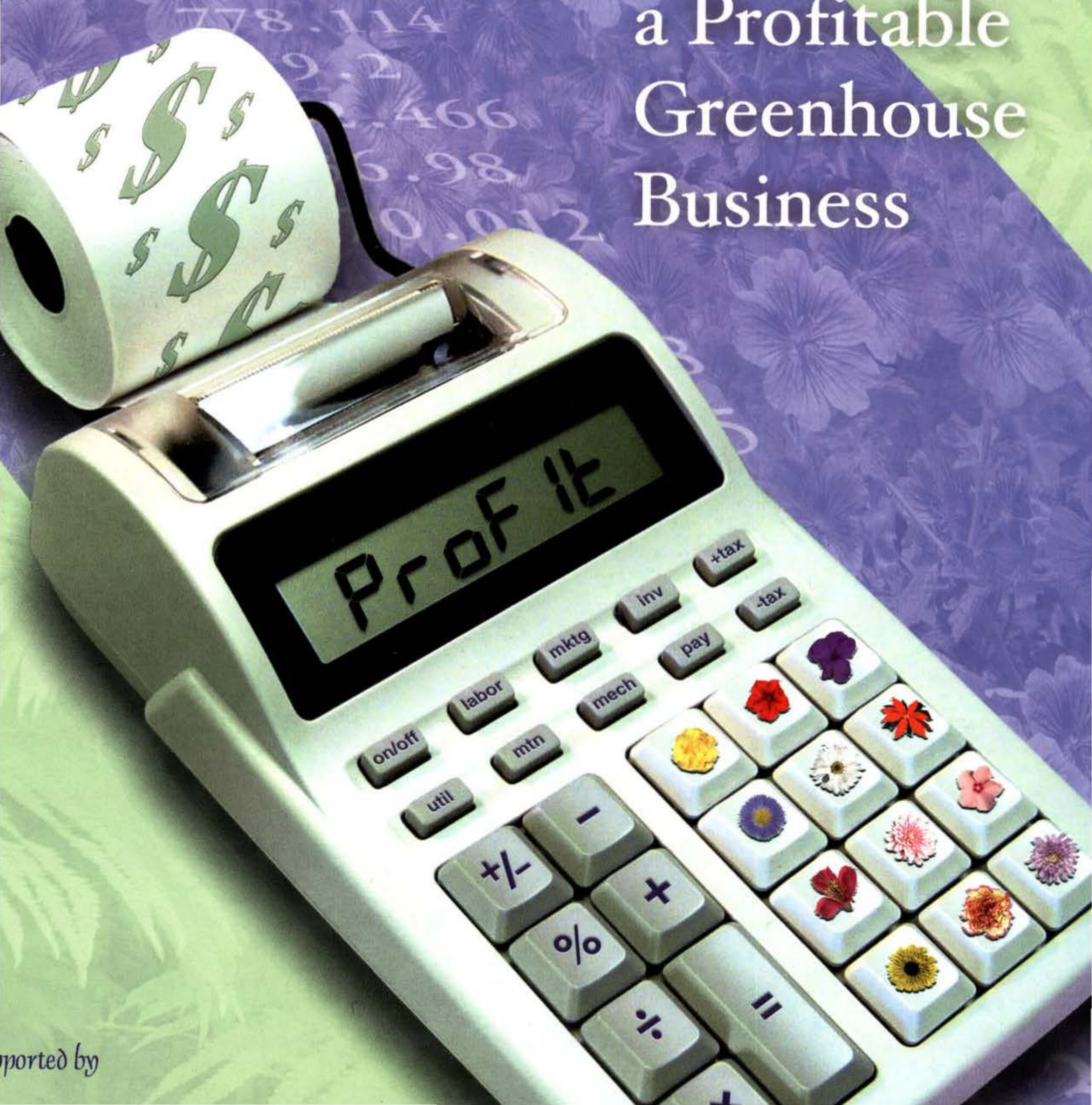
ciation of Floriculture Professionals

TIPS

On Operating a Profitable Greenhouse Business



pported by

Tips on Operating A Profitable Greenhouse Business

Copyright© 2005 — O.F.A Services, Inc.

2130 Stella Court, Columbus, Ohio 43215-1033 USA
Telephone: 614-487-1117 • Fax: 614-487-1216
e-mail: ofa@ofa.org • Web site: www.ofa.org

Editors

Managing Editor — Cheryl A. Cuthbert, OFA – an Association of Floriculture Professionals
Technical Editor — Stephen A. Carver, OFA – an Association of Floriculture Professionals

Cover Design

Zaunscherb Marketing Inc., Hamilton, Ontario, CANADA

Chapter Layout

Tonya Sharp — Sharp Designs, Groveport, Ohio

Disclaimer

The information supplied in this publication is intended as a tool to help you make educated and responsible decisions regarding the economic viability of your operation. Because the business climate is volatile, which can bear directly on some assumptions and suggestions made in this publication, neither OFA nor the authors and editors are responsible for losses resulting from use of the information in this publication.

No endorsement is intended for products mentioned, nor is criticism meant for products not mentioned. The editors, authors, O.F.A. Services Inc., OFA – an Association of Floriculture Professionals, and the advertisers assume no liability resulting from the use of these recommendations.

Authors and Editors

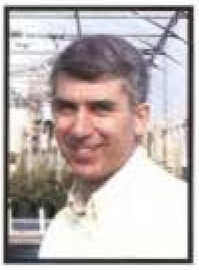
Authors

Raymond A. Cloyd
University of Illinois
Dept of Natural Resources
and Environmental Science
National Soybean Research Lab
1101 W Peabody Lab
Urbana, IL 61801
217-244-7218
Fax: 217-333-4777
rcloyd@uiuc.edu

Wen-fei L. Uva
Cornell University
Horticultural Business Management
& Marketing Program
Dept of Applied Economics &
Management
456 Warren Hall
Ithaca, NY 14853
607-255-3688
Fax: 607-255-9984
WL32@cornell.edu

James E. Faust
Clemson University
Dept of Horticulture
D-136 Poole Ag Center
Box 340375
Clemson, SC 29634-0375
864-656-4966
Fax: 864-656-4960
jfaust@clemson.edu

Kimberly A. Williams
Kansas State University
Dept HRFF
2021 Throckmorton Hall
Manhattan, KS 66506-5506
785-532-1434
Fax: 785-532-6949
kwilliam@oznet.ksu.edu



Peter Konjoian
Konjoian's Floriculture
Education Services
48 Brundrett Ave
Andover, MA 01810
978-683-0692
Fax: 978-683-6962
peterkfes@aol.com

Managing Editor

Cheryl A. Cuthbert
OFA – an Association of
Floriculture Professionals
2130 Stella Court
Columbus, OH 43215
614-487-1117
Fax: 614-487-1216
ccuthbert@ofa.org

Technical Editor

Stephen A. Carver
OFA – an Association of
Floriculture Professionals
2130 Stella Court
Columbus, OH 43215
614-487-1117
Fax: 614-487-1216
scarver@ofa.org

Table of Contents

Introduction

Peter Konjoian, Konjoian's Floriculture Education Services

How would you respond to the question "Do you feel that you're working harder and harder and making less and less?" If you're like many other greenhouse operators trying to make a living these days, your answer may be a resounding "Yes!"

This current installment in the *OFA Tips...* series has been written, unfortunately, out of necessity. Growers nationwide have been feeling the pinch of shrinking profit margins during the past decade and have become more interested in learning how they can manage their greenhouses in ways that will generate healthier profit margins (see Figure 1).

Traditional Attention

For several decades, we have focused our greenhouse management effort on costs of production. In this book, you will find an entire section of chapters dealing with cost analysis. Overhead cost determination, variable costs, whether to produce plugs on-site or buy them from a specialist, cost of using pesticides, and several others will be presented in detail. The second section of chapters deals with the other side of the picture, revenue analysis. We believe the time has arrived for growers to understand and use the entire profit equation; namely, Profit = Revenue – Costs.

A great analogy to the importance of discussing profitability from both the cost and revenue sides can be found in the concept of pH management. Think back 20 years to the first time you heard academic experts discuss the concept of irrigation water pH. In time, we shifted gears to understanding that pH was not the only factor to be concerned with, that alkalinity was just as, if not more, important in irrigation water and subsequent crop performance. Later still, our understanding evolved to the present where we understand the relationships between pH, alkalinity, and nutrition in order to manage pH drift in our crops. Many growers currently maintain charts in their head houses that list the various crop species they grow and whether they require low, medium, or high pH levels for optimal development.

Figure 1. A spring season retail greenhouse often contains potted crops, hanging baskets, and mixed containers to offer customers an assortment of gardening opportunities.

Think of the profit equation as you do the pH issue. Once our understanding of costs of production is solid, the next step is to focus on the revenue side. After both parts of the equation are understood, their interaction can be analyzed in order to manage our greenhouses to maximize profitability.

Turbulent Times

The commercial floriculture landscape continues to change. The growth of the mass market and large-scale production capacity our industry has enjoyed are influencing everything. Independents are learning to capitalize on niche market opportunities, while the big box outlets strive to supply inexpensive plants to large numbers of gardeners. A level of consolidation is taking place as wholesale growers try to obtain more leverage in dealing with national retailers. Fewer growers exist today compared to last year, and it is anticipated that fewer still will be present in the years to come.

Some wholesale growers have questioned whether they can compete in the arena of commodity marketing. Some have shifted to servicing independent garden centers, some have gone out of business, still others have tried their hand at retailing their own products. Whether at the wholesale or retail levels, all have learned that without a sufficient level of profitability, staying in business becomes difficult.

Work Hard... and Smart

It used to be enough to work really hard, grow really nice plants, and offer really good service. This formula defined success for generations of greenhouse growers. Working hard has never been an issue for floriculturists. It's agreed by many that greenhouse operators are very willing to work seven days a week, 365 days a year.

Today, however, greenhouse operators are realizing that the effort of growing quality plants by itself is not enough to stay in business (see Figure 2). Today's successful grower must also commit to working smarter than his or her competition. When there's not enough money left at the end of the day, it's as if the wind is dumped from one's sails. If there's not enough profit left on the bottom line, all of the hard work in the world can't keep one from questioning the future.

A Quick Preview

An aspect of profit analysis that we have found to be absolutely, unavoidably significant is that of crop shrinkage. This issue is dealt with in detail throughout the book. You will notice it as a recurring theme – a theme we found to be, without question, one of the major take-home messages for us to develop. A word of caution; many of us may be so enamored with what goes out the front door that we neglect to manage what goes out the back door. It's not a moment too soon for you to begin thinking about the plants you grow that do NOT make it to the front door (see Figure 3). This introduction will end on that note, along with a grateful thank you to our authors for bringing you such a timely book.

Figure 2. Growing quality plants is only half of a grower's concerns these days. Ensuring that profitability is a result of quality production requires much attention.

Figure 3. Most greenhouses have an area where unsaleable plants are dumped. Each plant that ends up on this pile diminishes profit from every plant sold at full price.

OFA

Chapter 1

Six Levels of Greenhouse Cost Accounting

James E. Faust, Clemson University

All businesses employ some method of managing finances. While there is no perfect method, the process of uncovering the financial details of your business is undoubtedly a key to profitability. Cost accounting is the process through which various expenses are attributed to the product produced. The task of attributing various expenses to specific crops may seem daunting; however, in this chapter, we will work through the process one step at a time. Each level will unravel additional layers of information. We will begin with the most easily accessible information and move toward the more detailed cost analyses.

There is no reason that one must proceed exactly along the order outlined in Table 1-1. The order of these levels is based on the ease of taking each step. For example, the easy-to-obtain variable costs for individual crops are accounted for in Level 2; while the more difficult-to-obtain variable costs are determined at Level 3. Some levels may be skipped. For example, Level 4 is perhaps the most difficult to complete. Many growers will skip this stage until they are ready to very closely compare and evaluate the profitability of specific crop mixes.

Following are the steps toward evaluating the costs of your business and the beginning of improving your business' profitability:

Level 1: General calculation of business profitability

The simplest method of managing a business utilizes one bank account. Earnings are deposited into the account, and expenses are paid from the account. The account balance at the end of the year indicates the profit.

Revenue – Costs = Profit

While this method does indicate overall business profitability, it provides no information for the owner to improve profitability. At the end of the year, there is no way to identify the most profitable or least profitable ventures or crops. The other major pitfall is that one may not be aware of the financial status of the company until after serious problems have occurred. This approach is simply an elementary business management tool, not a method of cost analysis, since no costs are really analyzed.

The next levels will require information about specific crops, which will allow you to determine the factors that contribute to or detract from greenhouse profitability.

Table 1-1. Six levels of greenhouse crop cost analysis.

Level	Cost Analysis Technique Applied
1	Revenue – Costs = Profit
2	Identifying the easily-obtained direct variable costs for specific crops
3	Estimating the difficult-to-obtain direct variable costs for broad crop categories
4	Determining all the direct variable costs for specific crops
5	Estimating the overhead costs for broad crop categories
6	Calculating the overhead costs for specific crops

Level 2: Identifying the easily-obtained direct variable costs per crop

The second level of cost accounting uses the variable costs that are most easily attributed to specific crops. The costs of the plant, pot, media, and tag, called "physical costs," are usually well-known or easily obtained (see Table 1-2). Although these expenses are only a component of the total production expenses, they do provide a starting point for comparing the cost of different crops. Perhaps more importantly, accounting for these factors provides a starting point from which more detailed cost accounting can take place.

There is not enough cost information available at Level 2 to identify the actual profit; however, this simple approach does allow one to make general comparisons between different crops.

Table 1-2. Easily-obtained direct variable costs for a specific crop (e.g. 4-inch vegetatively propagated annual, non-patented cultivar).

Item	Cost/unit
Container	$0.06
Growing Media	$0.05
Rooted Cutting	$0.34
Tag	$0.02
Total	$0.47

Level 3: Estimating the difficult-to-obtain direct variable costs for broad crop categories

Variable costs which are more difficult to apply to specific crops, such as fertilizer and chemical costs like pesticides and plant growth regulators, are included in Level 3. Labor costs, which are covered in more detail in Chapter 7, are also included in Level 3. Growers may find it easier to estimate these costs over the month, growing season, or year. In Table 1-3, we estimate the percentage of labor, fertilizer, and chemicals that each spring crop category requires for a hypothetical greenhouse.

Then, we simply add up all of these expenses for the season and divide those costs by the number of units produced (Table 1-4). In this example, 48,000 4-inch annuals are produced. Thus, 20 percent of the total labor expenses are attributed to those plants. As a result, $0.14 of labor is attributed to each 4-inch annual.

Combining this information with the variable costs listed at Level 2 provides the total direct variable costs per unit (see Table 1-5). (Variable costs are discussed in further detail in Chapter 5). Some businesses will double the direct variable costs to determine the wholesale price of a product. While this approach lacks some details, it usually provides a sufficient buffer to produce a profit.

Spreading the difficult-to-obtain variable costs equally across all the units produced has some obvious weaknesses, since not all units have similar inputs. For example, some crops require more labor (pinching), more pesticides (plant growth regulators or pesticides), or more fertilizer than the average crop. However, this technique is a starting point for providing a means for attributing costs to the products produced. In Level 4, the labor, fertilizer, and chemical costs will actually be determined for specific crops.

Table 1-3. An example of the estimations of the total labor, fertilizer, and chemical expenses required for different categories of spring crops for a hypothetical greenhouse.

Spring Crop	Estimated Labor	Estimated Fertilizer	Estimated Chemicals
Flats	35%	20%	30%
4" Annuals	20%	20%	30%
10" Hanging Baskets	15%	20%	10%
12" Combos	10%	10%	10%
Perennials	20%	30%	20%
Total	100%	100%	100%

Table 1-4. Calculating the expenses (labor, fertilizer, and chemicals) attributed to the production of 48,000 4-inch annuals based on the estimated percentages reported in Table 1-3.

Total Spring Season	Labor	Fertilizer	Chemicals
Variable Expenses	$33,600	$2,400	$4,800
Expenses attributed to 48,000 4-inch annuals	$6,720	$480	$1,440
Variable Cost/unit	$0.14	$0.01	$0.03

Level 4: Determining all the direct variable costs for specific crops

In Level 3, labor, fertilizer, and chemical costs have been spread evenly across all greenhouse crops. If our goal is to determine the profitability of different greenhouse crops, then we must be able to separate the labor, fertilizer, and chemical costs for individual crops. To accomplish this, time-motion studies must be conducted to determine the time to perform individual tasks, such as the time to transplant a flat or to move the flat from the head house to the greenhouse (see Tables 1-6 and 7-1, page 33). Records must be kept to separate the chemical and fertilizer costs for individual crops.

The value ($0.17/unit) for labor costs for the specific 4-inch annual crop in Table 1-6 will substitute for the general $0.14/unit cost listed in Table 1-5.

Level 4 may well be the most difficult level for small to mid-sized growing operations to determine reasonably accurate numbers since the labor force performs

Table 1-5. Total direct variable costs associated with growing 4-inch annuals.

Item	Cost/unit
Pot, plant, tag, and media	$0.47*
Fertilizer	$0.01**
Chemicals	$0.03**
Labor	$0.14**
Total Variable Costs/unit	$0.65

* From Table 1-2 (page 6).

** From Table 1-4.

Table 1-6. Results of a time-motion study to determine the specific labor requirements for a specific 4-inch annual crop.

Task	Time/unit (seconds)
Transplant a rooted cutting	24
Fertigation	16
Chemical Applications	12
Shipping/Harvest	25
Total	77
Labor Cost (@ $8/hour)	$0.17

many different tasks throughout the day. One does not need to complete this level before moving on to the next. The estimated variable costs determined in Level 3 will be adequate for many businesses.

Once Level 4 is completed for several different crops, growers will have a clearer picture for determining the profitability of different crops. However, overhead expenses will also need to be included in the cost analysis. Overhead expenses are discussed in Levels 5 and 6.

Level 5. Estimating overhead costs for broad crop categories

Levels 5 and 6 are very similar. Level 5 deals with broader crop categories, such as 4-inch annuals versus annual flats, while Level 6 is useful for comparing species within a category (4-inch New Guinea impatiens versus 4-inch geraniums) or for comparing the different method of production for a particular species (4-inch versus 6-inch New Guinea impatiens).

Overhead costs include all non-production related expenses such as office worker salaries, maintenance, taxes, et al. (see Chapter 3 for a detailed discussion of overhead costs). Table 1-7 provides an example of overhead costs for a greenhouse business.

Indirect variable costs include items that are associated with production, but often do not vary proportionately with production volume, like water, advertising, and electricity expenses. These costs can be determined on a per-crop basis, as is shown in Chapter 5. However, it is very common to include these indirect variable costs in the overhead cost calculation.

Table 1-7. Overhead costs for a greenhouse business.

Item	Annual Cost	
Salaries (non-production)	$85,000	42.5%
Utilities	$20,000	10.0%
Depreciation	$30,000	15.0%
Interest	$15,000	7.5%
Insurance	$8,000	4.0%
Repairs	$15,000	7.5%
Taxes	$1,500	0.8%
Advertising	$1,500	0.8%
Travel & Entertainment	$2,500	1.3%
Office Expenses	$1,000	0.5%
Professional Fees	$1,500	0.8%
Trucks & Rentals	$15,000	7.5%
Bad Debts	$1,000	0.5%
Miscellaneous	$3,000	1.5%
Total Overhead	$200,000	100%

Although overhead expenses occur regardless of whether or not a single plant is ever grown in the greenhouse, overhead expenses must be attributed to production. This is most often accomplished by dividing the overhead costs by the greenhouse production area. Thus, each square foot of greenhouse production space must support a fraction of the office workers' salaries, taxes, et al.

In a simplified example, one 3,000-square-foot greenhouse (2,400 square feet of actual growing space) must cover $18,000 worth of overhead expenses. Four-inch annuals are produced in that greenhouse for five months, and poinsettias are grown for four months. The greenhouse is empty for three months. Thus, the annuals must cover 5/9 or 56 percent of the overhead expenses ($10,000), while the poinsettias cover 4/9 or 44 percent ($8,000). If the greenhouse produces 24,000 4-inch annuals, then $0.40/pot goes toward overhead expenses ($10,000/24,000). If the greenhouse produces 2,400 6-inch poinsettias, then $3.33/pot goes toward overhead expenses ($8,000/2,400).

In this example, overhead expenses are dealt with in a fairly simple manner. One has to calculate the total overhead expenses, then divide that number by the total production space. One should only consider space that is actually occupied. (Using empty space for other crops will reduce the overhead expenses for all crops, since the same overhead costs will be attributed to more units sold.) Each general crop category occupies a fraction of that production space. This technique allows one to combine the direct variable and overhead costs to determine the actual costs for different crops. Thus, the profit or loss can now be calculated (see Table 1-8).

Level 6. Calculating overhead costs for specific crops

Level 5 allows growers to compare the profitability of different general crop categories. This will provide useful information about the profitability of crops in general. Level 6 will allow growers to make more specific crop profitability comparisons. This will allow businesses to further fine-tune their product lines toward crops that are most profitable, while the least profitable crops can be dropped or reduced if completely dropping an unprofitable crop is not possible.

Table 1-8. Total costs for 4-inch annual production.

Item	Costs/unit
Direct Variable Costs	$0.65*
Overhead Costs	$0.40
Total Costs	$1.05
Price/unit	$1.25
Profit (loss)	$0.20

*From Table 1-4 (page 7).

Level 6 makes the assumption that the more space occupied by a plant, the more overhead costs must be attributed to that plant. Thus, crops that are efficient space users are considered less expensive to produce. Efficiency is based on crop time and the area required per plant. The concept of **square foot weeks** is used to perform this task (square foot weeks is described in detail in Chapter 4). Square foot weeks represent the greenhouse space occupied over the life of the crop. For example, a plant that occupies one square foot for four weeks uses 4 square foot weeks, while a crop that occupies a 6-inch x 6-inch area for four weeks uses 1 square foot week.

Table 1-9. Comparison of the overhead expenses attributed to 4-inch annuals grown at different spacings. Assume an overhead value of $0.21 per square foot week.

Schedule	Overhead costs/unit				
4 weeks pot-to-pot (4" x 4")	$0.09	$0.09	$0.09	$0.09	$0.09
4 weeks at the noted spacing	Pot-to-pot $0.09	5" x 5" $0.15	6" x 6" $0.21	7" x 7" $0.29	8" x 8" $0.37
Total overhead costs/unit	$0.18	$0.24	$0.30	$0.38	$0.46

The example in Table 1-9 underscores the effect that spacing has on profitability. It is apparent that prostrate or spreading species must be properly growth regulated if they are to be profitable items.

Most businesses operate at Level 1. It takes a real effort and commitment of time to begin to pull together useful numbers that will allow you to get a real handle on your business' profitability. With a little bit of effort, Levels 2, 3, and 5 can be successfully completed in a reasonable time period. Undoubtedly, the process will be informative and revealing. Levels 4 and 6 are extremely detailed and can be difficult to fully complete for a large number of crops. One cannot expect to accomplish Levels 4 and 6 quickly. However, the process will be revealing. It will change the way one looks at greenhouse production, space use efficiency, and labor efficiency. This process will undoubtedly provide insight into how to make your business focus on profitability. The following chapters will describe this process in further detail.

OFA

Chapter 2

Using Spreadsheets as Cost Analysis Tools

James E. Faust, Clemson University

Spreadsheets are incredibly powerful tools for any size of business. In this chapter, a spreadsheet will be used to provide a template for cost accounting calculations. The spreadsheet has been developed to supplement this book, and is also available in the "OFA Bookstore" section of the OFA Web site (http://www.ofa.org/pdf/Ch2CostAcctgSpreadsheet.xls). Guidelines are provided in this chapter for using the accompanying spreadsheet or for growers to customize the spreadsheet for their unique business needs.

The spreadsheet provides space for growers to enter their specific costs. These cells are identified by WHITE cells. Numbers cannot be entered in the ORANGE cells, which contain formulas that calculate costs based on the user inputs in the WHITE cells.

Crop Information

The first sheet is for potted crops (see Table 2-1, page 11), while the second sheet is for flats (see Table 2-2, page 12). The two sheets are very similar; however, a few of the calculations are slightly different for flats and containers.

Units grown: Input the number of production units grown. A unit usually represents a flat or a container. However, a unit can be a larger product, such as a shuttle tray of 15 4-inch pots.

Container size: Enter container diameter for round pots or container width (measured side-to-side, not corner to corner) for square pots.

Containers filled: Enter the number of containers filled per cubic foot (ft^3) of media. The number of containers filled per cubic foot of media has been measured by Dr. Hugh Poole at Fafard Inc. (Table 2-3, page 13).

Number of plants per pot or flat: Enter the number of plants, seeds, plugs, or liners per pot or flat. For example, three plants per 6-inch pot or 36 plugs per 606 flat. Use the unit for which the price is known. For example, if a plug is purchased, use the plug cost, regardless of the number of seeds per plug.

Spacing: The spacing per flat is simply the width and length of the flats. For pots, there is the option to provide three different spacings per crop. The first spacing represents the initial spacing, the second spacing represents the intermediate spacing, and the third spacing represents the final spacing. For example, a poinsettia crop may be spaced for four weeks at 6-inch by 6-inch spacing, four weeks at 10-inch by 10-inch spacing, and four weeks at 12-inch by 12-inch spacing. Enter "0" weeks in the unused spacing column(s) if plants are only spaced once or twice.

Crop time: For pots, the number of weeks from transplant to finish is calculated as the sum of the number of weeks entered at the three different spacings. For flats, the user inputs a value that represents the time from transplant to finish.

Total space per unit: The total calculated space occupied (square foot weeks) by one unit from transplant to finish is based on the information entered in the spacing lines. See Table 2-4, page 14 for an example of this basic crop information. The square foot weeks concept is discussed in detail in Chapter 4.

Maximum greenhouse space: The bench space required when the crop is at its maximum spacing. For example, if the maximum spacing is 12 inches x 12 inches, then each pot requires one square foot. This value is multiplied by the number of units grown. So, 1,000 units would require 1,000 square feet when the crop is placed at its final spacing. This value is especially useful when comparing two different crops. For example, in comparing whether it is more profitable to grow a 4-inch crop or flats on a particular bench, the number of units grown can be manipulated so both crops occupy the same amount of bench space.

Variable Costs

Plants: Enter the cost per plant, plug, liner, or seed and the number of plants per unit. The total cost is calculated. Enter the real cost per plant; i.e. this value may include freight, royalty, and the tag.

Container: Enter the cost per pot or tray and insert.

Tag: Enter the cost per tag and the number of tags used per unit. Enter "0" if the tag cost is included in the plant price.

Fertilizer: Enter the total cost of fertilizer for the entire crop, and the fertilizer cost per pot grown is calculated.

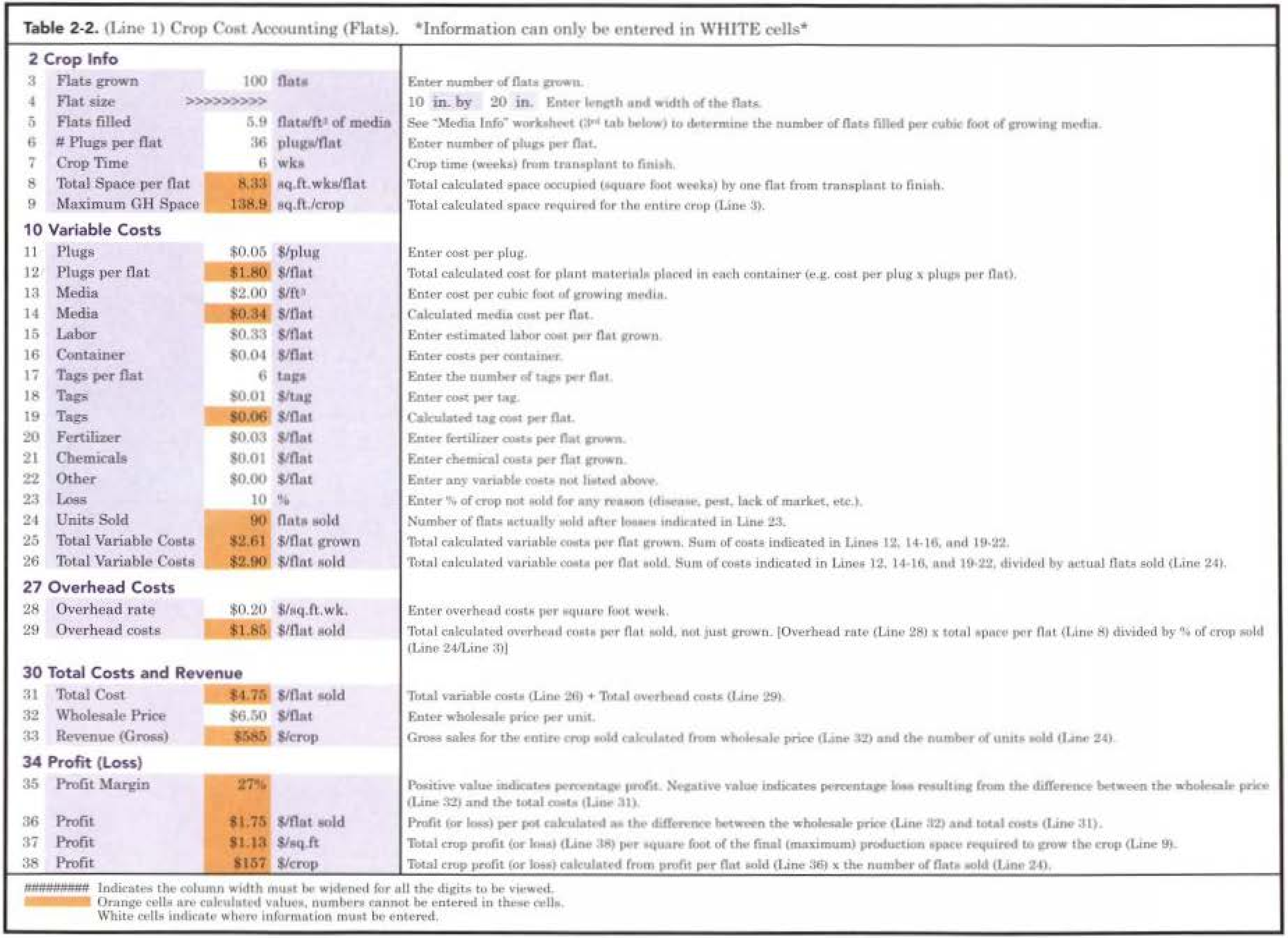
Chemicals: Enter the total chemical cost for the entire crop, and the chemical cost per pot grown is calculated. Chemicals include pesticides, fungicides, and plant growth regulators.

Table 2-1. (Line 1) Crop Cost Accounting (Pots). *Information can only be entered in WHITE cells*

2	**Crop Info**			
3	Units grown	1,000	pots	Enter number of pots grown.
4	Container size	4	inch	Enter container diameter for round pots, or container width (side to side) for square pots.
5	Containers filled	50	pots/ft³ of media	See "Media Info" worksheet (3rd tab below) to determine the number of flats filled per cubic foot of growing media.
6	# Plants per pot	1	plants/pot	Enter number of plants, liners, plugs or seeds in each pot.
7	Spacing #1	3	wks @	10 in. by 20 in. Enter number of weeks spent at this spacing. (Spacing cannot be lower than Line 4).
8	Spacing #2	3	wks @	10 in. by 20 in. Enter number of weeks spent at this spacing. (Enter 0 weeks if Spacing #1 is the final spacing).
9	Spacing #3	3	wks @	10 in. by 20 in. Enter number of weeks spent at this spacing. (Enter 0 weeks if Spacing #1 or 2 are the final spacing).
10	Crop Time	9	wks	Calculated time (weeks) from transplant to finish based on weeks entered in lines 7-9.
11	Total Space per Pot	4.08	sq.ft.wks/pot	Total calculated space occupied (square foot weeks) by one unit from transplant to finish based on weeks entered in lines 7-9.
12	Maximum GH Space	1,000.0	sq.ft./crop	Total calculated space required for the entire crop (Line 3) when the crop is at the widest spacing entered in Lines 7-9.
13	**Variable Costs**			
14	Cutting or Seed	$0.50	$/plant	Enter cost per plant or seed. Do not input double this number if two plants are used per pot.
15	Plants	$0.50	$/pot	Total calculated cost for plant materials placed in each container (e.g. cost per plant x plants per pot).
16	Media	$2.00	$/ft³	Enter cost per cubic foot of growing media (See "Media" worksheet for help to calculate this value).
17	Media	$0.04	$/pot	Calculated media cost per pot.
18	Labor	$0.25	$/pot	Enter estimated labor cost per pot grown.
19	Container	$0.04	$/pot	Enter costs per container.
20	Tag	$-	$/pot	Enter tag costs (enter total costs here if more than one tag per unit).
21	Fertilizer	$0.03	$/pot	Enter fertilizer costs per pot grown.
22	Chemicals	$0.01	$/pot	Enter chemical costs per pot grown.
23	Other	$0.00	$/pot	Enter any variable costs not listed above.
24	Loss	5	%	Enter % of crop not sold for any reason (disease, pest, lack of market, etc.).
25	Pots Sold	950	pots sold	Number of pots actually sold after losses indicated in Line 24.
26	Total Variable Costs	$0.87	$/pot grown	Total calculated variable costs per pot grown. Sum of costs indicated in Lines 15, 17-23.
27	Total Variable Costs	$0.92	$/pot sold	Total calculated variable costs per pot sold. Sum of costs indicated in Lines 15, 17-23, divided by actual pots sold (Line 25).
28	**Overhead Costs**			
29	Overhead rate	$0.20	$/sq.ft.wk.	Enter overhead costs per square foot week.
30	Overhead costs	$0.86	$/pot sold	Total calculated overhead costs per unit sold, not just grown. [Overhead rate (Line 29) x total space per pot (Line 11) divided by % of crop sold (Line 25/Line 3)]
31	**Total Costs and Revenue**			
32	Total Cost	$1.78	$/pot sold	Total variable costs (Line 27) + Total overhead costs (Line 30).
33	Wholesale Price	$2.00	$/pot	Enter wholesale price per unit.
34	Revenue (Gross)	$1,900	$/crop	Gross sales for the entire crop sold calculated from wholesale price (Line 33) and the number of units sold (Line 25).
35	**Profit (Loss)**			
36	Profit Margin	11%		Positive value indicates percentage profit. Negative value indicates percentage loss resulting from the difference between the wholesale price (Line 33) and the total costs (Line 32).
37	Profit	$0.22	$/pot sold	Profit (or loss) per pot calculated as the difference between the wholesale price (Line 33) and total costs (Line 32).
38	Profit	$0.21	$/sq.ft	Total crop profit (or loss) (Line 39) per square foot of the final (maximum) production space required to grow the crop (Line 12).
39	Profit	$213	$/crop	Total crop profit (or loss) calculated from profit per pot sold (Line 37) x the number of flats sold (Line 25).

########## Indicates the column width must be widened for all the digits to be viewed.
🟧 Orange cells are calculated values, numbers cannot be entered in these cells.
White cells indicate where information must be entered.

Table 2-2. (Line 1) Crop Cost Accounting (Flats). *Information can only be entered in WHITE cells*



2	**Crop Info**			
3	Flats grown	100	flats	Enter number of flats grown.
4	Flat size	>>>>>>>>>		10 in. by 20 in. Enter length and width of the flats.
5	Flats filled	5.9	flats/ft³ of media	See "Media Info" worksheet (3rd tab below) to determine the number of flats filled per cubic foot of growing media.
6	# Plugs per flat	36	plugs/flat	Enter number of plugs per flat.
7	Crop Time	6	wks	Crop time (weeks) from transplant to finish.
8	Total Space per flat	8.33	sq.ft.wks/flat	Total calculated space occupied (square foot weeks) by one flat from transplant to finish.
9	Maximum GH Space	138.9	sq.ft./crop	Total calculated space required for the entire crop (Line 3).
10	**Variable Costs**			
11	Plugs	$0.05	$/plug	Enter cost per plug.
12	Plugs per flat	$1.80	$/flat	Total calculated cost for plant materials placed in each container (e.g. cost per plug x plugs per flat).
13	Media	$2.00	$/ft³	Enter cost per cubic foot of growing media.
14	Media	$0.34	$/flat	Calculated media cost per flat.
15	Labor	$0.33	$/flat	Enter estimated labor cost per flat grown.
16	Container	$0.04	$/flat	Enter costs per container.
17	Tags per flat	6	tags	Enter the number of tags per flat.
18	Tags	$0.01	$/tag	Enter cost per tag.
19	Tags	$0.06	$/flat	Calculated tag cost per flat.
20	Fertilizer	$0.03	$/flat	Enter fertilizer costs per flat grown.
21	Chemicals	$0.01	$/flat	Enter chemical costs per flat grown.
22	Other	$0.00	$/flat	Enter any variable costs not listed above.
23	Loss	10	%	Enter % of crop not sold for any reason (disease, pest, lack of market, etc.).
24	Units Sold	90	flats sold	Number of flats actually sold after losses indicated in Line 23.
25	Total Variable Costs	$2.61	$/flat grown	Total calculated variable costs per flat grown. Sum of costs indicated in Lines 12, 14-16, and 19-22.
26	Total Variable Costs	$2.90	$/flat sold	Total calculated variable costs per flat sold. Sum of costs indicated in Lines 12, 14-16, and 19-22, divided by actual flats sold (Line 24).
27	**Overhead Costs**			
28	Overhead rate	$0.20	$/sq.ft.wk.	Enter overhead costs per square foot week.
29	Overhead costs	$1.85	$/flat sold	Total calculated overhead costs per flat sold, not just grown. [Overhead rate (Line 28) x total space per flat (Line 8) divided by % of crop sold (Line 24/Line 3)]
30	**Total Costs and Revenue**			
31	Total Cost	$4.75	$/flat sold	Total variable costs (Line 26) + Total overhead costs (Line 29).
32	Wholesale Price	$6.50	$/flat	Enter wholesale price per unit.
33	Revenue (Gross)	$585	$/crop	Gross sales for the entire crop sold calculated from wholesale price (Line 32) and the number of units sold (Line 24).
34	**Profit (Loss)**			
35	Profit Margin	27%		Positive value indicates percentage profit. Negative value indicates percentage loss resulting from the difference between the wholesale price (Line 32) and the total costs (Line 31).
36	Profit	$1.75	$/flat sold	Profit (or loss) per pot calculated as the difference between the wholesale price (Line 32) and total costs (Line 31).
37	Profit	$1.13	$/sq.ft	Total crop profit (or loss) (Line 38) per square foot of the final (maximum) production space required to grow the crop (Line 9).
38	Profit	$157	$/crop	Total crop profit (or loss) calculated from profit per flat sold (Line 36) x the number of flats sold (Line 24).

########## Indicates the column width must be widened for all the digits to be viewed.
🟧 Orange cells are calculated values, numbers cannot be entered in these cells.
White cells indicate where information must be entered.

Growing media: Enter the cost per cubic foot of growing media. Divide the cost per bag of media by the number of cubic feet of media per bag. (See Table 2-3 to determine the number of cubic feet of media for your media supply.) The media cost per pot is calculated by dividing the media cost per cubic foot by the number of pots filled per cubic foot of media entered in the "Crop Info" section.

Labor: Enter the total estimated labor cost per crop. The labor cost per pot grown is calculated.

Loss: Enter the percentage of crop not sold for any reason — e.g. disease, pests, lack of market, etc.

Units sold: The calculated number of units actually sold based on the percentage loss.

Total variable costs: The total calculated variable costs per unit grown and per unit sold.

Table 2-3. Number of containers per cubic foot of growing medium.

Pot Type and Size		Containers/ Cubic Foot of Media
Plastic Standard Pots	Belden Std 4"	50.3
	Belden 4.5" Geranium	38.9
	Belden Std 6"	14.3
	Belden Std 8"	6.7
	Belden Std 10"	3.2
Plastic Azalea Pots	Kord AZ 4" 100 mm AZ-S	72.8
	ITML AZ 6" 600	24.9
	ITML AZ 8" AZE0800	10.2
	Kord AZ 10" 250 mm	4.8
Plastic Square Pots	Kord SQ 4"	54.5
	Belden 4.25" Jumbo Junior	30.9
	Belden 5.75" Jumbo Senior	16.2
Hanging Baskets	Belden 6"	18.8
	Belden Pop Basket 8"	7.5
	Belden Basket w/Saucer 10"	5.3
	Belden 12"	3.0
Bowls	Dillen Bowl 12"	3.4
	ITML Planter 14"	1.2
	Dillen Planter 16"	3.2
Nursery Con-tainers	Nursery Supplies - Classic Pan 8"	8.8
	Nursery Supplies - Classic 300 (1 gal)	8.9
	Nursery Supplies - Classic 600 (2 gal)	4.2
	Nursery Supplies - Classic 1000 (3 gal)	3.0
Bedding Plant Flats	1204 Flat	7.0
	1206 Flat	7.9
	1801 Flat	6.2
	606 Flat	5.9
	606 Flat-Deep	5.2
	804 Flat	7.0

Thanks to Dr. Hugh Poole, Fafard Inc., for this table.

Overhead Costs

Overhead rate: Enter the estimated overhead costs per square foot week. See the discussion in Chapter 4 for an estimated value.

Total overhead costs: Total calculated overhead costs per unit sold, not just grown.

Total Costs and Revenue

Total costs: The sum of the total variable and overhead costs per pot sold.

Wholesale price: Enter the wholesale price per unit.

Revenue (Gross Income): Gross sales for the entire crop sold based on the wholesale price.

Profit (Loss)

Profit margin: The percentage of the gross sales above the total costs. Positive values indicate a profit, while negative values indicate a loss.

Profit per pot sold: Profit (or loss) per pot calculated as the difference between the wholesale price and total cost per pot.

Profit per square foot of greenhouse space: Total profit (or loss) per square foot of the final (maximum) production space required to grow the crop. This value provides a relative comparison between the profitability of different crops per greenhouse space required to grow the crop.

Profit per crop: Total profit (or loss) for the entire crop calculated from the profit per unit sold and the number of units sold.

Using the Spreadsheet

This spreadsheet can be used for several different purposes:

Crop comparisons. Comparisons of crop profitability for several different crops can be easily made. The appropriate data can be entered for a specific crop. The results can be printed, then data from another crop can be entered. These comparisons will assist growers with identifying the most profitable crops to grow. One can also compare growing different forms of the same species, e.g. 4-inch, 6-inch, and 10-inch New Guinea impatiens.

Improving crop profitability. The various different inputs can be altered to identify the most effective approaches for improving crop profitability. For example, the spreadsheet can be used to determine what price increase or cost cutting is necessary to make a crop more profitable.

Greenhouse business profitability. Compiling information from all the crops grown can provide insights into the profitability of the entire greenhouse business. This requires accumulating a large series of crop cost analyses. It may be more feasible to categorize crops into larger groups, such as 4-inch annuals, flats, herbs, etc..., rather than running cost analyses for each individual species or variety.

Table 2-4. An example of basic crop information.

Spacing	Spacing (in.) x (in.)	Total area (sq. in.)	Total area (sq. ft.)	Time (weeks)	Square foot weeks
Initial	4 x 4	16	0.11	3	0.33
Intermediate	6 x 6	36	0.25	2	0.50
Final	12 x 12	144	1.00	4	4.00
					4.83 Total

OFA

Chapter 3

Overhead or Fixed Costs

James E. Faust, Clemson University

Overhead or fixed costs refer to the cost of being in business. These expenses occur regardless of any production. A long list of items is included as overhead costs, and these expenses are usually calculated on an annual basis (see Table 3-1). Overhead costs can be divided into a few larger categories, such as structural costs, labor costs, utility costs, and marketing costs.

Some of the items listed below could be considered indirect variable costs – items associated with production, but not always varying in proportion to production volume. These indirect variable costs, such as heating expense for poinsettia production, could be either determined on a per-crop basis, as shown in Chapter 5, or included in overhead costs, as shown here.

Facilities and Structural Costs

- *Maintenance and repairs.* Maintaining physical facilities and equipment.
- *Property taxes.*
- *Interest.* Loans for capital investment.
- *Depreciation.* Annual cost of capital items, such as equipment and structures that will be used for more than one year. The total cost (minus the salvage value) is spread over the number of years of useful life. The salvage value is often considered to be zero.
- *Rentals.* Land, greenhouse, storage, or equipment.
- *Insurance.* Buildings, equipment, liability.

Utilities

- *Utilities.* Heating fuel oil or gas, water, and electricity.

Labor and Office Costs

- *Managerial and office staff.* Non-production employee salaries.
- *Production and shipping labor.* Labor can be regarded as a variable or a fixed cost (see Chapters 1 and 7). If labor can be attributed to individual crops, then it should be included as a variable cost; however this can be difficult to do. So, many businesses will consider labor to be a fixed cost and lump it into overhead.
- *Benefits and insurance.* Health, worker's compensation, unemployment.
- *Office expenses.* Supplies, facilities, telephone, photocopying, and equipment.
- *Professional dues and subscriptions.* Magazines, professional organizations, memberships.
- *Travel and entertainment.* Business meetings.
- *Training and education.* Conference fees and short courses.
- *Professional fees and consulting.* Professional consultations for legal, business, financial, and technical expertise.
- *Contributions.* Donations.

Shipping and Marketing

- *Truck expenses.* Fuel, equipment, maintenance, and operation expenses. These expenses could be considered variable costs if the cost is attributed to each production unit.
- *Equipment.* Racks and carts.
- *Advertising.*

Miscellaneous

- *Bad debt.* Unpaid accounts receivable.

Applying Overhead Expenses to Greenhouse Production

Overhead costs must be covered by production. This is frequently done by determining the production area and dividing the overhead costs by the production area and time of production. The calculated value is termed the square foot week. This is the topic of Chapter 4.

Table 3-1. Input your overhead expenses in this table to determine the total annual overhead cost for your business.

Overhead Expenses	Annual Overhead Cost
Facilities & Structural Costs	
Maintenance & repairs	
Property taxes	
Interest	
Depreciation	
Rentals	
Insurance	
Utilities	
Heating fuels or gas	
Water	
Electricity	
Labor & Office Costs	
Managerial & office staff	
Production & shipping labor	
Benefits & insurance	
Office expenses	
Professional dues & subscriptions	
Travel & entertainment	
Training & education	
Professional fees & consulting	
Contributions	
Shipping & Marketing	
Transportation expenses	
Equipment	
Advertising	
Miscellaneous	
Bad debt	
TOTAL OVERHEAD COSTS	$

Chapter 4

Square Foot Weeks: Applying Overhead Costs to the Greenhouse Production Area

James E. Faust, Clemson University

By definition, overhead costs occur regardless of greenhouse production. Examples of overhead costs are described in Chapter 3. Overhead costs must be covered by crop sales; therefore, it is valuable to develop a method of attributing overhead costs to production. This process is most frequently accomplished by dividing the overhead costs by the amount of greenhouse space and the time that the space is used.

EXAMPLE:

Overhead costs = $125,000
Greenhouse production space = 12,000 ft^2
Weeks of production = 52 weeks
$125,000 / 12,000 ft^2 / 52 wks = $0.20/ft^2 wk

This is an example of what is often referred to as the number of square foot weeks (ft^2 wk). Square foot weeks refer to the overhead costs attributed to each square foot of production space for each week of the season. In the above example, each square foot of production space must cover overhead expenses equaling $0.20 per week. If one plant was grown in one square foot for 10 weeks, then the overhead costs attributed to that plant would be $2.00.

The square foot weeks concept underscores the importance of using greenhouse space efficiently. Table 4-1 demonstrates the overhead cost per pot based on several different pot spacings. Simply by increasing the pot spacing from 5 inches x 5 inches to 6 inches x 6 inches, the overhead cost per pot increases by 30 percent. This example assumes that when plants are spaced more closely together, then the extra space can be used to grow additional plants. However, if no additional crops can utilize that space, then there is no practical benefit from growing plants at tighter spacing.

Table 4-1. The effect of container spacing of 4-inch diameter pots on the overhead cost per pot, assuming an overhead cost of $0.20 per square foot week and a crop grown for six weeks.

Container Spacing	Pots per square foot	Overhead cost per pot
4" x 4" (10x10 cm^2)	9.0	$0.13
5" x 5" (12.5x12.5 cm^2)	5.8	$0.20
6" x 6" (15x15 cm^2)	4.0	$0.30
8" x 8" (20x20 cm^2)	2.3	$0.53
10" x 10" (25x25 cm^2)	1.4	$0.83
12" x 12" (30x30 cm^2)	1.0	$1.20

Typical values used for greenhouse production range from $0.20 to $0.25 per square foot week. If you cannot easily calculate your actual overhead cost per square foot week, then a value in this range should be useful. If the overhead costs are much higher than this range, the business budgeting process should be more closely scrutinized.

There are several challenges to applying the square foot weeks concept to specific commercial greenhouse situations. We will discuss several of these challenges.

Multiple-Space Crop

Many greenhouse crops are grown at multiple spacings. For example, a poinsettia may start out pot-to-pot (6 inches x 6 inches), then be partially spaced (8 inches x 8 inches) before being placed at the final spacing (14 inches x 14 inches). The number of square foot weeks for this crop can be calculated as follows (assume an overhead cost of $0.22/ft^2 wk):

This example underscores the importance of efficient plant spacing, as it becomes obvious that the wide final spacing required by some crops results in considerable overhead costs being attributed to relatively few plants.

Spacing (inches)	Area per plant (ft^2)	Weeks	Square foot weeks	Overhead costs ($)
6 x 6	0.25	4	1.0	0.22
8 x 8	0.44	3	1.3	0.29
14 x 14	1.36	5	6.8	1.50
				$2.01 (total/plant)

Greenhouse Space vs. Space Used

Using the actual space used to grow plants provides a more reasonable method for attributing overhead costs to greenhouse production. If one includes aisle space and/or unused bench space, then you are effectively attributing overhead cost to non-productive areas, which is contrary to our goal. Certainly, unused space does cost money, but if no plants are grown in that space, then actual production space will have to cover the expenses attributed to the unused space anyway.

For example, Table 4-2 uses the actual greenhouse bench space used monthly (Column B). If the available bench space of 10,000 square feet were inputted for each month, then the costs attributed to low production months, like December, would be unreasonably high. This would make the costs associated with the crop grown in the 2,000 square feet of used space in December appear to be disproportionately high.

Hanging Baskets

Growers often consider the space occupied by hanging baskets as "free" space. The assumption is that the bench crops are covering all the overhead costs. This assumption causes the hanging baskets to appear to be extremely profitable, while the bench crops are relatively less profitable. To provide a more accurate picture of crop profitability, it is useful to assume that the hanging baskets occupy an area equal to the space occupied as if they were being grown on the bench. Thus, growing hanging baskets effectively increases the production area and spreads overhead costs over a larger area — reducing the overhead costs per square foot week.

For example, Table 4-2 provides an example of hanging baskets that effectively create an additional 3,000 square feet of production space from March through June. Attributing overhead costs to hanging baskets effectively reduces the overhead covered by the bench crop and places the hanging baskets and bench crops on equal footing, in terms of comparing profitability.

Accounting for Different Production Areas (unheated greenhouses and outdoor growing areas)

Not all production space requires the same overhead inputs. For example, an outdoor growing area does not require heating and electrical utilities. Therefore, it can be useful to separate overhead costs for different production areas. One can list all overhead expenses for greenhouse production (as shown in Chapter 3) and then remove those expenses that should not be attributed to lower cost production facilities.

For example, Table 4-2 shows overhead expenses for greenhouse space (Columns B & C) and an outdoor production area (Column D). In this example, the total overhead cost ($130,000) is divided between the greenhouse (75 percent) and the outdoor area

Table 4-2. An example of the monthly distribution of overhead expenses over the greenhouse bench space, hanging baskets, and an outdoor production area. The greenhouse has 10,000 square feet of bench space and hanging basket space equivalent to 3,000 square feet. An outdoor production area occupies an additional 10,000 square feet.

Cost/ft^2 wk	Total Cost	
$ 0.21	$97,500	Greenhouse Space
$ 0.15	$32,500	Outdoor Space
	$130,000	Total Overhead

	Production Space Used			Overhead Costs	
Column A	Column B	Column C	Column D	Column E	Column F
Month	Greenhouse bench (ft^2)	Greenhouse hanging basket (ft^2)	Outdoor production (ft^2)	Greenhouse space ($)	Outdoor production space ($)
January	4,000	0	0	$3,611	$0
February	8,000	0	0	7,222	0
March	10,000	3,000	0	11,736	0
April	10,000	3,000	10,000	11,736	6,500
May	10,000	3,000	10,000	11,736	6,500
June	10,000	3,000	5,000	11,736	3,250
July	6,000	0	10,000	5,417	6,500
August	6,000	0	10,000	5,417	6,500
September	10,000	0	5,000	9,028	3,250
October	10,000	0	0	9,028	0
November	10,000	0	0	9,028	0
December	2,000	0	0	1,806	0
Totals	**96,000 ft^2**	**12,000 ft^2**	**50,000 ft^2**	**$97,500**	**$32,500**

NOTE: assume all months have an equal number of days (30.3).

(25 percent). The percentages will vary for different businesses. For example, if the outdoor production area was used for year-round production of perennials (i.e. 10,000 square feet every month), then a larger percentage of the overhead (35 percent) would have to be attributed to the outdoor space. If this adjustment were not made, then outdoor production would seem remarkably profitable, since the cost/ft^2 wk would be very inexpensive.

Seasonal Variation in Overhead Costs

Certain overhead costs, such as utilities, vary seasonally, while many others are equally divided throughout the year. One can apply different overhead costs on a monthly basis, so that the first crop of bedding plants started in late winter is more expensive to produce than the second crop started in mid-spring. One could adjust each month so that, for example, January cost/ft^2 wk is higher than May cost/ft^2 wk. Examples of these types of calculations are shown in Chapter 6 for calculating indirect variable costs, which are often lumped together in overhead costs. However, it is more complicated to apply these costs to different crops that occupy space over a range of different months and portions of months.

Should You Grow an Unprofitable Crop?

Many growers consider poinsettias to be a relatively low-profit or unprofitable crop, yet they continue to grow them. Why? They pay for overhead expenses. Even if a crop makes no profit or actually loses money, it can be a beneficial crop since it covers overhead expenses that occur whether or not the crop is grown. Taxes and many other overhead expenses cannot be reduced if the greenhouse is empty. Table 4-3 demonstrates how growing poinsettias helps to reduce overhead expenses.

First, we assume that we want to maintain our overhead expenses so our cost per square foot week stays at \$0.22. The example on the left shows a greenhouse with 10,000 square feet of production space (no hanging baskets) without a poinsettia crop. The example on the right includes a poinsettia crop that uses 2,000 square feet in August, 3,500 square feet in September, 10,000 square feet in October and November, and 2,000 square feet in December. Without poinsettias, the overhead expenses need to be \$64,827 to maintain \$0.22/ft^2 wk. With poinsettias, the total annual overhead can be \$91,043 to maintain \$0.22/ft^2 wk. Therefore, if one stops growing poinsettias, overhead expenses would need to be reduced by 29 percent or \$26,217, or the profitability of all other crops will be reduced. Poinsettia production may not yield a large profit, but it can increase the profitability of everything else you grow.

Table 4-3. The overhead attributed to poinsettias and other crops (assuming \$0.22/ft^2 wk). In this example, the poinsettia crop accounts for 25 percent of the annual overhead, or \$26,217. If the poinsettia crop were eliminated, then the greenhouse overhead would have to be reduced by \$26,217 per year, or other crops would need to fill up the space used by the poinsettias.

	Greenhouse Space			Distribution of Annual Overhead	
Month	**Poinsettia (ft^2)**	**Other crops (ft^2)**	**Total (ft^2)**	**Poinsettias**	**Other crops**
January	0	4,000	4,000	\$ -	\$3,813
February	0	8,000	8,000	\$ -	\$7,627
March	0	13,000	13,000	\$ -	\$12,393
April	0	13,000	13,000	\$ -	\$12,393
May	0	13,000	13,000	\$ -	\$12,393
June	0	13,000	13,000	\$ -	\$12,393
July	0	6,000	6,000	\$ -	\$5,720
August	2,000	6,000	8,000	\$1,907	\$5,720
September	3,500	6,500	10,000	\$3,337	\$6,197
October	10,000	0	10,000	\$9,533	\$ -
November	10,000	0	10,000	\$9,533	\$ -
December	2,000	0	2,000	\$1,907	\$ -
			Total	**\$26,217**	**\$78,650**
				25%	75%
	Grand Total Annual Overhead			**\$104,867**	

OFA

Chapter 5

Variable Costs: General Discussion

Kimberly A. Williams, Kansas State University
Wen-fei L. Uva, Cornell University

Variable costs are the expenses directly associated with growing the product. If you stop production, you will not incur these costs. Unlike overhead or fixed costs, which are incurred regardless of whether or not you produce the crop, variable costs vary with production volume; therefore managers generally have more control over these costs at a given point in time.

Variable costs can be broken down into two main categories: "direct" and "indirect." **Direct variable costs** are items directly associated with production, and they vary proportionately with production volume. This category includes 1) physical costs – including the plant, container, and root medium; 2) fertilizer and chemical costs – including pesticide and plant growth regulator applications; and 3) direct production labor. **Indirect variable costs** include items that are associated with production, but often do not vary proportionately with production volume, such as heating, water, advertising, and electricity expenses. For ease of calcultion, many operations include indirect variable costs in overhead cost calculations (see Chapter 3, page 15.)

It is usually straightforward to identify direct variable costs for each crop. The cost of the pot, for example, is easily determined. On the other hand, it is not always clear how much of the indirect variable costs should be "charged" to a specific crop. Sometimes, indirect variable costs can be calculated so they can be assigned to a given crop. For example, assigning the cost of heating incurred during poinsettia production directly to this crop by including it in the variable cost category will more accurately reflect your expenses for producing poinsettias. However, it may be nearly impossible to assign the cost of heating incurred during spring production to a given crop because so many different species are produced in so many different container sizes during this time of year. At this point, it is easier to lump the indirect variable costs together with fixed costs and assign them to crops based on the space and time necessary to produce each one. This is the square foot weeks concept, and it was discussed in detail in Chapter 4. Categorizing hourly labor for production of a given crop is another quagmire; it is ideally considered as a variable cost, though it can also be lumped into overhead cost calculations, and this will be discussed in detail in Chapter 7.

The more specific that you can be in assigning costs to a specific crop, the more accurate the cost analysis will be for that crop. The strategy of tracking as many individual costs per crop as possible, such as breaking labor down into costs per crop, has been called "micro cost accounting." While it is the method that most precisely determines cost of each crop unit, it is also the most difficult and time-consuming to accomplish; see Chapter 1 (page 6) for more details.

On the Cost Analysis Spreadsheet (in Chapter 2, page 11), the variable costs are as follows: cuttings or plugs; media; production labor; container; tag; fertilizer; chemicals; and other (for any other direct costs, like sleeves, etc.). On the spreadsheet, these categories are treated as direct variable costs. Indirect variable costs that can be lumped together with overhead (fixed) costs include payroll expenses for management personnel; advertising; heating for the greenhouse; gas and diesel for trucks, gas-powered sprayers, etc.; electricity; water and sewage; and trucking and shipping costs. A detailed variable costs checklist is provided in Table 5-1, page 20. Again, note that these indirect variable costs might be more simply treated as overhead costs (see Chapter 3).

There will always be miscellaneous expenses that leave us trying to sort out the most appropriate category to place them in. For example, you may have an expense for herbicides that are used to control weeds around the greenhouse range. It may seem at first that this purchase of "chemicals" is a straightforward "direct variable cost." But because this expense is incurred regardless of what crops and how many units of each are produced, it would actually be most appropriate to include these herbicides in your indirect variable costs or overhead costs category. On the other hand, if you are producing perennials and apply specific herbicide sprays only to specific perennial crops, then these are ideally included in the direct variable costs for those specific crops.

Interest is another cost category that is not straightforward. Interest that is paid on fixed assets, including land and greenhouse structures, is included in overhead cost calculations. However, interest may also be paid on your production expenses if you borrow money to purchase supplies and pay labor before you sell plants and collect payment. These costs are ideally, but not essentially, a component of your variable cost calculations. To accomplish this calculation, begin by determining the annual interest rate and divide by 52 to obtain the weekly interest rate. Next, multiply this number by the number of weeks that your money is tied up for production of a given crop. For example, if you are paying an interest rate of 9 percent on $20,000 for 16 weeks to purchase supplies to produce fall mums, the interest rate per week is 0.173 percent. Sixteen weeks times 0.173 percent equals an interest rate of 2.8 percent. $20,000 times 2.8 percent equals $560 in interest that can be "charged" as a direct variable cost in the cost analysis for your mum production. If this calculation sounds like more than you want to mess with, just include your interest on operating capital in your overhead costs calculation.

Most commonly, variable costs are calculated on a per-unit basis. That is, variable costs are generally determined on a "per pot" or "per flat" basis, because this information is most helpful in establishing a minimum selling price based on production costs. Examples of calculating physical and chemical variable costs will follow in Chapter 6. The Cost Analysis Spreadsheet is set up to input physical and chemical variable costs, and indirect variable costs are included in the overhead cost calculations (Chapters 1, 3 and 6). See Table 5-2 for a specific, step-by-step example of calculating direct variable costs for a 10-inch New Guinea impatiens hanging basket using the Cost Analysis Spreadsheet.

Where does the money go?

A comparison of the percent of total costs spent on each variable cost category across many different geographical locations and crops is shown in Table 5-3, page 22. These results, from a wide and varied smattering of cost analysis research, suggest that broad generalizations about where expenses are incurred in the production process are not possible. It is this variability from crop to crop and business to business that underscores the need to make the effort to complete your own cost analysis.

Here are some examples: as a guiding principle, it is often assumed that labor costs account for about one-third of production costs. While this held true when labor costs for 29 New York greenhouse businesses were averaged, it is not usually the case when studying a single crop. For example, percent of total costs that were from labor were only about half of the 33 percent rule-of-thumb for production of ornamental cabbage and kale in two North Carolina operations; but these fall crops are grown outdoors and require minimal labor except for potting and harvest. Labor costs were also less, at 20 percent of the total costs, for a small grower in the Midwest who bought in pre-finished poinsettias.

Does using labor-saving automation make a difference in the cost of direct production labor? Undoubtedly. However, there is a balance between savings on direct production labor and the increased overhead costs due to capital investment for the automation. (Figures 5-1 and 5-2). When the costs of 4.5-inch geranium production on ebb-and-flow rolling benches in Northeast greenhouses are compared with general production costs of a wide range of New York greenhouses (Table 5-3, page 22), a couple of items jump out. First, direct production labor was 31.6 percent of variable costs for subirrigated production versus 41.4 percent as an average over New York greenhouse operations, so automation does contribute to reduced direct production labor costs. But the cost of the capital investment

Table 5-1. Variable Costs Checklist.

Direct Variable Costs	Indirect Variable Costs[z]
Physical Costs (all include freight)	Advertising / marketing[y]
Rooted or unrooted cutting, seed, or plug	Heating / fuel costs for greenhouse
Media	Gas / diesel for trucks, sprayers
Pot, flat, insert, hanging basket	Electricity
Tag (+ royalty per plant)	Water / sewage
Sleeve, bow, pot cover	Consultants' fees
Packing materials to ship	Interest on operating capital
Chemical Costs	**Trucking / shipping**[y]
Fertilizer (slow-release, soluble)	Truck rental
Insecticides	**Labor**[y]
Fungicides	Manager salaries
Plant growth regulators	Maintenance staff salaries
Crop-specific herbicide	Sales staff salaries
Labor	Secretarial staff salaries
Direct production labor	

[y] These indirect variable costs categories are usually treated as components of overhead cost; see Chapter 3.

[z] Can be included in overhead cost calculation, as in the Cost Analysis Spreadsheet; see Chapter 3.

Figures 5-1 and 5-2 (left to right): Two large, successful greenhouse operations in North Carolina that serve a similar market niche take a different approach to automation. One has opted for minimal automation in their completely depreciated structures, so their overhead costs are very low (left); the other has automated every process possible and has invested in moveable subirrigation trays to minimize labor costs (right). (Photos by Williams)

for this pricey equipment increases overhead costs – direct variable costs are only 3.2 percent of total costs for subirrigated production because of high fixed costs; variable costs are 19.0 percent of total costs for the data averaged across New York greenhouses.

Note that variable costs also range widely based on plant material produced. Geranium cuttings are expensive; this cost comprised about 42 percent of total variable costs in two geranium production examples (Table 5-3, page 22). Compare this to ornamental kale and cabbage, which was from plant

Table 5-2. An example for 10-inch New Guinea impatiens baskets of using the Cost Analysis Spreadsheet to calculate variable costs. Data was excerpted from Peter Konjoian's Section 9, Pricing and Profitability, in *Tips on Designing, Growing, and Marketing Mixed Baskets and Containers* (2002) by Peter Konjoian, Kathy Pufahl, and Terri W. Starman (p. 52).

Direct Variable Costs

Input cost of each New Guinea impatiens cutting, which is $0.35.	Cutting or Seed	$0.35	$/plant
3 cuttings per basket; because "3" plants/pot was entered in line 6, calculation is done automatically.	Plants	$1.05	$/pot
Input cost of root medium per cubic foot.	Media	$2.30	$/ft^{3}
Because "5.3" pots/ft^{2} media was entered in line 5, calculation is done automatically.	Media	$0.43	$/pot
Input cost of direct production labor, $0.84	Labor	$0.84	$/pot
Input cost of hanging basket, $0.47	Container	$0.47	$/pot
Input cost of tag (+ royalty), $0.05	Tag	$0.05	$/pot
Input cost of fertilizer per basket, $0.22	Fertilizer	$0.22	$/pot
Input cost of pesticides and growth regulators applied per basket, $0.14.	Chemicals	$0.14	$/pot
Add together any other direct variable costs, like packing sleeve, $0.10 and interest on variable costs, $0.14	Other	$0.24	$/pot
	Total Variable Costs	$3.44	$/pot grown
	Total Variable Costs	$3.44	$/pot sold

starts that were only 6 percent of the total variable costs. And not surprisingly, buying in a prefinished plant means substantial investment in the plant material; a prefinished poinsettia consumed 58 percent of the total variable costs in one cost analysis (Table 5-3). However, labor costs and other variable cost inputs during finishing should be much less for the grower.

Fertilizer and chemical costs are typically less than 4 percent of the total production costs, and for this reason, many growers pay them little heed when it comes to looking for ways to cut corners. This was true across all production scenarios in Table 5-3, except for production of ornamental kale and cabbage, where those costs crept up to about 15 percent. In this case, the cost of 18 soluble fertilizer applications, applications of the pesticides Thiodan and Cleary's 3336, and the growth retardant B-Nine added up to a substantial component of the cost of production.

The bottom line is that variable costs vary dramatically from operation to operation and crop to crop. Costs vary from one greenhouse operation to another because of geographical location, size of operation, managerial skill, market niche, season of year, space utilization, use of permanent versus part-time labor, and age and condition of the greenhouse facility. This makes it critical that within your operation, time is taken to track costs and complete cost accounting for each crop. This information will guide management decisions on many levels.

Table 5-3. Percent of total variable costs and percent of total costs (variable + overhead) for key variable cost categories for 29 New York greenhouse businesses in 2000; eight Texas foliage production operations in 1987; two North Carolina growers' ornamental cabbage and kale crop in 1998; 4.5-inch geraniums via subirrigation in northeast U.S. greenhouses, 4-inch geraniums in 1991; and one small Midwest grower's prefinished poinsettias in 2001.

	% of Total Variable Costs						% of Total Costs (Variable + Fixed)					
Cost Category	**29 NY Gh[1]**	**8 TX Gh[2]**	**2 NC Ops[3]**	**NE Gh Ger[4]**	**Geranium[5]**	**Mid-west[6]**	**29 NY Gh[1]**	**8 TX Gh[2]**	**2 NC Ops[3]**	**NE Gh Ger[4]**	**Geranium[5]**	**Mid-west[6]**
Labor	41.4	55.7	18.6	31.6	27.7	22.3	33.6	39.0	16.2	30.6	19.1	20.8
Seeds or plants	24.3	8.3	6.0	42.4	41.7	58.1	19.7	5.8	5.2	41.0	28.8	54.3
Container, tag, sleeve	9.0	12.6	15.7	14.5	12.9	4.2	7.3	8.8	13.6	14.1	5.6	3.9
Root medium	3.9	9.9	39.7	5.8	10.4	—	3.2	6.9	34.6	5.7	7.2	—
Fertilizer, chemicals	1.7	In overhead costs	16.6	1.3	3.0	0.4	1.4	In overhead costs	14.5	1.3	2.0	0.3
Heating fuel	6.2	—	—	2.5	—	7.0	5.0	—	—	2.5	—	6.5
Gas/diesel	0.9	—	—	—	—	—	0.7	—	—	—	—	—
Electricity	1.9	—	—	1.5	—	8.2	1.6	—	—	1.4	—	7.7
Water, sewage	0.2	7.1 (all utilities)	—	0.2	—	—	0.1	5.0 (all utilities)	—	0.2	—	—
Trucking, shipping	1.7	6.4	—	—	—	—	1.4	4.5	—	—	—	—
Other	8.6	—	0.5	—	4.3	—	7.1	—	0.4	—	3.0	—
					Overhead costs		19.0	29.8	12.9	3.2	30.9	6.5

[1] Uva, W. and S. Richards. 2002. New York Greenhouse Business Summary and Financial Analysis, 2000. Web address: hortmgt.aem.cornell.edu/pdf/hortbusiness/eb2002-03.pdf. 29 New York greenhouses, wholesale + retail, fall + spring crops.

[2] Stevens, A.B. 1990. Cost of Production Analysis for Greenhouse Grown Foliage Plants in the Rio Grande Valley of Texas. Texas A&M Univ. Dissertation. Eight Texas greenhouses, wholesale foliage.

[3] Whipker, B.E. 1998. Cost of Producing Ornamental Cabbage and Kale. North Carolina Flower Growers' Bulletin 43(4):9-12. Two North Carolina production operations, wholesale ornamental kale and cabbage crop.

[4] Uva, W. 2001. Compare Subirrigation Systems. Greenhouse Management and Production 21(11):42-54. Estimated cost to produce 4.5" geraniums via ebb-and-flow rolling benches in NE Gh.

[5] Brumfield, R.G. 1993. Production Costs, p. 145-156. In: J.W. White, ed. Geraniums IV. Ball Publishing, Batavia, IL. Cost to produce 4" geraniums from unrooted cuttings.

[6] Schulz, K.A. 2002. Profit and Cost Analysis of the Kansas Greenhouse Industry: A Survey, A Labor Study, and Enterprise Budgets. M.S. Thesis. Kansas State University. One Midwest greenhouse, wholesale pre-finished poinsettia.

Chapter 6

Calculating Variable Costs

Kimberly A. Williams, Kansas State University
Wen-fei L. Uva, Cornell University

Variable costs are generally determined on a per-unit basis because this data is easy to incorporate into cost analyses, such as in the Cost Analysis Spreadsheet found in Chapter 2, page 11. In addition, this information is most helpful in establishing a minimum sales price based on production costs. Direct variable costs, which include physical costs (e.g. container, plant, and root medium) and fertilizer and chemical costs (e.g. pesticides and plant growth regulators), are commonly calculated "per pot" or "per flat." Examples of calculating physical and chemical variable costs are included in this chapter as well as a discussion of how to calculate indirect variable costs, which is similar to overhead cost calculations as shown in Chapter 3. In fact, indirect variable costs are often treated exactly like overhead costs in cost analysis calculations and allocated on a square foot-per-week basis.

Physical Costs

Considering all of the different types of data that must be collected to complete cost analyses for a crop, data to calculate direct variable costs are generally the easiest and most straight-forward to obtain. The most difficult part of the process is simply keeping track of all of the information.

Physical costs vary from producer to producer based on considerations like quantity discounts and method of payment. When calculating cost per unit as shown in the following examples, the purchase price of materials in bulk quantities is eventually divided by the number of units per case, pallet, or truckload to get the "per pot" or "per flat" price. This can be accomplished either before the crop is grown by using catalog prices or quotes, or after the crop is grown by using information from invoices. All sales tax, royalty fees, shipping costs, and delivery charges should be included in direct variable cost calculations. For example, express or overnight shipping charges for quick delivery of unrooted versus rooted cuttings dramatically influences direct cost per cutting.

Example: Cost of Plant Material

	1,000 unrooted poinsettia cuttings	**1,000 rooted poinsettia cuttings**
Cost per 1,000	$304.00	$684.00
Royalties per 1,000	40.00	40.00
Air freight per 1,000	68.50	180.50
Cost per cutting:	**$412.50/1,000 = $0.41**	**$904.50/1,000 = $0.90**

The cost per cutting that would be input into the Cost Analysis Spreadsheet line 14 is $0.41 versus $0.90 for unrooted versus rooted cuttings, respectively. This substantial difference in cost per cutting could encourage an operation to opt for investment in a facility capable of mist propagation that would allow them to buy in unrooted cuttings and root on-site, or boom irrigation equipment that would allow them to direct-stick unrooted cuttings in the final container. For making such a decision, however, the cost analysis would not end with the information above. When comparing the cost of buying in unrooted cuttings, the true cost of rooting on-site would include the cost of the propagation material (e.g. Oasis wedges, Ellepots, plug trays, and germination media, etc.), labor to stick and maintain the young cuttings, overhead costs for the space used during the propagation period, depreciation of equipment, and shrinkage or loss. This is covered in more detail in Chapter 8. Calculating cost per seed or plug should take into account germination rates, and this is also included in Chapter 8.

The Cost Analysis Spreadsheet (page 11) is designed to calculate cost of plants per container (Figure 6-1). So using as a starting point, the cost of $0.90 per cutting as calculated above:

Figure 6-1. The cost of the pot or container is determined simply by dividing the cost, including shipping and sales tax, of a case of containers by the number of containers per case. (Photo by Williams)

If you placed one poinsettia cutting per 6.5-inch pot and pinched, enter "1" on line 6 and "$0.90" on line 14; Cost of plants is calculated as $0.90 on line 15. If you placed three cuttings per 7-inch pot and grew them as straight-ups, enter "3" on line 6 and "$0.90" on line 14. Cost of plants is calculated as $2.70 on line 15.

The cost of the pot or container is probably the most straight-forward calculation to make. Simply divide the cost of a case of the container (plus shipping) by the number of containers per case.

Example: Cost of Single Container

One case of 5-inch azalea pots = $29.10; 300 pots per case; $29.10/300 pots = **$0.097/pot or $0.10** entered into the Cost Analysis Spreadsheet, page 11, line 19.

Some products require that multiple containers be used during their production process. For example, bedding plants include not only cell packs or inserts, but flats as well.

Example: Cost of Multiple Containers

1 case of 1020 flats = $44.60; 100 flats per case; $44.60/100 flats = $0.446/flat

1 case of 1801 inserts = $28.80; 100 flats per case; $28.80/100 flats = $0.288/flat

Container cost per flat = $0.446 + $0.288 = **$0.73/flat** entered into the Cost Analysis Spreadsheet, page 12, line 16.

Some containers, such as plug trays, open web flats, and shuttle trays, are reusable. Therefore, their new cost may be divided by how many times you expect to be able to use each unit, and this number could be included in the direct variable cost. Alternatively, their new cost may not need to be included in the direct costs component of the cost analysis, but can be incorporated into other components of the analysis. For example, plug tray expense may be included in the cost per plug, which is shown in Chapter 8. Remember that washing or sterilizing pots or containers can contribute a substantial labor expense which should be included in the cost analysis somewhere.

Root medium cost per container is fairly straight-forward if you buy commercially available pre-mixed media. It is calculated by dividing the cost per bag (plus freight) that you purchase (which range in volume from 3 ft^3 to 60 ft^3) by the number of containers it will fill. Table 6-1 provides information about the number of containers that are filled from a variety of root medium volumes, and the most critical of this information (number of containers per ft^3) is additionally summarized on the "Media" sheet (Sheet 2) of the Cost Analysis Spreadsheet. The Cost Analysis Spreadsheet is designed to calculate cost per container if you input the cost per cubic foot of your root medium source. For root medium that is sold in compressed bales, you would calculate cost per cubic foot of the final volume after fluffing; the Cost Analysis Spreadsheet will then divide this by the number of containers filled per ft^3 (also in Table 6-1).

Example: Cost of Root Medium

For 1801 flats:

3.8 ft^3 compressed bale = $17.40; 3.8 ft^3 root medium fluffs to 7 ft^3; $17.40/7 ft^3 = **$2.49/ft^3** entered into the Cost Analysis Spreadsheet, page 12, line 13.

1 ft^3 fills between 5.8 and 6.5 1801 flats; assume **6.2 flats/ft^3** entered into the Cost Analysis Spreadsheet line 5.

After entering the above information, the spreadsheet calculates $2.49/6.2 flats = $0.40/flat on line 14.

If you opt to manufacture your root medium on-site (Figures 6-2 and 6-3), calculate the formulation cost.

Figure 6-2. The true cost of a root medium formulated on-site includes expenses such as depreciation of mixing equipment and the space used to hold the mixing operation, such as this equipment at Tagawa Greenhouses in Brighton, Colorado. (Photo by Williams)

Figure 6-3. Seasonal root medium mixing, such as on this pad at Kaw Valley Greenhouses in Manhattan, Kansas, includes expenses such as cost of pasteurization of the soil component. (Photo by Williams)

Table 6-1. The number of containers filled per volume of root media has been compiled for a variety of container brands and styles. Provided courtesy of Dr. Hugh Poole, Fafard, Inc.

Pot Type and Size		Actual Volume (L)	Actual Volume (Qts)	Quarts of Soil Required per container		Containers/ 8-Quart Bag		Containers/ 16-Quart Bag		Containers/ 1 Cubic Foot		Containers/ 3 cu. ft. Bag (78 Qts)		Containers/ Cubic Yard (700 Quarts)		Containers/60 Cu. Ft. Bulk Bag (1,560 Quarts)	
				Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Clay Pots	4" Standard	0.48	0.44	0.464	0.513	15.6	17.2	31.2	34.5	50.6	56.0	152	168	1364	1508	3039	3360.5
	6" (16 cm) Standard	1.577	1.43	1.525	1.687	4.7	5.2	9.5	10.5	15.4	17.0	46.2	51.1	415.0	459.0	924.9	1022.9
	5" Azalea	0.786	0.71	0.760	0.841	9.5	10.5	19.0	21.0	30.9	34.2	92.8	102.6	832.7	920.9	1855.7	2052.2
	8" (21 cm) Azalea	2.968	2.70	2.870	3.174	2.5	2.8	5.0	5.6	8.2	9.1	24.6	27.2	220.5	243.9	491.4	543.5
	3 Gallon Strawberry Jar	10.459	9.51	10.115	11.186	0.7	0.8	1.4	1.6	2.3	2.6	7.0	7.7	62.6	69.2	139.5	154.2
Plastic Standard Pots	Belden Std 4"	0.509	0.46	0.492	0.544	14.70	16.26	29.4	32.5	47.8	52.8	143.3	158.5	1286	1423	2867	3170
	Belden 4.5" Geranium	0,659	0.60	0.637	0.705	11.35	12.56	22.7	25.1	36.9	40.8	110.7	122.4	994	1099	2214	2449
	Belden Std 6"	1.786	1.62	1.727	1.910	4.19	4.63	8.4	9.3	13.6	15.1	40.8	45.2	366.5	405.3	816.8	903.3
	Belden Std 8"	3.821	3.47	3.695	4.087	1.96	2.16	3.92	4.33	6.4	7.0	19.1	21.1	171.3	189.4	381.7	422.2
	Belden Std 10"	7.913	7.19	7.653	8.463	0.95	1.05	1.89	2.09	3.1	3.4	9.22	10.2	82.7	91.5	184.3	203.9
Plastic Azalea Pots	Kord AZ 4" 100 mm AZ-S	0.433	0.39	0.419	0.463	17.27	19.10	34.5	38.2	69.1	76.4	168.4	186.3	1511.5	1671.6	3368.6	3725.3
	ITML AZ 6" 600	1.266	1.15	1.224	1.354	5.91	6.53	11.8	13.1	23.6	26.1	57.6	63.7	517.0	571.7	1152.1	1274.1
	ITML AZ 8" AZE0800	3.077	2.80	2.976	3.291	2.43	2.69	4.9	5.4	9.7	10.8	23.7	26.2	212.7	235.2	474.0	524.2
	Kord AZ 10" 250 mm	6,573	5.98	6.357	7.030	1.14	1.26	2.3	2.5	4.6	5.0	11.1	12.3	99.6	110.1	221.9	245.4
Plastic Square Pots	Kord SQ 4"	0.578	0.53	0.559	0.619	12.93	14.30	25.9	28.6	51.7	57.2	126.1	139.4	1131.6	1251.4	2521.8	2788.8
	Belden 4.25" Jumbo Junior	1.02	0.93	0.986	1.091	7.33	8.11	14.7	16.2	29.3	32.4	71.5	79.1	641.7	709.6	1430.0	1581.4
	Belden 5.75" Jumbo Senior	1.95	1.77	1.886	2.086	3.84	4.24	7.7	8.5	15.3	17.0	37.4	41.4	335.6	371.2	748.0	827.2
Hanging Baskets	Belden 6"	1.364	1.24	1.319	1.459	5.5	6.1	11.0	12.1	17.8	19.7	53.5	59.1	480	531	1069	1183
	Belden Pop Basket 8"	3.409	3.10	3.297	3.646	2.2	2.4	4.4	4.9	7.1	7.9	21.4	23.7	192	212	428	473
	Belden Basket w/Saucer 10"	4.835	4.40	4.676	5.171	1.5	1.7	3.1	3.4	5.0	5.6	15.1	16.7	135	150	302	334
	Belden 12"	8.651	7.86	8.367	9.252	0.9	1.0	1.7	1.9	2.8	3.1	8.4	9.3	76	84	169	186
Bowls	Dillen Bowl 12"	7.49	6.81	7.244	8.011	1.0	1.1	2.0	2.2	3.2	3.6	9.7	10.8	87	97	195	215
	ITML Planter 14"	21.4	19.45	20.70	22.89	0.3	0.4	0.7	0.8	1.1	1.3	3.4	3.8	31	34	68	75
	Dillen Planter 16"	8.06	7.33	7.795	8.620	0.9	1.0	1.9	2.1	3.0	3.3	9.0	10.0	81	90	181	200
Nursery Containers	Nursery Supplies-Classic Pan 8"	2.902	2.64	2.807	3.104	2.6	2.9	5.2	5.7	8.4	9.3	25.1	27.8	226	249	503	556
	Nursery Supplies-Classic 300 (1 gal)	2.892	2.63	2.797	3.093	2.6	2.9	5.2	5.7	8.4	9.3	25.2	27.9	226	250	504	558
	Nursery Supplies-Classic 600 (2 gal)	6.107	5.55	5.906	6.532	1.2	1.4	2.4	2.7	4.0	4.4	11.9	13.2	107	119	239	264
	Nursery Supplies-Classic 1000 (3 gal)	8.625	7.84	8.341	9.225	0.9	1.0	1.7	1.9	2.8	3.1	8.5	9.4	76	84	169	187
Bedding Plant Flats	1204 Flat	4.505	4.10	4.357	4.818	1.7	1.8	3.3	3.7	6.6	7.3	16.2	17.9	145.3	160.7	323.8	358.1
	1206 Flat	3.981	3.62	3.850	4.258	1.9	2.1	3.8	4.2	7.5	8.3	18.3	20.3	164.4	181.8	366.4	405.2
	1801 Flat	5.122	4.66	4.954	5.478	1.5	1.6	2.9	3.2	5.8	6.5	14.2	15.7	127.8	141.3	284.8	314.9
	606 Flat	5.384	4.89	5.207	5.758	1.4	1.5	2.8	3.1	5.6	6.1	13.5	15.0	121.6	134.4	270.9	299.6
	606 Flat-Deep	6.025	5.48	5.827	6.444	1.2	1.4	2.5	2.7	5.0	5.5	12.1	13.4	108.6	120.1	242.1	267.7
	804 Flat	4.499	4.09	4.351	4.812	1.7	1.8	3.3	3.7	6.7	7.4	16.2	17.9	145.5	160.9	324.2	358.5

Include not only freight and costs of the raw ingredients, but also preplant nutrient amendments like lime, depreciation cost of the mixing equipment, any conveyor belt lines and front-end loaders used to fill the mixer, buildings used for holding components of the root medium, cost of pasteurization if necessary, and all labor costs. You may be startled by the true cost of mixing your own root medium. Commercial root media may seem expensive at face value, but may actually be comparable in cost to individually formulated mixes for small to mid-size growers. Commercial mixes cost \$1.75 to 2.50/ft^3 delivered to the grower. Shipping adds \$1 to 2 per loaded mile for a 45,000-pound truckload of 100 to 120 yd^3 of soilless media. Ultimately, calculating cost per cubic foot of root medium mixed on-site can be entered into the Cost Analysis Spreadsheet, page 12, line 13.

Other possible direct variable costs in the physical costs category include tag (Cost Analysis Spreadsheet, page 12, line 18) and pot covers, sleeves, and other shipping and packaging materials (Cost Analysis Spreadsheet, page 12, line 22, "Other" category).

Fertilizer and Chemical Costs

Direct variable costs that are often classified as "chemical costs" include sprays and drenches of fungicides, insecticides, and plant growth regulators (Figure 6-4). In addition, fertilizer costs are also usually considered in this category. You may choose to simply group all chemical costs into your indirect variable cost calculations, for the sake of simplicity, which will be covered later in this chapter. However, in instances where the cost of a particular crop is dramatically influenced because of unique chemical applications, it makes sense to calculate them on a "per pot" or "per flat" basis. For example, production of blue hydrangeas is unique because up to six labor-intensive, drench applications of aluminum sulfate are required for production of this crop, but no other. To accurately gauge the additional cost to produce this crop compared to pink or white hydrangeas, the cost of these special drenches should be included in the direct cost analysis.

Figure 6-4. Chemical costs include sprays and drenches of fungicides, insecticides, and plant growth regulators. (Photo by Williams)

As another example, poinsettias typically receive an application of Marathon G (granular) to control whiteflies, which increases the cost of production by \$0.06 to \$0.07 per pot; and this is ideally included in direct cost calculations. Keep in mind that there are many ways to correctly complete calculations, and the examples that follow present only some of these. You could work through a calculation with a different method and then check to see if you arrive at the same answer. To assist you with these calculations, you can use unit conversion software. One source of freeware is available at www.joshmadison.com/software/convert/. Calculating the cost of granular Marathon application is a good place to begin some examples.

Examples: Granular Pesticide Application

MarathonG is applied to poinsettias at a rate of ¼ level teaspoon, which equals 1.3 grams (read off of the label) per 6-inch pot. The cost of 5 pounds of MarathonG is \$118.

- How many grams of MarathonG per pound? 454 grams/pound (from unit conversion software)
- How many grams per 5 pounds? 454 grams per pound x 5 pounds = 2,270 grams
- What is the cost of Marathon per gram? \$118/2,270 grams = \$0.052/gram
- What is the cost per pot? \$0.052 x 1.3 grams/pot = \$0.068/pot, or **\$0.07/pot** entered into the Cost Analysis Spreadsheet, page 11, line 22.

As an alternative, assume that you purchase two 5-pound containers of MarathonG for \$118 each. After finishing with the application of ¼ teaspoon per pot to your 2,600 6-inch poinsettias, you note that the application consumed all of one container (5 pounds) and half of the second (2.5 pounds).

- What is the total quantity of MarathonG used? 5 pounds + 2.5 pounds = 7.5 pounds
- What is the cost of Marathon per pound? \$118/5 pounds = \$23.60
- What is the cost of this application of Marathon? 7.5 pounds x \$23.60/pound = \$177
- What is the cost per pot? \$177/2,600 6-inch pots = \$0.068/pot, or **\$0.07/pot** entered into the Cost Analysis Spreadsheet, page 11, line 22.

Consider slow-release fertilizer cost as an example that is parallel to calculating granular pesticide applications. In addition, you can see how flexible you can be with the category assignments for chemical expenses. If you incorporate a slow-release fertilizer into your root medium preplant, it may be easiest to just lump this expense into the cost of your root medium.

Examples: Granular Fertilizer Application

Incorporate 50 pounds of 13-13-13 Osmocote into 10 yd^3 of root medium. A 50-pound bag costs $52.70.

- What is the cost of Osmocote per pound? $52.70/50 pounds = $1.05/pound
- How much Osmocote is incorporated per ft^3 root medium? There are 27 ft^3 per yd^3 (from unit conversion software). 10 pounds/yd^3 divided by 27 ft^3 = 0.37 pound Osmocote/ft^3
- How much does Osmocote cost per ft^3 root medium? 0.37 pound Osmocote/ft^3 x $1.05/pound = $0.39/ft^3
- How much does 1 ft^3 root medium with Osmocote cost? Using the cost of $2.49/ft^3 root medium previously calculated in this chapter, $2.49/ft^3 + $0.39 ft^3 = **$2.88/ft^3 root medium** entered into the Cost Analysis Spreadsheet, page 11, line 16.

If, however, you apply slow-release fertilizer as a topdress after planting, it may simplify things to just calculate the cost per container based on the amount that you applied.

Osmocote costs $1.05/pound, from the calculation above. Osmocote is applied as a topdress at a rate of 2 teaspoons, which equals 12 grams.

- How much does Osmocote cost per ounce? There are 16 ounces per pound (from unit conversion software). $1.05/pound divided by 16 ounces/pound = $0.07/ounce
- How many ounces of Osmocote are applied per pot? The label states that 1 ounce of Osmocote = 28 grams. 12 grams/pot divided by 28 grams/ounce = 0.43 ounce/pot
- How much does Osmocote topdress cost per pot? $0.07/ounce x 0.43 ounce/pot = **$0.03/pot** entered into Cost Analysis Spreadsheet, page 11, line 23 ("Other" category)

In general, however, costs of inputs like liquid fertilizers, plant growth regulators, and pesticide applications can be challenging to calculate, let alone allocate to a single crop. This is because the calculations for chemical costs are more involved than for physical costs. Also, chemical cost calculations are most difficult to allocate to a single unit because chemicals are often applied to a variety of crops and container sizes at once. For example, liquid fertilizer is injected into a water line at one location, but it is then used throughout the greenhouse range.

The good news is that excellent, easy-to-use, freely downloadable, spreadsheet-based software exists that calculates fertilizer and plant growth regulator application costs (as well as amounts to apply). These Microsoft Excel-based programs are called PGRCALC and FERTCALC; they were developed by Brian Krug, Brian Whipker, and Mary Peet at North Carolina State University. The programs are available at the Web addresses www.ces.ncsu.edu/depts/hort/floriculture/software/PGRCALC.htm and www.ces.ncsu.edu/depts/hort/floriculture/software/FERTCALC.htm, respectively. If there is a problem with the download, a CD with both programs can be purchased for a minimal charge from the North Carolina Commercial Flower Growers' Association, www.nccfga.org. In PGRCALC, entering the cost per quart of the growth regulators A-Rest, Atrimmec, Bonzi, Cycocel, Fascination, Florel, GibGro, Piccalo, ProGibb, or Sumagic, or the cost per pound of B-Nine, and information such as "desired ppm" and "number of pots or flats to drench" allows the program to calculate both "total cost per pot or flat" and "total cost of the spray." Similarly, FERTCALC will generate "cost per 1,000 gallons of fertilizer solution" if "cost of fertilizer per pound" has been input. An example of calculating cost per pot with this data is shown below. While software can be purchased to assist with pesticide application calculations, we are unaware of a software source that includes cost per application.

The cost of chemical inputs like fertilizer per unit can be determined via several different strategies, as shown below. Costs of supplies derived from either catalogs before production or invoices at the end of production can be used.

Examples: Liquid Fertilizer Calculations

Place a sheet next to each fertilizer injector (Figure 6-5) or at each mixing station (Figure 6-6, page 28) and record the number of fertilizer bags used to produce 9,500 6-inch chrysanthemums. Each 20-pound bag costs $20.90. Nine bags of 20-10-20 fertilizer were used.

Figure 6-5. Fertilizer used through this Smith injector is easy to track if, each time a bag is mixed into the stock tank, it is recorded on the clipboard hanging nearby. (Photo by Marci Spaw, Kansas State University)

Figure 6-6. Fertilizer usage in subirrigation systems can be tracked by recording the number of bags dissolved in main tanks at mixing stations such as this one at Van Wingerden International in Fletcher, North Carolina. (Photo by Williams)

- The cost of fertilizer for this crop is: 9 bags x \$20.90/bag = \$188.10 divided by 9,500 pots = **\$0.02/pot**, entered into the Cost Analysis Spreadsheet, page 11, line 21.

Alternatively, estimate (after measuring accurately during irrigation events) the amount of fertilizer solution applied per pot at each irrigation.

10 fluid ounces of 200 ppm N from 20-10-20 is applied to each 6-inch pot every three days during a 90-day production cycle.

- How many ounces of fertilizer are dissolved per gallon to provide 200 ppm N?

$$\frac{\text{(ppm)/(75)}}{\text{(decimal fraction of \% N in fertilizers)}} = \frac{(200)/(75)}{(0.20)} = \frac{\text{13.3 ounces/100 gallons}}{\text{OR 0.13 ounces/gallon}}$$

- How many ounces of fertilizer solution are applied to each chrysanthemum? 90-day production cycle divided by 3 days between irrigation events = 30 fertilizer applications/crop x 10 fluid ounces per irrigation event = 300 fluid ounces of fertilizer/pot.
- How many gallons of fertilizer solution are applied per pot? There are 128 fluid ounces per gallon. 300 fluid ounces divided by 128 ounces/gallon = 2.34 gallons/pot.
- How many pounds of fertilizer are applied per pot? There are 16 ounces per pound. 2.34 gallons/pot x 0.13 ounces of fertilizer per gallon divided by 16 ounces/pound = 0.019 pound of fertilizer/pot.
- What is the cost of fertilizer per pound? \$20.90 divided by 20 pounds = \$1.05/pound
- What is the cost per pot? 0.019 pound fertilizer/pot x \$1.05/pound = **\$0.02 per pot**, entered into the Cost Analysis Spreadsheet, page 11, line 21.

Finally, if you use the North Carolina State University FERTCALC program discussed above, which generates "cost per 1,000 gallons of fertilizer solution," you would determine the cost per pot for this chrysanthemum crop as follows:

- How many gallons of fertilizer solution are applied per pot? Based on the calculation above, 2.34 gallons.
- What is the cost per pot? FERTCALC calculated that 1,000 gallons of fertilizer cost \$8.75, which is \$0.00875/gallon. 2.34 gallons/pot x \$0.00875/gallon = \$0.02/pot, entered into the Cost Analysis Spreadsheet, page 11, line 21.

Tackling costs of pesticide or plant growth regulator applications on a "per pot" or "per flat" basis may seem a little daunting at first. Calculations for liquid chemical applications can be based on volume applied per area production space, which, as a rule of thumb, is 1 gallon of spray solution covering 200 square feet of bench space. Alternatively, knowing the amount of pesticide applied to a given number of pots or flats is also enough information to complete the calculation. And remember, PGRCALC determines cost "per pot" or "per flat" as well; this number could be input directly into the Cost Analysis Spreadsheet line 22 (page 11-pots) or line 21 (page 12-flats).

Examples: Liquid Chemical Applied as Foliar Spray to a Given Area

A poinsettia crop is sprayed with 1,500 ppm Cycocel. The concentration of the bottle is 11.8 percent active ingredient; because 1 percent = 10,000 ppm, this is equivalent to 118,000 ppm. One quart costs \$86.00. You will make the application to a crop of 6-inch poinsettias spaced 14 inches x 14 inches in 10,000 square feet.

- How much Cycocel (CCC) is needed per gallon for a rate of 1,500 ppm? This could be looked up from a table or calculated as:

  Have: 118,000 ppm CCC. Want: 1,500 ppm CCC. So, 78.7 times too concentrated.

$$\frac{1}{78.7} = \frac{x \text{ gallon}}{1 \text{ gallon}} \qquad x = 0.0127 \text{ gallons CCC / gallon water}$$

There are 128 fluid ounces per gallon. 0.0127 gallons CCC/gallon water x 128 fluid ounces/gallon = 1.6 fluid ounces CCC/gallon.

- How many gallons of 1,500 ppm CCC should be mixed? 10,000 ft^2 will be sprayed; 1 gallon of spray solution covers 200 ft^2. 10,000 ft^2 divided by 200 ft^2 = 50 gallons.
- What is the cost of CCC used? 50 gallons x 1.6 fluid ounces CCC/gallon = 80 fluid ounces CCC. There are 32 fluid ounces/quart. \$86/quart divided by 32 ounces/quart = \$2.69/fluid ounce x 80 fluid ounces = \$215.
- How many pots of poinsettias are spaced 14 inches x 14 inches in 10,000 square feet? There are

12 inches/foot. 14 inches divided by 12 inches = 1.17 feet; 1.17 feet x 1.17 feet = 1.37 ft^2/pot. 10,000 ft^2 divided by 1.37 ft^2/pot = 7,300 pots.

- What is the cost per pot? $215 divided by 7,300 pots = **$0.03/pot**, entered into the Cost Analysis Spreadsheet, page 11, line 22.

Calculation for a liquid pesticide applied as a foliar spray would be calculated much the same way, as below.

Akari miticide is used at a rate of 20 fluid ounces/100 gallons, and 1 quart costs $215. Via calibrated application from a hydraulic (high-volume) sprayer, 1 gallon is applied per 200 square feet, and 5,000 square feet of bedding plants will be treated, each using 1.4 square feet.

- How many flats are treated per 5,000 ft^2? 5,000 ft^2 divided by 1.4 ft^2/flat = 3,570 flats
- How much spray solution should be mixed? 5,000 ft^2 divided by 200 ft^2/gallon = 25 gallons
- How much Akari is needed for this application? 20 fluid ounces/100 gallons x 25 gallons (10 x 25 / 100) = 5 fluid ounces/25 gallons OR 20 fluid ounces/100 gallons divided by 4 = 5 fluid ounces/25 gallons
- What is the cost to treat each flat? There are 32 fluid ounces per quart (from unit conversion software); $215/quart divided by 32 fluid ounces/quart = $6.72/fluid ounce; 5 fluid ounces x $6.72 = $33.60; $33.60 divided by 3,570 flats = **$0.009/flat or $0.01/flat**, entered into the Cost Analysis Spreadsheet, page 12, line 21.

Example: Tank Mix of Liquid and Solid Chemicals Applied as a Drench

A drench application of a tank mix of Subdue MAXX (1 fluid ounce/100 gallons) and Cleary's 3336WP (8 ounces/100 gallons) is applied, 10 fluid ounces of the tank mix are applied per pot. Subdue costs $208/quart, and Cleary's 3336 costs $29/lb. A 100-gallon tank will be mixed.

- How many poinsettias are treated per 100 gallons? There are 128 fluid ounces per gallon. 100 gallons x 128 fluid ounces/gallon = 12,800 fluid ounces divided by 10 fluid ounces/pot = 1,280 pots.
- What is the cost of Subdue MAXX per 100 gallons? 1 fluid ounce of Subdue MAXX: $208/quart x 4 quarts/gallon = $832/gallon divided by 128 fluid ounces/gallon = $6.50/fluid ounce.
- What is the cost of Cleary's per 100 gallons? 8 ounces of Cleary's: $29/pound divided by 16 ounces/pound = $1.81/ounce x 8 ounces = $14.50 per 8 ounces.
- What is the cost of the two fungicides per 100 gallons? $6.50 + $14.50 = $21.00.
- What is the cost to treat each pot? $21 divided by 1,280 pots = $0.016/pot or **$0.02/pot**, entered into the Cost Analysis Spreadsheet, page 11, line 22.

Examples: Solid Chemical Applied as Foliar Spray with Both High-Volume and Low-Volume Application Equipment

A foliar spray of TriStarWSP insecticide is applied at a rate of two 16-gram water-soluble packets per 100 gallons with a hydraulic sprayer. One container of 12 16-gram packets cost $330. Via calibrated application from a high-volume sprayer, 1 gallon is applied per 200 square feet; 10,000 square feet of bedding flats will be treated, each requiring 1.4 square feet of bench space.

- How many flats are treated per 10,000 ft^2? 10,000 ft^2 divided by 1.4 ft^2/flat = 7,140 flats
- How much spray solution should be mixed? 10,000 ft^2 divided by 200 ft^2/gallon = 50 gallons
- How much TriStar is used for this application? Two 16-gram water soluble packets per 100 gallons = 32 grams/100 gallons x 50 gallons (32 x 50 divided by 100) = 16 grams (or one packet)/50 gallons
- What is the cost to treat each flat? $330 divided by 12 packets = $27.50/packet divided by 7,140 flats = **$0.004/flat**, entered into the Cost Analysis Spreadsheet, page 12, line 21.

If, instead of using a high-volume hydraulic sprayer, this same rate of TriStar was applied with a low-volume applicator like a mist blower with a 3-gallon tank, the calculation would follow:

Mist blower formulations are about 10 times more concentrated than hydraulic sprayers. 100 gallons for a hydraulic sprayer = 10 gallons for a mist blower. So instead of a 1-gallon high-volume spray covering 200 square feet, a 1-gallon mist blower spray covers 2,000 square feet. Using the rate of 32 grams of TriStar/100 gallons for a hydraulic sprayer, multiply by 0.3 (3 tenths of 10 gallons) for a mist blower with a 3-gallon capacity, which equals 9.6 grams TriStar/3 gallons.

- How much spray solution should be mixed up for a TriStar application through the mist blower for 10,000 ft^2 of bedding plants? 1-gallon spray from a mist blower covers 2,000 ft^2. 10,000 ft^2 divided by 2,000 ft^2 = 5 gallons.
- How much TriStar is used for this application? 9.6 grams/3 gallons x 5 gallons volume = 16 grams (or one packet)/5 gallons via the mist blower.
- What is the cost to treat each flat? Exactly the same as for the high-volume hydraulic sprayer as calculated above, **$0.004/flat**.

The cost of high-volume and low-volume pesticide applications is generally the same because cost of product, which contains the active ingredient, applied per square foot is the same regardless of the amount of carrier solution. Minor differences in the cost analyses between these spray application methods may be in differences in labor to mix, apply, and clean spray equipment.

Indirect Variable Costs

Indirect variable costs, which include items such as advertising, heating, electricity, water/sewage, and interest on operating capital, often vary with the crops produced and the season of the year. These costs are different from overhead costs in that they occur because crop production is occurring. They are usually incurred for a large portion of production, or even the entire operation, and are not crop specific. Therefore, indirect variable costs can be treated like overhead costs and allocated to specific crops on a square foot week basis as discussed in Chapter 3.

Greenhouse managers can usually easily determine indirect variable costs on an annual basis. For the indirect variable costs that occur fairly evenly throughout the year, the total production square foot weeks for the operation are used as a basis to allocate the costs. The indirect variable cost is first calculated on a per square foot of bench area per week basis by dividing the total annual indirect variable costs by the total production square foot weeks for the operation.

Example. Indirect Variable Costs Calculated on an Annual Basis

Total square foot weeks of bench area for a 50,000-ft^2 greenhouse with 80% bench area and operating 36 weeks per year	50,000 ft^2 x 80% x 36 weeks = 1,440,000 square foot weeks
Annual advertising and marketing expenses	$10,000
Average advertising and marketing expenses per square foot week of bench area	$10,000/1,440,000 square foot weeks = $0.007 per square foot week
Total square foot weeks of bench area used to produce 100 6-inch poinsettias using one spacing method (6" x 6" spacing for two weeks and 12" x 12" spacing for 11 weeks)	(25 ft^2 x 2 weeks) + (100 ft^2 x 11 weeks) = 1,150 square foot weeks
Advertising and marketing expenses for the poinsettia crop	1,150 square foot weeks x $0.007 per square foot week = $7.99
Advertising and marketing expenses per pot	$7.99/100 = **$0.08/pot**, entered into the Cost Analysis Spreadsheet, page 11, line 23

However, some indirect variable costs are not incurred evenly throughout the year, such as heating costs. In these cases, only the square foot weeks of bench area during heating months should be considered as the base of averages. Using the poinsettia production example, if the heating bill during the poinsettia production season is $5,000, the heating cost for the poinsettia crop will be calculated as follows:

Example. Indirect Variable Costs Calculated for a Partial Year

Total square foot weeks of bench area for a 50,000-ft^2 greenhouse with 80% bench area and operating 13 weeks with heating	50,000 ft^2 x 80% x 13 weeks = 520,000 square foot weeks
Heating expense for 13 weeks of poinsettia production	$5,000 [For more information about to break out this expense from other heating expenses, see the examples below]
Average heating expense per square foot week of bench area	$5,000/520,000 square foot weeks = $0.010 per square foot week
Total square foot weeks of bench area used to produce 100 6-inch poinsettias using one spacing method (6"x 6" spacing for two weeks and 12" x 12" spacing for 11 weeks)	(25 ft^2 x 2 weeks) + (100 ft^2 x 11 weeks) = 1,150 square foot weeks
Heating expenses for the poinsettia crop	1,150 square foot weeks x $0.010 per square foot week = $11.06
Heating expenses per pot	$11.06/100 = **$0.11/pot**, entered into the Cost Analysis Spreadsheet, page 11, line 23

To calculate indirect variable costs for a specific crop, the number of square foot weeks of production for that crop is used. The indirect variable costs per pot are determined by multiplying the per square foot week indirect variable costs by the number of square foot weeks that the crop uses, then divided by number of pots produced. This number can be entered into the Cost Analysis Spreadsheet, page 11, line 23 ("Other" category) or added to the Overhead Costs in Chapter 3.

Examples: Breaking out Seasonal and Monthly Heating Expense

Some guidelines to break apart heating expense to determine seasonal and monthly heating costs are shown via the following examples. Assume that a small greenhouse operation purchased 2,632 gallons of liquid propane for two greenhouses between August 2004 and May 2005; the propane cost $1.90 per gallon, so total cost for fuel was $5,000. Greenhouse A is 2,600 ft^2 and Greenhouse B is 3,200 ft^2.

Start by determining the heating cost per greenhouse. Note that other factors can affect allocation of heating expense between production space, such as differences in heat loss between greenhouse coverings and temperatures at which the structures are operating. However, the calculation below is a reasonable estimate for the cost to assign to each structure if the production space is similar. Total floor space is 2,600 ft^2 + 3,200 ft^2 = 5,800 ft^2 production space.

- What percent of space does each structure occupy? Greenhouse A is 2,600 ft^2/5,800 ft^2 = 45 percent and Greenhouse B is 3,200 ft^2/5,800 ft^2 = 55 percent.
- How much of the heating expense should be allocated to each greenhouse? Greenhouse A is 0.45 x $5,000 = $2,250 and Greenhouse B is 0.55 x $5,000 = $2,750. These numbers could then be used as a jumping off point for heating costs per square foot week in each structure.

To calculate monthly heating cost, begin by determining the percentage of fuel used per month. For example, if 260 gallons of propane were used in September to heat both greenhouses, the calculation would follow:

- What percent of the total fuel was consumed in September? 260 gallons in September/2,632 gallons used in year = 0.099 or 10 percent.
- What is the total heating expense for September? $5,000 x 0.10 = $500; this number could be used as a jumping off point for heating cost per square foot week for September.

To calculate heating expense during 13 weeks of poinsettia production, follow a similar strategy. For example, poinsettias are in Greenhouse A only from September 1 through December 7, although Greenhouse B was also under production; the operation consumed 1,600 gallons propane in total during this period.

- What percent of the total fuel was consumed during poinsettia production? 1,600 gallons during poinsettia production/2,632 gallons total = 61%
- How much of the total heating expense should be allocated to poinsettias in Greenhouse A? $5,000 x 0.61 = $3,050 x 0.45 = $1,373; this number could be used as a jumping off point for heating cost per square foot week for 13 weeks of poinsettia production.

Conclusion

In conclusion, calculating variable costs can be handled with a range of precision. The most important variable costs to assign to each crop are those that make up the largest percentage of the overall cost to produce it, like the plant and pot. Chemical costs are more difficult to allocate to specific crops, and calculations for these direct costs tend to be more involved. Because chemical costs usually comprise a small percentage of the total cost to produce a crop, they might be overlooked with only minor error introduced into the cost calculations. And finally, indirect variable costs can be included with overhead cost calculations for simplicity. So the message is to not let variable cost calculations overwhelm you – just start somewhere!

For more information:

Krug, B.A. and B.E. Whipker. Plant growth regulator calculator. Greenhouse Management and Production (GMPro) 24(1):71-76.

Krug, B.A., B.E. Whipker, and M. Peet. Fertilizer mixing calculator. Greenhouse Management and Production (GMPro) 24(2):41-45.

OFA

Chapter 7

Labor Costs

Kimberly A. Williams, Kansas State University

Payroll expenses can generally be broken down into administrative or management pay versus production labor pay. Typically, salaries or wages of personnel that support the entire operation, including sales and secretarial staff, managers and bookkeepers, and maintenance staff are included in the indirect variable or overhead cost calculation. Calculation of these two cost categories are illustrated in more detail in Chapter 3 (Overhead or Fixed Costs), page 15 and Chapter 6 (Calculating Variable Costs), page 23. Salaries or wages of personnel specifically associated with the production of a crop, like crews that pot, disbud, or harvest, are most accurately included as direct variable costs (Cost Analysis Spreadsheet line 18, page 11), and these will be the focus of this chapter. Such allocation of labor costs sounds relatively simple at first thought. However, while many growers know how much is spent on inputs like the container, etc. (direct variable costs) for each crop, most do not know how much is spent on labor, even though it is typically the greatest expense of producing a crop.

Although the greatest accuracy when calculating production costs comes from treating production labor as a variable cost, it has been argued that these elusive costs can instead be included in the overhead cost calculation. Tal White (2002) has stated, "We have found that while it's more accurate to track labor as a variable cost, it's nearly as accurate to treat it as an overhead cost. We feel attempting to collect the data can take more time and cost more than the information is worth." Similarly, Karl Batsche (2000) is quoted: "Labor used to be considered an elastic expense; in today's economy, however, growers no longer have the option of the layoff/rehire cycle. Labor has, in effect, become as fixed as taxes..." Ultimately, the choices can be simplified into 1) lumping all labor expenses, including production labor, together in the overhead costs category; 2) tracking labor costs per crop to include in the direct variable costs for that crop and assigning administrative salaries to the indirect variable or overhead costs calculation; or 3) using a hybrid of the two.

There are two approaches to increase profitability: decreasing costs and increasing revenues. Grower-managers often have little control over revenue when the market sets the price. Therefore, a key means by which costs can be cut, and thus profitability increased, is by improving labor efficiency. Because labor expense is a key component of production inputs (direct variable costs) and makes up a substantial portion of production costs, and because the grower has more control over labor costs than physical costs like seeds, cuttings, or the container, improving labor management can dramatically contribute to increased profitability. Therefore, even though it can be difficult and time-consuming to accomplish, it is easily argued that tracking labor costs per crop and per production process (e.g. potting, harvesting, etc.) can provide very powerful and useful information. Managing labor is managing profit.

Where Is Labor Used Most?

Evaluating labor costs is more effective when labor use is divided into different tasks. The "Stevens Model of Production" (Stevens et al., 1994) suggests how much insight can be gained from tracking labor costs by task. Essentially, this model simplifies the production process into three components: "Potting," "Care as Needed," and "Harvest." "Potting" includes all activities necessary to bring the pot, root medium, and plant together in a single unit and place it on the greenhouse bench. "Care as Needed" includes all activities involved with actually growing the crop, from watering and fertilizing to controlling pests. "Harvest" includes all activities involved with harvesting and shipping the product, including selecting, grooming, packing, staging, and loading.

When labor costs are tracked, the "Potting" process generally accounts for 20 percent to 25 percent of total direct labor. The "Care as Needed" process generally requires only about 25 percent of total labor, although these are the activities that growers typically focus on. Harvest activities, however, may consume up to 50 percent of direct labor; and this process is often the most poorly managed. The value of tracking labor costs is that it allows a grower-manager to identify the processes that require the greatest amount of labor for their specific operation and target these to improve labor efficiency. Some labor-intensive production activities for greenhouse operations include transplanting or potting, hand watering, plant selection for shipping, and moving plants into and out of a growing area. Other reasons to track labor costs include the insight that this information provides in evaluation of the expense and justifying the decision to invest in automation.

Repetitive, tedious, or time-consuming jobs are generally the first that should be automated, and hand watering is all three of these. It nearly always pays to move away from hand watering and automate irrigation. During the spring season, growers have reported that the daily labor savings from using an irrigation system such as drip tubes or ebb-and-flood benches can be as much as six hours per day per employee for each 20,000 square feet of production space – a 60 percent labor savings over hand watering the same crops (Stegelin and Thomas, 2003). Savings also comes from less fertilizer and water use. As an example, traditional hand watering in eight 30-foot x 100-foot quonset structures would cost about $58,935 per year, whereas labor and water costs in the same structures with an automated drip tube irrigation system would total about $29,240. That is a savings of nearly $30,000 per year on labor and water! The savings of $3,712 per structure per year would result in the cost of the irrigation system, $4,778 per quonset, being paid back in only 1.3 years (Stegelin and Thomas, 2003).

Labor costs can vary greatly, and it is important to track labor costs and develop a list of specific tasks for your own operation. Here are some examples. In research completed in 1990 by Stevens, the labor costs of large, foliage plant production firms in Texas' Rio Grande Valley was 39 percent of the total cost of production. In this research, potting labor and harvest labor were studied as being the most variable production processes. Stevens documented that potting labor varied between container sizes and plant species, as well as the form of the plant material potted. Potting labor expense was about 22 percent of total production labor and 6.6 percent of total costs. Similarly, harvest labor varied between container sizes, plant species, and shipping boxes used. Harvest labor was estimated to be 29 percent of total production labor and 7.8 percent of total costs. The combined cost to pot and harvest foliage plants was 51 percent of total production labor and 14.4 percent of total costs. Stevens concluded that any uniform allocation of production labor costs may introduce substantial error into the estimate of the cost to produce a plant.

Table 7-1. The cost of walking and carrying plants[z]. Derived from Bartok, J. 2003. Grower 101: Evaluating Plant Handling Systems. Greenhouse Product News (GPN) 13(6):36-42.

Round trip walking distance (feet)	Labor cost per hour	
	$8.00	**$12.00**
20	$0.018	$0.027
40	$0.028	$0.043
60	$0.040	$0.060
80	$0.051	$0.077
100	$0.062	$0.093
120	$0.073	$0.110
140	$0.084	$0.127
160	$0.096	$0.143
180	$0.107	$0.160
200	$0.118	$0.177

[z] Time figured at 0.5 to 1 second to pick up or set down the container/flat at a walking speed of 4 feet per second.

A study funded by the Horticultural Research Institute found that more than 70 tasks that require labor may take place in the shipping yard of a typical nursery (Bartok, 2000). Knowing what these tasks are, how long they take, and their cost allows a harvest and shipping system to be evaluated. Shipping tasks can be divided into four major areas: truck or trailer preparation; assembling orders (e.g. locating plants can take as much as 30 percent of the total time associated with shipping); plant grooming (e.g. pruning and removal of dead leaves/flowers can take a few seconds up to a minute); and loading. Two tasks associated with shipping – locating the right plants and then getting them loaded onto delivery trucks – require the most time (Bartok, 2003).

Walking and carrying plants costs a lot of money. Table 7-1 shows the labor cost to carry plants from distances of 20 feet up to 200 feet. As an example, walking time can be figured at 4 feet per second; therefore, at $8/hour, making a trip of 15 feet and back adds about 2 cents to the cost of a pot. Roller or trolley conveyors are a great way to minimize such costs. For example, if you are moving flats 30 feet from a bench to a cart, the time could be estimated as: "pick up from bench" (1.5 seconds), plus "walk 60 feet round trip" (15 seconds), plus "set flat on cart" (1.5 seconds) equals a total of 18 seconds. If two flats are carried, the time can be cut in half, although pickup time may increase (Bartok, 2000). The shipping process could be streamlined in a number of ways. A portable or monorail conveyor could be installed to speed plant handling; instead of pushing one cart at a time, employees could link five carts together. Direct loading onto the shipping cart could save one to three plant handlings (see Figures 7-1 to 7-6, page 34).

An analysis of labor costs for a small grower who bought in prefinished poinsettias in the Midwest was very eye-opening. In this operation, a greenhouse in town served as both a retail sales and production site, while a greenhouse outside of town was the primary production site. The total of labor activities associated with producing prefinished poinsettias at the "in town" site was 12.1 minutes per pot. Plant handling was half of this total because as purchases were made, pots were continually reorganized on the bench. The total of labor activities associated with producing plants in the production-only greenhouse was much less, at 7.3 minutes per pot. Plant handling was only a fraction of the time at this site, because after plants were potted and set on a bench, they were not moved until they were shipped (Schulz, 2002). This information provided key feedback for the grower about how to reduce inefficiencies in her production process.

Figure 7-1. A permanent conveyor speeds flat movement at Tagawa Greenhouses in Brighton, Colorado. (Photo by Williams)

Figure 7-2. Dutch trays with finished crops are moved to the shipping area for plant grooming and sleeving prior to shipping at Van Wingerden International in Fletcher, North Carolina. (Photo by Williams)

Figure 7-3. A train of carts is filled directly from production space and loaded onto trucks for shipping with no intermediate handling at Kaw Valley Greenhouses in Manhattan, Kansas. (Photo by Williams)

Figure 7-4.

Figure 7-5.

Figure 7-6.

Figures 7-4 to 7-6. A portable conveyor is disassembled in one production area (Figure 7-4), reassembled in an outdoor production area (Figure 7-5), and used to unload flats from carts (Figure 7-6) at Southern Gem Wholesale Greenhouses in Shelby, North Carolina. (Photos by Williams)

How to Track Production Labor Costs

Tracking labor costs can be as simple as requiring crew leaders to record by hand the basic information needed for labor cost calculations or as sophisticated as bar-coded personnel identification cards that are scanned at the beginning and end of each labor activity. Perhaps the labor tracking system is tied into payroll calculations. Regardless of the method, tracking labor can provide invaluable information, including who among crews needs to receive feedback about their performance.

For smaller growers, some simple record keeping is all that is necessary to determine labor costs for production tasks. Many of the steps in the production process involve a crew working with one size of container over several hours. A data sheet should include date, crew leader or contact person, activity, plant and container, number of flats or pots on which the activity was completed, the number of people on the crew, and their start and stop times (Table 7-2). Break times may or may not be included, as you choose. From these data, one can calculate the labor hours per unit, which can then be multiplied by the hourly wage plus benefits. Recording labor activities in 15-minute increments is more than adequate to obtain accurate labor costs to assign as direct variable costs. Some unallocated labor, such as trips to and from the greenhouse to begin or end the workday, could be included in indirect variable or overhead costs calculations. The two labor processes that are the most important to track are potting and harvesting. A major drawback with this type of system is that data must be entered into a computer spreadsheet and manipulated manually.

Table 7-2. A data sheet to collect labor data can be relatively simple, as shown here.

Date	Crew Leader	Activity	Plant	# Plants/ Container	Container	# Flats or Pots	# on Crew	Start Time	Stop Time
3/16	Alan	Transplant	Petunia	18	1801	116	3	8:15	10:45
3/16	Eleanor	Transplant	Impatiens	18	1801	138	3	8:15	10:30
3/16	Alan	Pot	NG Imp	7	12" basket	87	2	1:00	3:15
3/16	Eleanor	Fill flats	Bedding	-	1801	350	2	1:00	3:30

This data might be used in several ways:

Compare crews

To transplant plugs into 1801s:

Alan's a.m. crew worked 2.5 hours x 3 people = 7.5 payroll hours

7.5 payroll hours / 116 flats transplanted = 0.065 payroll hours/flat x $9/hour = **$0.585/flat**

Eleanor's a.m. crew worked 2.25 hours x 3 people = 6.75 payroll hours

6.75 payroll hours / 138 flats transplanted = 0.049 payroll hours/flat x $9/hour = **$0.441/flat**

Conclusion: Eleanor's crew was more efficient. Costs per flat across many crews can be averaged to obtain one number to use for cost analysis calculations: ($0.585/flat + $0.441/flat)/2 = $0.513/flat.

Compare container sizes

Efficiencies for various propagation materials and container sizes can be observed when time per plant is calculated:

Alan's a.m. crew required 0.065 hrs/flat / 18 plants/flat = 0.0036 hrs/plant x 60 min/hr = **0.22 min/plant**

Alan's p.m. crew worked 2.25 hours x 2 people = 4.5 payroll hours

4.5 payroll hours / 87 baskets transplanted = 0.052 payroll hours/basket x $9/hour = $0.466/basket

Alan's p.m. crew required 0.052 hr/basket / 7 plants/basket = 0.0076 hrs/plant x 60 min/hr = **0.45 min/plant**

Conclusion: Transplanting containers with various plants per unit and/or different propagation media nearly always influences labor cost. It is useful for these differences to be reflected in the direct variable costs component of the cost analysis.

Calculate transplant costs for an 1801 flat

At this operation, time to fill pots is separate from transplanting. To include this in the cost analysis, calculate labor cost to fill each flat and add this to the cost to transplant each flat.

To fill flats, Eleanor's p.m. crew worked 2.5 hrs x 2 people = 5 payroll hours

5 payroll hrs / 350 flats filled = 0.014 hrs/flat x $9/hr = $0.129/flat

Total cost to transplant an 1801 flat = $0.129/flat to fill + $0.513/flat to transplant plug and water in = **$0.642/flat**

Try to calculate labor costs as accurately as possible. Focusing on the potting process provides a few examples. Different sizes and styles of containers, species of plants, and forms of propagation material all result in differences in time to pot. If flats or pots are filled as a separate step from transplanting, this labor cost should be added to the time to transplant. Finally, many hanging basket styles require the labor-intensive installation of wire or plastic hangers, and this cost should not be overlooked. A few possible calculations are shown in Table 7-2, page 35.

Another example is based on the experience of a mid-size grower in the Midwest who tracked labor costs by having a point person for each crew record major labor activities, and then this data was entered into a spreadsheet (Table 7-3). By having container size, number of people, and hours that the crew worked on the task, it was simple to determine "hours per container" to multiply by an hourly wage. Even roughly tracking this type of labor data can illuminate key labor issues. Data on this spreadsheet indicates, for example, that when people must keep up with a moving belt when transplanting, they work faster. This helps justify additional capital investment in automation. By the same token, tracking labor costs helped this business identify inefficiencies in their "magic carpet" process of planting mixed containers. Essentially, the magic carpet process involved laying out containers in a serpentine pattern in an open space on the ground. Employees sat on a piece of cardboard and transplanted into the containers around their "magic carpet." This ergonomically unfriendly process contributed to high labor costs associated with it, and tracking labor data helped this business identify it as a process to improve upon.

Software is available to assist larger operations with tracking labor data. Accounting software packages with a base price of around $20,000 for software, plus hardware such as time clocks and bar-coded name badges or wands can be adopted if an operation can afford the capital investment. For example, each employee can be given a type of time card. As they start each new job, they swipe the card through a bar-code reader and indicate the type of work and crop they will be doing. Once they finish an activity, they swipe the card again and input a code to indicate their next job. Another version of this type of system involves employees picking up a scanner when they

Table 7-3. Example of Excel spreadsheet to track potting labor costs and calculate time spent per pot from a mid-size Midwest greenhouse operation.

Point Person	Container[z]	Date	Min./Container	Hrs./Container	Cont./Hour	# Flats or Pots	Man Hours	# People	Hours	Minutes	Plants/Pot	Mintues/Plant	Hours/Plant	Process Type
Mandi	4" RD	1/2/04	3.6923	0.0615	16.25	130	8.00	4	2		30	0.1231	0.0021	Wagon/Bench
Annette	14" oval	1/7/04	1.8462	0.0308	32.50	130	4.00	2	2		11	0.1678	0.0028	Magic Carpet
Annette	12" HB	1/8/04	1.9512	0.0325	30.75	123	4.00	2	2		9	0.2168	0.0036	Magic Carpet
Eli	1201	1/9/04	3.4864	0.0581	17.21	1067	62.00	8	7	45	48	0.0726	0.0012	Belt
Annette	10" HB	1/12/04	1.0737	0.0179	55.88	475	8.50	2	4	15	7	0.1534	0.0026	Magic Carpet
Annette	10" HB	2/6/04	1.0922	0.0182	54.94	879	16.00	2	8		3	0.4201	0.0070	Magic Carpet
Brandon	1801	2/6/04	3.2454	0.0541	18.49	379	20.50	3	4	10	18	0.1803	0.0030	Wagon/Bench
Eli	1201	2/19/04	3.5430	0.0591	16.93	779	46.00	6	7	40	72	0.0492	0.0008	Belt
Mandi	5" RD	2/20/04	3.0612	0.0510	19.60	392	20.00	5	4		8	0.3827	0.0064	Wagon/Bench
Brandon	5" SQ	3/12/04	2.5263	0.0421	23.75	95	4.00	4	1		10	0.2526	0.0042	Wagon/Bench
Brandon	1801	3/13/04	5.2632	0.0877	11.40	57	5.00	4	1	15	54	0.0975	0.0016	Wagon/Bench
Brandon	1801	3/17/04	3.6000	0.0600	16.67	100	6.00	3	2		18	0.2000	0.0033	Wagon/Bench
Annette	12" oval	3/20/04	1.2000	0.0200	50.00	900	18.00	3	6		8	0.1500	0.0025	Magic Carpet
Annette	10" oval	3/20/04	1.2000	0.0200	50.00	900	18.00	3	6		7	0.1714	0.0029	Magic Carpet

[z] Tracking container sizes and shapes in combination with labor to pot and/or harvest can shed light on production inefficiencies. Here, RD=round, HB=hanging basket, and SQ=square pots.

arrive at work, attaching it to a kiosk, and then putting their thumb on a sensor for computer identification. Each time an employee begins a new activity, they scan the appropriate bar code. At day's end, employees clock out with their thumbprints and plug their scanners into a kiosk, which retrieves data indicating their daily activities. Yet another version of this type of labor tracking system is represented in Figure 7-7.

Information is downloaded and converted into a text file for payroll programs that calculate overtime, absences, vacations, etc. The information is also used to analyze employee performance, job functions, crops, departments, bonuses, and costs associated with each. Very large growers have adopted such systems as tools that make it easier to plan production tasks according to labor hours. For example, instead of employees standing in front of a manager when they arrive in the morning as they wait for their assignments, they can go right to their jobs. Some grower-managers have also instituted incentives to encourage employees to be more productive. For example, one greenhouse operation was able to use the data generated through a system like this to reduce the labor costs of some jobs up to 16 percent, while paying productive employees up to 50 percent more through a bonus program (Onofrey, 1995).

These types of systems are time-consuming and expensive to implement. Bill Swanekamp of Kube-Pak Corp. supports a system that incorporates the collection of such specific labor data, but puts a limit on how far the labor costs are calculated. For Kube-Pak, the cost of the plant, pot, media, and labor cost to get the crop on the floor, plus labor cost for picking the crop to ship is assigned to each crop. The labor to water, apply plant growth regulators or pesticides, or move within the greenhouse is included in overhead. The advantage of this hybrid cost assignment strategy is that it is easier and less time-consuming to implement.

Figure 7-7. Mike Mellano, Jr. holds a data board that allows field crews to clock in and out of a computerized labor tracking system implemented about five years ago at Mellano & Co., a large cut flower operation in San Luis Rey, California. (Photo by Williams)

Ultimately, however, detailed tracking of labor data may lead to a re-design of labor processes that improves profitability. Some very progressive, large growers have even turned to Japanese manufacturing technology as a means to improve labor efficiency and quality of product. The processes of "lean" manufacturing, or using the minimum amount of resources (people, materials, and capital) to produce products, combined with "flow" manufacturing, or conversion of "assembly line" or fragmented production methods into continuous flow and synchronized production lines, are the basis for lean/flow production technology. Breaking each step of a labor-requiring process down into seconds has helped operations like Kerry's Bromeliads in Homestead, Florida, reduce labor inefficiencies (Figure 7-8). Essentially, "assembly line" production is eliminated and lean/flow stations of two to three people are used to accomplish

Figure 7-8. Kerry's Bromeliads in Homestead, Florida has implemented lean/flow production technology in all of their processes. Each process is broken down into its critical steps. (Photo by Williams)

labor-requiring activities like repotting (Figure 7-9). As people are trained for specific activities, given partners, and paired with a finished product, Kerry Herndon has seen labor inefficiencies plummet. He notes that many greenhouse operations make all of their profit during the spring season, but lose it to overtime. Attention to the minute details of labor use and a re-design of his manufacturing process has resulted in huge labor savings.

The True Cost of Wages

Remember that labor costs are more than hourly wages. Table 7-4 outlines the necessary additions to the base hourly wage to have a truer reflection of labor expense. Ultimately, benefits can comprise up to 30 percent or more of base hourly wage. Use an hourly wage plus benefits for the most realistic labor cost in your analysis.

Small and mid-size family operations may have the challenge of assigning salary costs to owners or family members who do much of the labor, because sometimes these workers do not collect official salaries, especially in times of financial stress. It is critical to include a cost for this labor of at least minimum wage in the cost analysis, however. A better approach would be to include the cost of what these critical members of the business should be paid.

To obtain the direct variable labor cost to produce a crop, add together the costs of each component of the labor that you have tracked; this is the number to be entered into the Cost Analysis Spreadsheet, line 15 (page 11). Other labor expenses (watering, fertilizing, spraying) can be allocated as overhead. For example, the direct variable cost calculation for 12-inch New Guinea Impatiens hanging baskets can be simply Potting + Harvest. Potting may break down into cost to fill the baskets + cost to transplant and water-in + cost to install wire hangers, and Harvest may be simply the cost to pick and groom the baskets. The rest of the labor expenses can be treated as indirect variable or overhead costs, and these can be allocated to each crop based on the square foot week concept, which accounts for the space and time that the crop is in production; details are provided in Chapter 3 (Overhead or Fixed Costs), page 15 and Chapter 6 (Calculating Variable Costs), page 23.

Figure 7-9. A lean/flow transplant station at Kerry's Bromeliads in Homestead, Florida. (Photo by Williams)

The idea of tracking labor costs can seem insurmountable at first, but the message is to just start somewhere! You might choose to begin by using the first season's data to simply gather information and obtain a general picture of where labor dollars are being spent, and then fine-tune your cost analysis with each passing season. Regardless of whether you choose to include all labor costs in your overhead cost calculation or get specific and track labor costs by crop, it takes sheer determination to collect and crunch all of the numbers. However, knowing what processes your labor costs are associated with can provide some of the most powerful information needed to reduce inefficiencies and "up" your bottom line.

For more information:

Bartok, J.W. Jr. 2000. Determine shipping labor costs. Greenhouse Management and Production (GMPro) 20(4):53-54.

Bartok, J.W. Jr. 2003. Reduce shipping season stress. Greenhouse Management and Production (GMPro) 23(4):54-55.

Batsche, K. 2000. A new approach to profitability. Grower Talks 63(12):100.

Onofrey, D. 1995. Labor savings around the clock. Greenhouse Grower. Apr. 95:27-32.

Schulz, K.A. 2002. Profit and cost analysis of the Kansas greenhouse industry: a survey, a labor study, and enterprise budgets. M.S. Thesis. Kansas State University.

Stegelin, F. and P.A. Thomas. 2003. Automating your irrigation systems is a great investment. Greenhouse Management and Production (GMPro) 23(3):43-46.

Stevens, A.B., S. Stevens, M.L. Albrecht, K.L.B. Gast. 1994. Starting a greenhouse business: A commercial growers' guide. Kansas State University Agricultural Experiment Station MF-1157.

White, T. 2002. Pricing for profit. Ohio Florists' Association Bulletin No. 868 (April 2002). p. 1, 6-7.

Table 7-4. Worksheet to calculate direct, mandatory, and fringe benefits in wage costs.

Direct Wage Costs

1. Total regular hours (__ hours/week x __ of weeks) = __ hours.
   Overtime hours (__ hours/week x __ of weeks) = __ hours.
2. Regular wages (__ hours x $__ /hour).
3. Overtime wages (__ hours x $__ /hour).
4. Cash bonuses ($__ or __ percent).
5. Total adjusted cash wages (Lines 2+3+4).

Mandatory Wage Costs

6. Employer's share of Social Security (__percent).
7. Federal unemployment insurance.
8. State unemployment insurance.
9. Workers' compensation.
10. Other.
11. Total mandatory costs (Lines 6+7+8+9+10).

Value of Fringe Benefits

12. Insurance (life, health, dental).
13. Retirement (business contribution).
14. Uniforms (purchase, rental, cleaning costs).
15. Education or certification expenses.
16. Transportation (__ miles/day x __ days x $__ rate/mile).
17. Other.
18. Total cost of fringe benefits (Lines 12+13+14+15+16+17).
19. Total labor costs (Lines 5+11+18)
20. Hours paid, but not worked (__hours holidays; __hours vacation; __hours sick leave).
21. Total hours on the job (Lines 1-20).
22. Total cost per hour on the job (Line 19/ Line 21).

OFA

Chapter 8

Calculating Costs of Propagation

Kimberly A. Williams, Kansas State University

The application of cost analysis to propagation of crops can direct greenhouse operators to answer several questions that could help them become more profitable. Analyzing the costs of seed propagation helps determine whether plugs should be bought in or produced on-site. Users of vegetatively propagated plant material can determine whether rooted or unrooted cuttings – or a combination of both – is most cost-effective for their particular operation. If stock plant production to produce vegetative cuttings is an option, a cost analysis would help determine the profitability of filling vegetative cutting needs in this way.

Seed Propagation

The two critical factors that greenhouse operators must manage to maximize profit, especially during the spring season when most of the greenhouse industry makes its profit, are production time and production space. Using plugs for spring bedding plant production is a key to optimize scheduling during the spring season. Plugs aid in keeping production schedules flexible, and their use is a secret to rapid crop turns of two to three times traditional spring-season volume. The decision to produce plugs on-site (Figure 8-1) versus buying them in is not always as simple as evaluating the cost to produce them. Purchasing plugs may allow a spring-only greenhouse operation to delay opening in the spring, which would save fuel and labor costs. Viewing the situation from the end of the spring season may result in an operation opting to produce plugs during the early part of the season, until production staff became distracted by shipping and the spring-season crunch. There is no question that buying in plugs helps save production headaches, because the plug production environment requires intensive management. Plug production is aided by automatic seeding equipment (Figure 8-2) and germination space, and both require substantial capital investment. And, if a plug crop fails mid-season, an operation may be unable to get the cultivars and/or species needed to fill orders at such a late date.

Figure 8-1. Plug production space is more intensively managed than basic production space. (Photo by Williams)

Figure 8-2. Automatic seeding equipment requires a capital investment that can be depreciated over time and assigned to the cost of plug production. (Photo by Williams)

Perhaps one of the best strategies is to produce on-site the majority of plugs needed, but purchase plugs of the species that are always a challenge to produce. For example, it is difficult in the Midwest and South to produce high-quality pansy plugs during late August. This is a job that may be ideally left to a facility that is in a geographical location where the environment is more optimal for this cool-temperature crop during this time of year, such as the Rocky Mountains or northern United States. One spring bedding grower in the Midwest, for example, simply decided that any species or cultivar that resulted in greater than 20 percent loss would be purchased as plugs in future years.

Table 8-1 shows examples of the cost to produce plugs of vinca, gerbera, and begonia given the assumptions stated. The "Overhead Costs" section of the table provides an example of how more than one overhead cost rate could be used for a single crop; because germination space and plug production space are typically more expensive to operate than basic production space, a higher overhead cost rate may be calculated for these production areas. Plug trays of various plant species require different amounts of time in each type of production space, and the appropriate overhead cost can be assigned accordingly.

The good. Vinca is an example of a bedding plant species that, assuming only 10 percent loss during production, can be profitable to produce on-site. Under the assumptions in the example calculation in Table 8-1, a plug costs only $0.03 to produce on-site, but $0.09 to buy-in.

The bad. Gerbera plugs are expensive to produce. Seed is costly, and they are under production for a longer period than the average bedding plant plug. In the example shown in Table 8-1, it would likely make sense to buy-in plugs of this species. Assuming only 10 percent loss during production, a plug costs $0.46 to produce and only $0.47 to buy-in. Save the headache and place an order!

The ugly. Begonia plugs can be tricky to produce (Figures 8-3 and 8-4, page 42). The ultra-small seed are very sensitive to moisture after germination, and the long production cycle lends itself to lots going wrong. If a greenhouse operator has trouble with this crop and routinely suffers substantial loss, this is an

Table 8-1. Comparison of the cost to produce plugs (200 plug trays) of three different bedding plant species with the conditions given.

Crop Information		Vinca "The Good"	Gerbera "The Bad"	Begonia "The Ugly"
Variable Costs				
Seed	Cost per 240 (Assumes 80% germination, so 40 extra seed are ordered per 200 plug trays)[y]	$1.13	$72.73	$1.40
Germination Medium	$9.60/3 ft^3 fills 13.8 plug trays	$0.70	$0.70	$0.70
Plug Trays	$69.20/case of 100 plug trays	$0.69	$0.69	$0.69
Label		$0.01	$0.01	$0.01
Chemicals	Fertilizer, PGRs, pesticides	$0.01	$0.01	$0.02
Labor (seeding)	168 flats seeded/hr; $10.56/hr	$0.06	$0.06	$0.06
Total Variable Costs		**$2.60**	**$74.20**	**$2.88**
Overhead Costs				
Space used per tray	11" x 21.5" = 236.5 in^2; divided by 144 in^2/ft^2 = 1.64 ft^2	1.64 ft^2	1.64 ft^2	1.64 ft^2
Time in germination chamber	days divided by 7 = weeks	8 d = 1.1 wk	0	8 d = 1.1 wk
Germ $/ft^2/wk	$0.48 x area x wks	$0.48 x 1.64 ft^2 x 1.1 wk = $0.53	0	$0.53
Time under mist or intensively-managed space	days divided by 7 = weeks	0	21 d = 3 wks	0
Mist $/ft^2/wk	$0.38 x area x wks	0	$1.14	0
Time in plug production space	days divided by 7 = weeks	28 d = 4 wk	97 d = 13.9 wk	89 d = 12.7 wk
Plug space $/ft^2/wk	$0.34 x area x wks	$2.23	$7.75	$7.08
Total Overhead Cost	Add germination + mist + plug production space	$0.53 + $2.23 = $2.76	$8.89	$7.61
Total Cost	**Variable + Overhead Cost**	**$5.36**	**$83.09**	**$10.49**
Loss	Additional cost assigned per flat due to plug loss is calculated as shown in "rooted versus unrooted cuttings" section of this chapter.	10%, $0.60/flat	10%, $9.23/flat	45%, $8.58/flat
Total Cost including Loss		**$5.96**	**$92.32**	**$19.07**
Cost per plug to produce	Cost per flat divided by number of plugs per flat	$0.03	$0.46	$0.095
Cost per plug to buy-in[z]		$0.09	$0.47	$0.090

[y] It may not be necessary to account for germination percentage if these plants are included, by default, in the % loss of plants in finished plug trays.

[z] Plug costs were obtained from various commercial suppliers, spring 2004.

example of a crop that it may make sense to buy-in. With the assumption of 45 percent loss, the cost analysis shown in Table 8-1 indicates that at $0.095 per plug, it actually costs a little more to produce this species on-site than to buy-in a plug for an even $0.09 each. So why not leave begonia plug production to a specialist who has the facilities to optimize germination and the techniques mastered to produce uniform, high-quality plugs for you (Figure 8-5)?

Figures 8-3 (above) and 8-4 (below). Begonia production can be challenging. It is not uncommon for best efforts to result in substantial losses. (Photos by Williams)

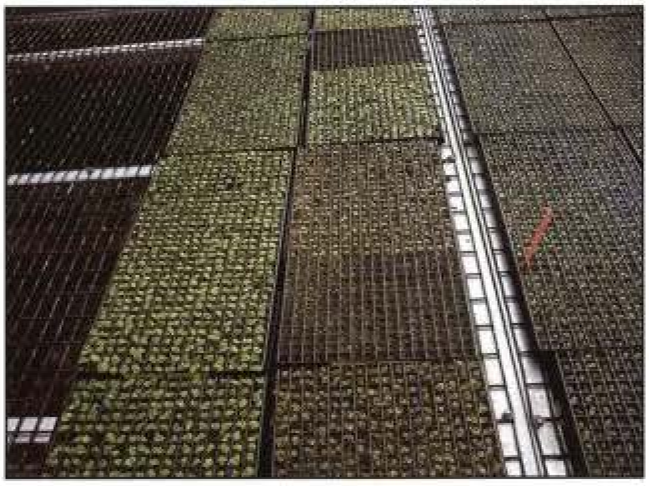


Figure 8-5. Some specialist plug producers have worked out the kinks of begonia plug production, and based on cost analyses, it may make sense to leave the headaches to them. (Photo by Williams)

A number of factors influence the profitability of producing plugs. As shown in the examples in Table 8-1 on page 41, the three most important factors are usually poor germination/plug losses, length of time to germinate/produce, and sometimes cost of seed. As another viewpoint, Styer and Koranski (1997) present examples of producing pansy plug trays and finished flats from both standard and primed seed. Although the primed seed is substantially more expensive than the standard seed, the improved germination rate and reduced production time for the primed seed usually result in it being the more profitable choice. Profitability of spring bedding production benefits from analyzing the costs of plug production.

Vegetative Propagation

Rooted versus Unrooted Cuttings

As shown in the example worked in Chapter 6, it is often more cost-effective to buy in unrooted cuttings, because the cutting material itself is less expensive and the shipping costs are much less. However, when compared with the cost of buying-in unrooted cuttings, the true cost of rooting on-site ideally includes the cost of the propagation material (e.g. Oasis wedges, plug trays, and germination media), labor to stick and maintain the young cuttings, overhead costs for the space used during the propagation period – which includes depreciation of propagation-specific equipment, and shrinkage or loss. The following calculation continues with this cost analysis where Chapter 6 left off.

Propagation space is more expensive to operate than basic production space (Figure 8-6). Temperature is

Figure 8-6. Typical vegetative cutting propagation space includes overhead mist, warmer temperatures, and often bottom heat. (Photo by Williams)

usually warmer, either because of the installation of bottom heat or maintenance of higher air temperature; mist, fog, or boom systems keep relative humidity high; and supplemental light is sometimes installed. For this reason, cost per square foot per week used for this calculation ideally considers these additional costs.

Shrinkage or loss should be taken into account when rooting your own cuttings. Not all cuttings will be usable due to disease, insect or slug damage, poor rooting, or another problem. One way to calculate the cost of losses and assign it back to usable cuttings is to add together all costs per cutting and multiply by the number discarded. Then divide by the number of healthy cuttings to assign the cost of losses to each usable cutting. As shown in the Table 8-2 example, if 3 percent loss is accrued, 3 cuttings out of 100 are discarded, or 30 cuttings out of 1,000 are discarded, or 96 cuttings out of 3,200 are discarded, etc. Therefore, the loss calculation would be the total variable plus overhead costs per cutting ($0.525) times 3 (or 30 or 96) cuttings discarded, divided by 97 (or 970 or 3,104) usable cuttings. A loss of $0.02 is added to the cost of each usable cutting.

Lack of success with accomplishing high rooting percentages from unrooted cuttings on-site is a reason to look toward purchasing rooted cuttings. As shown in the Table 8-2 example, a jump from 3 percent loss to 18 percent loss increases the cost per cutting from $0.45 to $0.64, which compares less favorably with the cost to spare the effort and just buy-in rooted cuttings at $0.90 each. Ultimately, looking at rooting percentages for each species, and perhaps even each cultivar if quantities justify the effort, can provide information to help a greenhouse operator make the most profitable decisions about what to propagate on-site and what to leave to a specialist.

Stock Plants versus Buying-in Cuttings

Stock plant production is an option for greenhouse operators to generate cuttings of non-patented, easy-to-root plants – like many coleus varieties – as well as cuttings of patented cultivars on which they will pay royalties. Some operators like the control over timing and quality of cuttings that comes with on-site propagation. However, knowing the cost of production from stock plants ensures that greenhouse space that would be more profitable if used for production of other crops is not being tied up. Cost analysis of stock plant production is the means to determine the cost per cutting, which must be known for input into cost calculations for the finished product (Cost Analysis Spreadsheet, page 11, line 14) or if the cuttings will be sold. In addition, cost analysis of cutting production from stock plants can reveal whether it is more profitable simply to buy-in unrooted cuttings instead of producing stock plants, and whether old stock plants should be re-flowered for sale or discarded.

Calculating the cost of producing cuttings from stock plants is complex. The two greatest expenses associated with stock plant production are typically overhead costs allocated to the stock plant container and labor to harvest cuttings. Total overhead cost applied to each stock plant is typically high because stock plants are produced in large containers (taking up space) and occupy space for long periods (taking up time) while successive cutting harvests are taken. Labor required by stock plants is substantial for the same reasons. For example, Brumfield (1993) reported

Table 8-2. Cost to root unrooted poinsettia cuttings, per cutting.

Cutting	$0.41	Includes royalty + shipping; from example in Chapter 6
Oasis wedge	$0.055	Cost per cell
Production Labor	$0.02	Cost to stick cutting, remove damaged lower leaves, fertilize lightly
Total Variable Costs	*$0.485*	
Overhead Cost	*$0.04*	$0.30 per square foot per week x 3.5 weeks divided by 26 cuttings per square foot = $0.04 per cutting
Cost per cutting	$0.525	Variable + Overhead Costs = $0.485 + $0.04 = $0.525
3% Loss	$0.02	3% Loss : $0.525 x 3 cuttings discarded divided by 97 usable cuttings = $0.02 per cutting
Total cost per cutting with 3% loss:	**$0.545**	$0.525 + $0.02 = $0.545
18% Loss	$0.115	18% Loss: $0.525 x 18 cuttings discarded divided by 82 usable cuttings = $0.115 per cutting
Total cost per cutting with 18% loss:	**$0.64**	$0.525 + $0.115 = $0.64

that half of the labor to produce geranium cuttings from stock plants is in harvesting cuttings. In one study with three foliage plant species, Krafka (1986) determined the economic feasibility of allocating production space to stock plants versus purchasing cuttings and using the stock space as a finishing area. The outcome was that when quality and availability of purchased material were comparable to stock production, the practice of maintaining stock plants was not economically optimal.

A simple way to get a handle on the cost per cutting generated from stock is to calculate the cost to produce a stock plant, then divide by the average number of cuttings produced per plant. For example, Table 8-3 shows how the Cost Analysis Spreadsheet might be adopted to calculate the cost to produce stock of geraniums. The same principles could be applied to stock production of unpatented varieties of crops like coleus, as well as stock production of patented varieties of poinsettias, ivy geraniums, and other crops on which growers pay a royalty per cutting. The variable plus overhead costs for each stock plant are $13.46 (line 32). If 2,800 cuttings were generated from these 200 stock plants, about 14 cuttings were harvested per plant (2,800 cuttings divided by 200 plants) over 29 weeks. $13.46 per plant divided by 14 cuttings per plant equals $0.96/cutting.

This is the cost per cutting if the fate of the stock plants is to be discarded; however, if the stock plants will be finished for sale after cuttings are harvested, the revenue generated from the sale of the finished plants will alter the economic feasibility of this production scenario. The calculations shown in Table 8-4 indicate that producing the geranium stock

Table 8-3. Example of adopting the Cost Analysis Spreadsheet to calculate the cost to produce stock plants of 10-inch geraniums. The geranium stock were potted in 10-inch baskets, cuttings were harvested twice, and the crop was finished for sale; and about 14 cuttings were harvested per container.

Line #[z]				
	Crop Info			
3	Units grown	200	Pots	
4	Container size	10	Inch	
5	Containers filled	5.3	Pots/ft^3 of media	
6	# Plants per pot	1	plants/pot	
7	Spacing #1	4	wks @	10 in. by 10 in.
8	Spacing #2	25	wks @	16 in. by 16 in.
9	Spacing #3	0	wks @	0 by 0
10	Crop Time	29	Wks	
11	Total Space per Pot	47.22	sq.ft.wks/pot	
12	Maximum GH Space	355.6	sq.ft./crop	
	Variable Costs			
14	Cutting or Seed	$0.37	$/plant	
15	Plants	$0.37	$/pot	
16	Media	$ 2.30	$/ft^3	
17	Media	$0.43	$/pot	
18	Labor	$1.70	$/pot	
19	Container	$0.97	$/pot	
20	Tag	$0.05	$/pot	
21	Fertilizer	$0.22	$/pot	
22	Chemicals	$0.14	$/pot	
23	Other	–		
24	Loss	1	%	
25	Pots Sold	198	pots sold	
26	Total Variable Costs	$3.88	$/pot grown	
27	Total Variable Costs	$3.92	$/pot sold	
	Overhead Costs			
29	Overhead rate	$0.20	$/sq.ft.wk.	
30	Overhead costs	$9.54	$/pot sold	
	Total Costs and Revenue			
32	Total Cost	$13.46	$/pot sold	
33	Wholesale Price	$15.00	$/pot	
34	Revenue (Gross)	$2,970	$/crop	

[z] Line number corresponds to the line or "row" number of the Cost Analysis Spreadsheet.

is only profitable if stock plants are finished and sold (for example, for $15.00 wholesale; line 33 of Table 8-3); if plants are discarded, loss is $8.82/pot because it is less expensive to buy in cuttings than to produce them on-site. Keep in mind that the most important decision for a greenhouse operator to make is whether it would be more profitable to use the space consumed by the geranium stock to produce other crops. Even if the stock geraniums are flowered and sold for a profit of $0.14 per square foot per week, the amount of profit that could be earned by production of other crops should be evaluated in comparison.

Calculating Stock Plant Productivity

To determine cutting productivity from stock plants of a given cultivar or species, it is easiest to determine the number of cuttings produced per square foot per week in the stock plant production area. Simply divide the number of cuttings produced per container by the number of square foot weeks per container. In the example in Table 8-3 with geranium, 14 cuttings per container divided by 47.22 square foot weeks per container = 0.30 cuttings produced per square foot per week. However, because the last 12 weeks of the production cycle are needed to flower and finish the large geranium plants after the second round of cuttings is harvested, a more appropriate calculation for this example would be 14 cuttings per container divided by 25.89 square foot weeks per container (from 4 weeks @ 10-inch x 10-inch spacing + 13 weeks @ 18-inch x 18-inch spacing, lines 7-8 of spreadsheet) – which equals 0.54 cuttings produced per square foot week. Changes to stock production practices like pot size, pot spacing, use of supplemental light, and carbon dioxide injection can then be easily evaluated for profitability based on how they change cuttings produced per square foot per week. The greenhouse operator's goal is always to maximize the number of cuttings produced per square foot per week.

As an example, research at the University of New Hampshire by Paul Fisher (www.ceinfo.unh.edu/Agric/AGGHFL.htm) indicates that even though supplemental lighting is a substantial investment, in the northern United States during the winter it can be profitable for stock plant production. For example, at least two extra cuttings per square foot per week at 350 footcandles or three extra cuttings per square foot per week at 575 footcandles must be produced to break even on lighting when cuttings were valued at $0.06 each; and this occurred for scaveola, supertunia 'Sun Snow,' and tapiens verbena. It was not profitable to light heliotrope, however. In addition, providing supplemental light was more profitable when combined with carbon dioxide injection.

Calculating Cost of Supplemental Lighting

Calculating the investment and operating costs for supplemental lighting is relatively straightforward. Table 8-5 (page 46) shows the breakdown of investment costs for two light levels from work by Fisher et al. (2001). If lights are run for 17 weeks per year in the winter, about $0.03 to $0.04 additional cost per square foot per week is added during this production period. A heating benefit from the lamps may accrue from fuel savings up to about $0.01 per square foot per week. Finally, operating costs are primarily

Table 8-4. Calculations to determine the profitability of geranium stock plant production when stock is finished and sold versus discarded.

Geranium stock are sold:	
Geranium stock cost $2,692 to produce	$13.46/container x 200 containers
$2,970 is generated from the sale of geranium stock	$15.00 x 198 containers (2 containers are discarded)
Extra cost to produce cuttings on-site is $1,652	$0.37 per cutting to buy-in x 2,800 cuttings = $1,036; $0.96 per cutting to produce on-site x 2,800 cuttings = $2,688. Extra cost to produce cuttings on-site = $2,688 - $1,036 = $1,652
Profit per crop is $1,291	$2,970 - $1,652 = $1,318; loss from 2 discarded containers is $13.46 x 2 = $26.92; $1,318 - $27 = $1,291
Profit per pot is $6.46	$1,291 divided by 200 containers
Profit per square foot per week is $0.14	$6.46/container divided by 47.22 square foot weeks per container
Geranium stock are discarded:	
Extra cost to produce cuttings on-site is $1,652	$0.37 per cutting to buy-in x 2,800 cuttings = $1,036; $0.96 per cutting to produce on-site x 2,800 cuttings = $2,688. Extra cost to produce cuttings on-site = $2,688 - $1,036 = $1,652
Loss per pot is $8.26	$1,652 divided by 200 containers

electrical and can be estimated as:

hours operated per day x $/kW/hour x 0.03 for 350 footcandles OR 0.05 for 575 footcandles. The constants 0.03 and 0.05 very roughly take into account the different amounts of energy (kW) consumed at the two different light levels.

For example, to operate high-pressure sodium lamps at 350 footcandles for 12 hours per day at $0.10/kW/hour = 12 x $0.10 x 0.03 = $0.036 per square foot per week for electricity (Fisher et al., 2001).

In summary, the value of keying in on cost analyses of propagation processes is that it allows greenhouse operators to make informed decisions about what makes sense to propagate on-site and what should be left to the specialists. Scrutinizing propagation processes offers substantial opportunity for a greenhouse operation to maximize profitability.

For more information

Brumfield, R.G. 1993. Production costs. In: J.W. White, ed. Geraniums IV, 4th ed. Ball Publishing, Batavia, Illinois.

Fisher, P., C. Donnelly, and J. Faust. 2001. Evaluating supplemental light for your greenhouse. OFA Bulletin No. 858 (May 2001).

Krafka, B.D.L. 1986. Greenhouse space allocation in the ornamental foliage industry in the Rio Grande Valley of Texas. M.S. Thesis. Texas A&M University, College Station.

Styer, R.C. and D.S. Koranski. 1997. Plug and transplant production: a grower's guide. Ball Publishing, Batavia, Illinois.

Table 8-5. Example investment costs for high-pressure sodium lamps to provide 350 or 575 footcandles of supplemental light in a 30-foot x 144-foot double-poly free-standing greenhouse. From Fisher, P., C. Donnelly, and J. Faust. 2001. Evaluating supplemental light for your greenhouse. OFA Bulletin No. 858 (May 2001).

	350 footcandles	575 footcandles
Lamp Design		
Number of 400 W fixtures	40	66
kW/greenhouse (400 W bulb + 64 W ballast)	18.6	30.6
Square feet of floor space/lamp	108	65
Initial Costs		
Purchase cost of fixtures @ $210	$8,400	$13,860
Installation cost @ $190 (assumes permanent installation by grower paid $12.15/hour)	$7,600	$12,540
Total purchase and installation[z]	$16,000	$26,400
Investment cost/square foot of greenhouse floor space	$3.80	$6.10

[z]The total purchase and installation cost could be depreciated over 10 years, a reasonable lifespan for HPS fixtures.

OFA

Chapter 9

Calculating Costs of Pest Management

Kimberly A. Williams, Kansas State University
Raymond A. Cloyd, University of Illinois

Integrated pest management (IPM) is an approach to deal with greenhouse pests – including insects, mites, and diseases – that uses a variety of management strategies. These include cultural (e.g. proper watering and fertility management, weed and algae control, and humidity management), physical (e.g. insect screening), chemical (e.g. pesticide applications), and biological (e.g. use of natural enemies of pests, including parasitoids, predators, and pathogens). In the past, insect, mite, and disease pests were controlled primarily by spraying pesticides on a calendar schedule. The advent of IPM encouraged growers to view pesticide applications as only one of many possible pest management strategies and to move away from solely relying on scheduled chemical applications without discerning if they were needed or not. It was initially the general opinion of some growers that IPM really meant "I Pay More;" but in fact, an IPM approach focuses on identifying the most economical as well as environmentally protective pest management strategies. The challenge is in determining the actual cost of pest management for a given crop or greenhouse operation, and that is the focus of this chapter.

The primary methods of dealing with insects, mites, and diseases are the use of 1) chemicals and 2) biological control agents, which accounts for most of the expenses associated with pest management. However, before either type of control program is implemented, greenhouse operations should be routinely scouted to make better decisions concerning pest control.

Scouting

Scouting is an essential component of pest management, whether using chemical or biological control. Scouting allows greenhouse producers to determine pest population trends, locate hot spots in greenhouses, time pesticide applications at the most vulnerable life stage of a given pest, and directly measure if pest control worked – instead of guessing. Greenhouse producers who fail to scout run the risk of increasing the potential for pesticide resistance, increasing worker exposure to pesticides, enhancing the likelihood of plant injury from either chemical phytotoxicity or unnoticed damage from pests, and increasing the potential for environmental impact through groundwater contamination. These are all unaccounted-for costs of poor pesticide stewardship. Scouting can reduce the number of chemical pesticide applications, which lowers the selection pressure placed on a pest population and decreases the possibility of resistance development. For example, Tim Galema of Galema's Greenhouses in West Lafayette, Indiana, has implemented a scouting program based on numbers of thrips, whiteflies, fungus gnats, and shore flies found on sticky cards. Before the scouting program, he would spray for thrips in winter even if just a few were detected; but with information obtained from years of scouting, he now knows that thrips will not become a problem until the weather warms (Davis, 1998). He has effectively been able to eliminate pesticide applications for thrips from November through March. Similarly, Cloyd and Sadof (2003) established an action threshold, or minimum number of pests detected before control action was taken, of 20 Western flower thrips/sticky card/week in a cut carnation greenhouse. Based on this action threshold, pesticide applications were not required between November and March.

The cost of scouting includes supplies and labor. The supply list includes yellow or blue sticky cards and holders, clipboards, hand lens, tally counters, handheld calculator, flagging tape, and possibly an aspirator and vials, head magnifier, good quality dissecting microscope, indicator plants, and a palm pilot or laptop computer. Labor involves inspecting plants (Figure 9-1) and sticky cards (Figure 9-2, page 48), recording data, replacing sticky cards, incorporating data into spreadsheets, and interpreting data over time. A professional scout could be hired to perform these duties, in which case charges would accrue as a flat fee per visit or by the hour. In fact, research at the University of California showed that using a professional scout at a

Figure 9-1. The labor cost to scout includes examining plants for insects and mites that do not fly, such as mealybugs and spider mites, to make pest observations and counts. (Photo by Marci Spaw, Kansas State University)

cut rose operation in Watsonville saved almost $4,500 in labor and pesticides compared to a grower's standard pest management program; this is equivalent to a 30 percent reduction in pesticide use (Shaw, 1996). The time required to scout, and thus the cost associated with it, depends on the skill and experience of the scout, the size of the area scouted, the number and size of crops produced, and level of pest infestation. A new scout may require 20 to 25 minutes per 1,000 square feet, while a scout who has experience and familiarity with the greenhouse layout may only require 3 to 12 minutes per 1,000 square feet. Five hours per week to scout plus 0.5 hour to discuss results with a grower is a typical amount of time for an experienced scout to cover a 2-acre greenhouse operation.

Because scouting occurs for all crops and should be practiced regardless of the pest control method – chemical, biological, or both – that is used, it is accurate to include the costs of scouting as indirect variable costs or in overhead cost calculations. Example 1 below, which assigns a scouting expense primarily composed of labor for a 13-week poinsettia crop based on the square foot week method, is simply an extrapolation of an indirect variable cost calculation presented in Chapter 6.

Figure 9-2. The labor cost to scout includes monitoring flying pests such as thrips, whiteflies, shoreflies, and fungus gnats on yellow sticky cards. (Photo by Cloyd)

Chemical Pest Control

The expense associated with using pesticides includes the pesticide, labor, and depreciation of equipment. The cost of a pesticide is the purchase price of a product plus sales tax and shipping and handling charges. Several examples of pesticide material cost calculations were presented in Chapter 6, page 23. Labor expense includes time to suit up in protective clothing (PPE; Figure 9-3), calibrating application equipment, mixing and loading the pesticide, applying the pesticide to the crop (Figure 9-4), cleaning up equipment, record keeping, and posting warning signs. In addition, there are indirect costs related to the training of employees (WPS) and certification.

Figure 9-3. Labor cost to apply pesticides includes the cost to suit up with personal protective equipment (PPE). (Photo by Williams)

Example 1. Assigning Scouting Expenses

Total square foot weeks of bench area for a 50,000-ft^2 greenhouse with 80% bench area for 13 weeks	50,000 ft^2 x 80% x 13 weeks = 520,000 square foot weeks
Scouting expense for 13 weeks of poinsettia production	7.5 hours/wk x $14.00/hr x 13 weeks = $1,365
Average scouting expense per square foot week of bench area	$1,365/520,000 square foot weeks = $0.0026 per square foot week
Total square foot weeks of bench area used to produce 100 6-inch poinsettias using one spacing method (6" x 6" spacing for two weeks and 12" x 12" spacing for 11 weeks)	(25 ft^2 x 2 wks) + (100 ft^2 x 11 wks) = 1,150 square foot weeks
Scouting expenses for the poinsettia crop	1,150 square foot weeks x $0.0026 per square foot week = $2.99
Scouting expenses per pot	$2.99/100 = **$0.03/pot**, entered into the Cost Analysis Spreadsheet (page 11) as a component for the total of line 18 ("labor") or line 23 ("other").

Figure 9-4. The labor to apply pesticides to the crop comprises a large percentage of the expense of chemical control. (Photo by Williams)

Certain formulations of pesticides such as aerosols and fumigants (Figure 9-5) are only applied once, which means that these products may have to be purchased more frequently depending on use and extent of an insect or mite infestation. However, the labor of mixing/loading and cleaning up is minimal compared to standard spray or drench applications of pesticides. The actual cost of a pesticide application will vary depending on whether the entire crop is treated or localized (spot) treatments are performed.

Figure 9-5. The labor cost associated with using pesticides formulated as aerosols is typically less than those associated with using liquids or solids. (Photo by Cloyd)

Estimating the time necessary to spray a crop thoroughly depends on a number of factors, including size of the crop, type of pesticide used (i.e. systemic versus contact), and number of plants infested by insects, mites, or disease.

Depreciation of pesticide application equipment would only be necessary for costly purchases. The assessment of application equipment costs involves the initial purchase, use or frequency of application, and maintenance. How long application equipment will last and, therefore, its depreciation value depends on a number of variables (Table 9-1), including:

Table 9-1. Longevity range of common high- and low-volume pesticide application equipment in greenhouses to estimate depreciation periods.

High-Volume Equipment	**Depreciation Period**	**Comments**
Hydraulic Sprayer	2-15 years	a, b, c, d
Backpack Sprayer	1-15 years	a, b, c
Low-Volume Equipment		
Mist Blowers	1-15 years	a, b, c
Control Droplet Applicators	4-8 years	a, b, c,
Ultra-Low Volume Applicators	2-20 years	a, b, c, d
Electrostatic Sprayers	1-15 years	a, b, c
Thermal Foggers	2-25 years	a, b, d
Mechanical Foggers/Cold Foggers	2-15 years	a, b, c, d
Smoke Generators	2-10 years	a, b

[a] Depends on routine maintenance performed [rinsing equipment thoroughly after use; equipment cleaning; lubricating seals; nozzle, hose, rubber gasket and seal replacement].

[b] Depends on frequency of use [increased use decreases longevity].

[c] Depends on formulation of pesticide [WP (wettable powders), DF (dry flowables), WDG (water-dispersable granules), F (flowables), EC (emulsifiable concentrates), SP (soluble powders), S (solutions)].

[d] Depends on equipment storage [exterior storage, interior storage].

- Degree of proper and frequent maintenance, such as rinsing thoroughly after use, replacing nozzles, seals, gaskets, and lubricating moving parts.
- Frequency of use.
- Formulation of pesticides used; in general, pesticides formulated as solids tend to be more abrasive on application equipment than liquid formulations.
- Storage conditions for equipment.

Depreciation of expensive types of pesticide application equipment would most easily be included in overhead cost calculations. However, it is a legitimate expense of pesticide applications; and a means to include equipment depreciation in cost per container is shown via Example 2.

A shortcut calculation to determine the same cost per square foot per week would be:

Cost per square foot per week =
$830/(50,000 sq. ft. x 0.8)/36 wks = $0.0006

If desired, it would be simple to tally the costs from the various components of the pest management program to assess the total cost of pest management per container. For example, these may include the following from the examples presented:

1. Cost to scout: $0.03/pot (from above).
2. Cost of pesticide material: MarathonG @ $0.07/pot + Subdue MAXX and Cleary's 3336 drench @ $0.02/pot = $0.09/pot (from Chapter 6).
3. Labor to apply the pesticides (not calculated in examples).
4. Depreciation of pesticide application equipment: $0.01/pot (from above).

Biological Pest Control

The cost of implementing biological control has often been deemed prohibitive even before it is attempted. However, when cost analyses are actually done, it may be comparable to or even less than pesticide applications. For example, a report on the expense of using biological controls in Canada indicated strikingly low costs (Table 9-2). As another example of the cost to release natural enemies, Deborah Sweeton of Techni-Growers Greenhouses, in Warwick, New York, manually released the predator *Neoseiulus cucumeris* (Figure 9-6) for thrips control. Total cost for the effective program was $0.027 per pot of tuberous dahlia. And finally, the per-plant cost of using

Example 2. Depreciation Calculations

	Purchase Price	**# of Yrs Depreciated (see Table 9-1)**	**Depreciation per Year**
Hydraulic Sprayer	$1,800	9	$200
Automatic aerosol generator	6,300	10	630

Total Depreciation per year: $830

For a 50,000-square-foot greenhouse in operation 36 weeks per year, cost per square foot per week for a 13-week poinsettia crop would be:

Total square foot weeks of bench area for a 50,000-ft² greenhouse with 80% bench area and operating 36 weeks per year	50,000 ft² x 80% x 36 wks= 1,440,000 square foot weeks
Pesticide equipment depreciation	$830
Pesticide equipment depreciation per square foot week of bench area	$830/1,440,000 square foot weeks = $0.0006 per square foot week
Total square foot weeks of bench area used to produce 100 6-inch poinsettias using one spacing method (6"x 6" spacing for two weeks and 12" x 12" spacing for 11 weeks)	(25 ft² x 2 wks) + (100 ft² x 11 wks) = 1,150 square foot weeks
Pesticide equipment depreciation for the poinsettia crop	1,150 square foot weeks x $0.0006 per square foot week = $0.69
Pesticide equipment depreciation per pot	$0.69/100 = **$0.0069/pot or $0.01/pot**, entered into the Cost Analysis Spreadsheet line 23, "Other" (page 11) if pesticide equipment depreciation is not included in overhead cost calculations.

Table 9-2. Ranges of average annual cost of using biological control agents per square foot. Reported for British Columbia, Ontario, and Alberta, CANADA. Converted from Canadian dollars using an exchange rate of 0.75 USD = 1 Canadian Dollar.[z]

	US $/ft²/year
Tomato	0.03 – 0.05
Pepper	0.02 – 0.06
Cucumber	0.06 – 0.14
Roses	0.16 – 0.42
Gerbera	0.17 – 0.56

[z]Source: Kuack, D. 2004. Don Elliott on the use of biocontrols. GMPro (Greenhouse Management and Production) 24(2):38-40.

biological control on poinsettias has been shown to be between $0.10 and $0.14, which is comparable to the $0.13 cost per plant when using chemical control (Van Driesche and Lyon, 2003).

On the other hand, using biological control or natural enemies may be more expensive than conventional chemical-based control (Stevens et al., 2000). There are differences in the expenses associated with using biological versus chemical control that are distinct, whereas other costs are less clear-cut. For example, with biological control, there are no costs associated with wearing personal protective equipment (PPE) such as protective clothing and respirators, which must be purchased and maintained; warning signs need not be posted, and labor activities are not disrupted from following restricted-entry intervals (REI); certification is not necessary for use; and potential plant injury (phytotoxicity) is not a threat, as it can be with some pesticides. The labor costs of using biological control may decline if scouting costs are similar to chemical control (Stevens et al., 2000). These factors should be considered when comparing the costs of pest management strategies.

Another perspective from which to view the true cost of using natural enemies in a pest control program is that they may last longer. For example, using an entomopathogenic nematode such as *Steinernema feltiae* to control fungus gnat larvae may cost twice as much per square foot as a pesticide application; however, the nematodes may be effective for up to three months, whereas the pesticide application may need to be repeated monthly. Over the length of the production cycle, the natural enemy may be less expensive than multiple pesticide applications. Similarly, using pesticides that are compatible with natural enemies can augment biological control programs. For example, insect growth regulators such as pyriproxyfen (Distance) and azadirachtin (Azatin/Ornazin) have been shown to be non-toxic to parasitoids.

Two basic strategies exist for adopting the use of natural enemies in a pest management program: 1) preventative releases on a calendar schedule, which may follow a recommendation of high release rates provided by the biological supplier; or 2) making releases on an as-needed basis in response to information gathered from scouting. Not surprisingly, the expense of following the first strategy may be prohibitive. For example, in 3,000 square feet of greenhouse tomato production in Kansas, the cost of releasing natural enemies according to a preventative recipe without using information from scouting was $678; cost of releases based on scouting was $215; and the cost of using pesticides was $150 (Marr and Westervelt, personal communication).

Figure 9-6. The predatory mite *Neoseiulus cucumeris* has been shown to be a cost-effective alternative for control of thrips. (Photo by Cloyd)

The expenses associated with biological pest control are similar to chemical control, which include 1) cost of natural enemies plus shipping and handling and 2) labor for their dispersal or application and record keeping. In addition, a consistent and thorough scouting program is most essential with biologically based pest management, because release rates of natural enemies are often based on information determined during scouting and because natural enemies do not reduce a pest infestation as quickly as pesticide applications, so pest problems must be addressed early. Ultimately, the cost of a biological control program depends on the crop grown and the length of the production cycle, the application rate used for the biological control agents, the price of the biological control agents, and the actual amount received (Lyon et al. 2003).

A key factor that is critical to the success of using biological control in greenhouses is checking the quality of the natural enemies prior to release; it is important to assess whether the biological control agents purchased – whether they are parasitoids, predators, or nematodes – are alive. Greenhouse producers should not assume that the natural enemies are alive upon arrival, as it is not uncommon for them to be harmed or killed during the shipping process.

In most cases, the primary costs of the biological control agents are express shipping charges, which are relatively set costs. In fact, the shipping charges can be more expensive than the actual product. Additionally, the costs of the various commercially available biological control agents are related to the ease or difficulty in rearing and maintaining them. Table 9-3 presents the commercially available biological control agents for the various insect and mite pests along with the range of costs per unit.

The labor required to release natural enemies varies substantially with the method used. The parasitic wasps *Encarsia* and *Eretmocerus* are usually released by attaching small cards on which parasitized pupae are glued to plants throughout production space (Figure 9-7). This is a relatively time-efficient method of release compared to other natural enemies like predatory mites, which arrive in bottles with a bran or vermiculite carrier material that must be dribbled by hand onto plants throughout the production area (Figure 9-8). This method is less labor-efficient. Therefore, other means to mechanically disperse natural enemies are being adopted by greenhouse producers. For example, one such method to disperse predatory mites is a mechanical dispenser consisting of PVC pipe that acts as a gun barrel through which the predatory mites are blown (Figure 9-9). Predatory mites can be dispersed over 3,000 square feet of production space in less than five minutes with this apparatus.

Figure 9-7. Parasitic wasps such as *Encarsia* and *Eretmocerus* can be efficiently released by distributing cards, to which unemerged pupae are glued, throughout the production area. (Photo by Cloyd)

Figure 9-8. Releasing natural enemies such as predatory mites using a "dribbling" technique is labor intensive; *Hypoaspis miles* is being applied to the soil for control of fungus gnats. (Photo by Cloyd)

Therefore, the cost analysis of using biological control for a commercial greenhouse operation includes 1) cost of the natural enemy (including shipping); 2) time spent determining quality of biological control agents; 3) time spent releasing or applying biological control agents; and 4) time spent recording information (i.e. release date, location). In general, it is easier to determine the cost of releasing biological controls on the basis of square feet of production space. For example, the cost of inundative releases of a predatory mite for thrips control may be calculated in the following manner:

Twenty *Neoseiulus cucumeris* are released per square foot of production space on a bi-weekly schedule for preventative thrips control. The greenhouse area is 3,000 square feet, with 80 percent floor area covered with bedding plants. The predator is released seven times during a 14-week spring season.

How many predators should be ordered for each release date? 3,000 ft^2 x 0.80 = 2,400 ft^2 production area x 20 predators/ft^2 = 48,000 *N. cucumeris* released bi-weekly. Note that the recommended rate of release of *N. cucumeris* for preventative control of thrips ranges between 5 to 20/ft^2.

What is the total cost of all releases for the 14 weeks? 25,000 *N. cucumeris* cost $16; order 50,000. Overnight shipping costs $23. ($16 x 2) + $23 = $55/release x 7 releases = $385/14-week spring season.

Figure 9-9. A mechanical dispenser can make releases of predatory mites very time-efficient. (Photo by Marci Spaw, Kansas State University)

Table 9-3. Costs of commercially available biological control agents for the major greenhouse insect and mite pests.

	No. per Unit	Cost[z]
Pest: Whiteflies		
Delphastus pusillus (=catalinae)	100	$20 to $25
	250	$30 to $37
	500	$60 to $85
	1,000	$100 to $120
Encarisa formosa	1,000	$9 to $12
	2,000	$15 to $20
	3,000	$20 to $25
	5,000	$30 to $35
	10,000	$65 to $70
	25,000	$140 to $150
	50,000	$260 to $275
Eretmocerus eremicus	3,000	$40 to $55
	5,000	$80 to $90
	10,000	$90 to $140
Pest: Aphids		
Aphidioletes aphidomyza	250	$10 to $15
	1,000	$20 to $25
Aphidius colemani	500	$23 to $32
Aphidius ervi	250	$45 to $55
Aphidius matricariae	500	$23 to $35
Aphelinus abdominalis	250	$60 to $70
Green Lacewing (eggs)	5,000	$12 to $24
	10,000	$25 to $30
	20,000	$50 to $60
Green Lacewing (larvae)	900	$35 to $40
	1,000	$15 to $35
	5,000	$63 to $70
Green Lacewing (adults)	500	$160 to $170
Pest: Fungus Gnats		
Hypoaspis miles	10,000	$24 to $34
Steinernema feltiae	1 Million	$20 to $30
Pest: Leaf Miners		
Diglyphus isaea	250	$40 to $100
Dacnusa sibirica	250	$45 to $55
Pest: Western Flower Thrips		
Neoseiulus cucumeris	1,000	$3 to $6
	5,000	$6 to $10
	10,000	$10 to $15
	25,000	$15 to $20
	50,000	$20 to $60
Amblyseius degenerans	1,000	$120 to $150
Orius insidiosus	500	$50 to $65
Hypoaspis miles	7,500	$15 to $20
	10,000	$22 to $25
	15,000	$20 to $25

(Table 9-3 continued on page 54.)

Table 9-3. (continued)

	No. per Unit	Cost[z]
Pest: Spider Mites		
Phytoseiulus persimilis	500	\$12 to \$15
	1,000	\$15 to \$20
	2,000	\$25 to \$30
	5,000	\$60 to \$75
	10,000	\$100 to \$120
Mesoseiulus longipes	1,000	\$15 to \$20
	5,000	\$70 to \$90
	10,000	\$120 to \$150
Neoseiulus californicus	1,000	\$15 to \$20
	2,000	\$20 to \$30
	5,000	\$50 to \$65
Neoseiulus fallacis	1,000	\$15 to \$20
	2,000	\$27 to \$30
	2,500	\$30 to \$40
	5,000	\$50 to \$65
	10,000	\$100 to \$120
Galendromus occidentalis	1,000	\$15 to \$20
	5,000	\$80 to \$90
Stethorus punctillum	100	\$30 to \$40
Feltiella acarisuga	250	\$90 to \$100
Pest: Mealybugs		
Cryptolaemus montrouzieri	100	\$20 to \$30
	1,000	\$190 to \$420
Pest: Scales		
Aphytis melinus	10,000	\$20 to \$35
Metaphycus helvolus	500	\$60 to \$80
	1,000	\$90 to \$100
Lindorus (=Rhyzobius) lophanthae	50	\$40 to \$50
	100	\$50 to \$70

[z] Differences in costs reflect the variability of individual commercial suppliers of biological control agents. These differences are primarily due to 1) the carrier material of the product (e.g. shipped in bran vs. vermiculite); 2) if the natural enemies are provided with a food source (e.g. grain mites) or not; and 3) how difficult (e.g. labor intensive) it is to rear each biological control agent.

What is the cost per impatiens flat that was in production in this space for four weeks? This could be determined by following a cost per square foot per week analysis as shown in Chapter 6 (see Example 3 on the next page.)

Cultural Pest Control with a focus on Relative Humidity

As a component of an IPM program, cultural controls may include a number of production strategies that minimize pest problems, including allowing adequate spacing between plants, fertilizing and watering properly, allowing for a fallow period, and controlling weeds and algae. Managing relative humidity in production space is a valuable strategy to minimize the onset of foliar diseases like *Botrytis*. During late fall, winter, and early spring, relative humidity can be reduced by venting each evening just after sunset to exchange the cooler outside air for air inside the greenhouse. As the cooler air is warmed, relative humidity decreases; this physical principle works for the same reason that evaporative cooling effectively reduces air temperature in the summer. For example, assume that it is 40°F and raining (which is equivalent to 100 percent relative humidity), and moisture content of the exterior air is 37 grains of water per pound of air. Inside the greenhouse, air temperature is 65°F and relative humidity equals 90 percent; moisture content of the interior air is

Example 3. Analyzing Cost Per Flat of Impatiens

Total square foot weeks of bench area for a 3,000-ft^2 greenhouse with 80% bench area for 14 weeks	3,000 ft^2 x 80% x 14 weeks = 33,600 square foot weeks
N. cucumeris expense for 14 weeks of spring bedding production, including labor + predators	0.5 hours/release x 7 releases x $9.00/hr = $31.50 labor + $385 predators including shipping = $417
Average *N. cucumeris* expense per square foot week of bench area	$417/33,600 square foot weeks = $0.012 per square foot week
Total square foot weeks of bench area used to produce 100 1.4 ft^2 impatiens flats for 4 weeks	100 x 1.4 ft^2 x 4 wks = 560 square foot weeks
N. cucumeris expense for 100 impatiens flats	560 square foot weeks x $0.012 per square foot week = $6.72
N. cucumeris expense per impatiens flat	$6.72/100 = **$0.07/flat**, entered into the Cost Analysis Spreadsheet as a component for the total of line 19, page 12, ("other"). Note that this cost could be substantially less if releases were made based on information from scouting, as opposed to the inundative releases via a preventative strategy.

83 grains of water per pound of air. The exhaust fans should be turned on long enough to vent half of the volume of the air in the greenhouse, and this is easily calculated by knowing the cfm (cubic feet per minute) capacity of the house's exhaust fans. If the example greenhouse is a small 86-foot x 36-foot quonset structure with a volume of 39,348 cubic feet, half of this air (19,674 cubic feet) is exchanged and then heated to 65°F. The end result is interior air of 65°F with 65 percent relative humidity and 60 grains of water per pound of air, which is a substantial reduction in relative humidity – which contributes to avoiding problems with foliar disease.

But is this economically feasible, given the cost of heating the outside air? The cost of the air exchange can be easily calculated. Within an acceptable margin of error, it can be assumed that one BTU can raise about 52 cubic feet of air 1°F. In the example above, 19,674 cubic feet of air must be raised 25°F. The BTU required from the heating system to heat this air is calculated:

1. 19,674 ft^3 divided by 52 ft^3/BTU/°F x 25°F = 9,459 BTU heater output.
2. Assuming a 70% efficient natural gas heating system, about 13,500 BTU would actually be consumed.
3. One dekatherm of natural gas equals 1,000,000 BTUs or 1 MBTU and costs $6.50 per MBTU (based on January 2003 cost).
4. 0.0135 MBTU to vent the greenhouse x $6.50/MBTU = $0.09 each time the greenhouse is vented.
5. If air is exchanged every evening during poinsettia production for 13 weeks, the increased fuel expense for the entire greenhouse would be approximately 13 weeks x 7 days/wk x $0.09 = $8.19.

Therefore, for less than $10, this disease management strategy could be accomplished. This expense is much less than the cost of a single fungicide application (fungicide material plus labor and depreciation of equipment) in the same greenhouse.

In summary, the costs associated with cultural, chemical, and biological pest management strategies can be broadly determined by incorporating them into overhead cost calculations; or they can be precisely assessed on a per-container basis. The primary reason that greenhouse producers should take the time to get specific and break out pest management costs from other overhead or indirect variable costs is that this allows for comparison of the expense associated with different pest management strategies.

For More Information

Cloyd, R. A., and C. S. Sadof. 2003. Seasonal abundance and use of an action threshold for Western flower thrips, in a cut carnation greenhouse. HortTechnology 13: 497-500.

Davis, T. 1998. Dedicated to scouting. GMPro (Greenhouse Management and Production) 18(11): 16-20.

Lyon, S., R. Van Driesche, K. Jacques, T. Smith, and P. Lopes. 2003. How much are you paying for whitefly control on poinsettia? Is biological control affordable? Floral Notes 14(1):7-11.

Shaw, J. 1996. Research reveals professional scouting saves money. GrowerTalks 59(14): 16.

Stevens, T. J., R. L. Kilmer, and S. J. Glenn. 2000. An economic comparison of biological control and conventional control strategies for whiteflies (Homoptera: Aleyrodidae) in greenhouse poinsettias. J. Econ. Entomol. 93: 623-629.

Van Driesche, R. G., and S. Lyon. 2003. Massachusetts grower achieves whitefly control on poinsettia with biological control at 10 cents a plant – as cheap as pesticides and a lot easier. Floral Notes 15(5):8-10.

OFA

Chapter 10

Greenhouse Productivity

James E. Faust, Clemson University

Greenhouse productivity is largely determined by the efficiency with which greenhouse space is utilized. Greenhouse space use is a function of how many plants can be grown in a fixed space and how fast those crops can be grown. The number of plants grown is limited by how much space each plant requires and how much light can be delivered to that space, while crop timing is determined by the greenhouse environment. Thus, one can conclude that greenhouse productivity is determined by the efficient utilization of temperature, light, and plant growth regulators.

Temperature

Temperature determines the rate of plant development. In other words, temperature affects crop timing. For spring production, temperature affects the number of crop turns in a given greenhouse space.

Having multiple temperature environments can improve greenhouse productivity. Take, for example, a business that has two greenhouses. During the late winter, petunias and New Guinea impatiens are transplanted into 4-inch pots and placed pot-to-pot in one greenhouse with a 68°F night temperature, while the other greenhouse remains empty. As winter comes to an end, the petunias are moved to the empty house which is now set to maintain a relatively low night temperature (50°F), and the New Guinea impatiens are re-spaced into the space previously occupied by the petunias. The petunias grow more slowly in the cool greenhouse, but the fuel costs are relatively low, while the New Guinea impatiens continue to grow well in the warm greenhouse. This scenario allows the grower to maximize the productivity in the warm greenhouse because a lower cost, minimum-heated facility is available for crops that tolerate cooler temperatures. Many spring crops grow very well and produce very high quality crops at cool temperatures. See Table 10-1.

Light

The light delivered to individual crops has a large impact on plant quality for three reasons. First, and most obvious, more light intercepted results in more photosynthesis and subsequently more plant growth. Second, competition for light amongst neighboring plants has a tremendous impact on stem elongation. Under high density production, plants stretch and quality is diminished. Third, photoperiod affects time to flower of many species; therefore faster crop production is possible, if proper photoperiods are delivered.

Table 10-1. List of low-temperature tolerance of various spring greenhouse crops.

Species that grow well at cool (50-65°F) temperatures*	Species that require warm (>68°F) temperatures for adequate growth
Argyranthemum	Ageratum
Bacopa	Angelonia
Brachyscome	Basil
Calibrachoa	Begonia
Cineraria	Celosia
Dianthus	Coleus
Diascia	Dusty Miller
Lobelia	Geranium
Nemesia	Impatiens
Osteospermum	Marigold
Pansy	New Guinea impatiens
Perennials (most species)	Nicotiana
Petunia	Peppers
Primula	Portulaca
Snapdragon	Salvia (red)
Verbena	Scaevola
	Vinca
	Zinnia

*Note: cool temperatures will nearly always increase the time to flower; however, these species will continue to make reasonable progress to flower under cool temperatures. In contrast, the species with a warm temperature requirement will experience large delays in time to flower and very long crop times when grown at cool temperatures.

Daily Light Integral

Daily light integral (DLI) refers to the daily light sum or light quantity delivered to a greenhouse crop. The unit for this measurement is moles/day (or mol $m^{-2} d^{-1}$), and most greenhouses will provide approximately 5 to 10 moles/day during the winter while 10 to 25 moles/day are typically delivered from spring through the fall. Plant growth is closely linked to the DLI delivered to greenhouse crops. The DLI measurement is a relatively new concept for the greenhouse industry, however new equipment is currently available that allows growers to easily make these measurements. *(See the FIRST Web site for a thorough discussion of the DLI concept for greenhouse operators; www.firstinfloriculture.org. Research Reports are located under the Research Grants tab.)*

Supplemental Lighting

Growers often have little control over the amount of light delivered to crops during winter months, during which time light definitely limits crop growth and quality. Supplemental lighting can certainly be beneficial. During the winter, supplemental lighting with high-pressure sodium lamps may well increase the DLI delivered to the crop by 25 percent to 100 percent, resulting in decreased time to flower.

Hanging Basket Production

During the spring, the number of hanging baskets grown overhead has a large impact on the amount of light that actually reaches the bench crops. The density of hanging baskets in a greenhouse is calculated by dividing the number of baskets by the area of the greenhouse. For example, if a 25-foot x 100-foot greenhouse contains two lines of hanging baskets and those lines have 66 baskets each (18-inch linear spacing), then 132 baskets are divided by 2,500 square feet. The hanging basket density is 0.0528 baskets/square foot or 0.47 baskets/square yard. (In this chapter, we will use baskets/square yard since this is a larger number.) This is considered to be a relatively low hanging basket density. The maximum hanging basket density observed in commercial greenhouses is approximately three baskets/square yard, if crops are going to be grown under the baskets; however, many factors influence the actual number of baskets that can be grown overhead. (Note: this discussion assumes the use of 10-inch hanging baskets. Larger baskets will obviously intercept more light.)

How many baskets can be grown overhead without affecting the bench crop? The simple answer is "none," since every basket intercepts light and every reduction in light will cause a slight reduction in plant growth and quality. The better question is "How many baskets can be grown while still producing a good quality bench crop?" The answer to that question depends on several factors, such as the size of the plant in the baskets. These factors will now be discussed.

Time of year and geographic location. The ambient light levels, or DLI, change dramatically during the year. The lowest light levels occur in December, while the highest DLI occurs in June. During the winter, the light levels decrease as one moves toward more northern locations. In contrast, the summer light levels are not much different from Florida to Maine or from Texas to Minnesota. In terms of hanging basket production, the most important consideration is to appreciate the rapidity with which the light levels increase during the spring production season (from January to May) and during fall production (from August to November). Each month during spring, the total amount of light available for plant growth (the DLI) increases by 20 percent to 40 percent. Thus, in January and February the number of baskets that can be grown overhead is very limited; while in April and May relatively high basket densities can be sustained, if excessive shade cloth is not used. This is noted because it is not uncommon for the April light levels in a greenhouse to actually be lower than March light levels because excessive shade (>60 percent) was placed on the greenhouse.

Plant size. The size of the plant growing in the hanging basket is a very important factor to consider. When hanging baskets are first hung, the plant in the basket is usually smaller than the basket. So, the plant doesn't intercept very much light that would otherwise reach the bench crop. However, as the crop grows, the plants may eventually intercept more light than the containers themselves. Fortunately, hanging baskets are not usually getting large until later in the spring, when the DLI is much higher than in February and March. If the hanging baskets can be marketed at a relatively small size, one can grow a lot more baskets and still allow sufficient light to be delivered to the bench crop.

Container color. The color of the hanging basket container is also important, since green containers can intercept nearly twice the light compared to white containers. The reflective white surface of hanging baskets can significantly increase light transmission of a crop. This is particularly true early in the hanging basket season when the plants are relatively small. As the plant in the hanging basket grows bigger, less light reflects off the side of the pot, so the effect of container color on light transmission is diminished. Our measurements indicate that white baskets intercept approximately half the light compared to green baskets. For example, if a particular arrangement of green baskets intercepted 10 percent of the light, then white baskets would be expected to intercept half that percentage, or 5 percent.

Line orientation. Hanging basket lines can be run north-south or east-west. North-south lines are recommended, because the shadow pattern across the benches is constantly changing, which results in a more uniform growing environment. East-west lines create relatively constant shadow patterns, especially from October to March. The result is poor uniformity of light delivered to the bench crops, thus some plants can receive much higher light levels than neighboring crops. Poor light uniformity creates a problem with watering, since light interception and water use are closely correlated.

Bench crop. The light requirements of the bench crop influence how many hanging baskets can be grown overhead. Obviously, more baskets can be grown over an impatiens crop than a marigold crop. Differences can also be observed amongst bedding plants that are considered to be "full sun" landscape plants. For example, ageratum and red salvia perform quite well at moderate light levels, while the quality of vinca and zinnia is much better at high light levels.

Hanging basket density. Based on this discussion, it is difficult to generalize the effect that hanging baskets have on light penetration to the bench crop. So, Figure 10-1 is an approximation. The bottom line represents the light interception of hanging baskets in which the plants are not reaching over the edge of the pot. As the plants grow over the edge of the pots, the line moves upward. The upper line represents a plant that is approximately 20 to 22 inches in diameter. Certainly, large plants, such as ferns and fuchsias may reach 24 inches wide or more.

Example:

Three lines of green hanging baskets are in a 21-foot x 100-foot greenhouse section. Each line has baskets arranged in a staggered spacing so that the linear spacing is 12 inches between each basket (Figure 10-2). This provides a hanging basket density of 1.3 baskets/square yard. While the baskets have small plants, Figure 10-1 suggests that those baskets intercept 13 percent; as the plants grow (Figure 10-3), the light interception increases to 32 percent.

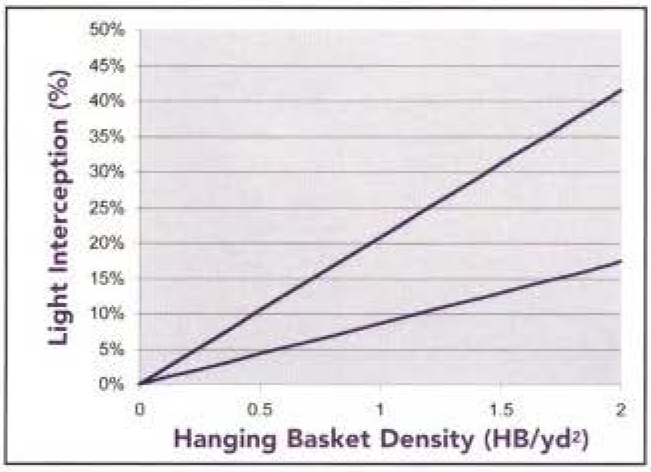
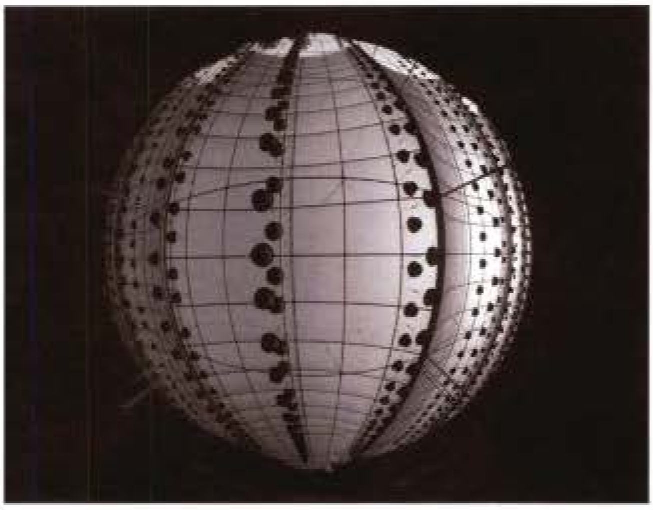


Figure 10-1. The estimated effect of hanging basket density on light interception by the baskets. The lower line represents empty baskets, while the upper line represents hanging baskets that contain a mature plant. For example, hanging baskets placed in a greenhouse at a density of one basket per square yard will initially intercept ~8 percent of the sunlight. As the plants in the baskets grow, the light interception will increase up to ~21 percent.

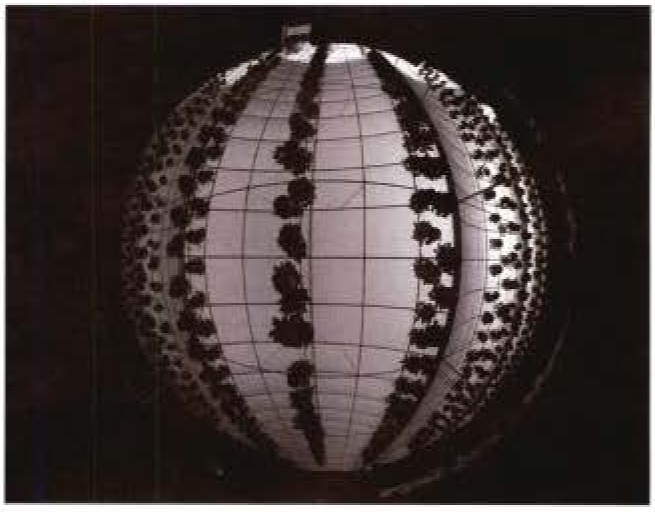
Shade Cloth Considerations

From late spring to early fall, shade cloth or whitewash is usually placed on greenhouses to assist with temperature control. The shade is not usually applied because the plants prefer lower light levels, but only to avoid heat stress. If a greenhouse cooling system is sufficient for temperature control, then no shade is required.

In recent years, many growers have invested in retractable shade curtain systems. These systems allow the curtains to open (no shade) when the ambient light conditions are low and then to close



Figures 10-2 (A: above) and 10-3 (B: below). Photographs of hanging baskets shot with a fish-eye camera lens. Green hanging baskets were grown with three lines per bay (21 feet wide) and the baskets placed 12 inches apart on the lines and arranged in a staggered spacing. **A.** Hanging baskets without plants intercepted 13 percent of the light, while **B.** hanging baskets with plants intercepted 32 percent of the light.



(provide shade) when light levels are high. These systems allow growers to provide higher DLI, while still providing shade during the hottest part of sunny days to minimize heat stress.

Retractable shade design and management. It is easy to provide excessive shade without being aware that you are doing so. First of all, the human eye is a fairly poor light sensor, because our eyes effectively adjust to low light levels. Actual light measurements should be regularly made inside the greenhouse to make sure that light levels are sufficiently high. In general, light intensities should be at 3,000 to 5,000 footcandles for most greenhouse crops (10 to 20 moles/day). Lower light levels will delay flowering and reduce lateral shoot growth, thus reducing plant quality.

Shade curtains are usually rated to provide 40 percent to 85 percent shade. In most situations, shade curtains that provide greater than 60 percent shade should be avoided, while 40 percent to 50 percent shade curtains work well for many growing situations. The actual percentage depends on the crops being grown and the cooling capacity of the greenhouse. For example, bedding plants benefit from higher light levels than many flowering potted plants, while a greenhouse equipped with fan and pad cooling requires less shade than a passively ventilated greenhouse.

Retractable shade curtains can be operated so they are partially open or closed. It is common to provide a slight (5 percent) crack in the curtains during warm weather to allow for ventilation to occur. It is usually not advisable to partially close a curtain (e.g. 50 percent closed), since this causes some of the bench crop to receive high light while the other portion of the crop receives shade. This creates irrigation challenges, since the plants receiving high light will use considerably more water than the shaded crops. Finally, a north-south curtain orientation (i.e. the curtain opens east to west) provides a more uniform shadow pattern when the curtains are open (retracted).

The best shade curtain strategy for most finished crops is to provide as high a light level as possible while minimizing heat stress and drought stress. For example, provide more than 3,000 footcandles unless temperatures exceed 95°F or plants are wilting and time is required before they can be watered.

Space Utilization & Light Quality

Light Quality. Light quality refers to the specific wavelengths of light delivered to a plant. Plants intercept red light quite efficiently, while far red light is transmitted through the leaf or reflected off the leaf. Thus, the environment immediately surrounding a plant tends to have relatively low red light and relatively high far red light. The ratio of red to far red light is a signal to plants that neighboring plants are competing for sunlight. The plant's response to neighboring plants is to increase stem elongation so the leaves are in a higher position and light interception remains high. As a result, the red-to-far red light ratio has a tremendous effect on stem elongation. In practical terms, stem elongation increases as plant density increases. So, close spacing diminishes plant quality by reducing the light quantity that is intercepted and by altering the red to far red light ratio (Figure 10-4). Therefore, the strategic use of plant growth regulators can be used to help control the increasing rate of stem elongation and thus become a key factor to influence space utilization and ultimately greenhouse profitability.

Extra Space. During peak production, it is possible to place plants in places that were not normally designed for plant production, such as under benches and in the aisles. Low light-requiring plants can tolerate these positions for a period of time, then they can be moved to better locations as space opens up. Impatiens, caladiums, spring bulbs, and foliage are examples of crops that tolerate very low light for a period of time.

Spacing Patterns. Proper spacing patterns should not be trivialized, because they can allow 5 percent to 15 percent more containers to fit in a fixed space. A spreadsheet is available on the OFA Web site to assist growers with calculating the best spacing patterns for your specific facility.

Figure 10-4. Two red salvia plants in 4-inch pots that are the same age and were grown in the space greenhouse. **Left:** Salvia grown pot-to-pot (16 square inches per plant); **Right:** Salvia grown on 5.6-inch x 5.6-inch spacing (32 square inches per plant). Note that the two plants are flowering at the same time, but the plant grown pot-to-pot is much taller due to the tight plant canopy which alters the light quality or red-to-far red light ratio. Proper use of plant growth regulators on the left plant could have produced a plant similar to the one on the right, while allowing for twice the number of pots produced in the same area.

There are three patterns that can be used to place round pots on a bench or floor (Figure 10-5: spacing patterns). The most efficient spacing pattern varies based on the specific dimensions of the bench or floor, although the staggered patterns are nearly always superior to the square pattern.

Photoperiod

Photoperiod manipulation can be a useful tool for increasing greenhouse productivity, since photoperiod affects the production timing (flowering) of many species. For bedding plant and herbaceous perennial production, many species are either day-neutral or long-day plants. Thus, long days can be provided using night-interruption lighting to accelerate flowering and reduce production time of the responsive species, while having no effect (positive or negative) on the day-neutral species. Short-day plants will be negatively affected (delayed flowering) by night-interruption lighting; however there are not many of these, so they can be placed in an un-lit section of the greenhouse. African marigold and some red salvia cultivars are examples of short-day bedding plants. Petunia and calibrachoa are spring crops that often benefit tremendously by providing long days during late winter and early spring. The faster crop time allows for more crop turns and thus more efficient use of greenhouse space.

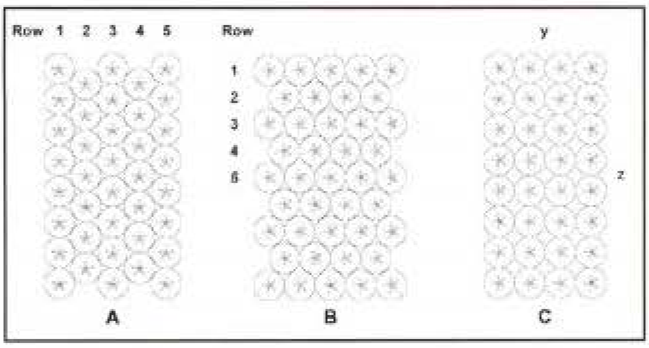


Figure 10-5. There are three possible arrangements for round pots (or round spacing patterns, e.g. 8-inch x 8-inch spacing), A. Long-staggered, B. Short-staggered, and C. Square. Each method will allow a different number of pots to fit in a specific area. A spreadsheet is available through the OFA Web site to assist growers with calculating which spacing pattern works best for your specific facility. A spreadsheet is available through the "OFA Bookstore" on the OFA Web site to assist growers with calculating which spacing pattern works best for your specific facility (http://www.ofa.org/pdf/Ch10BenchSpaceCalculator.xls).

Spreadsheet Notes

- This spreadsheet cannot account for non-circular spacing patterns; e.g., 6 inches x 8 inches.
- Also, the spacing arrangements suggested by the spreadsheet should be verified on an actual bench, because there are possible fractional errors that cannot be accounted for with the spreadsheet. For example, it is possible that a specific arrangement requires 6 feet, 0.2 inches for 10 rows to fit on a bench, while the bench is only 6 feet. In this situation, the spreadsheet will only allow 9 rows to be placed on the bench. The loss of one entire row may have a dramatic effect on the number of pots that fit on that bench. In reality, most growers would squeeze that extra row if it extends the bench area by only 0.2 inch.
- One way to reduce fractional errors is to input the actual space that a crop can occupy on a bench, not the specific bench dimensions. For example, if a bench is 6 feet x 20 feet, in reality 6 feet, 4 inches x 20 feet, 4 inches may be used for a poinsettia crop, since the crop can be spaced so it eventually extends 2 inches off the edge of the bench on all 4 sides.

Acknowledgement: The information in this chapter was developed with the financial support of FIRST. The author also acknowledges the contribution of several colleagues on these projects including Pam Korczynski, Kelly Lewis, and Elizabeth Will.

OFA

Chapter 11

Comparing Crop Revenue

Peter Konjoian, Konjoian's Floriculture Education Services

The perspective presented in earlier chapters was from the cost side of the profit equation. Detailed discussions and recommendations on calculating costs of production formed the foundation of those chapters. In this and following chapters, a different perspective will be used to view greenhouse crop profitability. Instead of starting with a cost analysis, we will instead start by examining the revenue of a specific crop first, followed by a comparison of this crop to other crops that could be grown on the same greenhouse bench, floor, or in its overhead space.

The Challenge

Consider for a moment the spring cycle in a commercial greenhouse. If the operation is a retail business, there will be a very long list of crop species and cultivars in production. The number of different cultivars in production can easily reach several hundred, particularly in operations that are 1 acre and larger. Today, there are more crop species and cultivars at our fingertips than at any other time in our industry's history.

Wholesale businesses may offer a slightly narrower product mix than retail operations in order to specialize and capitalize on production efficiencies and economies of scale. However, wholesale operations tend to turn their inventory more often than their retail counterparts; and in the final analysis, with more plantings of each cultivar, their production schedules are just as complex and challenging to manage.

Additionally, if for each cultivar in production an individual sowing of seeds, sticking of cuttings, or shipment of either type of plug is considered to represent an independent schedule, then today's spring production cycle can approach and often exceed 1,000 individual schedules that need to be managed. Each planting of a single cultivar constitutes a separate schedule based on the reality that each cultivar, whether from seed or cutting, needs to be ordered, received, stored, handled, planted, grown, and followed through sales separately (Figure 11-1). Each cultivar requires its own line in the crop production table. Some cultivars within a crop species even carry their own, distinct cultural requirements.

The reality of the complexity of managing a spring production cycle brings both good and bad news. The bad news is that managing a thousand production schedules is mindboggling. The good news is that with so many choices, it's very easy for an operation to offer a customized product mix to its customers that is almost guaranteed to be unique. No single grower can possibly produce every species and cultivar available.

Deciding What To Grow

What factors enter into the decision of which crops, cultivars, and container sizes will be produced? Who decides whether a crop of 4-inch zonal geraniums will occupy a given bench, bay, or house versus a crop of 4-inch vegetative annuals? For those growers who can go back a few decades, who decided whether those benches of geraniums would be zonal or seed? Go back even further; who decided whether that greenhouse was going to continue to produce cut flowers or switch to potted and bedding plants?

A primary method used to help decide what to grow involves the business's customer base. What did they buy last year? What did they ask for that was not grown? If they asked for an item, was it added to this year's product mix? There's a rule of marketing developed for retailing that states if you don't hear at least three people complain that your price is too high on any given day – it means your price is actually too low. Consider this principle in allowing customers to help shape an operation's product mix. While it may be unreasonable to add every item that every customer asks for, it may be very reasonable to add an item when three different customers ask for it on the same day, or over the same weekend. Keep a running tally of who asks for what. Use this effort in advertising and marketing to tout the fact that the establishment is

Figure 11-1. Several sowings of petunias allow for quality product to be available for shipping over the entire spring season.

customer-driven. Customers feel empowered and more intimately connected to a business that listens and responds to their requests. This principle works for both retail and wholesale situations.

Other resources used to decide what crops to offer include seed and cutting salespersons, trade magazines, conferences, trade shows, gardening magazines, and gardening shows on radio and television. For those involved in the retail side of the spring rush, how many times have you seen customers come to your garden center or greenhouse with a page torn out of a magazine, asking for items listed by the author?

Another Perspective

Actually, most growers use all of the above resources to varying degrees to develop their product mix over time. One's product mix is always changing as improved cultivars, new species, and different container sizes come along. It is unlikely that any grower produces an identical product mix two years in a row.

With a production mix that is in such a constant state of flux from one season to the next, not only is it important to grow what customers want, but it is also important to shape the product mix to maximize profitability. It is generally agreed that any of us can fill our greenhouses with almost anything available commercially and sell it all. However, at the end of the day, have we made enough profit to stay in business for another year, another decade, or another generation of the family?

A popular crop that illustrates this point is the poinsettia. Fewer and fewer growers are choosing to remain in poinsettia production as more and more of them find that the crop is not generating sufficient profit to justify their effort. Some large growers find no alternative but to produce the crop to help pay down overhead expenses and keep their employees busy through the fall.

Given the above argument that the choices of what can be grown far exceed the capacity of any operation, another way of deciding what to grow focuses on growing what's most profitable. This statement appears to be insultingly simple, yet most growers do not have the necessary tools to analize profitability accurately enough to make difficult decisions.

Many growers can be called to the mat on this point. A common profitability discussion can go something like this: "Of course that item's profitable, I sold every plant that I raised! I wish I had twice as many, they'd have scooped them up like hotcakes over that busy weekend." Another version also sounds familiar: "I've been growing and selling this cultivar for 30 years. Sells out every spring, of course it's profitable." How about this one: "The cutting didn't cost much, the pot and medium don't amount to much, so of course I'm making a profit."

Lastly, in a recent OFA-produced Profitability Workshop, after working through a profit analysis for a popular 4-inch spring crop with the group of growers, it was determined that the crop was not profitable and was actually losing money. A workshop participant raised his hand and offered his solution. "That's okay, I can always make it up on volume." Case closed – slam the door shut!

Comparing Apples and Oranges

Consider making the following decision. Assume that production space is limited and we need to decide whether to grow 4.5-inch New Guinea impatiens or 12-inch mixed containers in a given section of the greenhouse. The New Guineas retail for $3.99; the mixed containers retail for $35.00. If push comes to shove, how would you decide which crop gets the production space?

Traditional cost accounting would have you calculate the variable costs such as pot, growing medium, plant material, and so on. Then you would consider heat, time, and other overhead costs. The final analysis yields a cost for each unit produced, either a single 4.5-inch pot of New Guinea or a single 12-inch mixed container. The analysis takes another step when the cost is subtracted from the selling price. Now we have a profit associated with each item, but where do we go next?

Yes it's helpful to determine how much profit we're generating per pot of New Guinea impatiens or per mixed container, but we really need to be able to compare the two items on equal footing. If the comparison stops here, we've only managed to compare apples to oranges. An additional step is needed before the comparison becomes useful.

It's All About the Square Foot

Previous chapters on cost analysis calculated the costs associated with each container and then accounted for crop density by considering spacing. It is necessary in order to determine heat and other overhead costs on a common basis. Accounting for crop spacing, and hence density, is a key consideration and becomes the common denominator needed for us to compare very different crops. Apples and oranges become the same thing, and that 4.5-inch New Guinea can now be compared to that 12-inch mixed container. It's all about square feet.

If this example crop of New Guinea impatiens is grown at 6-inch centers, we know that four plants will occupy each square foot. If each mixed container from this example is spaced on 18-inch centers, it will occupy 2.25 square feet or 0.44 (1 divided by 2.25 = 0.44) containers will occupy each square foot. Whether the calculation is done by a computer spreadsheet or by hand by the grower, this translation must be made if the comparisons are going to be meaningful.

Other Units of Measurement

Another way to compare crop profitability is to use a convenient, standard production unit as the common denominator. The Konjoian Greenhouse's production setup includes 30-foot-wide greenhouses with peninsular benches measuring 5 feet wide by 13.5 feet long, a total of approximately 68 square feet per bench. Each bench is considered as a comparable production unit. Using actual crop examples and rounding numbers slightly for simplicity, a 4.5-inch crop of geraniums spaced at 8-inch centers (2.25 plants/square foot) will have approximately 150 pots/bench and retail for $3.49 per pot. A 5-inch crop of New Guinea impatiens spaced at 10-inch centers (1.44 plants/square foot) will have approximately 100 plants/bench and retail for $5.99 per pot. A crop of 12-inch mixed containers spaced at 18-inch centers (0.44 containers/square foot) will have 30 containers/bench and retail for $35 per container.

A relatively simple way to begin comparing the crops is to calculate gross revenue on a per-bench basis. How much revenue will be generated by producing each of the crops being considered? Multiplying the number of units/bench by their respective selling prices produces this number. Using the three examples just described at the densities and retail prices stated, each bench of geraniums yields approximately $524, New Guineas yield $599, and mixed containers yield $1,050. Returning to the assumption that production space is fixed, does this analysis of gross revenue give us useful information? Is it indicating that mixed containers may be a wise decision?

Depending on the scale of the operation, the production unit will differ. For larger growers, the entire 30- x 100-foot greenhouse is the logical unit. For others, each bay of a gutter-connected range may constitute a unit. For still others, half- or full-acre ranges may be the useful unit. Regardless of the scale of production, comparing crops based on revenue generated per production unit can be an excellent early step in the process of determining crop, and hence business profitability.

Production Decisions

In reality, the example here needs to be interpreted further. Geraniums and New Guineas are proven staple crops for many growers and, as such, occupy significant production space. It may be unreasonable to interpret the example as meaning geraniums and New Guineas should be eliminated from the production mix completely and replaced by mixed containers. Volume of sales needs to be considered. It is also probably unreasonable to conclude that every bench currently used for geraniums and New Guineas could be filled with mixed containers. How many mixed containers are in demand?

A way the analysis can help guide production decisions is as follows. If mixed containers yield more revenue, it may be desirable to grow more – providing demand is present. If geraniums and New Guineas are yielding less revenue, it may be reasonable to take some benches out of production to grow more mixed containers.

Many growers agree that the staple, backbone crops of geraniums and New Guineas are approaching commodity conditions. Resulting pressure to lower prices or, at the very least, not increase prices accompanies commoditization of a product. The law of supply and demand states that one way to increase price is to limit supply in order to stimulate demand. Doesn't it make sense, therefore, to manage the product mix in the current example by reducing the quantities of geraniums and New Guineas grown to the point where demand increases their price and profitability? At the same time, their production space will be dedicated to mixed containers that generate almost twice as much revenue per bench unit.

If we had a marketing expert in this discussion, he or she would pat us on the back and say something like "Now you've got it! Niche marketing means specializing in profitable items that offer added value, while walking away from commodity items. But don't start feeling too good about yourselves, because it's also an economic law that today's value-added item will become tomorrow's commodity item." This is a cold, hard lesson of free market economics. Products naturally seek to become commodities over their life cycles.

OFA

Chapter 12

Square Foot Revenue Tables

Peter Konjoian, Konjoian's Floriculture Education Services

The Cost Analysis Spreadsheet presented in Chapter 2 (page 10) is an excellent tool for growers to use in calculating costs of production and profitability. For growers not yet comfortable with computers, and for instances where it is desirable to view several crop analyses on a single page, the following Revenue Tables are presented. In the near future, these tables will also be incorporated into a spreadsheet for computer-proficient growers.

Table Setup

The Revenue Tables have been developed to allow growers to compare gross revenue of different crops. The key component of the table is converting each crop from spacing between pots to its common density. Each crop to be compared must first be converted into units/square foot. By doing this, we are able to compare a 4-inch crop of geraniums to a crop of 16-inch mixed containers. The goal of this analysis is to determine which crops generate the most revenue to assist growers in determining a product mix that will maximize profitability.

Crop Spacing

Tables 12-1 through 12-5 (pages 66-70) are set up similarly. Refer to Table 12-1 (page 66) during the following description of how the tables have been developed. The two columns on the left represent crop spacing and density. Crop spacing is presented as "inches on center." For example, a 4-inch crop grown pot tight is spaced on 4-inch centers, the distance between the centers of two neighboring pots. If this same 4-inch crop is spaced using 2 inches of space between neighboring pots, it is spaced on 6-inch centers. If 14-inch mixed containers are given 10 inches of space between pots, their spacing is on 24-inch centers. The most common method of spacing finds pots spaced equal distances, which results in a square space.

The range of spacings presented in the table starts at 24 inches for large containers and ends at 3 inches for very small pots. The last two spacings, represented by 6/1020 and 8/1020 represent bedding packs in traditional 1020 trays. Six packs per flat refers to the most common 606 and 612 configurations. Eight packs per flat refers to the most common 806 and 804 configurations. In the wholesale tables, Tables 12-4 and 12-5 (pages 69-70), the 6/1020 configuration has been replaced by a 12/1020 unit.

The value of the information in the tables to assist us in analyzing crop revenue begins to take shape when one realizes that the container size has little to do with the analysis. While most growers are primarily tuned in to what size pot a crop is grown in, it really doesn't matter at this stage of the discussion. Crop spacing and subsequent crop density are much more influential factors, as will be seen throughout this chapter. Whether we want to compare two different crops grown in 4-inch pots such as zonal geraniums and New Guinea impatiens, two different pot sizes of the same crop such as 4- and 6-inch vegetative petunias, or 806 packs of annuals to 16-inch mixed containers – the comparison becomes easy once the common denominator of units per square foot is calculated. Therefore, it's not the container size but the spacing that influences the determination of revenue and subsequent profitability.

Crop Density

The transformation of crop spacing to crop density takes place in the second column headed "units/sq.ft." in each table. Easy examples to refer to are 12-inch and 6-inch spacings. Spacing containers on 12-inch centers means each pot occupies a 12-inch by 12-inch space or 144 square inches, one square foot. When pots are spaced on 6-inch centers, each pot occupies a 6-inch by 6-inch space or 36 square inches. Dividing 36 square inches into a square foot, 144 square inches, yields a density of four pots per square foot of space.

The two left columns of Table 12-1 therefore present, from top to bottom, wider spacings with lower crop densities to tighter spacings with higher crop densities. While it was stated earlier that container size doesn't really influence the analysis, it is a fact of greenhouse life that wider spacings are used for larger containers and tight spacings are used for smaller ones. Smaller containers allow for higher production densities. Lastly, the cell pack configurations are presented out of order, at the bottom of the table, for visual simplicity and also because bedding plants are often considered their own category.

Selling Price

Tables 12-1, 12-2, and 12-3 present retail prices, and Tables 12-4 and 12-5 present wholesale prices. Retail pricing is presented with the commonly accepted last digit "9" and $0.10 as the smallest increment between prices. Wholesale pricing is presented with $0.25 as the smallest increment between prices. Table 12-1 presents the retail price range from $0.49 through $99.99. The bottom section of the table is a continuation of the top. Table 12-2 presents a more detailed listing of retail price points with smaller increments between successive prices. Its range however is narrower, extending from $0.49 through $9.99. Table 12-3 presents a more detailed view of the $9.99 through $99.99 retail price range. In each of the tables presenting retail pricing, prices in bold print represent established psychological price points. These are price barriers in the consumer's mind that influence buying decisions and will be discussed in a later chapter. These psychological price points do not apply to the wholesale side of business. Some would argue that, in the wholesale arena, ANY price increase represents a psychological barrier in a buyer's mind.

Revenue Determination

Now that the table setup is familiar, what do the numbers in the body of each table represent? Again, using Table 12-1 to illustrate, consider the following two extreme scenarios. Suppose we grow a crop at a wide spacing (low density) and sell it for a very low price. Find the row and column representing a crop grown on 24-inch centers (density of 0.25 units/square foot) that is sold for $0.49. The cell in the table found where the row and column intersect represents the revenue/square foot that will be generated by a single crop cycle of this item. In this extreme example, only $0.12/square foot will be realized.

On the other end of the range, let's suppose we grow a crop at a very tight spacing (high density) and sell it for a very high price. Find the row and column representing a crop grown on 3-inch centers (density of 16 units/square foot) that is sold for $99.99. In this extreme example, $1,600/square foot will be realized. While the first example would put us out of business, the second would retire us after a single season.

Because the low and high ranges of the table represent extreme situations, revenue figures generally below $5.00/square foot are not presented and are identified as "Not Profitable," while those above $50.00/square foot are not presented and are identified as "Unrealistically Profitable." Because wholesale pricing is generally lower than retail, the wholesale tables use the general range of $2.50/square foot as the low limit and $25.00/square foot as the high limit.

Worksheets

These five basic tables are intended to be photocopied and used as worksheets. It is suggested that several copies of each table be made and to avoid marking the tables on these pages in order to preserve the originals for future duplication. Chapter 13 will illustrate how the tables can be used.

Table 12-1. Revenue/square foot as a function of crop spacing and general retail price range of $0.49-99.99.

Spacing (center)	Units/ sq.ft.	Retail Price																		
		$0.49	0.69	0.79	**0.99**	1.29	**1.49**	1.79	**1.99**	2.29	**2.49**	2.99	3.49	3.99	**4.99**	5.99	6.99	7.99	8.99	**9.99**
24"	0.25	0.12																		
20	0.36																			
18	0.44						NOT PROFITABLE													
15	0.64																4.47	5.11	5.75	6.39
12	1.00														4.99	5.99	6.99	7.99	8.99	9.99
10	1.44												5.03	5.75	7.19	8.63	10.07	11.51	12.95	14.39
8	2.25								4.48	5.15	5.60	6.73	7.85	8.98	11.23	13.48	15.73	17.98	20	22
6	4.00				3.96	5.16	5.96	7.16	7.96	9.16	9.96	11.96	13.96	15.96	20	24	28	32	36	40
5	5.76			4.55	5.70	7.43	8.58	10.31	11.46	13.19	14.34	17.22	20	23	29	35	40	46	52	
4.5	7.11		4.91	5.62	7.04	9.17	10.59	12.73	14.14	16.28	17.70	21	25	28	35	43	50			
4	9.00	4.41	6.21	7.11	8.91	11.61	13.41	16.11	17.91	21	22	27	31	36	45					
3.5	11.76	5.76	8.11	9.29	11.64	15.17	17.52	21	23	27	29	35	41	47						
3	16.00	7.84	11.04	12.64	15.84	21	24	29	32	37	40	48								
6/1020*	4.00				3.96	5.16	5.96	7.16	7.96	9.16	9.96	11.96	13.96	15.96	20	24	28	32	36	40
8/1020*	5.33			4.21	5.28	6.88	7.94	9.54	10.61	12.21	13.27	15.94	18.60	21	27	32	37	43	48	

Spacing (center)	Units/ sq.ft.	Retail Price																		
		11.99	12.99	**14.99**	16.99	17.99	18.99	**19.99**	**24.99**	29.99	34.99	39.99	**44.99**	49.99	54.99	59.99	69.99	79.99	89.99	**99.99**
24"	0.25						4.75	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00	17.50	20	23	25
20	0.36		4.68	5.40	6.12	6.48	6.84	7.20	9.00	10.80	12.60	14.40	16.20	18.00	19.80	22	25	28	32	36
18	0.44	5.28	5.72	6.60	7.48	7.92	8.36	8.80	11.00	13.20	15.40	17.60	20	22	24	26	31	35	40	44
15	0.64	7.67	8.31	9.59	10.87	11.51	12.15	12.79	15.99	19.19	22	26	29	32	35	38	45	51		
12	1.00	11.99	12.99	14.99	16.99	17.99	18.99	19.99	25	30	35	40	45	50						
10	1.44	17.27	18.71	22	24	26	27	29	36	43	50									
8	2.25	27	29	34	38	40	43	45												
6	4.00	48	52																	
5	5.76																			
4.5	7.11																			
4	9.00												UNREALISTICALLY PROFITABLE							
3.5	11.76																			
3	16.00																			1600
6/1020*	4.00																			
8/1020*	5.33																			

Bold prices: psychological price points.
* cell packs; 6 packs per 1020, 8 packs

Table 12-2. Revenue/square foot as a function of crop spacing and detailed retail price range of $0.49-9.99.

Spacing (center)	Units/ sq.ft.	Retail Price																		
		$0.49	0.59	0.69	0.79	0.89	**0.99**	1.09	1.19	1.29	1.39	**1.49**	1.59	1.69	1.79	1.89	**1.99**	2.09	2.19	2.29
24"	0.25																			
20	0.36																			
18	0.44					NOT PROFITABLE														
15	0.64																			
12	1.00																			
10	1.44																			
8	2.25																4.48	4.70	4.93	5.15
6	4.00								4.76	5.16	5.56	5.96	6.36	6.76	7.16	7.56	7.96	8.36	8.76	9.16
5	5.76				4.55	5.13	5.70	6.28	6.85	7.43	8.01	8.58	9.16	9.73	10.31	10.89	11.46	12.04	12.61	13.19
4.5	7.11			4.91	5.62	6.33	7.04	7.75	8.46	9.17	9.88	10.59	11.30	12.02	12.73	13.44	14.15	14.86	15.57	16.28
4	9.00	4.41	5.31	6.21	7.11	8.01	8.91	9.81	10.71	11.61	12.51	13.41	14.31	15.21	16.11	17.01	17.91	18.81	20	21
3.5	11.76	5.76	6.94	8.11	9.29	10.47	11.64	12.82	13.99	15.17	16.35	17.52	18.70	20	21	22	23	25	26	27
3	16.00	7.84	9.44	11.04	12.64	14.24	15.84	17.44	19.04	21	22.24	24	25	27	29	30	32	33	35	37
6/1020*	4.00								4.76	5.16	5.56	5.96	6.36	6.76	7.16	7.56	7.96	8.36	8.76	9.16
8/1020*	5.33					4.74	5.28	5.81	6.34	6.88	7.41	7.94	8.47	9.01	9.54	10.07	10.61	11.14	11.67	12.21

Spacing (center)	Units/ sq.ft.	Retail Price																		
		2.39	**2.49**	2.79	2.89	2.99	3.49	3.99	4.49	**4.99**	5.49	5.99	6.49	6.99	7.49	7.99	8.49	8.99	9.49	**9.99**
24"	0.25																			
20	0.36																			
18	0.44																			
15	0.64														4.79	5.11	5.43	5.75	6.07	6.39
12	1.00									4.99	5.49	5.99	6.49	6.99	7.49	7.99	8.49	8.99	9.49	9.99
10	1.44						5.03	5.75	6.47	7.19	7.91	8.63	9.35	10.07	10.79	11.51	12.23	12.95	13.67	14.39
8	2.25	5.38	5.60	6.28	6.50	6.73	7.85	8.98	10.10	11.23	12.35	13.48	14.60	15.73	16.85	17.98	19.10	20	21	22
6	4.00	9.56	9.96	11.16	11.56	11.96	13.96	15.96	17.96	20	22	24	26	28	30	32	34	36	38	40
5	5.76	13.77	14.34	16.07	16.65	17.22	20	23	26	29	32	35	37	40	43	46	49	52	55	58
4.5	7.11	16.99	17.70	20	21	21	25	28	32	35	39	43	46	50						
4	9.00	21	22	25	26	27	31	36	40	45	49									
3.5	11.76	28	29	33	34	35	41	47			UNREALISTICALLY PROFITABLE									
3	16.00	38	40	45	46	48														
6/1020*	4.00	9.56	5.60	6.28	6.50	11.96	13.96	15.96	17.96	20	22	24	26	28	30	32	34	36	38	40
8/1020*	5.33	12.74	13.27	14.87	15.40	15.94	18.60	21	24	27	29	32	35	37	40	43	45	48	51	

Bold prices: psychological price points.
* cell packs; 6 packs per 1020, 8 packs

Table 12-3. Revenue/square foot as a function of crop spacing and detailed retail price range of $9.99-99.99.

Spacing (center)	Units/ sq.ft.	Retail Price																		
		9.99	10.49	10.99	11.49	11.99	12.49	12.99	13.99	**14.99**	15.99	16.99	17.99	18.99	**19.99**	20.99	21.99	22.99	23.99	**24.99**
24"	0.25														5.00	5.25	5.50	5.75	6.00	6.25
20	0.36								5.04	5.40	5.76	6.12	6.48	6.84	7.20	7.56	7.92	8.28	8.64	9.00
18	0.44		4.61	4.84	5.06	5.28	5.50	5.72	6.16	6.60	7.04	7.48	7.92	8.36	8.80	9.24	9.68	10.12	10.56	11.00
15	0.64	6.39	6.71	7.03	7.35	7.67	7.99	8.31	8.95	9.59	10.23	10.87	11.51	12.15	12.79	13.43	14.07	14.71	15.35	15.99
12	1.00	9.99	10.49	10.99	11.49	11.99	12.49	12.99	13.99	14.99	15.99	16.99	17.99	18.99	20	21	22	23	24	25
10	1.44	14.39	15.11	15.83	16.55	17.27	17.99	18.70	20	22	23	24	26	27	29	30	32	33	35	36
8	2.25	22	24	25	26	27	28	29	31	34	36	38	40	43	45	47	49	52		
6	4.00	40	42	44	46	48	50													
5	5.76																			
4.5	7.11																			
4	9.00									UNREALISTICALLY PROFITABLE										
3.5	11.76																			
3	16.00																			
6/1020*	4.00	40	42	44	46	48	50													
8/1020*	5.33																			

Spacing (center)	Units/ sq.ft.	Retail Price																		
		25.99	26.99	27.99	28.99	29.99	34.99	39.99	44.99	**49.99**	54.99	59.99	64.99	69.99	74.99	79.99	84.99	89.99	94.99	99.99
24"	0.25	6.50	6.75	7.00	7.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00	16.25	17.50	18.75	20	21	22	24	25
20	0.36	9.36	9.72	10.08	10.44	10.80	12.60	14.40	16.20	17.80	20	22	23	25	27	29	31	32	34	36
18	0.44	11.43	11.88	12.32	12.76	13.20	15.40	17.60	20	22	24	26	29	31	33	35	37	40	42	44
15	0.64	16.63	17.27	17.90	18.55	19.19	22	26	29	32	35	38	42	45	48	51				
12	1.00	26	27	28	29	30	35	40	45	50										
10	1.44	37	39	40	42	43	50													
8	2.25																			
6	4.00																			
5	5.76																			
4.5	7.11																			
4	9.00									UNREALISTICALLY PROFITABLE										
3.5	11.76																			
3	16.00																			
6/1020*	4.00																			
8/1020*	5.33																			

Bold prices: psychological price points.
* cell packs; 6 packs per 1020, 8 packs

Table 12-4. Revenue/square foot as a function of crop spacing and wholesale price range of $0.75-10.00.

Spacing (center)	Units/ sq.ft.	Wholesale Price																		
		$0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25
24"	0.25																			
20	0.36		NOT PROFITABLE																	
18	0.44														1.76	1.87	1.98	2.09	2.20	2.31
15	0.64									1.76	1.92	2.08	2.24	2.40	2.56	2.72	2.88	3.04	3.20	3.36
12	1.00						2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	5.25
10	1.44			1.80	2.16	2.52	2.88	3.24	3.60	3.96	4.32	4.68	5.04	5.40	5.76	6.12	6.48	6.84	7.20	7.56
8	2.25	1.69	2.25	2.81	3.38	3.94	4.50	5.06	5.63	6.19	6.75	7.31	7.88	8.44	9.00	9.56	10.13	10.69	11.25	11.81
6	4.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20	21
5	5.76	4.32	5.76	7.20	8.64	10.08	11.52	12.96	14.40	15.84	17.28	18.72	20	22	23	24	25			
4.5	7.11	5.33	7.11	8.89	10.67	12.44	14.22	16.00	17.78	19.55	21	23	25							
4	9.00	6.75	9.00	11.25	13.50	15.75	18.00	20	23	25										
3.5	11.76	8.82	11.76	14.70	17.64	21	24	26				UNREALISTICALLY PROFITABLE								
3	16.00	12.00	16.00	20	24	28														
8/1020*	5.33	4.00	5.33	6.66	8.00	9.33	10.66	11.99	13.32	14.66	15.99	17.32	18.66	20	21	23	24	25		
12/1020*	8.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20	22	24	26								

Spacing (center)	Units/ sq.ft.	Wholesale Price																		
		5.50	5.75	6.00	6.25	6.50	6.75	7.00	7.25	7.50	7.75	8.00	8.25	8.50	8.75	9.00	9.25	9.50	9.75	10.00
24"	0.25								1.81	1.88	1.94	2.00	2.06	2.13	2.19	2.25	2.31	2.38	2.44	2.50
20	0.36		2.07	2.16	2.25	2.34	2.43	2.52	2.61	2.70	2.79	2.88	2.97	3.06	3.15	3.24	3.33	3.42	3.51	3.60
18	0.44	2.42	2.53	2.64	2.75	2.86	2.97	3.08	3.19	3.30	3.41	3.52	3.63	3.74	3.85	3.96	4.07	4.18	4.29	4.40
15	0.64	3.52	3.68	3.84	4.00	4.16	4.32	4.48	4.64	4.80	4.96	5.12	5.28	5.44	5.60	5.76	5.92	6.08	6.24	6.40
12	1.00	5.50	5.75	6.00	6.25	6.50	6.75	7.00	7.25	7.50	7.75	8.00	8.25	8.50	8.75	9.00	9.25	9.50	9.75	10.00
10	1.44	7.92	8.28	8.64	9.00	9.36	9.72	10.08	10.44	10.80	11.16	11.52	11.88	12.24	12.60	12.96	13.32	13.68	14.04	14.40
8	2.25	12.38	12.94	13.50	14.06	14.63	15.19	15.75	16.31	16.88	17.44	18.00	18.56	19.13	20	20	21	21	22	23
6	4.00	22	23	24	25															
5	5.76																			
4.5	7.11																			
4	9.00																			
3.5	11.76																			
3	16.00																			
8/1020*	5.33																			
12/1020*	8.00																			

* cell packs; 8 packs per 1020, 12 packs

Table 12-5. Revenue/square foot as a function of crop spacing and wholesale price range of $10.00-50.00.

Spacing (center)	Units/ sq.ft.	Wholesale Price																		
		$10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	17.50	20.00	25.00	30.00	35.00	40.00	45.00	50.00
24"	0.25	2.50	2.66	2.75	2.88	3.00	3.13	3.25	3.38	3.50	3.63	3.75	4.38	5.00	6.25	7.50	8.75	10.00	11.25	12.50
20	0.36	3.60	3.78	3.96	4.14	4.32	4.50	4.68	4.86	5.04	5.22	5.40	6.30	7.20	9.00	10.80	12.60	14.40	16.20	18.00
18	0.44	4.40	4.62	4.84	5.06	5.28	5.50	5.72	5.94	6.16	6.38	6.60	7.70	8.80	11.00	13.20	15.40	17.60	20	22
15	0.64	6.40	6.72	7.04	7.36	7.68	8.00	8.32	8.64	8.96	9.28	9.60	11.20	12.80	16.00	19.20	22	26		
12	1.00	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50	14.00	14.50	15.00	17.50	20.00	25.00	30.00				
10	1.44	14.40	15.12	15.84	16.56	17.28	18.00	18.72	19.44	20	21	22	25							
8	2.25	23	24	25	26															
6	4.00																			
5	5.76																			
4.5	7.11																			
4	9.00										UNREALISTICALLY PROFITABLE									
3.5	11.76																			
3	16.00																			
8/1020*	5.33																			
12/1020*	8.00																			

* cell packs; 8 packs per 1020, 12 packs

Chapter 13

Pricing and Square Foot Revenue Examples

Peter Konjoian,
Konjoian's Floriculture Education Services

The revenue tables presented in the previous chapter can be used to help identify crops that are very profitable as well as those that are not profitable. These considerations are necessary while striving to grow the most profitable product mix possible.

Assumptions

Two important pieces of our profitability puzzle need to be discussed before proceeding. First, these tables represent crop spacing situations that are constant throughout the crop cycle and do not account for progressive spacing. Second, one must keep in mind that these tables only present gross revenue figures. They do not present any cost analysis information, nor do they account for crop loss. Use of these tables provides a quick and easy way to determine which crops and crop spacings, associated with their corresponding selling prices, generate the most revenue for a given bench, bay, or range.

Case Study

An advantage of being both a commercial grower and an academic is that textbook knowledge and experience have an opportunity to blend together in ways that strengthen each. I will use examples from my retail growing operation in Massachusetts to illustrate how the information in the tables has assisted me in recent production decisions.

Konjoian's Greenhouse is a 45,000-square-foot retail grow-and-sell operation located in Andover, MA. The evolution of the family business is typical of many throughout the country. Through the early and mid-1900s, we operated a truck farm and raised fresh vegetables marketed through our wholesale produce market in nearby Boston. In 1960, the first greenhouse was built, and geraniums, bedding plants, and hanging baskets formed the product mix. Crops were retailed directly from the greenhouse. The business grew from 2,500 square feet in 1960 to 55,000 square feet in 1990. Poinsettias and year-round production were managed from the mid-1970s to mid-1990s. During the last decade, the operation reacted to market pressures by returning to a spring-only cycle and reduced growing space by 10,000 square feet to its current size of slightly more than 1 acre.

The current product mix includes high-end hanging baskets and mixed containers, a full assortment of 4-inch spring crops, and flowering and vegetable cell packs. Vegetatively propagated crops are replacing seed-propagated crops, and cell pack business is declining due to this fact and mass market pressure. Quality, service, and a unique product mix are the current core strengths of the business which is run by my parents, two brothers, and myself.

Table 13-1 (page 72) will be used in the first part of the case study, and Table 13-2 (page 76) will be used in the second part. The exercise in part one will be to compare revenue generation from a number of existing crops in an effort to identify crops serving as profit centers and those serving as profit drains. The crops to be compared include:

Crop Description	**Spacing; Density**	**Retail Price**
5-inch New Guinea impatiens	10"; 1.44/sq.ft.	$5.99
4.5-inch seed geranium	8"; 2.25/sq.ft.	3.49
3.5-inch vegetative annual	18 count flat; 11.76/sq.ft.	2.49
606 cell pack seed annual	6 packs/flat; 4/sq.ft.	2.99
804 cell pack vegetative annual	8 packs/flat; 5.33/sq.ft.	5.99
16-inch mixed tub	24"; 0.25/sq.ft.	89.99
14-inch mixed hanging basket	20"; 0.36/sq.ft.	69.99
10-inch mixed hanging basket	18"; 0.44/sq.ft.	34.99

One of the additional questions this exercise helped answer was whether I could afford to grow hanging baskets and large mixed containers on prime bench space around my range. For decades, we had operated under the assumption that hanging baskets have to be hung in the greenhouse and that they had no business occupying bench space that could be used for potted crops. As demand for hanging baskets grew over the years, our greenhouses got to the point where, if a single additional basket was hung, the quality of the bench crops below would be jeopardized due to insufficient light. The solution called for either raising the retail price of our baskets because we could not raise any more, or produce more. By the way, building additional greenhouses was not an option.

Can hanging basket production be justified on benches? Can large mixed tubs be grown on 24-inch centers and compete with geraniums grown on 8-inch centers? Which crop generates more revenue, more profit? See Figures 13-1 to 13-4 (page 73).

Table 13-1. Revenue/square foot comparisons of various spring crops.

Spacing (center)	Units/ sq.ft.	Retail Price																		
		$0.49	0.69	0.79	**0.99**	1.29	1.49	1.79	1.99	2.29	**2.49**	2.99	3.49	3.99	**4.99**	5.99	6.99	7.99	8.99	**9.99**
24"	0.25	0.12																		
20	0.36																			
18	0.44						NOT PROFITABLE													
15	0.64																4.47	5.11	5.75	6.39
12	1.00														4.99	5.99	6.99	7.99	8.99	9.99
10	1.44												5.03	5.75	7.19	**8.63**	10.07	11.51	12.95	14.39
8	2.25								4.48	5.15	5.60	6.73	**7.85**	8.98	11.23	13.48	15.73	17.98	20	22
6	4.00				3.96	5.16	5.96	7.16	7.96	9.16	9.96	11.96	13.96	15.96	20	24	28	32	36	40
5	5.76			4.55	5.70	7.43	8.58	10.31	11.46	13.19	14.34	17.22	20	23	29	35	40	46	52	
4.5	7.11		4.91	5.62	7.04	9.17	10.59	12.73	14.14	16.28	17.70	21	25	28	35	43	50			
4	9.00	4.41	6.21	7.11	8.91	11.61	13.41	16.11	17.91	21	22	27	31	36	45					
3.5	11.76	5.76	8.11	9.29	11.64	15.17	17.52	21	23	27	**29**	35	41	47						
3	16.00	7.84	11.04	12.64	15.84	21	24	29	32	37	40	48								
6/1020*	4.00				3.96	5.16	5.96	7.16	7.96	9.16	9.96	**11.96**	13.96	15.96	20	24	28	32	36	40
8/1020*	5.33			4.21	5.28	6.88	7.94	9.54	10.61	12.21	13.27	15.94	18.60	21	27	**32**	37	43	48	

Spacing (center)	Units/ sq.ft.	Retail Price																		
		11.99	12.99	**14.99**	16.99	17.99	18.99	**19.99**	**24.99**	29.99	34.99	39.99	44.99	**49.99**	54.99	59.99	69.99	79.99	89.99	99.99
24"	0.25						4.75	5.00	6.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00	17.50	20	**23**	25
20	0.36		4.68	5.40	6.12	6.48	6.84	7.20	9.00	10.80	12.60	14.40	16.20	18.00	19.80	22	**25**	28	32	36
18	0.44	5.28	5.72	6.60	7.48	7.92	8.36	8.80	11.00	13.20	**15.40**	17.60	20	22	24	26	31	35	40	44
15	0.64	7.67	8.31	9.59	10.87	11.51	12.15	12.79	15.99	19.19	22	26	29	32	35	38	45	51		
12	1.00	11.99	12.99	14.99	16.99	17.99	18.99	19.99	25	30	35	40	45	50						
10	1.44	17.27	18.71	22	24	26	27	29	36	43	50									
8	2.25	27	29	34	38	40	43	45												
6	4.00	48	52																	
5	5.76																			
4.5	7.11																			
4	9.00											UNREALISTICALLY PROFITABLE								
3.5	11.76																			
3	16.00																			
6/1020*	4.00																			
8/1020*	5.33																			

Bold prices: psychological price points.
* cell packs; 6 packs per 1020, 8 packs

Figure 13-1. Hanging baskets of ivy geraniums being finished on benches.

Figure 13-3. 16-inch mixed tubs being finished on benches.

Figure 13-2. 14-inch mixed hanging baskets being finished on benches.

Figure 13-4. How does traditional 4.5-inch seed geranium production compare to hanging baskets and mixed containers in terms of profitability? Which crops yield higher profit margins?

Numbers Don't Lie

Revenue numbers for the crops listed on page 71 can be found by connecting the row in Table 13-1 representing the crop's spacing and density with the column representing its selling price. The appropriate rows and columns in the table are shaded for easy identification; the revenue numbers are in bold print where each pair of rows and columns intersect. Revenue figures for the crops are:

Crop Description	Spacing; Density(units/sq.ft.)	Retail Price($)	Revenue ($/sq.ft.)
5-inch New Guinea impatiens	10"; 1.44/sq.ft.	5.99	8.63
4.5-inch seed geranium	8"; 2.25/sq.ft.	3.49	7.85
3.5-inch vegetative annual	18 count flat; 11.76/sq.ft.	2.49	29.00
606 cell pack seed annual	6 packs/flat; 4/sq.ft.	2.99	11.96
804 cell pack vegetative annual	8 packs/flat; 5.33/sq.ft.	5.99	32.00
16-inch mixed tub	24"; 0.25/sq.ft.	89.99	23.00
14-inch mixed hanging basket	20"; 0.36/sq.ft.	69.99	25.00
10- inch mixed hanging basket	18"; 0.44/sq.ft.	34.99	15.40

Next we'll rank the various crops to identify revenue and profit trends:

Crop Description	Spacing; Density(units/sq.ft.)	Retail Price($)	Revenue ($/sq.ft.)
804 cell pack vegetative annual	8 packs/flat; 5.33 sq.ft.	5.99	32.00
3.5-inch vegetative annual	18 count flat; 11.76 sq.ft.	2.49	29.00
14-inch mixed hanging basket	20"; 0.36 sq.ft.	69.99	25.00
16-inch mixed tub	24"; 0.25 sq..ft.	89.99	23.00
10-inch mixed hanging basket	18"; 0.44 sq.ft.	34.99	15.40
606 cell pack seed annual	6 packs/flat; 4.00 sq.ft.	2.99	11.86
5-inch New Guinea impatiens	10"; 1.44 sq.ft.	5.99	8.63
4.5-inch seed geranium	8"; 2.25 sq.ft.	3.49	7.85

Commodity Floriculture

Beginning in the early 1990s, the mass market began its explosive growth in the floriculture arena. Since then, a number of traditional crop species and container sizes have seemingly become commodity items with accompanying declining prices. Four-inch production and bedding packs have fallen into this category, and many growers are struggling to maintain profitability with these crops.

When one considers the ranked table of gross revenue generated by the list of crops in this case study, who can argue that the profit centers in my operation lie in the area of specialty vegetative annuals, large mixed tubs, and mixed hanging baskets? The 4- and 5-inch pots of traditional crops such as seed geraniums and New Guinea impatiens, as well as cell packs of bedding plants, are at the bottom of the list.

To be fair, however, we must acknowledge that the commodity crop categories are accompanied by significantly higher production volume. I have a higher demand for 4- and 5-inch geraniums and New Guineas than I have for large mixed tubs and baskets. Life is not as easy as deciding to shift all of my bench space to mixed containers – I couldn't sell them all for the prices I'm currently commanding. The most basic economic law of supply and demand governs my decisions.

Product Mix Decisions

Given our current analysis, the answer to my question "Can I afford to raise hanging baskets and large containers on my prime benches?" is a resounding YES! Who would argue that growing a 16-inch mixed tub on 24-inch centers, generating gross revenue of $23/square foot, is not profitable compared to using that same bench space to grow 4.5-inch seed geraniums which generate $7.85/square foot?

Consider again that I'm not interested in expanding my production capacity. I'm in the category of growers who have answered the question "Do you feel that you're working harder and harder and making less and less?" with a categorical YES. Building more greenhouses is not an option at this point. Raising the profitability of the bench space I currently have is the priority in our current business climate.

What will happen to the profitability of my seed geranium crop if I shift some of its production space to mixed containers? By growing fewer seed geraniums, in other words limiting the supply, can I expect their price to rise? Taking this to an extreme, if I limit my seed geranium production to the point where my customers are fighting over them, shouldn't I be able to increase my retail price? **The law of supply and demand works in floriculture just as well as it does in any other industry.** By taking production space away from seed geraniums, my commodity crop, and putting it into large mixed containers, I accomplish two things that BOTH improve profitability. First, the mixed containers generate a whole lot more money on the same benches and, second, limiting the seed geranium supply will help raise its price and subsequent profitability.

What Do Your Numbers Say?

This may be a good time for you to start analyzing your own product mix using the revenue tables in these chapters. As you begin to connect the columns and rows to arrive at gross revenue figures for your operation, keep in mind the following assumptions that have been made to keep the tables relatively simple. First, crop shrinkage is not factored into the tables. It has been established that the plants NOT sold have a significant impact on the profit of those that are sold. Second, keep in mind that the tables represent final spacing; progressive spacing impacts the cost analysis and is accounted for in the cost analysis spreadsheet presented in Chapter 2 (page 10).

These tables should not be used to split hairs. In other words, without considering the cost analysis side of the equation, I should not base a decision of whether to grow 4.5-inch seed geraniums, which in my example generate $7.85/square foot, or 5-inch New Guinea impatiens which generate $8.63/square foot, on this analysis alone. For crops whose gross revenues are so close to one another, the final profit picture will be tied to production costs.

To Space or Not to Space

Another way to use the revenue tables is to compare a crop grown at different densities. It is a known fact that giving a crop more space results, within reason, in larger plants that command higher prices. Crop spacing is a good distinguishing factor between many small retail operations and large wholesale operations. Retailers are more willing to give crops more space and grow the crop longer in order to have a larger, higher quality crop to market at higher prices. Wholesale growers are not as willing to use their production space this way, because price pressures are greater in their arena.

An example is presented in Table 13-2, page 76, that illustrates a single crop grown at different spacings (densities). Consider a 4.5-inch crop grown pot-tight – 7.11 pots/square foot with a retail selling price of $1.99; the same crop grown on 6-inch centers – four pots/square foot with a retail price of $3.49; and also grown on 8-inch centers – 2.25 pots/square foot with a retail price of $5.99. The revenue per square foot generated by growing at these three densities and prices is $14.15, $13.96, and $13.48 respectively. On the surface, it appears that all three strategies are sound.

Our example has some limitations however. Are the retail prices assigned to the three crop qualities obtained by the various spacings realistic? Each grower needs to base his or her analysis on realistic prices in his or her marketplace. That said, it may be an excellent exercise to use the table using a "what if" approach. "If I give a pot-tight crop 2 inches of space, what price do I have to get in order to generate equal revenue?" "If I offer quantity discounts such as '10 for' pricing, what is the discounted price that will generate acceptable revenue?" And don't forget, these hypothetical cases need to be completed by considering the cost analysis to provide a true profit analysis. Lastly, what percent of the crop will not make it out the front door? How does shrinkage affect the profit picture?

Table 13-2. Revenue/square foot comparisons of a single crop grown at various spacings.

Spacing (center)	Units/ sq.ft.	Retail Price																		
		$0.49	0.59	0.69	0.79	0.89	**0.99**	1.09	1.19	1.29	1.39	**1.49**	1.59	1.69	1.79	1.89	**1.99**	2.09	2.19	2.29
24"	0.25																			
20	0.36																			
18	0.44					NOT PROFITABLE														
15	0.64																			
12	1.00																			
10	1.44																			
8	2.25																4.48	4.70	4.93	5.15
6	4.00								4.76	5.16	5.56	5.96	6.36	6.76	7.16	7.56	7.96	8.36	8.76	9.16
5	5.76				4.55	5.13	5.70	6.28	6.85	7.43	8.01	8.58	9.16	9.73	10.31	10.89	11.46	12.04	12.61	13.19
4.5	7.11			4.91	5.62	6.33	7.04	7.75	8.46	9.17	9.88	10.59	11.30	12.02	12.73	13.44	**14.15**	14.86	15.57	16.28
4	9.00	4.41	5.31	6.21	7.11	8.01	8.91	9.81	10.71	11.61	12.51	13.41	14.31	15.21	16.11	17.01	17.91	18.81	20	21
3.5	11.76	5.76	6.94	8.11	9.29	10.47	11.64	12.82	13.99	15.17	16.35	17.52	18.70	20	21	22	23	25	26	27
3	16.00	7.84	9.44	11.04	12.64	14.24	15.84	17.44	19.04	21	22.24	24	25	27	29	30	32	33	35	37
6/1020*	4.00								4.76	5.16	5.56	5.96	6.36	6.76	7.16	7.56	7.96	8.36	8.76	9.16
8/1020*	5.33					4.74	5.28	5.81	6.34	6.88	7.41	7.94	8.47	9.01	9.54	10.07	10.61	11.14	11.67	12.21

Spacing (center)	Units/ sq.ft.	Retail Price																		
		2.39	**2.49**	2.79	2.89	2.99	3.49	3.99	**4.49**	4.99	5.49	5.99	6.49	6.99	7.49	7.99	8.49	8.99	9.49	9.99
24"	0.25																			
20	0.36																			
18	0.44																			
15	0.64														4.79	5.11	5.43	5.75	6.07	6.39
12	1.00									4.99	5.49	5.99	6.49	6.99	7.49	7.99	8.49	8.99	9.49	9.99
10	1.44						5.03	5.75	6.47	7.19	7.91	8.63	9.35	10.07	10.79	11.51	12.23	12.95	13.67	14.39
8	2.25	5.38	5.60	6.28	6.50	6.73	7.85	8.98	10.10	11.23	12.35	**13.48**	14.60	15.73	16.85	17.98	19.10	20	21	22
6	4.00	9.56	9.96	11.16	11.56	11.96	**13.96**	15.96	17.96	20	22	24	26	28	30	32	34	36	38	40
5	5.76	13.77	14.34	16.07	16.65	17.22	20	23	26	29	32	35	37	40	43	46	49	52	55	58
4.5	7.11	16.99	17.70	20	21	21	25	28	32	35	39	43	46	50						
4	9.00	21	22	25	26	27	31	36	40	45	49									
3.5	11.76	28	29	33	34	35	41	47			UNREALISTICALLY PROFITABLE									
3	16.00	38	40	45	46	48														
6/1020*	4.00	9.56	5.60	6.28	6.50	11.96	13.96	15.96	17.96	20	22	24	26	28	30	32	34	36	38	40
8/1020*	5.33	12.74	13.27	14.87	15.40	15.94	18.60	21	24	27	29	32	35	37	40	43	45	48	51	

Bold prices: psychological price points.
* cell packs; 6 packs per 1020, 8 packs

Chapter 14

Completing the Profitability Equation

Peter Konjoian, Konjoian's Floriculture
Education Services

The final step in the profitability equation requires the basic mathematical function of subtraction. Once revenue and costs of production have been calculated for a series of crops, profitability can be calculated using the equation: Profit = Revenue – Costs.

The table from the previous chapter that ranks crops produced in my greenhouse during the spring of 2004 will be expanded in this chapter to complete the profitability discussion. The completion of this exercise will help me determine crop production mix for 2005 and advance my niche marketing strategies for upcoming seasons. The following table (Table 14-1) is reprinted from the previous chapter and includes gross revenue figures, on a square foot basis, for the eight crops discussed. Revenue was calculated based on crop spacing (density) and retail selling price using revenue tables from Chapter 12.

Production Costs

Several columns will be added to Table 14-1 to complete the profitability equation. The new columns are added next, accompanied only by the table's first crop for simplicity.

First, a column representing cost of production on a per-unit basis is inserted in the table and titled "Cost/pot." Numbers in this column were calculated using the cost analysis spreadsheet developed by Dr. Jim Faust in Chapter 2 (page 10). For this discussion of the profitability equation, the spreadsheet analysis was only followed through to the cost/pot number.

Second, to compare different crops as we did in the revenue discussion, the cost/pot is transformed into "cost/square foot." This calculation is based on crop spacing (density): it is calculated by multiplying the density (number of units per square foot) times the cost per unit. In the 804 cell pack example in the table, the cost/square foot is calculated by multiplying the number of packs/square foot (5.33) times the cost/pack ($1.79): 5.33 x $1.79 = $9.54.

Third, profitability of this crop is calculated by subtracting the cost/square foot from the revenue/square foot. In this example of 804 cell packs of vegetative annuals, the Revenue – Costs = Profit calculation is: $32.00 – $9.54 = $22.46.

Summarizing the analysis: the production of vegetative annuals in 804 cell packs that retail for $5.99/pack generates $32.00/square foot in gross revenue, costs $9.54/square foot to produce, and yields $22.46/square foot in profit.

Table 14-1. Revenue per square foot of various crop categories as a function of crop density and retail selling price.

Crop Description	Spacing; Density (units/ft^2)	Retail price($)	Revenue ($/$ft^2$)*
804 cell pack vegetative annual	8 packs/flat; 5.33 ft^2	5.99	32.00
14-inch mixed hanging basket	20"; 0.36 ft^2	69.99	25.00
3.5-inch vegetative annual	1801 flat; 11.76 ft^2	2.49	29.00
16-inch mixed tub	24"; 0.25 ft^2	79.99	20.00
10-inch mixed hanging basket	18"; 0.44 ft^2	29.99	13.20
606 cell pack seed annual	6 packs/flat; 4.00 ft^2	2.99	11.86
5-inch New Guinea impatiens	10"; 1.44 ft^2	5.99	8.63
4.5-inch seed geranium	8"; 2.25 ft^2	3.49	7.85

* Revenues greater than $20.00 rounded to nearest dollar.

Crop Description	Spacing; Density (units/ft^2)	Retail price($)	Cost/ Pot	Revenue ($/$ft^2$)	Cost/ ($/$ft^2$)	Profit ($/$ft^2$)
804 cell pack vegetative annual	8 packs/flat; 5.33 ft^2	5.99	1.79	32.00	9.54	22.46

The Big Picture

The complete table is presented in Table 14-2 and includes production costs and profit calculations for all eight crops in the case study. It is interesting in this analysis that the ranked order of crops that was based on gross revenue/square foot did not change upon completion of the profitability calculation. Note that the crop of 804 vegetative annuals returned the highest profit/square foot on my entire range, more than $22/square foot. This item was added to our production mix mainly for our do-it-yourselfers, those gardeners who already have pots and hanging baskets and enjoy planting their own containers (Figure 14-1). The small cell size is also appropriate for our customers who want to replant strawberry jars with more than seed bedding plants (Figure 14-2).

The 3.5-inch vegetative annual, also referred to as an "1801" flat, is the next item on my list of profitable crops, yielding nearly $20/square foot in profit. Our largest mixed baskets and tubs follow at just under $19 and $17/square foot, respectively. Once we get to the more traditional items – namely 10-inch baskets, bedding packs of seed annuals, 5-inch New Guinea impatiens, and 4.5-inch seed geraniums, the profit/square foot drops to less than $10.

This analysis and table has really opened my eyes as to what crops are making money and what crops are approaching commodity environments (Figures 14-3 to 14-7). Production decisions cannot be made solely on these numbers, however. I could never replace all of my traditional crop production with specialty crops, because there is a limit to how many of these unusual items my clientele demands. The volume of the business generated by 4.5-inch seed geraniums and 5-inch New Guinea impatiens still contributes significant profit to my operation.

Another way to use the numbers generated by this profitability analysis is as follows. Each season I try

Table 14-2.

Crop Description	Spacing; Density (units/ft²)	Retail price($)	Cost/ Pot	Revenue ($/ft²)	Cost/ ($/ft²)	Profit ($/ft²)
804 cell pack vegetative annual	8 packs/flat; 5.33 ft²	5.99	1.79	32.00	9.54	22.46
3.5-inch vegetative annual	1801 flat; 11.76 ft²	2.49	0.77	29.00	9.06	19.94
14-inch mixed hanging basket	20"; 0.36 ft²	69.99	17.64	25.00	6.35	18.65
16-inch mixed tub	24"; 0.25 ft²	89.99	24.36	23.00	6.09	16.91
10-inch mixed hanging basket	18"; 0.44 ft²	34.99	12.59	15.40	5.54	9.86
606 cell pack seed	6 packs/flat; 4.00 ft²	2.99	1.21	11.86	4.84	7.02
5-inch New Guinea impatiens	10"; 1.44 ft²	5.99	2.06	8.63	2.97	5.66
4.5-inch seed geranium	8"; 2.25 ft²	3.49	1.41	7.85	3.17	4.68

Figure 14-1. Offering 3.5-inch pots of items displayed in larger containers allows consumers to choose a retail price point that fits their budget.

Figure 14-2. Small plants can be very profitable for consumers looking to replant containers such as strawberry jars with small openings.

Figure 14-3. Four-packs of helichrysum retail for $5.99 and generate a profit of $22.46 per square foot. Cuttings are stuck directly into the cell packs, treated with Florel, and finished in six weeks.

Figure 14-5. Six-packs of New Guinea impatiens (three packs per flat) are equivalent to 3.5-inch production with 18 plants per flat and can be quite profitable.

Figure 14-4. Calibrachoa grown in 3.5-inch pots (an 18-count flat) generate $19.94 profit per square foot.

Figure 14-6. A 16-inch mixed tub retailing for $89.99 generates significantly more profit per square foot than 4.5-inch seed geranium production.

Figure 14-7. A mixed 10-inch basket.

to identify the most and least profitable items in my product mix. Production is either reduced or eliminated completely for the least profitable item(s) to dedicate more production space to increasing production of the most profitable item(s). Remember one caveat I mentioned earlier; I am not interested in expanding production space in the current economic climate. See Figures 14-8 to 14-11.

Do Gross Revenue and Profitability Always Correlate?

In this case study, it is very clear that gross revenue and profitability correlate well. In fact, the discussion presented in Chapter 13 was accurate: using revenue/square foot figures has been an accurate analysis on which I can base production and marketing decisions. However, revenue and profit will not always correlate this well. Costs of production always influence their relationship and need to be established, at least to form a solid baseline.

A return to the pH analogy presented in this book's introduction can help us once again, this time to understand this correlation factor. We recommend testing media pH throughout a crop's production cycle, but we only need to test our irrigation water pH and alkalinity two or three times each year. Think of performing the cost analysis as often as is needed to become confident in the numbers. Unless input costs change drastically and suddenly, a good baseline can be established with only an occasional cost analysis. On the other hand, routine revenue analysis using crop spacing and selling price as factors can offer valuable insight to maximizing profitability.

Figure 14-8. Shifting this house from traditional 4.5-inch production to mixed baskets and containers has significantly increased the profitability of the production space.

Figure 14-9. Traditional New Guinea impatiens production showing 5-inch pots on benches and hanging baskets above.

Figure 14-10. Here, 5-inch New Guinea impatiens are spaced on 10-inch centers.

Figure 14-11. Seed geranium production; 4.5-inch pots spaced on 8-inch centers.

What's the Answer?

This discussion is NOT inferring that controlling costs of production is not important in today's commercial greenhouse. Growers who do not control their production costs are often those who are forced out of business. However, as important as it is to control production costs, this case study shows that other factors can be even more influential in maximizing greenhouse profitability. Production decisions based on container size, spacing, and selling price can have significantly more effect on maximizing profitability than merely trying to cut costs. Growers can occasionally become enamored with focusing on the wrong side of the profitability equation by applying too much attention to cutting production costs.

Learning to trust the economic law of supply and demand can help a business find its most profitable niche. Returning to my case study, the profitability analysis proves that taking bench space in my range out of traditional crop production such as 4.5-inch seed geraniums and 5-inch New Guinea impatiens and replacing it with interesting sizes of vegetative annuals and mixed containers accomplished two things that BOTH improve overall profitability.

First, it's a no-brainer to grow as many of these specialty crops as my customers want to buy. Money would be left on the table by not recognizing their desire to purchase new and different plant material in sizes that range from extremely small to extremely large. Second, reducing the quantity (supply) of seed geraniums and New Guinea impatiens should eventually stimulate how my customers see these crops (demand). The result should be higher prices for these traditional items due to limited supply. Shifting my production philosophy to accommodate these two crop categories is an excellent way to maximize overall profitability (Figure 14-12).

Figure 14-12. Shifting production space from 4-inch crops to large mixed containers has improved overall profitability and exploits a niche market opportunity.

OFA

Chapter 15

Profitability in the Greenhouse Industry

Wen-fei L. Uva, Cornell University

In the previous chapters of this book, you have learned how to determine resources used to generate income from different greenhouse crops. This chapter will discuss how to evaluate the overall profitability and financial performance of your greenhouse business. Profitability is measured as the level of net returns to the business operator(s) and unpaid family member(s) for their labor contribution, management effort, and equity capital. Financial performance of a business can be assessed by comparing your business with others in the same industry (benchmark comparison), tracking the business's performance over time (trend analysis), or assessing it against your own management objectives.

Measuring Profitability of Your Greenhouse Business – The Income Statement

Profit is the difference between sales and costs of production and is measured by constructing an accrual income statement – more specifically, an income statement that makes accrual adjustments. An income statement is a summary of receipts and expenses for a specific accounting period (usually a year). Many greenhouse businesses keep records for tax purposes on a cash basis. However, cash accounting only reveals money received or spent during the year. When income and expenses associated with a product are not incurred in the same accounting period, accrual adjustments need to be made to cash accounting to reflect the true receipts and expenses in that particular time period.

For example, expenses are incurred and paid to produce a spring bulb crop in November and December of one year, but the crop is not sold until the following January and February (the next accounting year); or a poinsettia crop is sold in November and December of one year, but payments are not received until January or February of the following accounting year. In these situations, accrual adjustments need to be made to reconcile the true receipts and expenses associated with marketing and production of specific crops in the given year.

When constructing an income statement to evaluate business profitability, accrual adjustments need to be made to cash receipts and expenses for changes in inventories of products and supplies, prepaid expenses, and accounts payable and receivable during the accounting period. The following two examples demonstrate how to make accrual accounting adjustments to cash receipts and expenses. If it seems to be too confusing, work with your accountant to make those adjustments, – but do not skip it. If your income statement is based only on cash transactions, it may take a year to realize that a business is experiencing a loss and the extent of the loss. That will greatly hinder your ability to respond in a timely manner to stop the loss and prevent an adverse impact on your business.

Example 1 shows some situations in which we will need to make accrual adjustments to cash sales for accounts receivable and inventory changes during the accounting year. Changes in accounts receivable and inventory during the accounting year can be determined by comparing the differences between the beginning and ending accounts receivable values or the beginning and ending inventory values. The beginning accounts receivable and inventory values can be obtained from the previous year's balance sheet, and the ending accounts receivable and inventory values can be obtained from the current year's balance sheet.

If you have cash receipts of $100,000 during the accounting year, and the ending accounts receivable exceeds the beginning accounts receivable by $10,000, a positive adjustment of $10,000 to the cash income is required to indicate that, in addition to the cash sales, your true total income for the accounting year includes additional sales made during the accounting year, but you have yet not received the payments at the end of the year. Therefore, the accrual sales are $110,000. On the other hand, if the beginning accounts receivable exceeds the ending accounts receivable by $10,000, a negative adjustment of $10,000 to the cash income is required to indicate that, some of the cash receipts are from payments made for sales occurred in the previous accounting year and should not be included in income for the current accounting year. Therefore, your accrual sales are $90,000.

Similarly, if you have cash receipts of $100,000 during the accounting year, and the ending inventory exceeds the beginning inventory by $10,000, a positive adjustment is required to reflect the fact that some of the products produced during this period remain in inventory and have not been sold. The accrual sales are $110,000. Conversely, if the beginning inventory exceeds the ending inventory by $10,000, a negative adjustment of $10,000 is required to indicate that, in addition to this year's production, some of the initial inventory items were sold and are already included in the previous year's income.

Moreover, **Example 2** shows situations in which we will need to make accrual adjustments to cash expenses for accounts payable and supply inventory changes during the accounting year. Again, changes in accounts payable and supply inventory during the accounting year can be determined by comparing the differences between the beginning and ending values for accounts payable and supply inventory obtained from the previous and current years' balance sheets.

If you have cash expenses of $20,000 during the accounting year, and the ending accounts payable exceeds the beginning accounts receivable by $1,000, a positive adjustment of $1,000 to the cash expenses is required to indicated that, in addition to the cash expenses, your true total expenses for the accounting year includes additional expenses you made during the accounting year, but you have not yet paid for them at the end of the year. Therefore, the accrual expenses are $21,000. In a case when the beginning accounts payable exceeds the ending accounts payable by $1,000, a negative adjustment of $1,000 to the cash expenses is required to indicate that some of the cash expenses are used to pay for expenses incurred during the previous accounting year and should not be included in expenses for the current accounting year. Therefore, your accrual expenses are $19,000.

In contrast, if you have cash expenses of $20,000 during the accounting year, and the ending supply inventory exceeds the beginning supply inventory by $1,000, a negative adjustment is required to reflect the fact that some of the supplies you purchased during this period have not been used in production this year. Therefore, the accrual expenses for your production this year should be $19,000. Finally, if the beginning supply inventory exceeds the ending supply inventory by $1,000, a positive adjustment of $1,000 is required to indicate that, in addition to this year's supply expenses, some of the supply inventory from the previous year was used in this year's production. So the accrual expenses for your production this year should be $21,000.

An income statement lists receipts (revenue), expenses (variable and fixed costs), and profit (net income) in a structured format. Table 15-1 (page 84) shows a sample income statement for a greenhouse business with 40,000 square feet of production area. Many of the revenue and cost items in this table are discussed in previous chapters. There is more than one way to categorize them. You should organize them in a way best suitable for your own management purpose. Profitability in the income statement is expressed in the following ways:

- **Gross Margin:** It is the difference between the accrual revenue and the accrual variable costs and is often expressed as a percentage of sales (receipts). It is what is available to contribute to fixed costs and profit after the variable costs have been paid. A competitive benchmark for small businesses is a gross margin of 30 percent to 40 percent. The average gross margin for a survey with 45 New York greenhouse businesses is 28.3 percent in 2001, and the top 20 percent of these greenhouses with the highest gross margins averaged 37.2 percent.
- **Net Income or Profit Margin:** It is the difference between total receipts and total expenses (variable and fixed costs). Net income is the total combined return to the greenhouse operator and other unpaid family members for their labor, management, and equity capital. Generally, a small business needs to aim for a net income of

Example 1. An Accrual Adjustment to Sales.

Cash Sales	Change in Accounts Receivable during an Accounting Period	Accrual Sales
$100,000	Increased by 10,000 (+ $10,000)	$110,000
$100,000	Decreased by 10,000 (- $10,000)	$90,000

Cash Sales	Change in Product Inventory during an Accounting Period	Accrual Sales
$100,000	Increased by 10,000 (+ $10,000)	$110,000
$100,000	Decreased by 10,000 (- $10,000)	$90,000

Example 2. An Accrual Adjustment to Expenses.

Cash Expenses	Change in Accounts Payable during an Accounting Period	Accrual Expenses
$20,000	Increased by 1,000 (+ $1,000)	$21,000
$20,000	Decreased by 1,000 (- $1,000)	$19,000

Cash Expenses	Change in Supply Inventory during an Accounting Period	Accrual Expenses
$20,000	Increased by 1,000 (- $1,000)	$19,000
$20,000	Decreased by 1,000 (+ $1,000)	$21,000

Table 15-1. This is an example of an annual accrual income statement for a representative greenhouse business with 40,000 square feet of production area*:

	Total Amount	$/ft²	$/SFW	% of sales
RECEIPTS				
Wholesale greenhouse crops	$366,557	$9.16	$0.235	62.1%
Retail greenhouse crops	208,472	$5.21	$0.134	35.3%
Other income	14,861	$0.37	$0.010	2.5%
TOTAL ACCRUAL INCOME (A)	***$589,890***	***$14.75***	***$0.378***	***100.0%***
EXPENSES				
Direct Variable Costs				
Hired Direct/Production Labor	$159,890	$4.00	$0.102	27.1%
Seeds and Plants	109,802	$2.75	$0.070	18.6%
Fertilizer and Spray Chemicals	9,355	$0.23	$0.006	1.6%
Soil Mix Components	16,020	$0.40	$0.010	2.7%
Packaging Materials	28,478	$0.71	$0.018	4.8%
Hard Goods/Merchandise	31,672	$0.79	$0.020	5.4%
Indirect Variable Costs				
Hired Indirect/Office Labor	$13,789	$0.34	$0.009	2.3%
Advertising	$12,879	$0.32	$0.008	2.2%
Heating Fuel	36,457	$0.91	$0.023	6.2%
Gas/Diesel	4,301	$0.11	$0.003	0.7%
Electricity	8,570	$0.21	$0.005	1.5%
Water/Sewage	683	$0.02	$0.000	0.1%
Telephone	3,275	$0.08	$0.002	0.6%
Trucking/Shipping (Freight in and out)	8,857	$0.22	$0.006	1.5%
Greenhouse Tools and Other Misc. Supplies	1,763	$0.04	$0.001	0.3%
Sales Tax	8,768	$0.22	$0.006	1.5%
Total Accrual Variable Costs (B)	**$454,559**	**$11.35**	**$0.289**	**77.1%**
ACCRUAL GROSS MARGIN (A - B)	***$135,331***	***$3.39***	***$0.090***	***22.8%***
Fixed/Overhead Costs				
Interest	13,915	$0.35	$0.009	2.4%
Depreciation	20,243	$0.51	$0.013	3.4%
Insurance	14,097	$0.35	$0.009	2.4%
Repairs, Buildings	8,289	$0.21	$0.005	1.4%
Repairs, Equipment/Vehicles	9,919	$0.25	$0.006	1.7%
Property Taxes	5,314	$0.13	$0.003	0.9%
Lease/Rental	4,142	$0.10	$0.003	0.7%
Land Rent	7,462	$0.19	$0.005	1.3%
Office Supplies	4,388	$0.11	$0.003	0.7%
Professional Fees	3,922	$0.10	$0.003	0.7%
Education & Training	1,210	$0.03	$0.001	0.2%
Miscellaneous	15,920	$0.40	$0.010	2.7%
Total Accrual Fixed Expenses (C)	**$108,821**	**$2.73**	**$0.070**	**18.5%**
TOTAL ACCRUAL EXPENSES (D = B+C)	***$563,378***	***$14.08***	***$0.359***	***95.6%***
ACCRUAL NET INCOME (A - D)	***$26,512***	***$0.66***	***$0.020***	***4.3%***

* Source: Average accrual income statement for 45 New York greenhouse businesses, derived from their 2001 business records (Uva and Richards, 2003).

$40,000 to 50,000 per owner or per family, or a profit margin of 10 percent to 15 percent. According to the survey with 45 New York greenhouse businesses, their average profit margin was 5 percent in 2001, and the top 20 percent greenhouses had an average profit margin of 14 percent.

In addition to measuring profit and providing information to calculate profitability, the income statement allows the business owner to evaluate levels of receipts and expenses in different categories. The top four or five key expenses should be evaluated to determine if changes will increase profits. Any change in expenses must be compared to the expected effect on receipts. Although it is intuitive for business operators to want to reduce costs, a word of caution is that reducing expenses will not always result in increased profits. In fact, in some cases, additional spending on certain items, such as special growth hormone to improve product quality or advertising to expand marketing effort, may increase sales and/or operating efficiency and in time increase net income.

Other measures of economic efficiency often calculated when reviewing the income statement are:

- **The Rate of Capital Turnover:** This measure is an indication of how efficiently capital is being used in production. This equals the value of production per dollar of assets and is calculated by dividing the value of production (total receipts) by total capital (total business assets). The inverse of the capital turnover rate is the number of years it would take to produce products with a value equal to the total capital invested in the business. For example, a rate of capital turnover equal to 0.3 or 30 percent indicates the value of production is equal to 30 percent of the total capital invested in the business. This value means it would take 3⅓ years to produce products with a value equal to the total capital investment.
- **The Ratio of Cost of Production Relative to the Value of Production:** This involves dividing cost of production by the value of production. It measures the input costs required to produce a dollar of output. When this ratio is equal to or greater than one, the business has zero or negative profitability.
- **Return to Capital:** This is also called the return on investment and is calculated by net income – value of family unpaid labor – value of operator's labor and management + interest paid divided by average capital investment. It is a measure of how effectively the business uses the money (borrowed or owned) invested in its operations. The goal for the rate of return to capital should approximate the interest on borrowed capital. When return on capital is expressed as a percentage of total farm assets, it allows easy comparison with returns from other investments. When the return on capital is lower than returns from other investments (i.e. stock markets, other companies) which you could potentially invest your money in, you should reconsider your opportunity costs of investing in the greenhouse business and your personal and business goals.
- **Return on Equity:** The rate of return on equity indicates the percentage return to the owner's personal or equity capital, and it is calculated by net income divided by the average of the owner's equity. It should be greater than rate of return to capital if any borrowed money is used in the business. It indicates that the average return on borrowed capital is greater than the interest rate paid for its use. The rate of return on equity is perhaps the most important measure of profitability, because equity is the capital which would be available for alternative investments if the business is liquidated.

These calculations as well as the prior measure of efficiency are highly variable between greenhouse types, and therefore should be compared to accepted or identified industry standards – benchmarking.

Evaluating Your Financial Performance – Benchmarking and Trend Analysis

Knowing how your business compares with others in the industry helps you evaluate your business performance, identify strengths and weaknesses of your operation, and set meaningful goals. It is important to do benchmarking on a timely basis (i.e. annually at year-end) and in a consistent format. Several types of benchmarks are commonly used for assessing performance when reviewing the income statement: production efficiency (sales/square foot week), cost efficiency (total cost/square foot week), and labor efficiency (sales/worker equivalent or sales/dollar of labor expense).

As mentioned before, different business practices in different industries will result in very different benchmark measures, even different business types in the same industry. Tables 15-2 and 15-3 (page 87) show some examples of greenhouse industry average benchmarks by marketing channels (wholesale and retail) from a New York study (Uva and Richards, 2003). The retail sector in the greenhouse industry has a relatively low barrier of entry. The New York study included some small start-up retail greenhouse operations, which tend to be less efficient. On the other hand, the wholesale greenhouses in the study are in general larger and more established operations than the retail greenhouses in the same study. As a result, the average profitability measures for the wholesale greenhouse sector seemed to be better than the retail greenhouse sector in this study.

When comparing the financial performance of the top 20 percent greenhouse businesses in the retail and wholesale sectors, the two groups have comparable profitability (gross margin and profit margin). Retail operations have a higher average net income per square foot week ($0.54) than that of wholesale operations in this study ($0.42), but most retail greenhouses in New York do not operate year-round and many wholesale greenhouses do. It resulted in the overall comparable profitability for these two groups.

In addition, wholesale and retail greenhouses face different customer and market demands. Wholesale greenhouses produce higher volume, but receive lower prices for their products. Increasing production and cost efficiencies is the key for improving profitability for wholesale greenhouse operations. On the other hand, retail greenhouses generated higher average sales per square foot week, because they have more control over their product prices and receive the full end-consumer spending. However, retail usually requires more customer service and labor, a more diversified product mix, and a more complicated pricing system. As a result, the efficiency benchmark measures are different between wholesale and retail greenhouse sectors, and it is necessary to look at them separately and compare yourself to the category that fits your operation better.

There are many more types of benchmarks that could be used by greenhouse managers to evaluate their businesses. Individual greenhouse businesses might find one analysis more useful than another. Relationships between benchmark measures are complex and should be considered in the context of production and/or business cycles. Benchmark analysis is part of the big picture. It can also help you communicate with your bankers or investors on how well your business is doing in comparison with others in your industry.

Industry benchmarks may not always be available for your type of business or your specific geography location. Therefore, in addition to comparing with others in the industry, another approach to assess your business performance is to evaluate the progress of your business over time or conduct a trend analysis. You will want to compare the key variables, e.g. gross receipts, total expenses, labor expense or some other key expense item, net income, and net worth. This analysis will indicate how well you do over time and display the impact of different investment projects and business changes on your financial performance. You may also want to compare the growth trend of your receipts and income with a general economic index, i.e. Consumer Price Index (CPI), to ensure that the growth of your business is keeping up with the general economic growth and inflation.

You can also evaluate how well your business is doing by comparing the performance indicators with your own objectives. Some good indicators to use are return on assets and return on equity, and the objectives need to be SMART – specific, measurable, attainable, rewarding, and with a timeline. Setting optimistic but realistic objectives can help you push yourself toward your management goals.

As greenhouse operators face more and more price and market pressure, accurately calculating costs and closely monitoring the business's financial health will be the first line of defense. While knowing your profitability figures and financial ratios is not a substitute for good management, it is an important tool to help you make informed management decisions. Greenhouse operators need to set goals and measure performance throughout the year. This can lead to a shift in production and marketing efforts to more profitable crops and markets. Business success isn't simply "what you end up with," but something that is planned.

Reference

Uva, W.L. and S. Richard. 2003. *New York Greenhouse Business Summary and Financial Analysis.* E.B. 2003-09. Dept. of Applied Economics and Management, Cornell University, Ithaca, New York.

Table 15-2. Examples of wholesale greenhouse financial performance benchmarks.

	Average	Top 20%
Profitability Measures		
Net income per square foot week	$0.034	$0.070
% Gross Margin	30.8%	40.3%
% Profit Margin	8.1%	21.8%
Return on Equity	9.1%	48.4%
Production Efficiency Measures		
Sales per Square Foot Week Greenhouse Area	$0.35	$0.42
Cost Efficiency Measures		
Total Cost per Square Foot Week Greenhouse Area	$0.32	$0.18
Variable Costs as % of Sales	69.2%	47.4%
Fixed Costs as % of Sales	22.7%	13.7%
Labor Efficiency Measures		
Greenhouse Area (ft^2) per Worker Equivalent	8,502 ft^2	14,564 ft^2
Sales per Worker Equivalent	$101,981	$155,451
Hired labor cost as % of sales	24.1%	5.4%

* Source: Data analysis derived from the 2001 business records of 45 New York greenhouse businesses (Uva and Richards, 2003).

Table 15-3. Examples of retail greenhouse financial performance benchmarks.

	Average	Top 20%
Profitability Measures		
Net income per square foot week	$0.026	$0.114
% Gross Margin	26.2%	39.7%
% Profit Margin	2.5%	21.0%
Return on Equity	7.1%	23.9%
Production Efficiency Measures		
Sales per Square Foot Week Greenhouse Area	0.51	$0.54
Cost Efficiency Measures		
Total Cost per Square Foot Week Greenhouse Area	$0.49	$0.30
Variable Costs as % of Sales	73.8%	57.2%
Fixed Costs as % of Sales	23.7%	11.3%
Labor Efficiency Measures		
Greenhouse Area (ft^2) per Worker Equivalent	7,115 ft^2	8,494 ft^2
Sales per Worker Equivalent	$84,843	$105,769
Hired labor cost as % of sales	23.1%	10.5%

* Source: Data analysis derived from the 2001 business records of 45 New York greenhouse businesses (Uva and Richards, 2003).

The Original "True Blue"™ Solution

A family tradition and the choice of generations of professional growers

Reliable Water, Tissue and Media Analysis for over 57 Years

- Jack's Professional™ Fertilizers
- Jack's Classic® Retail Fertilizers
- J. R. Peters® Laboratory

The Peters Family—the originators of the world famous "True Blue" water soluble fertilizer—have been in the business of growing for more than 57 years. Growers of all sizes rely on their products to grow consistent, high quality crops that produce a maximum return on their investment. With every bag comes the support from the J. R. Peters Laboratory and technical team. That's why generations of growers have trusted their all important crops to J. R. Peters. Great science is the secret behind the art of growing!

The Finest in Soluble Fertilizers and Horticultural Lab Services

J. R. Peters, Inc. 6656 Grant Way, Allentown, PA 18016
www.jrpeters.com

JRP J.R. Peters, Inc.

Phone: **866-522-5752**