FEATURE

The Challenge of Commercial Production Cost Accounting in Nursery Management—A Practical Exercise

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Determining the cost of producing individual plants is one of the most essential, yet difficult, responsibilities of a nursery manager (Dinter, 1988; Taylor et al., 1986). An abundance of interacting and unpredictable variables exert enormous influence on the cost of production. Despite the complexity of the task, controlling production through accurate cost accounting is imperative to establish long-range business plans, evaluate and compare alternative production methods, and ultimately increase profits (Anderson and Raiborn, 1977; Davidson and Mecklenburg, 1981; Furuta, 1978; Pappas and Brigham, 1979).

Progressive nursery managers have increasingly relied on computer-assisted cost-accounting techniques (Kirschling, 1981; Dinter, 1988). The manager can accurately track and manipulate production system costs on a computer spreadsheet to ascertain the most efficient production strategies (Hoover and Markhart, 1987; Smith, 1986). Production data can then be integrated with other information bases within the business, such as fiscal control, personnel, marketing, and sales (Furuta, 1978; K. Finley, Wilson's Nursery, personal communication).

Direct experience with the challenges of nursery production cost accounting provides invaluable professional training for the nursery management student. A general spreadsheet program can be adapted for instruction in a wide range of production situations, unlike dedicated prepackaged or customized programs designed exclusively for specified nursery objectives. A practical computerized classroom project that illustrates the broad spectrum of product-related and temporal complications in analyzing plant production costs, and allows each student to test the cost implications of self-designed production strategies, is described in this paper.

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Unique aspects of production cost accounting in a nursery

Production cost accounting involves the collection, processing, and analysis of production information that is rarely straightforward in a typical nursery due to the unique nature of the nursery product—living plants. The nursery inventory is constantly growing and changing in acquired value over the entire span of production. A nursery may produce a multitude of species, each with characteristic growth rates and cultural requirements. Unpredictable environmental factors alter plant growth rate and habit. Consequently, predicted losses, required maintenance, and production costs change. For example, if drought conditions cause severe plant losses, there is an increase in the cost of producing the remaining plants (Davidson and Mecklenburg, 1981).

The uncertainty in estimating labor performance further complicates the calculation of production costs. Labor expenses are affected by the type of plant in production, labor efficiency, length of the production cycle, and production techniques (Dickerson et al., 1983). For example, it may take one laborer 4 hr to dig a large shade tree by hand, and two laborers only 1.5 hr. The efficiency of labor, in this case, increases by adding the second laborer but would diminish if more than two laborers were digging the same tree. In the same way, an expensive mechanized tree spade may dig a shade tree in minutes with one operator. The scale of the operation, however, may not warrant the large capital outlay for the tree spade if it can operate at only 50% capacity in a small nursery.

Selection of a production cost accounting method for the project

To reduce the complexity of estimating production costs, the production cycle can be divided into several phases such as propagation, liner bed, and field-growing, in which production objectives and requirements are very different (Smith, 1986). Nurseries often divide production costs in each of these phases into direct, product-dependent costs and indirect costs for accounting purposes (Davidson and Mecklenburg, 1981; Dickerson et al., 1983). Each production phase involves specific product-dependent costs such as fertilizer, labor, and other materials that are directly linked to the production method and the number of plants produced. Indirect costs include capital (such as land, building, equipment, and machinery) and overhead (such as administrative salaries, contingency

Assumptions	ha	m^2
Total area	24.28	242,803
Facilities (office, warehouse, storage)	0.61	6,070
Propagation area	2.43	24,280
Liner-bed and stock plant area	2.43	24,280
Field area in production	14.33	143,114
Unused areas (roads, waterways, fallow land)	4.07	40,753
Holding area	0.4047	3,376
Revenue producing land	19.19	191,900
Non-revenue producing land	5.09	50,900

Fig. 1. An example of "assumptions" on the computer spreadsheet template.

estimates, utilities, interest, and taxes).

Many nurseries calculate product-dependent growing costs together with capital and overhead costs on a per-plant basis. The total production cost per plant depends on how many plants are produced, but the plant tally is an inconsistent unit of reference. The number of plants produced is constantly changing throughout the production cycle due to production losses; therefore, estimates for capital and overhead costs are difficult to allocate on a per-plant basis.

One of the main differences in production costs among plant types is the amount of land required to produce them (Taylor et al., 1986). For this reason, calculating capital and overhead costs on a square-meter (SM) basis is a more versatile and flexible production cost-accounting method. This method relies on land area used (SM)—a consistent and easily measured unit of reference (Furuta, 1978; Taylor et al., 1986). For this method, the total annual estimated capital and overhead cost is divided by the total SM of revenue-producing land. The resulting capital and overhead cost/SM can be multiplied by the fraction of a year or years that plants occupy a particular production phase. This cost, when multiplied by the number of SM required per plant (spacing requirement for that phase of production) and the number of plants, will equal the indirect cost contribution for a particular phase of production. The total production cost per plant for each phase can be determined by adding the capital and overhead cost contribution to product-dependent costs and dividing by the final number of plants. The ease of use of the cost/SM approach to allocating capital and overhead cost contributions to the cost of production led to its adoption for the student project.

Student project—Part 1

In Part 1 of the project, each student assumes the role of wholesale production manager for an established nursery, and determines the economic feasibility of producing a new plant cultivar from propagation phase to the harvesting of landscape specimens. Students diagram the physical layout of the hypothetical nursery on paper, from provided descriptions of location and size of buildings, field areas, other production space, roads, and other unusable land. Students select from a list of plants representing a range of potential propagation and production methods, outline an appropriate production route, and justify their recommendations.

In practice, nursery managers may buy plant liners, but students initiate production from the propagation stage for purposes of this exercise. Individual phases in the production cycle are identified (Smith, 1986); facilities, equipment, supplies, labor, and other associated requirements determined; losses estimated; and the probable duration of each phase gauged. Students are provided with a collection of industry catalogs and other guidelines from which they can obtain information on material and supply costs. They weigh the advantages and disadvantages of alternative production strategies using information accumulated in class, and are also encouraged to consult with local nursery managers for production guidelines. Cost data for materials and supplies are collected during the research, but not integrated into the production cycle until Part 2 of the project.

Student project—Part 2

Students shift the data collected during Part 1 to a cost-of-production computer spreadsheet template in Part 2 of the project (Lotus

Description		ha	Useful life (yr)	Rent per ha ($)	Amount ($)	Annual total ($)
Annual capital costs						

Land		24.28		247.00	6,000.00	6,000.00
Rototiller			7		4,000.00	571.43
Sprayer			5		1,200.00	240.00
Subtotal for annual capital costs						14,067.62
Annual overhead						

Advertising					1,000.00	
Insurance					5,000.00	
Interest rate	0.07					
Interest					7,000.00	
Administrative costs					8,000.00	
Miscellaneous					600.00	
Subtotal for annual overhead costs						29,157.62

TOTAL ANNUAL CAPITAL AND OVERHEAD COSTS						43,225.24
SM of revenue producing land	191,900					
Capital and overhead cost per square meter					0.225	

Fig. 2. An area of the spreadsheet template where total annual capital and overhead costs are calculated on a square-meter (SM) basis.

1-2-3, Lotus Development Corp. Cambridge, Mass.) Students have access to personal computers within the department and the campus Microcomputer Teaching Laboratory. Introductory orientation sessions are provided to help students develop familiarity with spreadsheet applications and keyboard commands.

Students are provided with three separate cost-of-production templates; a field nursery, a container nursery, and a tissue culture laboratory. Separate templates are provided because there can be substantial variation in cost proportioning among different types of nurseries; e.g., overhead can account for 30% of total costs in container operations, but up to 60% in a field nursery (Phillips, 1982b). Students opting for tissue culture as the propagation method combine both that template and one of the others to design the complete production cost accounting picture for their crop.

The field nursery template was modeled after several field cost of production studies (Kneen et al., 1986; Phillips, 1982a; Smeal et al., 1979; Taylor et al., 1986). The container nursery template (Badenhop and Phillips, 1983; Perry, 1982; Phillips, 1982b; Taylor et al., 1983), and tissue culture template (Kyte, 1983; Strain, 1980) were designed from operational and laboratory cost projections.

Whereas the basic spreadsheet, similar to an accountant's ledger, is comprised of empty columns of cells for text and numbers, the project templates have been expanded to include preset "assumptions", indirect cost factors such as annual capital costs and overhead, and product-dependent cost categories arranged in a rational format so that each phase of production is linked to the next. The "assumptions" section includes information such as total area, buildings, and area of revenue-producing land (Fig. 1).

The annual capital and overhead cost, based on the SM of revenue-producing land, is automatically calculated for each phase (Fig. 2). This number is forwarded to another area of the template and incorporated into each of the production phase cost totals.

There are three categories of product-dependent direct costs in each phase of production: materials and supplies, machinery and equipment, and labor. Materials and supplies needed to produce the plant are listed by product name, units such as kilograms, quantity required, and unit cost in the appropriately labeled columns. Maintenance and cultural requirements such as spraying or pruning are expressed in terms of the number of hours of labor and equipment-use per task. The spreadsheet templates multiply the quantity of the item entered by the unit cost of each item and record the cost. Subtotals for each phase are then calculated automatically.

Project templates include a comprehensive list of different equipment and supply item categories, but each student uses only a limited selection for a particular plant and phase of production. Individualized situations are managed by means of an on/off cell column, placed to the far left side of the templates. For every individual product-dependent item, the student may enter a "1" in the cell to turn on the item, or a "0" to omit the item from the accounting process (Fig. 3). An item activated by a "1" in the on/off column has its unit cost multiplied automatically by the quantity entered and the line item cost is included in the phase subtotal. Additional material, supply and labor entries can be entered by the student for each individual growing phase. This is where the student has the most input, since he or she enters information unique to the production cycle designed.

Students enter the starting number of propagules in a labeled cell in the first phase of production and an estimated percentage loss for each phase. A built-in spreadsheet formula subtracts losses from the plant count and automatically carries the adjusted tally to the next phase of production. Annual capital and overhead total costs are automatically calculated with spreadsheet formulas using the cost/SM method (Fig. 4). After completing the entire production schematic on the template(s), students arrive at final number of salable plants and a final production cost per plant. These numbers are then used to calculate the grand total production cost: Total cost = final plant no. × [cost per plant + (SM per plant × cost per SM)]. Cost per plant is product-dependent; SM per plant and cost per SM are capital and overhead costs.

It is crucial in any business situation to have a method to calculate the effect of changing one element while all others remain the same. The latitude provided by the on/off column of cells (to either use a cost factor in calculations or turn it off) gives students the opportunity to manipulate cost options, such as labor expenses, or to test different production methods. Additional "what if" problems ask the student to determine the effects on cost of production for unexpected situations, such as a drought, a glutted market, or a different set of initial assumptions. Students can calculate the impact of omitting a treatment, a product, or a task on the cost of production. As the student becomes more experienced with manipulation of production cost data, he or she may consider sophisticated alternatives, such as leasing vs. purchasing machinery or hiring trained laborers vs. weekend high-school student help. This final assignment helps students identify at what point costs of production become prohibitive for the plant type in their operation. Ultimately, students compare calculated costs to current market prices and experiment with a range of markups to determine a competitive selling price.

Conclusions

The computerized cost of production project gives nursery management students the opportunity to test the ramifications of their production ideas without risking actual business losses. The project template format and the capacity for "what if" testing provides rapid feedback on the consequences of decisions involving a complex interaction of factors. One of the foremost advantages of this exercise is that it makes traditionally difficult-to-manage material more accessible to students. Business management and computer concepts are explored during in-class lectures to complement the project as it progresses, and the exercise is integrated with a similar inventory simulation project (Smith, 1986). Both are constructed with a phasic approach to the plant production process, and both can be adapted for nurseries that begin or terminate production at any point.

Some of the assumptions provided in the spreadsheet were designed to streamline the

Plant type:	'Techny' arborvitae				
Propagation	Phase				
on/off	Item description	Unit	Quantity	Cost per unit ($)	Total ($)
1	Propagules (Cuttings)	ea	20,000	0.20	4,000.00
1	Rooting media-sand, peat	cu m	75	8.00	600.00
1	Benomyl, 50WP	kg	10	30.00	300.00
1	Captan, 50WP	kg	25	35.00	875.00
1	Polyethylene film	ea	6	250.00	1,500.00
0	Burlap	ea	5,000	0.25	0.00
0	Tractor	h	600	18.00	0.00
1	Sticking cuttings	h	24	7.00	168.00
1	Miscellaneous		1	500.00	500.00
0	Other				
	Propagation phase subtotal				7,943.00

Fig. 3. The area of the spreadsheet template where product-dependent costs are tallied for the propagation phase. Entering a "1" in the far lefthand column includes that item in the total; entering a "0" omits the item from all calculations.

				Total ($)
Propagation phase subtotal (product-dependent)				7,918.00
		Loss	New plants	
			(no.)	
Plant loss in phase (%)	0.15	3,000	17,000	
Months in phase (no.)	6			
Total annual capital overhead costs				43,225.24
SM required in phase per plant	0.003			
Cost per SM	0.225			
Cost per plant	0.32			
Propagation phase capital overhead subtotal				100.00
Total propagation phase cost				8,018.00
Per plant cost forwarded to next phase of production				0.47

Fig. 4. Subtotals are forwarded to formulas within the spreadsheet template to calculate total and per plant cost of production by phase.

cost of production exercise. Actual nursery production cost accounting requires close observation, analysis of details, and record-keeping beyond the scope of student expertise. However, care was taken not to oversimplify the process for the student project, as this would reduce the accuracy of estimates considerably. One of the main advantages of this approach is that students do not have to struggle with spreadsheet organization. They can focus on defining production costs and making cost decisions. The purpose of the project is to encourage students to think like managers, not like computer programmers.

The project demands significant effort in time and production research to complete, but students have found it to be entertaining and useful outside of the classroom (e.g., for managing horticulture club sales of student-produced plants). Regardless of the eventual direction each student's career takes within the horticultural field, practical knowledge of production cost accounting will prove to be an invaluable analytical tool.

Additional materials and information including sample project disks, class handouts, and printouts are available from M.A.L. Smith upon request.

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