Farm management

The Ontario automatic cropping budget system for cash grain farms

A tool for detailed farm management

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Ontario
Ontario Ministry of Agriculture and Food
Legislative Buildings, Toronto, Ontario

THE ONTARIO AUTOMATIC CROPPING BUDGET SYSTEM FOR CASH GRAIN FARMS

A Tool for Detailed Farm Management

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ISSN 0318-1812 AEEE/76/3

In cooperation with
Economics Branch
Ontario Ministry of Agriculture and Food
Legislative Buildings, Queen's Park
Toronto, Ontario M7A 1B6
November, 1976

ECONOMICS INFORMATION

FOREWORD

Corn and soybean production has increased significantly in Ontario over the last ten years. Producers of the two crops are faced with many management problems, with a significant one being timeliness of fieldwork. Variation in fieldwork timeliness has been shown to significantly affect the yield potential of both crops and, hence, individual producers' profits. A computer model was constructed to simulate the production of these crops taking into account weather variations, machinery capacities, labor availability, and production costs and returns. Producers may apply the model using their own data to generate planning alternatives for their farms.

This report was made possible through the cooperation of the Economics Branch of the Ontario Ministry of Agriculture and Food and the School of Agricultural Economics and Extension Education of the University of Guelph. The author is indebted to W. Candler, H. Doster, P. Robbins, and their colleagues in the Department of Agricultural Economics at Purdue University who developed the original corn-soybean model for U.S. conditions. Thanks also to G.W. Lentz of the Economics Branch for his assistance in developing the Ontario version and to D.M. Brown at the University of Guelph for his assistance in supplying weather data for Ontario.

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INTRODUCTION

For many years farm management has relied heavily on partial budgeting as a means to effective production planning. Partial budgeting hinges around the concept of the potentials that a change in an existing farm situation holds for (1) increasing or decreasing returns or (2) increasing or decreasing costs, or both, such that the net effect can be measured. A farmer with detailed records of his past operations can use partial budgeting to study the effects of change on paper before they actually happen.

There is one problem associated with partial budgeting that most managers consider to be crucial. For most changes to any farm situation (a move, for example, to add soybeans to a traditional corn-spring grain-hay cropping program), a bewildering number of partial budgets could be constructed. With grain crops, a farm manager has many production methods, a range of machine sizes, many possible time sequences for field operations, etc. A separate partial budget could represent each combination of production method, machine size, and fieldwork schedule. By constructing a large number of budgets, a farm manager could select the one that represented the highest net gain. Obviously the whole set of partial budgets would depend on the prices for both inputs and products used in the budgeting process as well as on many other factors. The budgets would require revision as soon as a price changed. Farm managers have realized that while the concept of budgeting is appropriate to production planning, the task is often too large for manual calculation.

Mathematical procedures exist that can automate partial budgeting. More importantly, some of these procedures do more than generate and compare sets of alternative partial budgets. A class of computational techniques called "mathematical programming" is able to account for limitations (or constraints) on the resources of a farm and to search for the one best or optimal farm plan that is consistent with the goal of maximizing net returns. Because the computational procedures for mathematical programming are well defined, computers can be instructed to systematically solve large budgeting problems.

One technique called "linear programming" has been applied widely to farm organization and production planning situations. When a farm situation (productive enterprises, available resources, prices, costs, etc.) is built up according to linear programming procedures, the term "model" is commonly applied. A linear programming model is simply a numerical representation of a business from which a myriad of partial budgets can be derived. The linear programming procedure automatically searches for the one best set of partial budgets that employ the farm's productive resources to the fullest extent possible.

The Ontario Automatic Cropping Budget System for Cash Grain Farms is a packaged linear programming model that represents many common aspects of corn and soybean production on cash crop farms in Ontario. This publication is intended to familiarize farm managers with this management tool and the linear programming procedure that supports it.

CHAPTER I

CONCEPTS OF LINEAR PROGRAMMING FOR FARM MANAGERS

The economic aspects of modern agricultural production are often so complex that they are difficult to assess by even the most capable managers. Agricultural scientists are aware of the growing pressure to make their results more relevant or more usable in terms of everyday decisions concerning farming and agribusiness. The current emphasis on interdisciplinary work by researchers at agricultural colleges is one result of this pressure.

With the growth of interdisciplinary agricultural research has come the realization that the results often do not apply directly to on-farm operations and decision making. For example, even though a specialist in animal breeding can map out the genetic consequences of a particular breeding program, its usefulness in terms of profit to a farm business often remains unknown. Much of the impetus for interdisciplinary work has stemmed from the need to find better ways to apply research results to daily farm operations.

The problem of applying research results frequently hinges on finding a method by which technical data can be merged with business information to assist managers in achieving their goals. Agricultural economics has a role to play in assisting agricultural scientists to reach their ultimate audience—namely, the farm or agribusiness manager. Because agricultural economics is concerned primarily with alternative choices regarding the use of resources in food production, it has sought over the years to develop methods by which business operations could be simulated ahead of time to eliminate some of the uncertainty in making these choices. A major problem in explaining economic phenomena has been finding a laboratory in which experiments can be conducted to predetermine the consequences of various decisions.

THE MODELING APPROACH

Since the profitability of farm production partially depends on biological factors and market prices that are quantifiable, procedures using mathematics have been developed to model many aspects of farming. These procedures provide the means by which economic data can be systematically combined with technical data to plan decision strategies for handling the various uncertainties a business may encounter over time.

When one simulates the operation of an agricultural business with the use of mathematics, he is said to be building a model of that business. Modeling can be approached from various standpoints depending on how the results are to be used. Large models that map the operation of whole segments of the industry are often constructed to yield information that is useful for planning by governmental agencies. Other models are often constructed with the goal of furthering scientific research itself. For example, models to simulate market behavior have been built to help explain how consumers and merchants react to changing conditions that are reflected through prices and other market information. Models are sometimes constructed to simulate the biological response of an animal or plant to changes in its environment such as the weather, feed ingredients, or fertilizer. These models are often used to assist scientists in conducting experiments that are very complex because conditions are only partly controllable. They are also used to blend technical and economic data to perform planning for a single business firm.

Modeling farming systems for farm management applications uses techniques adopted from mathematics and statistics. One mathematical technique in particular—namely, linear programming—has been widely applied to farm management problems, with more than moderate success in many cases. For many years linear programming has been popular with agricultural economists as an approach to business simulation for research. Many attempts have been made to put this laboratory technique into the hands of business managers so that its potential could be realized in nonresearch situations.

MODELING IN AGRICULTURE

Linear programming has many varied uses in agriculture. It can, for example, be used in farm planning to answer questions concerning part of the farm business such as a possible feedlot expansion and least-cost mixes or blends such as feeds, bulk fertilizers, and agricultural chemicals. Today's farmers work with complex businesses and often find that the organization of their production activities should be changed as market conditions change. Narrow profit margins, new machines and chemicals, size changes, and new government farm programs are some of the forces that bring on a continuous flow of management questions. It appears that the demands on agricultural managers for correct, precise answers will continue to increase.

Linear programming used in farm planning can be made to look at all resources and alternative enterprises that fit the business. The principle of opportunity costs (the profit given up from other production possibilities when a particular possibility is chosen) is used to determine the one 'best' use of resources. And since less bias is usually built into a linear programming analysis than in other techniques such as budgeting, the answers supplied by linear programming are not predetermined. A budget for a 200-acre corn operation, for example, would likely be biased in two directions before the budget is worked out. First, somebody would have decided that growing corn is the most profitable use of resources and second, the size of the enterprise would have been predetermined at 200 acres.

Although the possibility of a bias that sways the result one way or the other is not completely ruled out with linear programming, the technique does give planners more opportunities to consider many alternatives. The market prices and alternative activities included in the linear programming model do, of course, bias the procedure in searching for the best plan. But because many more alternatives can be considered with linear programming, the effect of the bias is reduced. Some bias may be intentional, however, if, for example, an operator is willing to pursue only one cropping enterprise such as corn. In this case, some type of corn production would be forced into the final plan before other enterprises are considered by the linear programming procedure.

BUILDING A FARM MODEL

When using linear programming, the final farm plan is built from the ground up in a manner analogous to a mason laying bricks. Each brick in the linear programming process is a unit of farming activity such as 'Grow 1 acre of corn,' '1 sow and 2 litters,' 'Sell 1 ton of hay,' 'Buy 1 ton of hay,' or 'Borrow $1 of capital.' These units are called "activity units." As long as the plan or result can be improved, the linear programming process will continue to add and change activity units. The costs and returns for each unit selected in the 'best' plan are combined arithmetically to determine a net result.

The information and thinking required for linear programming analysis are nearly the same as those needed for the budgeting technique that is familiar to most managers—only the mathematics differs. The number of calculations required for a complicated farm budget, where several kinds and sizes of crop and livestock enterprises as well as other changes are to be considered, is usually so large that manual solution is almost impossible. Linear programming and the use of an electronic computer can solve large problems realistically and give management a precise answer in minutes. The procedure does, however, take just as much time as budgeting to assemble the information and think through the analysis.

Linear programming is a precise decision-making tool that usually relies on computer services to mechanize calculations. But this does not rule out a role by the manager. In most situations it forces management to think harder about all aspects of the business and the questions to be answered. This is particularly true when a computer is used because the machine logically considers anything that is fed into it. Linear programming forces the manager to (1) organize information and perhaps improve his methods of getting information, (2) clearly state his objective, (3) define the resources available, and (4) think through all realistic alternative enterprises and other activities. The land, labor, capital, and other requirements of each activity along with the net returns anticipated must be precisely specified. These considerations normally represent a good two thirds of the linear programming job.

RESULTS OF FARM MODELING

A linear programming analysis provides the manager with a 'best' plan for the use of land, labor, and capital and all other resources available. Such a plan can bolster confidence in decisions already made as well as provide direction for future production, processing, or marketing action. In addition, the 'best' plan can be used as a base for answering specific questions concerning parts of the business. Specialized farms or agribusinesses may be especially interested in using linear programming this way. A cash grain farm manager might be interested in questions concerning fieldwork timeliness or the feasibility of using more capital to expand the operation. A specialized cash grain producer might have questions on farmland expansion, building drying and storing facilities, crop rotations, or fertilizer schedules.

A linear programming solution can also tell a manager by how much profits would increase if one more unit of a limiting resource were available. For example, if the amount of labor available in May limits a farm's corn acreage, one additional hour of labor in May might add $25 to $30 to the plan's total profit. Similarly, linear programming models can indicate by how much profits would be reduced if a manager insists on keeping an enterprise that is not selected in the 'best' plan. For example, a person who likes and insists on keeping a few beef cows even though the enterprise was not selected in the 'best' plan will be provided with the dollar cost of using resources for this pleasure.

Linear programming can be used in variable resource and price analysis. Variable price analysis is especially helpful in farm management because it identifies ranges over which crop prices can vary without changing a particular 'best' plan. Similarly, a linear programming analysis can give the range of income or costs per unit for any activity in the plan. Thus a farm manager can get an indication of the stability of choices already made for the business or of new decisions before they are finalized.

CONSIDERING THE USE OF MODELING

Before investing the time and money required for a linear programming analysis, an agribusiness manager should list the important questions he needs to have answered. The first question might be "Is the present use of resources the most profitable?". Then the manager must judge whether or not linear programming will provide a better basis for answering the questions listed than will a complete budget or a partial budget.

The manager who decides to use linear programming as a management tool needs complete and accurate information on a farm's resources and enterprises. Since few managers have all the information readily available to do a useful linear programming analysis, it may be necessary to establish or revise a system for gathering and recording information.

The linear programming solution can only be as accurate as the information used in the analysis.

If an agribusiness manager has decided that linear programming will help him make better decisions and has the information available for an analysis, the farm planning procedure would be as follows:

1. Specify the resources available and limitations. For example:
   (A) Amount of land recorded by land use capability.
   (B) Labor, especially at peak periods.
   (C) Capital—operating capital and borrowing limits.
   (D) Allotments, marketing quotas, storage space, and other restrictions.

2. List enterprises that are feasible and fit the business.
   (A) Develop linear programming activities necessary to answer specific questions (for example, 'Add feedlot capacity,' 'Buy a new machine,' 'Hire labor').
   (B) For all activities it is necessary to develop activity budgets showing the returns, costs, and the resource requirements of each.

3. Develop a matrix. This is a work table that includes all of the resource and activity information in a form that is necessary to do the linear programming job. The matrix should be studied *thoroughly*. DO ALL RELATIONSHIPS MAKE SENSE?

4. Perform the linear programming calculations. Relatively simple problems can be solved using arithmetic and graphic or simplified programming methods. Most problems in this step require the use of computer services.

5. Interpret the results. This is a very important step.
   (A) Determine net income indicated by the linear programming solution.
   (B) Glean the results for all useful management information such as the activities selected, the resources used and not used, etc.
   (C) Investigate further use of linear programming for the information assembled.

Linear programming analysis is a long-run investment. Its costs can often be prorated over several years because the basic data can possibly be used for further analysis, normally with only slight changes. The Ontario Automatic Cropping Budget, in fact, has been developed over several years according to the steps outlined above. Technicians and researchers have worked through the design stages so that the model can be applied to specific farm situations with a minimum of effort. The following chapters describe the management environment in which field applications should be carried out and the data required to operate the Ontario Automatic Cropping Budget.

CHAPTER II

DEVELOPMENT OF THE ONTARIO AUTOMATIC CROPPING BUDGET

The Ontario Automatic Cropping Budget (OACB) is a computerized farm management model adapted from an earlier model built by researchers at Purdue University in Lafayette, Indiana for corn belt farmers. The OACB is a linear programming simulation of many of the production activities associated with corn, soybeans, and wheat. It has been developed by the author of this publication from work done at Purdue University and at the Economics Branch of the Ontario Ministry of Agriculture and Food in Toronto.

IMPORTANCE OF TIMELINESS

During the 1960's, extension economists, crop scientists, and engineers at Purdue became interested in the problem of timeliness in field operations on corn/soybean farms in the U.S. Midwest. New types of equipment, new hybrids, and alternative pest and disease control methods were being introduced to commercial corn and soybean producers, which led to many management questions. For many years corn belt farmers have known that their yields decline as planting proceeds beyond mid-May. "You lose a bushel a day past the 10th of May," is a common saying among farmers when they are asked about the effects of delayed corn planting. Time of planting and harvesting certainly affect both corn and soybean yields.[1/] Thus the timing of field operations for maximum yield is an important aspect of management on corn/soybean farms.

In managing cash grain operations for maximum timeliness in the field, several subsidiary factors need to be considered. The first is the weather. Most cash grain field operations require a low-moisture soil surface. Spring rains and wet soil conditions in the fall often seriously curtail field operations, which generates a significant drop in profits. And if wet conditions are widespread, there may be a decline in total production. In the latter case, market forces may increase product prices, which would mitigate some of the adverse effect on an individual producer's profits. This does not, however, diminish the importance of timeliness for individual growers. Timeliness becomes even more important under generally adverse growing conditions. In periods of general yield reductions, any grower who can maintain production has an abnormally high profit potential.

The use of large machinery is an obvious means of speeding up field operations. Research on the per-acre cost of operating machines of various sizes has led to the significant conclusion that the per-acre

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[1/] P. Van Die, D. Waud, L. Small, T. Weber, and M. Brown, *Dollars and Sense of Fieldwork Timeliness*, OMAF Factsheet No. 75-072 (Toronto: Ontario Ministry of Agriculture and Food, 1975).

costs of operations for large machines and small machines are nearly the same.[1] For this reason, decisions on machinery size are usually based on gains from timeliness in the field rather than on fixed costs of ownership such as depreciation, interest, and taxes.

Adverse weather conditions occur with varying frequency in various geographic locations. Research has shown that the probable number of good field workdays varies between central and extreme southwestern Ontario.[2] This holds many implications for different machinery decisions between these two areas. Other factors such as soil type, length of growing season, mean annual temperature and moisture, and drainage will also have a strong influence on possible timeliness gains in any area for any particular set of machinery.

Farm machines require labor for both operation and maintenance. The availability of labor during times of crucial crop activity may vary from farm to farm. Age of owner-operators, family size, and age of family members all contribute to interfarm variations in the amount of available labor. Furthermore, farmers may have trouble attracting hired labor because they have been unable to keep pace with other sectors of the economy in wages paid.[3] In many situations labor shortages may cause a farm to move in the direction of large equipment so that it can handle sufficient acreage to support a single family.

The constraints of weather, equipment size, and available labor on maximizing gains from timeliness in the field make managing cash grain farms an exceedingly complex problem. However, since many of the factors that influence decisions on timeliness can be quantified, the problem lends itself to mathematical simulation.

THE ROLE OF THE COMPUTER

The original Purdue Automatic Cropping Budget was unique in the way computerization was accomplished. The computer was put to work to automatically generate the linear programming initial tableau internally from data supplied directly from an input booklet that made no reference to the underlying mathematics. The OACB has been put together with the same feature. The purpose of this is to avoid confusing managers with unnecessary details.

1/ D.H. Doster, E.E. Carson, B.A. McKenzie, and S.D. Parsons, "Crop Machinery Time and Cost Co-efficients," Unpublished communique, Dept. of Agric. Econ. (Lafayette, Ind.: Purdue Univ., 1972).

2/ D.M. Brown and P. Van Die, *Spring Workdays in Ontario*, Dept. of Land Resource Science, Ont. Agric. Col. Tech. Memo. 74-1 (Guelph, Ont.: Univ. of Guelph, Jan. 1974).

3/ Brian B. Perkins, *Current Farm Income Problems in Canada*, Dept. of Agric. Econ., Ont. Agric. Col. (Guelph, Ont.: Univ. of Guelph, Sept. 1965).

The data booklet has been prepared with generous footnotes and explanations so that farm managers can understand the data requirements with little or no assistance from technicians. Furthermore, the booklet includes data for a case farm (for example, 400 acres with 4-row equipment in southwestern Ontario). For many items in the booklet, such as the probable number of good field workdays, data for the case farm serve to prompt the person supplying the information. In situations where farm records are inadequate, the system can be used with a mixture of actual and case farm data to budget the effects of major events such as a wet spring or an early frost. The computer retains the case farm data, which reduces the demand for input data whenever the case farm information fits the situation.

The computer is also programmed to develop summary tables of the final linear programming solution and to print them in a format that can be understood directly by farm operators and managers. By having the computer perform the tasks of processing farm data directly from a data booklet and producing a well-structured and readable report of results, minimum technical supervision is required to apply the OACB to specific farm situations. The computer program is written in FORTRAN IV for IBM/370 computers. The OACB allows the user to regard the computer as a black box. Technical knowledge of computerization is not required for farm applications. Farm managers with a working knowledge of linear programming can use it readily.

The Ontario Automatic Cropping Budget has found wide acceptance since its introduction in 1972.1/ It has set a precedent for future development of management-oriented linear programming models in Ontario. Its approach of direct data input, automatic matrix construction, and automatic report generation has been incorporated into the Ontario Dairy Farm Planning Model developed at the University of Guelph.2/ The same features have been built into a system developed by the author of this publication for computerizing a wide range of small linear programming simulation models on portable minicomputers.

1/A.N. Watson, "Questionnaire of Cash-Grain Workshop Participants" (unpublished, Extension Branch, OMAF, Chatham, Ontario, 1973).

2/H.C. Driver, J. Strom, L.W. Small, and C. Matthews, *Dairy Farm Planning Model,* Technical Report AE/73/6 of the School of Agricultural Economics and Extension Education (Guelph, Ont.: University of Guelph, 1974).

CHAPTER III

DATA REQUIREMENTS FOR THE ONTARIO AUTOMATIC CROPPING BUDGET

The Ontario Automatic Cropping Budget (OACB) uses information on a farmer's corn, soybean, and wheat production situation to suggest a 'good' corn/soybean/wheat cropping plan for his farm. It must be emphasized that this is a cropping plan since it does not take direct account of weather and price variability or machinery breakdown. Although the plan will not be realized in any one year, it will approximate average expectations and hence should be useful in suggesting long-run planning adjustments. The present-situation budget attempts to harvest the nominated corn/soybean/wheat acreages to best advantage.

The OACB has been designed to solve the problem of how much corn/soybeans/wheat a farmer should produce considering relative labor and machinery scarcities during land preparation, planting, and harvesting. In addition to a farmer's own resources, the model allows land rental, hiring seasonal labor, and custom combining work to be hired-in or hired-out. Corn may be sold wet or dry, with the model allowing for on-farm drying if necessary in the latter case.

It must be stressed that the OACB is a *long-term* or *preseason* planning budget and not a day-to-day operating plan. Its main objective is to formulate a working plan based on a farmer's various expectations, including expected planting and harvesting rates, expected number of working days per week during a particular time period, and expected prices and costs. In practice, of course, a farmer will have an above or below average season and actual planting or harvesting patterns, or both, will deviate somewhat from those planned. In light of this, the OACB can be very useful as a relatively quick way of preparing detailed and high-profit farm plans.

The OACB can be used for mixed-enterprise farms as well as for specialized corn/soybean farms. If planning for a mixed enterprise, it is essential to remember that labor availability and machinery field hours in the OACB represent time available for corn/soybean production only. These times are presumably less than the corresponding times available for all farm work.

LAND DATA AND GRAIN STORAGE CAPACITY

The linear programming (LP) matrix for the OACB has 144 activities and 101 constraints. Initially, the data booklet requires information on the land and grain storage available on the farm (Table 1). The OACB assumes a base situation of owned land that is available for corn, soybean, and wheat production. Managers should enter a figure that includes all owned acres plus land that is rented on a more or less permanent basis. The fixed land charge is usually calculated as an interest rate (for example, 7 percent) applied to the land's per-acre value (for example, $600 per acre) plus a tax component.

Table 1.--Land and Buildings

Item	Destination in LP matrix
Owned land, acres	Right-hand side
Fixed land charge, $ per acre	Objective function
Extra land available to rent, acres	Right-hand side
Rental charge, $ per acre	Objective function
Storage available for shelled corn or soybeans, bushels	Right-hand side

The OACB will attempt to include land that could be rented in the farm plan only if the time available for field operations is not used completely and only if renting extra land is profitable. The acreage available for rent should reflect the real situation for any farm. Enter a zero if none is available in the community. The rental charge should also reflect the actual rents paid per acre. The OACB considers the figure for rental acreage as an upper limit and may recommend renting less than that amount.

LABOR AND MARKETING DATA

The second major group of input data required for the OACB consists of general labor and marketing information (Table 2). The allowance made for permanent labor may be the salary that the farmer believes he could earn by working elsewhere. If more than one family member is employed on the farm, an average estimate should be made that includes each person. Nonfamily permanent labor should be entered at cost, including the cost of any extras furnished. A wage rate that reflects actual conditions (at least legal minimum wages) should be entered for extra labor. The computer program will recommend hiring part-time labor only if permanent labor is unavailable to utilize the time available for field operations and only if hiring such labor is profitable.

The OACB makes an allowance for the expected efficiency of hired labor. Hired labor efficiency refers to the percentage of paid time that hired labor can be expected to work. Indices of labor efficiency from available research indicate that 80 percent is a reasonable average figure. Many reasons can be cited for using a figure of less than 100-percent efficiency, with the weather usually being the major cause. Hired labor may not be required on a rainy day, for example, although it must be paid in most situations. An owner-operator, on the other hand, may use his own labor more efficiently by working at equipment maintenance, marketing, or general planning during bad weather.

Table 2.--General Farm Data

Item	Unit	Destination in LP matrix
Permanent labor, including family labor	No. of people	Right-hand side
Annual wages, average	$ per person	Post-optimal, not in matrix
Wage rate for part-time hired labor	$ per hour	Objective function
Hired labor efficiency	Percent	Hired labor transfer rows
Cost of combine services hired-in, corn	$ per bushel	Objective function
Hired-out price of combine, corn	$ per bushel	Objective function
Labor supplied per hour of custom combining, corn	Hours	Labor transfer rows
Labor supplied per hour of custom combining, soybeans	Hours	Labor transfer rows
Trucking costs to elevator for wet corn	$ per bushel	Objective function
Trucking costs to elevator for soybeans at harvest	$ per bushel	Objective function
Selling price, dry corn at farm at harvest	$ per bushel	Objective function
Selling price, wet corn at elevator at harvest	$ per bushel	Objective function
Selling price, soybeans at harvest	$ per bushel	Objective function
Stored corn price, dried and stored at farm	$ per bushel	Objective function
Stored soybean price, stored at farm	$ per bushel	Objective function
Base moisture for dry corn	Percent	Right-hand side
Variable drying costs on farm	¢/5 pct. pts.	Objective function
Drying capacity for your farm dryer, 5 pct. pts./bu./hr.	Bu. per hr.	Dry corn transfer rows
Dryer use per day	Hours per day	Right-hand side
Drying costs at elevator	¢/5 pct. pts.	Objective function
Misc. production costs, corn	$ per acre	Objective function
Misc. production costs, soybeans	$ per acre	Objective function

The OACB assumes that the farm has its own harvesting equipment. An allowance should be entered, however, to reflect the charges of extra harvesting hired-in as custom work. If no custom harvesting is to be allowed, enter an unrealistically large price (for example, $999) to prevent the computer program from considering hired-in custom work as profitable. The OACB will also consider cases of farms having extra harvesting capacity. In such situations the hired-in price of the combine should always be slightly higher than the hired-out price. Otherwise the computer program would be tricked into believing that a profit opportunity existed which in fact would be nonsensical for most farms. The OACB always considers the custom soybean harvesting charge to be twice the per-bushel rate for corn. The labor associated with one field hour of custom combining may be greater due to maintenance, fueling, lubrication, etc. Managers should enter their best estimate. Trucking costs per bushel will vary with distance to the elevator. The best estimate of variable costs for the farm's own truck usually brings meaningful results.

Market prices for grain are an important component of the OACB's profitability calculations. The computer program is usually run several times with varying market prices to predetermine the effect different prices may have on the farm's production plan. Estimated prices will be used in most cases because planning with the OACB is done in the winter or early spring prior to planting.

The OACB requires three prices for grain corn—the wet-corn price, the dry-corn price, and the stored-corn price. The wet-corn price is for grain taken to market directly from the harvester with a moisture content higher than 15.5 percent. The computer program will automatically calculate drying charges at the elevator (from figures entered later in the data input booklet) and apply the estimated per-bushel trucking charges to arrive at a net price. The dry-corn price is for corn dried on the farm. This price may exceed the price of wet corn sold to the elevator at harvest time. If trucking charges are incurred in selling farm-dried corn, they should be deducted before entering a figure in the data booklet. The stored-corn price is for corn sold from storage sometime after harvest. This price could be used to reflect grain contracted for delivery later in the year and stored either on the farm or at the elevator. The computer program will only allow as much grain to be stored as is indicated by the figure for on-farm storage capacity. If the entry for storage capacity actually refers to storage at the elevator, a very large figure could be entered if it is possible to store the whole crop.

Two soybean prices must be estimated for the OACB. One is for soybeans sold at harvest time and the other is for soybeans sold sometime after harvest. As with corn, this allows the computer program to consider expected price rises for sales made from storage. The computer program will make soybeans and corn compete for the same storage space. In the case of storage at the elevator, storage capacity should not be limiting. For on-farm storage, a figure should be entered that reflects the real situation in storage capacity that can be used for either corn or soybeans.

Moisture percentages entered for corn should reflect the highest moisture content permissible for on-farm storage. The variable costs of operating a dryer on the farm should be expressed in terms of reducing the moisture content of one bushel of corn by five percentage points. These costs should also reflect the labor required for operating the dryer. If an automated drying system with a very low labor requirement is used, this entry would probably reflect just gas and electricity costs. For custom drying corn at the elevator, costs should be entered on the basis of removing five percentage points of moisture from a bushel of wet corn. A dryer capacity should be entered that refers to the number of bushels from which five percentage points of moisture may be removed in one hour. The data input booklet also requires the daily running time for a dryer. An estimate of this time will be affected by dryers that require a shutdown period, such as hours during the day when supervision is unavailable.

TIME AVAILABLE FOR FIELDWORK

The third major category of input data concerns the fieldwork time available in two-week periods throughout the year (Table 3). The OACB has been designed to solve the problem of how many acres of corn/soybeans/wheat should be grown considering relative machinery and labor scarcities during land preparation, planting, and harvesting. It is necessary to estimate the total hours available for doing fieldwork for each time period listed. This depends on weather factors that include daylight hours per day, heavy dew, high winds, and thawing ground. For each period listed, the computer must work within the specified limits on available field hours. Figures based on weather data collected over 50 years at Harrow Research Station[1/] have been built into the OACB. A farm manager may agree with these figures or may enter his own estimates based on local data.

The computer program automatically terminates fall land preparation on December 12 if the farm manager has not terminated it earlier. This may be extended or shortened to represent actual conditions for any year on a particular farm. The OACB will consider spring fieldwork as early as April 5, but this too can be shortened to reflect actual conditions. The computer will attempt land preparation during available time when conflicting activities such as planting or harvesting are not going on. Managers should think carefully about early spring starting times. It is important to recognize that while the soil is not warm enough for planting, it may be warm and dry enough for tilling. All possible fieldwork time should be made available to the computer.

The farm manager must also calculate the total number of labor hours available for each time period. This figure should reflect only the time that can be devoted to crop production on each day considered suitable for fieldwork. Time used for other jobs, for managing other enterprises, for traveling, and so on, should be subtracted from the total before

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[1/] D.M. Brown and P. Van Die, *op. cit.*

Table 3.--Machine Time and Labor Availability

Time periods	Field hours available: Total no. days	Good work days	Hr. per day	Total hours	Labor hours available: Good work days	Hr. per day	Total men	Total hours
FALL LAND PREPARATION								
Before Sept. 27	14(2 wk.)	7.0 x	10.0 =	70.0	7.0 x	10.0 x	1.0 =	70.0
Sept. 27 - Oct. 17	21(3 wk.)	10.9 x	10.0 =	109.0	10.9 x	10.1 x	1.0 =	110.0
Oct. 18 - Nov. 7	21(3 wk.)	10.2 x	10.0 =	102.0	10.2 x	10.0 x	1.0 =	102.0
Nov. 8 - Nov. 28	21(3 wk.)	9.9 x	10.0 =	99.0	9.9 x	10.0 x	1.0 =	99.0
Nov. 29 - Dec. 12	14(2 wk.)	4.3 x	10.0 =	43.0	4.3 x	10.0 x	1.0 =	43.0
SPRING LAND PREPARATION AND PLANTING								
Apr. 5 - Apr. 25	21(3 wk.)	6.5 x	9.0 =	58.0	6.5 x	10.0 x	1.0 =	65.0
Apr. 26 - May 2	7(1 wk.)	2.1 x	12.0 =	25.0	2.1 x	12.0 x	1.0 =	25.0
May 3 - May 9	7(1 wk.)	2.1 x	12.0 =	25.0	2.1 x	12.0 x	1.0 =	25.0
May 10 - May 16	7(1 wk.)	2.7 x	12.0 =	32.0	2.7 x	12.0 x	1.0 =	32.0
May 17 - May 23	7(1 wk.)	2.7 x	12.0 =	32.0	2.7 x	12.0 x	1.0 =	32.0
May 24 - May 30	7(1 wk.)	3.3 x	12.0 =	40.0	3.3 x	12.0 x	1.0 =	40.0
May 31 - June 6	7(1 wk.)	3.3 x	12.0 =	40.0	3.3 x	12.0 x	1.0 =	40.0
June 7 - June 13	7(1 wk.)	3.3 x	12.0 =	40.0	3.3 x	12.0 x	1.0 =	40.0
June 14 - July 18	35(5 wk.)	16.6 x	12.0 =	199.0	16.6 x	12.0 x	1.0 =	199.0
HARVESTING								
Sept. 13 - Sept. 26	14(2 wk.)	7.0 x	10.0 =	70.0				
Sept. 27 - Oct. 17	21(3 wk.)	10.9 x	10.0 =	109.0				
Oct. 18 - Nov. 7	21(3 wk.)	10.2 x	7.0 =	92.0				
Nov. 8 - Nov. 28	21(3 wk.)	9.9 x	7.0 =	69.0				

Source: D.M. Brown and P. Van Die, *Spring Workdays in Ontario*, Dept. of Land Resource Science, Ont. Agric. Col. Tech. Memo. 74-1 (Guelph, Ont.: Univ. of Guelph, Jan. 1974).

entering a figure in the data input booklet. When there are several employees, the total hours available for the farm should be the sum of their individual hours.

The machine operations for each crop must be represented in addition to the total hours available for fieldwork throughout the growing season. Table 4 gives an example set of machine operations and their working rates. The rate is the same for corn and soybeans for certain operations. On any particular farm, the working rate will depend on the size, quality, and quantity of equipment available. The number of pieces of equipment is important since this information will be used to calculate a field-hour coefficient. To illustrate, a farmer with five tractors and five plows can plow approximately five times as much as a farmer who has five tractors but only one plow. The size of any one plow will be reflected in the rate (acres per hour), which a manager must estimate for his equipment and soil conditions.

Labor time is used to perform work connected with field operations such as plowing and fertilizing. Preparing for fertilization, for example, takes time. Before fertilizer can be spread, the spreader must be filled and moved to the field. The 1.33 hours estimated for spreading P and K (Table 4) assumes that for every hour spent in the field, 0.33 of an hour will be spent doing other things. The 2.2 hours estimated for harvesting implies that for each hour the combine operates, 2.2 hours of labor time are required—that is, time for one man to run the combine and time for one to haul grain.

Operations such as rotary hoeing and cultivating are performed some time after planting. The OACB assumes that rotary hoeing can begin two weeks after the crop is planted and that cultivating can begin four weeks after planting. Land preparation in the fall can be held up because tractors are required for harvesting and vice versa. Even if the harvester is self-propelled, a tractor may still be required for hauling. The number of tractors available during each of the two periods listed can include units owned, borrowed, or hired as long as they can perform the specified field operations at the specified field capacity.

The term "adjusted field capacity" appears in the data input booklet. Some operations (such as spreading P and K) may not occur every year. In the example in Table 4, 32.73 acres per hour actually represents an annual rate of 10.91 acres per hour multiplied by 3 to represent the operation taking place only once in three years. List the adjusted field capacity in acres per hour for one unit of equipment for all operations except combining. For combining, indicate the rate for all combines operating simultaneously for corn and also for soybeans. The computer program does not consider the possibility that a farmer might want to combine both crops at the same time. The computer reduces the hourly soybean harvest rate by one third to reflect the shorter harvest day length as compared with corn.

Other data items concerning machinery include (1) total fixed machinery costs, (2) fuel, oil, and repair costs for production activities, and (3) fuel, oil, and repair costs for harvesting both corn and soybeans.

Table 4.--Machine Operations, Working Rates, and Labor Requirements for Corn and Soybeans

Operations	Number of units of equipment	Adjusted field capacity		Labor time, men per field hour
		Corn	Soybeans	
		acres per hour		
LAND PREP., FALL OR SPRING				
Spread P & K	1	32.73	32.72	1.33
Disc stalks	1	7.04	——	1.02
Plowing	1	2.24	2.24	1.08
Disc (early)	1	6.70	6.70	1.02
PLANTING				
Disc (late)	1	6.70	6.70	1.10
Planting	1	4.59	4.59	1.16
POSTPLANT (2 wk. after planting for corn; 2 wk. after planting for soybeans)				
Rotary hoe	1	22.76	11.38	1.02
POSTPLANT (4 wk. after planting for corn; 4 wk. after planting for soybeans)				
Cultivate	1	26.00	5.17	1.04
HARVESTING AND HAULING				
Harvest at 150 bu. corn		2.17	xxxx	2.20
Harvest at 100 bu. corn		3.25	xxxx	2.40
Harvest at 45 bu. soybeans		xxxx	3.00	1.67
Harvest at 30 bu. soybeans		xxxx	3.30	1.67

Source: D.H. Doster, E.E. Carson, B.A. McKenzie, and S.D. Parsons, "Crop Machinery Time and Cost Co-efficients," Unpublished communique, Dept. of Agric. Econ. (Lafayette, Ind.: Purdue Univ., 1972).

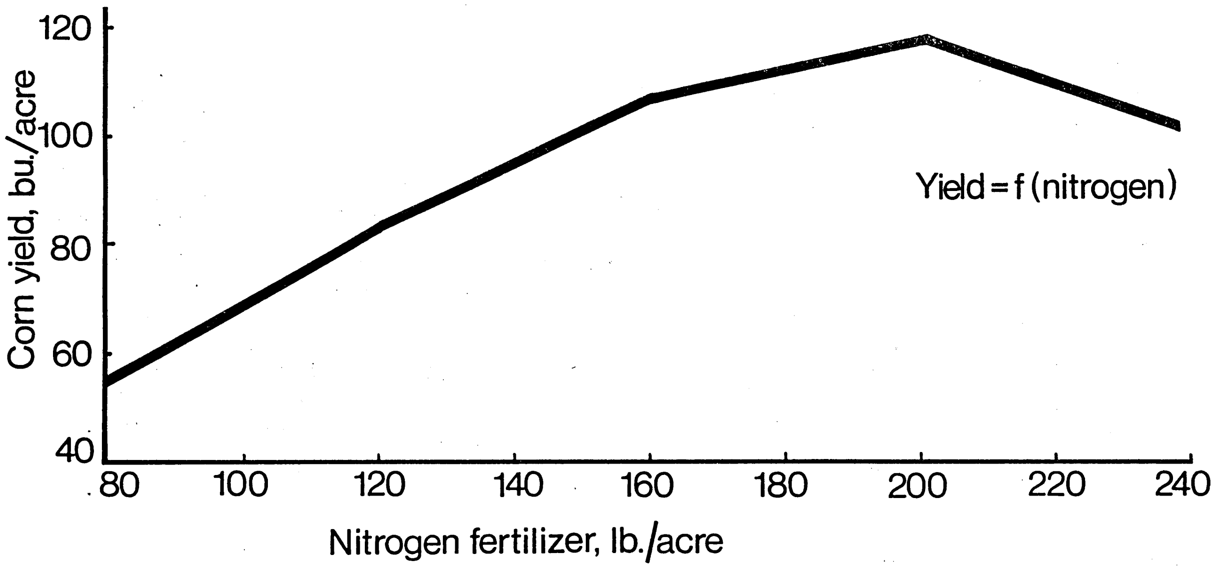

Figure 1.--Single Input Production Relationship for Corn

PRODUCTION-FUNCTION ANALYSIS

The heart of the OACB is its representation of the effects of time on crop yields. The method used in the computer program relates directly to a basic economics concept called the "production function." A production function is a mathematical representation of the output response to various levels of input into a productive process. Many precise economic decisions can be made if the shape of the production function for an input is known. A classical example of this concept is the response of corn (in bushel-per-acre yields) to various levels of nitrogen fertilizer application. A simple graph is usually drawn to represent the input-output relationship (Figure 1). Detailed and well-researched experimental data are basic to the successful use of production functions. Most agricultural experiment stations expend efforts to obtain such information from scientific field trials of many crops grown under semicontrolled conditions.

An assumption of production-function analysis is that only one input changes while all others remain at constant levels. The practicality of achieving such a situation in either field experiments or on farms often prevents the full application of this kind of analysis. To overcome this problem, the OACB uses a surrogate—namely, time—for many changing conditions associated with corn and soybean production. A production function with time on the lower axis of the graph is built up to represent the effects of various lengths of growing season on yield.

CORN

The OACB considers 18 different combinations of planting and harvesting times for corn with associated costs and yields (Table 5). Because the crop can be sold either as wet corn directly from the field or as dry corn dried at harvest time, the computer program provides 36 alternatives for growing corn. Each will generate its own profit potential for any farm, with the OACB determining the mix of alternatives that makes the best use of available machine time, labor, and suitable field hours.

Table 5 is essentially a statement of planned inputs or expected conditions. That is, if corn were planted in one particular period and harvested in one particular period, a particular yield and cost situation would be expected. The computer program uses this table, along with the field time and equipment available, to actually schedule planting, harvesting, and other field operations to maximize profits. Similar information is required for soybeans, which will be dealt with later.

The OACB assumes that delays in planting will reduce yields by 1 bushel per acre per day from May 10 to May 23 and by 2 bushels per acre per day from May 24 to June 6. Harvesting field losses are assumed to be 2 percent between the first and second harvest periods and 3 to 6 percent between the last two harvest periods. It is assumed that the full-season hybrid requires 2,800 Heat Degree days to mature to 30-percent moisture and that the mid-season hybrid requires 2,650 Heat Degree days. Field drying rate is assumed to be 0.4 percent per day, from 30- to 17.5-percent moisture. The OACB assumes that a full-season hybrid will be used in the first five planting periods and that a mid-season hybrid will be used in the last period. Seeding rate ranges from 27,000 kernels per acre in the first planting period to 22,000 kernels per acre in the last period. The computer program assumes a mortality factor of 15 percent in the first planting period and of 10 percent in the last five periods.

The assumed soil test is pH, 6.5; P, 30 pounds per acre (or high medium); K, 210 pounds per acre (or high medium). Also, 1.25 pounds of N are required per bushel produced. The OACB assumes the following annual application rates: N—180 pounds per acre plowed down as NH_3 (costed in cents per pound actual N, not including application costs); P_2O_5—55 pounds per acre bulk spread; K_2O—75 pounds per acre bulk spread; pop-up fertilizer—50 pounds per acre of 9-27-3; lime—1,000 pounds per acre equivalent (custom applied at 2 tons per acre every 4 years). The computer program assumes that Atrazine will be broadcast and disced in at $3\frac{3}{4}$ pounds per acre at cost for materials and that an approved insecticide will be broadcast and disced in every 3 years at an approximate cost of \$1.43 per acre per year for materials. It also assumes that 20 percent

Table 5.--Corn Technology: Yield and Input Costs

Harvest period	Production item	Planting periods: Apr. 26 to May 2	May 3 to May 9	May 10 to May 16	May 17 to May 23	May 24 to May 30	May 31 to June 6
Sept. 27 to Oct. 17	Yield, bu./a.	125.00	125.00	118.00	0	0	0
	Moisture content, %	24.00	26.00	28.00			
	Seed costs, $/a.	6.80	6.60	6.60			
	Fertilizer, $/a.	19.20	Same	Same			
	Herbicide, $/a.	8.25	Same	Same			
	Insecticide, $/a.	1.43	Same	Same			
Oct. 18 to Nov. 7	Yield, bu./a.	122.00	122.00	116.00	112.00	99.00	97.00
	Moisture content, %	19.00	21.00	23.00	26.00	30.00	25.00
	Seed costs, $/a.	6.80	6.60	6.60	6.60	5.80	5.60
	Fertilizer, $/a.	19.20	Same	Same	Same	Same	Same
	Herbicide, $/a.	8.25	Same	Same	Same	Same	Same
	Insecticide, $/a.	1.43	Same	Same	Same	Same	Same
Nov. 8 to Nov. 28	Yield, bu./a.	116.00	116.00	109.00	103.00	90.00	78.00
	Moisture content, %	18.00	19.00	20.00	22.00	25.00	22.00
	Seed costs, $/a.	6.80	6.60	6.60	6.60	5.80	5.60
	Fertilizer, $/a.	19.20	Same	Same	Same	Same	Same
	Herbicide, $/a.	8.25	Same	Same	Same	Same	Same
	Insecticide, $/a.	1.43	Same	Same	Same	Same	Same

of the total acreage will be cultivated each year, but this cost is considered in the machinery section. Financing is assumed to be required for 6 months at 9½ percent per annum for fuel, oil, and machinery maintenance costs and for seed, fertilizer, herbicide, insecticide, and drying and miscellaneous costs.

These assumptions pertain only to the sample figures presented in the data input booklet and Table 5. Variations will likely exist for each farm situation. Detailed farm records are very important to validating the figures in this section. The OACB is particularly sensitive to variations in crop yield, as is any actual cash crop operation.

SOYBEANS

Input data specific to the soybean crop are similar to those for corn. The OACB considers 6 different planting periods in combination with 3 harvest periods, giving 18 possible combinations. Because soybeans can be either sold directly from the field or stored and sold later, the computer program considers 36 alternatives when determining how to fit the soybean field operations together for maximum returns. Soybean yields and costs for fertilizer, seed, and herbicide are required for each combination

(Table 6). Like the table for corn, Table 6 is essentially a statement of planned inputs and expected conditions. That is, if soybeans were planted in one particular time period and harvested in one particular period, the farm would experience a specified yield and cost situation. The OACB uses this table as well as the available field time and equipment to actually schedule planting, harvesting, and other field operations to maximize profits.

The soybean yields in Table 6 are based on a mid-season variety for the harvest period September 13 to 26 and a full-season variety for the harvest period September 27 to October 17. When entering data for the OACB, each manager must determine appropriate figures based on his own seed, past experience with season length, and so forth. As with corn, the computer program can be very sensitive to variations in soybean yield. Care must be taken when interpreting OACB results to make certain that the computer was not tricked into its conclusions by spurious yield information.

WHEAT

The OACB has a small set of wheat (winter or spring varieties) activities built into its linear programming matrix. Wheat will compete with corn and soybeans for the limited resources available on a farm. Land is a limited resource and so are machinery and labor during land preparation, planting, and harvesting. Two time periods are allowed for land preparation and planting—September 13 to September 26 and September 27 to October 17. The only period allocated for harvesting is June 14 to July 18. Tables 7, 8, and 9 present sample data for these planting and harvesting activities.

SUMMARY

The OACB and its data requirements may seem formidable to a farm manager when he sees it for the first time. As mentioned earlier, one of the major benefits from a linear programming analysis of a business is a new familiarity with that business. Linear programming forces one to look carefully at many aspects of the business that normally may be overlooked. It often surprises a manager by showing him how sensitive his operation is to small changes. In the OACB, small variations in yield may cause large swings in the combination of cropping activities that is chosen to maximize returns. Because it is supported by computers, the OACB is the only approach that can perform calculations fast enough to allow a manager to plug in variations and observe the consequences.

The linear programming simulation in the OACB cannot, admittedly, represent all aspects of corn and soybean production on all farms. A farm manager who wants to use the OACB should first provide as much information specific to his farm as possible and observe the results. Then, by adopting a systematic process of data adjustment and recalculation, the manager can become familiar with the OACB's characteristics. If the OACB has delivered reasonable results at the end of this procedure, it may be used for detailed planning.

Anyone who uses a simulation based on linear programming should approach it slowly through many preliminary runs. A manager can thus avoid the common psychological trap of viewing the computer program as too inflexible for meaningful application. By understanding the tool's limitations, a manager is well prepared to interpret results and extrapolate them to day-to-day decision making.

Table 6.--Soybean Technology: Yield and Input Costs

Harvest period	Production item	Planting periods: Apr. 26 to May 2	May 3 to May 9	May 10 to May 16	May 17 to May 23	May 24 to May 30	May 31 to June 6
Sept. 13 to Sept. 26	Yield, bu./a.	0	45	45	45	0	0
	Fertilizer, $/a.	0	7.15	7.15	7.15	0	0
	Seed costs, $/a.	0	4.50	4.50	4.50	0	0
	Herbicide, $/a.	0	6.46	6.46	6.46	0	0
Sept. 27 to Oct. 17	Yield, bu./a.	0	47	44	42	41	40
	Fertilizer, $/a.	0	7.15	7.15	7.15	7.15	7.15
	Seed costs, $/a.	0	4.50	4.50	4.50	4.50	4.50
	Herbicide, $/a.	0	6.46	6.46	6.46	6.46	6.46
Oct. 18 to Nov. 7	Yield, bu./a.	0	0	0	0	0	0
	Fertilizer, $/a.	0	0	0	0	0	0
	Seed costs, $/a.	0	0	0	0	0	0
	Herbicide, $/a.	0	0	0	0	0	0

Table 7.--Machine Operations, Working Rates, and Labor Requirements for Wheat

Operation	Number units of equipment	Adjusted field capacity (acres/hour)	Men per field hour
Land prep. and planting			
Disc stalks	1	7.04	1.20
Plant	1	6.00	1.20
__________	__	_____	_____
__________	__	_____	_____
Harvest @ 45 bu./a.	1	2.75	1.50
Harvest @ 30 bu./a.		3.00	1.50

Table 8.--Yield Expectations for Wheat

Harvest period	Production item	Planting period: Sept. 13 to Sept. 26	Planting period: Sept. 27 to Oct. 17
June 14 to July 18	Owned land yield, bu./a.	40	40

Table 9.--Price and Cost Information for Wheat

Information item	Dollars
Market price per bu.	1.50
Production costs per acre:	
Miscellaneous	2.00
Total fuel and repair	4.00
Fertilizer	12.00
Seed	3.00
Herbicide and insecticide	0

APPENDIX

OUTPUTS OF THE ONTARIO AUTOMATIC CROPPING BUDGET

The Ontario Automatic Cropping Budget (OACB) belongs to a relatively new group of computerized farm management tools in which results are processed into readable tables. Because the OACB's linear programming simulation is based primarily on the way planting and harvesting time affects crop yields, most of its results pertain to scheduling field operations throughout the year. The figures in the following tables pertain to a computer run made for a farm in Kent County, Ontario in 1973 and are merely reproduced here to illustrate the type of information available from the OACB. A subsequent paper will deal with the interpretation of these output reports.

Table 1. Projected Annual Profit and Loss Statement

	Corn		Soybeans		Wheat		Total	
A. Sales(From 406. A.Corn,395. A.Soybeans And 213. A.Wheat)		$ 64938.		$ 41362.		$ 11490.		$117790.
B. Custom Combining Hired Out (83. Hrs.)								2708.
C. Less-Allocated Variable Costs								
1. Fertilizer	$ 7798.		$ 2822.		$ 2553.		$ 13174.	
2. Seed,Chemical	2706.		1776.		638.		5121.	
3. Insecticide and/or Herbicide	3932.		2550.		0.		6481.	
4. Fuel,Lubricants,Repairs	1566.		1324.		851.		3741.	
5. Drying at Farm	1588.						1588.	
6. Drying at Elevator	0.						0.	
7. Interest on OP.Funds,Misc	1625.		1022.		638.		3285.	
8. Total Allocated Variable Costs		19214.		9495.		4681.		33390.
9. Return to Allocated Variable Costs		45723.		31867.		6809.		87108.
D. Less-Unallocated Variable Costs								
1. Land Rental (313.7 A.X $ 20.00)							6273.	
2. Hired Labor (1106. Hrs. X 4.00)							4423.	
3. Custom Combining Hired In (118. Hrs.)							4240.	
4. Gross Profit(Returns to Fixed Resources)								72171.
E. Less - Fixed Costs								
1. Fixed Machinery Costs 2. Tractors							20430.	
2. Fixed Labor Costs(1.0 Men X 6000.00)							6000.	
3. Fixed Land Costs (700. A.X $ 35.00)							24500.	
4. Total Fixed Costs								50930.
F. Net Profit (Returns to MGMT. Before Income Taxes)								21241.

Table 2. Project Summary of Land Use,Yields and Income From Corn,Soybeans and Wheat

	Corn Wet	Corn Dry	Corn Stored	Soybeans	Soybeans Stored	Wheat
A. Total Acreage(Acres)	0.	0.	406.	0.	395.	213.
B. Total Production In Bushels (BU)	0.	0.	56467.	0.	16545.	9575.
C. Selling Price Per Bushel(Net of Truck Charges) ($)	1.02	1.05	1.15	2.37	2.50	1.20
D. Total Sales ($)	0.	0.	64938.	0.	41362.	11490.
E. Average Yield (Bu/Acre)	0.0	139.0	139.0	41.9	41.9	45.0
F. Average Harvest Moisture Percent	0.0	21.03	21.03			
G. Average Sales Per Acre ($/Acre)	0.0	0.0	159.9	0.0	104.8	54.0
H. Average Variable Costs Per Acre ($/Acre)	0.	0.	47.	0.	24.	22.
I. Average Return To Unallocated Variable Costs ($/Acre)	0.	0.	113.	0.	81.	32.

Table 3. Projected Corn Production By Date of Planting and Harvesting Date

	Harvesting Period							
	Sep.27-Oct.17		Oct.18-Nov.7		Nov.8-Nov.28		Total Acres Planted	Total Bu. From This Planting Period
Planting Period	Acres	Production	Acres	Production	Acres	Production		
A.Apr.26-May 2	0.0	0.	126.5	17963.	0.0	0.	126.50	17963.
B.May 3-May 9	0.0	0.	89.2	12664.	37.3	5075.	126.50	17740.
C.May 10-May 16	0.0	0.	137.3	18668.	0.0	0.	137.27	18668.
D.May 17-May 23	0.0	0.	15.9	2096.	0.0	0.	15.88	2096.
E.May 24-May 30	0.0	0.	0.0	0.	0.0	0.	0.00	0.
F.May 31-June 6	0.0	0.	0.0	0.	0.0	0.	0.00	0.
G.Total Acres and Bushels	0.0	0.	368.8	51392.	37.3	5075.	406.15	56468.
H.Av.Yield Per Acre		145.		139.		136.		139.

Table 4. Projected Soybean Production By Date Of Planting and Harvesting Date

	Harvesting Period							
	Sep.13-Sep.26		Sep.27-Oct.17		Oct.18-Nov.7		Total Acres Planted	Total Bu. From This Planting Period
Planting Period	Acres	Production	Acres	Production	Acres	Production		
A.Apr.26-May 2	0.0	0.	0.0	0.	0.0	0.	0.0	0.
B.May 3-May 9	0.0	0.	0.0	0.	0.0	0.	0.0	0.
C.May 10-May 16	0.0	0.	0.0	0.	0.0	0.	0.0	0.
D.May 17-May 23	121.4	5462.	0.0	0.	0.0	0.	121.38	5462.
E.May 24-May 30	0.0	0.	148.8	6103.	0.0	0.	148.85	6103.
F.May 31-June 6	0.0	0.	124.5	4980.	0.0	0.	124.49	4980.
G.Total Acres and Bushels	121.4	5462.	273.3	11082.	0.0	0.	394.72	16545.
H.Av.Yield Per Acre		45.		41.				42.

Table 5. Projected Wheat Production By Date Of Planting And Harvesting Date

Planting Period	Bushels Harvested In June 14 To July 20	
	Acres	Yield
A. Sept.27 -- Oct.17	212.8	9575.
B. Oct. 18 -- Nov. 7	0.0	0.
C. Total A. & Bu.	212.8	9575.
D. Av.Yield Per Acre		45.

Table 6. Schedule Of Machine Field Operations (Based On Field Hours Available - See Table 8)

	Acres Prepared			Acres Planted			Post Plant	Acres Harvested		
Time Period	Corn	Soybeans	Total	Corn	Soybeans	Total	Total	Corn	Soybeans	Total
A. Mar.15-Apr. 4	91.	0.	91.	0.	0.	0.	0.	0.	0.	0.
B. Apr. 5-Apr.25	131.	0.	131.	0.	0.	0.	0.	0.	0.	0.
C. Apr.26-May 2	0.	0.	0.	127.	0.	127.	0.	0.	0.	0.
D. May 3-May 9	0.	0.	0.	127.	0.	127.	0.	0.	0.	0.
E. May 10-May 16	0.	0.	0.	137.	0.	137.	127.	0.	0.	0.
F. May 17-May 23	0.	0.	0.	16.	121.	137.	127.	0.	0.	0.
G. May 24-May 30	0.	0.	0.	0.	149.	149.	264.	0.	0.	0.
H. May 31-June 6	0.	0.	0.	0.	124.	124.	264.	0.	0.	0.
I. June 7-Jun.13	0.	0.	0.	0.	0.	0.	286.	0.	0.	0.
J. Jun.14-Jul.18	0.	0.	0.	0.	0.	0.	535.	0.	0.	0.
K. Sep.13-Sep.26	0.	121.	121.	0.	0.	0.	0.	0.	121.	121.
L. Sep.27-Oct.17	0.	92.	92.	0.	0.	0.	0.	0.	273.	273.
M. Oct.18-Nov. 7	0.	48.	48.	0.	0.	0.	0.	369.	0.	369.
N. Nov. 8-Nov.28	88.	134.	222.	0.	0.	0.	0.	37.	0.	37.
O. Nov.29-Dec.12	96.	0.	96.	0.	0.	0.	0.	0.	0.	0.
Totals	406.	395.	801.	406.	395.	801.	1602.	406.	395.	801.

Table 7. Projected Use Of Available Machine Field Time For All Crops

	Field Hours Available (Hours)	Plus Custom In (Hours)	Less Custom Out (Hours)	Less Used In Table 7 (Hours)	Remaining Field Hours (Hours)	Estimated Value Of Extra Field Time ($/Hour)
Preparation And Planting						
A. Mar.15-Apr. 4	41.			41.	0.	40.62
B. Apr. 5-Apr.25	59.			59.	0.	40.62
C. Apr.26-May 2	25.			25.	0.	173.80
D. May 3-May 9	25.			25.	0.	176.35
E. May 10-May 16	32.			32.	0.	168.22
F. May 17-May 23	32.			32.	0.	144.13
G. May 24-May 30	40.			40.	0.	114.14
H. May 31-June 6	40.			40.	0.	100.51
I. June 7-Jun.13	40.			17.	23.	0.0
J. Jun.14-Jul.18	199.			158.	42.	0.0
K. Sep.13-Sep.26	70.			61.	9.	0.0
L. Sep.27-Oct.17	109.			109.	0.	0.00
M. Oct.18-Nov. 7	102.			26.	76.	0.0
N. Nov. 8-Nov.28	99.			99.	0.	8.68
O. Nov.29-Dec.12	43.			43.	0.	40.62
Harvesting						
P. Sep.13-Sep.26	70.	0.	30.	40.	0.	2.28
Q. Sep.27-Oct.17	109.	0.	0.	89.	20.	0.0
R. Oct.18-Nov. 7	92.	118.	0.	158.	52.	0.0
S. Nov. 8-Nov.28	69.	0.	54.	16.	0.	2.75
Totals	1295.	118.	83.	1108.	222.	

Table 8. Summary Of Projected Profile Of Labour Utilization

Time Period	Full-Time Available (Hours)	Labor Used (Hours)	Part-Time Labor Hired (Hours)	Total Labor Used (Hours)	Labor Equivalent Used (Hours)	Labor Equivalent Unused (Hours)	Estimated Value Of Extra Labor Time ($/hour)
A. Mar.15-Apr. 4	41.	41.	42.	83.	74.	0.	5.00
B. Apr. 5-Apr.25	59.	59.	61.	120.	107.	0.	5.00
C. Apr.26-May 2	25.	25.	31.	56.	50.	0.	5.00
D. May 3-May 9	25.	25.	31.	56.	50.	0.	5.00
E. May 10-May 16	32.	32.	34.	66.	59.	0.	5.00
F. May 17-May 23	32.	32.	34.	66.	59.	0.	5.00
G. May 24-May 30	40.	40.	37.	76.	69.	0.	5.00
H. May 31-June 6	40.	40.	31.	71.	64.	0.	5.00
I. June 7-Jun.13	40.	17.	0.	17.	17.	22.	0.0
J. Jun.14-Jul.18	199.	199.	0.	199.	199.	0.	4.21
K. Sep.13-Sep.26	70.	70.	140.	210.	182.	0.	23.51
L. Sep.27-Oct.17	109.	109.	218.	327.	283.	0.	28.13
M. Oct.18-Nov. 7	102.	102.	204.	306.	265.	0.	28.13
N. Nov. 8-Nov.28	99.	99.	198.	297.	257.	0.	22.39
O. Nov.29-Dec.12	43.	43.	45.	88.	79.	0.	5.00
Totals	955.	933.	1106.	2039.	1817.	22.	

Table 9. Projected Use Of Available Labor For Corn,Soybeans And Wheat

Time Period	Labor For Corn (Hours)	Labor For Soybeans (Hours)	Labor For Wheat (Hours)	Custom Combining Labor Provided For Use By Hire In: (Hours)	Out: (Hours)	Full Time Labor Reconciliation (Hours)
A. Mar.15-Apr. 4	74.	0.	0.			74.
B. Apr. 5-Apr.25	107.	0.	0.			107.
C. Apr.26-May 2	50.	0.	0.			50.
D. May 3-May 9	50.	0.	0.			50.
E. May 10-May 16	59.	0.	0.			59.
F. May 17-May 23	11.	48.	0.			59.
G. May 24-May 30	10.	59.	0.			69.
H. May 31-June 6	5.	59.	0.			64.
I. June 7-Jun.13	5.	12.	0.			17.
J. Jun.14-Jul.18	1.	83.	116.			199.
K. Sep.13-Sep.26	0.	150.	0.	0.	32.	182.
L. Sep.27-Oct.17	0.	210.	73.	0.	0.	283.
M. Oct.18-Nov. 7	363.	32.	0.	130.	0.	265.
N. Nov. 8-Nov.28	108.	90.	0.	0.	59.	257.
O. Nov.29-Dec.12	79.	0.	0.			79.
Totals	924.	743.	189.	130.	92.	1817.

Table 10. Value Of Additional Resources

As A Guide To Your Next Budget

The Following Resources Limit The Expansion Of Your Firm And Have The Following Values.
(For At Least Small Amounts)

Resource	Value Per Additional Unit ($/Unit) Column 1	No. Of Units This Value (Units) Column 2
Field Hours Preparation and Planting ($/hour)		
1. A. Mar.15-Apr. 4	40.62	9.55
2. B. Apr. 5-Apr.25	40.62	9.55
3. C. Apr.26-May 2	173.80	2.35
4. D. May 3-May 9	176.35	2.30
5. E. May 10-May 16	168.22	1.99
6. F. May 17-May 23	144.13	2.05
7. G. May 24-May 30	114.14	1.35
8. H. May 31-June 6	100.51	1.42
9. N. Nov. 8-Nov.28	8.68	29.58
10. O. Nov.29-Dec.12	40.62	9.55
Field Hours Harvesting ($/Hour)		
11. Sep. 13-Sep. 26	2.28	4.65
12. Nov. 8-Nov. 28	2.75	14.50
Harvested Land ($/Acre)		
13. Sep. 27-Oct. 17	0.15	13.50
Labor (Break Even Wage)($/Hour)		
14. K. Sep.13-Sep.26	18.81	12.10
15. L. Sep.27-Oct.17	22.51	16.37
16. M. Oct.18-Nov. 7	22.51	204.00
17. N. Nov. 8-Nov.28	17.91	23.13

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