A SYSTEM FOR GREENHOUSES TO MAXIMIZE PROFIT

I. INTRODUCTION

Joe J. Hanan and Charles W. Basham[1]

What if there was a program which, in less than 10 minutes from the time you submitted the data to when you got the printout, would tell you for your operation these things for each two-week period of the year:

1. The number of units (pots or flats) that should be produced to give maximum profit?
2. How much the profit would increase or decrease for each additional unit produced?
3. Show the total material costs (soils, liners, pots, etc.) for each time period?
4. Show the hours of labor required, surplus and deficit for each period?
5. Show the empty space for each period?
6. Show which space should be closed or opened?
7. Indicate diagrammatically the amount of area occupied by each crop, and the number of units in that space for each crop?
8. How much the price per unit could vary before the maximization was no longer valid?
9. Indicate what factor was preventing further profit increase?
10. Allow you to produce a crop, even though unprofitable, in order to stay in the market?

Would you be interested in a software program which could be dovetailed into existing budget and inventory systems that could tell you:

1. When to order, how much to order and how much cash you needed to have?
2. When and how much to change prices?
3. When to hire and when to lay off labor?
4. Which crops are most profitable?
5. Allows one to estimate costs and show which costs need to have more information?
6. Allows you to input cost change and see how that change would affect profitability?

[1]Professor and Assoc. Professor respectively.

Well, there are some problems before all this comes to pass. But, we have a system that is capable of doing this, and these are things we see down the line with successful implementation. The computer programs capable of answering the questions posed previously are called LINEAR PROGRAMS. They are programs using well-known mathematical processes (algorithms) to solve unknowns stated as a series of algebraic equations. These systems come into play when there are numerous decisions to be made which can be figured out when one has the tremendous number crunching ability of present-day computers. The idea is to arrive at a series of values for unknowns in such a way that one either minimizes cost of production or maximizes profit. We have, over the past three years, been working with LINEAR PROGRAMS for greenhouses for the purpose of maximizing profit.

We can best illustrate what LINEAR PROGRAMMING does by taking a very simple example: Assume a 400 acre farm which produces pinto beans and beets and the farmer wants to know how many acres of each to plant. The return per acre on beans is $202 and the return per acre for beets is $325. We want to maximize:

(Acres of beans) ($202) + (Acres of beets) ($325)

Unfortunately, there are *constraints* on production of these crops:

1. The total acreage is 400.
2. The total labor available is 5000 hours.
3. The total working capital is $60,000.
4. The total amount of water available is 20,000 acre-inches.

The requirements of the crops are:

	Land (acres)	Labor (hours)	Capital ($)	Water (acre-inches)
Pinto beans (per acre)	1	4.5	125	42
Beets (per acre)	1	25.0	240	66

The problem is formulated for LINEAR PROGRAMMING as follows:

(1) (1) (acres of beans) + (1) (acres of beets) equal to or less than 400.

(2) (4.5) (acres of beans) + (25) (acres of beets) equal to or less than 5000.

(3) (125) (acres of beans) + (240) (acres of beets) equal to or less than 60,000.

(4) (42) (acres of beans) + (66) (acres of beets) equal to or less than 20,000.

This problem with two variables can be solved graphically (Fig. 1). We can plot acres of beans and beets, and the line connecting either 400 acres of beans or 400 acres of beets is the solution for that constraint (Fig. 1a). Similarly, the limits for labor (1111 acres beans or 200 acres beets) are shown with line "b", the limits for capital (478 acres beans or 250 acres beets) by line "c", and the limits for water (476 acres beans or 303 acres beets) are shown by line "d". These lines represent all *feasible* solutions for each constraint. The region of *feasible* solutions for the problem lies to the left of the drawn lines. Starting at "0" (point 1), no crops produced and moving to the right shows that:

At point (2), the profit is $80,000 with all 400 acres in beans.

At point (3), the profit is *maximum* ($91,255) with 315 acres in beans and 85 acres in beets.

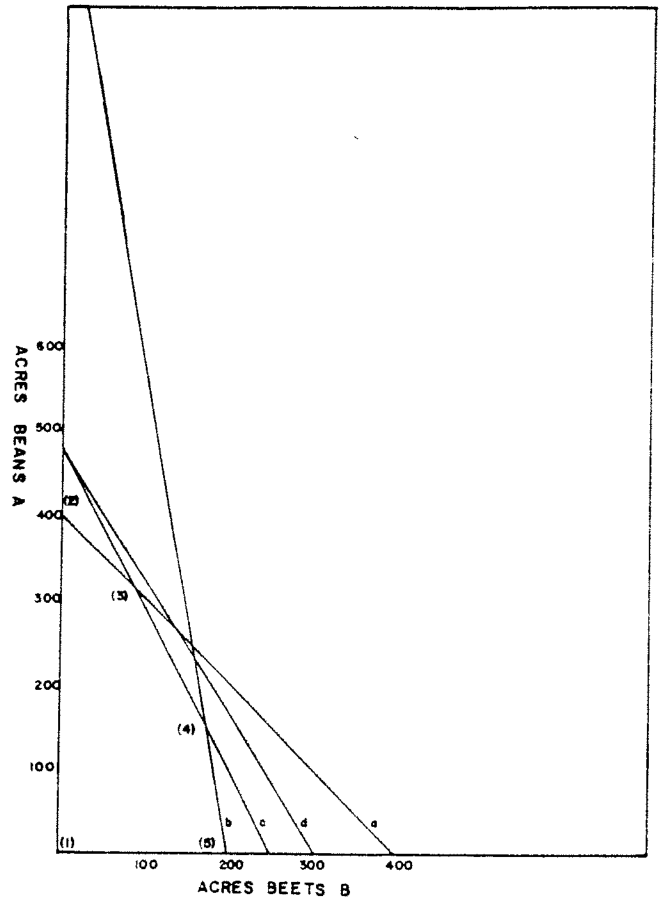

Fig. 1: Graphical solution to a linear program involving the number of acres of beans or beets to plant in order to maximize profit.
"a" —limit for area, 400 acres of beets or 400 acres of beans
"b" —limit for labor, sufficient for 1110 acres of beans or 200 acres of beets
"c" —limit for capital, 478 acres beans or 250 acres beets
"d" —limit for water, 476 acres beans or 303 acres beets

Feasible solutions for the problem are:

Point 1: Nothing produced, return to *objective function* (net profit) = 0.
2: Four hundred acres of beans produced, profit $80,000.00.
3: Maximized objective function, $91,255.00 return, 315 acres in beans, 85 acres in beets.
4: Next feasible solution, $85,155.00, 140 acres in beans and 175 acres in beets.
5: Two hundred acres in beets, no beans produced, return is $65,000.00.

There is no feasible solution to the right of any curve connecting the two axes.

At point (4), the profit is no longer maximum ($85,155) with 140 acres in beans and 175 acres in beets, and

At point (5), 200 acres in beets and no beans, the profit is further reduced to $65,000.

The result from maximizing (315 acres) ($202) + (85 acres) ($325) is called the *objective function.*

Now a knowledgeable grower can do this with a hand calculator and some time. But, most systems rapidly reach the point where the human brain cannot cope, and this is where the computer LINEAR PROGRAMS can reduce time and effort, and with the knowledge that at least the addition and subtraction — provided the right numbers are entered — are correct.

Linear Programs are now being used by oil refineries to optimize output and minimize costs, in transportation to determine the best routing of deliveries, as a means to provide better logistical support of infantry, in agriculture in more complex systems similar to the example just given, to minimize cost in food formulations for cattle feeding operations, or in factory production of hard goods where scheduling between warehouses and production lines must be correlated. Work on adaptation of LINEAR PROGRAMMING for greenhouses actually began several years ago by Massachusetts people, notably Vaut and Christensen (Coop. Extension Bulletin No. 93, 1973), and was a subject of a Ph.D. dissertation by Gortzig at Michigan State University in 1976. Unfortunately, this work was apparently allowed to lapse when resources and interest were lacking. There are significant problems in application to greenhouses which we shall discuss in future articles.

Published by
Colorado Greenhouse Growers Association, Inc.
Dick Kingman, Executive Vice President
2785 N. Speer Blvd., Suite 230
Denver, Colorado 80211
Bulletin 389

6

Direct inquiries to:
Office of the Editor
Horticulture Department
Colorado State University
Fort Collins, Colorado 80523