Agricultural Engineering

Dr. Fred E. Beckett, Editor

The Use of High-Speed Computers for Solving Linear Programming Problems in the Agricultural Industry

By K. R. Tefertiller
Texas A & M

INTRODUCTION

The linear programming technique has been widely used in the Agricultural Industry for several years. However, the arrival of the high-speed computer has greatly increased the feasibility of using Linear Programming for solving large complex problems.

Linear programming is a mathematical tool which can be used to give concrete answers to certain types of practical problems. However, *not all* problems in the agricultural industry or in economics in general are types of problems that can be solved by linear programming. What can be solved by linear programming? There are **three** necessary requirements for a problem to be adaptable to linear programming. **First**, there must be some objective or goal which can be maximized or minimized. **Second**, there must be at least one factor that is fixed or in limited supply. For example, in a farm situation quite often capital or land or both are factors which are fixed in supply. **Third**, there must be more than one way to attain the objective that is specified. For example, in a farm situation where there are scarce amounts of certain resources, there are many different ways for us to obtain profit on a farm. There are various field crops, and livestock enterprises such as beef cattle or poultry. Therefore, one type of problem that can be solved with linear programming would be that of finding the most profitable combination of enterprises for some particular farm situation. Let us assume that there is some particular farm with 300 acres of cropland, 1000 hours of labor, and 20,000 dollars of operating capital. These would be the restrictions that I mentioned earlier. Let us assume that the farmer is interested in maximizing profit and this would be his goal or objective and it is something that we can measure in terms of quantitative (in dollars and cents). So the first two requirements for linear programming problem have been satisfied. There must be more than one way to produce profit on a farm and this is not an unrealistic assumption on most farms. For instance on most Texas farms there is a possibility of using your limited land and capital in many different ways. You can produce field crops such as grain sorghum or cotton or many different livestock enterprises such as dairy, beef, poultry. Hence, linear programming could be used to find the most profitable combination of enterprises and this would be that combination of enterprises which would make the most efficient use of the limited resources which the farmer has available. I might add that one of the limitations in using liner programming for finding the most profitable combination of enterprises is in the technique itself, but perhaps a more serious limitation is the difficulty in obtaining adequate data for a given operation. This points out the need for more and better designed records of our farm businesses.

An example of how linear programming has been used in the poultry industry is finding a least-cost feed mix subject to specified requirements such as the amount of protein, the amount of fiber, the amount of fat that is needed. The problem shown in Table 1 is an example of a feed mix problem. It is a problem of finding the combination of the ingredients or nutrient sources which will give the least cost for a ton of this feed mix given specified restrictions and feed prices. In this particular case, there has to be not more than 8% fiber, at least 35% protein and at least 1.5% fat. **Second**, we see across the top that there are four different sources of nutrients from which the ton of feed mix can be made. In this particular case we have alfalfa meal, distillers solubles, fish meal and soybean meal as sources of nutrients. Also, we find that the cost per ton of each of these feeds is listed at the bottom of the table and this is the objective to be minimized. As we examine this problem, we see that all the components of a linear programming problem are present. We have an objective that is to be maximized or minimized and in this case it is to determine minimum cost for a specific ration. **Second**, there is at least one restriction in this case, to be exact, there are three restrictions. **Third**, there is more than one way to produce this particular ration. We have 4 different nutrient sources.

Now let us examine the solution for this particular problem. (Table 2.) We find the solution is made up of only three of the four possible nutrient sources. **First**, 14 percent (280 lbs.) of the ton of feed is made up of alfalfa; 55 percent (1100 lbs.) of the ton of feed is made up with soybean meal; and 31 percent (620 lbs.) of the ton of feed is made up with distilled soulbles. This combination of nutrient sources is equal to 2000 pounds of feed. All the restrictions have been satisfied. Exactly 8% of the ration is made up of fiber and exactly 35% of the ration is protein. Although 1.5% fat was the minimum requirement in this problem, 2.4% of the optimal feed mix is made up of fat. This does not violate the restriction because you recall that we had to have at least 1.5% fat. Hence, every restriction has been satisfied and this is the least-cost ration given the restrictions and feed prices. The total cost of the least-cost ration is $90.56. If feed ingredients of levels of the restrictions are changed, the least-cost combination of nutrient sources is likely to change. For instance, if instead of 8% fiber, the requirement was that there could not be more than 7% fiber in the ration, this would increase the cost of the ration by 85c. However, on the other hand if the fiber requirement was changed to say at least 9% instead of 8% fiber, this would decrease the cost by 85c. Likewise, if the requirement for protein had been 34% instead of 35%, the ration could have been decreased by 69c. Or, if the requirement had been 36% instead of 35% protein, the ration cost would have been increased by 69c.

This is some of the additional information furnished by a linear programming solution. These values allow one to evaluate the economic consequences that would result from changes in requirements for a feed mix. Since minimum and maximum requirement for certain rations are constantly being re-evaluated in this age of changing technology, linear programming could be a useful guide for showing the economic consequences of changing critical requirements. Likewise, price mapping can be used to determine how sensitive or how rapid the least-cost ration changes due to changes in prices of certain ingredients.

In conclusion, I would like to stress that even though the technique of linear programming is useful in giving answers to practical problems, it also may be used in certain cases as a guide for general direction of adjustment in the agricultural industry. One of the limitations of linear programming in solving actual problems is the limitations in the data required by linear programming. Therefore, I would stress that perhaps in some ways that our mathematical and computer techniques are ahead of the actual data that we have. This places greater strain on the importance of keeping good records.

TABLE 1.

Basic Data Required for a Least-cost Feed Mix Problem

Nutrient Source	Nutrient Requirements	Feed Ingredients: Alfalfa Meal	Distillers Solubles	Fish Meal	Soybean Meal
Fiber	8	25	3	1	6.5
Protein	35	17	25	60	45.0
Fat	1.5	2	5	7	.5
Cost per ton		$66	$92	$156	$95

TABLE 2.

A Least-cost Solution to the Feed Mix Problem

Nutrient Source	Amount of Nutrient (lbs.)	Cost per ton	Total Feed Cost
Alf. meal	280	$66.00	$ 9.24
Dist.. Sol.	620	92.00	28.52
Soy. Meal	1100	96.00	52.80
Total	2000		$90.56

Junior Colleges . . .

H. M. McKenzie, Editor

A Study of the Status and Role of the Junior Colleges in Providing Non-Transfer Agricultural Education in California

Ralph M. Vorhies

The major purpose of this study was to determine the past, present, and possible future of the California junior colleges in providing non-transfer agricultural education. An attempt was made to learn how extensive this type of training is in the junior colleges in the state. Information secured from the colleges and the former students included: (1) the number and type of courses offered, (2) the student's educational background, and (3) the employment record of the former students. Students who entered the program in 1959 were used for the study. Whenever the former students gave permission employers were asked to give their opinion of the employee and his training.

1. SUMMARY OF THE DATA

History

Agriculture has been taught in the junior colleges of California from the very beginning of the system. In 1910 when the Fresno School District established the first public junior college, agriculture was in the curriculum.

The number of junior colleges offering agriculture courses has declined somewhat in recent years, and at present only 19 are offering agriculture. These colleges are widely scattered in all of the agricultural areas of the state, but the greatest number are located in the Los Angeles area and in the San Joaquin Valley.

Enrollments in agriculture are increasing slowly, but not as rapidly as the total college enrollment.

The Extent of the Non-transfer Program

Many of the junior colleges in California that offer agriculture teach only transfer courses which are planned to parallel the courses of the four-year agricultural college to which most of their students transfer.

Some junior colleges have special non-transfer courses in English and mathematics for terminal students, but few offer separate courses in agriculture designed to fit the needs of the non-transfer student.

Recently at least two of the junior colleges, Modesto Junior College and Mount San Antonio College, have begun to offer special terminal curricula for training agricultural technicians. The surveys made by these colleges and reviewed in Chapter II have demonstrated a need for such training.

Most of the junior colleges studied had adequate facilities for offering non-transfer courses in agriculture that would fit students for work in the related agriculture field.

The staff in agriculture at the 10 junior colleges varied from two to 11 with an average of 4.4 instructors. Nearly all of the full-time instructors had the master's degree, and they had considerable experience as teachers of vocational agriculture in high school or as workers in production or related agricultural fields.

* Unpublished Doctoral dissertation, University of Missouri, Columbia, 1964