THE EFFECT OF AVAILABLE RESOURCES ON THE FORAGE-GRAIN FEEDING RATIOS AND FORAGE PRODUCTION SYSTEMS ON SELECTED VIRGINIA GRADE A DAIRY FARMS

by

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INTRODUCTION

Statement of Problem

Dairy farmers in Virginia are confronted with the problem of continually re-organizing and adjusting their farming operations in an effort to maintain or improve their competitive position. Increasing competition in dairying within the State as well as potential competition developing in areas outside of the State make it essential that dairymen operate efficiently. In particular, they must give careful consideration to various ways of reducing their production costs. Feed costs make up 50 to 60 percent of the total cost of producing milk. Consequently, the feeding program on any dairy farm greatly affects the cost of producing milk and, ultimately, the net return to the farmer.

Many dairy farmers are limited in the amount of milk they can sell at the milk base price. Therefore, it is desirable to adjust the forage and grain production system and forage-to-grain feeding ratio to minimize the cost of milk production or to maximize returns within the base limits.

In every dairy farming situation, the operator has some resources which are limited in quantity and a number of alternative forage-to-grain feeding ratios and forage and grain production systems which he may follow. One of his major problems is to determine the feeding program that will yield an optimum net return attainable with the resources at his command. Hence, the main emphasis of this study is on the development of information that will be useful to dairy farmers in

making decisions with regard to feeding ratios and forage and grain production systems.

Previous research and observation of practices followed on dairy farms suggests three basic hypotheses for this study: (1) with the present resource restrictions on the farms under study, the most profitable feeding ratio is one that contains a high proportion of forage relative to grain for various levels of milk production per cow; (2) with the present resource restrictions on the farms under study and the three levels of milk production per cow, 9,000, 11,000 and 13,000 pounds, the most profitable level of milk production per cow will not be 13,000 pounds production per cow; (3) on the farms under study, land is the most restrictive resource in determining an optimum forage and grain production system for the various levels of milk production per cow.

Objectives of Study

This study had four objectives: (1) to determine the available resources and their restrictions on the farms included in this study; (2) to determine an optimum forage and grain production system and forage-to-grain feeding ratio for three levels of milk production per cow with milk sales at the blend price not to exceed the present total base sales;[1/] (3) to determine which of the three levels of milk

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[1/] The base sales is the present milk sold at a blend price of $5.73 per hundred-weight (milk sold at base price of $6.00 per hundred-weight plus milk sold at surplus price of $3.35 per hundred-weight) rather than the conventional meaning of base which does not include surplus.

production is the most profitable at the present blend price of $5.73 per 100 pounds; (4) to study the effect of changes in the price of milk on the relative profitability of the three levels of production per cow and the forage-to-grain feeding ratios when the amount of profitable milk production is less than the present base.

Area of Study

There are three major geographical areas of grade A milk production in Virginia. These are the northern, west central and southwest areas of the State. In 1958, there were 3,148 grade A dairy farms in Virginia and 2,383 or 76 percent of these farms were located in these three areas. More than one-fourth or 26 percent of the grade A dairy farms in these areas were situated in the west central area. The farms included in this study are located in the west central area and, more specifically, in Roanoke, Franklin and Henry Counties. Franklin County, which contains the majority of the farms included in this study, ranks fourth in the State in number of grade A dairy farms and sixth in terms of number of dairy cows.[1/]

The value of all farm products sold in Roanoke, Franklin and Henry Counties was $12,110,000 in 1959. Dairy products, chiefly whole milk, accounted for 23 percent of the total value of all farm products sold

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1/ Virginia Joint Agricultural Publication No. 2, Looking Into the Grade A Dairy Industry in Virginia, Virginia Department of Agriculture and V.P.I. Agricultural Extension Service, June, 1959, pp. 5-6, pp. 36-37.

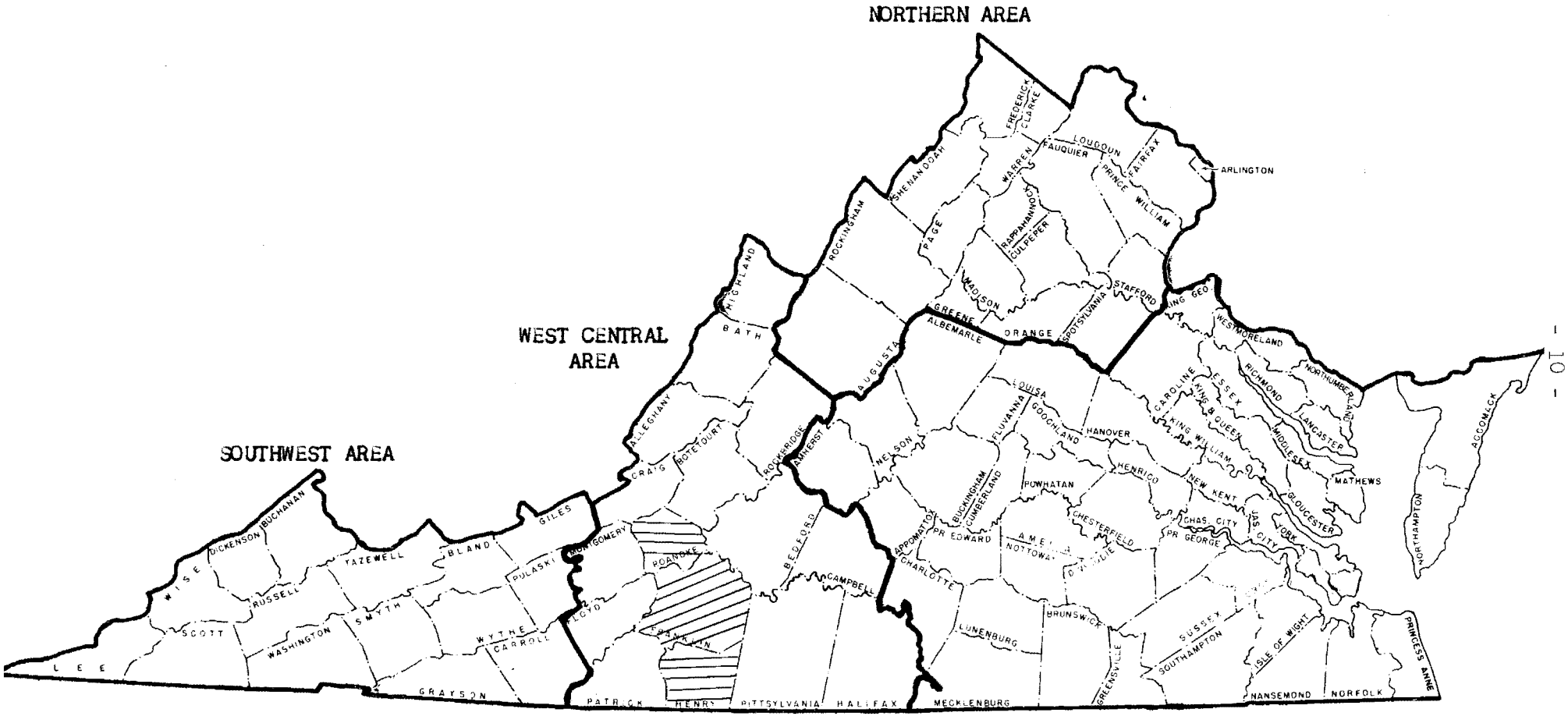

Figure 1. Area of Study, Roanoke, Franklin, and Henry Counties, Virginia .

indicating that grade A dairying provided a major proportion of the farm income in this three-county area. Franklin County was rated eighth in the State in terms of farm income from dairy products thus revealing the importance of dairying in this county.1/

Since the production of forage and grain crops is of primary interest in this study, the topography and soils of the area are an important and necessary consideration. Roanoke County embraces two limestone valleys and a fairly large area of the Piedmont Plateau. The extreme southern portion of Roanoke County is primarily made up of the Blue Ridge Mountains. Franklin County falls entirely in the Piedmont Plateau with the exception of approximately 10 percent which is in the Blue Ridge Mountains and the foothills of these mountains. Henry County lies in the southwestern part of the Piedmont Plateau. The Piedmont Plateau consists mainly of the Cecil, Appling and closely related soil series. These soils are suitable for the production of such forage crops as: alfalfa, ladino clover, orchard grass, red clover, lespedeza and permanent pasture. Corn and the various small grain crops also produce well on these soils.

The soils of the Piedmont Plateau are usually less fertile than those of the limestone valleys but more so than those of the mountainous areas.

1/ U. S. Bureau of the Census, U. S. Census of Agriculture, 1959, Vol. I, Counties, Part 24, Virginia, U. S. Government Printing Office, Washington, D.C., 1961, pp. 195-203.

REVIEW OF LITERATURE

Numerous studies have been conducted relating to the effect of available farm resources on an optimum combination of farm enterprises. There have been less numerous studies, however, which deal with determining the effect of available farm resources on an optimum forage and grain production system and forage-to-grain feeding ratio on grade A dairy farms with a restriction on the total farm milk sales.

Heady, Schnittker, Jacobson and Bloom conducted an experiment designed to provide estimates of the milk production function and feed substitution ratios in alternative dairy cow rations.[1] The primary objective of this study was to establish the rates at which grains and forages substitute under specific technical conditions and the rate at which feeds are transformed into milk for various production levels and rations. Conclusions from this experiment indicate that grains and forages do not substitute at constant rates for various ranges of milk production per cow and that there is a non-linear relationship between feed inputs and the output of milk. Also, this study reveals that the E.N.E. system of feed evaluation is more suitable for dairy animals than is the T.D.N. system. The feed input figures for various ratios of forage-to-grain and the corresponding milk output figures from this

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[1] E. O. Heady, J. A. Schnittker, N. L. Jacobson, and S. Bloom, Milk Production Functions, Hay/Grain Substitution Rates and Economic Optima in Dairy Cow Rations, Res. Bul. 444, Agricultural Experiment Station, Iowa State College, Ames, Iowa, October, 1956.

experiment were used as a basis for developing feed input - milk output relationships for three levels of milk production per cow in the present study.

Huffman and Duncan in a study of corn silage as a source of unidentified grain factors concluded that when corn silage replaced a part of an all-hay ration on an equal total digestible nutrient basis it produced a marked increase in the quantity of fat-corrected milk produced.[1] This study also indicated that a pound of total digestible nutrients in a ration of hay and corn silage, which included grain, was more valuable for milk production than the same quantity of digestible nutrients in an all-hay ration. Thus, it is important when using corn silage as a source of feed for dairy animals to account for the nutrients supplied in terms of grain and forage rather than forage alone. In this connection, a study conducted at the University of Illinois by Nevens, Harshbarger, Touchberry and Dungan provided some basic data from which a dependable estimate could be made of the grain and forage content of corn silage.[2] The findings of this study were based on a five-year trial in which corn forage harvested at pre-silage, early-silage, good-silage and late-silage stages were separated into ear and leaf-stalk

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[1] C. F. Huffman and C. W. Duncan, Corn Silage as a Source of the Unidentified Grain Factors Needed for Milk Production, Quarterly Bulletin, 37(1):23-26, Michigan Agricultural Experiment Station, East Lansing, Michigan, 1954.

[2] W. B. Nevens, K. E. Harshbarger, R. W. Touchberry, and G. H. Dungan, A Method of Estimating the Money Value of Corn Silage, Bulletin 576, Illinois Agricultural Experiment Station, Urbana, Illinois, May, 1954.

fractions and the amounts of each fraction measured. The results of this study were used as a basis for separating corn silage into grain and forage in the present study.

Walker prepared a guide to aid farmers in estimating the costs of owning specified machinery.[1] These guides included all costs of ownership and operation except labor. Also, Sheppard included as a part of his study a detailed breakdown of the equipment cost and labor hours involved with harvesting and storing forage using various equipment combinations.[2] These works by Walker and Sheppard were drawn on extensively in estimating equipment costs and labor requirements for the various crop budgets used in the present investigation.

A farm adjustment study was conducted by Walker, Kline and Arnold that included as one of its objectives to test the feasibility of the use of transfer procedures in the linear programming method of analysis.[3] This study revealed that the use of transfer activities has considerable merit towards increasing the flexibility of the program. Transfer functions were used to make the products of some activities available as inputs to other activities; to substitute one

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[1] H. W. Walker, Guide for Estimating Annual Cost for Owning and Operating Selected Farm Machinery, Special Report, Virginia Agricultural Extension Service, Blacksburg, Virginia, August, 1959.

[2] V. M. Sheppard, Jr., An Economic Analysis of Resource Requirements and Performance of Alternative Systems for Harvesting and Storing Forage, Unpublished M. S. Thesis, Virginia Polytechnic Institute, Blacksburg, Virginia, May, 1960.

[3] H. W. Walker, R. G. Kline, and C. J. Arnold, Farm Adjustment Opportunities - Southside Virginia, Tech. Bul. 150, Virginia Agricultural Experiment Station, Blacksburg, Virginia, May, 1961.

input for another when it is economical to do so; and to facilitate the realistic pricing of inputs without greatly increasing the number of activities. The findings in this study of the use of transfer functions in linear programming provided guidelines for incorporating transfers in the program for the present study.

The studies reviewed obviously are not inclusive of all previous work that has relevance to the present study. Those mentioned, however, do represent the previous studies that were used in developing the framework within which the present research was conducted.

THEORETICAL FRAMEWORK AND ANALYTICAL METHODS

The dairy farmer who is limited to his present resources has two basic economic principles to guide him in determining an optimum feeding program. These principles are: (1) equal marginal returns to inputs or resources in alternative uses, and (2) marginal rates of substitution of feed inputs.

The equal marginal returns principle is dependent upon the principle of opportunity costs.[1/] This principle is called opportunity cost because it considers the value sacrificed in one use of an input or resource as a cost in another use of the same input or resource. For instance, the dairy farmer may feed the corn he produces with his limited resources to dairy cows or he may sell the corn. Assume that the use of a unit of corn as feed to a dairy cow will net $1.20 whereas this same unit of corn sold as grain will net $1.00. If, in this illustration, the dairyman elects to feed his corn, he has an opportunity cost of $1.00 per unit in addition to his direct corn production costs. Selling the corn may be a profitable use but, in this case, it is not the most profitable use. The dairyman would continue to feed units of corn until the added return from this use is equal to its opportunity cost. This principle can be extended to other dairy feed inputs, such as hay, that are being produced with limited resources and have alternative uses.

[1/] E. O. Heady and H. R. Jensen, Farm Management Economics, Prentice-Hall, Inc., New York, 1954, pp. 78-79.

The farm milk base is logically included in the bundle of limited resources. With this inclusion, the most profitable combination of uses of feed may be to use some in producing milk and some for direct market sales. Also, the most profitable combination may be to use the feed to produce up to the milk base limitation and sell any feed not needed for milk production. The combination of uses that is most profitable will depend upon the prices received in various alternative uses, the costs attached to each use and the value sacrificed as one use is replaced partly or entirely with another one.[1/]

The rate of milk production per cow has a significant effect on the costs attached to the use of feed for producing a given milk base and, thus, has an influence on the most profitable combination of uses of feed inputs. Figure 2 illustrates some of the physical factors involved in determining the most profitable combination of uses for feed when total milk production is limited to the present farm milk base which can be produced with various rates of milk production per cow.

Assume that the isoquant AB in Figure 2 represents 400,000 pounds of milk base. This diagram shows various combinations of production per cow and numbers of cows for producing 400,000 pounds of milk base. Points a, c and e on the vertical axis indicate 6,000, 9,000 and 13,000 pounds of milk per cow respectively. To produce the assumed milk base at 6,000 pounds per cow requires about 70 cows; at 9,000 pounds per cow requires about 45 cows; and at 13,000 pounds per cow requires about 32

[1/] E. O. Heady and H. R. Jensen, op. cit., pp. 77-80.

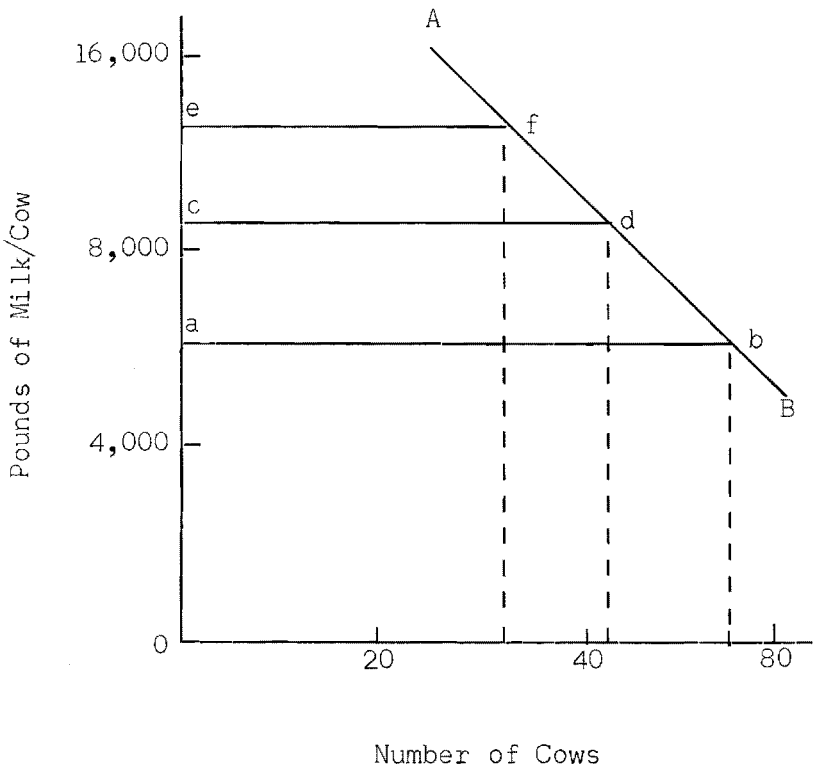

Figure 2. A Diagram Illustrating Numbers of Cows and Milk Production per Cow for Producing up to a Given Milk Base.

cows. The most profitable combination of uses of feed may be to produce milk somewhere to the left of a point such as b, d or f and to sell feed. The most profitable combination may be, however, to use the feed in producing the milk base limit at point b, d or f. Therefore, the dairyman must determine which rate of production per cow, such as point a, c or e and the number of cows as measured along such lines as ab, cd or ef, will give the most profitable combination of uses of feed.

To determine an optimum rate of production per cow and the consequent number of cows, the dairyman must also determine the least-cost ration for producing various rates of production per cow. Numerous combinations of grain and forage can be used to produce any given rate of milk production per cow. Grain and forage may substitute for each other at diminishing marginal rates in the dairy ration. That is, for any given rate of milk production per cow, as units of grain are added to the dairy ration, they substitute for fewer units of forage. This theorem is further explained by diagram (Figure 3).

Assume that the isoquant XY in Figure 3 represents 11,000 pounds of milk production per cow that can be produced with various combinations of grain and forage. The lines a'b, b'c, c'd, d'e, e'f and f'g represent unit changes (additional) in grain and the lines aa', bb', cc', dd', ee' and ff' represent the change in forage associated with each unit change (additional) in grain. From point a to point g on the isoquant XY, it is obvious that there is a diminishing marginal rate of substitution of grain for forage since the amount of forage saved diminishes (aa', bb', ---, ff') as units of grain are added. The

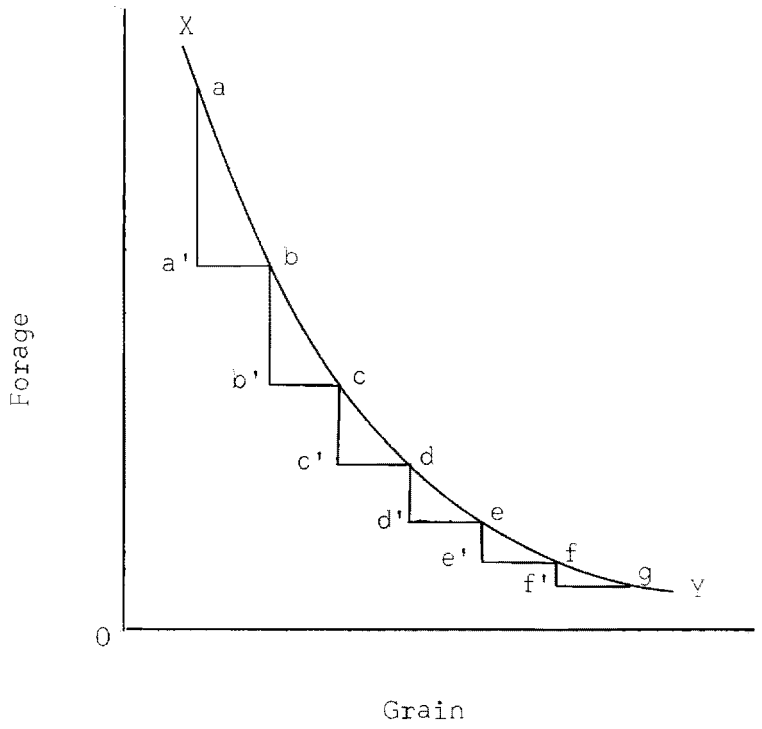

Figure 3. An Isoquant Illustrating the Marginal Rate of Substitution of Grain for Forage.

marginal rate of substitution principle as outlined thus far is a physical phenomenon since it indicates how much of one input (forage in Figure 3) can be saved with the output remaining at the same level if one unit of the other input (grain in Figure 3) is added to the ration.

To determine the least-cost combination of grain and forage, it is necessary to consider the prices of grain and forage. The combination of grain and forage which will yield a given quantity of output at least cost is where $\frac{\Delta G}{\Delta F} = \frac{P_F}{P_G}$. This is the same as saying that the cost of adding grain is equal to the reduction in cost from using less forage.[1/]

A change in the relative price of grain and forage changes the least-cost combination of grain and forage for producing a given rate of milk production per cow. The dairyman has alternative crop rotation systems for producing the grain and forage needed in the feed ration. Also, the dairyman may purchase the grain and forage for the feed ration. If the purchase price of grain and forage is less than its production cost, he will buy the grain and forage rather than produce it. Thus, changes in the price ratio are caused by changes in the production costs (including opportunity costs) associated with the alternative crop rotation systems and the relationship between the cost of producing and the cost of purchasing feed. Since both the substitution ratio of grain and forage $\left(\frac{\Delta G}{\Delta F}\right)$ and the inverse price ratio of grain and

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1/ C. E. Bishop and W. D. Toussaint, Introduction to Agricultural Economic Analysis, John Wiley and Sons, Inc., New York, 1958, pp. 95-98.

forage $\left(\frac{P_F}{P_G}\right)$ may vary, the dairyman is faced with a rather complex problem in determining the least-cost combination or where $\frac{\Delta G}{\Delta F} = \frac{P_F}{P_G}$.

For producing a given farm milk base, the least-cost combination of grain and forage for any rate of milk production per cow is also the point of maximum profit. An illustration indicating the least-cost - maximum profit point for producing a given farm milk base using 11,000 pounds of milk production per cow with various feed ratios and cost possibilities is provided in Figure 4.

Assume that points (A), (B), (C) and (D) on the horizontal axis in Figure 4 represent points on an isoquant such as those on XY in Figure 3. The shape of any one of the total variable cost curves in Figure 4 indicates the change that may occur in cost, with consideration given to opportunity cost, when a particular crop rotation system is used for supplying the feed for various forage-to-grain feeding ratios. Forage can be produced more cheaply than grain from some crop rotation systems, as illustrated by TVC_1, whereas grain can be produced more cheaply than forage from other crop rotation systems, as illustrated by TVC_3. Also, some crop rotation systems are best suited, from a cost standpoint, for producing approximately equal quantities of forage and grain, as illustrated by TVC_2. The cost of producing forage and grain from a particular crop rotation system depends upon such items as the type of crops that make up the rotation system, yields, length of time various crops remain in the rotation, cropping practices and the extent to which other rotations use the same restrictive resources. Thus, there is a range in costs, depending upon the crop rotation system and relative

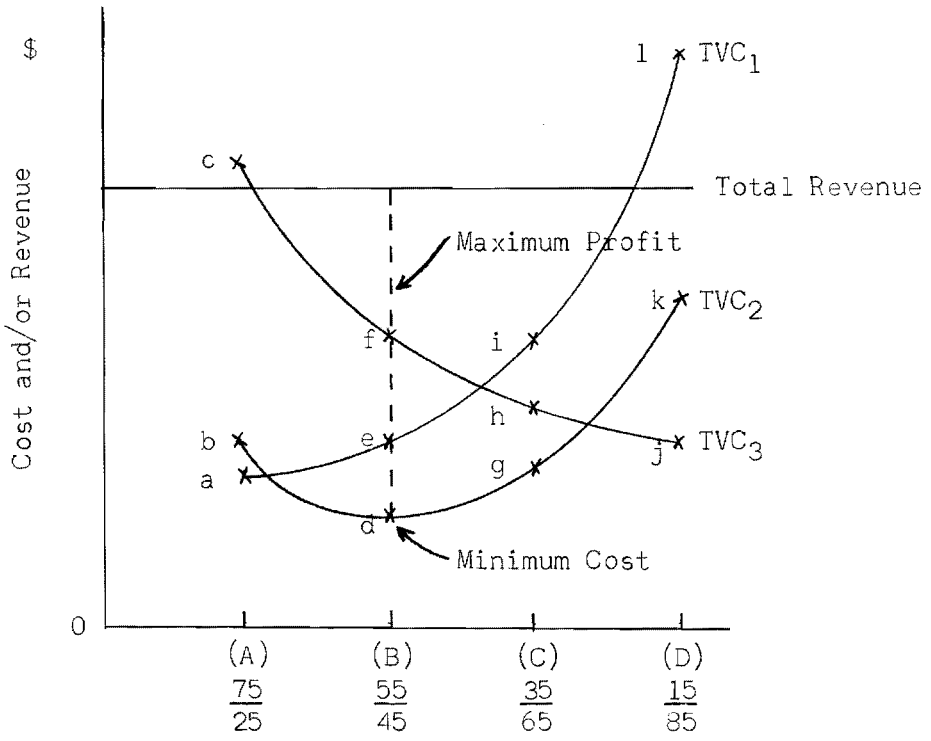

Figure 4. Point of Least-Cost or Profit Maximization for Producing a Given Milk Base at 11,000 Pounds of Milk per Cow with Various Ratios and Costs of Forage-to-Grain.

purchase prices, for the forage and grain in various feed ratios for producing a given rate of milk production per cow. The range in costs for different forage-to-grain ratios is indicated by the lettered points on the total variable cost curves in Figure 4. The illustration in Figure 4 contains three possible total variable cost curves, whereas in reality there may be many more of various shapes.

Knowing the milk base and price of milk, the total revenue can be determined as shown in Figure 4. Point d on the TVC_2 curve indicates that the least-cost combination of forage and grain for producing a given milk base at 11,000 pounds of milk per cow may be at a point such as the 55/45 ratio since the costs associated with all other possible ratios are greater than point d when measured on the vertical axis. Point d on the TVC_2 curve indicates that the least-cost ratio, such as 55/45, is also the point of maximum profit for producing a given milk base at 11,000 pounds of milk per cow. This is true since there is a wider margin between point d on the TVC_2 curve and the total revenue line than there is between any other points on the other total variable cost curves and the total revenue line.

Both marginal analysis and linear programming are adapted to decisions concerning the use of resources available to the firm and the method to apply in using the firm's resources. The marginal analysis has particular adaptation to problems when the available resources are unlimited, but this approach becomes awkward when limits are placed on the available resources. Problems involving many variable factors or products and fixed resources complicate the marginal approach. Many

farm problems are of the short-run variety where some factors are variable and others are fixed and, thus, marginal analysis would be inefficient as the analytical tool for obtaining a solution. In contrast, linear programming is particularly adapted to handling problems when limitations are placed on the available factors of production and when large or small changes in inputs or outputs are considered.

This study was short-run in scope, involved limitations on available resources and allowed for numerous alternative crop rotation systems (a finite number) to be considered. Since linear programming is especially suited for problems with these characteristics, it was the principal analytical technique used in this study. However, the theoretical guidelines for this study were provided by marginal analysis as well as by linear programming.

PROCEDURE

Selection of Sample and Collection of Data

The grade A dairy farms included in this study were a part of a stratified random sample selected from DHIA records from a large area of central Virginia. The random sample was stratified by numerical size of herd, milk production rates, feeding ratio of concentrate to milk and ratio of forage to concentrate. This study includes only those farms which were located in Roanoke, Franklin and Henry Counties. This part of the over-all sample consisted of 17 grade A dairy farms.

The data for this study covered the 1957 and 1958 production years and were obtained by means of a field survey. From each farm, data were collected which described the crop rotations, including acreage, yields and production practices; the soil classification; the available machinery and equipment; the available storage space for forage crops; the available annual labor supply; and the annual farm milk production. Soil maps were obtained from the Soil Conservation Service in each county to provide the basis for classifying the soils on the individual farms. Dairy Herd Improvement Association records were the source of information for obtaining annual farm milk production data on the sample farms.

Selection of Typical Resource Situation

The typical resource situation was selected from the data collected on the 17 grade A dairy farms. Land, labor, machinery and equipment, storage space for forage crops and farm milk base were the restrictive resources considered in selecting the typical situation. Since this study did not permit the option of buying additional units of these resources, with the exception of silage storage space, capital was not included as a restrictive resource. It was assumed that unlimited capital was available for the purchase of additional silage storage space.[1/]

The typical resource situation refers to the quantity of these resources that were available on most of the 17 farms (modal situation) and not the mean average quantity of these available resources on these farms.

Description of Available Resources and Their Restrictions on the Typical Farm

The typical grade A dairy farm contained 185.8 acres of total open land. With the soil maps obtained during the survey and assistance from agronomists at the Virginia Polytechnic Institute, it was determined that 142.8 acres of the total open land were suitable for cropland and 43 acres of the total open land were suitable for permanent pasture

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1/ The basis for permitting purchase of additional units of this resource is explained on page 30.

only. It was also determined that 31 percent of the 142.8 acres of cropland, or 44.3 acres, on the typical farm were suitable for continuous row crops. No consideration was given to acreage in woodland since this study was concerned with the production of forage and grain crops using the present available open land.

The open land that was suitable for continuous row crops consisted mainly of fine sandy loam and silt loam soils. The steeper slopes of Cecil, Appling and Lloyd were the predominant soils of the open land that was suitable only for permanent pasture. A major portion of the cropland that was suitable for rotated crops but not suitable for continuous row crops was located on the less steep slopes of the Cecil, Appling, Haysville and closely related soil series.

There were 7,684 annual man-hours or 2.59 man-equivalents of available labor on the typical grade A dairy farm. This available labor supply was composed of owner, tenant and family labor.

The amount of owner, tenant and family labor available was obtained for each farm in terms of months worked on the farm during the year. This labor was available during the various months according to number of days suitable for productive work.[1/] In determining the available man-hours, it was also assumed that a male worker under 15 years of age was equivalent to one-half an adult.

[1/] Assumed 234 man-hours in each of the months of January, March, November and December; 216 man-hours in the month of February; 260 man-hours in each of the months of April through October. Thus, one man-equivalent is equal to 2,972 man-hours.

Data describing the available machinery and equipment were obtained for each of the sample farms. Operations such as picking corn, combining small grain and spreading lime were accomplished by custom hiring on nearly all of the farms. The following items of machinery and equipment were available on the typical grade A dairy farm:

Item	Size and/or description
Tractor	Small
Tractor	Medium
Truck	2-tons
Plow	2-14" bottom
Disk	6' tandem
Mower	7'
Side delivery rake	8'
Hay conditioner	7'
Hay baler	Pick-up, PTO
Forage harvester	PTO with all attachments
Silage blower	8" pipe
Corn planter	2-row - with fertilizer attachment
Cultivator	2-row
Cultipacker	8'
Elevator	20'
Grain drill	13 x 7'
Wagon	8' x 16' - with false endgate
Lime and fertilizer spreader	8'
Manure loader	Front-end loader
Manure spreader	80 bushels
Pipeline milker	4-unit
Bulk milk tank	500 gallons
Hammer mill	10"

Each respondent provided estimates of the dimensions of available hay storage space in various structures on his farm. The typical farm

had approximately 157,600 cubic feet or 600.4 tons of total available storage space for hay.[1/]

The total annual available storage space for silage, assuming the silo is filled once a year, was 206 tons on the typical farm. It was felt that restricting the typical farm to its present available silage storage space would place an unrealistic limitation on the use of silage as a possible source of feed for dairy animals. Thus, the typical farm had the option of buying an unlimited amount of additional storage space for silage.

The farm milk base was a principal consideration in selecting the typical resource situation. There were 51 cows on the typical grade A dairy farm, and the amount of milk sold (base plus surplus) was 4,420 hundred-weights of four percent fat-corrected milk.[2/]

Description of Grade A Dairy Budgets Used in Linear Program

Milk production data obtained from DHIA records for the 17 sample farms revealed that these farms could be separated into low, average and high groups based on milk production per cow. The rate of milk production per cow, in terms of four percent fat-corrected milk, was

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[1/] Assumed 40 pounds per bale and 5.25 cubic feet of storage space required per bale.

[2/] The pounds of four percent milk produced were divided by the total acres in crops for each sample farm; the median of these quotients was multiplied by the total acres in crops on the typical farm; this farm milk production for the typical farm was reduced by the amount of milk fed to calves (350 pounds of milk per cow to calves) on the typical farm to arrive at the milk sale base.

7,000 pounds in the low group; 9,000 pounds in the average group; and 11,000 pounds in the high group. The DHIA records maintained at the Virginia Polytechnic Institute reveal that most grade A dairy farms in the State are averaging 9,000 pounds of milk per cow or more at the present time. Since most dairy farms in the State are at production rates above the 7,000 pounds of milk per cow represented by the low group of sample farms, the three rates of milk production per cow used in this study were 9,000 pounds, 11,000 pounds and 13,000 pounds.

Forage and grain coefficients were developed for individual forage-to-grain ratios at each of the three rates of milk production. The forage-to-grain ratios ranged from 75/25 to 15/85.[1/] The coefficients for the ratios were derived in terms of therms of estimated net energy from forage and from grain. Estimated net energy has an advantage over total digestible nutrients when comparing grain and forage feed for dairy animals. Results of a dairy feeding study at Iowa State College as well as suggestions from dairy nutritionists at the Virginia Polytechnic Institute were used to establish the E.N.E. coefficients for the three rates of milk production at various forage-to-grain ratios.[2/]

1/ See Appendix C, Table 1, for forage and grain coefficients and the range in ratios used at the three rates of production.

2/ E. O. Heady, J. A. Schnittker, N. L. Jacobson and S. Bloom, op. cit., Tables A-13 and A-14, p. 929.

A grade A dairy budget was prepared for each forage-to-grain ratio at the three rates of milk production.[1] Before developing the budgets, the feed requirements were converted from E.N.E. to T.D.N. to maintain standard values in terminology more familiar to dairymen.[2]

The grade A dairy budgets were prepared on a per-cow basis and included the requirements for replacements. Fixed costs on dairy animals, buildings and equipment were not considered since this study was short-run in scope. The items included in these budgets were:

1. The quantity of labor required was indicated by periods of the year, but, since labor was considered fixed, no cost was listed.
2. The only feed costs included in the budgets were for protein supplement, salt, minerals and calf starter.
3. The quantities of forage T.D.N. and grain T.D.N. required were listed in terms of possible sources with no costs. The costs associated with the forage and grain requirements were accounted for by transferring costs from the crop rotation activities and the "buy hay" and "buy corn" activities.[3]

   The forage T.D.N. required could come from hay, corn silage, grass silage and pasture. Hay, grass silage and pasture were considered sources of forage T.D.N. only. Corn silage, however, contains considerable grain as well as

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[1] See Appendix C, Tables 2 through 4, for grade A dairy budgets.

[2] See Appendix C, Table 1, for factors used in converting therms of E.N.E. to pounds of T.D.N.

[3] Transfers from one activity to another are discussed in the "Linear Programming Model" section.

forage and, thus, was considered as a source of both forage T.D.N. and grain T.D.N.[1] The grain T.D.N. required could come from corn, barley, the grain content of corn silage and protein supplement.

The grade A dairy budgets were not confined to the quantities of forage T.D.N. and grain T.D.N. indicated from the various sources. Minimum and maximum quantity limitations, however, were placed on some of the sources. At least 306 pounds of the required forage T.D.N. had to come from hay to assure that an optimum ration contained sufficient dry matter.[2] Not more than 2,400 pounds of the required forage T.D.N. could come from pasture to prevent the possibility of pasture furnishing forage when pasture is not normally available.[3] Other than these restrictions, hay, pasture, grass silage and the forage part of corn silage could substitute one for one on the basis of pounds of T.D.N.

4. The quantity of manure produced by the dairy cow was listed in pounds of nitrogen, phosphorus and potash. No value was attached since the manure produced was transferred to the crop

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[1] Divided on the basis of a ton of corn silage containing 167.64 pounds of forage T.D.N. and 198.71 pounds of grain T.D.N. See Appendix B for the derivation of these factors.

[2] Minimum hay requirement based on 2.8 pounds of hay per day for 215 days.

[3] Maximum pasture allowance based on 16 pounds of T.D.N. per day for 150 days.

rotations where its value was accounted for by way of providing some of the plant food requirements of crops that otherwise would have had to be purchased.[1/]

Description of Crop Rotation Budgets Used in Linear Program

The input-output relationships of various crops are affected by the crop rotation system used. In order to give consideration to the effect of the rotation system, the crop budgets used in this study were prepared on a rotation basis rather than on an individual crop basis.

The present crop rotations used on the typical farm were determined from the survey. County Extension Agents in the area of study and agronomists at the Virginia Polytechnic Institute suggested additional crop rotations that were adaptable to the typical farm. The crop rotations considered for the production of forage and grain on the typical farm are indicated in Table 1.

As previously mentioned, the total open land on the typical farm was divided into three categories -- land suitable for continuous row crops, land suitable for rotated crops and land suitable for permanent pasture only. The only difference made in budgeting procedure between land suitable for continuous row crops and land suitable for rotated crops was that row crops could be grown year after year on the continuous row crop land.

[1/] See Appendix C for manure coefficients used in grade A dairy budgets.

Table 1. Crop Rotations on the Typical Grade A Dairy Farm, Roanoke-Franklin-Henry-County Area, Virginia, 1960

Crops	Years in rotation	Crops	Years in rotation
(1) Corn for grain	1,	barley, lespedeza hay	(1)
(2) Corn silage, oats silage	1/		
(3) Corn silage	3,	alfalfa hay	4
(4) Corn silage alfalfa-orchard grass hay	1, 4	barley	1,
(5) Corn silage alfalfa-orchard grass hay	1, 4	oats silage, corn silage	(1),
(6) Corn silage red clover-orchard grass hay	2, 1	oats silage, lespedeza hay	(1),
(7) Corn silage alfalfa hay	1, 5	oats and vetch silage	1,
(8) Corn silage alfalfa-orchard grass silage-hay 2/	1, 4	barley	1,
(9) Corn for grain, oats silage	1/		
(10) Corn for grain, cover crop	1/		
(11) Millet pasture	1,	ladino clover-orchard grass pasture	5
(12) Bluegrass-white clover pasture	1/		

1/ Continuous.
2/ First cutting of alfalfa-orchard grass harvested for silage and the second and third cuttings harvested for hay.

The cropping practices on the typical farm and suggestions from agronomists at the Virginia Polytechnic Institute were used as guides in determining the coefficients for the crop rotation budgets.[1/]

Fixed costs were not considered in the crop rotation budgets since this study was short-run in scope. The items included in these budgets were:

1. The quantity of labor required was indicated by periods of the year, but, since labor was considered fixed, no cost was listed.
2. The quantities of crops produced from a rotation were listed as pounds of forage T.D.N. and grain T.D.N. with no values. Expressing the yields of crop rotations in this manner coincides with the unit of measure used in estimating feed requirements in the grade A dairy budgets, thus simplifying the transfer of crop outputs to feed inputs. The values of forage and grain produced were accounted for through "sell milk", "sell corn" and "sell hay" transfer activities.[2/] Corn silage yields were listed in terms of grain T.D.N. and forage T.D.N. by applying the same factors as those used in the grade A dairy budgets for dividing the feed input coming from corn silage.[3/]

[1/] See Appendix D, Tables 3 through 14, for crop rotation budgets.

[2/] These transfer activities are discussed in the "Linear Programming Model" section.

[3/] Refer to page 33, footnote 1, for these factors.

In estimating crop yields, a 10 percent loss was assumed on silage and an 8 percent loss was assumed on hay. Sixty-five percent utilization was assumed in estimating pasture yields.

3. The grade A dairy budgets included a cost for grinding and mixing grain based on the grain T.D.N. requirement of the ration. Since a part of the grain T.D.N. required in various rations could come from corn silage which does not require grinding and mixing, a credit was made to the crop rotation budgets producing corn silage to offset the cost of grinding and mixing grain from this source in the grade A dairy budgets.
4. The crop rotation budgets were set up to utilize the manure from dairy cows, and any additional fertilizer needed was purchased.

Linear Programming Model

The available resources on the typical farm and the coefficients from the grade A dairy budgets and crop rotation budgets were set up in matrix form for calculating an optimum forage and grain production system and forage-to-grain feeding ratio at the three rates of milk production per cow.

Some of the available resources, production processes and transfer activities are presented in Table 2 to illustrate the linear programming

model used in the analysis.[1] The available resources are located on the left side of the matrix in Table 2 and the alternatives for converting these limited resources into a salable product are set up on the right side.

The land resources were listed in terms of their suitability and the amount available was based on the proportion of total open land. Rotated crops could be produced on all of the open land except that which was suitable for permanent pasture only; thus 142.8 acres were available for these types of rotations. Since all the open land was suitable for permanent pasture, 185.8 acres were included as available for producing this crop.

Available labor was divided into three time periods based on the opportunity of substituting labor between months within certain periods of the year. The labor period shown in Table 2 indicates that July, August, September and October labor can substitute for each other; however, none of the labor in this period can substitute for labor in other periods of the year. For instance, corn should be planted during the period of March through June and it should be harvested during the period of July through October. Thus, the labor available in the period when corn should be planted can not be substituted for labor in the period when corn should be harvested.

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[1] See Appendix E for complete matrix used in this study.

Table 2. An Abbreviated Form of the Matrix Used for Basic Solutions[1/]

Resource or restriction	Unit	Amt.	Disposals P_2	Disposals P_{13}	Gainful activities: Dairy (11,000 lbs.) 55/45	Gainful activities: Rotation c. sil.-alfalfa	Transfer activities: Substitutions Hay to gr.sil.	Transfer activities: Buy corn	Transfer activities: Sell milk
P_2 Rot. cropland	Ac.	143	1			1			
P_3 Total open land	Ac.	186				1			
P_5 Labor (Jul.-Oct.)	Hr.	2,660			34	10			
P_7 Tot. gr. T.D.N.	Lb.	0			3,279	-1,150		-100	
P_9 Hay T.D.N.	Lb.	0			306	-1,851	1		
P_{10} C.sil.T.D.N.	Lb.	0			2,313	- 970			
P_{11} G.sil.T.D.N.	Lb.	0			1,488		-1		
P_{12} Past.T.D.N.	Lb.	0			2,400				
P_{13} Milk base	Cwt.	4,420		1	106				
P_{14} Milk sales	Cwt.	0			-106				1
P_{15} Hay storage	Ton	600				2			
P_{17} Max. fall sil.space	Ton	206				6			
Net return to fixed factors[2/]	Dol.				-80	-12		-3	6

[1/] All coefficients have been rounded to nearest whole number to conserve space.

[2/] The fixed factors include land, labor, investment capital and management.

The rows included as total grain T.D.N., hay T.D.N., corn silage T.D.N., grass silage T.D.N., and pasture T.D.N. are restrictions placed on the production and use of these products. The amount of these products produced and purchased must be at least as great as the amount fed and sold. For instance, the amount of hay produced from rotations and/or bought must be at least equal to the amount fed to dairy animals and/or sold. Restrictions of this kind were also placed on nitrogen, phosphorus and potash to assure that the manure supplied by dairy cows, and fertilizer purchased was sufficient to meet the plant food requirements of the crops.

Farm milk base was included in the matrix at the amount that could be sold. A milk sales restriction was set up to assure that no more than the base amount was sold.

The amount of available annual silage storage space may be double the actual storage capacity of the silos. Silage stored in the fall may be fed in the winter; thus an equal amount of silage could be stored and fed in the summer. The maximum amount of available fall silage storage space was included as a resource in the matrix. Two forage feeding periods, summer and winter, were set up as restrictions requiring silage stored in the fall to be fed in the winter or transferred, by transfer activities, to the summer forage feeding period. This procedure allows silage storage space to become available as silage is fed to the dairy animals. Additional silage space required could be purchased at a specified price.

Net return (revenue) values in this model may be positive or negative (costs) depending on the activities involved. With regard to the

grade A dairy activities, net revenue is negative since it represents gross receipts from cull cows and surplus calves less variable cash expenses. Revenue from milk is accounted for through a milk selling activity rather than the grade A dairy activities. Net revenue is also negative for the crop rotation activities. Values of crops are not considered in these activities since the yields of crops are transferred to the grade A dairy activities or selling activities. Net revenue in the buying activity columns is cost (- net revenue) and net revenue represents income in the selling activity columns.

An optimum forage and grain production system and forage-to-grain ratio may not utilize all of the available resources. A disposal activity is included for each resource in the matrix to permit the existence of unused resources in an optimum solution.

The gainful activities are the production possibilities for converting the available resources into a salable product. These activities include alternative grade A dairy feeding systems and alternative crop rotations. The coefficients in these columns of the matrix were supplied from the grade A dairy and crop rotation budgets. An optimum forage-to-grain ratio could be obtained at any ratio within the range of ratios considered.

The remaining columns in the matrix consist of various transfer activities. These activities make it possible for the product of one activity to be used by another activity. The substitution of one input for another, such as hay for grass silage, can be done with a transfer activity. Transfer activities can also perform the function of buying

inputs and supplying them directly to production activities. Conversely, the product of a production activity can be sold by using a transfer selling activity.

Separate matrices of the form shown in Table 2 were used in calculating an optimum solution for each of the three production rates per cow considered in this study. The three matrices were identical except for the coefficients in the grade A dairy activity columns which were different for each rate of milk production.

To study the effect of changes in the price of milk on the relative profitability of the three rates of milk production and forage-to-grain ratios, the matrices were recalculated after adjusting the coefficient in the net revenue row of the "sell milk" activity for each price considered.

An IBM 650 Digital Computer was used to solve the matrices involved with this study.

RESULTS AND IMPLICATIONS

An Optimum Forage-to-Grain Production and Feeding Plan for Each of Three Rates of Milk Production Per Cow with Milk Sales at $5.73 Per Hundred-Weight

9,000 pounds per cow

An optimum forage-to-grain feeding ratio for the 9,000 pounds production rate per cow was 35 percent forage E.N.E. to 65 percent grain E.N.E. when milk was sold at $5.73 per 100 pounds on the typical farm. The relationship between the cost associated with an optimum crop rotation system and the sale prices of milk, corn and hay were such that net return to the fixed factors was maximized by using forage and grain to produce 173 hundred-weights of milk less than the milk sales base limitation and to sell corn and hay (Table 3).

Labor during the July through October period was the most restrictive resource. An additional hour of labor during this period would increase net returns by $4.08 (MVP, Table 3). This is much higher than prevailing wage rates. All of the available resources, except hay storage space and milk sales base, were fully utilized. However, there were 23.9 acres of open land suitable for producing continuous row crops that were used, instead, for producing rotated crops.

Less total feed nutrients were required to produce a given rate of milk production per cow with a feed ratio containing a high proportion of grain relative to forage (Table 1, Appendix C). Also, less land was needed for producing the feed required in a ration containing a high proportion of grain. Since combining small grain and picking

Table 3. An Optimum Solution: Grain and Forage Combinations for Sales Base of 4,420 Hundred-Weights of Four Percent FCM at 9,000 Pounds Production Per Cow on a Typical Grade A Dairy Farm, Roanoke-Franklin-Henry-County Area, Virginia, 1960

Crop rotations and other factors	Unit	Size	Lbs. T.D.N. furnished: Forage	Grain
Crop rotations:[1]				
C.gr.(1yr.),bar.lesp.(1yr.)on Land B	Acre	45.9	24,414	96,626
C.sil.(3yrs.),alf.(4yrs.)on Land B	Acre	16.0	43,934	18,310
C.sil.(1yr.),bar.(1yr.),alf.-orch.gr.(4yrs.) on Land B[2]	Acre	60.3	171,567	41,949
C.gr.oats sil.(1yr.)on Land A	Acre	20.6	22,282	69,077
Blue gr.white clover pasture on Land C	Acre	43.0	45,437	
Total lbs. T.D.N. furnished			307,634	225,962

			Lbs. T.D.N. fed and sold: Forage	Grain
Dairy(fed to cows and replacements, excluding supplement)			207,531	187,141
Milk sold	Lb.	424,698		
Corn sold	Bu.	865		38,821
Hay sold	Ton	100	100,203	
Total lbs. T.D.N. fed and sold			307,634	225,962
Total lbs. T.D.N. fed to milking herd(including supplement) (35:65 forage-grain feeding ratio)[3]	Each	49.1	114,388	173,590

Table 3. (Continued)

Resource	Unit	Amount available	Amount used	Amount unused	MVP dollars[4]
Land A (continuous row crops)	Acre	44.3	20.4	23.9	
Land A + Land B (rotated cropland)	Acre	142.8	142.8		15.44
Land A + Land B + Land C (total open land)	Acre	185.8	185.8		6.40
Labor (March-June)	Hour	2,608.0	2,608.0		0.81
Labor (July-October)	Hour	2,660.0	2,660.0		4.08
Labor (November-February)	Hour	2,416.0	2,416.0		1.84
Hay storage space	Ton	600.4	131.3	469.1	
Milk sales restriction	Cwt.	4,420.0	4,247.0	173.0	
Maximum fall silage storage space[5]	Ton	206.0	206.0		0.80

Net return to land, labor, investment capital and management = $20,955.52[6]

[1] See Appendix E for identification - P_{27}, P_{29}, P_{34} and P_{35} respectively.

[2] First cutting of alfalfa-orchard grass harvested for silage and the second and third cuttings harvested for hay.

[3] This is the forage E.N.E.-to-grain E.N.E. feeding ratio to milk cows. The grain and forage figures include feed for 49.1 milk cows excluding replacements.

In calculating this ratio: 1 lb. grain T.D.N. = 1 therm E.N.E.
1.22 lbs. forage T.D.N. = 1 therm E.N.E.

[4] The MVP figures indicated in this column refer to the "net" value added at the margin to the fixed factors from an additional unit of the particular resource rather than the "gross" value added at the margin which is commonly interpreted as the MVP.

[5] It was necessary to buy 290.1 tons of additional fall silage storage space in this solution.

[6] Blend price of milk = $5.73 per hundred-weight.

corn were custom operations on the typical farm, a rotation system including crops harvested by these methods did not utilize as much of the available labor as a rotation system which produced primarily forage. The most economical system of feed production is to a large extent determined by the available resources.

An optimum rotation system at the 9,000 pounds production rate included rotations that produced large quantities of grain T.D.N. relative to forage T.D.N. per unit of labor required. Nearly one-third of the grain T.D.N. feed requirement was obtained from the grain in corn silage. It was more profitable to use the 43 acres of open land suitable only for permanent pasture to produce some of the forage feed requirements than for this land to remain unused.

The entire milk sales base could be produced by adding two additional cows and using a 47:53 forage-to-grain ratio. This plan would reduce the sale of corn by 800 bushels and the sale of hay by 23 tons. Net revenue would be reduced by only $546. Thus, there is some latitude in the selection of a feeding ratio and crop rotation system, at this particular rate of production, before significantly reducing the net return to fixed factors.

11,000 pounds per cow

An optimum forage-to-grain feeding ratio for producing 11,000 pounds of milk per cow on the typical farm was 43 percent forage E.N.E. to 57 percent grain E.N.E. It was more profitable to produce up to the base sales restriction, 4,420 hundred-weights of milk, and to increase the sale of both hay and grain over an optimum at the 9,000

pounds production rate (Table 4). At this production rate all available resources except March through June labor, November through February labor and hay storage space were fully utilized. Labor during the July through October period was also the most restrictive resource at the 11,000 pounds production rate as indicated by the high return of $4.02 per hour of additional labor (MVP, Table 4). Land, however, was somewhat more restrictive at this production rate than at 9,000 pounds per cow. At the margin, an annual addition of 100 pounds of milk sales base would increase net return to fixed factors by $2.73 (MVP, Table 4).

With dairy cows that have the same production potential, more total E.N.E. is required as the production rate per cow is increased (Table 1, Appendix C). However, the higher the production rate per cow, the fewer the number of cows required to produce a given milk sales base.

At the 11,000 pounds production rate as compared to the 9,000 pounds production rate, the labor saved by the reduction in cow numbers required to produce the milk sales base was applied to crop production. It was more profitable to use most of this labor to produce forage rather than grain and, thus, the least-cost ration for this production rate contained more forage than the least-cost ration for 9,000 pounds production per cow. Since forage was harvested by the available labor on the typical farm rather than by custom, the labor available during the forage harvesting period (July-October) was fully utilized. Land was more restrictive at this production rate since the change to increasing the forage content of the ration placed a greater requirement on the land resources for the production of a given quantity of feed nutrients

Table 4. An Optimum Solution: Grain and Forage Combinations for Sales Base of 4,420 Hundred-Weights of Four Percent FCM at 11,000 Pounds Production Per Cow on a Typical Grade A Dairy Farm, Roanoke-Franklin-Henry-County Area, Virginia, 1960

Crop rotations and other factors	Unit	Size	Lbs. T.D.N. furnished: Forage	Grain
Crop rotations:[1]				
C.gr.(1yr.),bar.lesp.(1yr.)on Land B	Acre	3.2	1,768	6,832
C.sil.(3yrs.),alf.(4yrs.)on Land B	Acre	70.8	199,929	81,449
C.sil.(1yr.),bar.(1yr.),alf.orch.gr.(4yrs.)on Land B[2]	Acre	24.5	71,425	17,060
C.gr.oats sil.(1yr.)on Land A	Acre	44.3	49,201	149,170
Blue gr.white clover pasture on Land C	Acre	43.0	46,798	
Total lbs. T.D.N. furnished			369,121	254,511

			Lbs. T.D.N. fed and sold: Forage	Grain
Dairy(fed to cows and replacements, excluding supplement)			224,202	167,283
Milk sold	Lb.	442,000		
Corn sold	Bu.	1,945		87,228
Hay sold	Ton	145	144,919	
Total lbs. T.D.N. fed and sold			369,121	254,511
Total lbs. T.D.N. fed to milking herd(including supplement) (43:57 forage-grain feeding ratio)[3]	Each	41.5	145,476	159,108

Table 4. (Continued)

Resource	Unit	Amount available	Amount used	Amount unused	MVP dollars[4]
Land A (continuous row crops)	Acre	44.3	44.3		3.47
Land A + Land B (rotated cropland)	Acre	142.8	142.8		21.93
Land A + Land B + Land C (total open land)	Acre	185.8	185.8		7.82
Labor (March-June)	Hour	2,608.0	2,506.2	101.8	
Labor (July-October)	Hour	2,660.0	2,660.0		4.02
Labor (November-February)	Hour	2,416.0	2,024.9	391.1	
Hay storage space	Ton	600.4	172.4	428.0	
Milk sales restriction	Cwt.	4,420.0	4,420.0		2.73
Maximum fall silage storage space[5]	Ton	206.0	206.0		0.80
Net return to land, labor, investment capital and management = $23,212.40[6]					

[1] See Appendix E for identification - P_{27}, P_{29}, P_{34}, P_{35} and P_{38} respectively.

[2] First cutting of alfalfa-orchard grass harvested for silage and the second and third cuttings harvested for hay.

[3] This is the forage E.N.E.-to-grain E.N.E. feeding ratio to milk cows. The grain and forage figures include feed for 41.5 milk cows excluding replacements.
In calculating this ratio: 1 lb. grain T.D.N. = 1 therm E.N.E.
1.22 lbs. forage T.D.N. = 1 therm E.N.E.

[4] The MVP figures indicated in this column refer to the "net" value added at the margin to the fixed factors from an additional unit of the particular resource rather than the "gross" value added at the margin which is commonly interpreted as the MVP.

[5] It was necessary to buy 453.3 tons of additional fall silage storage space in this solution.

[6] Blend price of milk = $5.73 per hundred-weight.

(E.N.E.). Since labor was less restrictive at 11,000 pounds production per cow than at 9,000 pounds production per cow, crop rotations were included which increased forage production and also increased grain production. Since less grain was used in the ration, more corn was sold.

There was also some flexibility in the selection of a feed ratio and crop rotation system for producing the milk sales base at 11,000 pounds of milk per cow without significantly reducing net revenue. The milk sales base could have been produced with a 32:68 forage-to-grain ratio and selling 173 tons of hay. This plan would have reduced net revenue by only $492.

13,000 pounds per cow

An optimum forage-to-grain feeding ratio for the 13,000 pounds production rate per cow was 38 percent forage E.N.E. to 62 percent grain E.N.E. The most profitable combination of uses of crops was to produce milk up to the sales base limitation, 4,420 hundred-weights, and to sell any excess corn and hay. The rotation from which a large part of the total feed needs were obtained included corn silage and a hay crop. Most of the hay produced from this rotation was sold since the forage requirement for the ration was obtained primarily from silage crops which could not be sold (Table 5).

Land suitable for rotated crops was the most restrictive resource. An additional acre of cropland was worth $58 annually (MVP, Table 5). All available resources, except labor and hay storage space, were fully utilized at this production rate. There were 18.5 acres of land suitable for continuous row crops that were used, instead, for producing rotated

Table 5. An Optimum Solution: Grain and Forage Combinations for Sales Base of 4,420 Hundred-Weights of Four Percent FCM at 13,000 Pounds Production Per Cow on a Typical Grade A Dairy Farm, Roanoke-Franklin-Henry-County Area, Virginia, 1960

Crop rotations and other factors	Unit	Size	Lbs. T.D.N. furnished: Forage	Grain
Crop rotations:[1]				
C.sil.oats sil.(1yr.)on Land A	Acre	2.0	6,835	5,418
C.sil.(3yrs.),alf.(4yrs.)on Land B	Acre	117.0	329,558	134,123
C.gr.oats sil.(1yr.)on Land A	Acre	23.8	26,569	80,512
Blue gr.white clover pasture on Land C	Acre	43.0	47,090	
Total lbs. T.D.N. furnished			410,052	220,053

			Lbs. T.D.N. fed and sold: Forage	Grain
Dairy(fed to cows and replacements, excluding supplement)			204,037	184,717
Milk sold	Lb.	442,000		
Corn sold	Bu.	788		35,336
Hay sold	Ton	206	206,015	
Total lbs. T.D.N. fed and sold			410,052	220,053
Total lbs. T.D.N. fed to milking herd(including supplement) (38:62 forage-grain feeding ratio)[2]	Each	34.9	137,832	180,564

Table 5. (Continued)

Resource	Unit	Amount available	Amount used	Amount unused	MVP dollars[3]
Land A (continuous row crops)	Acre	44.3	25.8	18.5	
Land A + Land B (rotated cropland)	Acre	142.8	142.8		57.95
Land A + Land B + Land C (total open land)	Acre	185.8	185.8		0.58
Labor (March-June)	Hour	2,608.0	2,116.5	491.5	
Labor (July-October)	Hour	2,660.0	2,630.5	29.5	
Labor (November-February)	Hour	2,416.0	1,753.9	662.1	
Hay storage space	Ton	600.4	234.1	366.3	
Milk sales restriction	Cwt.	4,420.0	4,420.0		4.38
Maximum fall silage storage space[4]	Ton	206.0	206.0		0.80

Net return to land, labor, investment capital and management = $23,509.05[5]

[1] See Appendix E for identification - P_{28}, P_{29}, P_{35} and P_{38} respectively.

[2] This is the forage E.N.E.-to-grain E.N.E. feeding ratio to milk cows. The grain and forage figures include feed for 34.9 milk cows excluding replacements.

In calculating this ratio: 1 lb. grain T.D.N. = 1 therm E.N.E.
1.22 lbs. forage T.D.N. = 1 therm E.N.E.

[3] The MVP figures indicated in this column refer to the "net" value added at the margin to the fixed factors from an additional unit of the particular resource rather than the "gross" value added at the margin which is commonly interpreted as the MVP.

[4] It was necessary to buy 680.2 tons of additional fall silage storage space in this solution.

[5] Blend price of milk = $5.73 per hundred-weight.

crops. Available labor remained unused during all periods. An additional 100 pounds of milk sales base per year would increase net return, at the margin, to fixed factors by $4.38 (MVP, Table 5).

Fewer cows are required for producing the milk sales base at 13,000 pounds per cow than at the lower rates of production. However, the 13,000 pounds production rate requires more feed nutrients per cow than the lower production rates. Also, at any given forage E.N.E.-to-grain E.N.E. ratio, 55:45, 35:65 et cetera, more forage is required to replace one unit of grain as production per cow increases. The reduction in number of cows released more labor that could be directed to crop production than was the case with the lower production rates. The additional labor available for producing feed at this production rate was best utilized in the production of rotations containing corn silage since both grain and forage could be obtained from this source. Other crops in the rotation system produced more grain than forage. Consequently, the least-cost ration contained a high proportion of grain relative to forage.

As was the case with the lower production rates, it was more profitable to supply some of the forage requirement from permanent pasture than for the land suitable only for this purpose to remain unused.

There is less latitude in the selection of an optimum forage and grain production system and forage-to-grain feeding ratio at the 13,000 pounds production rate than was true at the lower production rates. A 10 percent increase or decrease in the forage content of the forage-to-

grain ratio would result in a reduction in net return to fixed factors of more than $1,000.

Comparing Optimum Plans for Each of Three Rates of Production Per Cow with Milk Sales at $5.73 Per Hundred-Weight

With the present available resources and blend price of milk on the typical farm, 13,000 pounds per cow was the most profitable production rate. However, in moving from the 9,000 pounds production per cow to the 11,000 pounds and 13,000 pounds level, net return to fixed factors increased at a substantially decreasing rate. Net return to fixed factors increased $2,257 from the 9,000 pounds production to the 11,000 pounds production per cow, whereas the increase in net return to fixed factors at 13,000 pounds per cow was only $297 above that of the 11,000 pounds production rate. Thus, there would be little difference in the net return to fixed factors for production rates per cow ranging from 11,000 pounds to 13,000 pounds. A production rate much higher than 13,000 pounds, however, would probably result in less net revenue.

When the available resources are limited, an optimum forage-to-grain feeding ratio may vary either upward or downward as production per cow increases. An optimum crop production and feeding plan for 11,000 pounds production per cow contained the highest forage E.N.E.-to-grain E.N.E. ratio (43:57). However, the forage E.N.E.-to-grain E.N.E. ratio could range from 43:57 to 32:68 without greatly changing the returns to fixed factors. When production was 9,000 pounds per cow, labor became restrictive because of the additional cows and replacements required per 100 pounds of milk produced. Thus, large acreages of rotations that

contained grain crops which were harvested by custom were included in an optimum crop production system for 9,000 pounds per cow since this crop production system required less labor per 100 pounds of feed nutrients produced. Consequently, an optimum forage-to-grain ratio for 9,000 pounds per cow included more grain as compared to 11,000 pounds per cow. As production per cow went from 11,000 pounds to 13,000 pounds, the amount of feed nutrients per 100 pounds of milk increased and land became the most restrictive resource. Thus, an optimum crop production system for 13,000 pounds per cow contained rotations that produced large quantities of grain since crops producing feed nutrients in the form of grain required less land per 100 pounds of nutrients produced. Consequently, an optimum forage-to-grain ratio for 13,000 pounds per cow also included more grain as compared to 11,000 pounds per cow.

It was profitable to produce corn and hay for sale at each of the three rates of milk production per cow.

When relatively large quantities of corn silage are used in a ration and its feed value is accounted for in terms of forage and grain, the forage-to-grain feeding ratio will contain more grain relative to forage. Many dairymen in actual practice, are probably feeding a high proportion of grain relative to forage if one would consider both the forage T.D.N. and grain T.D.N. supplied by corn silage.

Net revenue could be increased by hiring additional labor at the 9,000 pounds and 11,000 pounds production rates. With the present restriction on milk sales (4,420 hundred-weights), hiring additional labor at the 13,000 pounds production rate would not have increased net

revenue since labor was unused during all periods of the year. The purchase of additional land suitable for rotated crops would have increased the net return to fixed factors at each of the three rates of milk production since, in each case, this resource was fully utilized.

Additional milk sales base would not increase net return to fixed factors at the 9,000 pounds production rate since some of the milk sales base at this production rate was unused. The total milk sales base was produced at both the 11,000 pounds and 13,000 pounds production rates. Based on the MVP values of $2.73 and $4.38 per hundred-weight for milk sales base at the 11,000 pounds and 13,000 pounds production rates respectively, net revenue would be increased if additional milk could be sold.

The Effect of Changes in the Price of Milk on the Relative Profitability of the Three Rates of Production Per Cow

An optimum forage and grain production system and forage-to-grain feeding ratio were determined for each of the three rates of milk production with the blend price per hundred-weight set at $4.00 and $3.00. All available resources and factors other than milk price were the same as previously outlined with the price per hundred-weight at $5.73.

Milk at $5.73 per hundred-weight

The relative profitability of the three rates of production per cow and the forage-to-grain feeding ratios with milk priced at $5.73 per hundred-weight are shown in Table 6. As discussed earlier in this section, 13,000 pounds per cow was the most profitable production rate

Table 6. Optimum Solutions: Grain and Forage Combinations for Producing 4,420 Cwts. of Four Percent FCM at Three Production Rates Per Cow with a Milk Price of $5.73 Per Cwt. on a Typical Grade A Dairy Farm, Roanoke-Franklin-Henry-County Area, Virginia, 1960[1]

Crop rotations and other factors	Unit	Pounds per cow 9,000	11,000	13,000
Crop rotations:[2]				
C.gr.(lyr.),bar.lesp.(lyr.)on Land B	Acre	46	3	
C.sil.oats sil.(lyr.)on Land A	Acre			2
C.sil.(3yrs.),alf.(4yrs.)on Land B	Acre	16	71	117
C.sil.(lyr.),bar.(lyr.),alf.orch.gr. (4yrs.)on Land B[3]	Acre	60	25	
C.gr.oats sil.(lyr.)on Land A	Acre	21	44	24
Blue gr.white clover pasture on Land C	Acre	43	43	43
Total forage T.D.N. furnished	Cwt.	3,076	3,691	4,101
Total grain T.D.N. furnished	Cwt.	2,260	2,545	2,201
Total T.D.N. fed to cows and replacements[4]	Cwt.	3,947	3,915	3,889
Grain T.D.N. sold (corn)	Cwt.	388	872	353
Forage T.D.N. sold (hay)	Cwt.	1,001	1,449	2,060
Milk sold	Cwt.	4,247	4,420	4,420
Number cows in milking herd	Each	49	42	35
Total forage T.D.N. fed to milking herd	Cwt.	1,144	1,455	1,378
Total grain T.D.N. fed to milking herd[5]	Cwt.	1,736	1,591	1,806
Forage-grain feeding ratio[6]	Pct.	35:65	43:57	38:62
Net return to fixed factors[7]	Dol.	20,956	23,212	23,509

[1] All figures have been rounded to whole numbers.

[2] See Appendix E for identification - P_{27}, P_{28}, P_{29}, P_{34}, P_{35} and P_{38} respectively.

[3] First cutting of alfalfa-orchard grass harvested for silage and the second and third cuttings harvested for hay.

[4] Includes farm produced forage T.D.N. and grain T.D.N. that were fed to cows and replacements.

[5] The grain T.D.N. fed to milk cows including protein supplement.

[6] This is the forage E.N.E.-to-grain E.N.E. feeding ratio to milk cows. In calculating this ratio: 1 lb. grain T.D.N. = 1 therm E.N.E.
1.22 lbs. forage T.D.N. = 1 therm E.N.E.

[7] The fixed factors include land, labor, investment capital and management.

at this milk price. However, the difference in net revenue from 11,000 pounds per cow to 13,000 pounds per cow was considerably less than the difference between the 9,000 pounds and 11,000 pounds production rates. Nearly the same forage-to-grain ratios were used at the 9,000 pounds and 13,000 pounds production rates. The forage-to-grain ratio at 11,000 pounds per cow contained more forage and less grain than either the 9,000 pounds or 13,000 pounds production rates. More cows were necessary at the 9,000 pounds production rate, and the resources available for producing the E.N.E. of feed for these cows were such that it was more profitable to produce and feed high grain relative to forage.

Milk at $4.00 per hundred-weight

When the milk price was lowered to $4.00 per hundred-weight, the relative profitability of the 9,000 pounds and 11,000 pounds production rates changed in that the difference in net return to fixed factors was reduced by a little more than one-third (Table 7). Since the relative profitability of the 11,000 pounds and 13,000 pounds production rates did not change appreciably, the 9,000 pounds production rate also gained in profitability relative to the 13,000 pounds production rate.

The relative feeding ratios for the 11,000 pounds and 13,000 pounds per cow did not change. However, it was more profitable, with $4.00 per hundred-weight for milk, to increase the forage content of the ration at the 9,000 pounds production rate. With the reduction in milk price and the price of corn and hay remaining constant, it was more profitable, at 9,000 pounds per cow, to produce considerably below the milk sales base and to sell more corn and hay. Since fewer cows were maintained

Table 7. Optimum Solutions: Grain and Forage Combinations for Producing 4,420 Cwts. of Four Percent FCM at Three Production Rates Per Cow with a Milk Price of $4.00 Per Cwt. on a Typical Grade A Dairy Farm, Roanoke-Franklin-Henry-County Area, Virginia, 1960[1]

Crop rotations and other factors	Unit	Pounds per cow		
		9,000	11,000	13,000
Crop rotations:[2]				
C.gr.(1yr.),bar.lesp.(1yr.)on Land B	Acre	3	85	
C.sil.oats sil.(1yr.)on Land A	Acre			2
C.sil.(3yrs.),alf.(4yrs.)on Land B	Acre	96		117
C.sil.(1yr.),bar.(1yr.),alf.-orch.gr. (4yrs.)on Land B[3]	Acre		14	
C.gr.oats sil.(1yr.)on Land A	Acre	44	44	24
Blue gr.white clover pasture on Land C	Acre	43	43	43
Total forage T.D.N. furnished	Cwt.	3,668	3,749	4,101
Total grain T.D.N. furnished	Cwt.	2,657	2,561	2,201
Total T.D.N. fed to cows and replacements[4]	Cwt.	3,257	3,777	3,889
Grain T.D.N. sold (corn)	Cwt.	1,403	947	353
Forage T.D.N. sold (hay)	Cwt.	1,665	1,586	2,060
Milk sold	Cwt.	3,405	4,264	4,420
Number cows in milking herd	Each	39	40	35
Total forage T.D.N. fed to milking herd	Cwt.	1,255	1,404	1,378
Total grain T.D.N. fed to milking herd[5]	Cwt.	1,145	1,535	1,806
Forage-grain feeding ratio[6]	Pct.	47:53	43:57	38:62
Net return to fixed factors[7]	Dol.	14,083	15,565	15,862

[1] All figures have been rounded to whole numbers.

[2] See Appendix L for identification - P_{27}, P_{28}, P_{29}, P_{34}, P_{35} and P_{38} respectively.

[3] First cutting of alfalfa-orchard grass harvested for silage and the second and third cuttings harvested for hay.

[4] Includes farm produced forage T.D.N. and grain T.D.N. that were fed to cows and replacements.

[5] The grain T.D.N. fed to milk cows including protein supplement.

[6] This is the forage E.N.E.-to-grain E.N.E. feeding ratio to milk cows. In calculating this ratio: 1 lb. grain T.D.N. = 1 therm E.N.E.
1.22 lbs. forage T.D.N. = 1 therm E.N.E.

[7] The fixed factors include land, labor, investment capital and management.

with the change in milk price, more labor was available at 9,000 pounds per cow for crop production than was available when milk was priced at $5.73 per hundred-weight. This additional labor not only enabled more corn and hay to be produced for sale, but also permitted more forage to be produced for use by the dairy cows. Forage, as mentioned previously, was a cheaper source of feed but required more labor per unit than grain.

With milk priced at $4.00 per hundred-weight, it was equally as profitable to produce 156 hundred-weights below the milk sales base at 11,000 pounds per cow and to sell 167 bushels more corn and 14 tons more hay. The reduction in milk production at this price for the 11,000 pounds production rate was not sufficient to alter an optimum forage-to-grain feeding ratio since the herd size was reduced by only two cows. The decrease in cow numbers, however, did permit a change in the forage and grain production system whereby more forage and grain could be produced for direct sales. The increase in corn and hay sales was equal to the decrease in the sale of milk.

At the 13,000 pounds production rate, the decrease in milk price was not sufficient to make the sale of corn and hay as profitable as milk production. Thus, an optimum feeding ratio and an optimum forage and grain production system for this production rate at $4.00 per hundred-weight was the same as when milk was priced at $5.73 per hundred-weight.

Milk at $3.00 per hundred-weight

A considerable change in the relative profitability of the three rates of milk production occurred when the price of milk was lowered to $3.00 per hundred-weight (Table 8). The difference in net revenue

Table 8. Optimum Solutions: Grain and Forage Combinations for Producing 4,420 Cwts. of Four Percent FCM at Three Production Rates Per Cow with a Milk Price of $3.00 Per Cwt. on a Typical Grade A Dairy Farm, Roanoke-Franklin-Henry-County Area, Virginia, 1960[1]

Crop rotations and other factors	Unit	Pounds per cow 9,000	11,000	13,000
Crop rotations:[2]				
C.gr.(1yr.),bar.lesp.(1yr.)on Land B	Acre			
C.sil.oats sil.(1yr.)on Land A	Acre			2
C.sil.(3yrs.),alf.(4yrs.)on Land B	Acre	103	121	117
C.sil.(1yr.),bar.(1yr.),alf.orch.gr. (4yrs.)on Land B[3]	Acre			
C.gr.oats sil.(1yr.)on Land A	Acre	40	22	24
Blue gr.white clover pasture on Land C	Acre	43	43	43
Total forage T.D.N. furnished	Cwt.	3,835	4,116	4,101
Total grain T.D.N. furnished	Cwt.	2,542	2,112	2,201
Total T.D.N. fed to cows and replacements[4]	Cwt.	3,164	3,396	3,889
Grain T.D.N. sold (corn)	Cwt.	1,350	700	353
Forage T.D.N. sold (hay)	Cwt.	1,802	2,132	2,060
Milk sold	Cwt.	3,291	3,813	4,420
Number cows in milking herd	Each	38	36	35
Total forage T.D.N. fed to milking herd	Cwt.	1,250	1,298	1,378
Total grain T.D.N. fed to milking herd[5]	Cwt.	1,087	1,344	1,806
Forage-grain feeding ratio[6]	Pct.	48:52	44:56	38:62
Net return to fixed factors[7]	Dol.	10,750	11,548	11,442

[1] All figures have been rounded to whole numbers.

[2] See Appendix E for identification - P_{27}, P_{28}, P_{29}, P_{34}, P_{35} and P_{38} respectively.

[3] First cutting of alfalfa-orchard grass harvested for silage and the second and third cuttings harvested for hay.

[4] Includes farm produced forage T.D.N. and grain T.D.N. that were fed to cows and replacements.

[5] The grain T.D.N. fed to milk cows including protein supplement.

[6] This is the forage E.N.E.-to-grain E.N.E. feeding ratio to milk cows. In calculating this ratio: 1 lb. grain T.D.N. = 1 therm E.N.E.
1.22 lbs. forage T.D.N. = 1 therm E.N.E.

[7] The fixed factors include land, labor, investment capital and management.

among the 9,000 pounds, 11,000 pounds, and 13,000 pounds production rates was narrowed substantially, and the 11,000 pounds per cow became slightly more profitable than the 13,000 pounds per cow.

With a milk price of $3.00 per hundred-weight, it was more profitable at the 9,000 pounds per cow to decrease milk production further and to sell more hay and slightly less grain. The trend towards more forage in an optimum forage-to-grain feeding ratio at 9,000 pounds per cow continued with the further reduction in milk price from $4.00 to $3.00 per 100 pounds. The reduction in milk production made available more labor for crop production. Since forage was a cheaper feed than grain, although forage crops required more labor, the amount of additional labor permitted a change to more acreage in rotations containing primarily forage. Thus, it was more profitable to include more forage in the ration and to increase hay sales at 9,000 pounds per cow when milk price was reduced to $3.00 per hundred-weight.

At the 13,000 pounds production rate, the reduction in milk price was insufficient to alter the combination of uses of feed. Thus, an optimum forage-to-grain feeding ratio and crop production system remained the same for a price range from $5.73 to as low as $3.00 when milk sales are restricted to the present amount.

Summary

As the price of milk declined, the lower milk production rates gained in profitability relative to the higher production rates. This trend occurred because the use of feed to produce milk as price dropped was less profitable. At the 9,000 pounds and 11,000 pounds production

rates, labor that otherwise would have been utilized to maintain more cows was available for producing corn and hay for direct sales. The additional corn and hay produced by this labor enabled more forage to be included in the ration which reduced the cost of producing milk and also permitted more corn and/or hay to be sold, which increased income from these sources. At 13,000 pounds production per cow, a decline in milk prices reduced income. However, income could not have been increased by producing less milk and selling more hay and grain. The result was that the margin of net revenue between the lower and higher production rates narrowed as the price of milk decreased. As one continues to decrease the price of milk with the resource limitations remaining the same, the lower production rates may become more profitable than the higher production rates. Thus, when the price of milk was reduced to $3.00 per hundred-weight, the 11,000 pounds production rate was more profitable than the 13,000 pounds production rate.

As the price of milk decreased, labor became less restrictive and land became more restrictive at the 9,000 pounds and 11,000 pounds production rates. Since it was more profitable to produce less milk at these production rates as the price of milk declined, more labor was available for grain and forage production and, thus, land became more of a limiting resource.

With a substantial reduction in the price of milk, the dairyman may obtain a greater net return to fixed factors by producing below his present milk sales and at a lower production rate per cow and directing more of his limited resources to producing forage and grain for direct

sales. Also, it is more profitable to increase the forage content of the ration at 9,000 pounds and 11,000 pounds per cow as the price of milk declines.

It is more profitable to produce pasture for feed to dairy animals on land suitable only for this purpose than for this land to remain idle even when the price of milk is as low as $3.00 per hundred-weight.

Manufactured milk producers who are producing at production rates of 9,000 pounds or below and have the same quality cows as described in this study could increase net return to fixed factors by producing at 11,000 pounds or 13,000 pounds per cow. Since this study included only one quality of cows, this implication would not be valid for manufactured milk producers who might produce 9,000 pounds of milk per cow with cows of lower production potential. The lower investment in the lower quality cow may make the 9,000 pounds rate of production economical.

SUMMARY AND CONCLUSIONS

The increasing competition in dairying within the State and the potential competition developing in areas outside of the State make it essential that dairy farmers in Virginia operate efficiently if they are to maintain or improve their competitive position. The dairy farmer has more control of milk production costs than of the price he receives for milk. Since the major part of the total cost of producing milk is comprised of feed costs, net return to the dairyman is greatly influenced by the feeding program used on the farm.

The dairy farmer has various resources, some of which are limited in quantity, that may be utilized to produce milk. Dairy farmers are limited in the amount of milk that can be sold at a milk base price. The dairyman has various alternative grain and forage crops that he can produce for feed or sale. Thus, the dairy farmer is confronted with the problem of determining the forage-to-grain feeding ratio and forage and grain production system that will maximize returns to his fixed resources.

A farm to represent a typical resource situation was selected from data collected on 17 grade A dairy farms located in the Roanoke-Franklin-Henry-County area of west central Virginia. The farm selected was a modal situation with 185.8 acres of open land, 7,684 annual man-hours of available labor, 600.4 tons of available hay storage space, 206 tons of available silage storage space and most of the major items of machinery needed for forage and grain production. The annual milk sales on the typical farm was 4,420 hundred-weights of four percent fat-corrected milk.

The levels of milk production per cow used in this study were 9,000 pounds, 11,000 pounds and 13,000 pounds. Forage and grain coefficients were developed in terms of estimated net energy for individual forage-to-grain ratios at each of the three rates of milk production per cow. The feed coefficients were based on a milk production potential of 13,000 pounds of four percent fat-corrected milk per cow. A grade A dairy budget was prepared for each forage-to-grain ratio at the three rates of milk production per cow. Budgets were prepared for various crop rotations adaptable to the area included in this study. The output of corn silage in the rotations containing this crop was estimated in terms of forage and grain. Since this study was short-run in scope, fixed costs were not included in either the grade A dairy budgets or the crop rotation budgets.

Linear programming was the principal analytical technique used in this study. An optimum forage and grain production system and forage-to-grain feeding ratio was determined for each of the three rates of milk production per cow with milk priced at $5.73 per hundred-weight. To study the effect of changes in the price of milk on the relative profitability of the three levels of production per cow, an optimum crop production and feeding plan was also determined for each production rate per cow with milk priced at $4.00 and $3.00 per hundred-weight.

An optimum forage E.N.E.-to-grain E.N.E. feeding ratio for 9,000 pounds per cow with milk priced at $5.73 per hundred-weight was 35:65 on the typical farm. Labor during July through October was the most

restrictive resource at this production rate. An optimum crop production system included rotations that produced large quantities of grain since less of the available labor supply was required per unit of feed nutrients produced from this source. The most profitable combination of uses of feed at 9,000 pounds per cow was to produce less milk than is now being sold (sales base restriction of 4,420 hundred-weights) and to sell corn and hay.

With milk priced at $5.73 per hundred-weight, an optimum forage E.N.E.-to-grain E.N.E. feeding ratio at 11,000 pounds per cow on the typical farm was 43:57. Labor during July through October was also the most restrictive resource at 11,000 pounds per cow. Land, however, was somewhat more restrictive at this production rate than it was at 9,000 pounds per cow. Fewer cows were required to produce a given milk sales base at 11,000 pounds per cow than was required at 9,000 pounds per cow. The labor saved by the reduction in cow numbers at 11,000 pounds per cow was more profitably utilized in the production of forage crops. Consequently, an optimum feed ration and crop production system for this production rate contained more forage than an optimum feeding and crop production plan for the 9,000 pounds production rate. It was more profitable to produce up to the milk sales base restriction at 11,000 pounds per cow and to sell any excess corn and hay.

An optimum forage E.N.E.-to-grain E.N.E. feeding ratio, with milk priced at $5.73 per hundred-weight, was 38:62 for the 13,000 pounds production rate per cow on the typical farm. Land was the most restrictive resource rather than labor when milk production per cow was

increased to 13,000 pounds. Fewer cows were required for producing the milk sales base at this production rate than were required at the lower production rates. However, more feed nutrients per cow were required and less grain was required to replace one unit of forage at 13,000 pounds per cow than at the lower production rates. Thus, an optimum crop production system for the 13,000 pounds production rate per cow contained crops that would supply large quantities of nutrients from grain for use in the feed ration. Considerable corn silage was included in an optimum crop production system at this production rate since both grain and forage could be obtained from this source. At 13,000 pounds per cow, it was more profitable to produce milk up to the sales base restriction and to sell any excess hay and corn.

There was some latitude in the selection of a forage-to-grain feeding ratio and forage and grain production system at both the 9,000 pounds and 11,000 pounds production rates before greatly reducing net return to fixed factors. At 13,000 pounds per cow, a relatively small change from an optimum feeding and crop production plan would substantially reduce net return to fixed factors.

With the available resources on the typical farm and milk priced at $5.73 per hundred-weight, 13,000 pounds per cow was the most profitable production rate. However, net return to fixed factors increased at a decreasing rate from the 9,000 pounds production per cow to the 11,000 pounds and 13,000 pounds production rates. The net revenue at 13,000 pounds per cow exceeded the net revenue at 11,000 pounds per cow by $297 when milk was priced at $5.73 per hundred-weight. Thus, either

of these production rates could be used with only negligible effect on the net return to fixed factors.

It was more profitable at each of the three rates of milk production per cow to supply some of the forage requirements of the ration from permanent pasture than for the land suitable only for this purpose to remain unused.

When the price of milk was reduced to $4.00 per hundred-weight, the lower production rates gained in profitability relative to the higher production rates. It was profitable to increase the forage content of the ration at 9,000 pounds per cow with milk reduced to $4.00 per hundred-weight. This reduction in milk price, however, was not sufficient to alter an optimum forage-to-grain feeding ratio at the 11,000 pounds and 13,000 pounds production rates.

When the price of milk was lowered to $3.00 per hundred-weight, the margin of net revenue among the three production rates per cow was narrowed considerably and the 11,000 pounds production rate became the most profitable. The forage content of the ration increased slightly at the 9,000 pounds and 11,000 pounds production rates with milk priced at $3.00 per 100 pounds. It was more profitable to produce below the milk sales base restriction and sell corn and hay at both the 9,000 pounds and 11,000 pounds production rates. At 13,000 pounds per cow, the reduction in milk price to $3.00 per hundred-weight was not sufficient to alter the combination of uses of feed and, thus, an optimum feeding ratio and crop production system did not change.

As the price of milk declined, labor became less restrictive and land became more restrictive at the 9,000 pounds and 11,000 pounds production rates. Land remained the most restrictive resource at 13,000 pounds per cow with changes in the price of milk.

REFERENCES CITED

Agronomy Department, A Handbook of Agronomy, Bulletin 97, Virginia Polytechnic Institute, Blacksburg, Virginia, June, 1959.

Bishop, C. E. and Toussaint, W. D., Introduction to Agricultural Economic Analysis, John Wiley and Sons, Inc., New York, 1958.

Heady, E. O. and Jensen, H. R., Farm Management Economics, Prentice-Hall, Inc., New York, 1954.

Heady, E. O., Schnittker, J. A., Jacobson, N. L., and Bloom, S., Milk Production Functions, Hay/Grain Substitution Rates and Economic Optima in Dairy Cow Rations, Res. Bul. 444, Agricultural Experiment Station, Iowa State College, Ames, Iowa, October, 1956.

Huffman, C. F. and Duncan, C. W., Corn Silage as a Source of the Unidentified Grain Factors Needed for Milk Production, Quarterly Bulletin, Michigan Agricultural Experiment Station, East Lansing, Michigan, 1954.

Morrison, F. B., Feeds and Feeding, Twenty-first Edition, The Morrison Publishing Company, Ithaca, New York, 1949.

Nevens, W. B., Harshbarger, K. E., Touchberry, R. W., and Dungan, G. H., A Method of Estimating the Money Value of Corn Silage, Bulletin 576, Illinois Agricultural Experiment Station, Urbana, Illinois, May, 1954.

Sheppard, V. M., Jr., An Economic Analysis of Resource Requirements and Performance of Alternative Systems for Harvesting and Storing Forage, Unpublished M. S. Thesis, Virginia Polytechnic Institute, Blacksburg, Virginia, May, 1960.

U. S. Bureau of the Census, U. S. Census of Agriculture, 1959, Vol. I, Counties, Part 24, Virginia, U. S. Government Printing Office, Washington, D. C., 1961.

Virginia Joint Agricultural Publication No. 2, Looking Into the Grade A Dairy Industry in Virginia, Virginia Department of Agriculture and V. P. I. Agricultural Extension Service, June, 1959.

Walker, H. W., Guide for Estimating Annual Cost for Owning and Operating Selected Farm Machinery, Special Report, Virginia Agricultural Extension Service, Blacksburg, Virginia, August, 1959.

Walker, H. W., Kline, R. G., and Arnold, C. J., Farm Adjustment Opportunities - Southside Virginia, Tech. Bul. 150, Virginia Agricultural Experiment Station, Blacksburg, Virginia, May, 1961.

VITA

The author, Robert Kenneth Reynolds, was born to Iva Mae and Ruben Ray Reynolds on October 5, 1931, at Washington, D. C. At the age of 11, he moved, with his parents, to a general farm in Orange County, Virginia.

He attended Emory Elementary School at Washington, D. C., and Unionville High School at Unionville, Virginia, graduating in June, 1948. He did post-graduate work at James Monroe High School, Fredericksburg, Virginia, 1948-1949. He entered Virginia Polytechnic Institute in September, 1949, received a Bachelor of Science Degree in Agricultural Economics in June, 1953, and was commissioned a Second Lieutenant in the United States Air Force Reserve.

He married Patricia Lucy Winesett of Galax, Virginia, on September 26, 1953. He has one daughter, Deidra Jo Reynolds, six years of age.

He was employed by the Virginia Agricultural Extension Service as an Assistant County Agent in Gloucester County from June, 1953, to June, 1954. He served on active duty with the Air Force from June, 1954, to July, 1956. After release from active military service, he was employed by the Virginia Agricultural Extension Service as Assistant County Agent in Tazewell County until November, 1958. He returned to Virginia Polytechnic Institute as Assistant Extension Farm Management Specialist in November, 1958.

He entered the Graduate School of Virginia Polytechnic Institute, on a part-time basis, in January, 1959.

At present, he is primarily responsible for the Virginia Electronic Farm Record Program.

Robert K. Reynolds

APPENDIX A

Prices Used in Budgets and Linear Program

Table 1. Prices Used in Budgets and Linear Program

Item	Unit	Price Paid	Price Received
Dairy:			
Grade A milk (4 percent FCM)	Cwt.	$	$ 5.7300
Cows (culls)	Each		145.0000
Heifers (over 1 year old)	Each		175.0000
Heifers (6 to 12 months old)	Each		70.0000
Calves (1 week old)	Each		10.0000
Artificial breeding	Per cow	7.0000	
D.H.I.A.	Per cow	5.0000	
Veterinary and medicine	Per cow	5.0000	
Utilities	Per cow	11.0000	
Bedding	Ton	15.0000	
Supplies	Per cow	4.0000	
Milk marketing	Cwt.	0.3700	
Feed:			
Protein supplement	Cwt.	4.5000	
Salt and minerals	Lb.	0.0300	
Calf starter	Lb.	0.0500	
No. 2 yellow corn	Bu.	1.4100	1.3100
Hay (alfalfa, all analyses)	Ton	45.7100	28.0000
Grinding and mixing	Cwt.	0.3000	
Seed:			
Corn, hybrid	Lb.	0.1920	
Barley	Bu.	2.0650	
Rye	Bu.	2.7900	
Oats	Bu.	1.6100	
Lespedeza	Lb.	0.1630	
Alfalfa	Lb.	0.4850	
Orchard grass	Lb.	0.3680	
Red clover	Lb.	0.4970	
Vetch	Lb.	0.1820	
Ladino clover	Lb.	1.3310	
Millet	Lb.	0.1000	
Kentucky bluegrass	Lb.	0.9240	
Timothy	Lb.	0.2340	
White clover	Lb.	1.0280	
Fertilizer:			
Nitrogen	Lb.	0.1297	
Phosphorus (P_2O_5)	Lb.	0.0738	
Potash (K_2O)	Lb.	0.0514	

Table 1. (Continued)

Item	Unit	Price Paid	Price Received
Custom rates:			
Picking corn	Acre	$ 7.0000	
Combining small grain	Acre	5.0000	
Spreading lime	Acre	1.0000	
Silage storage space	Ton	0.8000	

APPENDIX B

Factors Used in Calculating the Forage and Grain Content of Corn Silage

DERIVATION OF FACTORS USED IN DETERMINING

THE FORAGE T.D.N. AND GRAIN T.D.N. IN CORN SILAGE

Assume corn silage -- dent, well-matured, well-eared (28.4 percent total dry matter and 20 percent T.D.N.)[1]

1 ton of corn silage (28.4 percent dry matter) = 4.43 bushels of No. 2 yellow corn equivalent + 330 pounds of good grass hay equivalent (314 pounds from leaves and stalks + 16 pounds from cob).[2]

4.43 bushels of corn x 56 pounds per bushel = 248.08 pounds of shelled corn.

248.08 x 80.1 percent T.D.N. (corn, dent, grade No. 2)[3] = 198.71 pounds of grain T.D.N. per ton of corn silage.

330 pounds hay equivalent x 50.8 percent T.D.N. (Timothy hay, early bloom)[4] = 167.64 pounds of forage T.D.N. per ton of corn silage.

1/ F. B. Morrison, Feeds and Feeding, Twenty-first Edition, The Morrison Publishing Company, Ithaca, New York, 1949, p. 1,110.

2/ W. B. Nevens, K. E. Harshbarger, R. W. Touchberry, G. H. Dungan, A Method of Estimating the Money Value of Corn Silage, Bulletin 576, Illinois Agricultural Experiment Station, Urbana, Illinois, May, 1954.

3/ F. B. Morrison, op. cit. p. 1,116.

4/ Ibid., p. 1,096.

APPENDIX C

Grade A Dairy Budgets

DERIVATION OF MANURE COEFFICIENTS USED IN GRADE A DAIRY BUDGETS[1/]

Average amount of manure produced yearly by a dairy cow:

20,000 pounds solid manure

8,000 pounds liquid manure

28,000 total pounds or 14 tons

Composition of manure produced by a dairy cow:

79 percent water

11.4 pounds of nitrogen per ton

4.4 pounds of phosphorus per ton

12.5 pounds of potash per ton

Assuming any nutrient loss is offset by manure produced by replacements, the quantities of nitrogen, phosphorus and potash used in the grade A dairy budgets were:

159.6 pounds of nitrogen

61.6 pounds of phosphorus

175.0 pounds of potash

1/ Agronomy Department, A Handbook of Agronomy, Bulletin 97, Virginia Polytechnic Institute, Blacksburg, Virginia, June, 1959, pp. 112-113.

Table 1. Forage and Grain Coefficients for Various Forage-to-Grain Ratios at Three Rates of Milk Production Per Cow[1/]

Forage E.N.E.-to-grain E.N.E. ratio	Therms of E.N.E.			Pounds of T.D.N.[2/]		
	Forage	Grain	Total	Forage	Grain	Total
			9,000 pounds of milk per cow[3/]			
75/25	4,375	1,458	5,833	5,352	1,458	6,810
55/45	3,064	2,506	5,570	3,748	2,506	6,254
35/65	1,902	3,533	5,435	2,327	3,533	5,860
			11,000 pounds of milk per cow			
75/25	5,541	1,847	7,388	6,779	1,847	8,626
55/45	3,768	3,082	6,850	4,610	3,082	7,692
35/65	2,316	4,300	6,616	2,833	4,300	7,133
15/85	982	5,567	6,549	1,201	5,567	6,768
			13,000 pounds of milk per cow[4/]			
55/45	4,873	3,987	8,860	5,962	3,987	9,949
35/65	2,905	5,396	8,301	3,554	5,396	8,950
15/85	1,242	7,038	8,280	1,519	7,038	8,557

1/ On the basis of feeding a fixed ratio of seven pounds of hay to four pounds of concentrates for an initial 14-day adjustment period following calving, the cows in each rate of milk production per cow have the ability to produce 13,000 pounds of four percent fat-corrected milk.

2/ Factors used in converting therms of E.N.E. to pounds of T.D.N.:
1 lb. grain T.D.N. = 1 therm E.N.E.
1.22 lbs. forage T.D.N. = 1 therm E.N.E.

3/ Past experience has shown that the forage-grain price relationships have been such that the least-cost ration for producing 9,000 pounds of milk per cow would not contain less than 35 percent forage.

4/ Assuming a ration for producing 13,000 pounds of milk per cow which contained more than 55 percent forage would utilize forage inefficiently since it is approaching the stomach capacity of the cow.

Table 2. Grade A Dairy Budget for Producing 9,000 Pounds of Four Percent FCM with 75:25, 55:45 and 35:65 Forage-to-Grain Feeding Ratios (Activities P_{23}, P_{24} and P_{25})[1]

Item	Description	Price	Unit	Quantity	Amount
Income per cow:					
Milk[2]	4 percent FCM	$ 5.730	Cwt.	86.50	$495.64
Cows	Culls	145.000	Each	0.20	29.00
Heifers	Over 1 year old	175.000	Each	0.10	17.50
Heifers	6 to 12 months old	70.000	Each	0.10	7.00
Small calves	1 week old	10.000	Each	0.40	4.00
Gross cash receipts					$553.14
Manure credit	Nitrogen		Lbs.	159.60	
	P_2O_5		Lbs.	61.60	
	K_2O		Lbs.	175.00	
Expenses per cow:					
Forage T.D.N.[3]	Hay		Lbs.	306.00	
	Corn silage		Lbs.	1,463.00	
	Grass silage		Lbs.	3,080.00	
	Pasture		Lbs.	2,400.00	
Grain T.D.N.[3]	Corn silage		Lbs.	1,734.00	
Protein supplement		4.500	Cwt.	1.00	4.50
Salt and minerals		0.030	Lbs.	40.00	1.20
Calf starter		0.050	Lbs.	40.00	2.00
Grinding and mixing[4]		0.300	Cwt.	22.62	6.79
Records	D.H.I.A.	5.000	Each	1.00	5.00
Veterinary and medicine		5.000	Each	1.00	5.00
Breeding		7.000	Each	1.00	7.00
Utilities		11.000	Each	1.00	11.00
Bedding		15.000	Ton	0.50	7.50
Supplies		4.000	Each	1.00	4.00
Marketing	Hauling and other marketing cost	0.370	Cwt.	86.50	32.00

Table 2. (Continued)

Item	Description	Price	Unit	Quantity	Amount
Repairs	Dairy equipment	2.000	Each	1.00	2.00
Tractor operating costs	Clean-up[5]	0.517	Hours	1.17	0.60
Equipment operating costs	Clean-up[5]		Hours	1.17	0.09
Interest, insurance and taxes on livestock[6]					30.70
Total cost excluding fixed cost, farm produced feed, labor and management					$119.38
Net return to land, fixed capital, farm produced feed, labor and management					$433.76

Seasonal Labor Requirements

Period	Man-hours
March-June	35.2
July-October	34.2
November-February	45.6

1/ Includes replacements per cow based on 4.0 springing heifers, 6.0 heifers over 1 year old and 8.0 heifers under 1 year old per 20.0 cow unit.

2/ 350 pounds of milk per cow to calves.

3/ The T.D.N. figures represent possible quantities from various sources to fulfill the T.D.N. requirement of the ration. Except for the minimum hay and maximum pasture limitations as shown, the quantity figures for all sources could vary within the total T.D.N. requirement. The figures shown represent the 75:25 forage-to-grain ratio. Changes in the quantities shown that

Table 2. (Continued)

may represent the 55:45 and 35:65 forage-to-grain ratios are:

	55:45			35:65	
Forage T.D.N.:	corn silage	1,676 lbs.	Forage T.D.N.:	corn silage	1,518 lbs.
	grass silage	1,263 lbs.	Grain T.D.N.:	corn silage	1,800 lbs.
Grain T.D.N.:	corn silage	1,987 lbs.		corn-barley	2,009 lbs.
	corn-barley	795 lbs.			

4/ This cost represents the 75:25 forage-to-grain ratio and is based on the grain T.D.N. requirement of the ration. This cost is $10.71 for the 55:45 ratio and $14.56 for the 35:65 ratio.

5/ Clean-up involves loading manure only. The hauling and spreading cost is charged to the crop to which the manure is applied.

6/ Calculated at 7 percent of the average value of the milk cows and their replacements. Average values: cows -- $330; springing heifers -- $225; heifers over 1 year old -- $125; heifers under 1 year old -- $65.

Table 3. Grade A Dairy Budget for Producing 11,000 Pounds of Four Percent FCM with 75:25, 55:45, 35:65 and 15:85 Forage-to-Grain Feeding Ratios (Activities P_{23}, P_{24}, P_{25} and P_{26})[1]

Item	Description	Price	Unit	Quantity	Amount
Income per cow:					
Milk[2]	4 percent FCM	$ 5.730	Cwt.	106.50	$610.24
Cows	Culls	145.000	Each	0.20	29.00
Heifers	Over 1 year old	175.000	Each	0.10	17.50
Heifers	6 to 12 months old	70.000	Each	0.10	7.00
Small calves	1 week old	10.000	Each	0.40	4.00
Gross cash receipts					$667.74
Manure credit	Nitrogen		Lbs.	159.60	
	P_2O_5		Lbs.	61.60	
	K_2O		Lbs.	175.00	
Expenses per cow:					
Forage T.D.N.[3]	Hay		Lbs.	306.00	
	Corn silage		Lbs.	1,725.00	
	Grass silage		Lbs.	4,245.00	
	Pasture		Lbs.	2,400.00	
Grain T.D.N.[3]	Corn silage		Lbs.	2,044.00	
Protein supplement		4.500	Cwt.	2.00	9.00
Salt and minerals		0.030	Lb.	40.00	1.20
Calf starter		0.050	Lb.	40.00	2.00
Grinding and mixing[4]		0.300	Cwt.	27.48	8.24
Records	D.H.I.A.	5.000	Each	1.00	5.00
Veterinary and medicine		5.000	Each	1.00	5.00
Breeding		7.000	Each	1.00	7.00
Utilities		11.000	Each	1.00	11.00
Bedding		15.000	Ton	0.50	7.50
Supplies		4.000	Each	1.00	4.00
Marketing	Hauling and other marketing costs	0.370	Cwt.	106.50	39.41

Table 3. (Continued)

Item	Description	Price	Unit	Quantity	Amount
Repairs	Dairy equipment	2.000	Each	1.00	2.00
Tractor operating cost	Clean-up[5]	0.517	Hours	1.17	0.60
Equipment operating cost	Clean-up[5]		Hours	1.17	0.09
Interest, insurance and taxes on livestock[6]					30.70
Total cost excluding fixed cost, farm produced feed, labor and management					$132.74
Net return to land, fixed capital, farm produced feed, labor and management					$535.00

Seasonal Labor Requirements

Period	Man-hours
March-June	35.2
July-October	34.2
November-February	45.6

1/ Includes replacements per cow based on 4.0 springing heifers, 6.0 heifers over 1 year old and 8.0 heifers under 1 year old per 20.0 cow unit.

2/ 350 pounds of milk per cow to calves.

3/ The T.D.N. figures represent possible quantities from various sources to fulfill the T.D.N. requirement of the ration. Except for the minimum hay and maximum pasture limitations as shown, the quantity figures for all sources could vary within the total T.D.N. requirement. The figures shown represent the 75:25 forage-to-grain ratio. Changes in the quantities shown that

Table 3. (Continued)

may represent the 55:45, 35:65 and 15:85 forage-to-grain ratios are:

	55:45			35:65	
Forage T.D.N.:	corn silage	2,179 lbs.	Forage T.D.N.:	corn silage	2,024 lbs.
	grass silage	1,622 lbs.	Grain T.D.N.:	corn silage	2,398 lbs.
Grain T.D.N.:	corn silage	2,583 lbs.		corn-barley	2,099 lbs.
	corn-barley	696 lbs.			
	15:85				
Forage T.D.N.:	corn silage	392 lbs.			
Grain T.D.N.:	corn silage	465 lbs.			
	corn-barley	5,299 lbs.			

4/ This cost represents the 75:25 forage-to-grain ratio and is based on the grain T.D.N. requirement of the ration. This cost is $12.87 for the 55:45 ratio, $17.43 for the 35:65 ratio and $22.18 for the 15:85 ratio.

5/ Clean-up involves loading manure only. The hauling and spreading cost is charged to the crop to which the manure is applied.

6/ Calculated at 7 percent of the average value of the milk cows and their replacements. Average values: cows -- $330; springing heifers -- $225; heifers over 1 year old -- $125; heifers under 1 year old -- $65.

Table 4. Grade A Dairy Budget for Producing 13,000 Pounds of Four Percent FCM with 55:45, 35:65 and 15:85 Forage-to-Grain Feeding Ratios (Activities P_{24}, P_{25} and P_{26})[1]

Item	Description	Price	Unit	Quantity	Amount
Income per cow:					
Milk[2]	4 percent FCM	$ 5.730	Cwt.	126.50	$724.84
Cows	Culls	145.000	Each	0.20	29.00
Heifers	Over 1 year old	175.000	Each	0.10	17.50
Heifers	6 to 12 months old	70.000	Each	0.10	7.00
Small calves	1 week old	10.000	Each	0.40	4.00
Gross cash receipts					$782.34
Manure credit	Nitrogen		Lbs.	159.60	
	P_2O_5		Lbs.	61.60	
	K_2O		Lbs.	175.00	
Expenses per cow:					
Forage T.D.N.[3]	Hay		Lbs.	306.00	
	Corn silage		Lbs.	2,682.00	
	Grass silage		Lbs.	2,471.00	
	Pasture		Lbs.	2,400.00	
Grain T.D.N.[3]	Corn silage		Lbs.	3,179.00	
	Corn-barley		Lbs.	927.00	
Protein supplement		4.500	Cwt.	3.00	13.50
Salt and minerals		0.030	Lbs.	40.00	1.20
Calf starter		0.050	Lbs.	40.00	2.00
Grinding and mixing[4]		0.300	Lbs.	54.19	16.26
Records	D.H.I.A.	5.000	Each	1.00	5.00
Veterinary and medicine		5.000	Each	1.00	5.00
Breeding		7.000	Each	1.00	7.00
Utilities		11.000	Each	1.00	11.00
Bedding		15.000	Ton	0.50	7.50
Supplies		4.000	Each	1.00	4.00
Marketing	Hauling and other marketing cost	0.370	Cwt.	126.50	46.81

Table 4. (Continued)

Item	Description	Price	Unit	Quantity	Amount
Repairs	Dairy equipment	2.000	Each	1.00	2.00
Tractor operating cost	Clean-up[5]	0.517	Hours	1.17	0.60
Equipment operating cost	Clean-up[5]		Hours	1.17	0.09
Interest, insurance and taxes on livestock[6]					30.70
Total cost excluding fixed cost, farm produced feed, labor and management					$152.66
Net return to land, fixed capital, farm produced feed, labor and management					$629.68

Seasonal Labor Requirements

Period	Man-hours
March-June	35.2
July-October	34.2
November-February	45.6

1/ Includes replacements per cow based on 4.0 springing heifers, 6.0 heifers over 1 year old and 8.0 heifers under 1 year old per 20.0 cow unit.

2/ 350 pounds of milk per cow to calves.

3/ The T.D.N. figures represent possible quantities from various sources to fulfill the T.D.N. requirement of the ration. Except for the minimum hay and maximum pasture limitations as shown, the quantity figures for all sources could vary within the total T.D.N. requirement. The figures shown represent the 55:25 forage-to-grain ratio. Changes in the quantities shown that

Table 4. (Continued)

may represent the 35:65 and 15:85 forage-to-grain ratios are:

	35:65			15:85	
Forage T.D.N.:	corn silage	2,745 lbs.	Forage T.D.N.:	corn silage	710 lbs.
Grain T.D.N.:	corn silage	3,253 lbs.	Grain T.D.N.:	corn silage	843 lbs.
	corn-barley	2,262 lbs.		corn-barley	6,314 lbs.

4/ This cost represents the 55:45 forage-to-grain ratio and is based on the grain T.D.N. requirement of the ration. This cost is $21.54 for the 35:65 ratio and $27.68 for the 15:85 ratio.

5/ Clean-up involves loading manure only. The hauling and spreading cost is charged to the crop to which the manure is applied.

6/ Calculated at 7 percent of the average value of the milk cows and their replacements. Average values: cows -- $330; springing heifers -- $225; heifers over 1 year old -- $125; heifers under 1 year old -- $65.

APPENDIX D

Crop Rotation Budgets

Table 1. Average Percent Total Digestible Nutrients in Crops[1]

Crops	Percent T.D.N.
Corn for grain	80.1
Corn silage[2]	
Barley	77.7
Lespedeza hay	47.5
Oats and vetch silage	15.4
Alfalfa hay	50.3
Alfalfa-orchard grass hay	46.8
Oats silage	15.4
Ladino clover-orchard grass pasture	57.6
Bluegrass-white clover pasture	61.8
Millet pasture	54.2
Red clover-orchard grass hay	50.0
Alfalfa-orchard grass silage	17.0

[1] F. B. Morrison, Feeds and Feeding, Twenty-first Edition, The Morrison Publishing Company, Ithaca, New York, 1949.

[2] Corn silage was divided into grain T.D.N. and forage T.D.N. on the basis of one ton containing 198.71 pounds of grain T.D.N. and 167.64 pounds of forage T.D.N.

Table 2. Machinery and Equipment Costs

Item	Size and/or description	Operating cost per hour
Tractor[1]	Small	$0.404
Tractor[1]	Medium	0.517
Truck[2]	2-tons	0.620
Plow[2]	2-14" bottom	0.050
Disk[2]	6' tandem	0.060
Mower[1]	7'	0.200
Side delivery rake[1]	8'	0.150
Hay conditioner[2]	7'	0.100
Hay baler[1]	Pick-up, PTO	1.600
Forage harvester[1]	PTO - all attachments	0.500
Silage blower[1]	8" pipe	0.100
Corn planter[1]	2-row	0.080
Cultivator[1]	2-row	0.080
Cultipacker[2]	8'	0.020
Elevator[2]	20'	0.100
Grain drill[1]	13 x 7'	0.100
Wagon[2]	8' x 16'	0.100
Lime and fertilizer spreader[2]	8'	0.300
Manure loader[3]	Front-end loader	0.080
Manure spreader[2]	80 bushels	0.030

[1] H. W. Walker, Guide for Estimating Annual Cost for Owning and Operating Selected Farm Machinery, Special Report, Virginia Agricultural Extension Service, Blacksburg, Virginia, August, 1959.

[2] H. W. Walker, Unpublished Machinery Cost Estimates, Virginia Polytechnic Institute, Blacksburg, Virginia.

[3] Estimated cost: $500 new purchase cost
annual operating cost = 3 percent of new purchase cost
annual usage = 200 hours
estimated operating cost per hour = $\frac{.03 \times \$500}{200} = .08$

Table 3. Enterprise Budget for Two Years Corn-Barley and Lespedeza Rotation on Land B (Activity P_{27})

Item	Description	Price	Unit	Quantity	Amount
Income:					
Yield	Corn		Bu.	61.00	
	(Grain T.D.N.)		(Lb.)	(2,736)	
	Barley		Bu.	40.00	
	(Grain T.D.N.)		(Lb.)	(1,492)	
	Straw	$15.000	Ton	1.00	-$15.00
	Lespedeza		Ton	1.25	
	(Forage T.D.N.)[1/]		(Lb.)	(1,093)	
	Total grain T.D.N.		Lb.	4,228	
	Total forage T.D.N.		Lb.	1,093	
Expenses:					
Seed	Corn	0.192	Lb.	10.00	1.92
	Barley	2.065	Bu.	1.50	3.10
	Lespedeza	0.163	Lb.	25.00	4.08
Fertilizer[2/]	Nitrogen		Lb.	146.00	
	P_2O_5		Lb.	143.00	
	K_2O		Lb.	212.00	
Harvesting					
Corn	Custom	7.000	Acre	1.00	7.00
Barley	Custom	5.000	Acre	1.00	5.00
Tractor operating cost					
Small tractor		0.404	Hour	2.94	1.19
Medium tractor		0.517	Hour	15.99	8.27
Equipment operating cost					3.10
Net cost excluding fixed cost, fertilizer, land, labor and management					$18.66

Table 3. (Continued)

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Spreading manure	Spreader		3.25	3.25
Plowing for corn	2-14" bottom	1	1.40	1.40
Disking for corn	6' tandem	3	2.10	2.10
Planting corn	2-row planter with fertilizer att.	1	1.25	1.25
Cultivating corn	2-row cultivator	3	2.13	2.13
Hauling and storing corn	Tractor, wagon and elevator		1.54	1.16
Disking for barley	6' tandem	3	2.10	2.10
Distributing fertilizer and seeding barley	13 x 7' grain drill	1	1.03	0.80
Seeding lespedeza	13 x 7' grain drill	1	0.75	0.60
Hauling and storing barley	Tractor and wagon		1.11	0.56
Raking straw	8' side delivery rake	1	0.40	0.40
Baling straw	Pick-up baler, PTO	1	0.47	0.47
Hauling and storing straw	Tractor, wagon and elevator		1.60	0.54
Mowing lespedeza	7' mower	1	0.50	0.50
Raking lespedeza	8' side delivery rake	1	0.40	0.40
Baling lespedeza	Pick-up baler, PTO	1	0.59	0.59
Hauling and storing lespedeza	Tractor, wagon and elevator		2.00	0.68
Total for rotation			22.62	18.93

Seasonal Labor Requirements

Period	Man-hours
March-June	9.75
July-October	8.87
November-February	4.00

Table 3. (Continued)

1/ In calculating the pounds of T.D.N., it is assumed that 92 percent of the hay produced is available for consumption by the dairy animals. The remaining eight percent is not available as a result of loss during harvest and waste during feeding.

2/ Includes nine tons cow manure per acre (typical application) and commercial fertilizer on all crops in the rotation.

Table 4. Enterprise Budget for Corn Silage-Oats Silage Continuous Rotation on Land A (Activity P_{28})

Item	Description	Price	Unit	Quantity	Amount
Income:					
Yield	Corn silage		Ton	15.00	
	(Grain T.D.N.)[1]		(Lb.)	(2,683)	
	(Forage T.D.N.)[1]		(Lb.)	(2,263)	
	Oats silage[2]		Ton	4.00	
	(Forage T.D.N.)[1]		(Lb.)	(1,109)	
	Total grain T.D.N.		Lb.	2,683	
	Total forage T.D.N.		Lb.	3,372	
Credit[3]	Grinding and mixing (grain in corn silage)	$0.300	Cwt.	33.50	-$10.05
Expenses:					
Seed	Corn	0.192	Lb.	12.00	2.30
	Oats	1.610	Bu.	2.50	4.02
Fertilizer[4]	Nitrogen		Lb.	150.00	
	P_2O_5		Lb.	141.00	
	K_2O		Lb.	208.00	
Tractor operating cost					
Small tractor		0.404	Hour	4.94	2.00
Medium tractor		0.517	Hour	17.98	9.30
Equipment operating cost					7.29
Cover for silo[5]	Oats silage	0.130	Ton	4.00	0.52
Net cost excluding fixed cost, fertilizer, land, labor and management					$15.38

Table 4. (Continued)

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Spreading manure	Spreader		3.25	3.25
Plowing for corn silage	2-14" bottom	1	1.40	1.40
Disking for corn silage	6' tandem	3	2.10	2.10
Planting corn silage	2-row planter with fertilizer att.	1	1.25	1.25
Cultivating	2-row cultivator	3	2.13	2.13
Harvesting and storing corn silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		10.20	7.65
Disking for oats silage	6' tandem	3	2.10	2.10
Distributing fertilizer and seeding oats	13 x 7' grain drill	1	1.03	0.80
Harvesting and storing oats silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		3.04	2.24
Total for rotation			26.50	22.92

Seasonal Labor Requirements

Period	Man-hours
March-June	12.46
July-October	14.04
November-February	

Table 4. (Continued)

1/ In calculating the pounds of T.D.N., it is assumed that 90 percent of the silage produced is available for consumption by the dairy animals. The remaining 10 percent is not available as a result of spoilage in storage and waste during harvesting and feeding.

2/ Oats silage is harvested in early May and land is then planted to corn silage.

3/ The dairy budgets include a cost of 30 cents per hundred-weight for grinding and mixing grain based on the total grain T.D.N. requirement. Since a part of the total grain T.D.N. requirement in each dairy budget can be obtained from the grain included in corn silage and does not require grinding and mixing, it is necessary to credit the grain from this source to offset that proportion of the grinding and mixing cost included in the dairy budgets. The quantity figure is in terms of corn equivalent.

4/ Includes nine tons cow manure per acre (typical application) and commercial fertilizer on all crops in the rotation.

5/ Assuming the oats silage will be stored in a horizontal silo. No estimated cost is made in this category for corn silage since it is assumed the corn silage will be stored in a permanent-type upright silo.

Table 5. Enterprise Budget for Seven Years Corn Silage-Alfalfa Hay Rotation on Land B (Activity P_{29})[1]

Item	Description	Price	Unit	Quantity	Amount
Income:					
Yield	Corn silage		Ton	45.00	
	(Grain T.D.N.)[2]		(Lb.)	(8,048)	
	(Forage T.D.N.)[2]		(Lb.)	(6,788)	
	Alfalfa hay		Ton	14.00	
	(Forage T.D.N.)[3]		(Lb.)	(12,957)	
	Total grain T.D.N.		Lb.	8,048	
	Total forage T.D.N.		Lb.	19,745	
Credit[4]	Grinding and mixing (grain in corn silage)	$0.300	Cwt.	100.47	-$30.14
Expenses:					
Seed	Corn	0.192	Lb.	36.00	6.91
	Rye	2.790	Bu.	3.00	8.37
	Alfalfa	0.485	Lb.	25.00	12.12
Inoculant	Alfalfa				0.25
Lime	Ground limestone	5.580	Ton	2.00	11.16
	Custom spreading	1.000	Acre	1.00	1.00
Fertilizer[5]	Nitrogen		Lb.	298.00	
	P_2O_5		Lb.	681.00	
	K_2O		Lb.	886.00	
Tractor operating cost					
Small tractor		0.404	Hour	25.94	10.48
Medium tractor		0.517	Hour	65.59	33.91
Equipment operating cost					31.90
Net cost excluding fixed cost, fertilizer, land, labor and management					$85.96

Table 5. (Continued)

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Spreading manure[6]	Spreader		6.50	6.50
Plowing for corn silage	2-14" bottom	3	4.20	4.20
Disking for corn silage	6' tandem	9	6.30	6.30
Planting corn silage	2-row planter with fertilizer att.	3	3.75	3.75
Cultivating corn silage	2-row cultivator	9	6.39	6.39
Harvesting and storing corn silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		30.60	22.95
Disking for rye cover crop	6' tandem	4	2.80	2.80
Seeding rye cover crop	13 x 7' grain drill	2	1.50	1.20
Plowing for alfalfa	2-14" bottom	1	1.40	1.40
Disking for alfalfa	6' tandem	3	2.10	2.10
Distributing fertilizer	Lime spreader	1	0.80	0.50
Seeding (and inoculation) alfalfa	13 x 7' grain drill	1	0.80	0.60
Cultipacking alfalfa	Cultipacker	1	0.40	0.40
Topdressing alfalfa[7]	Lime spreader	3	2.40	1.50
Mowing alfalfa	7' mower	12	6.00	6.00
Conditioning alfalfa	Hay conditioner	12	6.00	6.00
Raking alfalfa	8' side delivery rake	12	4.80	4.80
Baling alfalfa	Pickup baler, PTO	12	6.58	6.58
Hauling and storing alfalfa	Tractor, wagon and elevator		22.40	7.56
Total for rotation			115.72	91.53

Table 5. (Continued)

Seasonal Labor Requirements	
Period	Man-hours
March-June	33.77
July-October	73.05
November-February	8.90

1/ Three years corn silage and four years alfalfa hay.

2/ In calculating the pounds of T.D.N., it is assumed that 90 percent of the silage produced is available for consumption by the dairy animals. The remaining 10 percent is not available as a result of spoilage in storage and waste during harvesting and feeding.

3/ In calculating the pounds of T.D.N., it is assumed that 92 percent of the hay produced is available for consumption by the dairy animals. The remaining eight percent is not available as a result of loss during harvest and waste during feeding.

4/ The dairy budgets include a cost of 30 cents per hundred-weight for grinding and mixing grain based on the total grain T.D.N. requirement. Since a part of the total grain T.D.N. requirement in each dairy budget can be obtained from the grain included in corn silage and does not require grinding and mixing, it is necessary to credit the grain from this source to offset that proportion of the grinding and mixing cost included in the dairy budgets. The quantity figure is in terms of corn equivalent.

5/ Includes nine tons cow manure per acre (typical preceding the second and third year corn crop) and commercial fertilizer on all crops in the rotation.

6/ Assuming that nine tons cow manure per acre is applied to the second and third year corn crops only.

7/ Assuming the alfalfa will not be topdressed after the last cutting year in the rotation.

Table 6. Enterprise Budget for Six Years Corn Silage-Barley-Alfalfa and Orchard Grass Hay Rotation on Land B (Activity P_{30})[1/]

Item	Description	Price	Unit	Quantity	Amount
Income:					
Yield	Corn silage		Ton	15.00	
	(Grain T.D.N.)[2/]		(Lb.)	(2,683)	
	(Forage T.D.N.)[2/]		(Lb.)	(2,263)	
	Barley		Bu.	40.00	
	(Grain T.D.N.)		(Lb.)	(1,492)	
	Straw	$15.000	Ton	1.00	-$15.00
	Alfalfa-orchard grass hay		Ton	14.00	
	(Forage T.D.N.)[3/]		(Lb.)	(12,056)	
	Total grain T.D.N.		Lb.	4,175	
	Total forage T.D.N.		Lb.	14,319	
Credit[4/]	Grinding and mixing (grain in corn silage)	0.300	Cwt.	33.50	- 10.05
Expenses:					
Seed	Corn	0.192	Lb.	12.00	2.30
	Barley	2.065	Bu.	1.50	3.10
	Alfalfa	0.485	Lb.	20.00	9.70
	Orchard grass	0.368	Lb.	4.00	1.47
Inoculant					0.25
Lime	Ground limestone	5.580	Ton	2.00	11.16
	Custom spreading	1.000	Acre	1.00	1.00
Fertilizer[5/]	Nitrogen		Lb.	150.00	
	P_2O_5		Lb.	575.00	
	K_2O		Lb.	721.00	

Table 6. (Continued)

Item	Description	Price	Unit	Quantity	Amount
Harvesting barley	Custom	5.000	Acre	1.00	5.00
Tractor operating cost					
Small tractor		0.404	Hour	19.38	7.83
Medium tractor		0.517	Hour	40.01	20.69
Equipment operating cost					21.57
Net cost excluding fixed cost, fertilizer, land, labor and management					$59.02

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Spreading manure	Spreader		3.25	3.25
Plowing for corn silage	2-14" bottom	1	1.40	1.40
Disking for corn silage	6' tandem	3	2.10	2.10
Planting corn	2-row planter with fertilizer att.	1	1.25	1.25
Cultivating corn silage	2-row cultivator	3	2.13	2.13
Harvesting and storing corn silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		10.20	7.65
Disking for barley	6' tandem	3	2.10	2.10
Distributing fertilizer and seeding barley	13 x 7' grain drill	1	1.03	0.80
Hauling and storing barley	Tractor and wagon		1.11	0.56
Raking straw	8' side delivery rake	1	0.40	0.40
Baling straw	Pick-up baler, PTO	1	0.47	0.47
Hauling and storing straw	Tractor, wagon and elevator		1.60	0.54
Disking for alfalfa-orchard grass	6' tandem	4	2.80	2.80
Distributing fertilizer	Lime spreader	1	0.80	0.50

Table 6. (Continued)

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Seeding (and inoculating) alfalfa-orchard grass	13 x 7' grain drill	1	0.80	0.60
Cultipacking alfalfa-orchard grass	Cultipacker	1	0.40	0.40
Topdressing alfalfa-orchard grass[6/]	Lime spreader	3	2.40	1.50
Mowing alfalfa-orchard grass	7' mower	12	6.00	6.00
Conditioning alfalfa-orchard grass	Hay conditioner	12	6.00	6.00
Raking alfalfa-orchard grass	8' side delivery rake	12	4.80	4.80
Baling alfalfa-orchard grass	Pick up baler, PTO	12	6.58	6.58
Hauling and storing alfalfa-orchard grass	Tractor, wagon and elevator		22.40	7.56
Total for rotation			80.02	59.39

Seasonal Labor Requirements

Period	Man-hours
March-June	25.01
July-October	49.36
November-February	5.65

Table 6. (Continued)

1/ One year corn silage, one year barley and four years alfalfa-orchard grass hay.

2/ In calculating the pounds of T.D.N., it is assumed that 90 percent of the silage produced is available for consumption by the dairy animals. The remaining 10 percent is not available as a result of spoilage in storage and waste during harvesting and feeding.

3/ In calculating the pounds of T.D.N., it is assumed that 92 percent of the hay produced is available for consumption by the dairy animals. The remaining eight percent is not available as a result of loss during harvest and waste during feeding.

4/ The dairy budgets include a cost of 30 cents per hundred-weight for grinding and mixing grain based on the total grain T.D.N. requirement. Since a part of the total grain T.D.N. requirement in each dairy budget can be obtained from the grain included in corn silage and does not require grinding and mixing, it is necessary to credit the grain from this source to offset that proportion of the grinding and mixing cost included in the dairy budgets. The quantity figure is in terms of corn equivalent.

5/ Includes nine tons cow manure per acre (typical application) and commercial fertilizer on all crops in the rotation.

6/ Assuming the alfalfa-orchard grass will not be topdressed after the last cutting year in the rotation.

Table 7. Enterprise Budget for Six Years Corn Silage-Oats Silage and Corn Silage-Alfalfa and Orchard Grass Hay Rotation on Land B (Activity P_{31})[1]

Item	Description	Price	Unit	Quantity	Amount
Income:					
Yield	Corn silage[2]		Ton	27.50	
	(Grain T.D.N.)[3]		(Lb.)	(4,918)	
	(Forage T.D.N.)[3]		(Lb.)	(4,149)	
	Oats silage		Ton	6.00	
	(Forage T.D.N.)[3]		(Lb.)	(1,663)	
	Alfalfa-orchard grass hay		Ton	14.00	
	(Forage T.D.N.)[4]		(Lb.)	(12,056)	
	Total grain T.D.N.		Lb.	4,918	
	Total forage T.D.N.		Lb.	17,868	
Credit[5]	Grinding and mixing (grain in corn silage)	$0.300	Cwt.	61.40	-$18.42
Expenses:					
Seed	Corn	0.192	Lb.	24.00	4.61
	Oats	1.610	Bu.	2.50	4.02
	Alfalfa	0.485	Lb.	20.00	9.70
	Orchard grass	0.368	Lb.	4.00	1.47
Inoculant					0.25
Lime	Ground limestone	5.580	Ton	2.00	11.16
	Custom spreading	1.000	Acre	1.00	1.00
Fertilizer[6]	Nitrogen		Lb.	198.00	
	P_2O_5		Lb.	630.00	
	K_2O		Lb.	778.00	

Table 7. (Continued)

Item	Description	Price	Unit	Quantity	Amount
Tractor operating cost					
Small tractor		0.404	Hour	23.15	9.35
Medium tractor		0.517	Hour	50.89	26.31
Equipment operating cost					27.55
Cover for silo 1/	Oats	0.130	Ton	6.00	0.78
Net cost excluding fixed cost, fertilizer, land, labor and management					$77.78

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Spreading manure	Spreader		3.25	3.25
Plowing for corn silage	2-14" bottom	1	1.40	1.40
Disking for corn silage	6' tandem	3	2.10	2.10
Planting corn silage	2-row planter with fertilizer att.	1	1.25	1.25
Cultivating corn silage	2-row cultivator	3	2.13	2.13
Harvesting and storing corn silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		10.20	7.65
Disking for oats	6' tandem	3	2.10	2.10
Distributing fertilizer and seeding oats	13 x 7' grain drill	1	1.03	0.80
Harvesting and storing oats silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		4.56	3.36
Plowing for corn silage	2-14" bottom	1	1.40	1.40
Disking for corn silage	6' tandem	3	2.10	2.10
Planting corn silage	2-row planter with fertilizer att.	1	1.25	1.25
Cultivating corn silage	2-row cultivator	3	2.13	2.13

Table 7. (Continued)

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Harvesting and storing corn silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		8.50	6.38
Disking for alfalfa-orchard grass	6' tandem	4	2.80	2.80
Distributing fertilizer	Lime spreader	1	0.80	0.50
Seeding (and inoculating) alfalfa-orchard grass	13 x 7' grain drill	1	0.80	0.60
Cultipacking alfalfa-orchard grass	Cultipacker	1	0.40	0.40
Topdressing alfalfa-orchard grass[8/]	Lime spreader	3	2.40	1.50
Mowing alfalfa-orchard grass	7' mower	12	6.00	6.00
Conditioning alfalfa-orchard grass	Hay conditioner	12	6.00	6.00
Raking alfalfa-orchard grass	8' side delivery rake	12	4.80	4.80
Baling alfalfa-orchard grass	Pick-up baler, PTO	12	6.58	6.58
Hauling and storing alfalfa-orchard grass	Tractor, wagon and elevator		22.40	7.56
Total for rotation			96.38	74.04

Seasonal Labor Requirements

Period	Man-hours
March-June	32.16
July-October	58.57
November-February	5.65

Table 7. (Continued)

1/ One year corn silage, one year oats silage and corn silage and four years alfalfa-orchard grass hay. The oats silage is seeded in the fall and harvested in early spring.

2/ Assuming the corn silage will yield 15 tons per acre in the year following alfalfa-orchard grass and 12.5 tons per acre in the year with oats silage.

3/ In calculating the pounds of T.D.N., it is assumed that 90 percent of the silage produced is available for consumption by the dairy animals. The remaining 10 percent is not available as a result of spoilage in storage and waste during harvesting and feeding.

4/ In calculating the pounds of T.D.N., it is assumed that 92 percent of the hay produced is available for consumption by the dairy animals. The remaining eight percent is not available as a result of loss during harvest and waste during feeding.

5/ The dairy budgets include a cost of 30 cents per hundred-weight for grinding and mixing grain based on the total grain T.D.N. requirement. Since a part of the total grain T.D.N. requirement in each dairy budget can be obtained from the grain included in corn silage and does not require grinding and mixing, it is necessary to credit the grain from this source to offset that proportion of the grinding and mixing cost included in the dairy budgets. The quantity figure is in terms of corn equivalent.

6/ Includes both nine tons cow manure per acre (typical preceding the first year corn crop) and commercial fertilizer on all crops in the rotation. It is assumed that no manure is applied on the second corn crop in the rotation.

7/ Assuming the oats silage will be stored in a horizontal silo. No estimated cost is made in this category for corn silage since it is assumed the corn silage will be stored in a permanent-type upright silo.

8/ Assuming the alfalfa-orchard grass will not be topdressed after the last cutting year in the rotation.

Table 8. Enterprise Budget for Four Years Corn Silage-Oats Silage and Lespedeza-Red Clover and Orchard Grass Hay Rotation on Land B (Activity P_{32})[1]

Item	Description	Price	Unit	Quantity	Amount
Income:					
Yield	Corn silage		Ton	30.00	
	(Grain T.D.N.)[2]		(Lb.)	(5,365)	
	(Forage T.D.N.)[2]		(Lb.)	(4,526)	
	Oats silage		Ton	8.00	
	(Forage T.D.N.)[2]		(Lb.)	(2,218)	
	Lespedeza		Ton	1.25	
	(Forage T.D.N.)[3]		(Lb.)	(1,093)	
	Red clover and orchard grass		Ton	2.00	
	(Forage T.D.N.)[3]		(Lb.)	(1,840)	
	Total grain T.D.N.		Lb.	5,365	
	Total forage T.D.N.		Lb.	9,677	
Credit[4]	Grinding and mixing (grain in corn silage)	$0.300	Cwt.	66.98	-$20.09
Expenses:					
Seed	Corn	0.192	Lb.	24.00	4.61
	Rye	2.790	Bu.	1.50	4.18
	Oats	1.610	Bu.	2.50	4.02
	Lespedeza	0.163	Lb.	10.00	1.63
	Red clover	0.497	Lb.	6.00	2.98
	Orchard grass	0.368	Lb.	4.00	1.47
Inoculant	Red clover				0.25
Fertilizer[5]	Nitrogen		Lb.	275.00	
	P_2O_5		Lb.	232.00	
	K_2O		Lb.	366.00	

Table 8. (Continued)

Item	Description	Price	Unit	Quantity	Amount
Tractor operating cost					
Small tractor		0.404	Hour	12.09	4.88
Medium tractor		0.517	Hour	39.32	20.33
Equipment operating cost					17.08
Cover for silo[6/]		0.130	Ton	8.00	1.04
Net cost excluding fixed cost, fertilizer, land, labor, and management					$42.38

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Spreading manure	Spreader		6.50	6.50
Plowing for corn silage	2-14" bottom	2	2.80	2.80
Disking for corn silage	6' tandem	6	4.20	4.20
Planting corn silage	2-row planter with fertilizer att.	2	2.50	2.50
Cultivating corn silage	2-row cultivator	6	4.26	4.26
Harvesting and storing corn silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		20.40	15.30
Disking for rye cover crop	6' tandem	2	1.40	1.40
Seeding rye cover crop	13 x 7' grain drill	1	0.75	0.60
Disking for oats silage	6' tandem	3	2.10	2.10
Distributing fertilizer and seeding oats silage	13 x 7' grain drill	1	1.03	0.80
Seeding lespedeza-red clover-orchard grass	13 x 7 grain drill	1	0.80	0.60
Harvesting and storing oats silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		4.56	3.36

Table 8. (Continued)

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Mowing lespedeza	7' mower	1	0.50	0.50
Raking lespedeza	8' side delivery rake	1	0.40	0.40
Baling lespedeza	Pick-up baler, PTO	1	0.59	0.59
Hauling and storing lespedeza	Tractor, wagon and elevator		2.00	0.68
Mowing red clover-orchard grass	7' mower	2	1.00	1.00
Conditioning red clover-orchard grass	Hay conditioner	2	1.00	1.00
Raking red clover-orchard grass	8' side delivery rake	2	0.80	0.80
Baling red clover-orchard grass	Pick-up baler, PTO	2	0.94	0.94
Hauling and storing red clover-orchard grass	Tractor, wagon and elevator		3.20	1.08
Total for rotation			61.73	51.41

Seasonal Labor Requirements

Period	Man-hours
March-June	21.17
July-October	34.06
November-February	6.50

Table 8. (Continued)

1/ Two years corn silage, one year oats silage and lespedeza and one year red clover-orchard grass hay.

2/ In calculating the pounds of T.D.N., it is assumed that 90 percent of the silage produced is available for consumption by the dairy animals. The remaining 10 percent is not available as a result of spoilage in storage and waste during harvesting and feeding.

3/ In calculating the pounds of T.D.N., it is assumed that 92 percent of the hay produced is available for consumption by the dairy animals. The remaining eight percent is not available as a result of loss during harvest and waste during feeding.

4/ The dairy budgets include a cost of 30 cents per hundred-weight for grinding and mixing grain based on the total grain T.D.N. requirement. Since part of the total grain T.D.N. requirement in each dairy budget can be obtained from the grain included in corn silage and does not require grinding and mixing, it is necessary to credit the grain from this source to offset that proportion of the grinding and mixing cost included in the dairy budgets. The quantity figure is in terms of corn equivalent.

5/ Includes both nine tons cow manure per acre (typical application) and commercial fertilizer on all crops in the rotation.

6/ Assuming the oats silage will be stored in a horizontal silo. No estimated cost is made in this category for corn silage since it is assumed the corn silage will be stored in a permanent-type upright silo.

Table 9. Enterprise Budget for Seven Years Corn Silage-Oats and Vetch Silage-Alfalfa Hay Rotation on Land B (Activity P_{33})[1]

Item	Description	Price	Unit	Quantity	Amount
Income:					
Yield	Corn silage		Ton	15.00	
	(Grain T.D.N.)[2]		(Lb.)	(2,683)	
	(Forage T.D.N.)[2]		(Lb.)	(2,263)	
	Oats and vetch silage[3]		Ton	8.00	
	(Forage T.D.N.)[2]		(Lb.)	(2,218)	
	Alfalfa hay		Ton	17.50	
	(Forage T.D.N.)[4]		(Lb.)	(16,197)	
	Total grain T.D.N.		Lb.	2,683	
	Total forage T.D.N.		Lb.	20,678	
Credit[5]	Grinding and mixing (grain in corn silage)	$0.300	Cwt.	33.50	-$10.05
Expenses:					
Seed	Corn	0.192	Lb.	12.00	2.30
	Oats	1.610	Bu.	2.00	3.22
	Vetch	0.182	Lb.	10.00	1.82
	Alfalfa	0.485	Lb.	25.00	12.12
Inoculant	Vetch				0.20
	Alfalfa				0.25
Lime	Ground limestone	5.580	Ton	2.00	11.16
	Custom spreading	1.000	Acre	1.00	1.00
Fertilizer[6]	Nitrogen		Lb.	150.00	
	P_2O_5		Lb.	673.00	
	K_2O		Lb.	862.00	

Table 9. (Continued)

Item	Description	Price	Unit	Quantity	Amount
Tractor operating cost					
Small tractor		0.404	Hour	23.35	9.43
Medium tractor		0.517	Hour	46.36	23.97
Equipment operating cost					26.51
Cover for silo[7/]	Oats and vetch	0.130	Ton	8.00	1.04
Net cost excluding fixed cost, fertilizer, land, labor and management					$82.97

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Spreading manure	Spreader		3.25	3.25
Plowing for corn silage	2-14" bottom	1	1.40	1.40
Disking for corn silage	6' tandem	3	2.10	2.10
Planting corn silage	2-row planter with fertilizer att.	1	1.25	1.25
Cultivating corn silage	2-row cultivator	3	2.13	2.13
Harvesting and storing corn silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		10.20	7.65
Disking for oats and vetch	6' tandem	3	2.10	2.10
Distributing fertilizer and seeding oats and vetch	13 x 7' grain drill	1	1.03	0.80
Harvesting and storing oats and vetch silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		4.56	3.36
Plowing for alfalfa	2-14" bottom	1	1.40	1.40
Disking for alfalfa	6' tandem	3	2.10	2.10
Distributing fertilizer	Lime spreader	1	0.80	0.50
Seeding (and inoculating) alfalfa	13 x 7' grain drill	1	0.80	0.60

Table 9. (Continued)

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Cultipacking alfalfa	Cultipacker	1	0.40	0.40
Topdressing alfalfa[8/]	Lime spreader	4	3.20	2.00
Mowing alfalfa	7' mower	15	7.50	7.50
Conditioning alfalfa	Hay conditioner	15	7.50	7.50
Raking alfalfa	8' side delivery rake	15	6.00	6.00
Baling alfalfa	Pick-up baler, PTO	15	8.22	8.22
Hauling and storing alfalfa	Tractor, wagon and elevator		28.00	9.45
Total for rotation			93.94	69.71

Seasonal Labor Requirements

Period	Man-hours
March-June	29.80
July-October	57.69
November-February	6.45

Table 9. (Continued)

1/ One year corn silage, one year oats and vetch silage and five years alfalfa hay.

2/ In calculating the pounds of T.D.N., it is assumed that 90 percent of the silage produced is available for consumption by the dairy animals. The remaining 10 percent is not available as a result of spoilage in storage and waste during harvesting and feeding.

3/ The same physical yield or yield in terms of T.D.N. is expected from the oats and vetch mixture as would be expected if oats alone were used. The protein content, however, would be greater with the oats and vetch mixture.

4/ In calculating the pounds of T.D.N., it is assumed that 92 percent of the hay produced is available for consumption by the dairy animals. The remaining eight percent is not available as a result of loss during harvest and waste during feeding.

5/ The dairy budgets include a cost of 30 cents per hundred-weight for grinding and mixing grain based on the total grain T.D.N. requirement. Since a part of the total grain T.D.N. requirement in each dairy budget can be obtained from the grain included in corn silage and does not require grinding and mixing it is necessary to credit the grain from this source to offset that proportion of the grinding and mixing cost included in the dairy budgets. The quantity figure is in terms of corn equivalent.

6/ Includes both nine tons cow manure per acre (typical application) and commercial fertilizer on all crops in the rotation.

7/ Assuming the oats and vetch silage will be stored in a horizontal silo. No estimated cost is made in this category for corn silage since it is assumed the corn silage will be stored in a permanent-type upright silo.

8/ Assuming the alfalfa will not be topdressed after the last cutting year in the rotation.

Table 10. Enterprise Budget for Six Years Corn Silage-Barley-Alfalfa and Orchard Grass Silage-Hay Rotation on Land B (Activity P_{34})[1]

Item	Description	Price	Unit	Quantity	Amount
Income:					
Yield	Corn silage		Ton	15.00	
	(Grain T.D.N.)[2]		(Lb.)	(2,683)	
	(Forage T.D.N.)[2]		(Lb.)	(2,263)	
	Barley		Bu.	40.00	
	(Grain T.D.N.)		(Lb.)	(1,492)	
	Straw	$15.000	Ton	1.00	-$15.00
	Alfalfa-orchard grass silage		Ton	30.00	
	(Forage T.D.N.)[2]		(Lb.)	(9,180)	
	Alfalfa-orchard grass hay		Ton	7.00	
	(Forage T.D.N.)[3]		(Lb.)	(6,028)	
	Total grain T.D.N.		Lb.	4,175	
	Total forage T.D.N.		Lb.	17,471	
Credit[4]	Grinding and mixing (grain in corn silage)	0.300	Cwt.	33.50	- 10.05
Expenses:					
Seed	Corn	0.192	Lb.	12.00	2.30
	Barley	2.065	Bu.	1.50	3.10
	Alfalfa	0.485	Lb.	20.00	9.70
	Orchard grass	0.368	Lb.	4.00	1.47
Inoculant					0.25
Lime	Ground limestone	5.580	Ton	2.00	11.16
	Custom spreading	1.000	Acre	1.00	1.00
Fertilizer[5]	Nitrogen		Lb.	150.00	
	P_2O_5		Lb.	575.00	
	K_2O		Lb.	721.00	
Harvesting barley	Custom	5.000	Acre	1.00	5.00

Table 10. (Continued)

Item	Description	Price	Unit	Quantity	Amount
Tractor operating cost					
Small tractor		0.404	Hour	22.00	8.89
Medium tractor		0.517	Hour	41.52	21.47
Equipment operating cost					26.08
Cover for silo[6]	Alfalfa-orchard grass silage	0.130	Ton	30.00	3.90
Net cost excluding fixed cost, fertilizer, land, labor and management					$69.27

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Spreading manure	Spreader		3.25	3.25
Plowing for corn silage	2-14" bottom	1	1.40	1.40
Disking for corn silage	6' tandem	3	2.10	2.10
Planting corn	2-row planter with fertilizer att.	1	1.25	1.25
Cultivating corn silage	2-row cultivator	3	2.13	2.13
Harvesting and storing corn silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		10.20	7.65
Disking for barley	6' tandem	3	2.10	2.10
Distributing fertilizer and seeding barley	13 x 7' grain drill	1	1.03	0.80
Hauling and storing barley	Tractor and wagon		1.11	0.56
Raking straw	8' side delivery rake	1	0.40	0.40
Baling straw	Pick-up baler, PTO	1	0.47	0.47
Hauling and storing straw	Tractor, wagon and elevator		1.60	0.54
Disking for alfalfa-orchard grass	6' tandem	4	2.80	2.80
Distributing fertilizer	Lime spreader	1	0.80	0.50

Table 10. (Continued)

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Man	Tractor
Seeding (and inoculating) alfalfa-orchard grass	13 x 7' grain drill	1	0.80	0.60
Cultipacking alfalfa-orchard grass	Cultipacker	1	0.40	0.40
Topdressing alfalfa-orchard grass[7/]	Lime spreader	3	2.40	1.50
Harvesting and storing alfalfa-orchard grass silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		22.80	16.80
Mowing alfalfa-orchard grass hay	7' mower	8	4.00	4.00
Conditioning alfalfa-orchard grass hay	Hay conditioner	8	4.00	4.00
Raking alfalfa-orchard grass hay	8' side delivery rake	8	3.20	3.20
Baling alfalfa-orchard grass hay	Pick-up baler, PTO	8	3.29	3.29
Hauling and storing alfalfa-orchard grass hay	Tractor, wagon and elevator		11.20	3.78
Total for rotation			82.73	63.52

Seasonal Labor Requirements

Period	Man-hours
March-June	32.55
July-October	44.53
November-February	5.65

Table 10. (Continued)

1/ One year of corn silage, one year of barley and four years of alfalfa-orchard grass silage-hay. The first cutting of alfalfa-orchard grass is harvested for silage and the second and third cuttings are harvested for hay.

2/ In calculating the pounds of T.D.N., it is assumed that 90 percent of the silage produced is available for consumption by the dairy animals. The remaining 10 percent is not available as a result of spoilage in storage and waste during harvesting and feeding.

3/ In calculating the pounds of T.D.N., it is assumed that 92 percent of the hay produced is available for consumption by the dairy animals. The remaining eight percent is not available as a result of loss during harvest and waste during feeding.

4/ The dairy budgets include a cost of 30 cents per hundred-weight for grinding and mixing grain based on the total grain T.D.N. requirement. Since a part of the total grain T.D.N. requirement in each dairy budget can be obtained from the grain included in corn silage and does not require grinding and mixing, it is necessary to credit the grain from this source to offset that proportion of the grinding and mixing cost included in the dairy budgets. The quantity figure is in terms of corn equivalent.

5/ Includes both nine tons cow manure per acre (typical application) and commercial fertilizer on all crops in the rotation.

6/ Assuming the alfalfa-orchard grass silage will be stored in a horizontal silo.

7/ Assuming the alfalfa-orchard grass will not be topdressed after the last cutting year in the rotation.

Table 11. Enterprise Budget for Corn for Grain-Oats Silage Continuous Rotation on Land A (Activity P_{35})

Item	Description	Price	Unit	Quantity	Amount
Income:					
Yield	Corn		Bu.	75.00	
	(Grain T.D.N.)		(Lb.)	(3,364)	
	Oats silage		Ton	4.00	
	(Forage T.D.N.)[1]		(Lb.)	(1,109)	
	Total grain T.D.N.		Lb.	3,364	
	Total forage T.D.N.		Lb.	1,109	
Expenses:					
Seed	Corn	$0.192	Lb.	12.00	$ 2.30
	Oats	1.610	Bu.	2.50	4.02
Fertilizer[2]	Nitrogen		Lb.	150.00	
	P_2O_5		Lb.	141.00	
	K_2O		Lb.	208.00	
Harvesting corn	Custom	7.000	Acre	1.00	7.00
Tractor operating cost					
Small tractor		0.404	Hour	2.55	1.03
Medium tractor		0.517	Hour	14.15	7.32
Equipment operating cost					2.42
Cover for silo[3]	Oats silage	0.130	Ton	4.00	0.52
Total cost excluding fixed cost, fertilizer, land, labor and management					$24.61

Table 11. (Continued)

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Spreading manure	Spreader		3.25	3.25
Plowing for corn	2-14" bottom	1	1.40	1.40
Disking for corn	6' tandem	3	2.10	2.10
Planting corn	2-row planter with fertilizer att.	1	1.25	1.25
Cultivating corn	2-row cultivator	3	2.13	2.13
Hauling and storing corn	Tractor, wagon and elevator		1.89	1.43
Disking for oats silage	6' tandem	3	2.10	2.10
Distributing fertilizer and seeding oats	13 x 7' grain drill	1	1.03	0.80
Harvesting and storing oats silage	PTO forage harvester, 2 tractors, 2-ton truck, wagon and blower		3.04	2.24
Total for rotation			18.19	16.70

Seasonal Labor Requirements

Period	Man-hours
March-June	12.46
July-October	5.73
November-February	

1/ In calculating the pounds of T.D.N., it is assumed that 90 percent of the silage produced is available for consumption by the dairy animals. The remaining 10 percent is not available as a result of spoilage in storage and waste during harvesting and feeding.

2/ Includes both nine tons of cow manure per acre (typical application) and commercial fertilizer on all crops in the rotation.

3/ Assuming the oats silage will be stored in a horizontal silo.

Table 12. Enterprise Budget for Corn for Grain-Cover Crop Continuous Rotation on Land A (Activity P_{36})

Item	Description	Price	Unit	Quantity	Amount
Income:					
Yield	Corn		Bu.	75.00	
	(Grain T.D.N.)		(Lb.)	(3,364)	
Expenses:					
Seed	Corn	$0.192	Lb.	12.00	$ 2.30
	Rye	2.790	Bu.	1.50	4.18
Fertilizer[1/]	Nitrogen		Lb.	125.00	
	P_2O_5		Lb.	91.00	
	K_2O		Lb.	158.00	
Harvesting corn	Custom	7.000	Acre	1.00	7.00
Tractor operating cost					
Small tractor		0.404	Hour	1.43	0.58
Medium tractor		0.517	Hour	12.13	6.27
Equipment operating cost					0.88
Total cost excluding fixed cost, fertilizer, land, labor and management					$21.21

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Spreading manure	Spreader		3.25	3.25
Plowing for corn	2-14" bottom	1	1.40	1.40
Disking for corn	6' tandem	3	2.10	2.10
Planting corn	2-row planter with fertilizer att.	1	1.25	1.25
Cultivating corn	2-row cultivator	3	2.13	2.13

Table 12. (Continued)

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Hauling and storing corn	Tractor, wagon and elevator		1.89	1.43
Disking for rye cover crop	6' tandem	2	1.40	1.40
Seeding rye cover crop	13 x 7' grain drill	1	0.75	0.60
Total for rotation			14.17	13.56

Seasonal Labor Requirements

Period	Man-hours
March-June	9.42
July-October	4.75
November-February	

1/ Includes both nine tons of cow manure per acre (typical application) and commercial fertilizer.

Table 13. Enterprise Budget for Six Years Millet-Ladino Clover and Orchard Grass Pasture Rotation on Land B (Activity P_{37})[1/]

Item	Description	Price	Unit	Quantity	Amount
Income:					
Pasture (millet)	Hay equivalent (air dry hay)		Lb.	7,800	
	(Forage T.D.N.)[2/]		(Lb.)	(2,748)	
Pasture (ladino clover-orchard grass)	Hay equivalent (air dry hay)		Lb.	21,070	
	(Forage T.D.N.)[2/]		(Lb.)	(7,888)	
	Total forage T.D.N.		Lb.	10,636	
Expenses:					
Seed	Millet	$0.100	Lb.	30.00	$ 3.00
	Ladino clover	1.331	Lb.	2.00	2.66
	Orchard grass	0.368	Lb.	10.00	3.68
Inoculant	Ladino clover				0.25
Lime	Ground limestone	5.580	Ton	2.00	11.16
	Custom spreading	1.000	Acre	1.00	1.00
Fertilizer	Nitrogen		Lb.	86.00	
	P_2O_5		Lb.	216.00	
	K_2O		Lb.	216.00	
Tractor operating cost					
Small tractor		0.404	Hour	0.90	0.36
Medium tractor		0.517	Hour	14.70	7.60
Equipment operating cost					2.27
Total cost excluding fixed cost, fertilizer, land, labor and management					$31.98

Table 13. (Continued)

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Plowing for millet	2-14" bottom	1	1.40	1.40
Disking for millet	6' tandem	3	2.10	2.10
Distributing fertilizer and seeding millet	13 x 7' grain drill	1	1.03	0.80
Disking for ladino clover-orchard grass	6' tandem	4	2.80	2.80
Distributing fertilizer	Lime spreader	1	0.80	0.50
Seeding (and inoculation) ladino clover-orchard grass	13 x 7' grain drill	1	0.80	0.60
Cultipacking	Cultipacker	1	0.40	0.40
Topdressing ladino clover-orchard grass 3/	Lime spreader	4	3.20	2.00
Clipping weeds	7' mower	10	5.00	5.00
Total for rotation			17.53	15.60

Seasonal Labor Requirements

Period	Man-hours
March-June	4.53
July-October	9.80
November-February	3.20

1/ One year millet pasture and five years ladino clover-orchard grass pasture.

2/ In calculating the pounds of T.D.N., it is assumed, in the case of both the millet and ladino clover-orchard grass, that 65 percent of the hay equivalent produced is available for consumption by the dairy animals grazing these pasture crops. The remaining 35 percent is not available as a result of trampling and unevenness of pasture growth.

3/ Assuming the ladino clover-orchard grass pasture will not be topdressed after the last grazing year in the rotation.

Table 14. Enterprise Budget for Bluegrass-White Clover Continuous Pasture on Land C (Activity P_{38})

Item	Description	Price	Unit	Quantity	Amount
Income:					
Pasture	Hay equivalent (air dry hay)		Lb.	2,700	
	Total forage T.D.N.[1]		Lb.	1,085	
Expenses:					
Establishment					
Seed	Kentucky bluegrass	$0.924	Lb.	6.00	$ 5.54
	Orchard grass	0.368	Lb.	6.00	2.21
	Timothy	0.234	Lb.	2.00	0.47
	White clover	1.028	Lb.	2.00	2.06
	Red clover	0.497	Lb.	2.00	0.99
Inoculant	White clover and red clover				0.25
Lime	Ground limestone	5.580	Ton	2.00	11.16
	Custom spreading	1.000	Acre	1.00	1.00
Fertilizer	Nitrogen		Lb.	16.00	
	P_2O_5		Lb.	96.00	
	K_2O		Lb.	96.00	
Prorated fertilizer	Nitrogen		Lb.	0.53	
	P_2O_5		Lb.	3.20	
	K_2O		Lb.	3.20	
Tractor operating cost					
Small tractor		0.404	Hour	0.90	0.36
Medium tractor		0.517	Hour	2.70	1.40
Equipment operating cost					0.34
Total establishment cost					$25.78

Table 14. (Continued)

Item	Description	Price	Unit	Quantity	Amount
Maintenance					
Fertilizer	Nitrogen		Lb.		
	P_2O_5		Lb.	170.00	
	K_2O		Lb.	85.00	
Prorated fertilizer[2]	Nitrogen		Lb.		
	P_2O_5		Lb.	56.67	
	K_2O		Lb.	28.33	
Lime	Ground limestone	5.580	Ton	2.00	11.16
	Custom spreading	1.000	Acre	1.00	1.00
Total lime cost					$12.16
Tractor operating cost					
Medium tractor		0.517	Hour	1.50	0.78
Equipment operating cost					0.35
Total tractor and equipment operating cost for maintenance					$ 1.13
Prorated establishment cost (expected life of 30 years)[3]					0.86
Prorated maintenance lime cost[4]					2.43
Prorated tractor and equipment operating cost for maintenance[5]					0.86
Total prorated cost excluding fixed cost, fertilizer, land, labor and management					$ 4.15

Table 14. (Continued)

Average Labor and Equipment Inputs

Operation	Type of equipment	No. times	Hours Man	Hours Tractor
Establishment:				
Disking	6' tandem	3	2.10	2.10
Distributing fertilizer	Lime spreader	1	0.80	0.50
Seeding (and inoculation)	13 x 7' grain drill	1	0.80	0.60
Cultipacking	Cultipacker	1	0.40	0.40
Maintenance:				
Topdressing	Lime spreader	1	0.80	0.50
Clipping weeds	7' mower	2	1.00	1.00
Total for one acre			5.90	5.10

Seasonal Labor Requirements[6/]

Period	Man-hours
March-June	
July-October	1.14
November-February	0.27

Table 14. (Continued)

1/ In calculating the pounds of T.D.N., it is assumed that 65 percent of the hay equivalent produced is available for consumption by the dairy animals grazing this pasture. The remaining 35 percent is not available as a result of trampling and unevenness of pasture growth.

2/ Assuming this pasture is topdressed once every three years.

3/ In the area included in this study, this type of pasture would last an indefinite period, however, for the purpose of this budget, an expected life of 30 years is assumed.

4/ Assuming this pasture is limed once every five years.

5/ The prorated tractor and equipment cost for maintenance was calculated on the assumption that this pasture is topdressed once every three years and clipped two times annually for weeds.

6/ Based on prorating the labor requirements for establishment over the 30 years expected life of the stand, prorating the labor requirements for topdressing over three years, and the labor requirements for clipping weeds twice each year.

APPENDIX E

Matrix Used in Basic Solutions

Code to Crop Rotation Activities

P_{27} (2 year rotation) - Corn for grain (1 yr.), barley, lespedeza hay (1 yr.)

P_{28} (continuous) - Corn silage, oats silage

P_{29} (7 year rotation) - Corn silage (3 yrs.), alfalfa hay (4 yrs.)

P_{30} (6 year rotation) - Corn silage (1 yr.), barley (1 yr.), alfalfa-orchard grass hay (4 yrs.)

P_{31} (6 year rotation) - Corn silage (1 yr.), oats silage, corn silage (1 yr.), alfalfa-orchard grass hay (4 yrs.)

P_{32} (4 year rotation) - Corn silage (2 yrs.), oats silage, lespedeza hay (1 yr.), red clover-orchard grass hay (1 yr.)

P_{33} (7 year rotation) - Corn silage (1 yr.), oats and vetch silage (1 yr.), alfalfa hay (5 yrs.)

P_{34} (6 year rotation) - Corn silage (1 yr.), barley (1 yr.), alfalfa-orchard grass silage-hay (4 yrs.)[1/]

P_{35} (continuous) - Corn for grain, oats silage

P_{36} (continuous) - Corn for grain, cover crop

P_{37} (6 year rotation) - Millet pasture (1 yr.), ladino clover-orchard grass pasture (5 yrs.)

P_{38} (continuous) - Bluegrass-white clover pasture

1/ The first cutting of alfalfa-orchard grass is harvested for silage and the second and third cuttings are harvested for hay.

Table 1. Matrix Used in Basic Solutions

	Resources	Unit	Amount	Disposal activities P_1 - P_{22}	Gainful activities: Dairy (11,000 lbs.) 75:25[1] P_{23}	Dairy (11,000 lbs.) 55:45[2] P_{24}	Dairy (11,000 lbs.) 35:65[3] P_{25}
P_1	Continuous row-cropland (A)	Ac.	44.3	1.0			
P_2	Rotated cropland (A + B)	Ac.	142.8				
P_3	Total open land (A + B + C)	Ac.	185.8				
P_4	Labor (March-June)	Hr.	2,608.0		35.20	35.20	35.20
P_5	Labor (July-October)	Hr.	2,660.0		34.20	34.20	34.20
P_6	Labor (November-February)	Hr.	2,416.0		45.60	45.60	45.60
P_7	Total grain (T.D.N.)	Lb.	0		2,044.00	3,279.00	4,497.00
P_8	Sell corn restriction (T.D.N.)	Lb.	0				
P_9	Hay (T.D.N.)	Lb.	0		305.71	305.71	305.71
P_{10}	Corn silage (T.D.N.)	Lb.	0		2,019.12	2,312.71	2,312.71
P_{11}	Grass silage (T.D.N.)	Lb.	0		3,951.18	1,488.59	
P_{12}	Pasture (T.D.N.)	Lb.	0		2,400.00	2,400.00	2,111.59
P_{13}	Milk sales restriction	Cwt.	4,420.0		106.50	106.50	106.50
P_{14}	Milk sales	Cwt.	0		-106.50	-106.50	-106.50
P_{15}	Storage space for hay	Ton	600.4				
P_{16}	Summer forage (T.D.N.)	Lb.	0		3,565.41	2,674.06	1,943.76
P_{17}	Maximum fall silage space	Ton	206.0				
P_{18}	Winter forage (T.D.N.)	Lb.	0		5,110.59	3,832.94	2,786.24
P_{19}	Nitrogen	Lb.	0		-159.60	-159.60	-159.60
P_{20}	Phosphorus	Lb.	0		- 61.60	- 61.60	- 61.60
P_{21}	Potash	Lb.	0		-175.00	-175.00	-175.00
P_{22}	Net return to fixed factors	Dol.	0	1.0	31.26[5]	26.63[5]	22.07[5]

Table 1. (Continued)

Resources	Unit	Amount	Gainful activities: Dairy (11,000 lbs.) 15:85 [4] P_{26}	C-B-L rotation P_{27}	CS-OS rotation P_{28}	CS-A rotation P_{29}	CS-B-AOG rotation P_{30}	CS-OSCS-AOG rotation P_{31}	CS-OSL-RCOG rotation P_{32}
P_1	Ac.	44.3			1.00				
P_2	Ac.	142.8		1.00	1.00	1.00	1.00	1.00	1.00
P_3	Ac.	185.8		1.00	1.00	1.00	1.00	1.00	1.00
P_4	Hr.	2,608.0	35.20	4.88	12.46	4.82	4.17	5.36	5.29
P_5	Hr.	2,660.0	34.20	4.44	14.04	10.44	8.23	9.76	8.52
P_6	Hr.	2,416.0	45.60	2.00		1.27	0.94	0.94	1.62
P_7	Lb.	0	5,764.00	-2,114.00	-2,683.00	-1,149.71	-695.83	-819.67	-1,341.25
P_8	Lb.	0		-2,114.00			-248.67		
P_9	Lb.	0	305.71	-546.50		-1,851.00	-2,009.33	-2,009.33	-733.25
P_{10}	Lb.	0	2,312.71		-2,263.00	-969.71	-377.17	-691.50	-1,131.50
P_{11}	Lb.	0			-1,109.00			-277.17	-554.50
P_{12}	Lb.	0	479.59						
P_{13}	Cwt.	4,420.0	106.50						
P_{14}	Cwt.	0	-106.50						
P_{15}	Ton	600.4		0.62		2.00	2.33	2.33	0.81
P_{16}	Lb.	0	1,273.12						
P_{17}	Ton	206.0			19.00	6.43	2.50	5.58	9.50
P_{18}	Lb.	0	1,824.88	-546.50	-3,372.00	-2,820.71	-2,386.50	-2,978.00	-2,419.25
P_{19}	Lb.	0	-159.60	73.00	150.00	42.57	25.00	33.00	68.75
P_{20}	Lb.	0	-61.60	71.50	141.00	97.29	95.83	105.00	58.00
P_{21}	Lb.	0	-175.00	106.00	208.00	126.57	120.17	129.67	91.50
P_{22}	Dol.	0	17.32 [5]	-9.33	-15.38	-12.28	-9.84	-12.96	-10.60

Table 1. (Continued)

Resources	Unit	Amount	Gainful activities					
			CS-OV-A rotation P_{33}	CS-B-AOG rotation P_{34}	CG-OS rotation P_{35}	CG (cont.) rotation P_{36}	M-LCOG rotation P_{37}	B-W-C pasture P_{38}
P_1	Ac.	44.3			1.00	1.00		
P_2	Ac.	142.8	1.00	1.00	1.00	1.00	1.00	
P_3	Ac.	185.8	1.00	1.00	1.00	1.00	1.00	1.00
P_4	Hr.	2,608.0	4.26	5.42	12.46	9.42	0.76	
P_5	Hr.	2,660.0	8.24	7.42	5.73	4.75	1.63	1.14
P_6	Hr.	2,416.0	0.92	0.94			0.53	0.27
P_7	Lb.	0	-383.29	-695.83	-3,364.00	-3,364.00		
P_8	Lb.	0		-248.67	-3,364.00	-3,364.00		
P_9	Lb.	0	-2,313.86	-1,004.67				
P_{10}	Lb.	0	-323.29	-377.17				
P_{11}	Lb.	0	-316.86	-1,530.00	-1,109.00			
P_{12}	Lb.	0					-1,772.67	-1,085.00
P_{13}	Cwt.	4,420.0						
P_{14}	Cwt.	0						
P_{15}	Ton	600.4	2.50	1.17				
P_{16}	Lb.	0					-1,772.67	-1,085.00
P_{17}	Ton	206.0	3.29	7.50	4.00			
P_{18}	Lb.	0	-2,954.00	-2,911.83	-1,109.00			
P_{19}	Lb.	0	21.43	25.00	150.00	125.00	14.33	0.53
P_{20}	Lb.	0	96.14	95.83	141.00	91.00	36.00	59.87
P_{21}	Lb.	0	123.14	120.17	208.00	158.00	36.00	31.53
P_{22}	Dol.	0	-11.85	-11.54	-24.60	-21.21	-5.33	-4.15

Table 1. (Continued)

Resources	Unit	Amount	Transfer activities: Hay for gr. sil. P_{39}	Gr. sil. for corn sil. P_{40}	Gr. sil. to summer P_{41}	Hay to summer P_{42}	Corn sil. to summer P_{43}
P_1	Ac.	44.3					
P_2	Ac.	142.8					
P_3	Ac.	185.8					
P_4	Hr.	2,608.0					
P_5	Hr.	2,660.0					
P_6	Hr.	2,416.0					
P_7	Lb.	0					
P_8	Lb.	0					
P_9	Lb.	0	100.00			100.00	
P_{10}	Lb.	0		-100.00			100.00
P_{11}	Lb.	0	-100.00	100.00	100.00		
P_{12}	Lb.	0			-100.00	-100.00	-100.00
P_{13}	Cwt.	4,420.0					
P_{14}	Cwt.	0					
P_{15}	Ton	600.4					
P_{16}	Lb.	0			-100.00	-100.00	-100.00
P_{17}	Ton	206.0			-0.35		
P_{18}	Lb.	0			100.00	100.00	100.00
P_{19}	Lb.	0					
P_{20}	Lb.	0					
P_{21}	Lb.	0					
P_{22}	Dol.	0					

Table 1. (Continued)

Resources	Unit	Amount	Buying and selling activities: Sell milk P_{44}	Buy corn P_{45}	Sell corn P_{46}	Buy hay P_{47}	Sell hay P_{48}	Buy sil. space P_{49}	Buy nitrogen P_{50}	Buy phosphorus P_{51}	Buy potash P_{52}
P_1	Ac.	44.3									
P_2	Ac.	142.8									
P_3	Ac.	185.8									
P_4	Hr.	2,608.0									
P_5	Hr.	2,660.0									
P_6	Hr.	2,416.0									
P_7	Lb.	0		-100.00	100.00						
P_8	Lb.	0			100.00						
P_9	Lb.	0				-100.00	100.00				
P_{10}	Lb.	0									
P_{11}	Lb.	0									
P_{12}	Lb.	0									
P_{13}	Cwt.	4,420.0									
P_{14}	Cwt.	0	100.00								
P_{15}	Ton	600.4									
P_{16}	Lb.	0									
P_{17}	Ton	206.0						-500.00			
P_{18}	Lb.	0				-100.00	100.00				
P_{19}	Lb.	0							-100.00		
P_{20}	Lb.	0								-100.00	
P_{21}	Lb.	0									-100.00
P_{22}	Dol.	0	473.00[6]	-3.14	2.92	-4.57	2.80	-400.00	-12.97	-7.38	-5.14

Table 1. (Continued)

1/ The coefficients in this column apply to 11,000 pounds production per cow, including replacements per cow, for a 75:25 forage-to-grain feeding ratio to milk cows.

The row changes in these coefficients to apply to 9,000 pounds production per cow, including replacements per cow, for a 75:25 forage-to-grain feeding ratio to milk cows were:

P_7	1,734.00	P_{11}	2,668.53	P_{14}	-85.60	P_{18}	4,269.94
P_{10}	1,874.76	P_{13}	86.50	P_{16}	2,979.06	P_{22}	24.62

2/ The coefficients in this column apply to 11,000 pounds production per cow, including replacements per cow, for a 55:45 forage-to-grain feeding ratio to milk cows.

The row changes in these coefficients to apply to 9,000 pounds production per cow and 13,000 pounds production per cow, including replacements per cow, for a 55:45 forage-to-grain feeding ratio to milk cows were:

9,000 pounds per cow				13,000 pounds per cow			
P_7	2,782.00	P_{16}	2,319.88	P_7	4,106.00	P_{16}	3,229.71
P_{11}	626.59	P_{18}	3,325.12	P_{11}	2,840.59	P_{18}	4,629.29
P_{13}	86.50	P_{22}	20.70	P_{13}	126.50	P_{22}	31.34
P_{14}	-86.50			P_{14}	-126.50		

3/ The coefficients in this column apply to 11,000 pounds production per cow, including replacements per cow, for a 35:65 forage-to-grain feeding ratio to milk cows.

The row changes in these coefficients to apply to 9,000 pounds production per cow and 13,000 pounds production per cow, including replacements per cow, for a 35:65 forage-to-grain feeding ratio to milk cows were:

9,000 pounds per cow				13,000 pounds per cow			
P_7	3,809.00	P_{16}	1,735.88	P_7	5,515.00	P_{14}	-126.50
P_{12}	1,605.59	P_{18}	2,488.12	P_{11}	432.59	P_{16}	2,240.12
P_{13}	86.50	P_{22}	16.85	P_{12}	2,400.00	P_{18}	3,210.88
P_{14}	-86.50			P_{13}	126.50	P_{22}	26.06

4/ The coefficients in this column apply to 11,000 pounds production per cow, including replacements per cow, for a 15:85 forage-to-grain feeding ratio to milk cows.

The row changes in these coefficients to apply to 13,000 pounds production per cow, including replacements per cow, for a 15:85 forage-to-grain feeding ratio to milk cows were:

P_7	7,157.00	P_{13}	126.50	P_{16}	1,403.82	P_{22}	19.92
P_{12}	797.59	P_{14}	-126.50	P_{18}	2,012.18		

Table 1. (Continued)

5/ Receipts from cull cows and replacements, and $1.00 per hundred-weight for milk less all expenses excluding fixed costs, farm produced feed, labor and management.

6/ One dollar per hundred-weight of the blend price for milk ($5.73 per hundred-weight) was included in the net revenue row of the dairy activity columns.

ABSTRACT

The dairyman has various resources, some of which are limited in quantity, that may be used to produce milk. Alternative forage and grain crops can be produced for feed or sale. A typical grade A dairy farm was selected in the Roanoke-Franklin-Henry-County area of Virginia to determine the forage-to-grain feeding ratio and forage and grain production system that would maximize returns to fixed resources.

Budgets were prepared for individual forage-to-grain ratios at three levels of milk production per cow and for various crop rotations adaptable to the typical farm. Linear programming was used to determine an optimum feeding and cropping plan at each level of production per cow.

With the present milk blend price, an optimum feed ration at each level of production per cow contained a high proportion of grain relative to forage. It was more profitable to produce less than the present milk sales restriction and sell corn and hay at the lower production rate, whereas, it was more profitable to produce up to the present milk sales restriction and sell any excess corn and hay at the two higher production rates.

With the present milk blend price, there was some latitude in the selection of an optimum feeding and cropping plan for the lower production rates before greatly reducing net return to fixed factors. This was not true for the higher production rate.

As the price was reduced from the present milk blend price, the lower production rates gained in profitability relative to the higher production rates.