# MILK PRODUCTION RESPONSE OF DAIRY COWS TO CONCENTRATE IN COLOMBIA*

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## OBJECTIVES.

The data presented in this paper were collected as a part of a broader study titled "Factors that affect the Efficiency of the Utilization of Concentrates on Commercial Dairy Farms in Antioquia, Colombia". The primary objective of the study was to determinate the quantitative relationship between concentrate consumption and milk production as affected by the quantity and quality of forage supplied and the quality of the herd. A secondary objective was to describe the management practices employed on the farms that supply milk to the city of Medellin.

The study was interdisciplinary and interinstitutional. It was interdisciplinary in that economists, animal scientists and agronomists participated actively in the planning and conduct of the study. It was interinstitutional in that 4 organizations made staff and/or budget contributions to the study.

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The organizations were the Nebraska Mission in Colombia, The Office of the Secretary of Agriculture of Antioquia, The Colombian Agricultural Institute and The National University in Medellin.

SOURCES OF DATA.

The data were collected between March and December 1971. Only farms situated in the "Cold Climate" (that is above 6500 feet in elevation) were included in order to reduce the climatic variation. Complete data were secured on 131 herds, 61 in an area East of Medellin and 70 in an area North of Medellin. About 20 observations were later discarded because of obvious errors in the data.

The research team was composed of 3 members with the following functions:

A.- An Animal Scientist-Specialist in Dairy Judging.

The animal scientist classified the herd on a 10 point scale based on the estimated ability to convert feed to milk. Notes were also made on the breed, size, condition, type and other attributes that would affect milk production (1).

(1) L.C. Garrison (Nebraska Mission) was the principal judge. He was assisted by H. Olarte (National University).

B.- An Agronomist-Specialist in Forage Production.

The agronomist classified the pastures on a 10 point scale based on the estimated adequacy of the forage supply for milk production. Measurements were made on the maximum, minimum and average height of the grass in the pasture accupied at the time of the visit and the pasture to be used next in the rotation system. Notes were also made on dominant species, weed infestation, disease, color and other relevant characteristics.

Where green chop was used, a sample ration was weighed and rated as to quality (2).

C.- An Interviewer.

Either the owner or manager of the farm was interviewed in order to secure data on the management practices employed on the farm. Primary emphasis was given to the type and amount of concentrate fed to the milk cows and the amount of milk produced (3).

(2) Dr. Gary Jolliff (Nebraska Mission) rated the pastures for the first area; G. Angel (Secretary of Agriculture, Antioquia) rated the pastures for the second area.

(3) Most of the interviews were conducted by G. Garcia (Secretary of Agriculture, Antioquia) assisted by other staff members from his office and J. Suescun (Colombian Agricultural Institute).

METHODS.

Sampling Methods:

In the first area the farms were selected on the basis of the known or estimated average milk production per cow per year. The farms were divided into low producers (less than 3000 kgs.), average producers (3000 - 4500 kgs.) and high producers (more than 4500 kgs.). Twenty observations were desired in each group.

When the herds and forage supply had been classified the following distribution resulted.

| | Supply of Forage | | | |
|---|---|---|---|---|
| Cow quality | Poor | Average | Good | Total |
| | Number of farms | | | |
| Good and very good (6 - 7 - 8 - 9) | 0 | 3 | 12 | 15 |
| Average (4 - 5) | 2 | 7 | 14 | 23 |
| Poor (1 - 2 - 3) | 6 | 10 | 7 | 23 |
| Total | 8 | 20 | 33 | 61 |

Since the number and distribution of the observations, at this time, seemed inadequate for the type of analysis to be performed the decision was made to continue securing observations but to secure these observation in an area North of Medellin. The goal was set of securing from 15 to 20 observations in each of the 9 possible combinations of cow quality and forage quality.

By December, when 131 farms had been visited, the distribution was as follows:

| | Supply of Forage | | | |
|---|---|---|---|---|
| Cow quality | Poor | Average | Good | Total |
| | Number of Farms | | | |
| Good and very good (6 - 7 - 8 - 9) | 2 | 11 | 15 | 28 |
| Average (4 - 5) | 17 | 18 | 19 | 54 |
| Poor (1 - 2 - 3) | 20 | 18 | 11 | 49 |
| Total | 39 | 47 | 45 | 131 |

As should have been anticipated, it was impossible to find 15 farms that combined the two extremes of cow quality and forage quality; that is good cows on poor forage and poor cows on good forage. Only 11 observations were secured where good cows were supplied average forage. With these 3 exceptions, all of the 9 possible combinations were represented by 15 or more observations.

LIMITATIONS OF DATA.

Data secured by the method outlined above have certain limitations which should be recognized. Among them are the following:

1.- All data relate to herd averages.

Milk production functions are most often derived from data generated by the performance of individual cows under experimental conditions. Data used in this study are averages generated by the performance of a herd of cows. In some herds the cows were fed concentrate according to production; in others they were not. Although it is reasonable to assume that feed would be used more efficiently under the former system than the latter, it was not possible to separate the data generated under the two systems of management.

2.- Data were based on recall information.

An attempt was made to secure the total milk production and total concentrate fed during the last year. Herd composition was secured by asking the average number of cows in milk, cows dry, heifers and calves maintained in the herd during the last year. In the absence of good production and feeding records supplying this information required an accurate recall of up to one year. There was a tendency to report the current situation in terms of herd composition, feeding practices and milk production which were then converted to a yearly average basis. In so far as the situation at the time of the interview was atypical of the yearly averages, an error was introduced.

3.- Problems of Aggregation.

On farms where green chop was feed data were available on the amount supplied per cow per day. On many farms the entire forage supply was secured from pasture which was rated on a 10 point scale at the time of the interview. About one forth of the farms used pasture supplemented by varing quantities of green chop. It was, therefore, necessary to combine pasture quality and pounds of green chop into some index of forage supply. For this purpose a 1 point change in pasture classification was evaluated as equivalent to 9 kilograms (19,8 pounds) of green chop. Subsequent investigation may reveal that green chop does not substitute for pasture at a constant rate or that the rate is other than 9 kilograms (19,8 pounds) per point of pasture classification.

The concentrate supplied also varied greatly with respect to nutrient content. All concentrates were, therefore, converted to a kilograms of protein and a kilograms of digestible nutrient basis. The co-efficients used in this conversion may be questioned by some.

Other studies have adjusted the milk production figures for fat content. In this study no milk was tested and no fat adjustments made. Since the holstein breed dominated the sample this source of error may be less serious than those mentioned above.

VARIABLES FOR EQUATIONS.

The variables used in the equations were as follows:

M = Average milk production per cow per year in kilograms (2.2 lbs.). This figure was computed by dividing the total kilograms of milk produced on the farm during the last year by the average number of cows in milk.

E = Average total digestible nutrients per cow per year in kilograms (2.2 lbs.). This figure was computed by converting to a T.D.N. basis all feed other than forage supplied to the cows in milk. This total T.D.N. was then divided by the average number of cows in milk.

C = Cow quality - 1 (poorest) to 10 (best). These ratings were assigned by the livestock judge. However there were no No. 10 herds and but 3 No. 9 herds. Likewise there was but 1 No. 1 herd. In effect, the cow quality scale ranged from 2 to 8.

P = Pasture quality - 1 (poorest) to 10 (best).

These ratings were assigned by the forage specialist. Again there were no No. 10 pastures but there were 3 No. 9's and 10 No. 1's.

F - Average Amount of green chop per cow per day in kilograms (2.2 lbs.) A sample was weighed at the time of the visit. The resulting figure was adjusted upward or downward where there was evidence of significant seasonal variation.

Z - Total Forage Supply - 1 (poorest) to 3 (best).

In order to reduce the forage supply to a single variable, pasture quality and kilograms of green chop were aggregated into a single measure of forage quality. Nine kilograms of green chop was assumed to substitute for 1 point change in pasture classification. After combining pasture and green chop the farms were divided approximately into thirds on the basis of the quality of the total forage supply.

MILK PRODUCTION FUNCTIONS - 114 HERDS - EAST AND NORTH COMBINED.

A large number of equations were tested, including linear, quadratic, square root, and exponential functions. On the total of 114 herds (East and North combined), the equation that appeared most satisfactory on the basis of production economics, dairy nutrition and statistical significance, is equation 1.

$$(1) \quad M = 1504.15 + 2011.66\, Z_1 - 70.276\, Z_2 + 1.0959\, E + 145.975\, C - 0.00007\, E^2 + .0757\, E \times C$$

$Z_1$ and $Z_2$ are two dummy variables to explain the differences in milk production because of the three types of total forage supply. As shown on table 1 equation (1) explains 70.1 per cent of the variance in milk production from the pooled observations of the two areas. The t values for the regression coefficients are also included in table 1. From these we can conclude that the model is practically linear given the value of $E^2$ and the low significance of its t value. From all of the transformations in the variable E that were tested in order to obtain decreasing returns to scale this was the least discouraging.

This equation provided estimates of annual milk production from all possible combinations of cow quality, forage quality and level of concentrate feeding. For purposes of illustration cow qualities 2, 5 and 8 on the 3 forage types are shown in figure 1a, 1b and 1c. The figures illustrate the combinations that can result in an average milk production per cow of 2000 kilograms (that is, poor cows on poor forage with little concentrate) to 6500 kilograms per cow (that is, good cows with good forage and a heavy rate of concentrate feeding). It also indicates that the advantage of good cows over poor cows increases as the level of concentrate feeding increases.

As a general guide to predicting the level of milk production the equation is perhaps adequate. The error is likely to be greatest on the unusual combinations such as good cows on poor forage with a low level of concentrate feeding or poor cows on good forage with a high level of concentrate feeding.

Under closer examination several aspects of the results are subject to question. The first is that the production functions are almost linear. Within the range of concentrate feeding programmed, under no condition are the cows approaching a maximum in milk production. Although the additional milk produced per kilogram of additional concentrate is higher for good cows than poor cows, it is the same for each cow class between and among forage group. This is in conflict with the findings of other studies.

The near linearity of the production functions also result in only a small decline in the marginal physical product as more concentrate is feed. As a result a small increase in the price of concentrate relative to the price of milk can change the optimum level of feeding from feeding concentrate at the maximum physiological level to producing milk entirely from forage (see figure 2). This conclusion also is questionable.

The final reservation relates to the small response in milk production resulting from forage improvement. Improving forage from class 1 to class 2 increased milk production by about 282 kilograms per cow per year and from forage 2 to forage 3 by about 187 kilograms per cow per year. These quantities remained constant for all cow qualities and all levels of concentrate feeding.

The reservations cited above led to certain questions concerning the basic data and the procedure followed. These questions were:

1.- Can data from the two areas be aggregated?

Although the two areas are similar climatically the soils are quite different. It is possible that there are nutritional differences in the forage that are not apparent from visual inspection. It is also possible that the standards used in classifying the inputs were altered between the two areas due to personnel changes in the research team.

2.- Can pasture and green chop be aggregated?

As indicated previously 9 kilograms of green chop was assumed to substitute for a 1 point change in pasture classification in arriving at the 3 point classification of the total forage supply. Such an aggregation may not be justified.

MILK PRODUCTION FUNCTIONS - 54 HERDS, EAST ONLY.

In order to overcome the limitations cited above a second run was made using only data from the 54 herds in the Eastern Area from which usuable schedules were obtained. The two types of forage were entered as separate inputs instead of as dummy variables as in the previous equation.

The equation eventually selected was of the following form:

$$(2) \quad M = 1467.313 + 1.332\ E + 39.241\ C + 6.943\ P + 16.704\ F - .00048\ E^2 - 15.574\ C^2 - 4.808\ P^2 - .185\ F^2 + .203\ E \times C - .056\ E \times P + .0093\ E \times F + 53.823\ C \times P + 1.471\ C \times F - 4.547\ P \times F$$

This equation explains 86.5 per cent of the variance in milk production. Table 1 shows the t values for the regression coefficients. On the basis of dairy nutrition at least each of the single variables (E, C, P, and F) should make a contribution to milk production. The variable P (green chop supply) requires further consideration. Out of the 54 observations there were 11 with zero or practically zero green chop supply, with all the forage supply coming from pasture. A run was made on these 43 observatinns and keeping the same model as equation (2). This new equation was consistent with the different aspects for selection, with t value of the regressicn coefficient on both P and $P^2$ significant at the .1 level of probability; but the equation highly overestimated the predicated response for the high levels of E, C, P and F. For this reason this equation was discarded.

A comment should be made on multicollinearity. The independent variables showed some intercorrelation; different runs were made on models including the single variable plus the square term (ie. $M = b_0 + b_1 E + b_2 E^2$). In all cases the F - test and the t values on the b's were highly significant. But when all these terms plus the cross - products were included as in equation (2) some of the t - values were practically non significant. Furthermore the t values on some of the cross - products are highly significant. (See table 1).

As with the previous equation production functions for cow classifications 2, 5 and 8 have been plotted for poor, medium and good forage (see figure 3a, 3b and 3c).

Upon examination two of the production functions are open to question. Is it true that good cows on poor forage produce less milk than poorer cows at low levels of concentrate feeding? A logical explanation of this relationship is possible but in the real world, and in our sample, this combination was rarely found. It could also be questioned if No. 2 cows produce less milk on good forage than on average or poor forage at all levels of concentrate feeding. Again, this is a combination that is rarely found in the real world. The remaining 7 combinations represent combinations that are frequently encountered in the real world although the extreme ends of the production functions are often projections.

As compared with the previous equation, this equation shows a more rapidly diminishing return to concentrate for all possible cow - forage combinations and a smaller difference between cow quality at lower levels of concentrate feeding but a greater difference at higher levels of concentrate feeding.

The equation also results in marginal product curves which, although linear and parallel, yield a different optimum rate of concentrate feeding for all possible combinations of cow and forage quality (see figure 4).

To illustrate these optimum rates of feeding 3 milk - concentrate price ratios were selected, 1:1.50, 1:1.33 and 1:1.2. The later approaches that representative of a producer near the consuming center who has little milk rejected because of quality standards. The first represents a producer more remote from the consuming center who would pay more transportation charges on both the milk and the concentrate. A greater distance from market could also increase the possibility of having milk rejected for failing to meet quality standards. The 1:1.33 ratio represents a position between these two extremes.

The optimum rate of feeding under all possible combinations of 3 cow qualities, 3 forage qualities and 3 milk-concentrate price ratios is shown in figure 4. The optimum feeding rates were then transferred to the production functions shown in figures 3a, 3b and 3c.

Good cows on good forage can economically produce milk at the level of 6500 to 7000 kilograms per cow per year. This will require 1800 to 2000 kilograms of TDN (3000 to 3330 kilograms of a concentrate containing 60% TDN). Class 5 cows on average forage produce most economically at about a 4000 kilograms annual average which requires about 1200 kilograms of TDN (2000 kilograms of a 60% TDN ration). For class 2 cows it is uneconomical under existing price conditions to attempt to achieve much more than a 2500 kilograms per cow average.

ISOQUANTS.

Two isoquants have been derived from equation 2; T.D.N. as a function of cow quality, and T.D.N. as a function of green chop forage (Figs. 5 and 6 respectively). Also, from equation (3) (the same model as equation (2) but fitted to 43 observations instead of 54) the isoquants T.D.N. as a function of green chop forage are presented in figure 6.

The flatness of the TDN -green chop curve indicates that when pasture of average quality is available to average cows there is only a small saving in concentrate from the supplying of additional green chop. The TDN- cow quality curve, however, is quite different. When provided with an average forage supply good cows produce any given level of milk with less concentrate than poorer cows. At the level of 5000 kilograms of milk per year a one point improvement in cow quality can result in a savings of 400 kilograms od TDN in concentrate.

COMPARISON WITH DAIRY COWS IN THE UNITED STATES.

Finally, an attempt was made to compare the results of this study with the results obtained elsewhere. In a recently published study Owen and Hoglund (1) provide estimates of the amount of milk that holsteins of average and good quality would produce when fed excellent, medium and poor quality forage along with varying quantities of a grain ration. By pairing the forage qualities, assuming a TDN contain of the grain ration (75% was used) and converting from pounds to kilograms, it was possible to make some direct comparisons between the two studies. The results are presented in figures 3a, 3b and 3c.

With good cows provided good forage and at heavy rates of concentrate feeding the expected milk production is approximately the same in the two studies. However, at low levels of concentrate feeding about twice as much milk would be expected from cows fed hay as compared with cows on pasture of green chop.

The above relationships result in the response to concentrate being higher and more sustained for cattle fed pasture or green chop as compared with cattle fed hay. With the same concentrate - milk price ratio it should,

(1) Owen, F.G. and C.R. Hoglund. A Guide for Optimizing Levels of Feeding Dairy Cows, Nebraska Agricultural Experiment Station, S.B. 511, October 1970.

therefore, be economic to feed concentrate at a higher level. This physical response advantage, however, is largely offset by the less favorable concentrate - milk price ratio that exists in Colombia.

An additional difference between the two studies should be noted. In the study reported by Owen and Hoglund the quantity of hay consumed was measured. As grain feeding increased from 0 to the maximums reported, hay consumption decreased from 20 per cent to nearly 30 per cent depending upon the cow and hay quality. This savings in forage cost was incorpotated in the feed-cost/milk price ratio.

In the study reported here pastures were classified on the basis of the feed available but no measurement of the pasture actually consumed was made. It is reasonable to assume that if the cows are receiving a heavy concentrate ration they will consume less pasture. The stocking rate could then be increased without any decrease in the quantity of forage available. In considering the optimum rate of concentrate feeding this issue was not taken into account.

SUMMARY.

This study demostrates that, in spite of the data limitations outlined earilier in this paper, it is possible to secure useful information related to milk production by interview and inspection using herd averages as the observational unit. Although the levels of significance of some of the variables are lower than desired the relationships seem, for the most part, consistent with those expected. If the conclusions are accepted as valid they have strong implications for the appropiate strategy to be pursued in improving the efficiency of milk production in Colombia.

During the field interviews each respondent was asked what he considered to be the major obstacle to profitable milk production. Problems associated with maintaining a good forage supply were mentioned more often than any other item. The second most often mentioned problem related to the price of milk, the price of concentrate or the relationship between the two. Mentioned by only a few operators was the problem of maintaining a herd with a high potential for milk production.

The results of this study would indicate that these priorities should be reversed. With good cows and existing concentrate - milk price ratios it is possible to achieve a high level of milk production and a high return per cow above purchased feed cost. The optimum level of production and the maximum return above feed cost is higher for good forage than for poor forage but the cow quality differential is much greater than the forage quality differential.

At the other extreme of possible combinations little milk can be produced from good forage and high rates of concentrate feeding if the cows do not have the genetic ability to convert this feed to milk.

Rations and the level of concentrate feeding can be changed easily and quickly. Changes in rotations and fertilization practices can influence forage quality in a time period of less than a year. However, the securing or maintaining of a herd of high producing ability is a costly and time consuming process. It requires a level of managerial skill and dedication that is not in abundant supply in Colombia. This study indicates, however, that the payoff is quite high for those who can perform this difficult task.

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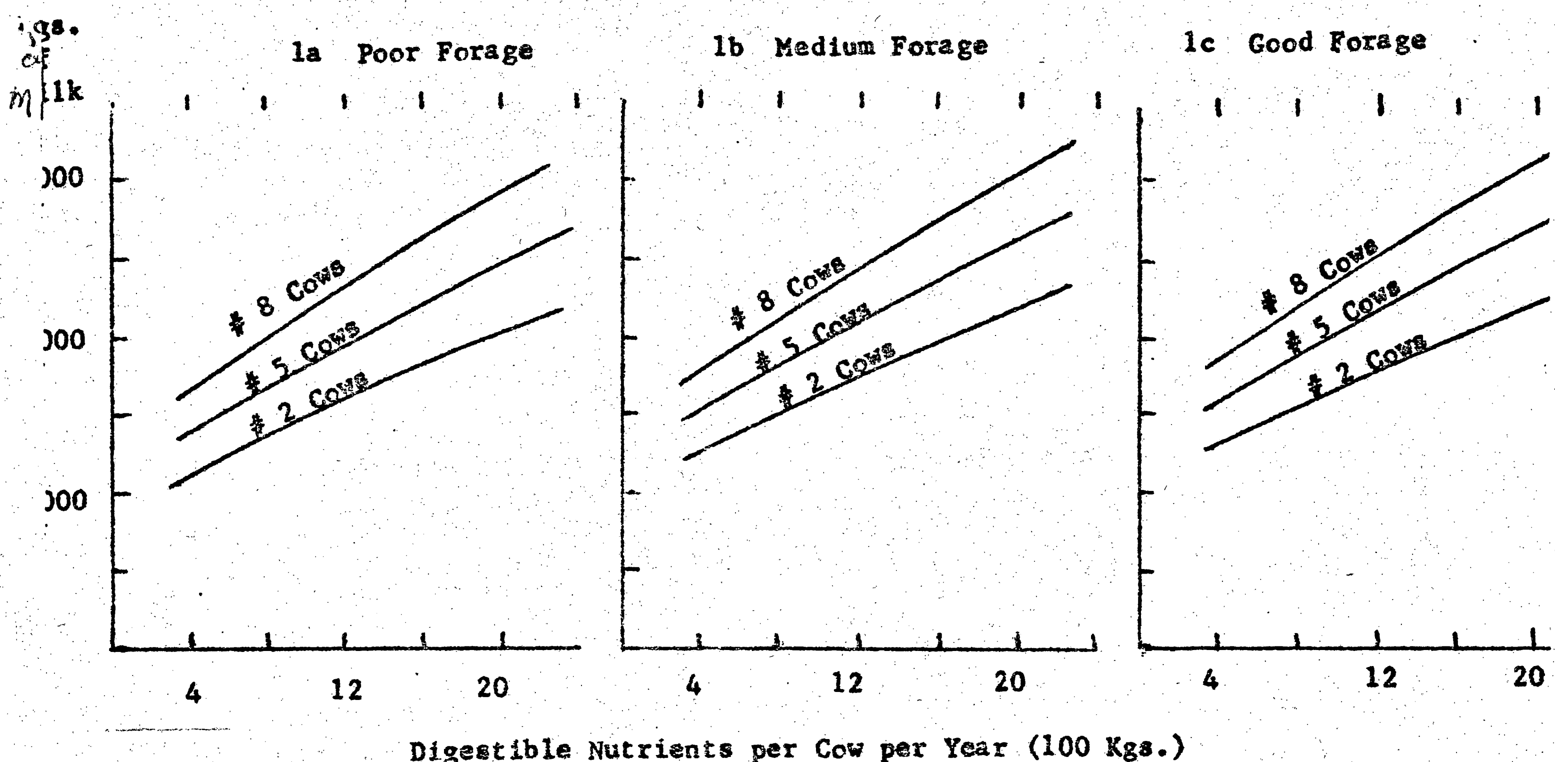



Fig. 1 Estimated Milk Production as a Function of Forage Quality, Cow Quality and Rate of Concentrate Feeding - 114 Herds in Two Areas.

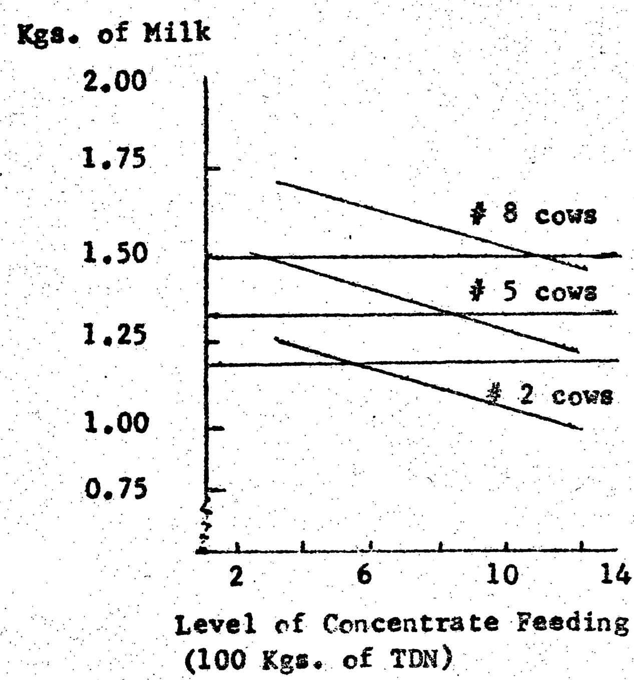



Fig. 2 Additional Kgs. of Milk per Kgs. of TDN in concentrate, 114 herds, equation 1

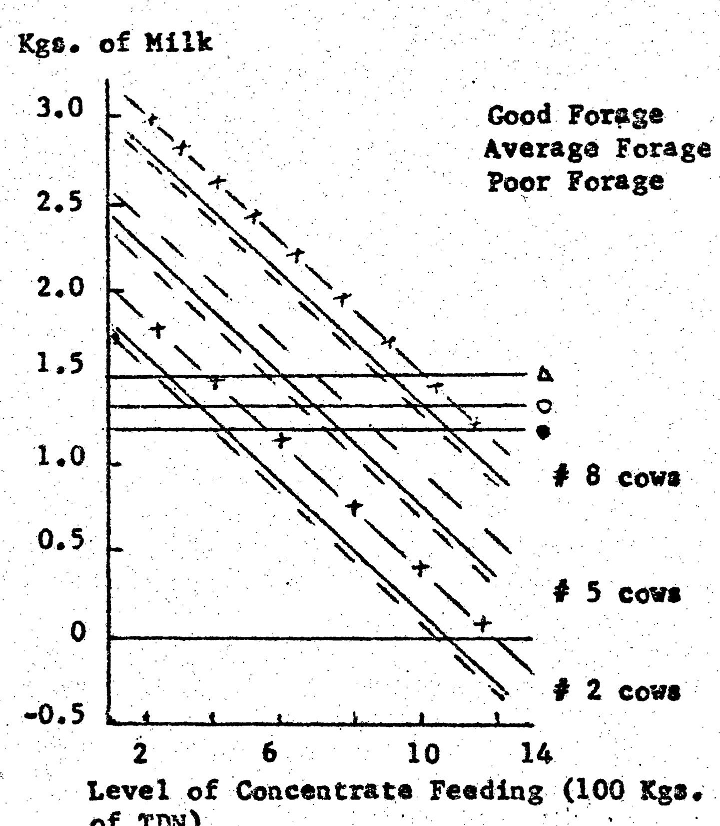



Fig. 4 Additional Kgs. of Milk per Kg. of TDN in Concentrate - 54 herds, Equation 2.

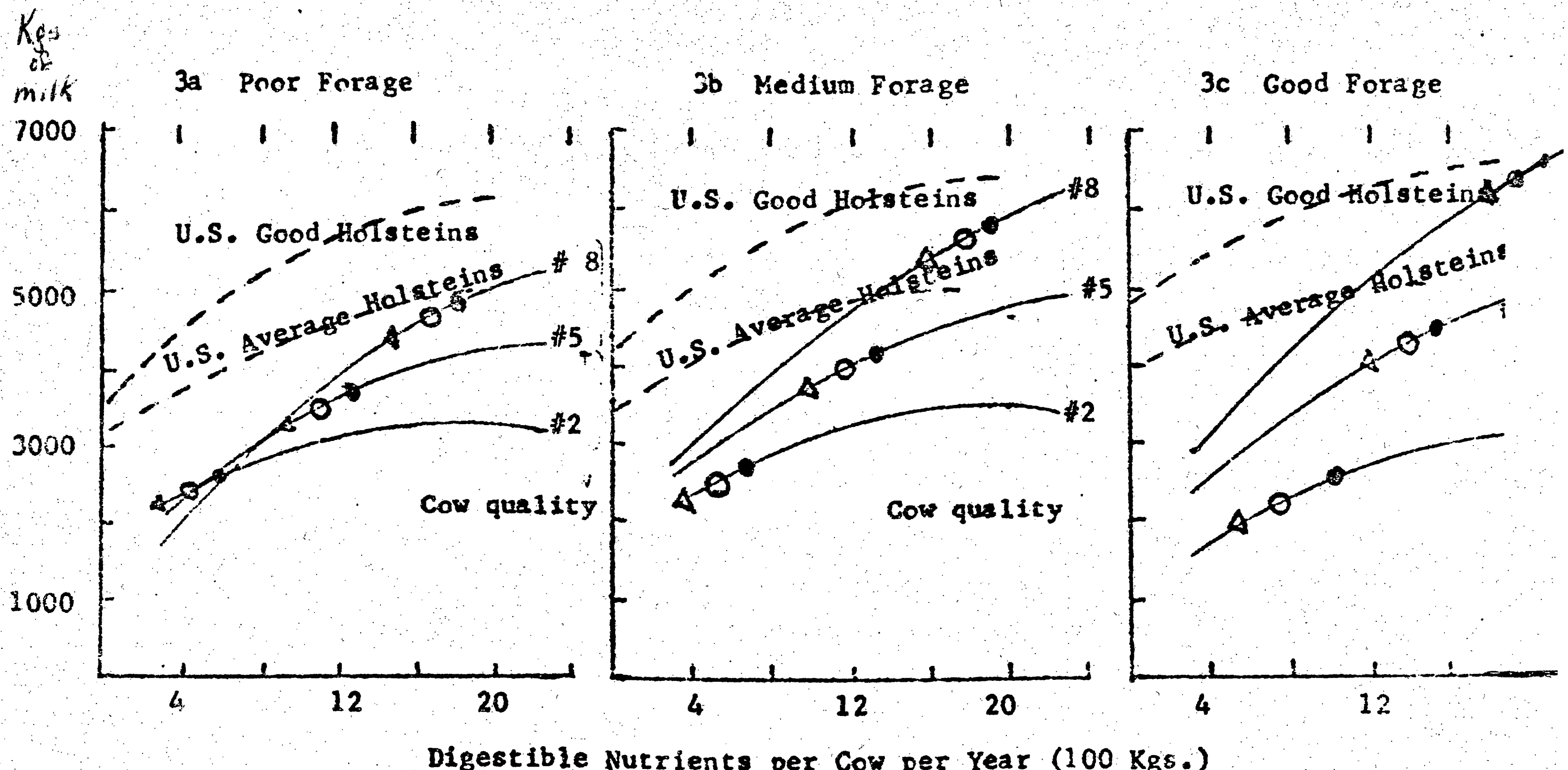
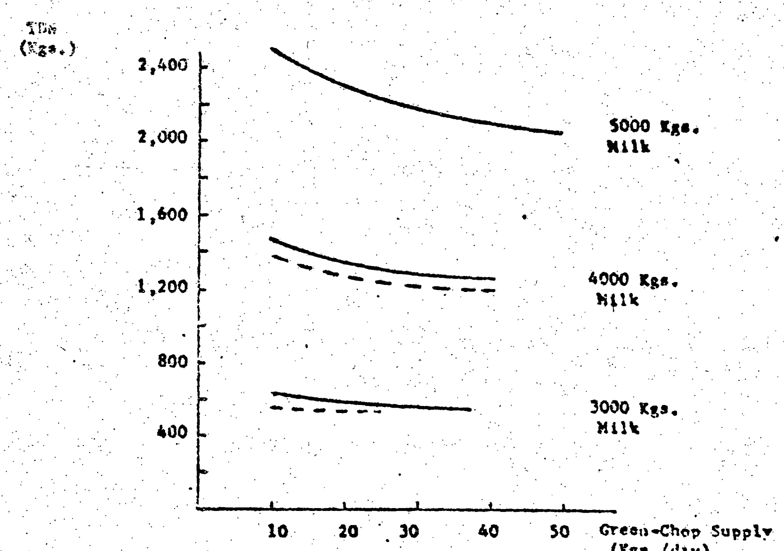



Fig. 3 Estimated Milk Production as a Function of Forage Quality, Cow Quality and Rate of Concentrate Feeding - 54 Herds in the East and Holsteins in the U.S.



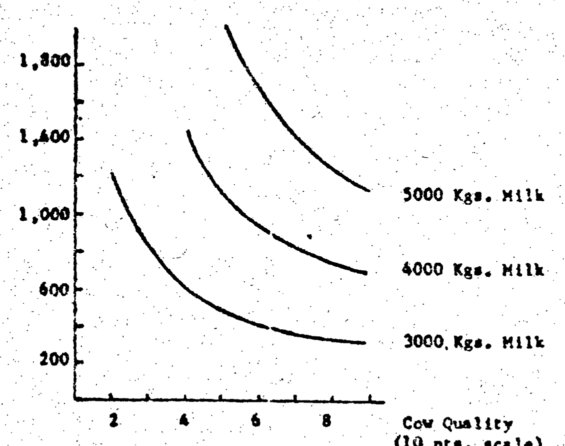




Fig. 5 Isoquants as estimated from equation 2, with other variables set at the mean.

Fig. 6 Isoquants as estimated from equation 2 (----), and equation 3 (——), with other variables set at the mean.

Table 1 Regression coefficients, t values and $R^2$ for equations (1), (2)

| Independent Variable | Equation (1) | | Equation (2) | |
|---|---|---|---|---|
| | b | t | b | t |
| E ..... | 1.096 | 2.083[1] | 1.332 | 1.784[2] |
| C ..... | 145.975 | 1.546[3] | 39.241 | 1.691[2] |
| P ..... | | | 6.943 | .035 |
| F ..... | | | 16.704 | 1.097[4] |
| $E^2$..... | -.00007 | -.318 | -.00048 | -1.20[4] |
| $C^2$..... | | | -15.674 | -1.18[4] |
| $P^2$..... | | | -4.808 | -.28 |
| $F^2$..... | | | -.185 | -1.145[4] |
| E x C ..... | .0757 | .997 | .203 | 2.03[1] |
| E x P ..... | | | -.056 | -.575 |
| E x F ..... | | | .0093 | .922 |
| C x P ..... | | | 53.823 | 2.636[1] |
| C x F ..... | | | 1.471 | .792 |
| P x F ..... | | | -4.547 | -2.04[1] |
| $Z_1$ ..... | 2011.660 | 2.565[1] | | |
| $Z_2$ ..... | -70.276 | .918 | | |
| $R^2$.... | .701 | | .865 | |

(1) Acceptable at the .05 level of probability
(2) " " " .1 " " "
(3) " " " .2 " " "
(4) " " " .3 " " "