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The contribution of technological change to the total change in milk production is estimated to be 36 per cent, implying that with the same levels of feed nutrients, the milk yield could be increased by 36 per cent with the introduction of cross-bred animals in place of Sahiwal breed. An increased use of feed inputs for cross-bred cow contributes about 34 per cent to the total change in milk yield. Thus, better feeding is an equally important instrument for increasing the milk yield along with genetic development through cross-breeding programme.

## III

### CONCLUSIONS

1. A major portion of feed effects in milk production was due to the carry-over effect which is distributed over the lactation period. Ignoring this effect leads to serious under-estimation of the productivity of feed inputs in the commonly used static milk production models.
2. The cross-breeding programme made extremely important contribution in increasing the productivity of milch cattle.
3. Proper feeding management over the entire cycle of milk production is essential for full exploitation of the genetic potential.

# FEED ECONOMY IN MILK PRODUCTION: A PROBE UNDER NEW DAIRY FARM TECHNOLOGY IN KERALA

T. P. Gangadharan*

The agricultural strategy followed since the mid-1960s has, by and large, left the small farmers behind due to the alleged resource-non-neutral nature of Green Revolution. In the light of this experience, and in view of the present emphasis on social justice in the planning documents, dairy farming, of late, is receiving scrupulous attention. The crucial role of dairying is further highlighted by the ever-increasing demand for milk and milk products and the need to provide a nutrient cover to combat the widely prevailing malnutrition problem. Nothing short of a basic change in the dairy farm technology will, it is asserted, improve the problem of low productivity of Indian cows. Consonant with this, cross-breeding for enhancing milk production is being given a fillip in our milk production system. Against the background of already precarious animal feed situation in the country, the influx of cross-bred cows with the existing stock of native cows draws a picture of scepticism in the dairy sector. This is because feed is a recognized principal input vector governing the potentiality and profit in dairying. Coherent knowledge

* Scientist-S1 (Agricultural Economics), Division of Dairy Economics, Statistics and Management, National Dairy Research Institute, Karnal.

about feed utilization by these two classes of cows is, therefore, necessary for pragmatic strategy formulation for dairy development. Unfortunately, there is no satisfactory information available on this score, except those flowing from experimental stations.

In the following exercise, we would in large part try to draw feed input-milk output linkage for cows maintained by small farm households. Focusing on small dairy farms is done in tune with the national objective, and further, it might help in understanding the problem in a proper perspective in the context of stringent resource constraints. Alleppey district in Kerala was purposively chosen for the study since cross-breeding programme initiated by Indo-Swiss Project has been in operation since 1963. The district is the smallest but most thickly populated, having no area under high lands. About 97 per cent of holdings belong to small and marginal farmers. The density of cattle population in the district according to Livestock Census (1972) was 178 per sq. km. as compared to 73 for the whole of Kerala. The data were collected from a random sample of 175 cattle owning households in the district. The approach adopted for the enquiry was one of cost accounting through specially structured, pre-tested questionnaires. The households were visited once in a fortnight, over a period from April 1973 to March 1974. For the purpose of ascertaining the influence of climatic elements, the whole year was divided into two season, *viz.*, rainy season (June to November) and summer season (December to May). The analysis essentially pertains to Brown Swiss cross-bred (BSC) cows—those born as a result of artificial insemination programme of Indo-Swiss Project—representing the improved technology and non-descript (ND) cows—native cattle without any breed characteristics—signifying the traditional technology in dairy farm front.

## FEED INTAKE AND CONVERSION EFFICIENCY

The average quantities of different feed groups given to lactating cows in the study area are presented in Table I. The green fodder included local grasses, hybrid napier and guinea grass. Paddy straw was the only dry fodder available in the area. Compounded cattle feed, groundnut oilcake, rice bran and tamarind seed were the major constituents of concentrates. BSC were fed relatively much higher quantities of feeds than ND cows. Visible seasonal variations in the amounts of feed supplied might principally be attributed to the dearth of green forage during the dry, summer period. This obviously necessitated compensation by increased amounts of dry fodder and concentrates amounting to higher feed expenditure during summer season. Turning now to milk productivity differential, BSC stood in the vanguard yielding three times the productivity of ND cows. The depression in milk yield during warm season was probably due to the thermal stress to which the cows, BSC in particular, were exposed.[1] Climatic stress appears to have direct and indirect effects on milk secretion. In the first category are mainly

1. R. E. McDowell: Improvement of Livestock Production in Warm Climates, W. H. Freeman & Co., San Francisco, 1972.

TABLE I—DAILY FEED INTAKE FOR LACTATING COWS

| Breed groups | Rainy | | Summer | |
|---|---|---|---|---|
| | BSC | ND | BSC | ND |
| Green fodder (kg.) | 4·28 | 4·11 | 3·49 | 2·69 |
| Dry fodder (kg.) | 4·14 | 1·82 | 4·86 | 2·18 |
| Concentrates (kg.) | 2·43 | 1·01 | 2·32 | 1·04 |
| Feed cost (Rs.) | 4·13 | 1·87 | 4·28 | 1·92 |
| Feed cost per kg. of milk produced (Rs.) | 0·70 (5·89) | 0·97 (1·93) | 0·90 (4·78) | 1·10 (1·75) |

Figures in parentheses are respective daily milk yield in kg.

high temperature and high humidity which cause physiological disturbances. The main indirect effect of climate, resulting from the interaction of rainfall (yearly precipitation and seasonal distribution) and temperatures, is on the vegetation available, both quantitatively and qualitatively, which, in turn, largely influences dairy cattle nutrition and milk yield. The perceptible drop of about 20 per cent in milk yield by BSC during summer as compared to the near-persistent output by ND cows implies that, in a production system dominated by cross-bred cows, sharp seasonal fluctuations in milk output could be expected. With a low profile, the feed cost per litre of milk, the barometer of profits in dairy business, speaks about excellence of BSC. The ND cows appeared expensive on this count. The reason why such sharp cleavage between the two classes of cows are manifested becomes apparent from Table II.

TABLE II—FEED CONVERSION EFFICIENCY

| Parameters | Rainy season | | Summer season | |
|---|---|---|---|---|
| | BSC | ND | BSC | ND |
| 1. Weight of a cow (kg.) | 294 | 194 | 282 | 190 |
| 2. Dry matter intake/day (kg.) | 6·77 | 3·37 | 7·16 | 3·44 |
| 3. Milk yield/day (kg.) | 5·89 | 1·93 | 4·78 | 1·75 |
| 4. Dry matter intake/kg. milk | 1·15 | 1·75 | 1·50 | 1·97 |
| 5. Gross TDN/day (kg.) | 4·07 | 2·08 | 4·22 | 2·15 |
| 6. Gross efficiency (per cent) | 27·1 | 18·7 | 21·2 | 16·4 |
| 7. Protein intake/day (gm.) | 540 | 240 | 528 | 230 |
| 8. Protein intake/kg. milk | 92 | 124 | 110 | 131 |

An important characteristic affecting profitability of any organism or machine is the efficiency with which it can convert inputs or raw materials into outputs of finished products. In dairy cow, efficiency is customarily defined as the ratio of milk output to feed input and does not consider other inputs such as capital, labour, management, etc. It is essentially the ability to convert plant materials which are mostly unsuitable for direct human consumption into milk which is extremely valuable as human food. The pointers like dry matter intake per litre of milk and protein intake per litre of milk were appreciably at a lower profile for cross-breds than for ND cows, indicating that BSC are economical. It was further observed that gross efficiency of milk production favoured BSC.[2] The higher conversion efficiency of digested food nutrients (and especially that of protein) into milk confers superiority on cross-breds, since more economic gains can be expected from their ability in the conversion of consumed nutrients into energy rich fluid milk.

### RESIDUAL FEED EFFECT

Till now, the build-up of the effect of level of feed intake has not been analysed exhaustively. The conventional system of feed allocation automatically awards more feed to the high-yielding cow whether the greater output is due to the potential of the cow or due to her previous feeding and, therefore, the effects of potential and of current ration are inextricably bound up with any residual effects of previous ration. In the process of feed transformation into milk, the different systems in the body may have involvement and the course of transformation may be delayed depending upon the interplay of several physiological functions. During the last three decades, many quantitative studies of milk production response have been carried out assuming implicitly that feed has once-for-all effect on dairy production. But what is evident from physiological research is that the cow may add to or draw from the body reserves according to the level of nutrition fed currently and previously. Hence, in actuality, the feed factor might be imparting both short run and long run impacts which remained unprobed in previous studies. From an economic point of view it is the long run effect which is more important, the short-term effect may, sometimes, be insufficient to cover the cost of extra feed. The classical static production function would, then, fail to expose such dynamic input-output relationship in dairy production. As a recourse, a distributed log model, parallel to the one popularised by Nerlove[3] was employed. The model can be written as:

$$Y_t^* = b_0 + b_1F_t + e_t \qquad \ldots. \ (1)$$

$$\text{and } Y_t - Y_{t1} = \delta\,(Y_t^* - Y_{t-1});\ 0 < \delta \leqslant 1, \qquad \ldots. \ (2)$$

2. $\text{Gross efficiency} = \dfrac{750 \times \text{FCM produced in kg.}}{4{,}000 \times \text{TDN consumed in kg.}}$

where one kg. FCM (Fat Corrected Milk) is equivalent to 750 kcals. and one kg. TDN (Total Digestible Nutrients) to 4,000 kcals. See S. Brody: Bio-Energetics and Growth, Reinhold Publishing Co., New York, 1945.

3. Marc Nerlove, "Distributed Lags and Estimation of Long-Run Supply and Demand Elasticities: Theoretical Considerations", *Journal of Farm Economics*, Vol. 40, No. 2, May 1958, pp. 301-311.

where $Y_t^*$ = long run equilibrium milk output which represents the milk yield if there were no physiological rigidities,

$F_t$ = feed factor,

$\delta$ = coefficient of adjustment of milk output to equilibrium level, assumed to lie between zero and one.

By substituting (1) into (2)

$$Y_t = \Pi_0 + \Pi_1 F_t + \Pi_2 Y_{t-1} + w_t \quad \ldots. (3)$$

where $\Pi_0 = \delta b_0$, $\Pi_1 = \delta b_1$, $\Pi_2 = (1 - \delta)$, $w_t = \delta e_t$.

Both short run and long run elasticities can be obtained from this model. The adjustment coefficient determines the relationship which exists between these elasticities. Short run elasticity($\eta_S$) evaluated at the mean of observations, and long run elasticity ($\eta_L$) are given by $\Pi_1$ $(\bar{F}/\bar{Y})$ and $\eta_S/\delta$ respectively. Although one cannot, *a priori*, make out the appropriate span of the lag, a one-fortnight lag on feed input was specified in order to reflect rigidity in the adjustment of milk production. This is done since the data were available on fortnightly basis. Further, it appeared that the choice of the two-week lag fitted well with our general pre-conception about the dynamic relationship. Linear and double-log forms were fitted and the latter was seen conforming better to the underlying logic. There is also the practical advantage that the regression coefficient is an elasticity. The results are presented in Table III.

TABLE III—DISTRIBUTED LAG FUNCTIONS (DOUBLE-LOG)

| Breed | Constant ($\log \Pi_0$) | Regression coefficients of: Total feed expenditure ($F_t$) | Milk yield lagged by one fortnight ($Y_{t-1}$) | Seasonal dummy variable (D) | $R^2$ | h | Coefficient of adjustment | Long run elasticity |
|---|---|---|---|---|---|---|---|---|
| BSC .. | 0·031 | 0·099** (0·047) | 0·820** (0·036) | —20·327 (123·536) | 0·93 | 1·14 | 0·180 | 0·548 |
| ND .. | —0·037 | 0·095* (0·057) | 0·888** (0·067) | 13·934 (27·271) | 0·90 | 0·95 | 0·112 | 0·846 |

Figures in parentheses are standard errors.
** Significant at 5 per cent level.
* Significant at 20 per cent level.

The coefficients are of an acceptable magnitude and sign. Very high values obtained for lagged milk yield are reasonable. The ND cows showed less immediate response to total feed expenditure than BSC. A value much lesser than unity for long run elasticity provided glaring evidence of residual, distributed effects of feed on milk production in BSC and ND. The residual effect can be explained from the manner of partition of food between milk and body reserves. At lower levels of milk yield the cow might be devoting to her body reserves food energy not excreted in milk. A generous feeding at any time, therefore, should result in increase in both milk and body reserves. The economic significance emanating from this observation is that *ad lib* feeding of a cow, when seasonal feed price does not loom large, might not prove desolate; it may rather conduce towards economic milk production during times of feed scarcity.

The shorter time lag in quick adjustment by BSC to feed intake as compared to ND cows demonstrates the breed characteristics and the dairy merit of the former by virtue of its excellence in feed conversion.

STRUCTURING BALANCED AND HANDY FEED BASKET

A wide variety of feed stuffs are offered to milking cows in the study area. Such a wide spectrum of feed materials, that too in atomistic quantities, poses problems in choice making. Procurement, storage and allocation of feeds are also made more intricate. Bringing down the number of feeds to a minimum consistent with the nutrient requirements and availability of capital, therefore, appears to be of paramount importance. Formulation of concise and economic feeding schedules was done by employing linear programming technique. The objective function of the model was set as:

$$\text{Minimize } Z = \sum_{j=1}^{n} P_j X_j$$

where $Z$ = cost of feed materials,
$X_j$ = quantity of jth feed material,
$P_j$ = price per unit of jth feed material,
$n$ = number of feed materials included in the plan.

Minimum restriction was imposed on digestible crude protein, total digestible nutrients, calcium and roughage. Maximum limit was specified for dry matter, phosphorus and paddy straw.[4] The nutrient contents of different feeding stuffs were compiled from the study of Sen and Ray.[5]

The activities and their levels obtained in the optimal plans along with the existing schedule at the current levels of milk production for BSC and ND cows are given in Table IV. The two schedules differed very much both in composition as well as in quantities. Local grasses, paddy straw, groundnut oilcake and compounded cattle feeds were, as the optimal plans suggested, most economical for the dairy herds. Local grasses, surprisingly, entered in the improved plan displacing hybrid napier and guinea grass. Although these cultivated fodders are relatively superior in terms of nutrient content, the prohibitive cost put them at a disadvantage. The optimal plan could not accomplish any saving in feed cost for ND cows, evidently due to higher dry matter requirements than the existing level.[6] But the increase in feed cost was only nominal (about 7 to 10 per cent) and the improved plan still appeared appealing as it conferred a distinct advantage of procuring only a few feed materials with a considerable decrease in the amount of concentrates. This

4. These restrictions were framed in consultation with the nutritionists and physiologists of National Dairy Research Institute. For detailed exposition, see T. P. Gangadharan: Studies in Feed-Milk Relationship in Cattle in Kerala, Unpublished Ph. D. Thesis, Panjab University, Chandigarh, 1978.

5. K.C. Sen and S.N. Ray: Nutritive Values of Indian Cattle Feeds and the Feeding of Animals, Research Series No. 25, Indian Council of Agricultural Research, New Delhi, 1964.

6. It is seen that the dry matter supply fell short of the recommended level by 20 to 25 per cent, although the protein (DCP) and energy (TDN) requirements have been nearly met.

TABLE IV—EXISTING AND OPTIMAL FEED PLANS

(*quantity in kg.*)

| | BSC | | | | ND | | | |
|---|---|---|---|---|---|---|---|---|
| | Rainy | | Summer | | Rainy | | Summer | |
| | Existing | Optimal | Existing | Optimal | Existing | Optimal | Existing | Optimal |
| Local grasses | 3·08 | 12·45 | 2·58 | 9·72 | 3·88 | 6·50 | 2·30 | 3·91 |
| Hybrid napier grass | 1·01 | — | 0·84 | — | 0·12 | — | 0·25 | 2·59 |
| Guinea grass | 0·14 | — | 0·04 | — | 0·06 | — | 0·05 | — |
| Others* | 0·05 | — | 0·03 | — | 0·05 | — | 0·09 | — |
| Paddy straw | 4·14 | 4·00 | 4·86 | 4·00 | 1·82 | 3·00 | 2·18 | 3·00 |
| Groundnut oilcake | 0·57 | 0·65 | 0·62 | 0·59 | 0·25 | 0·40 | 0·31 | 0·38 |
| Coconut oilcake | 0·16 | — | 0·11 | — | 0·06 | — | 0·04 | — |
| Gingelly oilcake | 0·14 | — | 0·15 | — | 0·05 | — | 0·03 | — |
| Tamarind seed | 0·35 | — | 0·32 | — | 0·24 | — | 0·19 | — |
| Cotton seed | 0·04 | — | 0·04 | — | — | — | — | — |
| Gram | 0·03 | — | 0·02 | — | — | — | — | — |
| Rice bran | 0·32 | 0·30 | 0·27 | 0·28 | 0·22 | — | 0·23 | — |
| Compounded cattle feeds | 0·76 | 0·50 | 0·72 | 0·50 | 0·16 | 0·10 | 0·19 | 0·10 |
| Others** | 0·06 | — | 0·07 | — | 0·03 | — | 0·05 | — |
| Feed cost per kg. milk (Rs.) | 0·70 | 0·61 | 0·90 | 0·68 | 0·97 | 1·04 | 1·10 | 1·21 |
| Per cent change in feed cost in optimal plan over existing plan | —12·9 | | —24·4 | | +7·2 | | +10·0 | |

* Includes tapioca residues, plantain leaves, etc.
** Includes jaggery, fenu greek, rice residue, etc.

would rather effect centralizing the resources at the disposal of the milk producers in the study area. The resources saved, especially by keeping BSC cows, can be channelised to maintain more animals at the current level of feeding or to maintain existing animals at a higher plane of nutrition.

## CONCLUSIONS

The exercise seeks to demonstrate empirically the pattern of feed utilization by BSC and ND cows symbolising two distinct technologies in the dairy sector. The introduction of the semi-foreign cow with proven feed transformation capacity has been well founded in the context of stringent feed position in the predominantly small farm economy of Kerala. Generous feeding during rainy season might render less costly milk production during the succeeding summer period, due to the revealed residual effect. The results further imply that, for popular acceptance of the new biological technology in the wake of mounting pressure on land for human consumption, the State demands special attention in exploring alternate sources of feeds and enriching the locally available roughages like paddy straw.