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Ration Balancing: Promising Option for Doubling Income from Dairying

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Abstract

This paper has examined the extent of productivity increase and cost reduction on adoption of balanced animal ration. The study is based on the database extracted from Information Network for Animal Productivity and Health (INAPH) pertaining to the milk yield and feeding records of about 15000 cattle and buffaloes that were covered under Ration Balancing Program (RBP) of the National Dairy Plan I implemented in the states of Gujarat and Punjab. The econometric analysis of secondary data following before-after impact assessment approach has also been complemented using with-without approach applying Propensity Score Matching technique on the data from field survey collected from 40 villages during the year 2015-16. In Gujarat, the analysis has shown that the ration balancing intervention enhanced the productivity of cows by around 13 per cent and of buffaloes by nearly 5.5 per cent. The quantum of increase discernible from the with-without approach after controlling for the confounding factors was higher, 19.5 per cent for cows and 18 per cent for buffaloes. In Punjab, the estimates of productivity gain for cows was close to 13 per cent based on either approach. Ration balancing has been cost effective in terms of percentage reduction in feed cost and feed cost/litre Fat Corrected Milk (FCM) of both, cattle and buffalo, with the cost efficiency being more pronounced in cows. In cattle, the feed cost per litre FCM reduced in between 5.76 and 9.86 per cent in Gujarat and by 10.83-18.53 per cent in Punjab. The field level data have also indicated a clear impact in reducing the feed cost per litre of milk by about 18-19 per cent in case of cows in both the states and about 2.6 per cent in buffaloes in Gujarat. Given the potential of this intervention in enhancing the dairy income, the paper has also discussed various ways in which its adoption can be promoted among the dairy farmers.

Key words: Impact, farm advisory, propensity score matching, ration balancing

JEL Classification: Q12, Q16, O33

Introduction

The estimates of farmers' income based on Situation Assessment Survey (SAS) carried out by National Sample Survey Organization (NSSO) show that crop cultivation is the major single source of farmers' income (>45%), but during 2002-03 (59th Round) and 2012-13 (70th round), in terms of percentage share, maximum increase has taken place in the income from animal farming. The livestock income that accounted for 4 per cent of the total farm household income in 2002-03 rose to 12 per cent in 2012-13 (Satyasai and Bharti, 2016). In 11 out of major 18 states, the percentage point change in the share of

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income from animal farming has increased from 3 per cent to over 20 per cent (Ranganathan, 2015). In the past two decades, with manifestation of continuous deceleration in the rate of production growth of most of the food and non-food-grain crops, the role of livestock sector, particularly of dairy became vital in maintaining the growth in the agriculture sector.

The approach paper of the last Five Year Plan reiterated that for achieving targeted growth rate of 4 per cent in agriculture during the Plan period, while the crop production was anticipated to grow by about 2 per cent, horticulture, livestock, dairying, poultry and fisheries would grow at 5 to 6 per cent and would be the harbinger of agricultural growth (GoI, 2011). In the contemporary policy framework, to fulfil the resolution of the Indian Government regarding doubling the income of farmers by 2022, a focus on income from cultivation alone will be inadequate. Increasing net income from animal farming should be the key element to achieve the welfare target that has been laid out (Chandrasekhar and Mehrotra, 2016). The road map and action plan prepared by the NITI Ayog to double the income of farmers (Chand, 2017) emphasizes on the productivity enhancement of livestock through development initiatives focused on widening the coverage of artificial insemination, improving the reproductive efficiency of dairy animals, technology generation and dissemination.

Three-pronged strategy focused on breeding, feeding and management interventions is key to addressing the challenge of enhancing animal productivity in the country. Animal feed is the most crucial input in livestock production. Empirical studies in India have shown that enhancing quality and quantity of feed input has greater impact than breed improvement on increasing milk productivity (Lalwani, 1989; Gaddi and Kunal, 1996). Feed shortage (Angadi *et al.*, 2005; GoI, 2012), poor nutritional quality of feed (Vaidya, 1999; Pathak and Garg, 1999) and imbalanced feeding are the key problems that impinge on productivity growth in the dairy sector.

Expenditure on feed and fodder accounts for 60-70 per cent of the total cost of milk production. The productivity of feed input is inversely related to the cost of milk production. Field study in the semi-arid region of Rajasthan showed that an improvement in feed input productivity (defined as milk output per kg. dry matter intake) by 12 per cent decreased the cost of milk production by 18 per cent in case of crossbred cows (Chand and Sirohi, 2012).

This paper presents a quantitative assessment of the extent to which feeding of balanced ration to dairy animals increases the animal productivity, reduces the feed cost and thereby, enhances the income of the dairy farmers. A major initiative in this direction in the form of Ration Balancing Program (RBP) was undertaken by the National Dairy Development Board (NDDB) as a key component in the National Dairy Plan I (NDP I) initiated in 2012-13. A first of its kind in the Indian context, the intervention provided in this program is in the form of advisory services to the dairy farmers about the optimal quantity of dry fodder, green fodder, concentrate and supplements that should be fed to dairy animal, depending upon animal-specific particulars of age, weight, lactation order and stage of lactation. The advisory support is provided at farmer's doorstep, through a Local Resource Person (LRP), preferably a resident of the target village. The LRP is provided necessary training by the implementation agency for carrying out the work and is equipped with a netbook preloaded with required software Information Network for Animal Productivity and Health (INAPH) for ration balancing developed by NDDB.

Data and Methodology

The study is based on both secondary and primary data pertaining to milk-shed areas of two milk unions in Gujarat (Banaskantha and Surat) and two in Punjab (Ludhiana and Ropar), since in terms of coverage of RBP, these two states have been the leader in western and northern India, respectively.

Secondary Data — The secondary data pertained to the INAPH database which is a rich source of information on animals covered under RBP. Besides the identification variables (viz., name of milk union, state, district, tehsil, village, owner and animal identification tag), the animal-specific information about species, breed, age, weight, calving date, order of lactation, daily milk production, fat composition of milk, daily feed and fodder intake on the basis of fresh matter, dry matter and nutrient intake (TDN, CP, Ca, P), prices of different feed fodder fed to animals, date of providing Ration Balancing Advisory, etc. are available in the database. The data on all the available

animal-specific variables were taken for two points of time, (i) on the date of first ration balancing advisory (t=0) and (ii) after a period of at least 180 days of first advisory (t=1). Thus, the dataset was restricted to those lactating animals that had received advisory services for at least 180 days and were milking at both the points of time.

Primary Data — Field visits were undertaken to collect data on the well-structured survey schedules from the beneficiary and non-beneficiary farm households as per the following sampling plan:

Selection of villages — 10 villages under each Milk Union were selected randomly out of the villages where RBP was being implemented. The twin criteria followed was : (i) RBP programme should be implemented at least for a period of 6 months at the time of village selection, (ii) villages should geographically well represent the study area, that is should not be concentrated in one tehsil or area of the district/milk shed area.

Selection of households — A sample of 10 beneficiary and 10 non-beneficiary dairy farmers from each village were selected randomly. In case the number of beneficiaries or non-beneficiaries in the selected village was less than 10, a cluster of proximate villages constituted the sample frame for selection of respondents. The total number of sample households was 400 (200 beneficiary+ 200 non-beneficiary) in each state.

Selection of milch animals — All the milch animals on the sample households (both beneficiary and non-beneficiary) were covered for the study.

Analytical Framework

The study has used both, "before-after" and "with-without" approaches, to bring out the effect of ration balancing with empirical firmness.

Before–After Approach: INAPH Database

The number of lactating animals (up to June 2015) that fulfilled the selection criteria mentioned above were 4489 cows and 4956 buffaloes from Banaskantha and Surat Milk Unions of Gujarat. The corresponding numbers were 2105 cows and 3767 buffaloes from Ludhiana and Ropar Milk Unions of Punjab. There were a number of outliers in the dataset, perhaps due to errors in data collection or entry by the LRP. All such observations were deleted from the dataset as they unduly affected the regression results. The regression Equation (1) was estimated in the base period (t=0) for cows and buffaloes separately in each of the two states (Gujarat and Punjab).

$$Y_{tis} = \beta_k X_{tisk} + \delta_k Z_{tisk} + \gamma_k S_{tisk} + \varepsilon_{tis} \quad \ldots(1)$$

where, t= 0, i= cows, buffaloes, s= Gujarat, Punjab

Y is the milk yield, X_k represent variables related to feeding of animals (k= total dry matter intake, mineral mixture), Z_k represent variables related to animal characteristics (k= lactation order, stage of lactation (in days), breed dummy), S_k represent control variables related to seasonal and locational aspects (k= seasonal dummy, Milk Union dummy)

As feed is the most important variable input influencing milk productivity, and also the 'treatment' variable under the RBP, the selection of appropriate specification of this variable was crucial for the robustness and logical consistency of the results. Several specifications of regression equation were tried with alternate forms of variable relating to the feed input, such as quantity of dry fodder, green fodder, concentrate and supplements fed to animals; or in terms of total dry matter intake from roughage and concentrates, or as nutrient availability from the feed and fodder (i.e. TDN, CP, Ca, P). Based on the econometric tests and common knowledge of animal nutrition, the final specification in the regression equations of both cattle and buffaloes in Gujarat and Punjab included two feed-related variables, daily total dry matter intake (TOTALDM) and quantity of mineral mixture fed to the animals (MM).

The original dataset did not provide information on the stage of lactation (SOL) in days, and the same was generated from the data of date of calving and that of RBP. The log specification of this variable was included to capture the established shape of the lactation curve.

Based on regression results of the base period, the predicted yield in period 1 was worked out by changing only the relevant animal (stage of lactation) and seasonal parameters that would change in period of 180 days. The predicted yield thus, gave the production without altering the feeding pattern, but as affected by the changes in season and stage of lactation. The

difference between the predicted yield so obtained for period 1 (Y_1^p) and the observed yield (Y_1) in the same period can thus be attributed to the effect of RBP on the animal productivity. Thus,

Y_1^p (Z=Stage of lactation$_{=1}$, Season $_{t=1}$) – Y_1 = Change in Y due to RBP …(2)

Besides taking milk productivity as the outcome variable to assess the impact, the effect on feed cost per day and per litre of Fat Corrected Milk (FCM) was also studied. From the data on prices and quantity of different feed and fodder fed to the animals in the two time periods, feed cost was worked out and the differences in the same were computed for the final sample of observations that were also used in the regression equation.

With-Without Approach: Primary Data

Propensity Score Matching Technique (PSM), propounded by Rosenbaum and Rubin (1983) was used for quantifying the impact on milk productivity and feed cost. This statistical matching technique attempts to estimate the effect of a treatment, policy, or other intervention by accounting for the covariates that predict receiving the treatment. The basic premise of the approach is to work out the average treatment effect on the treated (ATT):

$$ATT = E(\Delta| X,T=1) = E(Y_t^1 - Y_t^0| X,T=1)$$
$$= E(Y_t^1| X,T=1) - E(| X,T=0)$$

where, Y is the outcome variable of interest at time t between two treatments, denoted by the superscripts 1 and 0 (i.e. T=1 implies received RBP intervention and T=0, no intervention). Since the RBP beneficiary households also had animals that were not explicitly covered under the advisory services, hence the X was taken as a vector of animal characteristic, rather than household characteristic. To estimate the effects of RBP, propensity scores were estimated to match animals with similar observable characteristics, varying only the treatment, which is ration balancing intervention.

Results and Discussion

Effect on Ration Balancing on Milk Productivity

The positive effect of feeding on productivity is well discernible in the regression results based on the data of base period (Table 1). In Gujarat, the quantum of mineral mixture fed to the buffaloes was low and hence, though the regression coefficient had a positive sign, it did not show a significant influence on milk productivity. The regression coefficient of animal parameter (SOL) and the difference in breed had the expected signs. The productivity of animal declines with increase in the stage of lactation after the animal achieves its peak yield by about 70 days after calving. Hence, this is a very important control variable for evaluating the efficacy of ration balancing. The breed dummy for cows was positive and significant, establishing that among the animals of various breeds covered under RBP, the Holstein Friesian and Jersey crosses are higher-yielding animals. The breed dummies for buffaloes, though insignificant, are in consonance with the *a–priori* hypothesis of higher productivity of Mehasana and Murrah buffaloes. In terms of location, the productivity of animals in the milk shed area of Banaskantha was higher than that of Surat; while in Punjab base level productivity differentials were not notable in the two milk unions under study.

The seasonal effect on milk production was captured through a dummy variable of flush season. In Gujarat, the negative and significant sign of the flush season coefficient was in contrast to the *a-priori* expectations, but a detailed examination of the data set revealed that this variable was dominated by the location effect. In the Surat district, where average yield was lower, there were more observations in the lean season than flush season because of which the expected results were distorted. For the overall data, the average productivity of cows in flush season was 9.73 kg as against 8.84 kg in the lean season, while the corresponding figures for buffaloes were 7.22 kg in flush and 6.90 kg in lean season.

Based on the regression results that depict the scenario before RBP intervention, the difference between the predicted yield and observed yield after 180 days shows that there have been positive gains in productivity of dairy animals due to the ration balancing intervention provided to them (Table 2). In Gujarat, the productivity enhancement has been higher for cows (around 13%) than buffaloes (nearly 5.5%). In the case of crossbred cows, the productivity enhancement has been as high as 24 per cent in Banaskantha. A similar kind of gains have been discernible in Surat also for the local cows, but their

Table 1. Determinants of milk productivity

Dependent Variable: log (Yield)

Variables	Regression coefficients			
	Cattle		Buffaloes	
	Gujarat	Punjab	Gujarat	Punjab
C	0.7502 (14.45)	0.3825 (6.33)	0.7182 (11.21)	0.4387 (11.72)
SOL	-0.0010* (-8.14)	-0.0007* (-6.12)	-0.0011* (-7.79)	-0.0011*(-14.88)
Log(SOL)	-0.0033 (-0.31)	0.0123 (1.03)	0.0112 (0.74)	0.0230* (4.54)
FLUSH_A	-0.0221 (-2.33)	-	-	-
FLUSH_B	-	-	-0.0133 (-1.39)	-
FLUSH_C	-	0.0044 (0.29)	-	0.0036 (0.34)
DM_HFJRS	0.2338* (13.48)	0.1487* (5.40)	-	-
DM_MEH	-	-	0.0158 (0.96)	-
DM_MURRA	-	-	-	0.0220 (1.73)
MM	0.0201** (2.49)	0.0948** (2.29)	0.0099 (0.94)	0.1034* (4.81)
TOTALDM	0.1189* (40.89)	0.1468* (43.31)	0.100* (39.01)	0.1148* (46.55)
DM_DISTRICT	-0.1377* (-12.35)	0.0033 (0.27)	-0.0792* (-5.54)	0.0070 (0.87)
R^2	0.5478*	0.6389*	0.4730*	0.6015*
n	3994	2018	4293	3566

Note: *, ** Significant at p<0.01 and p<.005, respectively.

Figures within the parentheses are t-ratios

FLUSH _A = 1 for Oct. to March,= 0 otherwise; FLUSH _B = 1 for Sept.. to Feb., =0 otherwise; FLUSH_C= 1 for Nov.-Feb., =0 otherwise; DM_HFJRS=1 for Holstein Friesian and Jersey crosses, = 0 otherwise; DM_MEH= 1 for Mehasana Buffaloes, = 0 otherwise; DM_MURRA= 1 for Murrah Buffaloes, = 0 otherwise; DM DISTRICT =0 for Banaskantha, =1 for Surat for Gujarat, =0 for Ludhiana, =1 for Ropar for Punjab

Table 2. Effect of ration balancing on animal productivity: INAPH data

Gujarat	Percentage gain in yield	Punjab	Percentage gain in yield
		Cows	
Banaskantha All	22.42	Ludhiana All	10.57
HF Jersey	24.33	HF Jersey	10.54
Others	11.25	Others	10.95
Surat All	1.80	Ropar All	16.42
HF Jersey	0.85	HF Jersey	16.83
Others	24.47	Others	7.87
Gujarat All	12.76	Punjab All	13.01
HF Jersey	12.64	HF Jersey	13.22
Others	13.82	Others	10.03
		Buffaloes	
Banaskantha All	5.26	Ludhiana All	14.2
Mehasana	5.31	Murrah	14.48
Others		Others	12.91
Surat All	6.04	Ropar All	21.68
Mehasana	5.16	Murrah	22.03
Others	6.79	Others	17.95
Gujarat All	5.44	Punjab All	17.35
Mehasana	5.29	Murrah	17.86
Others	6.43	Others	14.18

Table 3. Average milk yield of lactating animals on sample households

(litres/day)

Households	Animals	Gujarat		Punjab	
		Cattle	Buffalo	Cattle	Buffalo
Participants in RBP	Under RBP	11.80	8.41	10.04	7.16
	Not covered under RBP	8.52	7.12	6.69	4.20
Not participating	Not covered under RBP	9.47	6.63	9.25	8.33

number is far too less (<100) to establish the robustness of results.

In the case of buffaloes, the extent of productivity gains has been little higher for breeds other than Mehsana. The estimates of productivity gain due to RBP intervention were also similar to Gujarat in case of cows (about 13%), and much higher in case of buffaloes. The number of local cows are far too few in the region but the results of the productivity gains are quite encouraging. In the case of buffaloes, the effect of RBP in terms of productivity gains was more pronounced in Murrah. However, the analysis based on the field survey was in stark contrast to these results in the case of buffaloes in Punjab.

Based on the simple averages of the milk yield from field survey data of 400 dairy farm households in each state, the productivity of the RBP animals on the treated households worked out to be higher than the Non-RBP animals, except in case of buffaloes in Punjab (Table 3). In the context of the present study, as all the dairy animals of the beneficiary households were not covered under the program, the control group of animals was available not only on the non-participating (untreated) households but also within the participating (Treated) households. Hence, the conditional probability of participation was not estimated at the household level but at the animal level, with order of lactation, stage of lactation, breed, location (district dummy) as the observational characteristics.

There are several matching algorithms such as nearest neighbour, radius matching, kernel, non-linear, etc. Each method requires the definition of a measure of proximity in order to identify non-participants who are acceptably close (in terms of the propensity score) to any given participant. Here the focus was on *nearest-neighbour matching* as this method assigns a weight of one to the nearest non-participant and zero to others. If there are more than one individual in the neighbourhood then the method assigns equal weight to each and a zero weight to people outside the neighborhood. Hence, it is expected that this matching would have also picked up the locational effect of a village, since observations were arranged according to the sample village.

A formal analysis of the data substantiates that in Gujarat ration balancing has increased milk productivity of both cows and buffaloes by about 19.5 per cent and 18.0 per cent, respectively (Table 4). The quantum of increase discernible from the with-without approach after controlling for the confounding factors, is higher than the same estimated based on before-after approach using a much larger sample. The case of Punjab is somewhat different than that of Gujarat. The average productivity of cows was significantly higher for lactating animals under RBP as per both, the unmatched data and the estimation of Average Treatment on Treated (ATT). But unlike Gujarat, in Punjab the ATT effect was higher (16.7%) than the unmatched difference (15.2%). The productivity differentials in buffaloes that showed significantly lower productivity of RBP animals than non-RBP animals in the unmatched sample turned out to be non-significant after PSM, implying that in buffaloes the effect of RBP has not been established based on the field survey. The results of impact analysis from field data and INAPH database are in consonance for cows but not for buffaloes.

Effect of Ration Balancing on Feed Cost

Ration balancing is a cost-effective intervention leading to a decrease in the daily expenditure on animal feeding. The feed cost decline is discernible not only in terms of unit output of milk but also in absolute terms that is per cattle head (Table 5). The cost

Table 4. Milk productivity differentials of lactating animals with and with-out ration balancing advisory in Gujarat and Punjab

Animal	Sample	Treated	Controlled	Difference	Percentage change
			Gujarat		
Cow	Unmatched	11.90 (n=274)	9.55 (n=354)	2.35* (S.E.= 0.41)	24.63
	ATT	11.90 (n=271)	9.95 (n=326)	1.94* (S.E.= 0.64)	19.54
Buffalo	Unmatched	8.41 (n=135)	6.82 (n=226)	1.59* (S.E.= 0.37)	23.31
	ATT	8.41 (n=135)	7.11 (n=226)	1.30** (S.E.= 0.64)	18.31
			Punjab		
Cow	Unmatched	10.04 (n=109)	8.72 (n=244)	1.32* (S.E.= 0.33)	15.18
\	ATT	10.04 (n=109)	8.61 (n=244)	1.43** (S.E.= 0.55)	16.66
Buffalo	Unmatched	7.17 (n=191)	7.77 (n=161)	-0.60** (S.E.= 0.26)	-7.66
	ATT	7.17 (n=189)	7.42 (n=161)	-0.24 (S.E.= 0.50)	-3.26

Note: ATT- Average Treatment on the Treated, SE- Standard error, * Significant at 1 per cent level, ** Significant at 5 per cent level

Table 5. Decrease in feed cost from ration balancing intervention: INAPH database

Particulars	Feed cost per day			Feed cost/litre FCM		
	Before RBP (₹)	After RBP (₹)	Change (%)	Before RBP (₹)	After RBP (₹)	Change (%)
			Gujarat: Cattle			
Banaskantha	101.97	92.93	-8.87	12.52	11.29	-9.86
Surat	100.43	79.84	-20.50	13.17	12.41	-5.76
State	101.19	86.29	-14.72	12.85	11.86	-7.73
			Gujarat: Buffalo			
Banaskantha	85.45	77.36	-9.47	9.88	9.01	-8.76
Surat	84.16	76.20	-9.45	10.39	9.30	-10.42
State	85.13	77.07	-9.47	10.00	9.08	-9.19
			Punjab: Cattle			
Ludhiana	156.73	138.89	-11.38	19.71	17.58	-10.83
Ropar	170.12	153.61	-9.70	22.02	19.44	-11.71
State	162.54	145.27	-10.62	20.71	18.38	-11.25
			Punjab: Buffalo			
Ludhiana	144.82	131.45	-9.23	16.08	15.66	-2.61
Ropar	152.21	150.11	-1.37	16.37	16.10	-1.65
State	147.99	139.39	-5.81	16.20	15.85	-2.20

Table 6. Effect of ration balancing on feed cost and milk-feed ratio: evidence from sample survey

Animal		Sample	Treated	Controlled	Difference	Change (%)
			Gujarat			
Cow	Milk- feed ratio	Unmatched	1.76	1.54	0.21* (0.05)	13.69
		ATT	1.76	1.55	0.21** (0.08)	13.22
	Feed cost/ litre	Unmatched	17.66	21.67	-4.01* (1.12)	-18.51
		ATT	17.66	21.50	-3.84** (1.73)	-17.87
Buffalo	Milk- feed ratio	Unmatched	2.33	2.06	0.27*** (0.16)	13.12
		ATT	2.33	2.21	0.12 (0.26)	5.64
	Feed cost/ litre	Unmatched	28.15	32.37	-4.21 (2.59)	-13.02
		ATT	28.15	28.90	-0.75 (3.78)	-2.60
			Punjab			
Cow	Milk- feed ratio	Unmatched	1.70	1.32	0.38* (0.07)	28.80
		ATT	1.70	1.27	0.43* (0.11)	34.08
	Feed cost/ litre	Unmatched	17.36	20.55	-3.20* (0.94)	-15.55
		ATT	17.36	21.47	-4.11** (1.62)	-19.16
Buffalo	Milk- feed ratio	Unmatched	1.93	1.78	0.15*** (0.08)	8.43
		ATT	1.93	1.64	0.29** (0.13)	17.85
	Feed cost/ litre	Unmatched	24.38	25.92	-1.55 (1.47)	-5.97
		ATT	24.38	29.79	-5.41*** (2.95)	-18.16

Note: Figures within the parentheses are standard errors, * Significant at 1 per cent level, ** Significant at 5 per cent level, ** * Significant at 10 per cent level

efficiency is more pronounced in cows than buffaloes. In cattle, the feed cost per litre FCM reduced by 5.76 - 9.86 per cent in Gujarat and by 10.83 - 18.53 per cent in Punjab.

The field level data also indicated a clear impact in reducing the feed cost per litre of milk by about 18-19 per cent in case of cows in both the states and about 2.6 per cent in buffaloes in Gujarat. The unit cost of feed declined significantly ($p<0.10$) in the case of buffaloes also in Punjab, although the productivity differences between RBP and non-RBP animals were not significant. The decrease in feed cost and significant increase or non-significant change (Punjab buffaloes) in milk productivity has led to improvement in milk-feed ratio, i.e. the ratio of gross returns from milk output per unit of feed cost.

Table 7. Required increase in milk productivity and reduction in feed cost for doubling dairy income from ration balancing

Particulars	Scenario I Low cost-low productivity-low prices		Scenario II Average cost-average productivity-average prices	
	Crossbred cow	Buffalo	Crossbred cow	Buffalo
Daily maintenance cost (₹/animal)	150	160	200	190
Daily feed cost (₹/animal)	105	112	130	123
Milk yield (kg/day)	4.3	3.2	7.3	5.8
Farm gate prices of milk (₹/kg)	25	32	30	38
Target change in real net income (%)	≥ 100	≥ 100	≥ 100	≥ 100
Warranted change in				
Milk yield (%)	35 (5.8)	40 (4.5)	5 (7.7)	5 (6.1)
Daily feed cost (%)	5	11	5	11

Note: (i) Cost estimates at 2016-17 prices (ii) Milk yield 2015-16 (iii) Prices 2016-17 (iv) Figures within the parentheses indicate warranted milk yield

Potential of Enhancing Dairy Income

Despite divergence in the estimated productivity gains and feed cost reduction based on two approaches, the evidence of positive effect of ration balancing intervention is unambiguously established in the case of crossbred cows. In buffaloes also, although manifestation of gains in productivity are somewhat uncertain in Punjab, yet its influence on decreasing feed cost is clear-cut. At the state level, the current milk productivity levels of crossbreds range from 4.3 kg/day in Assam to 10.8 kg/day in Punjab with all-India average of 7.3 kg/day, while the average milk yield of buffaloes is about 3.2 kg/day in Karnataka and 9.0 kg/day in Punjab, averaging to 5.8 kg/day in the country (DAHD&F, 2016). The extensive field survey carried out in 18 districts representing diverse dairy production environments (dynamic, transient and underdeveloped) and geographical belts[§] has indicated that at 2012-13 prices the maintenance cost of crossbred cows and buffaloes ranged from about ₹ 100/animal/day in the hill region of Uttrakhand and tribal region of Chhattisgarh to ₹ 205 (for crossbreds) and ₹ 220/day (for buffaloes) in western Maharashtra (Sirohi *et al.,* 2015). The feed cost component was about 70 per cent of the maintenance cost in the low cost regions and in the high cost regions where share of labour and miscellaneous expenses was relatively higher, expenditure share on feed input was close to 65 per cent. Drawing from this comprehensive study on the cost of milk production and correcting for the inflationary trends since 2012-13; the estimated daily maintenance cost of dairy animals at current prices worked out to be at least ₹ 150-160/animal with all-India mean of ₹ 190-200/day (Table 7). The corresponding feed cost worked out at the rate of 70 per cent of the gross cost in low cost region and at average rate of 65 per cent is also given in Table 7. Given the estimates of milk yield, gross and feed cost; current farm-gate price of milk is another important item that is required for getting useful insights about the potential of ration balancing to double famers' income. There are wide regional variations in the country with respect to price of milk realized by the famers. The areas such as Gujarat where organized milk marketing network is well-established, the procurement price of cow milk (4.5% fat and 8.5% SNF) is about ₹ 38/kg and that of buffalo milk (6.0% fat and 9.0%

§ **Dynamic Production Environment:** Belt 1 Northern Plains (Moga and Bulandshahar), Belt 2 Gujarat (Anand and Mehsana), Belt 3 Tamil Nadu (Coimbatore and Trichy)
Transient Production Environment: Belt 1 Malwa region (Indore and Ratlam), Belt 2 Western Maharashtra (Ahmednagar and Pune), Belt 3 Eastern Uttar Pradesh& Bihar (Patna and Gorakhpur)
Underdeveloped Production Environment: Belt 1 North-east (East Khasi Hill and Ri-bho), Belt 2 Chattisgarh (Koriya and Surguja), Belt 3 Uttrakhand hills (Almora and Nainital)

SNF) is nearly ₹ 45/kg. In several regions where milk is largely disposed-off by the famers to the vendors, the corresponding rates are much lower, ₹ 25/kg for cow and ₹ 32/kg for buffalo milk (Sirohi *et al.*, 2016).

The simple back-of-the-envelope calculations have shown that for the crossbred animals that have milk productivity and costs similar to respective national averages, ration balancing intervention can double the real dairy income (at 2016-17 prices) even with only 5 per cent increase in milk yield and 5 per cent decline in feed cost. However, taking the low cost-productivity-milk price scenario, as the possibility of reducing the feed cost would be limited (5% decline), the milk yield from ration balancing should increase by at least 35 per cent (5.8 kg/day from the existing level of 4.3 kg/day) to get positive returns from rearing crossbreds.

In the case of buffaloes, where potential of yield increase is not as profound as for crossbreds, the ration balancing can be an option for doubling dairy farm income if at least 11 per cent feed cost reduction is achieved with 5% productivity gain in average scenario and 40 per cent gain (4.5 kg/day from 3.1 kg/day) in least-productivity scenario.

The discussions in the earlier sections have indicated that realized gains in milk productivity of crossbreds from ration balancing are 10-20 per cent and from feed cost reduction 10-15 per cent. Hence, for the famers rearing crossbreds with average milk productivity of about 7.3 kg/day, this intervention alone has immense potential to enhance net real income from dairy farming. But, in the case of low-producing animals, management of feeding will not suffice to achieve the desired outcome and has to be supplemented by interventions to improve the breeding and reproductive efficiency of the animals. Similarly, on buffalo-dominant farm households, the potential exists for milk yielders of average 5.8 kg/day, while for low-producing buffaloes, efforts other than ration balancing would also be required.

Conclusions

Ration balancing has shown a clear quantifiable positive impact on enhancing income from dairy farming in Gujarat and Punjab, the two leading states in the dairy sector. The intervention is provided in the form of advisory services to the farmers under the NDP. The farm advisory programs are more difficult to implement and monitor successfully in comparison to any other type of farmer-oriented development program. For the success of the program it must be demand-driven. The development of demand-driven advisory services emerge when the farmers are motivated, they have adequate capacity and organisations to formulate their demands, there is a good choice of advisers available to deliver the service and the delivery systems make service providers accountable to the users. Motivation of the famers is linked to availability of reliable and profitable market opportunities and requires unambiguous evidence that any service serves the interest of the users. As part of the action plan to double farmers' income, the farmers will have to be motivated through massive advertising about the benefits of ration balancing through print and digital media, screening of documentary in villages about successful case studies, etc.

At present, the main delivery agent of advisory services is the Local Resource Person in the village. However, to enhance the choice of advisers/source of advice, support should be forthcoming through developing a mobile app of the ration balancing as part of Digital India campaign, dissemination of information about use of app, periodic training of farmers groups about using the app, keeping a netbook at dairy cooperative societies, where farmers can access the facility free of cost, creating the expertise of ration balancing advisory with private suppliers of the prepared cattle feed, Krishi Vigyan Kendras and other extension functionaries. The experience of RBP under the NDP can provide useful learning lessons for inculcating among farm households the system of balancing the animal ration and hence realize notable gains in income from dairy farming.

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