

Impact of Ration Balancing on Productive Performance and Economics of Milk Production in Field Conditions

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ABSTRACT

A field survey was conducted to assess the extent of productivity increase and cost reduction on the adoption of ration balancing programme (RBP) of dairy animals undertaken by ICAR-NDRI. Out of four villages selected, two villages received services such as the provision of the mineral mixture from ICAR-NDRI and ration balancing programme implemented under NDP-I (Treatment villages – Lalukheri and Alipur) and the other two villages didn't receive any kind of services (Control villages – Dhansaini and Bhoura-Khurd). From each village, about 50 dairy farmers were randomly selected. Data were collected on feeding management practices using a pre-tested interview schedule. The collected data was analyzed using propensity score matching to control bias due to confounding variables. Results revealed that more cattle and buffaloes were fed on a balanced ration in treatment villages as compared to control villages. Attributed to ration balancing the average daily milk yield of Murrah, HF and Jersey crossbreds was significantly increased by 25.7%, 18.8% and 37.0% (unmatched) respectively, and the corresponding quantum of increase after controlling for the confounding factors by calculation of average treatment on the treated (ATT) resulted in an 8.8%, 9.3% and 13.4% increase. Fat% and SNF% were improved significantly ($p < 0.01$) only in Murrah buffaloes fed with balanced ration. Total feeding cost didn't vary between RBP and non-RBP animals after the calculation of ATT. However, the cost of feed per kg of milk of the RBP animals was found to be around 15% ($p < 0.01$) lower than the non-RBP animals. The total returns, net returns from milk production as well as the milk-feed ratio of RBP animals were significantly higher.

Key words: Feed cost, Milk yield, Propensity score matching, Ration balancing.

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INTRODUCTION

In India, livestock rearing is an important element of the rural economy and social fabric. Animal husbandry plays an important part in the sustaining livelihood of India's rural population by providing employment, social security and food security throughout the year (Ali, 2007). In India, 70% of rural households depend on livestock for their livelihood and majority of them are landless, marginal, and small households (Otte *et al.*, 2012). In the case of landless farmers, livestock is sometimes their only source of capital (Dash, 2017). The government of India has implemented various dairy development projects like National Dairy Plan, National Programme on Bovine Breeding and Dairy Development, AICRP (All India Coordinated Research Projects), TRYSEM (Training of Rural Youth for Self-employment) etc. The general objective of these projects is to enhance the productivity of milch animals through effective feeding, breeding, disease control measures, and proper marketing channels. The average daily milk production figures of 8.09 kg for crossbred cows, 3.90 kg for indigenous cattle, and 6.43 kg for indigenous buffaloes is substantially lower than their genetic potential (DAHD, 2020-21). It is well acknowledged that disparities in nutrition have a significant role in dairy cows' reduced productivity and health-related problems (Mudgal *et al.*, 2003).

The cost of feeding contributes to 70% of the overall cost of milk production; hence balanced feeding of dairy animals

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using available feed supplies is critical to achieving economic advantages from milk production (Duncan *et al.*, 2013). It's also crucial to fulfilling the nutritional requirements of growing and lactating animals in terms of energy, protein, minerals, and vitamins so that they can produce milk that meets their genetic potential while minimizing total milk production costs. Efforts should be made to boost farmers' income by assisting them with livestock processes such as breeding, feeding, management, and healthcare interventions to improve livestock performance. The fundamental idea of increasing income is to improve productivity while stabilising income and managing risk using a comprehensive approach. Keeping in view of the status of dairy animals in western Uttar Pradesh (Muzaffarnagar), ICAR-NDRI had started a

field operational project and conducted a ration balancing programme and also provided mineral mixture in the study area. Therefore, it was pertinent to analyse the impact of ration balancing intervention on the production performance of dairy animals in the farmers' herd.

MATERIALS AND METHODS

Selection of Villages and Animals

The present study was conducted in the RBP (Ration Balancing Programme) and non-RBP implemented villages of the Muzaffarnagar district of Uttar Pradesh during the year 2021. Ration balancing programme under NDP-I was implemented in the study area. Out of four villages selected randomly, two villages received services (ration balancing programme and provision of mineral mixture) from the ICAR-NDRI centre located near Lalukheri (Treatment villages – Lalukheri and Alipur) and the other two villages didn't receive any kind of services from the ICAR-NDRI centre in past (Control villages – Dhansaini and Bhoura-Khurd).

From each village, around 50 dairy farmers were randomly selected for collecting the information regarding feeding practices using a pre-tested schedule. All respondents had at least one lactating dairy animal at the time of data collection. Number of HF and Jersey crossbred cattle covered under RBP treatment from Lalukheri and Alipur were 29 and 27, and Murrah buffaloes 24 and 26, respectively, while the corresponding figures of cattle covered under non-RBP village Dhansaini and Bhoura-Khurd were 26 and 25, and buffaloes 25 and 24, respectively. Thus, the data of 206 lactating animals were collected. Initial data on body weight, parity, stage of lactation, peak yield, pregnancy status, feed ingredients, daily feed intake, cost of feed, daily milk yield, fat and SNF content in milk were recorded.

Propensity Score Matching

The effect of the RBP on beneficiaries and non-beneficiaries was quantified using the propensity score matching (PSM) approach. Propensity score matching is a method of "correcting" the estimation of treatment effects by controlling for the presence of confounding factors. PSM, is an algorithm that matches treated and non-participants based on the conditional probability of participation (propensity scores) given observable attributes. Various matching algorithms are available, including nearest neighbour, kernel matching, radius matching, non-linear matching, and so on. In order to find nonparticipants who are acceptably close (in terms of the propensity score) to any particular participant, each approach requires the formulation of a measure of proximity.

The approach to calculate the average treatment effect on the treated, *i.e.*, ATT was as under (Wang *et al.*, 2013):

$$\begin{aligned} \text{ATT} &= E(\Delta | X, T=1) = E(Y_t^1 - Y_t^0 | X, T=1) \\ &= E(Y_t^1 | X, T=1) - E(Y_t^0 | X, T=0) \end{aligned}$$

Where, Y is the outcome variable of interest at time t between two interventions, indicated by the superscripts 1

and 0 (*i.e.*, T=1 means RBP intervention was received, while T=0 means no intervention).

Because the programme did not cover all dairy animals in beneficiary households, the control group of animals was present not only in non-participating (untreated) households but also in participating (Treated) households in the current study. As a result, the conditional probability of participation was calculated at the animal level rather than at the household level. Hence, vector X was taken as a vector of animal characteristics, *i.e.*, weight, age at first calving, order of lactation, stage of lactation, peak yield and village (dummy) as observational variables. To evaluate the effects of RBP, propensity scores were calculated to match animals with comparable observable traits, with the treatment, which is ration balancing.

Statistical Analysis

The collected data were scored, compiled, and tabulated using Microsoft Excel, 2019 and analyzed systematically commensurate with the objectives of the study using statistical software SPSS 22 (SPSS version 22, SPSS Inc. Chicago, Illinois), and STATA version 15 was used for propensity score matching.

RESULTS AND DISCUSSION

Adoption of Balanced Feeding Practices

In the practice of feeding a balanced ration, feed ingredients such as green fodder, dry fodder, concentrates, mineral mixture and supplements are offered in such quantities which allow dairy animals to perform efficiently and remain healthy by fulfilling their nutritional requirements in terms of energy, proteins, minerals and vitamins. In most circumstances, the amount of feed/fodder provided to dairy animals exceeds or falls short of the needs. Dairy farmers rarely offer mineral mixture to the animals or in very fewer quantities usually less than 50 gm per day. This causes a protein, energy, and mineral imbalance in their diet. Animals on such a traditional ration produce milk inefficiently, resulting in greater milk production costs and a negative impact on animal health and fertility.

It is clear from Table 1 that in treatment villages around 25% of the cattle and buffaloes were fed on a balanced ration, while in control villages 16% of cattle and buffaloes were fed on a balanced ration. In control villages, a lesser number of dairy farmers were aware of the significance of balanced feeding, which might be attributable to a lack of execution of the ration balancing programme or any extension activity regarding the feeding of dairy animals. This suggests that there is a wide opportunity to encourage dairy farmers to adopt balanced feeding practices to produce quality and quantity milk. These findings are in line with the results of Patil *et al.* (2014), who reported that 20.5% of dairy farmers were found to offer a balanced ration in Ramtek Tahsil of Nagpur. Whereas Rathod *et al.* (2014) reported that 46.5%



of dairy farmers in the Bidar District of Karnataka adopted balanced feeding.

Table 1: Percentage of dairy animals fed on balanced ration in select villages

Feeding practice	Treatment village				Control village			
	Lalukheri		Alipur		Dhansaini		Bhoura-Khurd	
	N	%	N	%	N	%	N	%
Balanced ration	13	24.52	14	26.41	7	13.72	9	18.36
Traditional ration	40	75.48	39	73.59	44	86.28	40	81.64

Effect of RBP on Milk Production

The data on RBP and non-RBP animals were analysed by propensity score matching to control the confounding variables. According to both unmatched data and the calculation of average treatment on treated (ATT), the average productivity of the RBP animals in the treated households worked out to be significantly higher than the non-RBP animals (Table 2). However, the difference in productivity due to the ATT effect was smaller than the unmatched difference. Because RBP animals were comparable to their non-RBP counterparts in terms of weight, age at first calving, order of lactation, stage of lactation, and peak yield, there was a smaller difference following the propensity score matching and computation of ATT.

Table 2: Milk productivity differentials of lactating animals with and without ration balancing

Animal	Sample	Milk productivity (L)		Difference	
		Treated	Control	Absolute	% change
Murrah buffalo	Unmatched	11.84 (n=21)	8.78 (n=78)	3.06** (SE=0.47)	25.7
	ATT	11.84 (n=21)	10.79 (n=78)	1.05* (SE=0.46)	8.8
Holstein Friesian cross	Unmatched	12.37 (n=12)	10.04 (n=46)	2.33** (SE=0.52)	18.8
	ATT	12.37 (n=12)	11.20 (n=46)	1.17* (SE=0.50)	9.3
Jersey cross	Unmatched	9.75 (n=11)	6.71 (n=39)	3.04** (SE=0.48)	37.0
	ATT	9.75 (n=11)	8.45 (n=39)	1.30** (SE=0.48)	13.4

ATT - Average Treatment on the Treated, SE - Standard error, ** Significant at 1%, *Significant at 5%

The results of the present study are in accordance with the findings of Deen *et al.* (2019), who reported that after ration balancing, milk productivity of lactating crossbreds increased significantly (p<0.01) by 18.0%. Sherasia *et al.* (2016) reported only 3.6% increase in milk productivity after ration balancing. Moreover, our findings are lesser than the observations earlier reported by Sirohi *et al.* (2017) on dairy

animals in Gujarat and Punjab wherein they found that in Gujarat, milk productivity of cows and buffaloes under RBP increased by 19.5% and 18.0% after applying propensity score matching (calculation of ATT) on the primary data, while in Punjab milk productivity of RBP cows increased by 16.66%.

Increased rumen degradability of dry matter, which might be caused by improved rumen microbial flora and rumen microbial biomass, could explain the rise in milk output. The balanced ration also contains essential nutrients required for optimal efficiency, that is why it increased milk yield (Kannan *et al.*, 2011). In addition to this, dietary energy and protein might be used by lactating animals more effectively when fed in a balanced manner (Garg and Bhandari, 2011).

Effect on Milk Composition

Fat% was significantly (P < 0.01) higher in the case of Murrah buffaloes fed with balanced ration than non-RBP buffaloes. In case of HF crossbreds, there was a significant (P < 0.01) difference in fat% before propensity score matching but after calculation of ATT, there was no significant difference between RBP and non-RBP HF crossbreds. While in Jersey crossbreds there was no significant difference in fat% (Table 3).

Table 3: Effect of RBP on milk fat% in different categories of dairy animals

Animal	Sample	Milk fat%		Difference	
		Treated	Control	Absolute	% change
Murrah buffalo	Unmatched	7.17 (n=11)	6.85 (n=43)	0.32** (SE=0.09)	4.3
	ATT	7.17 (n=11)	6.82 (n=43)	0.35** (SE=0.12)	4.7
Holstein Friesian cross	Unmatched	3.70 (n=7)	3.57 (n=27)	0.13** (SE=0.04)	3.2
	ATT	3.70 (n=7)	3.67 (n=27)	0.03 (SE=0.05)	0.5
Jersey cross	Unmatched	4.57 (n=7)	4.55 (n=23)	0.02 (SE=0.04)	0.2
	ATT	4.57 (n=7)	4.52 (n=23)	0.05 (SE=0.06)	0.8

ATT - Average Treatment on the Treated, SE - Standard error, ** Significant at 1%, *Significant at 5%

A similar trend was seen in the case of SNF%, there was a significant (P < 0.05) difference in SNF% of RBP and non-RBP buffaloes in unmatched data and after calculation of ATT, the difference between RBP and non-RBP animals in terms of SNF% slightly increased to 1.34% (Table 4).

The findings of the present study are partially in line with the results of Sirohi *et al.* (2017), who reported that milk fat didn't differ to any significant level in both cattle and buffalo after feeding of balanced ration. Similarly, Deen *et al.* (2019) found that ration balancing had no effect on milk fat, but SNF exhibited 7% improvement. However, the result of the present study is contrary to that observed by Atturi *et al.* (2018), who reported that Ongole cows had the highest increase in milk fat (25.84%) after ration balancing, followed

Table 4: Effect of RBP on milk SNF% in different categories of dairy animals

Animal	Sample	Milk SNF%		Difference	
		Treated	Control	Absolute	% change
Murrah buffalo	Unmatched	9.66 (n=11)	9.57 (n=43)	0.09* (SE=0.04)	0.8
	ATT	9.66 (n=11)	9.52 (n=43)	0.14* (SE=0.05)	1.34
Holstein Friesian cross	Unmatched	9.14 (n=7)	9.14 (n=27)	0.00 (SE=0.02)	0
	ATT	9.14 (n=7)	9.16 (n=27)	-0.02 (SE=0.03)	-0.2
Jersey cross	Unmatched	8.84 (n=7)	8.89 (n=23)	-0.05 (SE=0.035)	-0.4
	ATT	8.84 (n=7)	8.86 (n=23)	-0.02 (SE=0.041)	-0.1

by Jersey crossbreds (24.6%) and HF crossbreds (5.88%). Vagamashi *et al.* (2016) observed a significant improvement in milk fat content of 8.54% as well after ration balancing. According to Garg *et al.* (2016), balancing the feeds of cattle in field conditions resulted in a significant improvement ($p < 0.05$) in the SNF content of milk.

The improvement in milk fat and SNF may be attributed to the optimal level of nutrients in the ration of lactating animals which in turn improved the microbial flora of rumen. The main factors affecting the effectiveness of rumen fermentation and, subsequently, the synthesis of milk components in mammary glands, are the relative quantities and ideal levels of energy, protein, and minerals that are present in the rumen.

Effect on Daily Feeding Cost

The daily total feeding cost of Murrah buffaloes and Jersey crossbreds was significantly ($p < 0.01$) higher according to unmatched data, But after calculation of ATT there was no significant difference in total feeding cost between RBP and non-RBP animals. However, in the case of HF crossbreds, there

was no significant difference, even in the case of unmatched data (Table 5). This increase in feeding cost in unmatched data was attributed to increased inclusion of selected ingredients in the practice of balanced ration feeding to supplement lactating animals' optimal intake of deficit nutrients.

These results are in general agreement with the findings of Deen *et al.* (2019), who reported a 20% increase in the overall cost of ration after RBP. However, the results are contrary to those observed by Sherasia *et al.* (2016), where feeding costs decreased by 17%, after feeding crossbred cows with a balanced ration.

Effect on the Cost of Feed per kg of Milk Production

According to both unmatched data and the calculation of ATT, the cost of feed per kg of milk produced by the RBP animals in the treated households worked out to be significantly ($p < 0.01$) lower than the non-RBP animals (Table 6), and the difference in cost of feed per kg of milk produced due to ATT effect was almost same to the unmatched difference. This advantage came from a reduction in excess feeding waste and an increase in production efficiency.

Table 5: Effect of RBP on daily total feeding cost per head in different categories of dairy animals

Animal	Sample	Total feeding cost (Rs)		Difference	
		Treated	Control	Absolute	% change
Murrah buffalo	Unmatched	261.78 (n=21)	223.24 (n=78)	38.54** (SE=10.67)	14.71
	ATT	261.78 (n=21)	262.07 (n=78)	-0.29 (SE=11.57)	-0.001
Holstein Friesian cross	Unmatched	206.87 (n=12)	192.80 (n=46)	14.07 (SE=10.82)	6.80
	ATT	206.87 (n=12)	217.50 (n=46)	-10.63 (SE=11.61)	-5.13
Jersey cross	Unmatched	182.00 (n=11)	144.36 (n=39)	37.64** (SE=10.83)	20.68
	ATT	182.00 (n=11)	183.45 (n=39)	-1.45 (SE=13.41)	-0.007

ATT - Average Treatment on the Treated, SE - Standard error, **Significant at 1%, *Significant at 5%



Table 6: Effect of RBP on the cost of feed per kg of milk in different categories of dairy animals

Animal	Sample	Cost of feed/kg milk (Rs)		Difference	
		Treated	Control	Absolute	% change
Murrah buffalo	Unmatched	22.13 (n=21)	25.65 (n=78)	-3.52** (SE=0.53)	-15.90
	ATT	22.13 (n=21)	24.37 (n=78)	-2.24** (SE=0.64)	-10.16
Holstein Friesian cross	Unmatched	16.68 (n=12)	19.17 (n=46)	-2.49** (SE=0.49)	-14.86
	ATT	16.68 (n=12)	19.34 (n=46)	-2.66** (SE=0.66)	-15.82
Jersey cross	Unmatched	18.69 (n=11)	21.52 (n=39)	-2.83** (SE=0.56)	-15.0
	ATT	18.69 (n=11)	21.68 (n=39)	-2.99** (SE=1.00)	-16.0

ATT - Average Treatment on the Treated, SE - Standard error, **Significant at 1%, *Significant at 5%

Table 7: Effect of RBP on net returns in different categories of dairy animals

Animal	Sample	Net returns (Rs)		Difference	
		Treated	Control	Absolute	% change
Murrah buffalo	Unmatched	333.29 (n=21)	212.85 (n=78)	120.44** (SE=13.98)	36.13
	ATT	333.29 (n=21)	270.78 (n=78)	62.51** (SE=15.47)	18.75
Holstein Friesian cross	Unmatched	242.50 (n=12)	164.75 (n=46)	77.75** (SE=12.56)	32.06
	ATT	242.50 (n=12)	172.84 (n=46)	69.66** (SE=13.21)	28.72
Jersey cross	Unmatched	198.40 (n=11)	115.50 (n=39)	82.90** (SE=10.34)	41.34
	ATT	198.40 (n=11)	147.36 (n=39)	51.04** (SE=15.21)	25.72

ATT - Average Treatment on the Treated, SE - Standard error, **Significant at 1%, *Significant at 5%

Table 8: Effect of RBP on milk-feed ratio in different categories of dairy animals

Animal	Sample	Milk-feed ratio		Difference	
		Treated	Control	Absolute	% change
Murrah buffalo	Unmatched	2.27 (n=21)	1.95 (n=78)	0.32** (SE=0.042)	14.09
	ATT	2.27 (n=21)	2.04 (n=78)	0.23** (SE=0.062)	10.13
Holstein Friesian cross	Unmatched	2.19 (n=12)	1.86 (n=46)	0.33** (SE=0.068)	14.61
	ATT	2.19 (n=12)	1.83 (n=46)	0.36** (SE=0.074)	15.98
Jersey cross	Unmatched	2.10 (n=11)	1.81 (n=39)	0.30** (SE=0.05)	14.28
	ATT	2.10 (n=11)	1.81 (n=39)	0.30** (SE=0.10)	13.8

ATT - Average Treatment on the Treated, SE - Standard error, **Significant at 1%, *Significant at 5%

The findings of the present study are partially in agreement with Deen *et al.* (2019) who reported a significant ($p < 0.05$) decrease in the cost of feed per kg of milk production by 18% after balanced feeding. Similar 18-19% reduction was seen by Sirohi *et al.* (2017) in the cost of feed

per kg of milk in cows of Gujarat and Punjab. Garg *et al.* (2009) also reported a significant ($p < 0.05$) decrease in the cost of feeding (Rs/kg milk) as a result of ration balancing, which also led to higher income for the dairy farmer.

Effect on Net Returns over Feeding Cost

According to both unmatched data and the calculation of ATT the net returns over feeding cost (Rs per animal per day) from the RBP animals in the treated households worked out to be significantly higher than the non-RBP animals (Table 7). However, the difference in net returns due to the ATT effect was smaller than the unmatched difference. This increase in net returns was attributed to the increase in milk productivity of dairy animals and efficient utilisation of feed ingredients. The findings of the present study are in consonance with the findings of Deen *et al.* (2019), who reported a 30% increase in net returns after feeding of balanced ration.

Effect of Ration Balancing on Milk-Feed Ratio

According to both unmatched data and the calculation of ATT the milk-feed ratio of RBP animals in the treated households was worked out to be significantly higher than that of non-RBP animals (Table 8). However, the difference in milk-feed ratio due to the ATT effect was almost similar to the unmatched difference.

These findings partially supported the results of Sirohi *et al.* (2017), who reported significantly increased milk-feed ratio by 13.22% in the case of cows and 5.6% in the case of buffaloes of Gujarat, whereas in Punjab the milk-feed ratio increased significantly by 34% in the case of cows and 17.8% in buffaloes.

CONCLUSION

It is evident from the data that the adoption of balanced feeding practices was higher in treatment villages than in control villages. Ration balancing had improved the production performance of animals and dairy producers' profit. The promotion of balanced feeding and ration balancing methods is necessary under field conditions. The comprehensive econometric analysis used in this paper is crucial for understanding the field-level consequences of implementing the practise of providing balanced ration to livestock on cost of milk production and net profits from dairy farming. This study provides evidence that may be used to improve feeding practices for lowering cost of milk production.

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