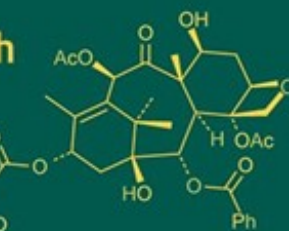
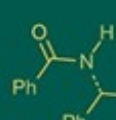


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Effect of mineral supplementation and deworming on productive and reproductive performance of lactating crossbred cows in hilly area of Uttarakhand

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ABSTRACT

The study examined the efficacy of supplementing a mineral mixture on the productive and reproductive performance of lactating crossbred cows. Lactating crossbred cows reared under hilly farming conditions of Uttarakhand often suffer from mineral deficiency and parasitic infestation, which depress milk production and impair reproductive efficiency. A two-year front line demonstration study was conducted with 20 farmers to evaluate the effect of mineral mixture supplementation (40 g/animal/day for 60 days) combined with deworming (fenbendazole, two doses 21 days apart) on the productive and reproductive performance of lactating crossbred cows, in comparison with a control group maintained under existing farmer practice without supplementation. Supplemented cows showed significantly ($P < 0.001$) higher average daily milk yield, peak milk yield and total 60-day milk yield compared with control cows. Reproductive performance also improved significantly ($P < 0.001$) in the demonstrated group, with earlier onset of first postpartum estrus, fewer artificial inseminations required per conception and a shorter conception period. Economically, mineral mixture and deworming supplementation increased daily milk yield by 20.5% over control, generating additional milk worth 72.63 rupees per animal per day against a supplementation cost of only 9.67 rupees per animal per day, yielding a highly favourable benefit-cost ratio of 7.51 for the intervention alone. The overall benefit-cost ratio also improved in supplemented cows. The findings demonstrate that mineral mixture supplementation combined with periodic deworming in the hills of Uttarakhand significantly improved nutrient utilization and mineral bioavailability and hence the productive and reproductive parameters. It is an effective, farmer-adoptable intervention that offers a highly favourable return on investment, making it a viable and economical option for smallholder dairy farmers of the hills of Uttarakhand.

Keywords: Mineral mixture, Deworming, Crossbred cows, Milk yield, Reproductive performance, Benefit-cost ratio

Introduction

Dairy farming is a cornerstone of Uttarakhand's agrarian economy. Dairying forms a major component of the mixed crop-livestock farming system practised by smallholders in the hilly regions of Uttarakhand, contributing significantly to household income and nutritional security (Ministry of Agriculture, 2019) [1]. However, productivity of crossbred cows in these areas remains considerably below their genetic potential, largely due to widespread mineral deficiency in locally available feeds and fodder, and a high prevalence of gastrointestinal parasitism under extensive grazing systems.

A large number of livestock in the hilly areas suffer from deficiencies or imbalances in mineral nutrition. Minerals are essential for growth and reproduction and are involved in a large number of digestive, physiological and biosynthetic processes in the body (Singh *et al.*, 2020) [2]. Soil and feed analyses from the hill region of Uttarakhand have repeatedly shown calcium, phosphorus, zinc, manganese and copper to be below critical levels (Tiware *et al.*, 2012) [3]. Mineral deficiency in dairy animals is the foremost cause of poor growth rate, suppressed body immunity, decreased milk yield and various reproductive disorders (Bindari *et al.*, 2013) [4]. Supplementation of mineral mixture has been shown to improve mineral status, reproductive performance and milk yield of dairy animals under field conditions of the Kumaun hills (Tiware *et al.*, 2012) [3].

Similarly, supplementation of mineral mixture in crossbred cows has been reported to increase milk yield and fat-corrected milk yield through improved nutrient utilization (Sahoo *et al.*, 2017) [5], while mineral block supplementation has also been shown to improve nutrient utilization, milk production and reproductive performance of crossbred cattle under field conditions (Khadda *et al.*, 2014) [6], along with strategic deworming to subside the subclinical parasitic infestation.

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Despite the demonstrated benefits of these interventions, their combined adoption remains limited among hill farmers due to lack of exposure and localized extension evidence. The present study was therefore undertaken to demonstrate and statistically evaluate the combined effect of supplementation of mineral mixture and deworming on the productive and reproductive performance of lactating crossbred cows under farmers' field conditions in the hilly area of Pithoragarh district of Uttarakhand, over a period of two years.

Materials and Methods

Study area

The study was carried out under farmers' field conditions in the hilly region of Pithoragarh district of Uttarakhand over two consecutive years (2023–24, Year 1 or Y_1 ; 2025–26, Year 2 or Y_2).

Selection of farmers

Twenty farmers rearing lactating crossbred dairy cows at a similar stage of lactation and parity were selected. To ensure uniform feeding and management, two cows from each farmer were chosen: one served as the control (T_1) and the other as the demonstrated animal (T_2), giving 20 cows per group. From the first day after calving, T_2 cows were supplemented with a mineral mixture and dewormed with fenbendazole (one 2 g bolus per dose, two doses 21 days apart). Daily milk yield was recorded in the morning and evening. The data on onset of first postpartum estrus and number of inseminations required for conception were recorded on the basis of the owners responses. The demonstration was conducted for a period of 60 days.

Treatment and experimental design

Cows in the demonstrated group were supplemented with chelated mineral mixture (TRIMIN Gold) at 40 g/animal/day for 60 days and dewormed using fenbendazole bolus at 5–7.5 mg/kg body weight, administered twice at an interval of 21 days after calving. Cows in the control group were maintained entirely under the farmers' existing management practice (chokar and salt supplementation) without mineral mixture supplementation or deworming. Both groups were otherwise reared under comparable feeding and management conditions prevailing in the hill farming system, and the protocol was repeated identically in the second year.

Feeding and management

All the dairy cattle were managed under the farmers' management practices. Both groups were fed 5–6 kg dry fodder, 25–30 kg green fodder and 3–4 kg concentrate per crossbred cow per day. The composition of the concentrate was similar for both groups. The concentrate was offered twice a day, just before milking in the morning and evening. Lactating cattle at nearly the same lactation stage, milk yield and parity were selected from the farmers.

Data recorded

Average daily milk yield (kg/day), peak milk yield (kg/day), total milk yield (kg) and 60-day milk yield (kg) were recorded to assess productive performance. First postpartum estrus (days), number of AI/services required for conception and conception period (days) were recorded to assess reproductive performance. Economic indicators, namely rearing cost, gross return, net return and benefit:cost (B:C) ratio, were computed on a per-animal, per-day basis using the prevailing cost of mineral mixture (Rs 200/kg), dewormer (Rs 50/dose), rearing cost (Rs 210/day/animal) and milk sale price (Rs 50/litre).

Statistical analysis

The data were analyzed through the general linear model (GLM) procedure. A linear model was used for all variables using least-squares analysis of variance. In the present study, the fixed factor was treatment (T_1 , control group; T_2 , demonstrated group). The statistical analysis was carried out using SPSS software, version 23. The level of statistical significance was set at $P < 0.05$.

Results and Discussion

Productive performance of lactating crossbred cows with supplementation

The present study demonstrated that supplementation of chelated mineral mixture and deworming significantly ($P < 0.001$) improved milk production traits in the demonstrated group (T_2) in both years. Supplemented cows recorded significantly ($P < 0.001$) higher average daily milk yield, peak milk yield, total milk yield and 60-day milk yield than control cows (T_1) in both years of the study (Table 1). The improved milk traits with supplementation of mineral mixture and deworming in our study were in accordance with (Sahoo *et al.*) [5] from the hill and sub-mountain regions of northern India, where area-specific mineral mixture supplementation improved milk yield by 9.5% and fat-corrected milk yield by 11.8% in crossbred cows through improved nutrient digestibility and mineral bioavailability. Similarly, (Khadda *et al.*, 2014) [6] also stated that mineral and nutritional interventions enhanced milk production under field conditions in crossbred cattle under a semi-arid ecosystem. According to (Mushtaq *et al.*, 2020) [7], pre-partum micro-mineral supplementation significantly increases milk yield while also reducing postpartum oxidative stress in dairy cows. The comparatively larger response observed in the present study may be attributed to the additional benefit of deworming, which likely improved nutrient absorption efficiency by reducing the parasitic burden competing for host nutrients, over and above the mineral supplementation effect alone (Kantwa *et al.*, 2021) [8].

Reproductive performance of lactating crossbred cows with supplementation

The reproductive performance, first postpartum estrus, number of AI/services required for conception and the conception period of the T_1 (control) and T_2 (demonstrated) groups are depicted in Table 2. The first postpartum estrus came significantly ($P < 0.001$) earlier in the demonstrated group (T_2) than in the control group (T_1) in both years. The number of AI/services was significantly ($P < 0.001$) lower in T_2 , which resulted in a significantly ($P < 0.001$) shorter conception period in T_2 than in T_1 in both studied years (Y_1 and Y_2). This magnitude of reproductive improvement is in agreement with earlier field-level evidence that mineral mixture supplementation can improve reproductive efficiency of crossbred cattle by correcting trace-mineral-linked anoestrus and delayed cyclicity (Tiwari *et al.*, 2012) [3], and is consistent with reports of improved reproductive performance and milk quality following mineral mixture supplementation in dairy animals of the sub-mountainous zone (Mohsina *et al.*, 2017) [9]. The deworming alongside mineral supplementation in the present study likely contributed an incremental benefit by reducing the metabolic drain of parasitism on the animal, thereby supporting faster resumption of ovarian cyclicity post-calving (Kumar *et al.*, 2020) [10]. A shorter conception period observed in this study may be attributed to the role of minerals in influencing the physiological changes associated with estrus and reproduction. Minerals play a crucial role in maintaining hormonal balance, which in turn affects the timing of postpartum estrus (Lalhruiipuii *et al.*, 2023) [11].

The early onset of first postpartum estrus in the demonstrated group agrees with the established role of minerals such as copper, zinc, cobalt, manganese, selenium and phosphorus in ovarian activity and hormone function (Singh *et al.*, 2020) [2]. However, deficiency of these minerals delays the return to cyclicity and depresses estrus expression.

The fewer inseminations needed per conception in the demonstrated group point to better fertility. The present findings are in conformity with the results of (Rathore *et al.*, 2017) [12], who reported that mineral supplementation and deworming have a positive effect in reducing the service period of buffaloes. Adequate trace minerals support oocyte quality, uterine involution and early embryo survival. Lower numbers of services per conception also reduce semen, labour and veterinary costs for the farmer (Singh *et al.*, 2020; Kumar *et al.*, 2020) [2, 10]. Similar findings were also reported by (Gupta *et al.*,

2017; Tanwar *et al.*, 2019) [13, 14], who observed a significant difference in service period between mineral mixture supplemented and non-supplemented groups of dairy animals.

Economics of supplementation of mineral mixture and deworming

The economics of supplementation of mineral mixture and deworming are presented in Table 3. Cows in the demonstrated group (T_2), supplemented with mineral mixture and deworming, showed significantly higher average milk yield than the control group (T_1) in both years. The average milk yield was 7.09 kg/day/animal in T_1 (mean of Y_1 and Y_2), whereas in T_2 it was 8.54 kg/day/animal. Therefore, supplementation gave an additional mean of 1.45 kg/day/animal (mean of Y_1 and Y_2), a mean increase of 20.5% by the intervention.

In the present study, labour and housing costs were excluded as they are common fixed costs. The feed cost of rearing was Rs 210.00/day/animal in T_1 in both years. In T_2 it was Rs 219.67/day/animal, which includes Rs 9.67/day for the mineral mixture and dewormer. Despite the higher daily cost, the mean rearing cost per litre of milk was lower in T_2 (Rs 25.72; mean of Y_1 and Y_2) than in T_1 (Rs 29.62; mean of Y_1 and Y_2), a reduction of Rs 3.90 per litre.

The mean gross return per animal per day was Rs 427.13 in T_2 as compared with Rs 354.50 in T_1 . As a result, the mean net return rose from Rs 144.50 (T_1) to Rs 207.46 (T_2) per animal per day, a gain of Rs 62.96. The B:C ratio was therefore higher in T_2 (1.94) than in T_1 (1.69).

The mean value of additional milk was Rs 72.63/day/animal. Against this, the mineral mixture and deworming cost Rs 9.67/day/animal. The B:C ratio for mineral supplementation and deworming alone was therefore 7.51, indicating that the mineral mixture and deworming programme was highly cost-effective on a stand-alone basis.

The B:C ratio is a key measure for evaluating the economic impact of interventions in livestock production. In the present study, the demonstrated crossbred cows produced about 1.45 kg/day (20.5%) more milk than the control cows.

This response was consistent across both years, which suggests that the effect was genuine and not seasonal. Both groups received the same basal ration of dry fodder, green fodder and concentrate, so the improvement can be attributed to mineral mixture supplementation and strategic deworming, not to differences in feeding. In the present study, the B:C ratio improved from 1.69 in the control group to 1.94 in the demonstrated group, confirming that mineral supplementation and deworming are economically viable. These findings are in agreement with earlier reports in dairy animals (Singh *et al.*, 2020; Rathore *et al.*, 2017; Tanwar *et al.*, 2019; Somvanshi *et al.*, 2026) [2, 12, 14, 15]. (Sivaraman *et al.*, 2019) [16] reported B:C ratios of 2.76 and 3.36 in control and treatment milch cows, respectively, when fed an area-specific mineral mixture. Similarly, (Islam *et al.*, 2023) [17] recorded B:C ratios of 1:1.87 and 1:2.01 in control and supplemented crossbred dairy cows of Kashmir, respectively.

Conclusion

The two-year on-farm study demonstrated that combined mineral mixture supplementation and deworming significantly improved both productive and reproductive performance of lactating crossbred cows under hill farming conditions of Uttarakhand. It not only increases the milk yield but also improves the socioeconomic conditions. Hence, awareness needs to be created among dairy farmers to supplement minerals and vitamins and to deworm their animals to get more profit from dairy enterprises. Higher return on investment, enhanced milk production and faster breeding result in higher net return and improved B:C ratios for dairy farmers of the hills. Therefore, wider dissemination of this combined intervention through structured front-line demonstrations and extension programmes is recommended to enhance dairy productivity and farmer income in hill agro-ecosystems.

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Table 1. Productive performance of lactating crossbred cows supplemented with mineral mixture and dewormed (Mean $\pm$ SEM)

Treatment	Average daily milk yield (kg/day)		Peak milk yield (kg/day)		Total milk yield (kg)		60-day milk yield (kg)	
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2
T_1 ($n = 20$)	6.94 $\pm$ 0.097	7.24 $\pm$ 0.097	9.52 $\pm$ 0.116	9.87 $\pm$ 0.119	1987.75	2070.00	416.40	434.40
Control group					$\pm$ 26.300	$\pm$ 26.570	$\pm$ 5.800	$\pm$ 5.800
T_2 ($n = 20$)	8.35 $\pm$ 0.115	8.74 $\pm$ 0.114	11.51 $\pm$ 0.145	11.96 $\pm$ 0.136	2427.75	2544.75	500.70	524.40
Demonstrated group					$\pm$ 34.600	$\pm$ 34.510	$\pm$ 6.900	$\pm$ 6.870
<i>P</i> value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Level of significance	*	*	*	*	*	*	*	*

* $P < 0.01$.

Table 2. Effect of mineral mixture supplementation and deworming on reproductive parameters of crossbred cows (Mean $\pm$ SEM)

Treatment	First postpartum estrus (days)		No. of AI/service required for conception		Conception period (days)	
	Y1	Y2	Y1	Y2	Y1	Y2
T_1 ($n = 20$)	70.00 $\pm$ 1.28	67.15 $\pm$ 1.24	3.30 $\pm$ 0.15	2.60 $\pm$ 0.11	110.70 $\pm$ 2.02	107.40 $\pm$ 1.99
Control group						
T_2 ($n = 20$)	54.35 $\pm$ 0.99	51.65 $\pm$ 1.04	2.05 $\pm$ 0.15	1.85 $\pm$ 0.18	92.10 $\pm$ 1.33	88.75 $\pm$ 1.28
Demonstrated group						
<i>P</i> value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Level of significance	*	*	*	*	*	*

* $P < 0.01$. AI, artificial insemination

(continued on next page)

Table 3. Economics of mineral mixture supplementation and deworming in lactating crossbred cows

Parameters	T1 (Control group)			T2 (Demonstrated group)		
	Y1	Y2	Mean	Y1	Y2	Mean
Average milk yield (kg/day/animal)	6.94	7.24	7.09	8.35	8.74	8.54
Rearing cost (Rs/day/animal)	210.00	210.00	210.00	219.67	219.67	219.67
Average rearing cost per litre of milk (Rs)	30.26	29.01	29.62	26.32	25.13	25.72
Gross return (Rs/day/animal)	347.00	362.00	354.50	417.25	437.00	427.13
Net return (Rs/day/animal)	137.00	152.00	144.50	197.58	217.33	207.46
B:C ratio	1.65	1.72	1.69	1.90	1.99	1.94
Additional milk yield by supplementation (kg/day)	–	–	–	1.41	1.50	1.45
Milk yield increase over control (%)	–	–	–	20.2	20.7	20.5
Value of additional milk (Rs/day/animal)	–	–	–	70.25	75.00	72.63
Cost of mineral mixture and dewormer (Rs/day/animal)	–	–	–	9.67	9.67	9.67
B:C ratio for mineral mixture and deworming alone	–	–	–	7.27	7.76	7.51

Rearing cost = Rs 210/day/animal; milk sale price = Rs 50/litre; mineral mixture + dewormer cost = Rs 9.67/day/animal (treatment only). Labour and housing costs are excluded as they are common fixed costs. B:C, benefit:cost; Y₁, Year 1; Y₂, Year 2.

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