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Resource Productivity and Allocation Efficiency in Milk Production in Himachal Pradesh

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Agriculture is the main occupation of the people of Himachal Pradesh as about 76 per cent of the population depends directly on it. Out of the total geographical area of 55.7 lakh hectares, an area of 6.21 lakh hectares is under cultivation which is cultivated mostly by the small and marginal farmers. Animal husbandry is a prominent subsidiary occupation in the state providing regular income throughout the year. The State Government has undertaken various cattle development programmes under which sustained efforts are being made to improve the cattle breeds and provide extensive cattle health care facilities to the farmers. The efforts made by the State Government during the Seventh Plan resulted in an increase in milk production by 31 per cent, in egg production by 45.51 per cent and in wool production by 10.63 per cent (*The Times of India*, September 5, 1990).

There is a great variation in the relative economic efficiency of different breeds/species of milch animals reared in different resource situations due to variations in genetic characters, feeding and management practices. Ultimately, these factors affect milk production. Improved dairying with high yielding milch animals is faced with the problems of use of scarce resources at the farm level and these resources have to be optimally utilised on the basis of their marginal value productivities (MVPs) in order to get maximum income from dairy enterprise. Precise estimation of resource productivities and examination of allocation efficiency of various factors affecting milk production would help the farmers to allocate their resources optimally. The specific objectives of this study are *(i)* to estimate input-output relationship in milk production, *(ii)* to determine the MVPs of different inputs used in milk production and *(iii)* to find out the extent of increase in milk yield by reallocation of resources optimally.

METHODOLOGY

Hill Cattle Development Programme (HCDP) is in operation in Chamba, Hamirpur, Kangra, Kullu, Shimla, Solan and Una districts of Himachal Pradesh. The study relates to Kangra and Kullu districts of the state. All the artificial insemination (AI) centres functioning in these selected districts were classified into 'good' and 'poor' categories on the basis of conception rate. Four AI centres distributed over two districts, two from good category and two from poor category, were randomly selected. One cluster of two villages was selected from each selected AI centre. In addition to this, two clusters of two villages each not covered under this scheme were selected as a control for comparison from each selected district. Therefore, in all two clusters of two villages each in the project area and two from the control area in each selected district were selected for the present investigation. Keeping in view the time and resource constraints, it was decided to select 100 beneficiaries (covered under the HCDP) and 100 non-beneficiary households (not covered under the HCDP). The input-output data were obtained from the sample households on a well structured schedule

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for the agricultural year 1989-90 through seasonal visits in the rainy, winter and summer seasons.

Production function analysis was used as an analytical tool for achieving the objectives of the study. Linear, Cobb-Douglas and semi-log types of production functions were used to express the relationship between milk output per animal and various factors influencing it.

The variables included in the production function were as follows:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8)$$

where Y = value of milk produced per animal per day (Rs.),
X_1 = value of green fodder fed per animal per day (Rs.),
X_2 = value of dry fodder fed per animal per day (Rs.),
X_3 = value of concentrates fed per animal per day (Rs.),
X_4 = human labour cost per animal per day (Rs.),
X_5 = age of the animal (years),
X_6 = order of lactation (number),
X_7 = stage of lactation (months after calving) and
X_8 = miscellaneous expenditure per animal per day (Rs.).

However, before doing the analysis, zero-order correlation matrices were worked out and the correlation coefficients were examined for multicollinearity. From zero-order correlation matrices of the variables, it was observed that age of the animal (X_5) and order of lactation (X_6) variables were found highly correlated in all the breeds of lactating animals. In order to overcome the problem of multicollinearity, age of the animal (X_5) was deleted and then the regression analysis was done.

In order to capture the effect of different seasons on milk production, the dummy variables representing different seasons (D_1 and D_2) were incorporated in the production functions to account for variation in milk production attributable to changes brought about by climatic factors.

The final production function selected was:

$$Y = f(X_1, X_2, X_3, X_4, X_6, X_7, X_8, D_1, D_2)$$

where D_1 = 1 for summer season,
= 0 for other seasons.
D_2 = 1 for rainy season,
= 0 for other seasons.

The optimum allocation of resources was done under the constraint of available capital as given. The simplest method is to maximise the profit function using Lagrange multiplier with the constraint equation.

Assuming production function as:

$$Y = f(X_1, X_2, X_3)$$

and capital constraint as:

$$P_1 X_1 + P_2 X_2 + P_3 X_3 = C$$

where P_1, P_2 and P_3 are input prices and X_1, X_2 and X_3 are levels of inputs used. 'C' is the finite amount of capital.

The profit equation is:

$$\pi = P_y Y - \sum_{i=1}^{3} P_i X_i \; + \; \lambda \left(\sum_{i=1}^{3} P_i X_i \; - \; C \right)$$

where λ is Lagrange multiplier. The term $\left(\sum_{i=1}^{n} P_i X_i - C \right)$ indicates the restraint that the total amount spent $\left(\sum_{i=1}^{n} P_i X_i \right)$ on the inputs can not be greater than the amount of capital 'C'.

To determine the profit maximising amount of each input, take the partial derivatives of profit equation with respect to each input and λ and set them equal to zero, *i.e.*,

$$\frac{\partial \pi}{\partial x_1} = P_y \frac{\partial Y}{\partial x_1} - P_1 + \lambda P_1 = 0$$

$$\frac{\partial \pi}{\partial x_2} = P_y \frac{\partial Y}{\partial x_2} - P_2 + \lambda P_2 = 0$$

$$\frac{\partial \pi}{\partial x_3} = P_y \frac{\partial Y}{\partial x_3} - P_3 + \lambda P_3 = 0$$

$$\frac{\partial \pi}{\partial \lambda} = \sum_{i=1}^{3} \; P_i X_i - C = 0$$

These equations can be solved for X_i's and λ to determine the magnitude of inputs which maximise profit under the restraint set out above (Heady and Dhillon, 1988, pp. 54-55).

RESULTS AND DISCUSSION

Impact of HCDP on Selected Parameters

In order to examine the impact of the HCDP on certain parameters, such as average milk yield per day, quantities of green fodder, dry fodder and concentrates fed and human labour use per animal, comparison of sample beneficiary and non-beneficiary households was done and 't' statistics was used to test the statistical significance. The results are presented in Table I.

It may be observed from the table that the average daily milk yield of cross-bred cow in the case of beneficiary households was 5.441 litres, which was more than double and significantly higher than that of non-descript cow on the non-beneficiary households. In the case of buffaloes, the average milk yield of graded Murrah buffalo was 5.502 litres per day while the average yield of local buffalo was 3.041 litres per day. There was a significant difference in the milk yield of graded Murrah buffalo and local buffalo. The average daily feed intake per animal was also significantly higher on sample beneficiaries as compared to the non-beneficiaries, but the difference was not significant in the case of dry fodder for buffaloes. The human labour use per animal was also significantly higher in the case of beneficiaries as compared to the non-beneficiaries. The higher milk yields, human labour employment and feed intake on the beneficiary group as compared to the non-beneficiary group obviously demonstrate the wholesome impact of the HCDP on these parameters in the study area.

TABLE I. AVERAGE DAILY MILK YIELD, FEED INTAKE AND HUMAN LABOUR USE PER MILKING ANIMAL ON BENEFICIARY AND NON-BENEFICIARY HOUSEHOLDS

Particulars	Cows					Buffaloes		
	Beneficiary		Non-beneficiary	Mean difference		Beneficiary	Non-beneficiary	Mean difference
	CBC	NDC	NDC	MD I	MD II	GMB	LB	MD
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Average milk yield (litres)	5.441	2.934	2.207	3.234*** (0.3678)	0.727*** (0.1835)	5.502	3.041	2.461*** (0.3381)
Quantity of green fodder fed (kg)	16.085	9.191	7.569	8.516*** (1.3210)	1.622* (1.0253)	18.400	11.040	7.360** (2.0160)
Quantity of dry fodder fed (kg)	5.133	4.306	3.746	1.387* (0.8341)	0.560 (0.4062)	5.808	4.792	1.016 (0.9740)
Quantity of concentrates fed (kg)	1.827	0.489	0.367	1.460*** (0.2972)	0.122 (0.0847)	1.693	0.675	1.018*** (0.3132)
Human labour use (minutes)	135	115	112	23** (9.1482)	3 (4.9013)	144	118	26** (10.3413)

Note: CBC = Cross-bred cows; NDC = Non-descript cows; GMB = Graded Murrah buffaloes; and LB = Local buffaloes.

Figures in parentheses are standard errors of difference between mean values of beneficiary households and non-beneficiary households.

***, **, * significant at 1, 5 and 10 per cent level respectively.

Milk Production Functions

The regression coefficients, standard errors and coefficients of multiple determination of the milk production functions for summer, rainy and winter seasons for different breeds of cows and buffaloes on the beneficiary and non-beneficiary households are presented in Tables II, III and IV respectively.

Summer season: A perusal of Table II indicates that the independent variables included in the regression equation explained 72 to 82 per cent of the variation in milk production, being maximum in non-descript cows and minimum in local buffaloes on the non-beneficiary households. Among the different inputs, the regression coefficients of green fodder and concentrates were positive and highly significant in all the equations fitted. The concentrate was the most important variable which had significant and positive regression coefficient in all the equations. On the beneficiary households the regression coefficient of concentrates was maximum in the case of non-descript cows (0.1506) and minimum in the case of cross-bred cows (0.0932), while in the case of non-beneficiaries, the regression coefficient of this input was maximum in the case of non-descript cows (0.1734) and minimum in the case of local buffaloes (0.1724). It shows that the concentrate was the most important factor affecting the milk production in all the breeds of cows and buffaloes both on the beneficiary and non-beneficiary households. Similar findings have been reported by Kumar and Raut (1971), Singh and Jha (1975) and Rai and Gangwar (1976). The regression coefficient of green fodder on the beneficiary households was minimum for graded Murrah buffaloes

TABLE II. REGRESSION COEFFICIENTS, STANDARD ERRORS AND COEFFICIENTS OF MULTIPLE DETERMINATION IN MILK PRODUCTION IN DIFFERENT BREEDS OF MILCH ANIMALS (SUMMER SEASON)

Breed/ species	No. of obser-vations	Algebraic form	Inter-cept	Regression coefficients							
				X_1	X_2	X_3	X_4	X_6	X_7	X_8	R^2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
						Beneficiaries					
Cross-bred	105	Semi-log	2.2033	0.1063***	0.0550***	0.0932***	0.0168	0.0133	-0.0205***	0.0781	0.7913***
cows		(log Y)		(0.0215)	(0.0171)	(0.0172)	(0.0259)	(0.0100)	(0.0080)	(0.0219)	
Non-descript	54	Semi-log	1.9611	0.0925***	0.0186	0.1506***	0.0206	0.0100	-0.0103***	0.4255	0.7966***
cows		(log Y)		(0.0252)	(0.0175)	(0.0205)	(0.0243)	(0.0098)	(0.0048)	(0.2872)	
Graded Murrah	56	Semi-log	2.1129	0.0813***	0.0226	0.1169***	0.0620**	0.0049	-0.0019	0.0761**	0.8154***
buffaloes		(log Y)		(0.0273)	(0.0263)	(0.0254)	(0.0293)	(0.0146)	(0.0070)	(0.0369)	
						Non-beneficiaries					
Non-descript	116	Semi-log	2.2524	0.0888***	0.0194	0.1734***	-0.0508	0.0123	-0.0194***	-0.4754***	0.8252***
cows		(log Y)		(0.0272)	(0.0150)	(0.0220)	(0.0354)	(0.0085)	(0.0060)	(0.1773)	
Local buffaloes	62	Semi-log	1.9803	0.0896**	0.0232	0.1724***	0.0296	0.0237	-0.0125*	0.2417	0.7159***
		(log Y)		(0.0358)	(0.0179)	(0.0300)	(0.0603)	(0.0132)	(0.0073)	(0.2128)	

Note: Figures in parentheses are standard errors of the coefficients.
R^2 = Coefficient of multiple determination.
***, **, * significant at 1, 5 and 10 per cent level respectively.

TABLE III. REGRESSION COEFFICIENTS, STANDARD ERRORS AND COEFFICIENTS OF MULTIPLE DETERMINATION IN MILK PRODUCTION IN DIFFERENT BREEDS OF MILCH ANIMALS (RAINY SEASON)

Breed/ species	No. of obser- vations	Algebraic form	Inter- cept	Regression coefficients							
				X_1	X_2	X_3	X_4	X_6	X_7	X_8	R^2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
						Beneficiaries					
Cross-bred cows	129	Semi-log	2.1490	0.0453**	0.0583***	0.0893***	0.0941***	0.0050	-0.0251***	0.0369***	0.7675***
		(log Y)		(0.0180)	(0.0189)	(0.0160)	(0.0277)	(0.0098)	(0.0060)	(0.0087)	
Non-descript cows	58	Semi-log	1.4986	0.1393***	0.0969***	0.0967***	0.0482	-0.0127	0.0006	0.0903***	0.9111***
		(log Y)		(0.0247)	(0.0264)	(0.0203)	(0.0297)	(0.0154)	(0.0076)	(0.0238)	
Graded Murrah	60	Semi-log	2.1761	0.0643**	0.0479	0.0907***	0.0961**	0.0081	-0.0233**	-0.0373	0.6222***
buffaloes		(log Y)		(0.0310)	(0.0401)	(0.0284)	(0.0395)	(0.0209)	(0.0100)	(0.2867)	
						Non-beneficiaries					
Non-descript cows	114	Semi-log	2.0205	0.0328	0.1189***	0.1579***	0.0033	-0.0084	-0.0267***	0.1087	0.7367***
		(log Y)		(0.0301)	(0.0305)	(0.0232)	(0.0486)	(0.0117)	(0.0062)	(0.2263)	
Local buffaloes	77	Linear	1.1287	0.9321**	0.3408	1.9089***	2.0453***	0.2368	-0.2532***	1.0220	0.8001***
				(0.3505)	(0.4245)	(0.3920)	(0.7236)	(0.1833)	(0.0923)	(2.3785)	

Note: Figures in parentheses are standard errors of the coefficients.
R^2 = Coefficient of multiple determination.
***, **, * significant at 1, 5 and 10 per cent level respectively.

TABLE IV. REGRESSION COEFFICIENTS, STANDARD ERRORS AND COEFFICIENTS OF MULTIPLE DETERMINATION IN MILK PRODUCTION IN DIFFERENT BREEDS OF MILCH ANIMALS (WINTER SEASON)

Breed/ species	No. of obser- vations	Algebraic form	Inter- cept	Regression coefficients							
				X_1	X_2	X_3	X_4	X_6	X_7	X_8	R^2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
						Beneficiaries					
Cross-bred cows	130	Semi-log	2.5197	0.0944***	0.0183	0.0844***	0.0169	0.0059	-0.0305***	0.0719***	0.7483***
		(log Y)		(0.0247)	(0.0164)	(0.0141)	(0.0242)	(0.0108)	(0.0063)	(0.0200)	
Non-descript cows	59	Linear	7.0948	1.5436***	1.1977***	0.3310***	1.5230***	0.1687	-0.6996***	4.4508	0.9004***
				(0.3900)	(0.3206)	(0.4706)	(0.4590)	(0.1704)	(0.1331)	(2.9536)	
Graded Murrah	58	Linear	17.9164	0.3873	1.9484***	2.5061***	-0.4193	-0.0885**	-1.3010***	- 7.5763	0.8304***
buffaloes				(0.7975)	(0.5604)	(0.5502)	(0.9109)	(0.4529)	(0.2925)	(6.2055)	
						Non-beneficiaries					
Non-descript cows	121	Linear	7.8471	1.1067***	0.2603	1.9353***	0.3381	0.0784	-0.2432***	-2.3027	0.7595***
				(0.3723)	(0.2605)	(0.2950)	(0.5114)	(0.1356)	(0.0801)	(2.6472)	
Local buffaloes	68	Semi-log	2.1775	0.1400**	0.0346	0.1396***	-0.0624	0.0071	-0.0188***	0.4363*	0.8404***
		(log Y)		(0.0269)	(0.0218)	(0.0196)	(0.0387)	(0.0118)	(0.0062)	(0.2306)	

Note: Figures in parentheses are standard errors of the coefficients.
R^2 = Coefficient of multiple determination.
***, **, * significant at 1, 5 and 10 per cent level respectively.

(0.0813) and maximum for cross-bred cows (0.1063), whereas in the case of non-beneficiaries, the regression coefficient of this input was minimum for non-descript cows (0.0888) and maximum for local buffaloes (0.0896), showing the corresponding percentage increase in value of milk due to one rupee increase in expenditure on green fodder. Positive relationship between green fodder and milk yield was also observed by Pandey *et al.* (1980) and Rao (1985). Though the regression coefficient of dry fodder was positive it was not statistically significant in all the regression equations fitted, except for cross-bred cows on the beneficiary households. The reason for non-significant regression coefficients of dry fodder can be described to the lack of variation in the quantity of dry fodder.

The regression coefficient of labour was significant only in the case of graded Murrah buffaloes and order of lactation was significant in the case of local buffaloes only. The regression coefficient of stage of lactation was negative and statistically significant for all the equations on both the groups. This shows that with the advancement in the stage of lactation of the animal, its milk yield starts decreasing after a period of time. The regression coefficient of expenditure on miscellaneous items such as minor repairs of cattleshed and store, dairy equipments, electricity and water charges, health care expenses, etc., was significant and positive in the case of graded Murrah buffaloes and significantly negative in non-descript cows on the non-beneficiary group.

Rainy season: An examination of the coefficient of multiple determination of the regression equations given in Table III indicates that the various factors influencing milk production included in the production functions explained about 62 to 91 per cent of the total variation in milk production in the case of beneficiary households whereas on the non-beneficiary group these variables explained about 74 to 80 per cent of the variation.

It may be observed from Table III that green fodder, dry fodder and concentrates were the important inputs in influencing milk production having significant regression coefficients. The coefficient of green fodder was significant and positive for all the breeds of cows and buffaloes on both the beneficiary and non-beneficiary groups except for non-descript cows on the non-beneficiary group. The regression coefficient of dry fodder was also significant in most of the cases except for graded Murrah and local buffaloes. Another variable having a fairly widespread explanatory influence was expenditure on concentrates; the regression coefficient of this variable was highly significant for all the breeds on both the groups of households. The labour input exercised a significantly positive impact on milk production for cross-bred cows and graded Murrah buffaloes on the beneficiary households and for local buffaloes on the non-beneficiary group. The order of lactation had uniformly poor influence in explaining the variation in milk production. The stage of lactation showed negative and significant coefficient for all the breeds of animals except for non-descript cows on the beneficiary group.

The regression coefficient of miscellaneous expenditure was significant for cross-bred and non-descript cows on the beneficiary households. Miscellaneous expenditure had uniformly poor influence on the non-beneficiary households and graded Murrah buffaloes due to lack of variation in the variable itself and also due to the low degree of engagement.

Winter season: It may be seen from Table IV that the regression coefficient of green fodder was significantly positive for all the breeds on the beneficiary and non-beneficiary households except for graded Murrah buffaloes, indicating thereby that milk production would register an increase in all breeds with an increase in green fodder at their mean levels.

The dry fodder had a significantly positive impact on milk production only for non-descript cows and graded Murrah buffaloes on the beneficiary group. The regression coefficient of concentrates was highly significant and positive for all the breeds on both the groups except for non-descript cows on the beneficiary group. The stage of lactation, as expected, had significant and negative impact on milk production for all the breeds. The coefficient of labour was significant and positive only for non-descript cows on the beneficiary households and that of order of lactation was significant and negative for graded Murrah buffaloes.

Overall: The effect of seasons could be examined by testing the estimates of parameters for different variables by applying suitable statistical test of significance. This entails the comparison of magnitude of each variable in different seasons. Another way to study the seasonal impact is to introduce a dummy variable for each season into pooled data for a year and testing the coefficients of dummy variables for statistical significance. The latter method is more simple and straight forward than the former. The results of the equation fitted to the pooled data are presented in Table V.

It may be observed from Table V that green fodder, dry fodder and concentrates were again the important inputs in the milk production having significant regression coefficients. The regression coefficient of labour was positive and significant for all the breeds on the beneficiary households. The stage of lactation had a negative and significant impact on milk production on both the groups of households. The dummy variables for summer and rainy season had negative regression coefficients on both the beneficiary and non-beneficiary households, except for local buffaloes for which the dummy variable for summer season was not significant. It confirms that milk yield is higher in the winter season as compared to the summer and rainy seasons in all the breeds of animals on the beneficiary and non-beneficiary households, except for local buffaloes where there is no significant difference in milk yield in the summer and winter seasons. This clearly demonstrated that the winter season contributed significantly to milk yield as compared to the summer and rainy seasons on both the beneficiary and non-beneficiary households.

Marginal Value Products (MVPs)

The MVPs of inputs were computed for only those resources whose regression coefficients were statistically significant in the production functions and are set out in Table VI along with their prices. Since all the inputs and output are expressed in monetary terms, the acquisition cost of the inputs is taken as one rupee. The criterion used here to assess the resource allocation efficiency is to test the MVPs against unity (Heady and Dhillon, 1988).

Summer season: An examination of Table VI reveals that the MVP of concentrates was positive and significantly higher than acquisition cost for all the breeds of animals on the beneficiary and non-beneficiary households in the summer season. It shows that the farmers would increase their milk output by feeding higher levels of concentrates to the animals. The MVP of green fodder was positive for all the breeds on both the groups except for non-descript cows on non-beneficiary group. In the case of cross-bred cows, the MVP of dry fodder was positive and higher than its acquisition cost, but the difference was not statistically significant showing near optimal use of this input. The MVP of miscellaneous expenditure was positive and higher than its acquisition cost for graded Murrah buffaloes but did not differ significantly revealing almost efficient use of the input. Since the regression

TABLE V. REGRESSION COEFFICIENTS, STANDARD ERRORS AND COEFFICIENTS OF MULTIPLE DETERMINATION IN MILK PRODUCTION IN DIFFERENT BREEDS OF MILCH ANIMALS (OVERALL)

Breed/ species	No. of obser-vations	Algebraic form	Inter-cept	Regression coefficients									
				X_1	X_2	X_3	X_4	X_6	X_7	X_8	D_1	D_2	R^2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
							Beneficiaries						
Cross-bred	364	Semi-log	2.4249***	0.0774***	0.0352***	0.0892***	0.0404***	0.0070	-0.0283***	0.0473	-0.0923***	-0.2249***	0.7574***
cows		(log Y)		(0.0120)	(0.0096)	(0.0088)	(0.0144)	(0.0059)	(0.0037)	(0.1048)	(0.0250)	(0.0446)	
Non-descript	171	Linear	2.0308	2.1247	0.8217	1.5740	1.3629	0.0130	-0.1729	4.4408	-1.5660	-3.3974	0.8719
cows				(0.2493)	(0.2283)	(0.2220)	(0.2715)	(0.1282)	(0.6170)	(2.1869)	(0.4684)	(0.7783)	
Graded Murrah	174	Semi-log	2.3180	0.0675***	0.0588***	0.1173***	0.0518**	-0.0067	-0.0181***	-0.0221	-0.1036**	-0.1673**	0.7145***
buffaloes		(log Y)		(0.0169)	(0.0172)	(0.0143)	(0.0208)	(0.0107)	(0.0056)	(0.1564)	(0.0358)	(0.0764)	
							Non-beneficiaries						
Non-descript	351	Linear	8.3682	0.6795***	0.3564***	1.9319***	0.2164	0.0438	-0.2432***	-1.8545	-0.6105**	-1.7543***	0.7472***
cows				(0.1948)	(0.1388)	(0.1531)	(0.2760)	(0.0700)	(0.0419)	(1.3758)	(0.2456)	(0.4947)	
Local buffaloes	207	Semi-log	2.0275	0.4874***	0.0365***	0.1623***	0.0246	0.0154**	-0.0161***	0.0986	-0.0053	-0.2389***	0.8004***
		(log Y)		(0.0160)	(0.0120)	(0.0140)	(0.0266)	(0.0071)	(0.0037)	(0.1097)	(0.0255)	(0.0536)	

Note: Figures in parentheses are standard errors of the coefficients.
R^2 = Coefficient of multiple determination.
***, **, * significant at 1, 5 and 10 per cent level respectively.

coefficient of miscellaneous expenditure was negative for non-descript cows on the non-beneficiary households, its MVP was also found negative and the difference was significant.

Rainy season: As the regression coefficients of all the inputs were positive, the estimated MVPs were also found positive for all the breeds on both the groups. It indicates that at the present level of resource use, an additional rupee invested in the different inputs would add positively to the returns through milk production. Interestingly, the comparison of MVPs of dry fodder, human labour and miscellaneous expenditure with unity revealed that in all the situations except for human labour in the case of cross-bred cows, the difference was not significant. It may, therefore, be inferred that the farmers were quite rational and efficient in using these resources. However, the MVP of concentrate was higher than its acquisition cost and the difference was statistically significant for all the breeds on both the groups except for non-descript cows on the beneficiary households. Therefore, the farmers would increase their profit by feeding more of concentrates. The MVP of green fodder was higher than its acquisition cost on the beneficiary households and lower on the non-beneficiary households, but the difference was significant only for non-descript cows on the beneficiary group. The MVP of dry fodder was higher than its acquisition cost but the difference was not statistically significant, showing near optimal use of this input.

Winter season: The MVP of concentrates was positive and significantly higher than its price for all the breeds on both the groups of households. The MVP of green fodder was also positive and higher than its price, but the difference was statistically significant for cross-bred cows and local buffaloes only. The MVP of dry fodder was higher than its acquisition cost in the case of non-descript cows and graded Murrah buffaloes on the beneficiary households but the difference was not significant showing near optimal use of this input. The MVP of labour was higher than its acquisition cost for non-descript cows on the beneficiary group, but the difference was not significant.

Overall: It may be observed from Table VI that the MVP of concentrates was positive and significantly higher than its price for all the breeds of animals on both the groups. The MVP of green fodder was positive and higher than its acquisition cost for cross-bred and non-descript cows on the beneficiary group and lower than its price for non-descript cows on the non-beneficiary group. Though the MVP of this input was higher than its acquisition cost for graded Murrah and local buffaloes, the difference was not significant showing optimal use of this input. The MVP of dry fodder was lower than its price for all the breeds on the beneficiary and non-beneficiary households, except for graded Murrah buffaloes where it was higher than its price but the difference was not significant. The MVP of this input was significantly lower than its price in the case of non-descript cows on both the groups and local buffaloes. The MVP of labour did not differ significantly from its acquisition cost.

Existing and Optimum Levels of Dairy Inputs

The existing and optimum levels of dairy inputs, *i.e.*, green fodder, dry fodder, concentrates and human labour were estimated to examine the possibility of increasing the output with limited capital available for these inputs. The optimum levels of dairy inputs were computed for only those resources whose regression coefficients were positive and significant in the production functions. For the resources whose regression coefficients were negative or statistically not significant, the existing levels as such were used. The optimum levels of inputs with existing levels along with output are presented in Table VII.

TABLE VI. MARGINAL VALUE PRODUCTS OF DAIRY INPUTS ON BENEFICIARY AND NON-BENEFICIARY HOUSEHOLDS

Inputs	Summer season					Rainy season				
	Beneficiaries			Non-beneficiaries		Beneficiaries			Non-beneficiaries	
(1)	CBC (2)	NDC (3)	GMB (4)	NDC (5)	LB (6)	CBC (7)	NDC (8)	GMB (9)	NDC (10)	LB (11)
Green fodder										
MVP	2.62	1.19	1.91	0.98	1.35	1.03	1.93	1.46	-	0.93
Price	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-	1.00
Difference	1.62***	0.19	0.91	-0.02	0.35	0.03	0.93***	0.46	-	-0.07
Standard error of difference	0.53	0.32	0.63	0.30	0.53	0.40	0.34	0.70	-	0.35
Dry fodder										
MVP	1.36	-	-	-	-	1.33	1.34	-	1.29	-
Price	1.00	-	-	-	-	1.00	1.00	-	1.00	-
Difference	0.36	-	-	-	-	0.33	0.34	-	0.29	-
Standard error of difference	0.42	-	-	-	-	0.42	0.36	-	0.33	-
Concentrates										
MVP	2.30	1.94	2.75	1.92	2.60	2.04	1.34	2.07	1.71	1.91
Price	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Difference	1.30***	0.94***	1.75***	0.92***	1.60***	1.04***	0.34	1.07*	0.71***	0.91***
Standard error of difference	0.42	0.26	0.59	0.24	0.45	0.36	0.28	0.60	0.25	0.39
Human labour										
MVP	-	-	1.46	-	-	2.15	-	2.19	-	2.04
Price	-	-	1.00	-	-	1.00	-	1.00	-	1.00
Difference	-	-	0.46	-	-	1.15*	-	1.19	-	1.04
Standard error of difference	-	-	0.68	-	-	0.63	-	0.90	-	0.72
Miscellaneous expenditure										
MVP	-	-	1.78	-5.28	-	0.83	1.25	-	-	-
Price	-	-	1.00	1.00	-	1.00	1.00	-	-	-
Difference	-	-	0.78	-6.28***	-	-0.17	0.25	-	-	-
Standard error of difference	-	-	0.86	1.95	-	0.19	0.33	-	-	-

(Contd.)

TABLE VI (*Concld.*)

Inputs	Winter season					Overall				
	Beneficiaries			Non-beneficiaries		Beneficiaries			Non-beneficiaries	
	CBC	NDC	GMB	NDC	LB	CBC	NDC	GMB	NDC	LB
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Green fodder										
MVP	2.37	1.54	-	1.11	2.11	1.87	2.12	1.60	0.68	1.27
Price	1.00	1.00	-	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Difference	1.37**	0.54	-	0.11	1.11***	0.87***	1.12***	0.60	-0.32	0.27
Standard error of difference	0.62	0.39	-	0.37	0.40	0.29	0.25	0.40	0.19	0.23
Dry fodder										
MVP	-	1.20	1.95	-	-	0.85	0.82	1.39	0.36	0.53
Price	-	1.00	1.00	-	-	1.00	1.00	1.00	1.00	1.00
Difference	-	0.20	0.95	-	-	-0.15	-0.18*	0.39	-0.64***	-0.47***
Standard error of difference	-	0.32	0.57	-	-	0.23	0.11	0.30	0.13	0.18
Concentrates										
MVP	2.12	-	2.51	1.99	2.10	2.16	1.57	2.78	1.93	2.35
Price	1.00	-	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Difference	1.12***	-	1.51***	0.99***	1.10***	1.16***	0.57**	1.78***	0.93***	1.35***
Standard error of difference	0.35	-	0.55	0.29	0.29	0.21	0.22	0.34	0.15	0.20
Human labour										
MVP	-	1.52	-	-	-	0.98	1.36	1.23	-	-
Price	-	1.00	-	-	-	1.00	1.00	1.00	-	-
Difference	-	0.52	-	-	-	-0.02	0.36	0.23	-	-
Standard error of difference	-	0.42	-	-	-	0.35	0.27	0.49	-	-
Miscellaneous expenditure										
MVP	1.79	-	-	-	6.58	-	4.44	-	-	-
Price	1.00	-	-	-	1.00	-	1.00	-	-	-
Difference	0.79	-	-	-	5.58	-	3.44	-	-	-
Standard error of difference	0.50	-	-	-	3.46	-	2.18	-	-	-

Note: CBC = Cross-bred cows; NDC = Non-descript cows; GMB = Graded Murrah buffaloes; and LB = Local buffaloes.
***, **, * significant at 1, 5 and 10 per cent level respectively.

TABLE VII. EXISTING AND OPTIMUM LEVELS OF DAIRY INPUTS

(Rs.)

Inputs	Summer season					Rainy season					Winter season				
	Beneficiaries			Non-beneficiaries		Beneficiaries			Non-beneficiaries		Beneficiaries			Non-beneficiaries	
	CBC	NDC	GMB	NDC	LB	CBC	NDC	GMB	NDC	LB	CBC	NDC	GMB	NDC	LB
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Green fodder															
Existing	2.19	1.32	2.12	0.80	1.02	5.21	3.81	5.56	2.92	4.22	2.52	1.07	2.43	1.21	1.53
Optimum	3.00	0.95	1.93	0.49	0.62	3.35	4.49	4.47	2.92	2.65	2.69	1.29	2.43	0.83	1.54
Dry fodder															
Existing	5.69	3.64	5.49	3.61	5.25	1.93	1.50	1.59	1.03	1.27	4.90	3.23	5.36	3.45	4.53
Optimum	4.03	3.64	5.49	3.61	5.25	1.60	1.23	1.59	0.85	1.27	4.90	3.01	4.14	3.45	4.53
Concentrates															
Existing	4.21	2.11	3.52	1.59	2.34	3.93	2.34	3.64	1.82	2.31	3.78	1.21	3.15	1.64	2.26
Optimum	5.06	2.48	4.60	1.90	2.74	4.98	1.93	4.13	2.00	2.97	3.61	1.21	4.37	2.02	2.25
Labour															
Existing	3.21	2.02	2.87	1.91	2.46	3.43	2.15	3.00	2.01	2.41	3.15	1.38	2.84	1.85	2.34
Optimum	3.21	2.02	1.98	1.91	2.46	4.57	2.15	3.60	2.01	3.32	3.15	1.57	2.84	1.85	2.34
Output															
Existing	24.59	12.85	23.60	11.12	15.03	22.90	13.78	22.80	10.84	14.24	25.15	10.42	26.47	12.58	15.26
Optimum	26.49	13.13	24.95	11.41	15.54	25.25	14.19	23.55	10.92	15.40	25.20	10.54	28.37	12.92	15.19
Change over existing output (per cent)	7.73	2.18	5.72	2.61	3.39	10.26	2.97	3.30	0.74	11.67	0.20	1.15	7.18	2.70	0.20

Note: CBC = Cross-bred cows; NDC = Non-descript cows; GMB = Graded Murrah buffaloes; and LB = Local buffaloes.

As expected, the optimisation of resources on all categories of beneficiary and non-beneficiary households indicated that a part of capital should be transferred from green fodder, dry fodder and labour to purchase more concentrates for feeding the animals. The reallocation of limited capital had improved the milk output on both the groups of households in all the seasons. However, the increase in milk output through optimum allocation was of limited significance in the case of non-descript cows in all the seasons on both the groups of households as it was less than 5 per cent in general, but the optimisation of resources significantly increased the milk output in the case of cross-bred cows in the summer (by 8 per cent) and rainy seasons (by 10 per cent), in the case of graded Murrah buffaloes in the summer (by 6 per cent) and winter seasons (by 7 per cent) and in the case of local buffaloes in the rainy season (by 12 per cent). Therefore, in general, the beneficiary and non-beneficiary households were not rational in the allocation of their limited capital in the case of cross-bred cows and buffaloes. Overall, it may be concluded that the scope existed for optimisation of resources in increasing the milk output of buffaloes and cross-bred cows.

CONCLUSION

The foregoing analysis indicates that the concentrate is the most important input affecting milk production. The regression coefficients of this input were positive and statistically significant in all the equations fitted, indicating that the farmers can increase their milk output by feeding more concentrates to the animals on both the groups of households. The regression coefficients of green fodder and dry fodder were also positive and significant in most of the equations fitted. The coefficient of stage of lactation was significantly negative for all the breeds of animals. The analysis indicated that milk yield was higher in the winter season than in the summer and rainy seasons. The optimisation of resources with the existing capital indicated the possibility of increasing the milk output in cross-bred cows and buffaloes by diverting a part of funds from green fodder, dry fodder and labour to concentrates. The final analysis suggested a significant scope for raising milk production by readjustment of feed inputs in all the seasons on both the beneficiary and non-beneficiary households.

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