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farmers. They may not afford to keep stronger and more efficient animals and make full utilization of their capacities. We believe that the solution to the problem may be found in the institutional rearrangement of the resource-use in agriculture, for instance, co-operative use of the work animals and the national utilization of their capacities.

RELATIVE PROFITABILITY OF DAIRY ENTERPRISE VIS-A-VIS CROP CULTIVATION IN THE PUNJAB

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INTRODUCTION

The recent technological and economic changes in farming have rendered existing production patterns of the farmers sub-optimal. In the context of a shifting equilibrium, production patterns have become more cereal oriented. Consequently, the diversification of Punjab agriculture would become necessary. This problem needs to be examined to find the levels at which the dairy (milch cow and buffalo) can profitably enter the production programmes of the farmers and also promote the diversification of agriculture.

Again, the consumers cannot be satisfied with the consumption of cereals only. With the improvement in the farm incomes, more and more emphasis will come on the consumption of such protective foods as milk, poultry, vegetables and fruits. The demand for protective foods being much more income elastic, it would increase faster than the demand for cereals. Another important factor, which could influence the decision of the farmers about their enterprise-mix, is the regular flow of income from dairy cattle throughout the year, when income from crop husbandry is lagged by a few months.

A more recent development in dairying is the cross-breeding programme with much higher milk yield potential, which makes dairying more profitable. But rearing of milch animals on commercial lines requires heavy investment, particularly on three major items: (*i*) purchase of animals, (*ii*) construction of cattle sheds, and (*iii*) purchase of machinery and equipment. We should, therefore, find an answer to the question at what level dairying could be incorporated in the output-mix of the farmer with profit.

More specifically, the major objective of the study is to examine the extent to which the dairy enterprise can be profitably incorporated in the production patterns of the various farm size-groups at different levels of technology.

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METHODOLOGY

This study was conducted in Ludhiana district of the Punjab, where the Punjab Dairy Development Corporation was actively engaged. Two villages were selected at random. The operational holdings in all the two villages were pooled and arranged in the ascending order of the cultivated areas. These holdings were divided into three categories in such a way that each stratum covered almost equal cultivated area. The distribution of operational holdings in the selected villages was thus transformed to indicate small, medium and large holdings. Four representative farm situations were selected, *i.e.*, (*i*) small farm situation, (*ii*) medium farm situation bullock operated-I, (*iii*) medium farm situation tractor operated-II, and (*iv*) large farm situation tractor operated.

Resource Restrictions

Land, labour, capital and farmyard manure are the most limited resources on the Punjab farms. These were treated as constraints in the production of different activities.

Selection of Activities

In order to determine an optimal programme for different sized holdings, only those activities were considered which were acceptable to the farmers, or the activities which were already accepted by the farmers in their existing production programmes. Different crop activities presented difficulty in classification because of their non-linear input-output relationship in the context of differences in soil, sowing time and crop rotations in which each activity figured. So an individual crop was treated as an activity for the purpose of analysis as shown in Appendix 1.

A milch animal was considered one activity and its young one another activity although the latter was not treated as a commercial enterprise. The young one was weaned and separated from its mother after calving and reared separately or disposed of. Following the same pattern, a cross-bred cow was considered as a separate activity. Farmyard manure produced by these activities was used for growing green fodder to feed the animals. Normally, a buffalo calves after 18 months and a cross-bred cow after 15 months. Therefore, variable costs and returns to fixed farm resources were reduced to 12 months-period so that the analysis could be done within the framework of crop activities. In the case of dairy activity, cash requirements were broken down in twelve parts (months) because this activity generated regular monthly income. So cash expenses were involved for incurring variable expenditure for a period of only one month on a recurrent basis. The working capital for this enterprise would thus be equal to the cash expenses over a period of one month for each season.

Yields

The budgeted yields of different farm production enterprises at the improved level of technology were based on package of practices recommended by the experts of Punjab Agricultural University, Ludhiana. The yields of different enterprises at both the levels of technology are given in Appendix 1.

Prices

The post-harvest product prices of different commodities in 1974-75 were used to estimate the returns from the individual enterprise. Generally, procurement prices of cereals were used in the analysis. Prices of products are given in Appendix 1.

Returns to Fixed Farm Resources

The operational cost was estimated and deducted from the gross returns to obtain the net return to fixed resources from different farm enterprises. Dairy was treated as a special activity and its variable cost included not only operational cost but also depreciation of shed, animals, equipment, interest on capital invested in this activity and insurance cost of the animals. In the case of animals, depreciation was included because their productive period was reduced year after year or lactation after lactation. Depreciation on the value of an animal in an accounting year, therefore, becomes a cost. Similarly, depreciation on shed, equipment, and insurance cost was treated as a variable cost. Also interest on capital invested in milch cattle was included because this resource was not shared by other activities and was entirely used for dairy activity.

Borrowed and Hired Activities

Most of casual human labour hiring, if at all done, took place during the peak periods. So a labour hiring activity was introduced in the matrix for each of labour peak period. Similarly, capital borrowing activities were introduced in the matrix for these seasons. The capital in turn was fed by borrowing activities which carried the cost coefficient (negative return) in the objective function.

Level of Technology

Technology comprised two components, one divisible and the other indivisible. Only divisible technology was considered at one level recommended by agricultural experts. In the case of indivisible technology, the resource position was not changed in the analysis.

The optimal plans were developed through linear programming analysis using the following model.

$$Z = C\ X \text{ to be maximized}$$

Subject to

$$B \geqslant A\ X$$
$$X \geqslant 0$$

where Z represents total returns over prime cost and fixed cost of shed, animal value and equipment meant for milch cattle. C are the returns from activities (X), A are inputs for activities (X) and B are the resources.

RESULTS AND DISCUSSION

The existing and optimal production patterns, developed at the recommended level of technology, are given in Table I. A close perusal of the table showed that maize and groundnut were the major crops in the *kharif* season. Maize occupied 15.04 to 29.17 per cent of the total cropped area on different sizes of holdings and groundnut had 10.47 to 15.64 per cent of the total cropped area. Sugarcane and *desi* cotton were raised only on a small area in the existing production plans, whereas paddy was raised to the extent of soil suitability on the farms, which indicated that paddy was one of the most profitable enterprises.

Mexican wheat occupied the largest proportion of the cultivated area in the existing enterprise-mix on all the situations in the *rabi* season and covered 18.64 to 44.11 per cent of the total cropped area. Other crops in the *rabi* season were grown on a limited acreage.

Dairy buffaloes and cross-bred cows were reared on commercial basis as well as for domestic needs on all the selected situations. The selected farm situations were located in these villages which were covered with a network of milk co-operative societies and milk collection and chilling centres of the Punjab Dairy Development Corporation. The number of dairy cattle reared was not exactly proportionate to the size of farm but it varied directly with the size of farm. The farmers reared both the buffaloes as well as cross-bred cows for milk production. Table I shows that the farmers were interested to rear heifers, *i.e.*, they had more heifers than even milch cattle on their farms, and the number varied from 9 to 23 on different sizes of farms. This phenomenon was attributed mainly to two factors, *i.e.*, (*i*) the farmer knows the progeny characteristics of the young one, and (*ii*) it costs the farmer much less to rear a heifer than purchase full grown animals from the market.

The results of the study showed that the cross-bred cows were relatively more profitable than the buffaloes. Secondly, in the case of crop cultivation, the Punjab farmers were not operating at optimal level, particularly they were not following plant protection measures in the *kharif* season, which lowered

TABLE I—OPTIMAL PRODUCTION PATTERNS ON DIFFERENT SIZED HOLDINGS WITH TWO LEVELS OF TECHNOLOGY, LUDHIANA DISTRICT OF PUNJAB : 1974-75

(area in acres)

Enterprises	Existing plans				Optimal plans at recommended technology			
	Farm situations				Farm situations			
	S	M-I	M-II	L	S	M-I	M-II	L
***Kharif* season**								
1. Maize	4.00 (21.05)	7.00 (29.17)	5.00 (15.04)	16.00 (16.74)	3.78 (19.88)	6.46 (25.65)	—	16.00 (14.56)
2. Cotton (*desi*)	0.50 (2.64)	—	—	3.00 (3.14)	—	—	—	12.00 (10.92)
3. Sugarcane	—	0.70 (2.92)	1.50 (4.52)	3.00 (3.14)	—	—	—	—
4. Groundnut	2.00 (10.53)	2.60 (10.83)	5.20 (15.64)	10.00 (10.47)	3.00 (15.78)	2.50 (9.92)	5.00 (14.25)	10.00 (9.10)
5. Paddy	—	—	—	5.00 (5.23)	—	—	—	5.00 (4.55)
6. *Kharif* fodder	3.00 (15.78)	2.00 (8.34)	5.80 (17.44)	3.50 (3.66)	2.72 (14.31)	3.64 (14.45)	12.50 (35.63)	6.39 (5.82)
7. *Kharif* fallow	Nil	2.25	Nil	14.50	—	—	—	—
***Rabi* season**								
1. Wheat	8.00 (42.11)	8.00 (33.33)	6.20 (18.64)	32.00 (33.48)	7.13 (37.50)	10.29 (40.85)	7.16 (20.41)	45.00 (40.95)
2. Gram	—	—	—	3.00 (3.14)				
3. Barley	—	2.00 (8.33)	2.80 (8.44)	11.00 (11.52)				
4. Sugarcane	—	0.70 (2.92)	1.50 (4.52)	3.00 (3.14)				
5. *Metha*	—	—	—	3.00 (3.14)				
6. *Rabi* fodder	1.50 (7.89)	1.00 (4.16)	5.30 (15.98)	3.00 (3.15)	2.37 (12.46)	2.31 (9.17)	10.34 (29.47)	10.00 (9.10)
7. Dairy cross-bred cows	3	2	4	13	7	6	39	40
8. Dairy buffaloes	4	5	5	4	—	—	—	—
9. *Rabi* fallow	—	—	1.70	—	—	—	—	—
Heifers	9	12	17	23				
Intensity of cropping	200	—	189.72	190.28	200	200	200	200

S=Small farm situation. M-I=Medium farm situation, bullock operated. M-II=Medium farm situation, tractor operated. L=Large farm situation.

Figures in parentheses are the percentages to the total cropped area.

down the profitability of crops compared to the milch cattle. Thirdly, the demand for milk is income elastic, so the relative price increase was more in milk than in the crops in the last two years.

Optimal Production Patterns at Recommended Level of Technology

Table I shows that if the package of recommended practices was adopted in full, maize, paddy and groundnut crops turned out to be more remunerative than any other crop in the *kharif* season. The area under groundnut reached its maximum limit set by the soil suitability. Similarly, the acreage under the wheat crop remained the same on all sized holdings, except on the large farm, where it increased from 33.48 to 40.95 per cent of the total cropped area. This analysis indicated that if the full package of practices was adopted and weather remained favourable, maize, paddy and groundnut in the *kharif* season and wheat in the *rabi* season were the most paying enterprises. Thus maize would pay if the full package of recommended practices was followed but not otherwise.

The optimal production plans showed that there was an increase in the number of cross-bred cows when the recommended level of technology was used. The number of cows in the plans was almost the same as was reared in the existing plans of the small and medium-I farms, whereas the number of cross-bred cows increased to 39 and 40 on medium-II and large farms, respectively, though the number of animals reared was roughly the same as was in the existing plans. Milch buffaloes were eliminated from the optimal plans, which indicated that the cross-bred cows were more profitable than the buffaloes.

The returns over variable expenses were greater in all the plans developed at the recommended level of technology than those obtained from the existing product-mix of different sized holding as shown in Table II.

TABLE II—RETURNS TO FIXED FARM RESOURCES FROM DIFFERENT SIZED HOLDINGS AT TWO LEVELS OF TECHNOLOGY, LUDHIANA DISTRICT OF PUNJAB : 1974-75

Sr. No.	Size-group	Income from existing plans (Rs.)	Income from optimal plans at recommended level of technology (Rs.)	Percentage increase in income over existing plan
1.	Small	16,795.21	24,194.64	44.06
2.	Medium bullock operated	22,503.85	33,735.51	49.91
3.	Medium tractor operated	24,390.17	40,719.45	66.95
4.	Large tractor operated	78,552.38	1,38,897.36	76.82

It was noted that at the recommended level of technology, the large tractor farms gave an increase of 76.82 per cent, compared to 44.06 per cent increase on the small farms and 66.95 per cent increase on the medium tractor operated farms. Thus there existed a significant potential for raising farm income through the adoption of a complete package of recommended practices and rational use of resources and by augmenting resources where necessary for the implementation of optimal plans.

Resource Use Pattern and Demand for Additional Resources

Some of the imbalances in resource use of different sized holdings were removed by introducing activities for hiring casual labour in the peak periods and by borrowing seasonal liquid capital.

It will be seen from Table III that the whole land was cropped even in the existing production plan on the small farm but some acreage was left uncropped

TABLE III—RESOURCE USE PATTERN ON DIFFERENT SIZED HOLDINGS AT TWO LEVELS OF TECHNOLOGY, LUDHIANA DISTRICT OF PUNJAB: 1974-75

Resources	Existing plans				Optimal plans at recommended technologies			
	Farm situations				Farm situations			
	S	M-I	M-II	L	S	M-I	M-II	L
1. *Kharif* land (acres)	0	+0.25	0	+14.50	0	0	0	0
2. *Rabi* land (acres)	0	+0.95	+1.70	0	0	0	0	0
3. Labour period-I* (man-hours)	—711	—81	—733	—2,400	0	0	—3,025	—2,268
4. Labour period-II* (man-hours)	—260	+15	—440	—1,804	—220	+62	—2,849	—2,668
5. Labour period-III* (man-hours)	—417	—32	—1,660	—3,466	—70	—626	—2,981	—3,738
6. *Kharif* cash (Rs.)	—2,844.16	—1,217	—873	—6,989	—1,807	—1,960	—6,692	—16,297
7. *Rabi* cash (Rs.)	—1,147.71	—1,500	—6,465	—8,732	—1,834	—1,497	—6,757	—11,436
8. Farmyard manure (cart loads)	0	0	0	0	—63	—115	—74.40	—445

* Labour period-I = 15 April to end May.
* Labour period-II = 15 June to end July.
* Labour period-III = 15 October to end November.

(+) Positive sign indicates surplus of a resource
(—) Negative sign [illegible]

on the medium and large farms. This showed that as the size of farm increased, the acreage of uncropped land also increased. In the optimal plans, no piece of land was left uncropped at the recommended level of technology.

Table III also shows that permanent labour was fully employed on different sized holdings in all the three labour peak periods of the year even in the existing production patterns. Moreover, there was a demand for casual labour to the tune of 711, 81, 733 and 2,400 hours from 15th April to the end of May, 260, zero, 440 and 1,804 hours from 15th June to the end of July, and 417, 32, 1,660 and 3,466 hours from 15th October to the end of November period on the small, medium bullock operated, medium tractor operated and large farm situations respectively. Thus the demand for casual labour was more on the large farms than on the small and medium ones.

Again, working capital was a scarce resource on all the situations during both the seasons in the existing as well as in the optimal plans at both the levels of technology (Table III). The results of this study showed that modern capital intensive technology could not be adopted, especially dairy enterprise on commercial lines, unless credit facilities were further expanded.

CONCLUSIONS AND SUGGESTIONS

The overall analysis of different sized holdings showed that the total income could be raised by reorganizing the production plan, by adopting recommended packages of practices. The hypothesis that there was a great scope for increasing farm income by developing optimal plans, which used improved varieties of crops and full package of recommended practices, was accepted.

Generally, there was a shift of area from general crops to fodder crops in the optimal plans, developed at the recommended level of technology. Dairy cattle figured predominantly in all the plans which showed that dairy was a paying proposition at the existing level of technology, as well as at the recommended level of technology.

Maize, groundnut and paddy in the *kharif* season and wheat in the *rabi* season were the most paying enterprises. Groundnut and paddy were more remunerative crops than any other crop in the *kharif* season. Hence the area under these two crops could be expanded to the maximum limit set by soil suitability.

Recognizing the fact that the Punjab Dairy Development Corporation was very intensively operating in the study area and the price of milk was assured to the cultivators, the farmers could expand milk production on commercial lines to be able to diversify their production patterns and also raise their incomes.

APPENDIX 1

YIELD PER ACRE OF VARIOUS ENTERPRISES IN THE STUDY AREA, PUNJAB : 1974-75 AND PRODUCT PRICES USED FOR THE DEVELOPMENT OF INPUT-OUTPUT MATRICES

Enterprise	Average yield at existing level (quintals)	Yield at optimum level (quintals)	Product prices (Rs./quintal)
1. Maize (hybrid)	7.88	16.00	76.00
2. Paddy (IR-8)	29.00	30.00	76.00
3. Cotton (*desi*)	3.00	6.00	225.00
4. Groundnut	5.25	8.90	200.00
5. Sugarcane	236.00 (cane)	360 (cane)	12.00
6. Wheat	14.75	17.00	113.00
7. Barley	8.00	11.50	100.00
8. Gram	5.00	6.00	200.00
9. *Metha*	3.00	—	—
10. Dairy enterprise			
(*a*) Buffalo	1,080 litres (1,620 litres/lactation)	1,200 litres/year (1,800 litres/lactation)	Rs. 1.75 per litre of buffalo's milk
(*b*) Cross-bred cow	1,764 litres (2,205 litres/lactation)	2,000 litres (2,500 litres/lactation)	Rs. 1.50 per litre of cow's milk

LACTATIONWISE PRODUCTION FUNCTION AND CONCENTRATION IN MILK PRODUCTION FOR HARYANA COWS

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INTRODUCTION

Milk production is a complex process and can be conceived as a function of several variables. The knowledge of relative importance of the resource inputs influencing milk production is essential for the dairy farmer for introducing desirable changes in his operation at the micro level and for the policy-maker for formulating plans for improvements in dairy cattle productivity based on sound economic principles at the macro level. Although few studies have been undertaken in the country to assess the resource productivity, milk production functions were not ascertained for different individual lactations.[1] The milk production potential varies in different lactations and is the net outcome of the genetic and environmental effects. Thus the lactationwise studies on input-output relationships in milk production assume considerable

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1. For example, see (*i*) T. Jacob, R. K. Srivastava and V. N. Amble, "A Study on Resource Productivity in Milk Production," *Indian Journal of Agricultural Economics*, Vol. XXVI, No. 1, January-March, 1971, (*ii*) T. Jacob, V. N. Amble, M. L. Mathur and A. Subba Rao, "Milk Production Functions and Optimum Feeding Schedules," *Indian Journal of Agricultural Economics*, Vol. XXIV, No. 2, April-June, 1969, (*iii*) P. Kumar and K. C. Raut, "Some Factors Influencing the Economy of Milk Production," *Indian Journal of Agricultural Economics*, Vol. XXVI, No. 2, April-June, 1971, (*iv*) Ghansham Dass Aul, *et. al.*, "Milk Production Functions in Ludhiana," *Indian Journal of Dairy Science*, Vol. XXVII, No. 4, December, 1974, (*v*) P. Kumar, *et al.*, "Economic Response of Feed on Milk Production for Different Breeds of Milch Cows," Brief Communication, *XIX International Dairy Congress*, Vol. IE, 1974.