NOTES

RESPONSE OF HYBRID MAIZE TO LEVELS OF NITROGENOUS AND PHOSPHATIC FERTILIZATION*

In an earlier communication,[1] field experiments were reported which showed the importance of nitrogenous and phosphatic fertilization in determining the yield of hybrid maize, Texas-26, under the conditions of Indian Agricultural Research Institute, New Delhi. It was demonstrated that the hybrid maize was particularly responsive to high doses of nitrogen and phosphate fertilization in the crop season of 1961 when the growth conditions for maize were adverse due to exceptionally high rainfall. Since, in this crop season, there was a significant interaction between the nitrogen and phosphate fertilization treatments in affecting the grain yield, the study of individual fertilizer response curves was insufficient to get information on the optimum combination of variable input factors. The latter necessitated a polyfactor analysis of yield. This paper reports the results of such an analysis, describes the developed production function and discusses the utilization of same in obtaining certain important agronomic information including the economic analysis of fertilizer use in the production of hybrid maize.

MATERIALS AND METHODS

The details of the materials and methods used in growing experimental crop and collection of the data have already been given elsewhere.[2] The yield data for the year 1961, when the response of hybrid maize to nitrogen fertilization was significantly affected by the levels of phosphatic fertilization, have been reproduced in Table I for ready reference.

TABLE I—EFFECT OF NITROGEN AND PHOSPHATE FERTILIZATION ON THE GRAIN YIELD OF MAIZE

(in quintals per hectare)

Treatment	Levels of nitrogen (kg. N per ha.)					
	0	44.8	89.6	134.4	179.2	Mean
Kg. P_2O_5 per ha.						
0	4.80	8.03	11.52	13.68	13.07	10.22
44.8	5.24	9.96	16.92	16.81	17.78	13.34
89.6	4.98	11.72	15.67	17.63	18.23	13.64
134.4	5.22	11.84	15.97	17.70	17.65	13.67
Mean	5.06	10.39	15.02	16.45	17.40	

L.S.D. 5% : 0.89 q. per ha. for marginal column (*i.e.*, mean P — effect).
0.99 q. per ha. for marginal row (*i.e.*, mean N — effect).
1.98 q. per ha. for main body of the table (*i.e.*, N × P — effect).

*Contribution from the Division of Agronomy, Indian Agricultural Research Institute, New Delhi-12.

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1. M. C. Saxena and O. P. Gautam, "Nitrogen and Phosphate Fertilization of Hybrid Maize: 1. Response of 'Texas-26' to Levels of Nitrogen and Phosphate Fertilization," *Journal of Indian Society of Soil Science*, Vol. 14, No. 2, 1966.
2. *Ibid.*

To develop the production surface, a multiple regression equation of the type

$$y = a + bX_1 + cX_1^2 + dX_2 + eX_2^2 + fX_1X_2 \quad \ldots \quad \ldots \quad \text{I}$$

containing the linear, square and cross-product terms of the two independent variables, was fitted to the above yield data by the procedure of least-squares.[3] The data on yield, predicted by this function for various combinations of the two variable nutrients—nitrogen and phosphate—were plotted as a three dimensional production surface. By adopting the appropriate procedures of calculus,[4] equations were derived for the family of 'isoquants' and 'isoclines' from the production function.

RESULTS AND DISCUSSION

Production Surface

The grain yield (y) as a function of levels of nitrogen (N) and phosphate (P) fertilization could be described by the following multiple regression equation :

$$y = 3.35 + 6.368N - 0.957N^2 + 2.867P - 0.773P^2 + 0.260NP \quad \ldots \quad \text{II}$$

where y refers to the expected yield of maize grain (q. per ha.) for the given units of nitrogen and phosphate fertilizers, a unit being 44.8 kg. N or P_2O_5. The regression component of the yield variance, when compared against the residual variance, showed that the regression was highly significant. The multiple regression equation had a coefficient of determination of above 97 per cent. To test the significance of partial regression coefficients, their standard errors were computed. The standard errors (S.E.b) for the coefficients of N, N^2, P, P^2 and NP terms of equation II were found to be 0.5674, 0.1266, 0.7178, 0.2218 and 0.1194, respectively. The corresponding t-values $\left(t = \frac{b}{S.E._b}\right)$ were 11.22, 7.55, 3.99, 3.49 and 2.16. Since at 5 per cent level of probability and 14 degrees of freedom (n—p—1) the table value of t was 2.14, it is apparent from the t-test that all the partial regression coefficients were significant.

The grain yields, predicted by the above function, for different combinations of levels of nitrogen and phosphate fertilization employed in the present experiment are displayed as a smooth three dimensional production surface in Figure 1.

It is apparent that the yield increased sharply as the level of nitrogen fertilization was raised at the zero level of phosphate fertilization. When the first unit of phosphate was applied, the yield increases due to nitrogen fertilization were greater. As the input of phosphate was further raised, even higher yield returns to nitrogen applications were obtained. This clearly indicates the positive complementarity effect of nitrogen and phosphate fertilization in the production of hybrid maize under the conditions of this experiment.

3. W. G. Cochran and G.M. Cox : Experimental Designs, John Wiley and Sons, Inc., 1957.
4. R. D. Munson and J. P. Doll, "The Economics of Fertilizer Use in Crop Production," *Advances in Agronomy*, Vol. 11, 1959, pp. 133-169.

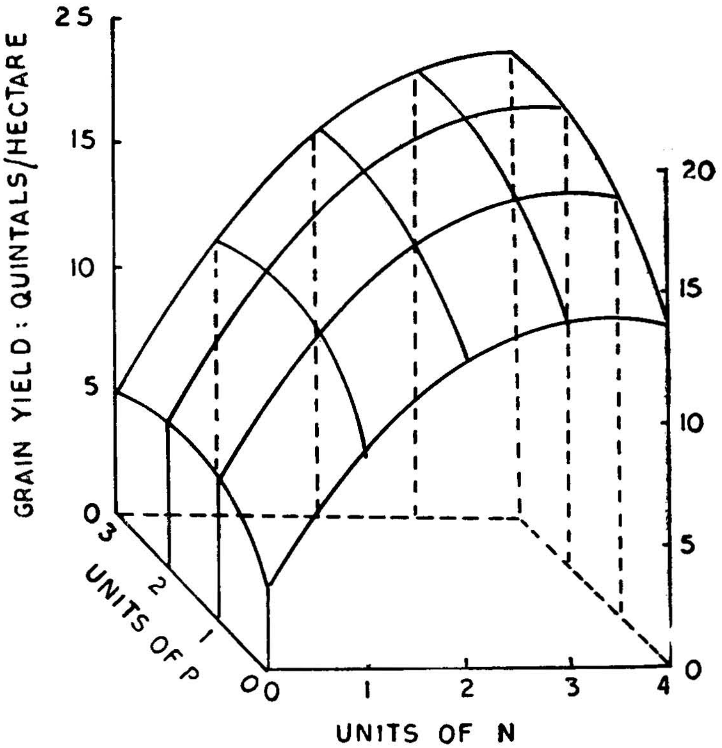


FIGURE 1—PREDICTED PRODUCTION SURFACE FOR YIELD OF MAIZE GRAIN (ONE UNIT N=44.8 KG. N; ONE UNIT P=44.8 KG. P_2O_5)

The three-dimensional production surface can be reproduced in two dimensional form as a family of contours. For the general isoquant family, an equation, describing one nutrient as a function of other and yièld, has to be derived from the fitted production function. Thus, phosphate (P) as a function of nitrogen (N) and yield (y) could be described by the relation :

$$P = 0.64641 \left[2.867 + 0.260N \pm \sqrt{18.593 - 3.094\,y + 21.194N - 2.892N^2}\right] \ldots III$$

and isoquants computed for various yield levels (*viz.*, y = 6, 9, 12, 15 and 18 (q.per ha.) are depicted in Figure 2 as an isoquant map. The curvature of isoquants exhibits the marginal rate of substitution of one nutrient for the other. The points of zero and infinite rates of substitution of the two nutrients on different isoquants are bound by dashed lines—the so-called 'ridge-lines.' In Figure 2, the ridge-lines PQ and PR connect the points of $\frac{dN}{dP} = 0$ and $\frac{dN}{dP} = \propto$, respectively, on whole isoquant map.

Almost vertical isoquants for lower yield levels suggest that yields up to 12 quintals per hectare could be obtained with nitrogen fertilization alone. For higher yield levels, however, some minimum quantities of both the nutrients—nitrogen and phosphorus—were necessary. That is why, the isoquants for higher yields became more and more curved and showed clearly the necessity of applying

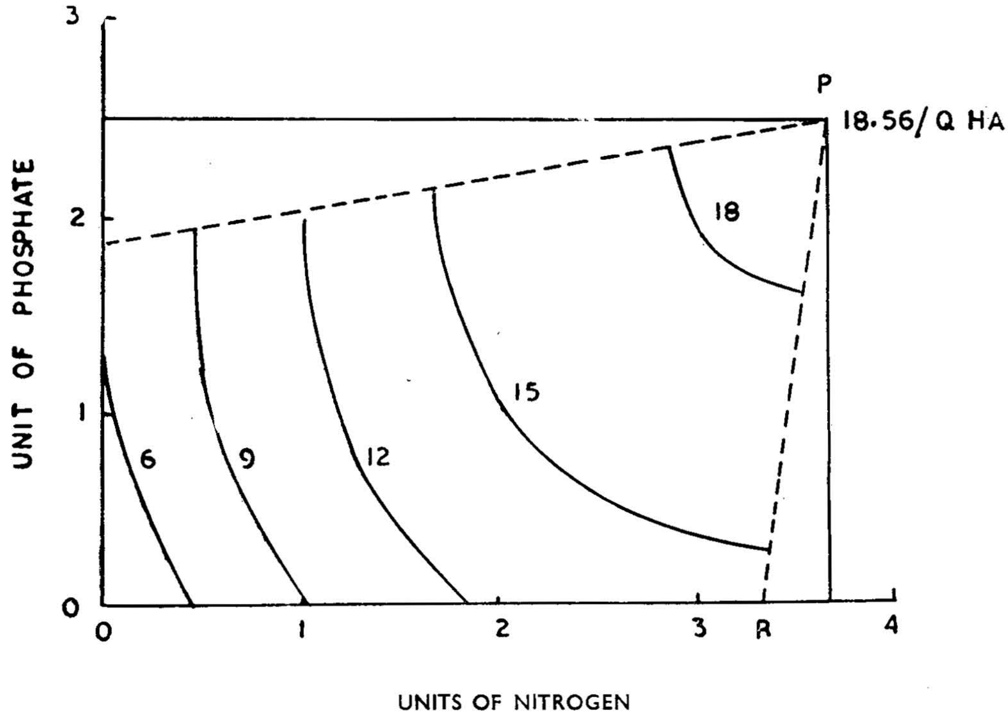


FIGURE 2—PREDICTED MAIZE GRAIN YIELD ISOQUANTS FOR 6, 9, 12, 15 AND 18 QUINTALS/HECTARE YIELD LEVELS AND THE RIDGE LINES PQ AND PR (P IS THE POINT OF MAXIMUM YIELD)

phosphatic fertilizers to increase the efficiency of higher doses of nitrogen application. The isoquant for the maximum yield reduced to a point, that is, there was only one specific nutrient combination which could result in maximum yield. For determining this point, which indicates the production potential of the crop for the grain yield under given set of conditions, the prediction equation for the production function (equation II) was first differentiated once with respect to nitrogen and once with respect to phosphate and these partial derivatives were then set to zero resulting in following equations :

$$\frac{\partial y}{\partial N} = 6.368 - 1.19134N + 0.26012P = 0 \quad \ldots \quad IV$$

$$\frac{\partial y}{\partial P} = 2.867 - 1.54700P + 0.26012N = 0 \quad \ldots \quad V$$

The simultaneous solution of these equations gave the nutrient combination of 3.66 units of nitrogen (164 kg. N per ha.) and 2.47 units of phosphate (112 kg. P_2O_5 per ha.) to be the one producing maximum yield. This combination predicted a maximum grain yield of 18.56 quintals per hectare. For comparison, the maximum yields, obtainable with one nutrient when the other was set at zero level, were computed by setting up the partial derivatives of each nutrient equal to zero and solving individually. The maximum yield at zero level of phosphate fertilization was 13.95 quintals per hectare (*i.e.*, about 74 per cent of yield potential) with 149 kg. N per ha. level, and at zero level of nitrogen was 6.01 quintal per hectare (*i.e.*, about 32 per cent of the yield potential) with 83 kg. P_2O_5 per ha. level. From these yield data it becomes once again very apparent that a judicious combination of nitrogen and phosphate fertilizer rather than the supply of any one alone, was important for obtaining higher yields of hybrid maize.

Economics of Fertilizer Use

When two nutrients are varied simultaneously, two economic problems are involved, namely, (a) determination of the least-cost combination of the variable nutrients for any particular yield level and (b) calculation of the most profitable level of fertilization considering the nutrient cost and yield price ratios. For these economic considerations, apart from nature of response function information is needed on the prevailing price structure (*i.e.*, the cost of fertilizers and price of the produce in market), which for the present experiment has been given as a note to Table II. The area of the isoquant map (Figure 2) covered within the ridge-lines, PQ and PR, only would be of interest because outside this area higher quantities of both nitrogen and phosphorus may be needed to produce the same yield. A line joining the points of identical slope on all the isoquants is termed as 'isocline,' which can be superimposed on the isoquant map. One such line could describe the least-cost (*i.e.*, profit maximizing) combination of nitrogen and phosphate fertilizers for various yield levels. However, a particular amount of yield could be produced at minimum cost only when the marginal rates of substitution of the two nutrients were equal to the ratio of their costs. Depending upon the cost ratios, therefore, various isoclines, connecting the points of maximum profit on various isoquants, could be obtained.

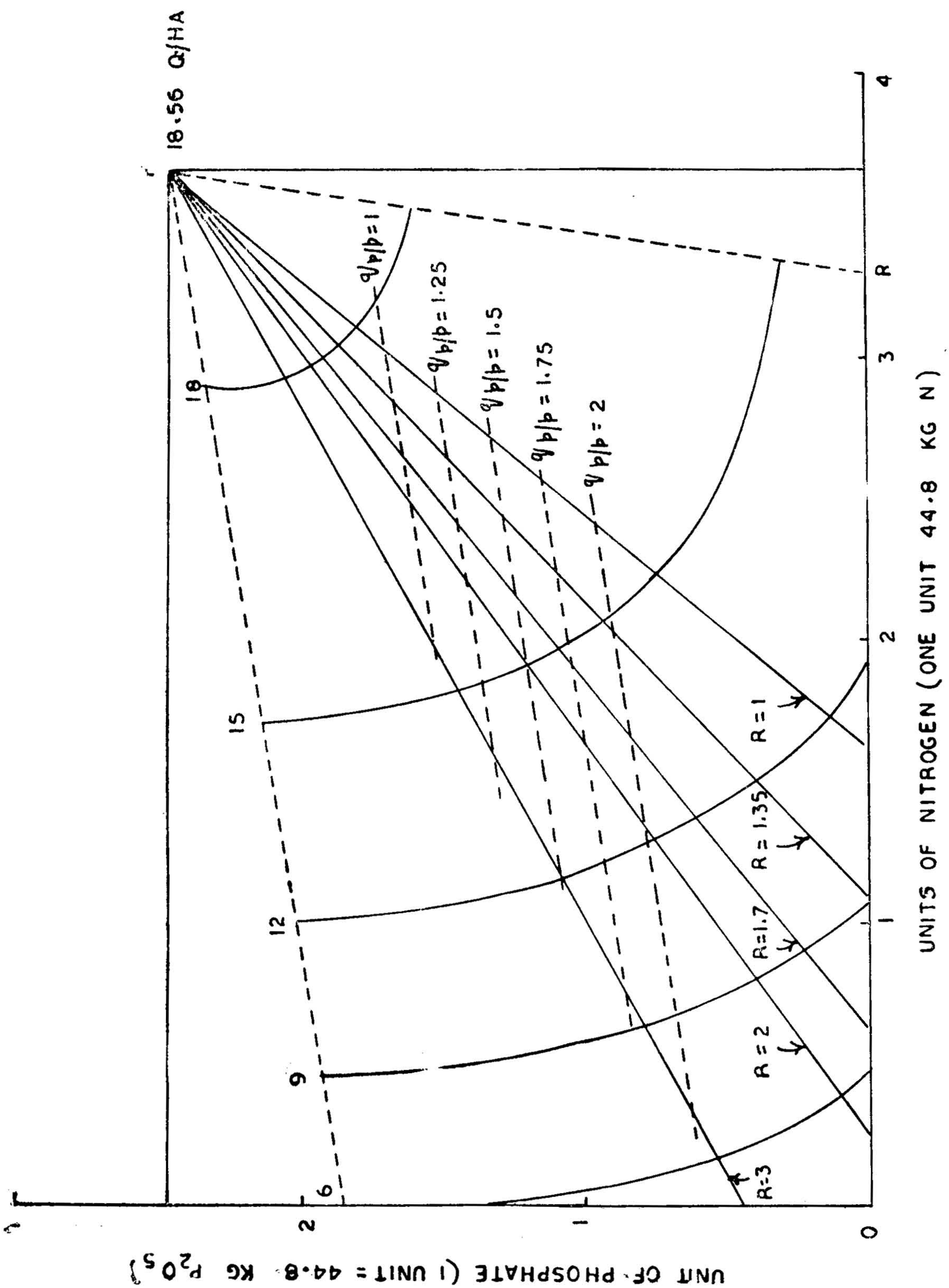
The profit maximizing condition for the present experiment can be expressed by the following equation (VI) derived from the production surface (equation II) by suitable procedures of calculus :

$$\frac{6.368-1.913N+0.260P}{2.867-1.547P+0.260N} = \frac{q_N}{q_P} \quad \ldots \quad \text{VI}$$

where q refers to the cost of one unit of the subscripted nutrient. This relation holds good for all the yield levels. The general isocline equation derived from equation VI is given as follows :

$$P = \frac{(2.867R) - (6.368) + (1.913 + 0.260R)N}{(0.260 + 1.547R)} \quad \ldots \quad \text{VII}$$

where R is the ratio of the cost of a unit of nitrogen and a unit of phosphate (*i.e.*, $R = \frac{q_N}{q_P}$). By substituting the above values of P and various yield levels in the fitted production surface (equation II) isoclines were obtained for R values ranging from 1 to 3 and are depicted in Figure 3 as superimpositions on the isoquant map.


18.56 Q/HA
18
15
12
9
6
q/p = 1
q/p = 1.25
q/p = 1.5
q/p = 1.75
q/p = 2
R = 1
R = 1.35
R = 1.7
R = 2
R = 3
R
UNITS OF NITROGEN (ONE UNIT 44.8 KG N)
UNIT OF PHOSPHATE (1 UNIT = 44.8 KG P2O5)
0
1
2
3
4

It is evident that the curvature of isoquants along the line of a fixed quantitative proportion of the two nutrients was not same, suggesting thereby that the proportion of the two nutrients giving maximum profit changed with the yield level. Thus, at prevailing cost structure (*i.e.*, $q_N/q_P = R = 1.35$) an application of nitrogen alone at the rate of 1.08 units per hectare was optimum to produce a yield level of 6 quintals per hectare, whereas at the yield levels of 12 and 13 quintals per hectare the fertilizer combinations of 1.5 units of nitrogen and 0.4 units of phosphate and 2.08 units of nitrogen and 0.95 units of phosphate, respectively, were found to be optimum. The optimum nitrogen and phosphate combinations, for all levels of production for different cost ratios (R = 1, 1.35, 1.7, 2.0 and 3.0) can directly be read as the co-ordinates of the points, where the isoquants are intersected by various isoclines in Figure 3.

The problem of getting most profitable combination under the conditions of present experiment can be solved graphically when the lines corresponding to various phosphate cost-maize price ratios (q_P/P) are developed. These lines, for q_P/P ratios ranging from 1 to 2, have been shown as the horizontal dashed-lines in Figure 3. The co-ordinates of the points where the dashed-lines intersect the isoclines give the most optimum nutrient combinations at different cost-price structures. Consequently, Figure 3 gives almost complete economic information for recommending the nitrogen-phosphorus combinations. The least-cost combinations could also be calculated from the simultaneous solution of following equations.

$$6.368-1.913N+0.260P = \frac{q_N}{p} \qquad \ldots \quad \text{VIII}$$

$$2.867-1.547P+0.260N = \frac{q_P}{p} \qquad \ldots \quad \text{IX}$$

and are reported in Table II for some important nutrient cost-produce price ratios. It is evident that at cost-price structure prevailing in 1962 the optimum dose was

TABLE II—OPTIMUM DOSE COMBINATIONS AS UNITS OF NITROGEN (N) AND PHOSPHATE (P) FOR VARYING COST-PRICE RATIOS

q_P/p	q_N/p 1.8		2.0		2.2	
	N	P	N	P	N	P
1.3	2.58	1.45	2.48	1.43	2.37	1.41
1.5	2.57	1.31	2.46	1.30	2.35	1.28
1.7	2.55	1.18	2.44	1.16	2.33	1.15

Note : 1. q_N = cost of one unit of nitrogen (44.8 kg. N).
q_P = cost of one unit of phosphate (44.8 kg. P_2O_5).
2 p = price of 1 quintal of maize grain.
3 Prevailing q_N = Rs. 81.59; q_P = Rs. 60.70 ; p = Rs. 40.00.

2.46 units (110.2 kg. per ha.) nitrogen and 1.30 units (58.28 kg. per ha.) P_2O_5. At this combination, the yield predicted by the production function (equation II) was 16.48 quintals per hectare which gives a net income of Rs. 379.50 per hectare over the cost of fertilizers. With increasing q/p ratio for each nutrient the optimum dose decreases, which suggests that inputs of both the nutrients could profitably be increased if the fertilizers were available at cheaper rates or the produce were sold at higher price.

SUMMARY

A two factor—nitrogen and phosphorus—analysis of the grain production of hybrid maize, Texas-26, grown under the field conditions of Indian Agricultural Research Institute, New Delhi, has been reported. The grain yield could well be expressed as a production surface, which is described by the equation : $y = 3.35 + 6.368N + 2.867P + 0.260NP - 0.957N^2 - 0.773P^2$. In this equation, which has a coefficient of determination of above 97 per cent based on analysis of treatment variance, y is the expected grain yield in quintals per hectare for given units of nitrogen (N) and phosphate (P) fertilizers, whereby one unit refers to 44.8 kg. of N or 44.8 kg. of P_2O_5 per hectare. From this production surface a maximum grain yield of 18.56 quintals per hectare was predicted for a fertilizer combination of 164 kg. N and 113 kg. P_2O_5. At prevailing price structure of 1962 (44.8 kg. N and P_2O_5 costing Rs. 81.59 and Rs. 60.70, respectively, 1 quintal maize grain selling at Rs. 40.00), the most profitable level of fertilization was found to be the combination of 110.2 kg. N and 58.3 kg. P_2O_5, which was capable of producing a grain yield of 16.48 quintals per hectare and gave a profit of Rs. 379.50 per hectare over the cost of fertilizers.

M. C. SAXENA†
AND
O. P. GAUTAM*

INPUT COSTS AND RETURNS OF MAJOR IRRIGATED CROPS IN MANDYA DISTRICT (SUGARCANE, PADDY AND KAR RAGI)‡

Farm management studies were initiated in 1962-63 in the Mandya district of Mysore State where the Intensive Agricultural District Programme is in operation since 1961-62. Among other things, farm management study provides information on input-output data so essential for formulating farm plans. In this study an attempt is made to provide information on costs and returns of major irrigated crops.

† Pool Officer.

* Head of the Division of Agronomy and Deputy Director (Research), Indian Agricultural Research Institute, New Delhi-12.

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IMPORTANCE OF COST STUDY

In a developing economy like India, farming is becoming progressively commercialized. This is particularly true of irrigated farming. A farm enterprise, to justify its continuance, should return a net profit above all costs. The farmer's chief concern therefore is to secure a satisfactory margin between the cost and selling price of his products. It is therefore extremely important for farmers to know their production costs. The basis for intelligent farm organization consists of a knowledge of the relative profitability of the various enterprises which may be suited to the particular locality. In farming, as in other business, cost statements are desirable to point out the places where production cost should be lowered and the extent to which operations can be expanded profitably. Cost studies in an area not only furnish information on the relative profitability of the enterprises but also serve as a guide for better choice and combination of farm enterprises for maximizing returns. Enterprise cost studies thus provide a variety of results of practical value for improving farming efficiency. These studies are therefore vital to plan future use of resources.

Importance of a suitable price policy is recognized both in the developed and developing countries. Fixation of price is necessary to provide satisfactory incentive and protection to marginal farmers. Knowledge of cost of production is a pre-requisite in price fixation. Study of average costs of a group of farmers is helpful in providing information about the input costs but is not of much help for purposes of price fixation as it does not cover large percentage of farmers. For this purpose the bulk-line cost which is usually defined as the cost covering 85 per cent of production has been calculated for sugarcane and paddy which have been brought within the fold of price policy.

Brief Description of the District

The district is situated in the Deccan plateau with a maximum elevation of 2,291 feet above sea level. The soils are mainly lateritic and range from red sandy loams to red clayey loams. The average rainfall is 687.9 mm. and is spread over 65 rainy days from March to November. The total area of the district is 16,65,677 acres of which 5,89,003 acres are cultivated. Of the cultivated area nearly 1,60,683 acres or 27.28 per cent are under irrigated crops, which is considerably higher as compared to the 7 per cent of the area under irrigation in Mysore State.

Canals and tanks form important sources of irrigation. Sugarcane, paddy and irrigated (*kar*) *ragi* cover bulk of the area under irrigation. Sugarcane is the chief cash crop. Paddy is the chief food crop and is raised both in monsoon (*hain*) and summer (*kar*) seasons. It serves both as a rotation and a competitive crop to sugarcane. Irrigated (*kar*) *ragi* is another food crop grown mainly as a rotation crop.

Objectives

The objectives set for this study, therefore, are :

(1) to determine the average input costs and returns of paddy and irrigated *ragi*, and

(2) to determine the bulk-line costs of production of sugarcane and paddy.

Sample

The holdings included in this note are from the multi-stage stratified sample drawn for the Farm Management Study in Mandya district. It comprises 22 holdings of sugarcane producers, 118 holdings of paddy producers and 14 holdings of *ragi* producers. The data were collected by the fieldmen in the year 1962-63.

SUGARCANE

The cost of production of sugarcane per acre comes to Rs. 1,296.20 (Rs. 3,200.45 per hectare) (Table I). The average cost per ton of sugar works out to Rs. 27.58. The gross return being Rs. 2,697.53 per acre (Rs. 6,660.47 per hectare), net return comes to Rs. 1,401.33 (Rs. 3,460.02 per hectare) and returns over direct costs comes to Rs. 1,843.95 (Rs. 4,552.90 per hectare).

TABLE I—COST OF PRODUCTION PER ACRE OF SUGARCANE, 22 HOLDINGS, MANDYA DISTRICT, MYSORE STATE : 1962-63

Sr. No.	Item	Cost of production per acre (Rs.)	Per cent to total
1.	Labour Cost	523.92	40.42
	A. Human Labour	427.35	32.97
	(i) Family	245.72	18.96
	(ii) Annual	16.57	1.28
	(iii) Hired	165.06	12.73
	B. Bullock Labour	96.57	7.45
	(i) Owned	70.57	5.44
	(ii) Hired	26.00	2.01
2.	Variable Cost	329.66	25.43
	(i) Manure	36.95	2.85
	(ii) Fertilizers	149.55	11.54
	(iii) Seed rate	118.81	9.16
	(iv) Repair charges	14.92	1.15
	(v) Miscellaneous charges	9.43	0.73
3.	Fixed Cost	442.62	34.15
	(i) Rent and rental value	413.15	31.87
	(ii) Revenue and taxes	14.98	1.16
	(iii) Interest on investment	9.24	0.71
	(iv) Depreciation charges	5.25	0.41
	Total cost	1,296.20	100.00
	Yield (in tons)	47.20	
	Gross income (Rs.)	2,697.53	
	Net profit (Rs.)	1,401.33	

Labour is an important item of cost. It forms 40.42 per cent of the total cost, of which human labour alone accounts for four-fifth of the total labour cost or 32.97 per cent of the total cost. Family and hired labour claim the major share of human labour. Bullock labour forms only 7.45 per cent. Major share of the bullock labour comes from owned bullocks.

Other variable costs account for 25.43 per cent of the total cost. Fertilizers and seeds are important components of variable costs and they together account for 20.70 per cent of the total cost which is nearly 80 per cent of variable costs. Variable costs come to Rs. 853.58 per acre which is 65.85 per cent of the total cost.

Fixed costs account for 34.15 per cent of total cost of which rental value alone accounts for 31.87 per cent, claiming major share of fixed cost.

Bulk-line Cost

Bulk-line cost of sugarcane is Rs. 30.60 per ton which covers 81.50 per cent of the area and 66.80 per cent of the holdings. Harvest price is Rs. 57 per ton which is little less than double the bulk-line cost.

TRANSPLANTED PADDY

It costs Rs. 465.95 (Rs. 1,150.48 per hectare) to grow an acre of transplanted paddy (Table II). The average cost of production per 100 lbs. will be Rs. 15.62. Gross income (from grain and straw) being Rs. 541.5 (Rs. 1,337.12 per hectare), it yields a net return of Rs. 75.59 per acre (Rs. 186.65 per hectare). The returns over direct costs come to Rs. 352.80 (Rs. 871.10 per hectare).

Labour and other variable costs form 25.4 per cent and 15.49 per cent of the total cost respectively. They together account for 40 per cent of the total cost, human labour is nearly four-fifth of the total labour cost and family labour claims a major share of it. Manures and fertilizers are important items of variable costs and they together form 10.56 per cent of the total cost.

Fixed costs are nearly 60 per cent, which is quite high. Rent is an important item of fixed costs, which alone accounts for 54.99 per cent of the total cost.

Bulk-line Cost

Bulk-line cost of paddy is Rs. 15.60 per 100 lbs. (Rs. 34.32 per 100 kgs.) which covers 78.25 per cent of area and 71 per cent of holdings.

Harvest price being Rs. 16.79 per 100 lbs. (Rs. 36.94 per 100 kgs.), it covers more than the bulk-line cost.

KAR RAGI

The cost of irrigated *ragi* is Rs. 345.85 per acre (Rs. 853.94 per hectare) (Table III). The average cost per 100 lbs. will be Rs. 17.60. Gross return from grain and straw comes to Rs. 440.10 per acre (Rs. 1,086.80 per hectare), leaving

TABLE II—COST OF PRODUCTION PER ACRE OF TRANSPLANTED PADDY, 118 HOLDINGS, MANDYA DISTRICT, MYSORE STATE : 1962-63

Sr. No.	Item	Cost of production per acre (Rs.)	Per cent to total cost
	Labour Cost	118.42	25.41
	A. Human Labour	96.45	20.70
	(i) Family	56.09	12.04
	(ii) Annual	5.50	1.18
	(iii) Hired	34.86	7.48
	B. Bullock Labour	21.97	4.71
	(i) Owned	20.65	4.43
	(ii) Hired	1.32	0.28
2.	Variable Cost	70.32	15.09
	(i) Manure	25.55	5.48
	(ii) Green manure	2.72	0.58
	(iii) Fertilizers	18.27	3.92
	(iv) Seed rate	4.52	0.97
	(v) Repair charges	6.27	1.35
	(vi) Miscellaneous charges	12.99	2.79
3.	Fixed Cost	277.21	59.50
	(i) Rent and rental value	255.28	54.79
	(ii) Revenue and taxes	12.01	2.58
	(iii) Interest on investment	5.71	1.23
	(iv) Depreciation charges	4.21	0.90
	Total cost	465.95	100.00
	Yield (in kgs.) Grain	1,356	
	Yield (in kgs.) Straw	2,727	
	Gross income (Rs.) Grain	471.54	
	Straw	70.00	
	Total	541.54	
	Net profit	75.59	

TABLE III—COST OF PRODUCTION PER ACRE OF KAR RAGI, 14 HOLDINGS, MANDYA DISTRICT, MYSORE STATE : 1962-63

Sr. No.	Item	Cost of production per acre (Rs.)	Per cent to total cost
1.	Labour Cost	98.47	28.47
	A. Human Labour	78.29	22.64
	(i) Family	38.18	11.04
	(ii) Annual	9.28	2.68
	(iii) Hired	30.83	8.92
	B. Bullock Labour	20.18	5.83
	(i) Owned	19.46	5.63
	(ii) Hired	0.72	0.20
2.	Variable Cost	52.64	15.22
	(i) Manure	29.99	8.67
	(ii) Fertilizers	6.48	1.87
	(iii) Seed	1.42	0.42
	(iv) Repair charges	4.02	1.16
	(v) Miscellaneous charges	10.73	3.10
3.	Fixed Cost	194.74	56.31
	(i) Rent	181.48	52.48
	(ii) Revenue and taxes	5.20	1.50
	(iii) Interest on investment	4.13	1.19
	(iv) Depreciation charges	3.93	1.14
	Total cost	345.85	100.00
	Grain yield (in kgs.)	893	
	Straw yield (in kgs.)	902	
	Gross income : Grain	376.21	
	Straw	63.95	
	Total	440.16	
	Cost of production	345.85	
	Net profit	94.31	

a net return of Rs. 94.31 per acre (Rs. 232.86 per hectare). Returns over direct cost come to Rs. 289.05 (Rs. 713.69 per hectare).

Labour and rental value form major items of cost. They together form nearly 75 per cent of the total cost. Human labour forms the major part of the total labour cost, of which family labour is nearly half. Rental value forms 52.48 per cent of the fixed costs. It is the largest single item of cost.

CONCLUSION

In this note the cost of production of sugarcane is compared to the costs of production of paddy and irrigated *ragi.* It is nearly three times the cost of production of paddy and four times the cost of production of irrigated *ragi.* Sugarcane producers have earned a net income of Rs. 1,400 per acre (Rs. 6,660 per hectare) which is nearly 20 times the net income from paddy and 15 times the net income from irrigated *ragi.* It is nearly 8 times more than the net incomes derived from producing both paddy and irrigated *ragi.* Paddy is mainly grown as a competitive crop to sugarcane and farmers expect higher net returns. But the present analysis shows that it does not pay even as much as irrigated *ragi* (gross returns from paddy is about Rs. 100 more than from irrigated *ragi*) which is mainly grown as a subsidiary and rotation crop to sugarcane and paddy. This, however, needs further investigation by covering sufficient number of holdings for a period of three years. The bulk-line cost of sugarcane is Rs. 30.60 per ton, which is far lower than the harvest price of sugarcane (average harvest price is Rs. 57). The bulk-line cost of paddy is Rs. 15.60 per 100 lbs. which is about the harvest price of paddy (average harvest price is Rs. 16.79 per 100 lbs).

N. P. PATIL*

REORGANIZATION OF CASE FARM IN LUDHIANA DISTRICT (PUNJAB) (APPLICATION OF BUDGETING TECHNIQUE)

Introduction

A farm business is both complex and complicated : complex because it contains many individual parts, complicated because these parts are both intertwined within the business and interwoven within the competing influences of other businesses. Because of this complexity thousands of disasters have occurred in organizing farm business.

This 33-acre farm under study is located 15 miles from Ludhiana city. The farm land is located in two pieces but one piece consists of only 4.27 acres at a distance of half a mile from the other piece. There is no drainage problem and slopes of the fields being moderate, water can reach every field. The land was till now operated with bullock power. The owner desires to change from bullock cultivation to a tractor operated farm. He and some other farmers of the area have similar questions. What will be the economic consequences of changing from bullocks to tractors ? The answer to this type of question requires complete reorganization of such farms, *i.e.,* changing crop mix, etc., and then comparing the efficiency of new plan with the existing one.

* Director of Research, University of Agricultural Sciences, Malleswaram, Bangalore-3.

This is an attempt to reorganize a case farm with the introduction of new source of power. The reorganization recommended here is not the most profitable organization but one of the most profitable organizations. It is very difficult to say that the optimum is achieved. Our aim should be to reach as close to the optimum as possible.

Object

Specifically, the objectives of this study are (*i*) to examine existing resources and restrictions of the case farm; (*ii*) to suggest a suitable reorganization for the farm; and (*iii*) to estimate capital requirements for implementing the new plan.

Procedure and Discussion

There can be many approaches to farm reorganization. A more meaningful and realistic approach is to optimize the returns to the most limiting resource. A study of the existing resources of the farm indicated that capital and labour were relatively less limiting factors and land was the most limiting factor. Hence this reorganization was built around the "land" factor. Other restrictions are shown in Appendix I. The important features of this organization are :

(*i*) Inventory of farm resources was taken on March 13, 1965.

(*ii*) Looking to the physical possibilities on the farm, two alternative plans and cropping schemes were prepared (Appendix II).

(*iii*) Feasibility of these two alternatives was tested in "preliminary reorganization test sheet (Appendix III-IV). The position with regard to capital requirements, tractor hours requirement, irrigation requirements and risk rating was nearly the same but there was a difference of Rs. 6,469.18 in returns to fixed resources and hence cropping plan II was recommended for this farm.

(*iv*) The layout of the farm also needs to be changed according to the new rotation programme.

(*v*) Peak labour requirements were smoothened and month-wise and enterprises-wise labour requirements were estimated in Appendix V. After deducting operator's labour and permanent hired labour, the requirements of casual labour were estimated.

(*vi*) Tractor hours required month-wise and enterprise-wise were worked out in Appendix VI. Surplus tractor hours during the months of May and October, could be custom hired off the farm to earn extra income.

(*vii*) Short term capital requirements and cash receipts were also worked out by months (Appendix VII). March and April seem to be most critical months for finance. Highest amounts of receipts were therefore planned to be forthcoming in February, March and May. Short term capital requirements included cash variable expenses and payments to casual labour hired.

(*viii*) Irrigation requirements were estimated month-wise (Appendix VIII) to show that there will be no difficulty in irrigating the crops during any critical period.

(*ix*) Planned gross receipts, expenses, net farm earnings and returns to management and operator's labour were worked out in Appendix IX. Repayment capacity and credit needs (long-term) for new plan is shown in Appendix X. A loan of Rs. 10,000 for purchase of tractor was proposed. The farmer has sufficient repayment capacity to repay the loan.

Results

The existing organization was compared with new plan by using the following efficiency measures :

Measures	Present plan	Alternative plan	Remarks
A. Land			
1. Cropping intensity ..	175%	200%	Cropping intensity was increased because of the increase in power available.
2. Per cent area under fodder	6%	3%	With the introduction of the mechanical power it was possible to replace animal power and thus area under fodder was reduced to half.
B. Business (Rs.)			
3. Gross returns per acre	539.00	1,782.17	Gross returns were increased due to change in the cropping pattern. Major area in the new plan was put under sugarcane and hence gross returns were increased.
4. Net farm earnings	14,407.50	35,268.60	Net returns per acre increased three times because of the fact that (i) sugarcane as an income bright enterprise was increased in the plan to 5 times. (ii) Farm operator devoted more time operating his farm organization. (iii) Shift in source of power made it possible to bring all area under self-cultivation.
5. Labour earning (including management)	8,407.50	27,843.30	Labour earnings also increased 4 times because labour was complemented by machinery or capital and creation of this complementary relationship resulted in a significant increase in the efficiency of labour.
6. Management returns	8,407.50	27,014.98	Change in cropping mix of the farm for profitability and other changes in this organization were indicative of higher management ability and resulted in higher returns to management.

(*Contd.*)

Measures	Present plan	Alternative plan	Remarks
C. Labour			
7. Crop acres per man	11.00	13.2	In this existing organization 22 acres were operated by 2 permanent hired labour whereas in new plan 33 acres will be operated by 2 permanent labour and operator's own labour (½ man equivalent) ; therefore crop acres per man increased.
8. Gross income per man (Rs.)	8,992.50	23,524.62	Gross income per man also increased more than twice because of the reason that labourer had now adequate capital and machinery to work with.
9. Labour earning per man (Rs.)	4,203.75	11,137.32	Total labour earnings increased thrice, while labour earnings per man increased twice because now instead of two permanent labourers there will be 3 (one operator's labour). More even distribution of labour throughout the year contributed to this increase.
D. Capital			
10. Gross income per Rs. 1,000 operating capital invested	6,403.25	3,081.86	Income per rupee invested was reduced to half because operating capital increased proportionately more than the increase in gross income. But this return was not the major consideration because capital was not limiting on this farm.
11. Rate of capital turnover	17%	45.4%	Rate of capital turnover increased more than twice due to provision of high income crops such as sugarcane in the new plan. With only a slight increase in capital investment gross income increased considerably.
12. Operating costs per acre (Rs.)	126.50	583.53	Operating costs per acre were higher because sugarcane was a major enterprise in the new plan and the costs per acre for sugarcane were considerably higher than any other enterprise.

A. S. KAHLON*
AND
S. S. ACHARYA†

*Dean, College of Basic Sciences and Humanities, Punjab Agricultural University, Ludhiana.
†M.Sc. Student of Farm Management, Punjab Agricultural University, Ludhiana.

APPENDIX I

Summary of Assumptions and Restrictions on Farm Organization

A. Land

(*a*)	Acres owned : 33	Acres cultivated: 33
(*b*)	Acres rented in : nil	Acres rented out: 11 (with new organization all will be owner operated)
(*c*)	Acres irrigated : 33	Acres unirrigated : nil
(d)	Soil type: loamy sand medium fertility Ph —7-8	

No area is limited in use by its physical restrictions, only a piece of one acre was slightly low lying but now it has been reclaimed.

B. Labour

(*a*) Family labour : When farm was bullock-operated, owner was not working on the farm. With the mechanization of the farm, tractor will be operated by the owner. As such depending on the work load it was assumed that his labour will be available month by month as follows :

	in hours		
February	124	June	124
March	124	July	124
April	260	October	260
May	260	November	260

(*b*) Permanent hired labour : Two permanent labour were hired for the organization. Assuming 24 days of 8 hours each during non-peak period and 26 days of 10 hours each during peak period, following labour hours will be available :

January	384	May	520	September	384
February	520	June	520	October	520
March	520	July	520	November	520
April	520	August	348	December	380

(*c*) Casual labour : There was no restriction on casual labour availability for this farm. Families of two permanent labourers and 3 other families were available for farm work as and when desired. As such it was assumed that any amount of casual labour needed during any period will be available.

C. Irrigation

In all seasons, as far as water availability was concerned, it could be pumped for any length of time. So under normal conditions assuming 12 hours per day, 84 irrigation hours per week will be available. (It takes 5 hours to irrigate one acre with 5 H.P. electric engine and 4 units of electricity are consumed per hour. Each unit costs Re. 0.10) and whenever needed it can irrigate 17 hours per week. In the month of June it is assumed that whenever needed, it will be operated 14 hours a day.

D. Capital

It was assumed that the farmer will provide Rs. 20,000 for the farm business. In fact he did not require short term capital. Fertilizer loan was available to the extent of Rs. 250 at one time ; Rs. 20,000 could be borrowed for purchase of tractor. Except long-term loan for tractor he did not need to borrow any credit.

E. Management

1. The farmer desired to operate his holding at 200% crop intensity.
2. The cultivator was willing to take limited risk but desired that income variability should not be excessive.
3. He is well educated and possesses adequate skill for performing mechanical farm operations.
4. He is involved in many community and development activities.
5. He owned a 750-acre sugarcane farm in East Africa and used to manufacture jaggery and export it to U.K. He has thus good experience of sugarcane cultivation.
6. There is no problem as far as experience with different enterprises is concerned. He can also manage to carry out all the operations in time.

F. Others

It is assumed that out of 4 bullocks now with the farmer, two will be disposed off at once. Two bullocks will be used as supplementary power. The farmer will himself operate the tractor, but some times he may not like to work or he may be out. To fill this gap, this bullock pair will be kept. As no operations can be specified, no mention of bullock power is made in the plan. One acre area in each season and by-products of wheat and maize crop if needed will be fed to them. In addition, fodder will also be needed to be supplied to one buffalo kept for milk purposes. This is likely to continue only for 2 or 3 years and after that only goats will be kept. As this is a suplementary enterprise and fodder requirements will be raised on the farm, no details were worked out for this enterprise. But cropping scheme will include at least one acre *kharif* and one acre *rabi* fodder.

G. Custom Hiring

Cane crusher will be custom hired at Rs. 320 per season. It needs partial budgeting to decide whether it is profitable to custom hire or to own the cane crusher. Chaff cutter for chaffing wheat stalks before threshing will also be custom hired.

H. Technology

It is assumed that technology during the three years for which the plan is prepared will remain the same.

APPENDIX II

Two Alternative Crop Mixes for Comparison

Cropping Scheme I

	First Year		Second Year		Third Year	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
4 acres	Hybrid maize	Wheat	Hybrid maize	Wheat	Groundnut	Wheat
4 acres	Hybrid maize	Wheat	Groundnut	Wheat	Hybrid maize	Wheat
4 acres	Groundnut	Wheat	Hybrid maize	Wheat	Hybrid maize	Wheat
4 acres	Sugarcane	—	First Ratoon	—	Groundnut	Wheat
4 acres	Groundnut	Wheat	Sugarcane	—	First Ratoon	—
4 acres	First Ratoon	—	Groundnut	Wheat	Surgarcane	—
2 acres	Hybrid maize	Wheat	Hybrid maize	Gram	—	—
2 acres	Hybrid maize	Gram	Hybrid maize	Wheat	—	—
4 acres	Hybrid maize	Wheat	—	—	—	—
1 acre	*Chari*	Berseem	—	—	—	—

Acreage

Kharif		*Rabi*	
Hybrid maize	.. 16 acres	Wheat	.. 22 acres
Groundnut	.. 8 acres	Sugarcane	.. 8 acres (*Contd.*)
Sugarcane	.. 8 acres	Gram	.. 2 acres
Chari	.. 1 acre	Berseem	.. 1 acre
Total	.. 33 acres	Total	.. 33 acres Intensity 200%

CROPPING SCHEME II

	First Year		Second Year		Third Year	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
8 acres	Sugarcane	—	First Ratoon	—	Groundnut	Wheat
8 acres	Groundnut	Wheat	Sugarcane	—	First Ratoon	—
8 acres	First Ratoon	—	Groundnut	Wheat	Sugarcane	—
2 acres	Hybrid maize	Wheat	Hybrid maize	Wheat	Groundnut	Wheat
2 acres	Groundnut	Wheat	Hybrid maize	Wheat	Hybrid maize	Wheat
2 acres	Hybrid maize	Wheat	Groundnut	Wheat	Hybrid maize	Wheat
1 acre	*Chari*	Berseem	—	—	—	—
2 acres	Hybrid maize	Gram	—	—	—	—

Acreage

Kharif		*Rabi*	
Sugarcane	16 acres	Wheat ..	14 acres
Hybrid maize	6 acres	Sugarcane ..	16 acres (*Contd.*)
Groundnut	10 acres	Gram ..	2 acres
Chari	1 acre	Berseem ..	1 acre
Total	33 acres	Total ..	33 acres Intensity 200%

Farmer's Original Restrictions

(*i*) Gram : 2 acres

(*ii*) Area under fodder for one pair of bullocks and one buffalo kept for ensuring pure milk supply for home consumption

Chari	1 acre
Berseem	1 acre

(*iii*) Crops to be compared are sugarcane, hybrid maize, groundnut and wheat.

(*iv*) Cropping intensity not less than 200%. Detailed comparisons are shown in preliminary farm reorganization test sheet.

Comparison of Two Alternative Plans

(1) Intensity : Cropping intensity in both plans was equal, *i.e.*, 200%.

(2) Short term capital required : Short term capital required for Plan I was Rs. 17,200 and for Plan II Rs. 17,256, *i.e.*, approximately equal. However there was difference in the requirements of short term capital by season. Plan II required more capital in *kharif* than Plan I and Plan I required more *rabi* capital than Plan II. But the restriction of short term capital figuring in inventory was Rs. 20,000. As such this aspect did not disqualify any of the plans.

(3) Peak labour requirements, April-May: Assuming that during April-May, farm owner will work on tractor for 8 hours a day, there will be deficit of permanent labour of 952 hours in Plan I and deficit of 1,380 hours in Plan II which could be met by hiring casual labour.

(4) Peak labour required, October-November: Here 362 hours in Plan I and 510 hours in Plan II were surplus which will be devoted off the farm for ploughing and discing operations.

(5) Tractor power requirements, April-May: 244 hours were surplus in Plan I and 278 hours in Plan II and as such more could be earned by working off the farm according to Plan II.

(6) Tractor power requirements, October-November: 254 hours were surplus in Plan I and 332 hours in Plan II. Here again Plan II had an advantage of earning extra income by working off the farm.

(7) Irrigation in June : There was no restriction of irrigation in critical period in both the plans.

(8) Risk rating : Risk rating in both the plans was the same.

(9) Returns to fixed factors : When returns to fixed factors were compared, Plan II provided Rs. 6,469.18 more income over Plan I and again Plan II had an advantage of sparing more tractor hours for work off farm. Hence the alternative Plan II could be safely recommended for this farm.

APPENDIX III

Preliminary Farm Reorganization Test Sheet—Plan I

Enterprise selected	No. of acres of land	Short term capital required (Rs.)	Peak labour required April-May	Peak labour required October-November	Tractor hours required April-May	Tractor hours required October-November	Irrigation hours required May-June	Risk rating: farmers rate* 1:2:3	Weighted risk of organiza-tion	Returns to fixed resources (Rs.)
Kharif										
Hybrid maize	16	4,620.64	—	544	—	32	—	1	16	7,859.36
Groundnut	8	1,004.16	—	—	—	—	—	1	8	2,867.84
Sugarcane	8	4,854.00	860	160	32	—	240	1	8	13,946.00
Chari (fodder)	1	179.17	—	—	—	—	—	1	1	460.83
Total	33	10,657.97	860	704	32	32	240			25,134.03
Available	33	13,000.00								
Surplus or deficit	—	+2,342.03								
Rabi										
Wheat	22	5,944.18	1,606	451	198	187	—	1	22	9,024.62
Gram	2	216.00	2	18	2	2	—	3	6	650.00
Berseem	1	382.63	44	25	4	5	40	1	1	277.37
Sub-total	25 (+8 Com.)	6,542.81	1,652	494	204	194	40			9,951.99
Available	33	7,000.00	1,560	1,560	480	480	720			
Surplus or deficit	—	+457.19	—952	+362	+244	+254	440		70/66=1.06	
Grand Total	66	17,200.78	2,512	1,198	236	226	280			35,086.02

* Only gram was considered as high risk crop.

APPENDIX IV

PRELIMINARY FARM REORGANIZATION TEST SHEET—PLAN II

Enterprise selected	No. of acres of land	Short term capital required (Rs.)	Peak labour required April-May	Peak labour required October-November	Tractor hours required April-May	Tractor hours required October-November	Irrigation hours required May-June	Risk rating: farmers rate* 1:2:3	Weighted risk of organization	Returns to fixed resources (Rs.)
Kharif										
Hybrid maize	6	1,732.74	—	396	—	12	36	1	6	2,947.26
Groundnut	10	1,255.20	—	—	—	10	50	1	10	3,584.80
Sugarcane	16	9,708.00	1,632	320	64	—	640	1	16+16	27,892.00
Chari	1	179.17	—	—	—	—	—	1	1	460.83
Total	33	12,875.11	1,632	716	64	22	726			34,884.89
Available	33	13,000.00								
Surplus or deficit	—	+124.89								
Rabi										
Wheat	14	3,782.66	1,022	287	126	119	—	1	14	5,742.94
Gram	2	216.00	66	18	2	2	—	3	6	650.00
Berseem	1	382.63	220	29	10	5	20	1	1	277.37
Sub-total	17 (16 Com.)	4,381.29	1,308	334	138	126	20			6,670.31
Available	33	7,000.00	1,560	1,560	480	480	766		70/66=1.06	
Surplus or deficit	—	+2,618.71	—1,380	+510	+278	+332	+20			
Grand Total	66	17,256.40	2,940	1,050	202	148	746			41,555.20

* Only gram was considered as high risk crop.

APPENDIX V

Labour Requirements of Reorganized Farm

Enterprise selected	No. of units	Monthly man-hours required					
		January	February	March	April	May	June
Chari (Fodder)	1	—	—	—	—	—	3
Hybrid maize	6	—	—	—	—	—	67
Sugarcane New	8	—	—	2,854	1,200	176	400
Sugarcane First Ratoon	8	—	2,835	544	80	176	416
Groundnut	10	—	—	—	—	—	72
Wheat	14	98	70	140	896	126	—
Gram	2	10	—	—	66	—	—
Berseem	1	110	110	110	130	110	—
Total		218	3,015	3,648	2,372	588	958
Total available from farm family	1	—	124	124	260	260	124
Surplus or deficit		—218	—2,891	3,524	—2,112	—328	—834
To be furnished from permanent hired labour		384	520	520	520	520	520
Surplus or deficit		+166	—2,371	—3,004	—1,592	+192	—314

(Contd.)

APPENDIX V (*Concluded*)

Enterprise selected	No. of units	Monthly man-hours required						
		July	August	September	October	November	December	Total
Chari (Fodder)	1	11	—	117.5	—	—		131.5
Hybrid maize	6	84	78	156	204	192	—	781
Sugarcane New	8	502	96	40	80	80	80	5,508
Sugarcane First Ratoon	8	504	96	40	80	80	80	4,931
Groundnut	10	140	50	960	10	—	—	1,232
Wheat	14	—	—	—	259	28	518	2,135
Gram	2	—	—	17	18	—	10	121
Berseem	1	—	—		24	5	15	614
Total		1,241	320	1,330.5	675	385	703	15,453.5
Total available from farm family	1	124	—	—	260	260	—	1,536
Surplus or deficit		—1,117	—320	—1,330.5	—415	—125	—703	
To be furnished from permanent hired labour		520	384	384	520	520	384	
Surplus or deficit		—597	+ 64	—946.5	+105	+395	—319	

1. Assuming family and permanent hired labour will work 24 eight-hour days during non-peak months and 26 ten-hour days during peak months of April-May and October-November.
2. Any remaining labour requirements in this line will have to be met by casual hired labour. If you have large unused supplies in many months, suggest how it might be used or what mechanization needs to be done to relieve the peak period problem.

APPENDIX VI

Tractor Hours Requirements of Reorganized Farm

Enterprise selected	No. of units	Monthly bullock/tractor hours requirements					
		January	February	March	April	May	June
Hybrid maize ..	.. 6	—	—	—	—	—	36
Groundnut ..	.. 10	—	—	—	—	—	21.5
Sugarcane New	.. 8	—	—	64	32	—	—
Sugarcane Ratoon	.. 8	—	—	64	32	—	—
Chari (Fodder)	.. 1	—	—	—	—	—	3
Wheat ..	.. 14	—	—	—	—	126	—
Gram ..	.. 2	—	—	—	—	2	—
Berseem ..	.. 1	5	5	5	5	5	—
Total requirement ..		5	5	133	69	133	60.5
Total available from farm power ..	..	5	5	150	100	260	100
Surplus or deficit ..		—	—	+17	+31	+127	+39.5

Enterprise selected	No. of units	Monthly bullock/tractor hours requirements						
		July	August	September	October	November	December	Total
Hybrid maize	6	6	—	—	12	—	—	54
Groundnut	10	10	—	—	10	—	—	41.5
Sugarcane New	8	—	—	—	—	—	—	96
Sugarcane Ratoon	8	—	—	—	—	—	—	96
Chari (Fodder)	1	4	—	21.5	—	—	—	28.5
Wheat	14	—	—	—	91	28	—	245
Gram	2	—	—	4.4	2			8.4
Berseem	1	—	—	—	5	—	—	30
Total requirement		20	—	25.9	120	28	—	599.4
Total available from farm power		40	—	30	260	50	—	1000
Surplus or deficit		+20	—	+4.1	+140	+22	—	400.6

APPENDIX VII

ESTIMATED MONTHLY SHORT TERM CAPITAL REQUIREMENTS AND GROSS RECEIPTS FOR REORGANIZED FARM

Enterprise	No. of units	Monthly operating capital required (Rs.), Variable cash expenses + Casual labour					
		January	February	March	April	May	June
Hybrid maize ..	6	—	—	—	—	—	294.42
Groundnut ..	10	—	—	—	—	—	320.00
Sugarcane ..	16	—	1,197.27	5,263.48	3,624.96	256.00	372.18
Chari (Fodder) ..	1	—	—	—	—	—	—
Wheat ..	14	112.00	28.00	56.00	555.52	—	—
Gram ..	2	4.00	—	—	—	—	—
Berseem ..	1	8.00	8.00	8.00	8.00	8.00	—
Total capital ..		124.00	1,233.27	5,327.48	4,188.48	264.00	986.60
Receipts by months		132.00	20,932.00	16,932.00	998.00	9,657.60	—

(*Contd.*)

Enterprise	No. of units	Monthly operating capital required (Rs.), Variable cash expenses + Casual labour						
		July	August	September	October	November	December	Total
Hybrid maize	6	1,019.16	84.00	107.52	—	—	—	1,505.10
Groundnut	10	778.10	20.00	434.50	—	—	—	1,552.60
Sugarcane	16	508.89	192.00	32.00	64.00	64.00	64.00	11,638.78
Chari (Fodder)	1	173.32	2.00	2.00	—	—	—	177.32
Wheat	14	—	—	—	2,436.28	459.34	146.03	3,793.17
Gram	2	—	—	4.80	199.94	—	4.00	212.74
Berseem	1	—	—	—	328.98	2.00	6.00	376.98
Total capital		2,479.47	298.00	580.82	3,029.20	525.34	220.03	19,256.69
Receipts by months		—	—	640.00	4,840.00	4,680.00	—	58,811.60

APPENDIX VIII

ESTIMATED IRRIGATION REQUIREMENTS (HOURS IRRIGATION REQUIRED BY WEEKS)

Enterprise	No. of units	January				February				March				April				May				June*			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Hybrid maize	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	34	2	—	—
Groundnut	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	50	—	—	—
Sugarcane	16	—	—	—	—	—	—	—	—	—	—	—	—	80	80	—	—	80	80	80	80	—	96	98	126
Chari	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Wheat	14	70	—	—	—	70	—	—	—	70	—	70	—	—	—	—	—	—	—	—	—	—	—	—	—
Gram	2	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Berseem	1	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	—	—	—	—
Total	33	75	15	5	5	75	5	5	5	75	5	75	5	85	85	5	5	85	85	85	85	84	98	98	126

(*Contd.*)

Enterprise	No. of units	July				August				September				October				November				December				Total
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Hybrid maize	6	—	30	—	30	—	—	30	—	—	30	—	—	—	—	—	—	—	—	—	—	—	—	—	—	156
Groundnut	10	50	—	—	—	50	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	150
Sugarcane	16	—	—	80	—	—	80	50	30	—	—	80	—	—	80	—	80	—	80	—	80	—	80	—	80	1600
Chari	1	—	5	—	—	5	—	—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	15
Wheat	14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	84	—	—	—	—	—	70	—	—	—	434
Gram	2	—	—	—	—	—	—	—	—	12	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	32
Berseem	1	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	5	—	—	—	5	—	5	5	125
Total	33	50	35	80	30	55	80	80	30	17	30	80	—	5	80	84	80	5	80	—	80	75	80	15	85	2512

* In June, tube-well be operated 14 hours a day in the second, third and fourth week including 28th and 30th June also.

APPENDIX IX

PLANNED GROSS RECEIPTS AND EXPENSES FOR THE REORGANIZED FARM

(*in rupees*)

Enterprise selected	No. of units	Total gross receipts	Total cash variable expenses*	Hired casual labour	Returns to fixed factors
Kharif					
1. Hybrid maize	6	4,680.00	1,491.60	35.52	3,152.88
2. Groundnut	10	4,840.00	1,255.20	314.50	3,270.30
3. Sugarcane	16	37,600.00	8,716.00	2,757.34	26,126.66
4. *Chari*	1	640.00	179.97	—	460.03
Sub-total		47,760.00	11,642.77	3,107.36	33,009.87
Rabi					
1. Wheat	14	9,525.60	3,166.38	673.55	5,685.67
2. Gram	2	866.00	216.00	—	650.00
3. Berseem	1	660.00	277.37	—	382.63
Sub-total		11,051.60	3,659.75	673.55	6,718.30
Grand Total		58,811.60	15,302.52	3,780.91	39,728.17

* Excluding all labour charges (including interest).

Permament hired labour charges	Rs.	2,000.00
Land revenue	Rs.	187.40
Water charges (if canal irrigated)	Rs.	—
Other cesses	Rs.	—
Depreciation	Rs.	2,272.17
Total to be deducted from returns to fixed factors	Rs.	4,459.57
Net farm earnings	Rs.	35,268.60
Opp. Interest on investment at 6%	Rs.	7,425.30
Returns to operator's labour and management	Rs.	27,843.30
Opportunity cost of family labour†	Rs.	828.32
Returns to management	Rs.	27,014.98

† Opportunity cost of family labour was calculated at Re. 0.62 per hour in peak month and Re. 0.37 in non-peak months.

APPENDIX X

EQUIPMENT NEEDS TO IMPLEMENT THE NEW PLAN

(*in rupees*)

Equipment	New cost	Yearly depre-ciation*	Long-term credit required	Short term credit required	Why equipment is needed?
1. Tractor 35 H.P. ..	17,000.00	1,416.67	10,000.00	—	Shift from bullock power to mechanical Cultivator
2. 9 type cultivator ..	1,930.00	183.00	—	—	
3. 7 disc hallow ..	1,775.00	177.50	—	—	
4. 2 row maize plants ..	800.00	40.00	—	—	
5. Seed drill	1,600.00	80.00	—	—	
6. Power sprayer ..	2,000.00	100.00	—	—	
7. Drum type thresher	750.00	75.00	—	—	
8. Other small equipment	500.00	100.00	—	—	
Total			10,000.00		

* In many cases, the equipment will have been charged off as a function of hours of use in enterprise budgets. Check your plan if a charge has not been made, then be sure it is included in depreciation.

What repayment schedule is necessary with credit required in (1) and (2) above?: It should be paid in 10 half yearly instalments of Rs. 1,000 each.

EXPECTED FINANCIAL POSITION, REPAYING CAPACITY AND CREDIT NEEDS FOR FARM PLAN

Expected Financial Position	*Kharif*	*Rabi*
1. Estimated Cash Receipts :		
(*a*) Crop sales	47,760.00	11,051.60
(*b*) Live product sales	—	—
(*c*) Other farm income (List)	—	—
(*d*) Total gross receipts from agriculture	47,760.00	11,051.60
2. Estimated total cash expenses (cost and casual hired) ..	14,750.13	4,333.30
3. Gross cash receipts less cash expenses	33,009.87	6,718.30
4. Family living allowance	3,000.00	3,000.00
5. Remainder (item 3 minus item 4)	30,009.87	3,718.30
6. Do you have any debts overdue ? : Amount Rs. Nil. How long overdue ? : Nil.		
7. How much do you expect to pay on old loan each season?	—	—
Repaying Capacity		
8. Total gross receipts from agriculture (1) above (A) ..	47,760.00	11,051.60
Estimated total cash expenses (including casual labour hired)	14,750.13	4,333.30
Family living cost	3,000.00	3,000.00
Payment to permanent hired labour and land revenue—depreciation (IX B)	2,229.78	2,229.79
Total (B)	19,979.91	9,563.09
Estimated total repaying capacity (A—B)	27,780.09	1,488.51

AN INDEX TO COMPARE THE PERFORMANCE IN COMMUNITY DEVELOPMENT BLOCKS

Periodical stock-taking of accomplishments and failures is an integral part of the administration of any programme. The problem of stock-taking is rather simple in the case of programmes where the factors involved are few and measurable. But in a vast and complex programme like that of Community Development where the objective is often intricate and sweeping and the factors involved are numerous, the problem is not so simple. In this paper an attempt is made to analyse the problem and to indicate a method for measuring the periodical performance of Community Development Blocks. To understand the problem in its clear perspective, a brief outline of the objectives and mode of functioning of the Community Development programme is given below.

Community Development has been defined by the U.N. as "the process by which the efforts of people themselves are united with those of Governmental authorities to improve the economic, social and cultural condition of communities, integrate these communities into the life of the nation and to enable them to contribute fully to national progress." The objective of the programme is thus not merely economic but also social and cultural development of man through self-help and co-operation. The Community Development programme as understood in this sense can broadly be classified into two processes : one the 'extension education' and the other 'the programme.' The purpose of extension education is to bring about a change in the attitude of the individual, make him progressive-minded, desirous of developing his living conditions. In other words, it aims at improving the quality of the human being as a member of the community. The 'programme' is the medium through which the methods of Community Development are applied. For example, villagers can be made healthy and sanitation-minded only through taking up programmes on health and sanitation. Farmers can be taught better farming methods only by taking up programmes in agricultural improvement.

The unit of Community Development activity is the block. As soon as a block is formed a socio-economic survey is conducted to assess the felt needs of the people in the area and the resources of the locality. On the basis of the data collected a plan of action is drawn up for the development of the area. For the efficient working of the programme there must be definiteness about the results aimed at. Since the objective of the Community Development programme is not merely material development but also the intellectual and moral development of the community, there is bound to be an element of vagueness in specifying the result expected from each activity. However, for the working of the programme there must be definiteness at least about the activities to be completed in specified periods. In other words it should be possible to decide the activities to be performed, fix priorities and set the targets under the various activities. Once these targets are set and the programme is put into operation, the sponsors of the programme should be vigilantly assessing the programme and make an objective evaluation of its success or failure including people's response and the causative factors of success and failures. The object of this paper is to evolve a measure of the performance of a block in relation to its targeted programmes and use it to compare the performance in the various blocks in the State.

The method generally followed at present in assessing the performance is to compare the physical or financial target with the physical/financial achievement under the various activities in a block or district or State. This type of evaluation is based on the assumption that the level of development that was considered possible by the implementation of each unit of the activity will be actually realized when the unit of activity comes into existence. An example will make the idea clear. Suppose it was expected that 10 wells planned to be dug in a block would irrigate an area of 50 acres. If by the stipulated period, the number of wells actually dug was 9, the percentage of performance can be taken as 90. Here we make an assumption that the 9 wells dug have irrigated 45 acres. Conceding that the error in this type of assumption does not matter much, the ratio of physical achievement to the physical target is a good indicator of performance of an activity. This method would be all right if the number of activities happen to be very few. When the number of activities and the fields of operation are many the real difficulty is in finding a suitable measure of the overall performance of the block, both for evaluating the performance of the block programme as a whole, as well as for making comparisons between blocks. The former is made difficult by the multiplicity of activities in the block and the latter by the shift in emphasis of activities from block to block.

An ideal measure of the performance of Community Development programme will be the percentage of development achieved to the development planned in a block. Development in the ordinary sense (*i.e.*, economic and social development) can be measured by various indicators like per capita income, standard of living, etc. But in the present case the intangible nature of human 'objectives' included in the Community Development programme renders the calculation of the above type of indicators difficult. Because of the difficulty in measuring development, the ratio of development, though ideal, cannot be used as a measure of the performance of block.

In this situation, we can think of a weighted average of performance of individual activities to be used to measure performance of blocks as well as to compare the performance between blocks. We may consider whether the activities in different fields can be translated to a common measure for the purpose of aggregation. The problem then boils down to the common index number problem.

THE PROBLEM

The problem can be stated as below :

(*i*) First we have to compare two situations—namely, the programme targeted and its achievement during the stipulated period.

(*ii*) Corresponding to each situation there are two sets of data. For the first situation, we have the target for each activity and the quantum of development desired to be achieved by the implementation of the activity. For the second situation, we have the actual physical achievement of the activity and the actual development realized. The ratio of development realized to development targeted gives the index of performance.

The above ideas can be explained symbolically as follows :

Suppose we write :

$x_1, x_2 \ldots x_n$	for the physical targets corresponding to n activities during a certain period,
$y_1, y_2 \ldots y_n$	for the physical achievement of the n activities, during the period,
$a_1, a_2 \ldots a_n$	targeted rate of development per unit of each activity, and
$b_1, b_2 \ldots b_n$	rate of development actually realized per unit of each activity.

Now, development targeted $= x_1 a_1 + x_2 a_2 + \ldots\ldots + x_n a_n$

and development realized $= y_1 b_1 + y_2 b_2 + \ldots\ldots + y_n b_n$.

The ratio (D) of development achieved to that aimed at is given by :

$$D = \frac{y_1 b_1 + y_2 b_2 + \ldots\ldots + y_n b_n}{x_1 a_1 + x_2 a_2 + \ldots\ldots + x_n a_n}$$ and this ratio can be taken as a measure of performance in the stipulated period. For convenience we may call the ratio (D) as development ratio.

(*iii*) If D is less than 1 it indicates a shortfall in the development achieved to the development aimed at. This shortfall may be due to (*a*) the slackness on the part of the officers in implementing the activities or (*b*) due to the non-realization of targeted development from the activities implemented and (*c*) both. Examples of the second kind are numerous. For instance, there are cases where fullest irrigation potential planned by completion of major and minor irrigation projects have not been achieved. This may be due to various reasons like inaccurate planning of the projects or the unpreparedness of the local community to make use of the irrigation projects, etc.

The full achievement of the potential benefit of any development activity is dependent upon the accuracy in the planning of the activities as well as on the organizational factors in their physical realization. This leads to the fact that the development ratio (D) is composed of two components. One is the physical realization of the various units of activities as per the targets set, which mainly depends on the organizational factors at the block level. The other component is the realization of the potential benefit from each activity coming into physical existence or in other words, the rate of development achieved from each unit of activity which mainly depends on the level of accuracy in the planning. The numerator and denominator of the development ratio (D) are the aggregates of the products of the above two measures. It should therefore be possible to conceive the development ratio as the product of two ratios—one measuring the physical performance and the other measuring the degree of realization of development planned. Thus we can write :

$$D = P.R$$

Where P is a measure of the physical performance and R a measure of the degree of realization of the development planned.

$$\text{Now } D = \frac{\sum_{i=1}^{n} y_i\, b_i}{\sum_{i=1}^{n} x_i\, a_i}$$

$$= \frac{\sum y_i\, a_i}{\sum x_i\, a_i} \times \frac{\sum y_i\, b_i}{\sum y_i\, a_i}$$

$\sum y_i\, a_i$ is the development attained due to the activities achieved on the assumption that each unit of activity has realized the full potential benefit aimed at. $\sum x_i\, a_i$ is the development planned or aimed at.

The ratio $\frac{\sum y_i\, a_i}{\sum x_i\, a_i}$ therefore measures whether all the activities have been implemented according to plan and is therefore an index of performance. We can therefore write the required index of performance as

$$P = \frac{\sum y_i\, a_i}{\sum x_i\, a_i} \times 100 = \sum \frac{y_i}{x_i} \text{ x } w_i \text{ where } w_i = \frac{x_i\, a_i}{\sum x_i\, a_i} \times 100.$$

P can be interpreted as the weighted average of performance of each activity in the block, the weights being proportional to the quantum of development capable of contribution by the activity. It measures the percentage of overall implementation of the activities in relation to their targets.

COMPUTATION OF THE INDEX

The process of framing the index of performance of blocks is explained here. The construction of index involves mainly three steps : (*i*) Choice of items; (*ii*) Assigning weights and formation of group index for each block; (*iii*) Formation of the final index of performance for each block.

(*i*) *Choice of Items*

There are more than 150 items of work under the Community Development programme. It is neither possible nor necessary to include all these items in the index. Some of the activities, like dissemination of knowledge on improved methods of cultivation are not directly measurable. But it is possible to make a judicious selection of a set of representative items from each sector of development the performance under which can be taken as a sufficient indication of the performance in that sector of development. These representative items usually called the indicators of progress may vary in content from block to block depending on the shift in emphasis of the programme. For each item there will be an annual target. The achievement for the period divided by the pro-rata target gives the performance (relative) for the period. For the sake of illustration, one list of key indicators of progress is given below.

List of Key Indicators of Progress

Agriculture

A. Distribution of improved seeds :
1. Paddy (Kg.)

B. Distribution of fertilizers and manures:
2. Chemical fertilizers (Metric tonnes)
3. Green manure seeds (Kg.)

C. Distribution of improved implements :
4. Iron ploughs (Nos.)
5. Seed drillers (Nos.)

D. Agriculture demonstrations :
6. Demonstrations held (Nos.)

E. Other items :
7. Insecticides and pesticides distributed (Kg.)
8. Compost pits dug (Nos.)
9. Area brought under Japanese method of paddy cultivation (Acres).

Animal Husbandry
10. Improved animals supplied (Nos.)
11. Improved birds supplied (Nos.)
12. Animals castrated (Nos.)
13. Artificial insemination conducted (Nos.)
14. Natural insemination conducted (Nos.)

Irrigation
15. Pumpsets supplied (Nos.)
16. Area irrigated (Acres)

Health and Rural Sanitation
17. Rural latrines constructed (Nos.)

Social Education
18. Literacy centres started (Nos.)
19. Adults trained (Nos.)
20. Functional leaders trained (Nos.)
21. Women's camps held (Nos.)

Communication

22. *Kacha* roads constructed (fgs.)

Village and Small Industries

23. Beehives introduced (Nos.)

Co-operation

24. Membership in credit societies (Nos.)
25. Membership in farming societies (Nos.)
26. Membership in industrial societies (Nos.)
27. Membership in others (Nos.)

(*ii*) *Assigning Weights and Formation of Group Index*

The weights to each item should be the proportion of development resulting from the implementation of the activity. But in actual practice, it is not possible to find the quantum of development attributable to each activity separately. Various activities have to be implemented simultaneously to get the desired development. For example, development in the agricultural sector would be due to the simultaneous implementation of programmes on distribution of improved seeds, fertilizers, etc. Each activity like distribution of seeds have therefore to be viewed as forming part of a complex group, namely, development of the agricultural sector. Since the activities in this group is selected on a representative basis, the simple arithmetic mean of the performance (relatives) in respect of each activity in the sector will give the overall performance of the group. The assumption is that each of the selected activities contribute equally to the overall development in the group. This arithmetic mean can be called the group index.

(*iii*) *Formation of the Final Index*

The weighted arithmetic mean of the various group indices where the weights are proportional to the contribution of each sector to the overall development of the block gives the performance index for the block. But in actual practice, it is very difficult to find a measure of the contribution of individual groups to the overall development. The calculation of group weights therefore poses a problem. If the weights can be viewed as a measure of importance attached to each activity in the block programme, it would not be irrational to assume that budget allotments to each sector of development is an indicator of the proportionate importance attached to the sector. The proportion of budget allotments to the sectors can therefore be taken as close substitutes for the true weights for the group indices for computing the overall index.

INTERPRETATION OF THE INDICES

The index measures the performance of a block in terms of its activities on the assumption that the targeted rate of benefit under each unit of activity would be realized with the creation of the unit of activity in its physical form. It cannot be said by comparing the indices that one block has brought about more development than the other, because of the fact that the shifts of emphasis on activities differ from block to block. The index can however be used to rank the blocks according to their performance measured in terms of their achievements relative to the set targets under the "indicators of progress." But it should be specially noted that the comparison will be erroneous if the targets are not fixed up by all the blocks in a realistic manner. For example, suppose in a block it was necessary and possible to construct 20 drinking water wells in a particular period. Against this, if the target was fixed as 10 and during the period actually 15 wells were dug, the index of performance will give an exaggerated picture of the performance. It would therefore be of utmost importance to ensure that the blocks set the targets for the various activities under the Community Development programme in a judicious and realistic manner. This is indispensable not only for the emergence of a true index of performance of the blocks but also for the successful achievement of the true objective and philosophy of the Community Development programme as a whole.

S. BHAGAVATHEESWARA IYER
AND
G. RAMACHANDRAN NAIR*

THE 1961 CENSUS AND ITS IMPLICATIONS IN TERMS OF LABOUR FORCE GROWTH, EMPLOYMENT AND INCOME—A COMMENT

In his article entitled "The 1961 Census and Its Implications in Terms of Labour Force Growth, Employment and Income" published in the July-September, 1965 issue (Vol. XX, No.3) of this Journal, B. R. Kalra raises a number of issues of considerable significance. On three points, however, it is difficult to agree with him.

Firstly, Kalra refers to the demographic aspects of working force. He suggests that the fall in the proportion of persons, males and females in the age-group 15-59 (the working age-groups) between the censuses of 1951 and 1961, was counterbalanced by a rise in the participation rate of those in the age-group 0-14. Kalra says : 'How far the effect of adverse age composition of population is made good by *higher* participation of population in younger age-groups may be seen from Table III. Similar table could not be compiled for 1951 since economically active population was not classified by age during that census." (p. 35, emphasis added). It may be mentioned that Table III gives the "participation rates in broad age-groups by rural and urban : 1961." But Kalra's proposition can only be proved by comparing the age-group specific participation rates of 1951 and 1961. If it is found that the participation rate for the age-group 0-14 is higher in 1961 than in 1951, the proposition stands proved. In this context a study of the 1961 urban and rural participation rates strikes one as being illuminating in itself, but irrelevant to the proposition under discussion. This is not to suggest, however, that data exist to test the proposition, but merely to point out that, given the paucity of data, the proposition cannot be tested.

Secondly, in Tables VI, VII and VIII, figures are given for rural and urban workers *separately*, for 1951 and 1961, and changes in participation rates and industrial distribution of working force are discussed. This presumes that com-

* Assistant Director and Research Officer respectively, Bureau of Economics and Statistics, Trivandrum.

parability exists or has been obtained for working force data of 1951 and 1961 involving the rural-urban breakdown. That such comparability exists is highly doubtful. As the Census Commissioner for 1951 pointed out :

"The tests prescribed for distinguishing towns from villages in different states are based on ideas common to all states, but they are not identical nor have they been applied with meticulous uniformity."[1] But this itself is an under-statement for he goes on to show that different States did, in fact, have different operational definitions of urban areas. The 1961 definition is rigorous and uniform,[2] and as Ashish Bose points out : " . . . .the new definition, while it gives a more realistic picture of urbanization than was given in earlier censuses, has created the problem of comparability over time. . . .and unless proper adjustments are made a study of urbanization for the 1951-61 decade can be very misleading."[3]

Karla has (*i*) to ensure uniformity in concept in 1951, (*ii*) to establish a correspondence between the 1961 definition and the new uniform 1951 concept. If he has done this, he deserves much praise; but since he does not indicate whether he has in fact achieved this happy result, it becomes difficult to take his results for granted.

Finally, in Tables XI, XII and XIII comparisons are made between income and number of workers for different sectors of the economy for the period 1950-51 to 1960-61. In the C.S.O. estimate of income that Kalra uses, in a large number of sectors income is obtained as a product of the number of workers and the net income per worker (or net earnings per worker or net output per worker) in that sector. Thus, implicit in the income estimates to a considerable degree, are worker estimates. If the 1950-51 and 1960-61 income estimates were based on the 1951 and 1961 census results respectively, then the comparison of the increase in output with the increase in workers would, for sectors where the income method has been used, appear merely trivial—since the income estimate, in each case, depends on the worker estimate. But, in Kalra's analysis the defect is much more serious since the income estimates for 1960-61 depend on projections of the 1951 census worker figures using 1941-51 growth rates, while the employment figures for 1960-61 are based on the 1961 census results. Thus the defect is not merely of circular reasoning, but of methodological inconsistency. In view of this, comparisons for sectors where the income method has been used appear invalid.

J. KRISHNAMURTY†

1. Census of India, 1951, Vol. I, India, Part I-A—Report 1953, p. 45.

2. For an account of the 1951 definition see Census of India, 1951, Vol. I, India, Part 1-A—Report, p. 45 ; and for the 1961 definition and an admission of the seriousness of the comparability problem see Census of India, 1961, Paper No. 1, 1962, p. xxxvii.

3. Ashish Bose, "A Note on the Definition of Town in the Indian Census : 1901-1961," *Indian Economic and Social History Review*, Vol. I, No. 3, January-March, 1964, p. 92.

† Research Associate, Centre for Advanced Study in Economic History and Economic Development, University of Delhi, Delhi.

IMPACT OF RAINFALL ON CROP YIELD AND ACREAGE[1] : A COMMENT

In his paper, Ram Dayal has tried to find out the effect of rainfall in the months relevant to the production of wheat in the Punjab on its yield rate and acreage by the usual multiple regression analysis. While there is need for such a study to be carried out crop-wise in various regions and while Dayal's attempts in this direction serve well to illustrate the method of approaching the problem, it hardly needs any elaboration to point out that the aggregation of the rainfall data over the State as a whole in such studies is not very proper. It is unrealistic to determine the rainfall-crop relationship in a single analysis for any State, unless the entire State constitutes a homogeneous region from the point of view of precipitation. Obviously, between districts rainfall will show very wide fluctuations in the Punjab (as almost in all other States also) and as such the State cannot be considered a homogeneous region with regard to rainfall. Even though Dayal recognizes that the low significance of coefficients in eq. (2) may be due to the above-mentioned fact, besides other factors, he has ignored it perhaps owing to the gross under-estimation of its importance.

Secondly, the interpretation given to eq. (2), *viz.*, "an increase of 1 millimetre of rainfall in January and February results in an increase of 1.8 and 0.71 lbs. in the yield rate, while a similar increase in the months of December and March results in a decline of yield rates of 0.35 and 0.68 lbs. respectively" is not a valid interpretation. In no analysis should the coefficients of multiple regression be subjected to any interpretation unless these coefficients have been tested and found to be statistically significant at a satisfactory and accepted level of significance which is usually 5 per cent or less. While it has been agreed in the paper that the coefficients of December and March are insignificant—and consequently no interpretation to these coefficients should have been given—it may be added that the coefficients of January and February also are not significant at 1 or even 5 per cent level. These are significant at 20 per cent which is an extremely poor level for any interpretation. A similar argument applies to the interpretation given to eq. 16. Therefore, linear regressions do not seem to fit the data. Further, in this context, although it has been shown that the semi-log form is an improvement over the linear form, the latter has again been adopted (refer eq. 6) while dealing with fortnightly data.

Finally, there are serious objections to the constraint put on the coefficients b's of eq. 6. These are given by the relation $b_t = a_o + a_1 t + a_2 t^2$ (refer eq. 7). It is inconceivable that 'b' coefficients of regression on rainfall could be expressed by any function of time. This type of constraint assumes that the effects of rainfall in various fortnights are orderly ones following some mathematical rule and are related amongst themselves. Fortnightly rainfalls being random and stochastic variables should *a priori* have no relationships amongst themselves if they have to retain their random character and thus cannot be assumed to have yield effects which are related. Secondly, this method of putting constraint on parameters amounts to dropping some of the variables or as in this case, transforming the original set of variables into a new set. One can do this provided the new set

1. Ram Dayal, *Indian Journal of Agricultural Economics*, Vol. XX, No. 3, July-September, 1965, pp. 48-54.

of variables are independent. This has not been ensured in this case. We have a hunch that the new variables W_1, W_2, W_3 are highly correlated. In the absence of any data, the pair-wise correlation coefficients amongst W_1 W_2, W_3 can be worked out theoretically under the following two assumptions, *viz.*, (1) $\underset{i \neq j}{\text{Cov.}} (X_i, X_j) = 0$ and (2) $V(X_i) = \sigma^2$ for all i. The first is only a valid assumption while the second is a simplifying assumption based on intuition and can be proved wrong if it can be shown on the basis of the data that variances of X_i's are significantly different from each other. Under these assumptions the pair-wise correlation coefficients between W_1, W_2, W_3 seem to be very high. Moreover, if the aim is to reduce the number of variables (also ensuring that the new set contains only independent variables), there are other well-known methods such as factor analysis or principal component analysis.

S. S. SRIVASTAVA*

* Lecturer, Gokhale Institute of Politics and Economics, Poona-4.