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NOTES

PRODUCTION RESPONSE AND PARAMETRIC PROGRAMMING[1]

In this paper, an attempt is made to estimate input requirements of two types of chemical fertilizers, nitrogenous and phosphatic, for paddy and wheat crops under different soil conditions. It is well-known that the use of chemical fertilizers increases the yield to a significant extent under conditions of adequate rainfall or irrigation. The present exercise deals with measurement of crop response, and the computation of optimum units of nitrogen and phosphorus to get maximum physical yield for paddy and wheat under various assumptions.

Data

The main source of data is the Report on Fertiliser Trials on Wheat and Paddy published by the Indian Council of Agricultural Research. The 15-acre complex experimental results are available for the period 1953-56. District-wise data for wheat and paddy are obtained at three levels of nitrogen and three levels of phosphorus. During a year, nine observations, giving the output at different levels of N and P together with the combined effect of N and P are available. For paddy, such data are available for 7 districts located in different paddy growing regions of India, and for wheat, for 8 districts situated in different wheat growing regions of the country.

Surface Function

From the above set of data over a period of three years it is proposed to derive technical requirements of nitrogen and phosphatic nutrients. We decided to fit a quadratic surface function for estimating the requirements as experimental data are available only at three levels of nitrogen and phosphorus. Had the responses between N20 and N40 (20 and 40 lbs. of nitrogen) and over N70 and N100 been available, it would have been possible to fit a response function of higher order than two.

Our quadratic surface function[2] is of the form

$$Y = a + bN + cP + dNP + eN^2 + fP^2$$

which means that six parameters are to be estimated from nine observations available for each year. On grounds of statistical reasoning,[3] we have decided to combine the data for two or three years depending upon the adequacy of the available data.[4] a is predetermined in the sense that it is the mean yield or the controlled yield. The signs of b, c, d, e and f depend upon the actual response obtained over a period of two or three years on the same plots.

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1. This paper is prepared at the Institute of Economic Growth, Delhi. The author wishes to thank Dr. C. H. Hanumantha Rao, Dr. K. Krishnamurty, Dr. C. H. Shah and Shri D. U. Sastry for their helpful suggestions and Shri A S. Sethi for his valuable statistical assistance.

2. See E. O. Heady and J. L. Dillon: Agricultural Production Functions, Iowa State University Press, Ames, Iowa, 1961, pp. 475-525.

3. The number of degrees of freedom will be only three if six parameters are estimated from nine observations.

4. A careful examination showed that pest-diseases and heavy rainfall at times neutralised the effect of fertilizers. As far as possible, we have not considered such observations in our response function. A homogeneity test of variances was also carried out.

$\frac{\partial^2 y}{\partial N^2} < 0$ when $P = 0$, means that the diminishing returns operates with increasing doses of N after a certain level.

$\frac{\partial^2 y}{\partial N^2} > 0$ when $P = 0$, means that the increasing returns will operate with ever increasing doses of N. As such, numerical values of N and P_2O_5 depend upon the coefficient of the interaction term[5] (when $P \neq 0$).

Tables I and II show the value of the coefficients, their standard errors, R^2— the coefficient of multiple determination, the number of observations considered in each case and the standard error of the estimate. These results are given for three paddy growing districts and four wheat growing districts.

Results

In the case of paddy, R^2 is found to be significant for three districts: Ponnampet, Bhagwai and Burdwan. In the case of wheat, R^2 is significant for four districts : Obedullahganj, Niphad, Satna and Kanpur. This means that the variations in output of each crop in the above districts is highly associated with the input of fertilizers. For Burdwan, the coefficient related with the linear term P is found to be negative and significant while with a quadratic term P^2, it is found to be significant and positive. This suggests that increasing returns to factors operated if a large quantity of P_2O_5 is used in the absence of nitrogen. The increasing returns may be violated by the coefficient of interaction term. In the case of Kanpur, both coefficients associated with the linear term are highly significant. In case of Obedullahganj, the coefficient associated with linear term N is significant while others are not significant. In the case of Niphad, both the coefficients relating to nitrogen are highly significant. In the case of Bhagwai, coefficient of P is significant.

Maxima

Table III shows physical maximum obtained at four and three districts for wheat and paddy respectively.

The physical maxima do not indicate the economic feasibility by taking into account price structure or prices which the farmers pay for fertilizers. Secondly, these physical maxima may not be attainable under the actual circumstances. In such a situation, we compute economic maximum for each district by equating the marginal productivities of each nutrient to the inverse of price-ratios.[6] We consider actual price of nitrogen as Re. 0.75 per lb. and that of P_2O_5 as Re. 0.50

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5. If $\frac{\partial^2 y}{\partial N^2}$ and $\frac{\partial^2 y}{\partial P^2}$ are both negative at a stationary point, then y must be a maximum in each of the fundamental directions and it is likely that y may be a maximum in all directions; similarly, if $\frac{\partial^2 y}{\partial N^2}$ and $\frac{\partial^2 y}{\partial P^2}$ are both positive at such a point, then y is likely to have minimum value for all directions of variations. The sufficient condition for maximum is $\frac{\partial^2 y}{\partial N^2} \cdot \frac{\partial^2 y}{\partial P^2} > \left(\frac{\partial^2 y}{\partial N \partial P}\right)^2$ Where it is *vice-versa*, the results are minimum. But the case where $\frac{\partial^2 y}{\partial N^2} \cdot \frac{\partial^2 y}{\partial P^2} = \left(\frac{\partial^2 y}{\partial N \partial P}\right)^2$ is still open and stationary value considered may be a maximum or minimum or it may not. To rule out minima, we make one of the two factors zero and carry out analysis. However, these results are by no means certain.

6. Derived from the marginal substitution of each factor under perfect competition.

$\frac{\partial y}{\partial N}\Big| P_n = \frac{\partial y}{\partial P}\Big| P_p = \frac{1}{P_y}$

TABLE I—15-ACRE BLOCK EXPERIMENTS FOR WHEAT

QUADRATIC SURFACE FUNCTIONS—STANDARD ERRORS OF PARAMETERS (IN PARENTHESES)

Soil	Name of district	Mean yield	Coefficients					R^2	No. of observations	Standard error of the estimate
Medium black soils or trap and gneissic origin	Obedullahganj (Madhya Pradesh)	Y=9·09	·259900*N (.1106)	·0·54000 P (·1106)	·001779 NP (·0018)	—·002875 N^2 (·0024)	—·000750 P^2 (.0024)	·79	18	2·00
Medium black soils or trap and gneissic origin	Niphad (Maharashtra)	Y=9·05	211610**N (·026)	·037270 P (·026)	·000905*NP (.00042)	—·020000**N^2 (·0006)	·000100 P^2 (·0006)	·976	18	·48
Mixed red and black soil	Satna (Madhya Pradesh)	Y=5·02	·028984N (·0415)	·096574* P (·0415)	·000531 NP (·0007)	—·000187 N^2 (.0009)	—·000937 P^2 (·0009)	·81	18	·78
Grey and brown soils of Indo-gangetic basin	Kanpur (U.P.)	Y=12·20	·146950**N (·034)	·351007**P (·034)	·000031 NP (·00056)	—·001187 N^2 (.0008)	—.002125*P^2 (·0008)	·98	18	·63

TABLE II—15-ACRE BLOCK EXPERIMENTS FOR PADDY

QUADRATIC SURFACE FUNCTIONS—STANDARD ERRORS OF PARAMETERS (IN PARENTHESES), STANDARD ERROR OF THE ESTIMATE AND THE COEFFICIENT OF DETERMINATION R^2

Soil	Name of district	Mean yield	Coefficients					R^2	No. of observations	Standard error of the estimate
Recent alluvium	Ponnampet (Mysore)	Y=30.81	.259494**N (·027)	·028754 P (·027)	—·000782 NP (·00137)	—·002375 N^2 (.00194)	—.000250 P^2 (·00194)	·81	18	1·56
Medium black	Bhagwai (Madhya Pradesh)	Y=15·49	·394357**N (·1524)	·210550 P (.1524)	·003560 NP (·00245)	—·006187 N^2 (·00346)	—·003375 P^2 (·00346)	·82	18	2·77
Recent alluvium	Burdwan (West Bengal)	Y=37·22	·103385**N (·019)	·365583**P (·019)	·000375 NP (·00030)	—·001163**N^2 (·00043)	—·008083*P^2 (·00043)	·96	27	0·42

* Significant at 5 per cent level. ** Significant at 1 per cent level.

TABLE III—MAXIMUM PHYSICAL OUTPUT*

Name of the district	Maximum output (maunds)	N (lbs.)	P_2O_5 (lbs.)
Paddy			
Burdwan	39·52	44	0
Bhagwai	30·94	48	57
Ponnampet	37·90	55	0
Wheat			
Obedullahganj	24·48	89	140
Kanpur	31·08	62	82
Niphad	9·61	5·29	0
Satna	14·60	252	123

* $\frac{\partial Y}{\partial N} = 0$ and $\frac{\partial Y}{\partial P} = 0$. Solving them simultaneously, N and P are obtained. At these levels of N and P utilisation, the physical output is maximum. This is a necessary condition but not sufficient as mentioned in footnote 5. Where this gives minimum value, one of the inputs is not utilised. We find such results in case of Burdwan and Niphad. P is kept at zero and then $\frac{\partial Y}{\partial N} = 0$ and $\frac{\partial^2 Y}{\partial N^2} < 0$ provides us the maximum value.

per lb., while the price of wheat and paddy is Rs. 14 and Rs. 12 respectively per maund. In Table IV, amounts of nitrogen and phosphorus to attain the economic maximum are indicated.

TABLE IV—ECONOMIC MAXIMUM

Name of the district	Maximum output (maunds)	N (lbs.)	P_2O_5 (lbs.)
Paddy			
Burdwan	38·64	17	0
Bhagwai	30·46	40	46
Ponnampet	37·46	41	0
Wheat			
Obedullahganj	22·11	58	76
Niphad	9·58	4	0
Kanpur	30·32	38	74
Satna	7·48	0	46

The presence of irrigation facilities, insecticides and pest control medicines on demonstration plots guarantees the output; but these may be non-existent on cultivators' fields. Hence optimum doses of nitrogen may not be used by cultivators. In view of this, the principle of discounted yield is followed.

This means that 100 per cent yield is not realised, but some percentage of the yield may be the realised yield under uncertainty. Let x be the percentage of realised yield, which means that (1—x) be the rate of discount. *A priori*, the lower and upper limits of the rate of discount will be zero and unity respectively. When the cultivators expect 100 per cent risk, they will not use fertilizers. The interesting problem is to consider the maximum risk (1—x) or minimum x at which the application of nitrogen and/or phosphorus may be undertaken. x is to be chosen under the constraints that the marginal productivities of each nutrient are equated to the inverse of their price-ratios, value of nitrogen, and phosphorus nutrients are non-negative and x is positive, between zero and one. Since marginal productivities are strictly equated to the inverse of price-ratios, we can solve the problem by enumerative method. Minimum x means that when the rate of discount or risk is more than (1—x), the farmers will not use nitrogenous and/or phosphatic fertilizers. For paddy and wheat the following range of x's were obtained.

	Minimum x	Maximum x
Paddy		
Burdwan	0·6045	1 for $N \geqslant 0$, $P = 0$
Bhagwai	0·1842	1 for $N \geqslant 0$, $P \geqslant 0$
Ponnampet	0·2408	1 for $N \geqslant 0$, $P = 0$
Wheat		
Obedullahganj	0·3540	1 for $N \geqslant 0$, $P \geqslant 0$
Niphad	0·2533	1 for $N \geqslant 0$, $P = 0$
Kanpur	0·2455	1 for $N \geqslant 0$, $P \geqslant 0$
Satna	0·7190	1 for $N = 0$, $P \geqslant 0$

The above results indicate that as long as the discounted rate is below 82 per cent in Bhagwai, 76 per cent in Ponnampet and 40 per cent in Burdwan, one or both the fertilizers may be used. In wheat growing districts, it is found that as long as the discount rate falls below 65 per cent in Obedullahganj. 75 per cent in Niphad, 76 per cent in Kanpur and 28 per cent in Satna, the application of one or more fertilizers will be possible. For illustrative purposes, we take x = .80, which means that the farmers discount yield by 20 per cent. In Table V, the results showing the maximum yield at (1—x) = .20 are presented.

TABLE V—ECONOMIC MAXIMUM

(at x = ·80)

Name of the district	Maximum physical output (maunds)	N (lbs.)	P_2O_5 (lbs.)
Paddy			
Burdwan	29·94	2	0
Bhagwai	24·14	38	43
Ponnampet	29·79	38	0
Wheat			
Obedullahganj	17·44	56	72
Niphad	7·64	3·61	0
Satna	5.59	0	37
Kanpur	11.18	33	73

Conclusions

The results are inconclusive as the coverage is limited and number of observations are few. The discounted yield may vary from farmer to farmer due to the risk of storage, and psychological costs. Our experimental data do not give the results for individual farms but an average of number of government demonstration plots. The risk parameter $(1-x)$ which is also a function of weather, insects, pest-diseases and other natural hazards might operate quite randomly in the system. Perhaps, the use of probability distribution would have shed more light on the utilisation of nitrogen and phosphorus. We may conclude that all the districts analysed in this study (excepting Satna) permit the use of nitrogen. On an average, the response obtained by the use of N and P on wheat soils was higher than that on paddy soils. The values of the mean yield are higher in case of paddy than wheat. Phosphatic fertilizers are not effective in increasing the response of paddy because the acid soils might react unfavourably to phosphate. Our results also indicate that for attaining the maximum yield of wheat, the fertilizer inputs used should be much larger than those for paddy. Uncertainty on account of non-availability of facilities like insecticides and pesticides may discourage the cultivators to use the economic doses of nitrogen and phosphorus. In such situations, a maximum rate of discount constrained by non-negative fertilizer inputs is obtained by the technique of parametric programming.

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ECONOMICS OF FERTILIZER USE ON THE NAGPUR FARM

This Note makes an attempt to present an economic analysis of a series of fertilizer experiments[1] carried out on the Government Experimental Farm, Nagpur during the years 1954-55 to 1957-58. The object of the above experiments was to explore the efficacy of the use of ammonium sulphate, ammonium sulphate nitrate and urea by way of substitutes for ammonium sulphate, the demand for which has considerably increased in recent years. The results of the above experiments provide the data on the physical relations established between the above fertilizers as input factor and the resulting output. The present study is a follow-up analysis from the economic point of view with reference to the factor-price and product-price relations existing in the respective years through which the experiment was conducted.

The experiment was carried out to study the effect of ammonium sulphate, ammonium sulphate nitrate and urea at 20 lbs. and 40 lbs. nitrogen per acre on cotton, juar and wheat under unirrigated conditions. In addition to the reported data on physical input and output, the money costs incurred and the prices received for the products by the farm were collected from records and processed wherever necessary. Cost on transport of fertilizers to the farm and of its application was estimated and apportioned according to relevant cost accounting principles. The data were available for two years in the case of cotton, three years in case of wheat and four years in case of juar and was, therefere, averaged for purposes of further analysis.

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1. A. M. Deshpande and Y. N. Kunte, "Response of Cotton, Juar and Wheat to the Application of Various Nitrogenous Fertilizers," *The Nagpur Agricultural College Magazine*, Vol. XXXVI, No. 2, 1962, pp. 31-37.

Cotton

Table I gives the economic analysis in regard to the application of the three fertilizers to cotton.

TABLE I—ECONOMIC RESPONSE OF FERTILIZER EXPERIMENTS ON COTTON

S.No.	Dose	Average yield per acre (lbs.)	Marginal product (lbs.)	Marginal value product (Rs.)	Marginal cost (Rs.)	Percentage of column 5 to column 6
1	2	3	4	5	6	7
			Ammonium Sulphate			
1.	0 N	724	—	—	—	—
2.	20 N	758	34·00	14·89	17·40	86
3.	40 N	882	124·00	54·29	17·40	312
			Ammonium Sulphate Nitrate			
1.	0 N	724	—	—	—	—
2.	20 N	801	77·00	33·71	17·12	197
3.	40 N	920	119·00	52·09	17·12	304
			Urea			
1.	0 N	724	—	—	—	—
2.	20 N	723	—1·00	—0·44	16·03	—3
3.	40 N	794	71	31·08	16·03	194

From the above table, it is seen that the first additional dose of 20 lbs. nitrogen applied in the form of ammonium sulphate has resulted in a loss. But the second dose of 40 lbs. nitrogen resulted in high marginal value product which has made up more than the cost of three such additional doses. This level of fertilizer, therefore, possesses high economic efficiency.

In case of ammonium sulphate nitrate, the first dose (20 lbs. N) has increased the return from it by 97 per cent and the second dose (40 lbs. N) has increased it by 204 per cent. As such, economic efficiency is found to be the highest at the level of 40 lbs. nitrogen per acre and at this level. it is fairly comparable with the efficiency of ammonium sulphate.

In the case of urea, it is however found that the first dose of 20 lbs. nitrogen per acre has resulted in a loss, while the second dose of 40 lbs. nitrogen per acre has responded with 94 per cent extra gain against the investment under fertilizer. The response however is not comparable to the one obtained from ammonium sulphate and ammonium sulphate nitrate though the cost is somewhat lower.

The general conclusion would therefore be that ammonium sulphate and ammonium sulphate nitrate would be most efficient from the economic standpoint at the level of 40 lbs. nitrogen per acre.

Juar

In the case of juar, the experiment was repeated for four years during which a variety of seasonal conditions has been covered. Table II gives the average position.

TABLE II—ECONOMIC RESPONSE OF FERTILIZER EXPERIMENTS ON JUAR

S.No.	Doses	Average yield per acre (lbs.)	Marginal product (lbs.)	Marginal value product (Rs.)	Marginal cost (Rs.)	Percentage of column 5 to column 6
1	2	3	4	5	6	7
			Ammonium Sulphate			
1.	Control	938	—	—	—	—
2.	20 N	1,297	355	45·52	17·40	262
3.	40 N	1,390	93	11·79	17·40	68
			Ammonium Sulphate Nitrate			
1.	Control	938	—	—	—	—
2.	20 N	728	−210	−26·63	17·12	156
3.	40 N	1,473	745	94·46	17·12	552
			Urea			
1.	Control	938	—	—	—	—
2.	20 N	1,085	147	18·64	16·03	116
3.	40 N	1,116	31	3·92	16·03	25

The above table shows that the first dose of 20 lbs. nitrogen per acre in the form of ammonium sulphate has increased the marginal value product by 162 per cent over the marginal cost. However, the next additional dose of 40 lbs. has resulted in a loss, the marginal value product being only 68 per cent of marginal cost.

With ammonium sulphate nitrate, it is seen that the first dose has responded most unfavourably. The next dose has surprisingly showed an extraordinary increase, *i.e.*, 452 per cent over the marginal cost. These responses appear to be erratic but it is clear that the level of 40 lbs. nitrogen proves highly efficient from economic standpoint. As between ammonium sulphate and ammonium sulphate nitrate, it is seen that the application of the former needs to be restricted to 20 lbs. nitrogen only, while it is essential to raise it to 40 lbs. nitrogen per acre in the case of ammonium sulphate nitrate.

Results of the application of urea show that the additional cost involved in the application of the first dose of 20 lbs. N has just more than paid for itself; and at a level of 40 lbs. N per acre, it has resulted in economic loss.

In comparison to the other two fertilizers, and also by itself, the use of urea in the case of juar is therefore likely to prove uneconomic.

Wheat

The experiment on wheat was conducted for three years and Table III presents the average position of the above period.

TABLE III—ECONOMIC RESPONSE OF FERTILIZER EXPERIMENTS ON WHEAT

S. N.	Doses	Average yield per acre (lbs.)	Marginal product (lbs.)	Marginal value product (Rs.)	Marginal cost (Rs.)	Percentage of column 5 to column 6
1	2	3	4	5	6	7
			Ammonium Sulphate			
1.	0 N	844	—	—	—	—
2.	20 N	910	66	13·22	17·40	76·00
3.	40 N	935	25	5·00	17·40	29·00
			Ammonium Sulphate Nitrate			
1.	0 N	844	—	—	—	—
2.	20 N	847	3	0·60	17·12	4·00
3.	40 N	766	-81	-16·84	17·12	98·00
			Urea			
1.	0 N	844	—	—	—	—
2.	20 N	844	—	—	16·03	—
3.	40 N	972	28	5·59	16·03	35·00

A glance at the relationship between the marginal costs and marginal value products in respect to all the three fertilizers used shows that the additional cost incurred in the application of these fertilizers in wheat growing has not even paid for itself. As such it may be concluded that under the soil and climatic complex as obtained on the Nagpur Farm, the above three fertilizers used for wheat do not stand the economic test.

In conclusion, it may be stated that for attaining a higher level of production commensurate with its economics, the potentialities in the use of ammonium sulphate nitrate when applied to cotton offer the best comparative advantage.

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EFFECTS OF ADOPTION OF IMPROVED PRACTICES ON THE YIELD OF RAGI

Ragi is an important food crop in the Mysore State. The State contributes nearly one-third of the production of *ragi* in the country. In the year 1958-59, the area under *ragi* in the Indian Union was 6.2 million acres, with a total production of 18.7 lakh tons, whereas in the Mysore State, the area under *ragi* was 2.3 million acres with a total production of 6.7 lakh tons. *Ragi* is one of the hardiest food crops suited for dry farming. It can grow under conditions of low rainfall and can withstand severe drought. The crop is reasonably free from pests and diseases. Its cultivation is concentrated in the red soils area of the southern districts of Mysore State.

Yield of Ragi

Long run yield data in the past have shown no appreciable increase in the per acre yield of *ragi*. One of the main contributing factors to the slow increase in the yield is the lack of adoption of improved practices. Those who have adopted improved practices have done so in an isolated way and large number of them have adopted only one or two practices and that too, on a small area.

TABLE I—TREND OF RAGI YIELDS IN BANGALORE DISTRICT

Year	Yield per acre in lbs.	3 years moving average
1950-51	586	—
1951-52	412	459
1952-53	380	458
1953-54	583	521
1954-55	600	651
1955-56	769	694
1956-57	713	838
1957-58	1,031	808
1958-59	681	764
1959-60	581	—
Average	633	

Average yield of *ragi* during the decennial period comes to 633 lbs. per acre. The yield has shown an upward trend particularly after 1955-56. It has increased at an average rate of only 4 per cent per year.

Objectives

The objectives of this study are two-fold :

(1) to assess the extent of adoption of improved practices by farmers, and

(2) to find out the extent of increase in yield through the adoption of improved practices.

A purposive sample of 98 farmers included in the Farm Management Study in the Bangalore district was selected for the study. The following assumptions have been made : (1) Application of farmyard manure or compost is a common practice adopted by farmers and is not listed as an improved practice; And (2) farmers who have followed any one of the improved practices even on a very small area are considered as adopting improved practice.

With a view to stepping up per acre yield of *ragi*, the following improved practices have been recommended by the Department of Agriculture from time to time : (1) use of iron plough in place of country plough; (2) use of improved seed (H-22) in place of local seed (Hullubele, Bilekaddi and others); (3) drill-sowing or transplanting in place of broadcasting. (There are no cases of transplanting in this sample); (4) use of fertilizers preferably with a basal dose of farmyard manure or compost; and (5) rotation of *ragi* with groundnut or a leguminous crop. These recommendations are based on the results of experiments conducted by the Department in the past.

The experiments in ploughing with country and improved (iron) plough have shown that the yield of *ragi* could be increased by 38 per cent. The experiments on the use of improved variety have shown that improved variety gives 7 per cent more yield than local varieties. The results of farm management research indicate that drill-sowing gives an increased yield of 27 per cent over broadcasting. The experiments on the application of fertilizers have shown that by the application of nitrogen alone, yield could be increased by 20 to 50 per cent; combined use of nitrogen and phosphorus gives 58 per cent more yield and that of nitrogen, phosphorus and potash gives about 100 per cent increase in yield. Rotational experiments have shown that *ragi* after groundnut gives 27 per cent increase in yield. The sum total of these improved practices is nearly 200 per cent. But owing to the interaction of factors the results may not be additive. In the absence of any data on the combined use of improved practices, it is hazardous to predict the extent of increase in yield. One can, however, safely estimate doubling of the present per acre yield.

Adoption of Improved Practices

Table II presents data regarding different improved practices adopted by the selected farmers.

Out of the total number of 98 farmers, 65 have adopted iron ploughing, 11 have used improved seed, 32 drill-sowing, 5 have used fertilizer and 4 have rotated *ragi* with groundnut.

Effects of Adoption of Improved Practices on Ragi Yield

Table III shows the number of improved practices adopted by the farmers and the extent of increase in *ragi* yield.

About 20 per cent of the farmers have not adopted any improved practice. However, the average yield of these farmers, particularly in villages D, F and G are pretty high. This is due to variation in yield from village to village and the use of liberal dose of farmyard manure or compost, old earth or tank silt by

TABLE II—FARMERS ADOPTING DIFFERENT IMPROVED PRACTICES—DRY *Ragi* 98 FARMERS, RED SOILS AREA, BANGALORE DISTRICT : 1960-61

S. No.	Villages	Total No. of cultivators	Number of cultivators adopting different practices				
			Iron ploughing	Improved seed	Improved method of sowing	Fertilizers	Rotation
1	A	10	9	—	1	—	—
2	B	10	7	10	6	4	—
3	C	10	—	—	6	—	—
4	D	10	1	1	3	1	—
5	E	10	10	—	8	—	4
6	F	9	6	—	—	—	—
7	G	9	6	—	—	—	—
8	H	10	7	—	—	—	—
9	I	10	9	—	5	—	—
10	J	10	10	—	3	—	—
Total		98	65	11	32	5	4
Per cent of farmers			66	11	32	5	4

TABLE III—NUMBER OF IMPROVED PRACTICES ADOPTED AND THE EXTENT OF INCREASE IN YIELD PER ACRE, 98 FARMERS, RED SOILS AREA, BANGALORE DISTRICT: 1960-61

Villages	Farmers not adopting any improved practice	Average yield per acre in lbs.	Farmers adopting any one improved practice	Average yield per acre in lbs.	Farmers adopting any two improved practices	Average yield per acre in lbs.	Farmers adopting three and more improved practices	Average yield per acre in lbs.
A	—	—	9	515	1	536	—	—
B	—	—	1	327	2	828	7	931
C	4	241	6	334	—	—	—	—
D	7	860	2	704	—	—	1	877
E	—	—	1	562	6	685	3	749
F	3	939	6	582	—	—	—	—
G	3	878	6	867	—	—	—	—
H	3	625	7	1,036	—	—	—	—
I	—	—	5	723	5	822	—	—
J	—	—	7	631	3	721	—	—
Average	20	708	50	628	17	718	11	832
Per cent	20·41		51·02		17·35		11·22	
Per cent of increase in yield over one improved practice adopted	—		—		14·33		32·48	

these farmers. This also reflects the efforts of the farmers to improve the yields through their own methods. About 50 per cent of the farmers have adopted only one improved practice. This group consists of 41 farmers who have adopted iron ploughing; 8 farmers who have adopted drill-sowing and one farmer who has used improved seed. About 18 per cent of the farmers have adopted two improved practices. This group includes 13 farmers who have combined iron ploughing with drill-sowing; two farmers who have combined iron ploughing with improved seed; one farmer who has combined iron ploughing with the use of fertilizers and one farmer who has combined iron ploughing with rotation. About 12 per cent have adopted three or more improved practices. This group included four farmers who have combined iron ploughing with improved seed and drill-sowing; three farmers who have combined iron ploughing, drill-sowing and rotation; three farmers who have combined iron ploughing, improved seed, drill-sowing and fertilizer use and one farmer who has combined iron ploughing with improved seed and application of fertilizer.

Farmers who have adopted more than one improved practice have got more yields than those who have not adopted any improved practices and also those who have adopted one improved practice. Farmers who have adopted two improved practices have obtained 14.33 per cent more yield whereas farmers who have adopted three or more improved practices have realised 32.48 per cent more yield than those who have adopted one improved practice.

Conclusions

The results of evaluation reveal that about 20 per cent have not adopted any improved practice. Nearly 70 per cent of farmers have adopted only one or two improved practices such as iron ploughing and drill-sowing. Only a small percentage of them have used improved seeds, applied fertilizers and followed crop rotation. The results of experiments conducted by the Department in the past have clearly shown that adoption of improved practices results in substantial increase in yield. The combined use of these improved practices would possibly double the present level of yield. With the present 2.3 million acres under *ragi* it is possible to produce 13.4 lakh tons of *ragi* every year in the State as against the present production of about 6.7 lakh tons. One way to popularise the improved practices is to educate the farmers on the profitableness of combined use of improved practices, through properly laid out demonstrations.

N. P. PATIL*

REAL EFFECTS OF FOREIGN SURPLUS DISPOSAL IN UNDER-DEVELOPED ECONOMIES—A COMMENT†

There has been a widespread concern about the adverse effects on agricultural production of foreign surplus disposal in under-developed countries. A persistent price disadvantage will naturally tend to divert the area from the particular crop suffering the disadvantage though this all depends on the real alternatives available within the soil, climate, water complex of the farm and other institutional and physical rigidities in which a farmer is operating. And the price effect itself

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will depend on whether the price disadvantage has crossed the threshold by which growing of other crops becomes profitable on the whole. A facile assumption that in every circumstance a comparatively unfavourable price situation for any crop will be had for its total production is unwarranted, though it being comparatively bad for its producer goes without saying. However, the ethical question of distribution is vast and cannot be tackled in this piecemeal way. I avoid it in what follows.

In respect of the area response, the following information about India may be interesting. If we consider 1952-53 as base year, the total cropped area in India increased by 146 per cent by the year 1961-62. In the same period the area under wheat increased by about 37 per cent. With the same base, the index number of the prices of wheat in 1961 was 89.3 in comparison with 101.6 for cereals as a whole (including wheat), 150.0 for fibres and 157.8 for oilseeds. The percentage increase in area of wheat has been the largest for any important crop and no other major crop suffers that much price decline.

The above tendency has been a long term trend as can be seen from the relevant time series (not given here for brevity).

It may be well to remember that PL 480 operations had contributed their due share in maintaining the price of wheat that low. It seems that, apart from other factors, as conceived by Schultz[1] the beneficial effects of reduction in fluctuations in wheat prices due to PL 480 outweighed the detrimental effects of low comparative prices.

One remark about methodology is in order. There seems to be a tendency to rely too much on the correlation coefficient between time series of the area (or relative area) under crop and prices to determine the causes of the crop pattern adopted by the cultivator. Though these are important, they are not definitive as there can be lots of other tendencies which will make for observed high correlations. For instance, cyclical fluctuations in acreage generated through, say, weather pre-conditions and/or various rotation practices may have a very high correlation with lagged prices which may themselves be the result of the area in previous cycle, etc.

To get at the factors determining the crop pattern a large number of micro studies at village level are required. In one such study Muranjan[2] found that the crop pattern in a village changed due to "heavy rains in the sowing time." In another one in Khandesh district, Mulla[3] found that the crop pattern is almost pre-determined by rotation practices. I do not imply that big and long term price changes have no influence on cropping pattern, but only that an unirrigated traditional agriculture operates under very many constraints. And to be able to appreciate the role that price changes of the order observed can play in that can only be appreciated by making detailed study at the grass roots rather than relying on some aggregative data and possibly spurious correlations.

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1. T. W. Schultz, "Value of U. S. Farm Surpluses to Underdeveloped Countries," *Journal of Farm Economics*, Vol. XLII, No. 5, December, 1960, p. 1029.
2. S. W. Muranjan, "Factors Influencing Cropping Patterns on Individual Holdings," *Artha Vijnana*, Vol. I, No. 3, September 1959, p. 199.
3. G. R. Mulla, Ph. D. thesis under preparation at Gokhale Institute of Politics & Economics, Poona.

It may not be a mere accident that two comments[4] fearful of the adverse effects of PL 480 on local agriculture have come from experts who have analysed Pakistan's experience while enthusiastic comments are from those who had India's experience in their background. From Falcon's account it seems that Pakistan has not taken the precautions necessary in the use of PL 480 aid for development purposes as detailed in the FAO document,[5] while India seems to have integrated them into its total planning.[6]

It may be worthwhile to recount the way this aid was originally planned to be used and as it was used by India and Pakistan to highlight its economic effects on local economy.

F.A.O. approach may be termed as a project approach, in which the extra demand of various commodities generated by the expenditure on each individual project is to be estimated with the help of various demand studies and the estimates of extra income and its distribution generated by the project expenditure. Then this extra bundle of commodities was to be made available with the help of surplus disposal schemes at the right time and the right place, so that the expenditure on the project may not exert any demand pressure at any point of the economy.[7] This was a scheme that was designed to provide similar safeguard to internal commodity market as the total surplus disposal scheme was designed to provide for the international commodity market.

The above approach involves a lot of research and an enormous amount of calculations for each project together with the physical necessity of making available at the project site the whole bundle of consumption goods required at the appropriate time. The whole bundle of consumption goods was not available under surplus disposal programme, mostly it was only wheat that was available and to a smaller extent cotton. This made the above atomistic programming approach mostly unfeasible. In India, therefore, they used market as an indicator of underlying economic conditions. The essentials of the procedure adopted may be summarised as follows. The whole of the wheat imported under surplus disposal programme was imported by the Government, and stored at convenient points. The development projects, on the other hand, were taken up in different parts of the country financed at the margin by deficit financing. Wherever the scarcity of foodgrains showed itself up, the supplies of stored surplus grains were rushed and issued to fair price shops for distribution. Thus the prices of wheat have mostly been not allowed to rise and the amount of development activity has been kept up at the high level which could not have been sustained without substantial aid in terms of surplus foodgrains. Under this procedure it is not possible to pinpoint the projects that have benefited from this type of aid. For accounting purposes any of agreed sub-set of the development projects, the rupee expenditure

4. (i) C. Beringer, "Real Effects of Foreign Surplus Disposal in Underdeveloped Economies—A Comment," *Quarterly Journal of Economics*, Vol. LXXVII, No. 2, May, 1963; (ii) W. P. Falcon, "Real Effects of Foreign Surplus Disposal in Underdeveloped Economies—Further Comments," *Quarterly Journal of Economics*, Vol. LXXVII, No. 2, May, 1963.

5. Mordecais Ezekeil: Uses of Agricultural Surpluses to Finance Economic Development in Under-developed Countries, Commodity Policy Study No. 6, F.A.O., Rome, 1955.

6. S. R. Sen, "Impact and Implications of Foreign Surplus Disposal on Underde.eloped Economies—The Indian Perspective," *Journal of Farm Economics*, Vol. XLII, No. 5, December, 1960.

7. For detailed calculations of demand generated by individual projects see V. M. Dandekar: Use of Food Surpluses for Economic Development, Gokhale Institute of Politics & Economics, Poona, 1956.

on which is of equivalent value to the loans and grants received, are shown as financed through the surplus disposal schemes. In fact this disposal of surplus foodgrains makes feasible many more projects than they get a credit of, because only about one-fourth[8] of the rupee expenditure of a project is to be on foodgrains. This means that so much quantity of foodgrains is made available that would take care of extra demand generated for foodgrains by the putting up of the projects requiring rupee financing of an order of about four times the total value of foodgrains made available. Of course, about three-fourth of finances for these projects will have to come from other sources, but the important point to note is that if this 75 per cent of finance could have been made available even otherwise, it would not have been possible to utilise it in view of the stress on foodgrain market, inflationary pressures on which would have affected the working of all sectors of the economy.

The procedure for surplus disposal used in Pakistan[9] is very different. The sale of domestic wheat in the largest cities is banned or reduced to about ten per cent of total wheat marketing, so that the wheat imported under the programme may be disposed off easily. In effect this would imply unloading the surpluses in the wheat growing area which was previously supplying this market. Apparently, no effort is made to establish development projects in the same area, which might have generated extra demand capable of absorbing the surplus in the region. With the known market imperfections in Indo-Pakistan sub-continent where the transmission of forces between various markets is very incomplete, it is understandable that this procedure of disposal would have led to "substantial decreases in prices received by West Pakistan farmers."[10]

Further, it would seem that the total financing of the local currency component of development project is done through counterpart funds created by surplus disposal programme. If this is so, it means that even in the aggregate the extra demand for wheat generated by the development programmes will be only about 25 per cent of the extra wheat pumped into the economy and the remaining portion of the project expenditure will generate demands for the commodities which have neither been made available through surplus disposal programme nor have their already existing demand curtailed through appropriate taxation or regulatory measures. This will tend to depress wheat prices and put an undue strain in the markets of other consumption commodities.

Thus it will be seen that the availability of surplus commodities would not be a complete substitute for revenue collection for the purpose of financing development projects. In fact if unwanted economic consequences are to be avoided, a major portion of such expenditure will have to be financed through own resources of the receiving countries. The fears of Mr. Beringer[11] on this account that the surplus disposals may become substitute for increasing fiscal efficiency need not be realised if it is assured that the receiving country sticks to the rules of the game.

But, however good effect the surplus disposal programme may have on a newly developing country, the long run solution of this problem is the establish-

8. V. M. Dandekar : *Op. cit.*
9. As described by C. Beringer, *Op. cit.*, pp. 321-322.
10. *Ibid.*
11. *Ibid.*, p. 322.

ment of normal trade relations. For instance, it should be possible for India to pay for its food imports in the near future. There are two impediments—one psychological on the part of receiving country which cannot conceive of a long term goal of non-self-sufficiency and another on the part of the donor which cannot easily adjust to extra imports of the commodities, these newly developing countries can provide. The second is a more important constraint because for the first it need never be admitted that in long term planning there is a scope for imports of foodgrains.

P. N. MATHUR*

MINIMIZING COSTS OF TRANSPORTATION THROUGH LINEAR PROGRAMMING

The Central and State Governments in India have taken a number of measures to procure rice and some other foodgrains from the farmers at the floor prices to ensure minimum prices to the producers. Large quantities of foodgrains are imported from U.S.A. under PL 480 Agreement, which are received at different ports in India and distributed throughout the country. Further, the Government intend to build up buffer stocks at selected centres in the country and rush them to the deficit areas to prevent the rise in prices. Boards have been set up for several commodities which assemble them at some centres and transport to other areas for distribution. The State Governments are entrusted with the distribution of scarce articles like sugar, cement, iron and steel. All these involve considerable amount of transportation at huge cost. Where the commodity is produced at numerous centres and transported to other areas through a central agency like the Government or some industrial unit, linear programming offers potentialities for minimizing the transportation costs resulting in lowering the retail prices of commodities.

Problem

The problem of distributing sugar from the various supply centres represented by the sugar factories to the different consuming centres denoted by the districts in the Mysore State is considered here.[1] The problem pertains to the period from the middle of May to the middle of June, 1963.

Objective

The main object of the paper is to distribute sugar from the different factories to the various districts in the State at minimum transportation cost simultaneously satisfying the supply and demand restraints.

Assumptions

(1) The available supplies of sugar at the factories and the quantities demanded at the districts are equal.[2]

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1. In technical terminology it is common to consider the transportation of commodities from the origins to the destinations. In the present case, the factories are the origins and the district headquarters are the destinations.

2. When the supplies and demands are not equal, they should be equalised by including a dummy row or column as the case may be.

(2) Sugar from any of the factories is equally acceptable at all consuming centres. In other words, quality will not affect demand.[3]

(3) The cost of transportation is linear.[4]

(4) Sufficient transport facilities are available through routes specified in the programme.

Analysis

During the period under consideration sugar is supplied to the nineteen districts of Mysore State by eight sugar factories in Mysore and four from Maharashtra. Since the transportation costs per ton of sugar from each factory to the different districts are not available, distances by the shortest route between each factory and the different districts have been considered for analysis.[5] Lack of information about the distances between the various sugar factories in Maharashtra and the district headquarters in Mysore State necessitated the exclusion of sugar supplied by the factories in Maharashtra from the analysis. To equalise the demand and supply of sugar within the Mysore State, the quantities supplied from the factories in Maharashtra to the different districts in Mysore State are deducted from the demands of the respective districts. As two districts have derived their entire supply from the factories in Maharashtra, only the demands from seventeen districts have been considered for analysis. The factories which are in a very close proximity are grouped together and are denoted by the important factory of the area. This helps to keep the problem within reasonable limits and reduce the computational work considerably (Table I).

The distances by the shortest routes between the factories and the districts are obtained from the Public Works Department of the Mysore State.[6] Costs of transportation at the rate of Re. 0.02 per ton per mile considered as the nearest approximations to the actual costs are included for calculating the transportation cost per ton of sugar from each supply centre to every consuming centre[7] (Table II).

In a transportation problem to be solved by linear programming the general procedure is to start with an initial feasible programme and go on improving it with respect to the objective function until an optimum is reached[8] (Table III).

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3. In the present example due to the scarcity of sugar in the country, quality has no effect on the quantities demanded.
4. In some cases, the transportation cost may vary according to the truck loads of the commodity available for transportation. In such cases the transportation cost per truck load of the commodity per mile may be considered as the unit.
5. Where the means of transportation are owned and operated by the agency which takes up the distribution of commodities, the object would be to minimize the distance over which the goods are to be transported.
6. Due to scarcity or non-availability of suitable transport facilities on the shortest routes, it may be necessary to channel the supplies through other routes. The costs of transportation from the origins to the destinations through such routes may be included in the analysis and the costs of the programmes will go up to that extent.
7. Actual costs of transportation, if available, may be included which will make the solutions more realistic.
8. A feasible programme is one which satisfies both the demand and supply restrictions. An optimum programme is a feasible programme which does not permit an improvement in the objective function.

TABLE I—QUANTITIES OF SUGAR SUPPLIED FROM DIFFERENT FACTORIES TO THE VARIOUS DISTRICTS IN MYSORE STATE DURING THE PERIOD FROM THE MIDDLE OF MAY TO THE MIDDLE OF JUNE, 1963

Districts		Factories				Total
		Mandya (P)	Shimoga (Q)	Hospet (R)	Ugar (S)	
		Sugar in tons				
1. Bangalore	(A_1)	293	—	961	—	1,254
2. Mysore	(A_2)	600	—	—	—	600
3. Coorg	(A_3)	90	—	—	—	90
4. Mangalore	(A_4)	575	—	—	—	575
5. Hassan	(A_5)	175	—	—	—	175
6. Shimoga	(A_6)	—	280	—	—	280
7. Tumkur	(A_7)	—	—	250	—	250
8. Kolar	(A_8)	—	—	250	—	250
9. Chitradurg	(A_9)	—	—	275	—	275
10. Chikkamaglur	(A_{10})	137	—	—	—	137
11. Bellary	(A_{11})	—	—	250	—	250
12. Dharwar	(A_{12})	—	—	—	780	780
13. Bijapur	(A_{13})	—	—	—	429	429
14. Belgaum	(A_{14})	—	—	—	850	850
15. Karwar	(A_{15})	—	—	—	350	350
16. Raichur	(A_{16})	—	—	340	—	340
17. Mandya	(A_{17})	210	—	—	—	210
Total		2,080	280	2,326	2,409	7,095

TABLE II—ESTIMATED COSTS OF TRANSPORTATION OF SUGAR FROM EACH FACTORY TO EACH DISTRICT HEADQUARTERS IN MYSORE STATE DURING THE PERIOD FROM THE MIDDLE OF MAY TO THE MIDDLE OF JUNE, 1963

Districts	Factories			
	Mandya (P)	Shimoga (Q)	Hospet (R)	Ugar (S)
	Cost in rupees per ton			
1. Bangalore (A_1)	1·22	3·40	4·58	7·74
2. Mysore (A_2)	0·52	3·04	5·10	8·24
3. Coorg (A_3)	2·06	2·48	4·72	8·12
4. Mangalore (A_4)	3·50	1·96	4·24	6·72
5. Hassan (A_5)	1·08	1·54	7·40	6·98
6. Shimoga (A_6)	2·18	0	2·24	5·16
7. Tumkur (A_7)	2·08	1·26	3·30	6·78
8. Kolar (A_8)	2·04	4·26	4·80	8·46
9. Chitradurg (A_9)	2·56	1·24	1·70	5·16
10. Chikkamagiur (A_{10})	2·00	0·82	3·20	6·32
11. Bellary (A_{11})	3·68	1·26	0·80	5·26
12. Dharwar (A_{12})	5·42	2·86	1·80	2·34
13. Bijapur (A_{13})	7·40	4·54	4·00	3·92
14. Belgaum (A_{14})	6·36	3·80	2·74	1·40
15. Karwar (A_{15})	5·36	2·56	3·60	3·48
16. Raichur (A_{16})	6·38	3·86	1·92	5·62
17. Mandya (A_{17})	0	2·18	4·16	8·86

TABLE III—QUANTITIES OF SUGAR TO BE SUPPLIED FROM DIFFERENT FACTORIES TO THE VARIOUS DISTRICTS IN MYSORE STATE ACCORDING TO THE OPTIMUM PROGRAMME FOR THE PERIOD FROM THE MIDDLE OF MAY TO THE MIDDLE OF JUNE, 1963

Districts	Factories				Total
	Mandya (P)	Shimoga (Q)	Hospet (R)	Ugar (S)	
	Sugar in tons				
1. Bangalore (A_1)	1,254	—	—	—	1,254
2. Mysore (A_2)	600	—	—	—	600
3. Mercara (A_3)	—	—	90	—	90
4. Mangalore (A_4)	—	—	575	—	575
5. Hassan (A_5)	16	159	—	—	175
6. Shimoga (A_6)	—	—	280	—	280
7. Tumkur (A_7)	—	—	250	—	250
8. Kolar (A_8)	—	—	250	—	250
9. Chitradurg (A_9)	—	—	275	—	275
10. Chikkamaglur (A_{10})	—	121	16	—	137
11. Bellary (A_{11})	—	—	250	—	250
12. Dharwar (A_{12})	—	—	—	780	780
13. Bijapur (A_{13})	—	—	—	429	429
14. Belgaum (A_{14})	—	—	—	850	850
15. Karwar (A_{15})	—	—	—	350	350
16. Raichur (A_{16})	—	—	340	—	340
17. Mandya (A_{17})	210	—	—	—	210
Total	2,080	280	2,326	2,409	7,095

Various methods like the North-west Corner Rule, the Inspection Method and the Vogel's Approximation Method are available for determining the initial feasible plan. In this case, the Vogel's Approximation Method is adopted for determining the initial feasible plan, since it provides an initial plan which would be nearer to the optimum plan. After determining the initial plan, the vacant cells are evaluated through the Modi Valuation Method and the programmes are improved by the square or stepping stone method until an optimum is reached.

The initial feasible programme and the subsequent improved programmes eventually leading to the optimum are given along with their costs in the Appendix. The factories are denoted by P, Q, R, S and the district headquarters are denoted by A_1, A_2, A_3, ... A_{17}. The quantities of sugar to be supplied according to the optimum programme are given in Table III.

It is seen from the optimum programme that the available supplies at each factory and the quantities of sugar demanded at each district are fully met. The cost of the present programme is Rs. 16,992.42 whereas that of the optimum programme is Rs. 15,004.62 (Appendix). Hence it is possible to save to the tune of Rs. 1,987.80 or about 12 per cent of the present cost of transportation by adopting the optimum programme.

For the purpose of easy comparison, the allotments of sugar according to the present and optimum programmes are given in Table IV. It is observed that in majority of the districts the allotments of sugar by the present and the optimum programmes are the same. Only in six cases changes are proposed by the optimum programme. Adopting the proposed changes would effect considerable savings in the costs of transportation.

It is important to note that the optimum programme will minimize the cost of the programme as a whole. This may not be true of each consuming centre. In other words, every consuming centre is not supplied from its nearest supply centre. Sometimes, it may be advisable, considering the programme as a whole, to send the sugar produced at a particular factory to other areas and obtain its supply from some other factory. This may appear ridiculous considering the single consuming centre but would be logical when the programme as a whole is considered.

If certain districts are to be supplied from some specific factories, then the demands of these districts can be deducted from the supplies of the respective factories and only the demands of the remaining districts and the residual supplies of the factories can be considered for analysis.

Conclusion

The results reveal that it is possible to save to the tune of Rs. 1,987.80 or about 12 per cent of the present cost of transportation by adopting the optimum programme.

TABLE IV—ALLOTMENT OF SUGAR FROM THE FACTORIES TO THE DIFFERENT DISTRICTS IN MYSORE STATE ACCORDING TO THE PRESENT AND OPTIMUM PROGRAMMES FOR THE PERIOD FROM THE MIDDLE OF MAY TO THE MIDDLE OF JUNE, 1963

Districts		Allotments according to Present Plan		Allotments according to Optimum Plan		Total for the district (tons)
		Origins	Quantity (tons)	Origins	Quantity (tons)	
1. Bangalore	(A_1)	Mandya Hospet	293 961	Mandya	1,254*	1,254
2. Mysore	(A_2)	Mandya	600	,,	600	600
3. Mercara	(A_3)	,,	90	Hospet	90*	90
4. Mangalore	(A_4)	,,	575	,,	575*	575
5. Hassan	(A_5)	,,	175	Mandya Shimoga	16 159*	175
6. Shimoga	(A_6)	Shimoga	280	Hospet	280*	280
7. Tumkur	(A_7)	Hospet	250	,,	250	250
8. Kolar	(A_8)	,,	250	,,	250	250
9. Chitradurg	(A_9)	,,	275	,,	275	275
10. Chikkamaglur	(A_{10})	Mandya	137	,, Shimoga	16 121*	137
11. Bellary	(A_{11})	Hospet	250	Hospet	250	250
12. Dharwar	(A_{12})	Ugar	780	Ugar	780	780
13 Bijapur	(A_{13})	,,	429	,,	429	429
14. Belgaum	(A_{14})	,,	850	,,	850	850
15. Karwar	(A_{15})	,,	350	,,	350	350
16. Raichur	(A_{16})	Hospet	340	Hospet	340	340
17. Mandya	(A_{17})	Mandya	210	Mandya	210	210
Total	..	..	7,095		7,095	7,095

* Proposed changes in distribution according to the optimum programme as compared to the present programme.

Linear programming can be effectively used to determine optimum programmes for minimizing the costs of transportation. The data used in the analysis should be reliable and accurate since the reliability of the results cannot be more precise than the data used. Linear programming offers tremendous potentialities of application both in private and public sector industries in India. It has already made its mark in the economically advanced countries where the technique is being used in many spheres.

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APPENDIX

ALLOTMENT OF SUGAR FROM DIFFERENT FACTORIES TO VARIOUS DISTRICT HEADQUARTERS ACCORDING TO THE PRESENT PROGRAMME FOR THE PERIOD FROM THE MIDDLE OF MAY TO THE MIDDLE OF JUNE, 1963

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}	Total
P_1	293*	600*	90*	575*	175*					137*							210*	2,080
Q						280*												280
R	961*						250*	250*	275*		250*					340*		2,326
S												780*	429*	850*	350*			2,409
Total	1,254	600	90	575	175	280	250	250	275	137	250	780	429	850	350	340	210	7,095

Cost of the Present Programme = Rs. 16,992.42

ALTERNATE PROGRAMME I

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}	Total
P	1,020*	600*						250*									210*	2,080
Q					0*	280*		0*										280
R	234*		90*	575*			250*		275*	137*	250*,	175*				340*		2,326
S					175*							605*	429*	850*	350*			2,409
Total	1,254	600	90	575	175	280	250	250	275	137	250	780	429	850	350	340	210	7,095

Cost of Programme I = Rs. 15,626.50.

(Contd.)

APPENDIX (*Contd.*)

ALTERNATE PROGRAMME II

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}	Total
P	1,020*	600*						250*									210*	2,080
Q						280*												280
R	234*		90*	575*			250*		275*	137*	250*	175*				340*		2,326
S					175*							605*	429*	850*	350*			2,409
Total	1,254	600	90	575	175	280	250	250	275	137	250	780	429	850	350	340	210	7,095

Cost of Programme II = Rs. 15,626.50

ALTERNATE PROGRAMME III

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}	Total
P	1,020*	600*						250*									210*	2,080
Q					175*	105*												280
R	234*		90*	575*		175*	250*		275*	137*	250*	0*				340*		2,326
S												780*	429*	850*	350*			2,409
Total	1,254	600	90	575	175	280	250	250	275	137	250	780	429	850	350	340	210	7,095

Cost of Programme III = Rs. 15,161.00

(*Contd.*)

APPENDIX (*Contd.*)

ALTERNATE PROGRAMME IV

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}	Total
P	1,254*	600*						16*									210*	2,080
Q					175*	105*												280
R			90*	575*		175*	250*	234*	275*	137*	250*	0*				340*		2,326
S												780*	429*	850*	350*			2,409
Total	1,254	600	90	575	175	280	250	250	275	137	250	780	429	850	350	340	210	7,095

Cost of Programme IV = Rs. 15,020.60

ALTERNATE PROGRAMME V

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}	Total
P	1,254*	600*						16*									210	2,080
Q					175					105*								280
R			90*	575*		280*	250*	234*	275*	32*	250*	0*				340*		2,326
S												780*	429*	850*	350*			2,409
Total	1,254	600	90	575	175	280	250	250	275	137	250	780	429	850	350	340	210	7,095

Cost of Programme V= Rs. 15,005.90

(*Contd.*)

APPENDIX (*Concld.*)

ALTERNATE PROGRAMME VI (OPTIMUM PROGRAMME)

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}	Total
P	1,254*	600*			16*												210*	2,080
Q					159*					121*								280
R			90*	575*		280*	250*	250*	275*	16*	250*	0*				340*		2,326
S												780*	429*	850*	350*			2,409
Total	1,254	600	90	575	175	280	250	250	275	137	250	780	429	850	350	340	210	7,095

Cost of Optimum Programme = Rs. 15,004.62

RESEARCH IN PROBLEMS IN AGRICULTURAL ECONOMICS IN INDIA—AN ANALYSIS OF ARTICLES PUBLISHED IN THE INDIAN JOURNAL OF AGRICULTURAL ECONOMICS, 1940-1964*

The period 1940-1964 has been full of challenges to research workers in all fields including Agricultural Economics. In India World War II gave rise to grave problems of production, prices and administration of food distribution. The post-war era was followed by the three Five-Year Plans. During the period of the three Five-Year Plans, agriculture was assigned an important role. Problems relating to the institutional frame, expansion of the flow of productive resources into agriculture, the working of the prices and the distribution system, operative efficiency of farms, distribution of earnings, received attention during the Plan periods. These and other topical questions were studied by agricultural research workers. Problems of more abiding interests not limited by the immediate needs of the time were also attended to.

I

The Indian Journal of Agricultural Economics, and the Annual Conferences of agricultural economists together with the special seminar meetings held occasionally provide a publication medium and forum for exchanging experiences of research workers engaged in agricultural economics research in India. The Journal and the Conferences can be trusted, therefore, to reflect the trends in agricultural economics during the past twenty-five years. The analysis of the papers read at the Conference and of articles and notes published in the Journal brings out the growth of the total volume of writings and shifts in interest from year to year during this period. The period is divided mainly into four parts : (*i*) the pre-plan period 1946-50, (*ii*) the First Plan period 1951-55, (*iii*) the Second Plan period 1956-60, and first four years of the Third Plan period (1961-64). One limitation of the period up to 1955 may be noted first. The Indian Journal of Agricultural Economics which was started in 1946 was published only twice a year for the first ten years. It was converted into a quarterly in 1956 and since then it has been regularly published every quarter. The first annual conference was held in 1940 and so far 24 Conferences were held. Whereas financial resources and also the reader's convenience require the size of the Journal to be restricted no such limit applied to the number of papers read at the Conference.

During the period 1946-1964 much research work has been done in the field of agricultural economics, which was independently published in the form of reports or research publications. Besides, some of it found its way to Journals other than the Indian Journal of Agricultural Economics in the recent period. The Indian Journal of Agricultural Economics and allied activities cannot claim to reflect therefore the total research work done in the field, it being a Journal devoted specially to the subject and which can claim only to reflect the major trends. Table I summarises the major trends as reflected by the Journal.

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* This is a revised version of the Paper which was submitted to the Conference on Agro-Economic Research convened by the Directorate of Economics and Statistics, Ministry of Food & Agriculture, Government of India in October, 1961 at New Delhi. We are grateful to the organizers of the Conference for permitting the publication of this Paper ahead of the printing of the entire proceedings.

TABLE I—CONTRIBUTIONS ON DIFFERENT TOPICS PUBLISHED IN THE INDIAN JOURNAL OF AGRICULTURAL ECONOMICS : 1946-64

Topics	1946-1950		Total	1951-1955		Total	1956-1960		Total
	Articles	Notes		Articles	Notes		Articles	Notes	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Land Use	2	2	4 (8.16)	—	—	—	7	4	11 (6.83)
Livestock & Dairying	—	—	—	—	—	—	—	—	—
Agricultural Planning & Development ..	5	2	7 (14.28)	9	2	11 (23.40)	7	12	19 (11.80)
Food Problem	4	1	5 (10.21)	—	3	3 (6.38)	6	6	12 (7.45)
Farm Costs, Management & Productivity	2	—	2 (4.08)	1	—	1 (2.13)	17	12	29 (18.00)
Structural Problems (Land Problems, Agrarian Structure) ..	6	6	12 (24.49)	4	6	10 (21.28)	13	4	17 (10.55)
Agricultural Labour Problems	2	3	5 (10.21)	5	—	5 (10.63)	1	3	4 (2.48)
Agricultural Income in relation to other Incomes	—	—	—	1	2	3 (6.38)	—	—	—
Co-operation	1	—	1 (2.04)	1	1	2 (4.26)	11	6	17 (10.55)
Agricultural Marketing & Prices	1	—	1 (2.04)	—	2	2 (4.26)	8	3	11 (6.83)
Agricultural Finance & Investment	—	1	1 (2.04)	1	1	2 (4.26)	4	7	11 (6.83)
Agricultural Insurance	—	—	—	—	—	—	2	—	2 (1.24)
Land Values & Taxation	—	—	—	—	—	—	—	—	—
Foreign Trade & Commodity Problems ..	1	—	1 (2.04)	—	—	—	3	—	3 (1.86)
Rural Life & Organisation (Village Surveys)	—	2	2 (4.08)	—	2	2 (4.26)	1	3	4 (2.48)
Agricultural Research, Education & Statistics	4	1	5 (10.21)	1	3	4 (8.50)	6	10	16 (10.00)
Agricultural Economic Theory & Policy ..	—	—	—	—	—	—	5	—	5 (3.10)
Summary of Reports ..	3	—	3 (6.12)	2	—	2 (4.26)	—	—	—
Total	31	18	49 (13.92)	25	22	47 (13.35)	91	70	161 (45.74)

(Contd)

TABLE I—(*Concld.*)

Topics	1961-1964		Total	Total 1946-1964		Grand Total
	Articles	Notes		Articles	Notes	
	(11)	(12)	(13)	(14)	(15)	(16)
Land Use	4	3	7 (7.37)	13	9	22 (6.25)
Livestock & Dairying	2	3	5 (5.26)	2	3	5 (1.42)
Agricultural Planning & Development	11	3	14 (14.74)	32	19	51 (14.50)
Food Problem	4	—	4 (4.21)	14	10	24 (6.82)
Farm Costs, Management & Productivity	16	13	29 (30.52)	36	25	61 (17.33)
Structural Problems (Land Problems, Agrarian Structure)	4	1	5 (5.26)	27	17	44 (12.50)
Agricultural Labour Problems	1	3	4 (4.74)	9	9	18 (5.11)
Agricultural Income in relation to other Incomes	2	—	2 (2.11)	3	2	5 (1.42)
Co-operation	5	—	5 (5.26)	18	7	25 (7.10)
Agricultural Marketing & Prices	4	3	7 (7.37)	13	8	21 (5.97)
Agricultural Finance & Investment	2	3	5 (5.26)	7	12	19 (5.40)
Agricultural Insurance	—	—	—	2	—	2 (0.57)
Land Values & Taxation	—	1	1 (1.05)	—	1	1 (0.28)
Foreign Trade & Commodity Problems	1	1	2 (2.11)	5	1	6 (1.70)
Rural Life & Organisation (Village Surveys)	2	—	2 (2.11)	3	7	10 (2.84)
Agricultural Research, Education & Statistics	1	1	2 (2.11)	12	15	27 (7.67)
Agricultural Economic Theory & Policy	—	1	1 (1.05)	5	1	6 (1.70)
Summary of Reports	—	—	—	5	—	5 1.42)
Total	59	36	95 (26.99)	206 (58.52)	146 (41.48)	352 (100.0)

N. B. : **Figures in brackets indicate percentage to the total.**

In all, 352 articles and notes during the last 19 years, or about 18 articles and notes per year, were published in the Journal. Of these, the articles were about 206. The growth of the volume of activity is indicated by the fact that compared to the initial years the total articles and notes published in 1960 were nearly three times larger in number. Or to state it differently, in the first 10 years only 27 per cent of the total notes and articles were published and during 1956-60 and 1961-64, 46 per cent and 27 per cent of total notes and articles respectively were published. Of the total writings, 294 were contributed by Indian authors and 58 by authors from abroad. Thus the writings reflect mainly the research work done on problems relating to Indian economy.

Considering the entire period of 1946-64 the analysis shows that (*i*) farm costs and farm management and productivity, (*ii*) agricultural development, and (*iii*) study of structural problems and structural reforms, were the most favoured topics; these three fields together accounted for 44 per cent of total articles and notes published in the Journal. Of the remaining, agricultural research and education, co-operation, food problem, land use, agricultural marketing and prices and finance, agricultural labour problems, village surveys were important to engage the research workers' attention; they accounted for further 47 per cent of the writings. What is noteworthy is that topics other than of immediate interest, *e.g.*, agricultural economic theory, research methods, terms of trade of agriculture, received the least attention of the research workers.

During the four periods, there are some major shifts in interest. Firstly, the enlargement of volume of writings provided a scope for variety. In the first two periods, the interest was limited mainly to institutional problems and problems of development, nearly 40 to 50 per cent of the notes and articles were devoted to them. Their proportion declined during 1956-60 and 1961-64 to less than one-third. During the years 1956-64 two new fields engaged the attention, namely, (*i*) co-operation and (*ii*) farm costs and management.

On the whole, the analysis gives an impression that the shifts were dictated largely by the shifts in the government policy. During 1946-50 land problems engaged the attention most, during 1951-55 problems of development and role of agriculture in a planned economy came to the fore; though structural problems and structural reforms and problems of agricultural labour continued to engage the attention. The food problem as a field of interest for research workers declined in importance. It was during the period of the First Plan that relative incomes in agriculture came to be studied.

The third period, the period of the Second Plan (1956-60) was characterised by an eclipse of interest in the problems of economic development and role of agriculture, even the structural reforms receded in importance. During this period production problems, problems of economies of scale and land use occupied the research workers' attention most. It was during the Second Plan that co-operative programme was vigorously taken up subsequent to the recommendation of the Committee of Direction of the Rural Credit Survey. Research workers paid prominent attention to these problems. Rising prices provided incentive to write on this problem and problems of marketing and prices gained in prominence

as a topical subject during this period. But more important feature of 1956-60 period is that the problems of theory received attention for the first time. The food problem has received continuous attention during all the four periods. Agricultural labour received relatively less attention during the third period.

During the fourth period (1961-64), study of economics of livestock enterprise including dairy and land values and taxation received attention for the first time in the Journal. More importantly, greater attention has been paid to the study of problems of farm costs and farm management and organisation as also land utilisation and marketing and prices. During this period, interest was revived in the study of the role of agriculture in economic development.

II

Twenty-four Annual Conferences of agricultural economists were organised by the Indian Society of Agricultural Economics during the period 1940-1964. At the Conferences, in all 602 papers were read, *i.e.*, an average of 25 per year, more than the contributions made to the regular Journal. The number of papers contributed has fluctuated from year to year between 14 in 1940 and 49 in 1962. Fluctuations are further illustrated by the fact that during the Second Plan period the number was as low as 18 in 1957, and as high as 34 in 1959. Judged by the number of papers contributed interest in agricultural economics attained heights during post-Independence period 1947-50 and the Third Plan period (1961-64). During these two periods, on an average 29 and 36 papers per year respectively were contributed. During the First and the Second Plan period, average of 26 papers per year indicates continuance of interest.

In regard to the Conference papers one limitation is that those working on the problems or who have worked or thought about the problems announced for the Conference could contribute. Table II gives the analysis of the number of papers on various topics published in the Conference Number of the Journal.

The interest evinced, judged from the number of papers, seems to be widely dispersed. Marketing and prices, which account for 12.46 per cent has the largest share (75 out of the 602 papers). If we add 'problems of marketable surplus' the share of this group of subjects will increase to nearly 16 per cent. Research methodology, co-operation, land problems, farm costs and management and planning and development of agriculture are other subjects with relatively larger share (34 per cent) in the total contributions. Agricultural labour, indebtedness and the food problem, all the three believed to be most vexed problems did not rank sufficiently high in regard to the share in the total Conference papers.

The period 1940-1964 is divided into four sub-periods : 1940-50, 1951-55, 1956-60, and 1961-64, for the purpose of studying shifts in interest. The analysis of the papers contributed in different fields does not reveal any major shift. The study of land problems and marketing and prices continued to dominate during all the four periods though attention was also paid to the study of problems of agricultural development and productivity and farm costs and management. Research methodology and co-operation have received greater attention during the first three periods.

TABLE II—CONTRIBUTIONS ON SUBJECTS DISCUSSED AT THE ANNUAL CONFERENCES OF THE SOCIETY : 1940-64

Subjects	1940-1950	1951-1955	1956-1960	1961-1964	Grand Total
Problems of Land Use	17 (7.52)	10 (8.00)	—	21 (14.68)	48 (7.97)
Agricultural Planning & Policy	11 (4.86)	—	—	—	11 (1.83)
Agricultural Development & Productivity	7 (3.10)	9 (7.20)	11 (10.19)	11 (7.69)	38 (6.31)
Food Problem	18 (7.96)	—	—	—	18 (2.99)
Population Problem	5 (2.21)	8 (6.40)	—	—	13 (2.16)
Animal Husbandry & Dairying	5 (2.21)	—	—	10 (7.00)	15 (2.50)
Rural Income Distribution	—	—	5 (4.63)	—	5 (0.83)
Agricultural Labour Problems	12 (5.32)	—	13 (12.04)	—	25 (4.15)
Economics of Mixed Farming	1 (0.44)	—	8 (7.41)	—	9 (1.50)
Problems of Low Income Farmers ..	12 (5.32)	—	—	—	12 (2.00)
Land Problems	24 (10.62)	13 (10.40)	8 (7.41)	9 (6.30)	54 (8.97)
Agricultural Taxation	6 (2.65)	—	6 (5.56)	—	12 (2.00)
Farm Costs & Management	13 (5.75)	9 (7.20)	7 (6.48)	9 (6.30)	38 (6.31)
Indebtedness, Finance & Capital Formation	9 (3.98)	16 (12.80)	—	22 (15.38)	47 (7.31)

(Contd.)

TABLE II—(*Concld.*)

Subjects	1940-50	1951-55	1956-60	1961-64	Grand Total
Marketing & Prices (including Processing)	22 (9.73)	18 (14.40)	14 (12.96)	21 (14.68)	75 (12.46)
Problems of Marketable Surplus	3 (1.33)	—	15 (13.88)	—	18 (2.99)
Co-operation	11 (4.87)	13 (10.40)	7 (6.48)	—	21 (5.15)
Terms of Trade in Agriculture	—	4 (3.20)	4 (3.70)	—	8 (1.33)
Small Scale, Village Industries	1 (0.44)	—	—	—	1 (0.16)
Rural Life (Social Structure)	12 (5.32)	—	—	19 (13.28)	31 (5.15)
Village Organisation	21 (9.29)	—	—	—	21 (3.48)
Research Methodology (Techniques of Field Surveys & of Evaluation of Rural Development Programmes, Statistical Concepts in Agricultural Economics, Techniques of Measuring Rural Unemployment)	7 (3.10)	15 (12.00)	10 (9.26)	—	32 (5.31)
Agricultural Exports & Economic Development	—	—	—	6 (4.20)	6 (0.99)
Risk & Uncertainty in Agriculture ..	—	—	—	15 (10.49)	15 (2.50)
Agricultural Economic Theory & Policy ..	9 (3.98)	10 (8.00)	—	—	19 (3.15)
Total	226 (37.54)	125 (20.76)	108 (17.95)	143 (23.75)	602 (100.00)

N. B.: Figures in brackets indicate percentage to the total.

Years 1942 and 1958 were excluded as no conference was held owing to War and the Tenth International Conference of Agricultural Economists which was held at Mysore (India) in August-September, 1958, respectively. A Special Number was brought out in October-December 1958 to mark this occasion. The main theme of the Conference was "Agriculture and Its Terms of Trade." This Special Number contained the summaries of Papers and Proceedings of the Tenth International Conference.

In fact there seems to be some eclipse in the interest in theoretical problems, just the opposite of the trend revealed by the Journal. This is probably borne out of the fact that the Committee deciding on the topics for the Conference came to be occupied more with the current problems.

III

By way of conclusion, what emerges from the foregoing analysis is not quite heartening. Some problems like agrarian structure and structural reforms have received disproportionately large attention. Problems of fundamental importance relating to economic theory and its application to agriculture have received much less attention.

If the immediate problems receive major share of the research workers' devotion, there is in one sense in it a sign of being alive to the situation and contributing the mite to urgent needs of the society. However, what happens unfortunately for the research worker is that he is called upon (or led) to study the problem *post-facto*. In most cases, the die is already cast and the after-thought and delayed wisdom borne out of *post-facto* research work has little scope of being direct help in the solution of the problem.

A new and a more happy trend that has developed during the Second Plan period is the attention to more fundamental problems of production and problems of theory, both of enduring interest. These problems have come to occupy the attention of research workers.

On the whole, the period 1940-64 has been a period of challenges for research workers in agricultural economics, but these challenges have been taken up mostly to understand the problems created by these challenges. This provides the desired training to the research worker. Much remains to be done if the research worker's contribution is to be of use as guidance for decision-making in the community. A trained research worker will be judged by his ability to see problems ahead of their rising, to predict the events before they occur and guide the decision-making by the community to adjust to it with ease and promptness. For this, more attention to theoretical problems, empirical problems involving quantitative analysis and study of the behaviour of economic units is necessary.

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