Vol XXIII
No. 1

JANUARY-MARCH
1968

ISSN 0019-5014

INDIAN JOURNAL OF AGRICULTURAL ECONOMICS

INDIAN SOCIETY OF
AGRICULTURAL ECONOMICS,
BOMBAY

NOTES

AN INVESTIGATION ON THE ERRORS IN THE ESTIMATES OF YARDSTICKS OF PRODUCTION FROM FERTILIZERS USE

It is proposed to increase the food production during the Fourth Five-Year Plan by 28 million tonnes over the Third Five-Year Plan. The major contribution to this additional production is to come from the use of fertilizers. In order to set up realistic targets of production from the use of inputs, such as, fertilizers, it is necessary to have a knowledge of the response per unit of the input. Such relationship between output and the input has been termed as yardstick of production for purpose of planning.

The estimates of yardsticks of production for fertilizers and manures have been worked out for several crops.[1] These yardsticks were based on the results of experiments conducted in a sample of cultivators' fields for a period of generally 3 to 4 years. Consequently, the estimates are subjected to sampling errors. Further, there are certain non-sampling errors also involved in the use of the calculated yardsticks for estimating the additional production from the use of fertilizers. The sampling errors and biases involved in the estimates of yardsticks of fertilizers are discussed in the present paper.

Definition of Yardstick

The main purpose of calculating a yardstick is to estimate the expected change in the production from a specified change in the quantity of the fertilizer input used in a State or a region. From this point of view, we may define the yardstick R as the yield which when multiplied by the units of the additional input of fertilizer gives the estimate of the additional expected production. Thus, if Q_t and Q_o are the quantities of fertilizer, say, nitrogen used at time t and at time o (base period) respectively, P the additional production, then $P=R\ (Q_t-Q_o)$.

Therefore, $R=\frac{P}{Q_t-Q_o}$ which we may designate as the true yardstick. In practice, we calculate a quantity, say, R' which approximates to the true yardstick as closely as possible.

Nature of Data Used and Method Adopted for Calculating Yardsticks from Fertilizers Use

The yardsticks given in the study referred above were calculated based on the data of extensive fertilizer experiments conducted in scattered cultivators' fields in various districts, the fields for the experiments being selected randomly after stratification of the district suitably. The trials which consisted of application of various combinations and levels of nitrogen, phosphorus and potash were superimposed on the normal practices of farmers so that the responses obtained could be considered directly applicable under farmer's conditions. Quadratic response curves were fitted to the responses from these trials in each State and the responses

1. V. G. Panse, T. P. Abraham and C. R. Leelavathi: Yardsticks of Additional Production of Certain Foodgrains, Commercial and Oilseed Crops, Institute of Agricultural Research Statistics (I.C.A.R.), New Delhi, 1964.

to 22.4 kg. per hectare of the nutrient were estimated from the average response curve. This response divided by the dosage is taken as the yardstick.

The sources of error that are encountered in estimating yardsticks in the above manner are :

(1) Sampling error which arises due to estimating the parameters only from a sample of the fields and not from all the fields. Further, the variation due to seasons also adds to this error.

(2) Specification error which is due to the failure of the model to reflect accurately the conditions actually obtained in the farm and also errors in the statistical specification of the model, such as, the response curves.

(3) Aggregation error defined as the difference between the aggregate additional production as developed from the summation of production from individual fields and that developed from the average response curve.

The data utilized in the calculation of yardsticks are those obtained from cultivators' fields and, as such, can be considered to reflect properly the conditions obtaining in their fields. A quadratic fertilizer response curve has been assumed in the calculation. The work done with extensive fertilizer trial data in the country has shown that this function gives an adequate representation of the responses.[2] Therefore, in the subsequent discussion only sampling errors and aggregation errors have been mainly considered. It may, however, be observed that in the calculation of yardstick a standard dose has been taken for calculating the response. This standard dose was 22.4 kg. per hectare (20 lbs. per acre) for cereals. The error introduced due to this standardization has, however, been taken into account in the discussion.

Sampling Error of the Estimated Yardstick

The sampling error of the estimates is composed of the two components: (*a*) error arising out of the sampling of fields (σ_e^2) and (*b*) error due to year to year differences in the responses (σ_b^2). These two components of variation are estimated from the analysis of variance of the responses in each year in each district and are given in Tables I and II for nitrogen and phosphorus on rice and irrigated wheat. The year component of variation for nitrogen yardstick on rice is quite large, particularly, in Kerala, Andhra Pradesh and Assam. On the average, the year to year variation is nearly 60 per cent of the variation within the district in a given year.

The average year component of variation is larger than the variation between fields within district for irrigated wheat. Generally, for the latter crop, the variance components were higher than for rice. In the case of phosphate, the year component was relatively smaller compared to within district variation. This shows that while response to phosphate is more variable from field to field, it is more stable from year to year compared to nitrogen, indicating that seasonal factors exert less

2. T. P. Abraham and V. Y. Rao, An Investigation of Functional Models for Fertilizer Response Surfaces, *Journal of the Indian Society of Agricultural Statistics*, Vol. 18, No. 1, 1966.

TABLE I—NITROGEN YARDSTICK
COMPONENTS OF VARIANCE, YARDSTICK, STANDARD ERROR AND CONFIDENCE INTERVAL

Crop	State	Yard-stick in kg. per kg. of nitrogen	Standard error in kg./kg.*	95 per cent confidence interval in kg./kg.	σ_e^2 in kg. of response per kg. of nutrient	σ_b^2 in kg. of response per kg. of nutrient
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rice	Andhra Pradesh	10.75	1.70	7.41 to 14.11	3.4275	2.2335
	Assam	10.71	1.91	6.96 to 14.46	2.2496	2.3230
	Bihar	11.61	0.60	10.40 to 12.81	1.4330	0.2681
	Kerala	12.10	3.06	6.12 to 18.08	0.9264	7.4163
	Madras	10.40	0.53	9.37 to 11.43	5.9668	0.0000
	Madhya Pradesh	13.08	1.57	10.00 to 16.16	4.7410	1.3797
	Mysore	11.29	0.86	9.60 to 12.99	4.2087	0.4548
	Punjab	12.14	1.24	9.69 to 14.60	3.3026	1.1049
	Uttar Pradesh	10.22	0.40	9.42 to 11.03	0.8618	0.1155
	West Bengal	8.57	1.02	6.56 to 10.58	1.3843	0.7428
Irrigated Wheat	Bihar	12.77	1.70	9.46 to 16.07	3.0293	2.2281
	Punjab	16.16	2.97	10.36 to 21.96	5.5026	6.9234
	Rajasthan	9.78	1.91	6.03 to 13.53	4.2928	2.7134
	Uttar Pradesh	15.89	0.95	14.02 to 17.77	1.2276	0.7015

* Standard error underlying confidence interval.

TABLE II—PHOSPHATE YARDSTICK
COMPONENTS OF VARIANCE, YARDSTICK, STANDARD ERROR AND CONFIDENCE INTERVAL

Crop	State	Yard-stick in kg. per kg. of nitrogen	Standard error in kg./kg.*	95 per cent confidence interval in kg./kg.	σ_e^2 in kg. of response per kg. of nutrient	σ_b^2 in kg. of response per kg. of nutrient
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rice	Andhra Pradesh	6.70	1.02	4.68 to 8.70	2.7863	0.7663
	Assam	10.40	0.89	8.66 to 12.14	4.8429	0.3885
	Bihar	8.44	0.82	6.83 to 10.04	1.6455	0.5025
	Kerala	9.37	0.20	8.97 to 9.78	0.4747	0.0000
	Madras	7.45	1.97	3.57 to 11.34	6.6479	2.6815
	Madhya Pradesh	8.39	2.61	3.30 to 13.48	6.0120	4.1939
	Mysore	8.26	1.40	5.49 to 11.03	4.5488	1.4684
	Punjab	6.07	1.48	3.17 to 8.97	2.7376	1.6489
	Uttar Pradesh	5.80	0.66	4.51 to 7.10	0.8086	0.3123
	West Bengal	3.84	1.01	1.87 to 5.80	1.2523	0.7294
Irrigated Wheat	Bihar	9.37	0.28	8.84 to 9.91	2.7941	0.0000
	Punjab	8.26	0.44	7.41 to 9.11	7.6012	0.0000
	Rajasthan	7.50	1.45	4.64 to 10.36	5.0581	1.4259
	Uttar Pradesh	9.55	0.71	8.17 to 10.94	1.4768	0.3937

* Standard error underlying confidence interval.

disturbing influence on phosphatic response. The standard error of the estimated yardstick varies from 2.18 per cent in Uttar Pradesh to 10.83 per cent in Assam with nitrogen on rice and from 2.81 per cent in Uttar Pradesh to 10.04 per cent in Rajasthan on irrigated wheat. The variation with phosphorus ranged from 1.90 per cent in Kerala to 19.15 per cent in Madhya Pradesh on rice and from 2.86 per cent in Bihar to 10.71 per cent in Rajasthan on irrigated wheat.

Confidence Interval of the Estimated Yardsticks

The yardsticks are used for predicting the yield response in a future year. It will, therefore, be of interest to calculate the confidence interval in using yardstick for this purpose.

Using the estimates of the components of variance σ_b^2 and σ_e^2 the 95 per cent confidence interval for the true yardstick of lth year can be approximately put as

$$\bar{x}_{mn} - 1.96\sqrt{\hat{\sigma}_b^2\left(1+\frac{1}{n}\right)+\frac{\hat{\sigma}_e^2}{mn}} \leqslant \mu.l \leqslant \bar{x}_{mn} + 1.96\sqrt{\hat{\sigma}_b^2\left(1+{}^{n}\right)+\frac{\check{\sigma}_e^2}{mn}}$$

where 1.96 is the 95 per cent point of a standardized normal deviate, $\bar{x}_{mn}$ the mean yardstick based on m districts and n years. The calculated confidence intervals are also given in Tables I and II.

The 95 per cent confidence intervals for nitrogen yardstick on rice are comparatively large for all the States except Bihar, Madras, Mysore and Uttar Pradesh. The same is true for irrigated wheat also except in Uttar Pradesh. The confidence interval of yardstick of phosphorus except for Kerala on rice and Bihar for wheat are also very large.

From the magnitude of the sampling errors and the corresponding confidence interval of the estimated yardsticks it appears that in using these yardsticks for estimating the production for any particular year, there is a relatively large component of error involved. However, the margin of error is considerably reduced when it is used to estimate the production for a period of years.

Bias due to Specification and Aggregation Errors

The bias introduced in the yardstick due to the combined error of aggregation and differences in the doses actually used by farmers from the standard dose used in the estimation of yardstick can be shown to be approximately.

$$\gamma\left[s - \frac{\sigma_t^2-\sigma_o^2}{\mu_t-\mu_o} - (\mu_t+\mu_o)\right] + \frac{1}{\mu_t-\mu_o}\left[\text{cov}\,(b,\triangle x) - \text{cov}\,(c,\, x_t^2) + \text{cov}\,(c,\, x_o^2)\right] \quad \ldots \quad (1)$$

where x_t and x_o are the rates of application in the tth year and base year respectively, b the linear coefficient of the fertilizer yield regression equation, c the corresponding quadratic coefficient, $\triangle x$ the difference in $x_t - x_o$, μ_t and μ_o the expected values of x_t and x_o and Υ the expected value of c. We have assumed that the rate of application is not correlated with the size of the field. If we further assume that the rates of application are uncorrelated with the magnitudes of the b and c coefficients, the bias will become

$$\Upsilon\left[s-\frac{\sigma_t^2-\sigma_o^2}{\mu_t-\mu_o}-(\mu_t+\mu_o)\right] \quad .. \quad .. \quad .. \quad (2)$$

Therefore the bias will vanish if s, the standard level is taken as

$$\frac{\sigma_t^2-\sigma_o^2}{\mu_t-\mu_o}+(\mu_t+\mu_o) \quad .. \quad .. \quad .. \quad (3)$$

Thus even if we assume no correlation between the rates of application and the magnitudes of the response curves, the calculation of the bias will require a knowledge of the mean rates of application in the base year and in the current year as well as the corresponding variances of the rates of application in addition to the expected value of the quadratic component of the response function. The mean rates of application can be easily calculated given the total quantities of the fertilizers to be applied in the current year and what actually was applied in the base year, for, these quantities divided by the corresponding area under the crop give the mean rates of application. Here again, while information on the fertilizer quantities will be available for all crops together, it will be difficult to get information on the fertilizer consumption for each crop separately. Even more difficult is to get an estimate of the variance of rates of application which can be obtained only by undertaking sample surveys to collect information on the rates of application. If all this information was available, we could practically remove the bias by suitable choice of the standardization level for calculation of yardstick. The Institute of Agricultural Research Statistics has carried out some sample surveys in selected districts to study the fertilizer practices of the farmers. In a few districts, repeat surveys were also carried out after a period of 5 to 6 years. The data provide information on the rates of application of fertilizers on various crops which could be utilized to examine the nature of bias involved in using the yardstick.

The details of the surveys are given in the report on Farmer's Fertilizer Practices.[3] Information was collected on the rates of application of fertilizer from each holding. The mean rates of application together with the mean and standard deviation are given in Table III for nitrogen application in Coimbatore and Barabanki districts where repeat surveys were carried out. Coimbatore district represents an area where the rates of application of fertilizer have been high while Barabanki, located in Uttar Pradesh, has comparatively lower rate of fertilizer. It will be of interest to work out the bias involved in these two extreme cases. The biases involved in the yardstick, taking first year of the survey as the base year and the repeat survey as the last year, are given in Table III. The bias has been calculated using formula (2).

3. Indian Council of Agricultural Research: Farmer's Fertilizer Practices: Coimbatore (Madras) 1954-55, and Barabanki (Uttar Pradesh) 1956-57.

TABLE III—ESTIMATED BIAS OF YARDSTICK FOR NITROGEN

District	Crop	Year	Mean rates of application kg. N/ha.	Standard deviation of rates of application kg.N/ha.	Bias
Coimbatore	Rice	1954-55	24.0	23.9	+ 7.8
		1961-62	35.7	29.9	
Barabanki	Rice	1956-57	6.8	8.9	+ 0.5
		1962-63	9.1	10.2	
	Wheat	1956-57	5.4	12.1	+ 4.6
		1962-63	6.6	14.3	

Standardisation level 22.4 kg. N/ha.
$\gamma = 0.12$ per kg. N and kg. response.

The expectation of the quadratic coefficient of the response function has been taken as 0.12, the units being kg. of output and kg. of nutrient. This value has been taken since extensive fertilizer trials in cultivators' fields showed that by and large the average c value (quadratic coefficient) of the response function is of this order. It will be noted that in the case of Coimbatore, where the rates of application even in the base year have been higher than the standard level taken for calculation of yardsticks, the bias in the use of yardstick is very high being an overestimate by about 8. At Barabanki, similar calculation shows for rice the bias of the order of only 0.5 while for wheat in the same district, the bias is nearly 5 units which should be considered quite large since the yardsticks are generally of the order of 10 to 14 units. Thus we find that in Barabanki even though the rates of application are not much different for rice and wheat, the bias due to aggregation is much larger for wheat due to larger variability in its rate of application.

The analysis carried out above indicate that apart from sampling error, the biases introduced by aggregation and standardization of level are quite considerable in some cases. With low rates of application, as in the case of Barabanki, the error introduced is not likely to be large, but with rates of application as large as in Coimbatore, the situation is different. It will be desirable to use different standardization levels in the calculation of yardsticks for different areas depending on the pattern of fertilizers use. In order to use such differential yardsticks for estimation of additional production it is also necessary to obtain information on the targets of distribution in these areas. With rapid increase in the use of fertilizers if we have to make realistic estimates of the additional production from fertilizer use, these changes regarding the standardization level and the areawise targetting will be essential.

Summary

Yardsticks of production from fertilizer use have been given by Panse, Abraham and Leelavathi.[4] In the present paper, the sources of error that are encountered in the estimation of these yardsticks have been examined. These

4. *loc. cit.*

errors are the sampling error, the specification error and the aggregation error. The standard error of the estimated yardsticks varied from about 2 to 10 per cent generally.

The formula for bias involved has been worked out under certain assumptions. It was found that the bias due to aggregation and standardization can be considerably reduced if the standardization level is chosen as somewhat higher than the sum of the average rates of application in the base year and the current year. The calculations are illustrated with the data obtained in fertilizer survey carried out in a few selected districts. It has been brought out that it is essential to use different standardization levels in different areas if substantial errors in the use of the yardsticks have to be avoided.

T. P. ABRAHAM
AND
C. R. LEELAVATHI†

MEASUREMENT OF SIZE OF FARM AND EFFICIENCY—SOME ALTERNATIVE APPROACHES*

Objective

The article attempts to examine the definition of the 'size of farm' and to show that measures of size and efficiency other than those currently used for measuring size (namely, geographical area) and efficiency (namely, the yield per acre) lead to different conclusions. An analysis of this problem has also been made by Raj Krishna.[1]

SIZE OF FARM

In practically all the available studies relating to agriculture whether by census of land holdings, cost data or input/output analysis, the size of the farm is invariably measured by its geographical area. The size of a farm can, in fact, be measured either in terms of physical output, gross receipts (total and per acre), total inputs, etc. It is of importance to choose the concept of size correctly, because the size distributions of farms according to different measures of size are not similar.

The classifications of farms according to the land and labour input would be useful provided that classifications by value added and by each of the other major input groups such as, say, seeds, manures, fertilizers, etc., are also given. But such data are rarely available together. However, classification according to inputs only, ignoring the aspect of output, is not wholly satisfactory. This flows from the fact that the scale distribution proper and the effect of relative efficiency of different farms are mixed up. This prevents identification of size and efficiency magnitudes and analysis of the relation between them.

† Assistant Statistical Adviser and Statistician, respectively, Institute of Agricultural Research Statistics (Indian Council of Agricultural Research), New Delhi-12.

* The views expressed in this paper are the personal views of the author and not necessarily of the organization he has the privilege to serve.

1. Raj Krishna, "The Optimum Firm and the Optimum Farm," *The Economic Weekly*, Vol. XIV, Nos. 40 and 41, October 6 and 13, 1962.

It can be argued that the current measures of size of farms is administratively convenient. Also that it is a good measure because land is the 'scarcest' input. However, it is easy to see that output can be tabulated farmwise along with the data on inputs, as has been done in various cost studies.

EFFICIENCY

Raj Krishna[2] points out that when we turn from the measurement of size to the measurement of efficiency or the criteria for determining the optimum farm size, we come across a multiplicity of these in the current literature. The size of the 'basic holdings,' 'economic holdings,' etc., are determined by asking how many acres of land of different qualities will keep a normal family reasonably fully occupied or provide a reasonable net income or reasonably keep a pair of bullocks fully occupied. A. M. Khusro,[3] on the basis of the farm management data concludes that holdings of 7.5 to 10 acres would more or less meet the bullock pair, family employment and minimum income criteria. The minimum income norm is an equity norm and not an efficiency norm. It is, of course, desirable that rural households should be assured of a certain minimum income. However, the current discussions are concerned with examining the different approaches to measurement of size and efficiency.

The single most important test of efficiency in agricultural policy discussions so far has been the yield per acre test. Farm Management Studies have indicated that output per acre is inversely proportional to farm area. This has weakened the case for the enlargement of the holdings.

In the theory of the firm, the optimum firm is defined as one whose short-run average cost curve is tangential to the envelope curve at its lowest point. If the average cost of any one particular input is the dominant component of the total average cost and provided further that the elasticity of substitution between inputs is negligible, it should be all right to suppose that the average cost of the dominant input would vary more or less in the same way as total average cost and would therefore be good approximation to it.

However, it has been seen from the various Farm Management Studies that the (imputed) cost of the land input is quite low being around 20 per cent. Therefore, we cannot use the average cost of one of the inputs as an approximation to total average cost as a test for efficiency.

CONCLUSION

Where farm size is measured in terms of geographical acreage, efficiency is measured in terms of yield per acre. Thus as Raj Krishna[4] points out, on the basis of simple and theoretically undefended methods of measurements, 'optimal' firm sizes are sought to be determined and often enforced. Size policy is applied more in the agricultural sector, where the asymmetry of the optima indicated by the different criteria is maximum. What is really needed is measurement of sizes in

2. Raj Krishna, "The Optimum Firm and the Optimum Farm," *op. cit.*
3. A. M. Khusro : An Analysis of Agricultural Land in India by Size of Holding and Tenure, Institute of Economic Growth, New Delhi, as quoted by Raj Krishna, *ibid.*
4. Raj Krishna, *op. cit.*

terms of net value added and in the estimation of statistical cost relations which indicate the effect of scale on costs excluding effects of factors other than the scale. In the meanwhile, the prevailing judgment about sizes and efficiency and the policies based on them must be held to be unsatisfactory and inefficient.

EMPIRICAL EXERCISES

The holdingwise data available from the Farm Management report relating to Andhra Pradesh were examined, and some empirical illustrations of the above theoretical discussions are presented below.

Size of Farm

Table I presents the distribution of holdings during the three years of study (1957-58, 1958-59 and 1959-60), according to (i) geographical area and (ii) gross output (value), in respect of the paddy crop (Season I—irrigated).

TABLE I—DISTRIBUTION OF HOLDINGS ACCORDING TO (i) AREA AND (ii) GROSS OUTPUT (VALUES) (I SEASON—PADDY, IRRIGATED, WEST GODAVARI DISTRICT, ANDHRA PRADESH: 1957-58 to 1959-60)

(i) Holdings size (in acres)	Number of holdings			(ii) Gross output (value in Rs.)	Number of holdings		
	1957-58	1958-59	1959-60		1957-58	1958-59	1959-60
0.01 — 1.25	22	22	17	0 — 500	19	15	19
1.25 — 2.50	11	10	14	500 — 1,000	18	23	16
2.50 — 5.00	16	16	12	1,000 — 2,500	22	24	21
5.00 — 7.50	9	8	10	2,500 — 5,000	11	14	10
7.50 — 10.00	4	7	5	5,000 — 7,500	9	8	8
10.00 — 15.00	8	12	14	7,500 — 10,000	6	5	7
15.00 — 20.00	12	8	3	10,000 and above	4	4	7
20.00 and above	7	10	13				
Total	89	93	88	Total	89	93	88

It is seen that the distribution of holdings by the two criteria is very different. Thus, the size of farm, if defined by the geographical area gives a completely different picture of concentration of holdings as compared to the one obtained by considering gross output. It is easy to see that a similar situation will arise if we consider the other definitions of size, *viz.*, gross input, total human labour, etc.

Efficiency

The average cost of any single input cannot be approximated to the total average cost, while in search of the optima. This is because no single item of cost approximates to total average cost. Table II gives the break-up of total cost.

TABLE II—BREAK-UP OF TOTAL COST

(percentages to total)

State	Human labour	Bullock labour	Seed	Manures and fertilizers	Depreciation	Rent and rental value	Interest on fixed capital	Land revenue charges, etc.	Irrigation charges, etc.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Madras (Irrigated Paddy-I)	19.96	36.15	3.39	13.87	2.99	15.57	6.85	0.46	—
Uttar Pradesh (Wheat Irrigated)	21.06	53.71	6.72	0.53	6.49	3.16	3.40	—	5.93
Bombay (Ahmednagar-Wheat Irrigated)	34.63	23.09	11.04	3.56	4.67	14.01	5.69	1.27	—
Andhra Pradesh (Paddy-I Season)	20.69	12.40	5.72	3.42	1.33	51.62	0.65	3.58	—
Madhya Pradesh (Paddy)	32.94	18.55	11.23	4.88	1.48	24.69	2.29	0.76	2.17

Source : Farm Management Studies in the respective States published by the Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India.

Therefore, no single input, like acreage of the holding, or labour input, can be considered, while arriving at the optimum size of the farm.

We could now illustrate that the optimal size of the farm varies when we consider different efficiency criteria. Table III may be examined.

The striking result of Table III is that the accepted definition of size, *viz.*, geographical area, comes out to be different for each of the efficiency criterion. Similarly, the accepted concept of efficiency, *viz.*, highest yield per acre, indicates that farm number 23 of size 3.22 acres is the most efficient, while farm number 68 of size 33.80 acres is the least efficient. Similarly, the rate of return on capital investment is maximum for a larger sized (acreage) farm than smaller farm. Again, the farm number 78 is both the most efficient (minimum per acre cost) and the least efficient (minimum gross output per acre). The asymmetry of the optima on the different bases of efficiency is very pronounced.

D. RAMESH*

* Assistant Director, Agricultural Prices Commission (Department of Agriculture), Government of India, New Delhi.

TABLE III—SIZE OF FARM, EFFICIENCY OF RESOURCE USE AND COST OF PRODUCTION

IRRIGATED PADDY (SEASON-I) ANDHRA PRADESH: 1957-60*

Efficiency basis	Holding identification number	Size: Farm size (acres)	Area under the crop (acreage)	Gross value of output (Rs.)	Gross value of output per acre (Rs.)	Total input (value) (Rs.)	Total yield (maunds)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. Maximum gross output per acre	10	0.29	0.29	364.38	1,256.48	214.73	11.12
2. Minimum gross output per acre	78	11.20	2.00	340.70	30.42	366.58	14.00
3. Maximum cost per acre	21	5.51	0.51	2,480.20	450.13	11,915.02	13.61
4. Minimum cost per acre	78	11.20	2.00	340.70	30.42	366.58	14.00
5. Maximum return per man-day (total) (farm)	15	3.99	3.59	1,922.10	481.73	696.43	84.01
6. Minimum return per man-day (total) (farm)	21	5.51	0.51	2,480.20	450.13	11,915.02	13.61
7. Maximum rate of return on capital investment } Basis I	12	8.89	8.85	4,690.46	527.61	2,858.14	237.00
8. Minimum rate of return on capital investment } Basis I	21	5.51	0.51	2,480.20	450.13	11,915.02	13.61
9. Maximum rate of return on capital investment } Basis II	15	3.99	3.59	1,922.10	481.73	696.43	64.01
10. Minimum rate of return on capital investment } Basis II	44	2·21	2.21	545.13	248.67	637.89	41.99
11. Maximum input-output ratio (farm)	15	3.99	3.59	1,922.10	481.73	696.43	84.01
12. Minimum input-output ratio (farm)	21	5.51	0.51	2,480.20	450.13	11,915.02	13.61
13. Maximum input-output ratio (cropwise)	18	1.06	1.06	782.87	738.56	428.05	38.00
14. Minimum input-output ratio (cropwise)	62	2.20	2.18	1,390.09	631.86	1,166.60	80.98
15. Maximum yield per acre	23	3.22	3.00	2,896.70	899.60	1,513.19	150.00
16. Minimum yield per acre	68	33.80	3.00	9,572.83	283.22	7,076.69	13.98
17. Maximum cost @ per maund (cropwise)	62	2.20	2.16	1,390.09	631.86	1,166.60	80.98
18. Minimum cost @ per maund (cropwise)	23	3.22	3.00	2,896.70	899.60	1,513.19	150.00
19. Maximum return per man-day (total) (cropwise)	18	1.06	1.06	782.87	738.56	428.03	38.00
20. Minimum return per man-day (total) (cropwise)	56	0.80	0.80	183.20	229.00	252.78	8.00

* Farm Management data, relating to West Godavari district.

THE BHAL TRACT (GUJARAT STATE)

On the two sides of the Bay of Cambay, where river Sabarmati meets the sea, the terrain is completely flat. This tract is known as the Bhal tract, part of it lies in Dhandhuka and Dholka talukas of Ahmedabad district, parts of it in Matar and Cambay talukas of Kaira district, and a small portion of Vallabhipur taluka of Bhavnagar district. The soils are generally of clay type with an impervious sub-soil which prevents percolation of water in soil. Due to this peculiarity, even if the average rainfall is not much in this area, there is stagnation of water in vast stretches whenever it rains. Due to this characteristic of water logging in the soil and general flatness of the area, the tract has acquired certain peculiarities in its cropping pattern.

The area under various crops in the five talukas of the Bhal tract is given in Table I. The largest area is under wheat, with an acreage of 3,34,729 acres; and cotton stands second with 2,84,019 acres. The third major crop jowar, principally grown for fodder, covers 1,78,257 acres. These and the remaining crops except chillies are all unirrigated which indicate poor availability of irrigation water. The salinity in sub-soil water is high and in many villages even drinking water has to be brought from long distances.

Cotton, though grown in smaller area than wheat, is a preferred crop due to the higher per acre income earned from cotton crop. If rainfall is timely and not excessive, the cultivators would prefer to sow cotton. Even if the first sowing of cotton is damaged due to water logging, the cultivators attempt to sow cotton a second time and similarly even a third time to obtain a reasonable stand of cotton crop. The variety of cotton grown in the tract, *viz.*, Kalyan, is adapted to irregular sowing time, but yield declines, with late sowings. Consequently when several re-sowings do not result in a reasonable stand of cotton crop, the field is harrowed out, kept fallow in the rest of the *kharif* season, and prepared for wheat to be grown in the *rabi* season.

The growth of wheat in the *rabi* season, on residual moisture of late *kharif* showers, without irrigation and in the absence of precipitation in winter is characteristic of this area. The variety grown belongs to durum group, and fetches a premium over others, due to its special quality, and suitability for preparing unleavened bread. The quality of the Bhal wheat, with bold amber colour grains, is as famous in Bombay and Ahmedabad markets as Khandwa wheat of Madhya Pradesh.

In contrast to the problem of rain water stagnation faced by cotton crop in *kharif* for growth of wheat, water is to be impounded in late *kharif* so as to provide enough moisture for sowing in mid-November. For this purpose, temporary small bunds are constructed around the field in which wheat is to be sown. The impounding of water in wheat fields, and the necessity to drain it out in case of excess, creates a special problem if cotton is standing in adjoining fields. In the absence of any planned and controllable drainage system, farmers enter into mutual understanding for the disposal of excess water from their fields, but in case of conflicting interests clashes are not uncommon.

The contrasting requirement of cotton and wheat crop to be sown in the same field results in the wide fluctuation in the area under these two crops. Due to

TABLE I—AREA UNDER PRINCIPAL CROPS IN THE BHAL TRACT: 1963-64

(*in acres*)

Year 1963-64	Crops													
	Rice	Wheat	Jowar	Bajri	*Ragi*	*Kodra*	Gram	*Tur*	Total food-grains	Chillies	Ground-nut	Sesa-mum	Cotton	Toba-cco
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Dholka	10,774	1,41,642	38,289	8,453	25	463	3,432	1,181	2,06,314	742	2,023	459	93,801	186
Dhandhuka	41	97,465	87,919	23,397	—	—	5,375	2	2,19,384	1,016	24,308	2,977	1,31,214	—
Matar	28,566	18,534	3,167	16,920	2,007	4,253	1,857	3,923	81,186	270	68	5,544	20,733	1,254
Cambay	13,870	60,198	—	28,986	511	6,386	480	3,982	1,18,769	545	27	3,746	19,564	2,770
Vallabhipur	16	16,890	48,882	5,827	—	—	29	—	71,737	1,316	15,303	1,160	18,707	—
Total	53,267	3,34,729	1,78,257	83,583	2,543	11,102	11,173	9,088	6,97,354	3,889	41,747	13,186	2,84,019	4,210

Source : Season and Crop Report, 1963-64 (unpublished).

impervious soil, and flat terrain, controlled drainage system would benefit the area greatly. If this is provided, cotton which is the more remunerative crop could be grown with confidence. The same system may then help to store moisture for wheat, if part of the area is ultimately found more suited to the crop. In order to pave the way for a suitable developmental programme for the Bhal tract, it is first considered necessary to analyse the variations in the area under cotton and wheat, and its possible relationship with rainfall in the tract. This understanding will make it possible to examine the technical necessity of controllable drainage system in order to improve the rural economy of the area.

In Table II is shown the area under cotton and wheat in the five talukas of the Bhal tract from 1953-54 to 1965-66. The violent fluctuations in the area under cotton and wheat is almost self-evident from the data. It is assumed that most of the gain in the area under wheat is at the cost of the area under cotton. Considering the area under wheat as a dependant variable (Y) and the area under cotton an independent variable (X), a linear regression of the area under wheat on the area under cotton is fitted for all the five talukas of the tract and coefficients of correlation have been worked out as follows :

(1) Dholka

$Y = 204.0466 — 0.8057\ x$

$r = — 0.82^{**}$

$r^2 = 0.6724$

$b = — 0.8057^{**}$

S.E. of $b = 0.17$

(2) Dhandhuka

$Y = 167.0570 — 0.5052\ x$

$r = — 0.5556^{*}$

$r^2 = 0.3087$

$b = — 0.5052^{*}$

S.E. of $b = 0.2279$

(3) Matar

$Y = 35.5098 — 0.7763\ x$

$r = — 0.7182^{**}$

$r^2 = 0.5158$

$b = — 0.776^{**}$

S.E. of $b = 0.2269$

(4) Cambay

$Y = 73.0786 — 0.7683\ x$

$r = — 0.7976^{**}$

$r^2 = 0.6361$

$b = — 0.7683^{**}$

S.E. of $b = 0.1752$

(5) Vallabhipur

$Y = 19.6964 + 0.1223\ x$

$r = 0.1037$ (N. S.)

$r^2 = 0.0108$

$b = 0.1223$ (N. S.)

S.E. of $b = 0.4151$

* Significant at 5 per cent level.
** Significant at 1 per cent level.
N.S. = Not significant at 5 per cent level.

The analysis of variance is given in Table III. In all the talukas except Vallabhipur, coefficients of correlation are significant and dependence of the area

TABLE II—AREA UNDER COTTON AND WHEAT IN DHOLKA, DHANDHUKA, MATAR, CAMBAY AND VALLABHIPUR TALUKAS (BHAL TRACT) OF GUJARAT STATE

(in thousand acres)

Year	Dholka		Dhandhuka		Matar		Cambay		Vallabhipur	
	Cotton x	Wheat y	Cotton x	Wheat y	Cotton x	Wheat y	Cotton x	Wheat y	Cotton x	Wheat y
1953-54 ..	54	149	76	123	11	23	16	57	—	—
1954-55 ..	111	115	151	93	18	21	29	54	—	—
1955-56 ..	93	127	125	119	16	27	21	62	—	—
1956-57 ..	89	144	147	110	19	29	23	66	26	18
1957-58 ..	139	81	95	106	24	14	23	55	17	21
1958-59 ..	116	116	140	100	22	20	29	56	20	23
1959-60 ..	99	168	129	149	14	25	12	67	18	28
1960-61 ..	169	60	142	87	24	13	44	39	14	28
1961-62 ..	143	86	159	65	21	17	26	51	17	21
1962-63 ..	165	76	149	66	27	16	56	30	9	11
1963-64 ..	94	142	131	97	21	19	20	60	19	17
1964-65 ..	150	81	145	94	16	22	16	57	19	25
1965-66 ..	88	91	101	109	19	20	25	35	23	26
	$\Sigma x=$ 1510	$\Sigma y=$ 1436	$\Sigma x=$ 1610	$\Sigma y=$ 1318	$\Sigma x=$ 252	$\Sigma y=$ 266	$\Sigma x=$ 340	$\Sigma y=$ 689	$\Sigma x=$ 172	$\Sigma y=$ 218
	$\bar{x}=$ 116.2	$\bar{y}=$ 110.5	$\bar{x}=$ 130.0	$\bar{y}=$ 101.4	$\bar{x}=$ 19.4	$\bar{y}=$ 20.5	$\bar{x}=$ 26.2	$\bar{y}=$ 53.0	$\bar{x}=$ 17.2	$\bar{y}=$ 21.8

under wheat on the area under cotton is well-established. In Dhandhuka taluka, the coefficient of correlation is just significant while in the remaining three talukas, there is a very high degree of negative correlationship. The test for homogeneity leads to a conclusion that the coefficients of correlation in these four talukas of

TABLE III—ANALYSIS OF VARIANCE TABLE

Source	d.f.	Dholka S. S.	Dholka M. S.	Dholka F	Dhandhuka S. S.	Dhandhuka M. S.	Dhandhuka F	Matar S. S.	Matar M. S.	Matar F	Cambay S. S.	Cambay M. S.	Cambay F
		1			2			3			4		
Regression	1	9288	9288	23**	1892	1891	491*	143	143	11.7**	1014	1014	19.23**
Error	11	4399	399		4237	385		134	12.19		580	5273	
Total	12	13687			6128			277			1594		

Source	d. f.	Vallabhipur S. S.	Vallabhipur M. S.	Vallabhipur F.	Remarks
		5			6
Regression	1	2.8129	2.8129	0.0868 (N.S.)	Table F1, 11(1) at 5 per cent level of significance. (2) at 1 per cent (1) 4.84 (2) 9.65
Error	8	259.1871	32.3984		
Total	9	262.000			

Dholka, Dhandhuka, Matar and Cambay are homogeneous. The pooled estimates of coefficients of correlation for these talukas works out to be —0.7352.

We have further endeavoured to examine whether the statistical analysis would support the common belief that rainfall and the area under cotton are co-related. Since the total rainfall in the season is not as important as the rainfall in the early months for successful growth of cotton, an attempt is made to fit a multiple regression equation to study the area under cotton (y) on monthly rainfall, (x_1) July, (x_2) August and (x_3) September. In Table IV are shown the monthly rainfall in the months of June to September and the area under cotton in the four talukas of the tract. Since late sowing of cotton can be practised in this area, it can be assumed that the rainfall in June which begins in the middle of the month,

TABLE IV—MONTHLY RAINFALL OF THE FOUR MONTHS AND AREA UNDER COTTON IN FOUR TALUKAS OF THE BHAL TRACT

Year	Dholka					Dhandhuka					Matar					Cambay				
	Area	June	July	August	September	Area	June	July	August	September	Area	June	July	August	September	Area	June	July	August	September
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1953	54	104	261	495	172	76	—	11	35	12	11	115	288	442	178	16	132	80	238	141
1954	111	22	359	404	211	151	—	16	20	17	18	40	307	239	367	29	23	80	244	386
1955	93	140	87	217	195	125	—	6	39	24	16	98	24	213	198	21	67	22	305	240
1956	89	94	300	265	55	147	—	21	23	7	19	46	564	371	137	23	106	295	266	108
1957	139	67	229	79	6	95	—	33	14	2	24	45	252	150	10	23	64	287	118	13
1958	116	40	168	67	342	140	44	197	29	274	22	67	245	172	449	29	81	271	162	194
1959	99	82	346	80	341	129	59	379	159	162	14	2	554	111	303	12	128	364	211	290
1960	169	192	104	120	23	142	189	214	72	180	24	150	101	265	48	44	95	64	192	95
1961	143	—	168	150	190	159	315	101	165	100	21	0	349	171	349	26	153	267	157	89
1962	165	3	201	147	134	149	72	119	135	111	27	68	216	140	213	56	5	167	51	225
1963	94	23	150	263	185	131	33	183	211	249	21	27	285	240	257	20	97	242	277	105
1964	150	47	164	150	154	145	68	249	97	249	16	71	262	219	152	16	86	352	174	264
1965	88	—	333	41	40	101	26	383	—	—	19	—	370	157	10	25	—	382	145	2
	1510	814	2870	2478	2048	1690	806	1912	1000	1387	252	729	3817	2890	2671	340	1037	2943	2540	2152
	$\bar{y}$=	74.0	$\bar{x}_1$=	$\bar{x}_2$=	$\bar{x}_3$=	$\bar{y}$=	100.8	$\bar{x}_1$=	$\bar{x}_2$=	$\bar{x}_3$=	$\bar{y}$=	60.8	$\bar{x}_1$=	$\bar{x}_2$=	$\bar{x}_3$=	$\bar{y}$=	86.4	$\bar{x}_1$=	$\bar{x}_2$=	$\bar{x}_3$=
	116.2	$\bar{x}$=0	220.8	190.6	157.5	130	$\bar{x}$=0	147.1	83.3	115.6	19.4	$\bar{x}$=0	294	222	205	26.2	$\bar{x}$=0	226.4	195.4	165.5

in whatever quantity is not detrimental to the area under cotton ; likewise rainfall in October by which time cotton is sufficiently grown, will be too late to affect the area under the crop. Therefore, multiple regression is fitted with three independent factors, *viz.*, monthly rainfall of July, August and September and area under cotton as a dependent variable. The regression equations are given below. The analysis of variance for multiple regression is given in Table V.

Dholka

$Y = 175.0312 - 0.126891\,x_1 - 0.1116\,x_2 - 0.061\,x_3$
R = 0.646 (N. S.).
S.E. of b_1 = 0.098 $R^2 = 0.4162$
S.E. of b_2 = 0.066
S.E. of b_3 = 0.081

Matar

$Y = 24.4498 - 0.0041\,x_1 - 0.02333\,x_2 + 0.0064\,x_3$
R 0.523 (N. S.)
S.E. of b_1 = 0.0092 $R^2 = 0.2718$
S.E. of b_2 = 0.014
S.E. of b_3 = 0.0094

Cambay

$Y = 65.705 - 0.06079\,x_1 - 0.1293\,x_2 - 0.0032\,x_3$
R = 0.805*
S.E. of b_1 = 0.021 $R^2 = 0.6487$
S.E. of b_2 = 0.036
S.E. of b_3 = 0.022

Dhandhuka

$Y = 120.00239 - 0.029859\,x_1 + 0.077122\,x_2 + 0.084665\,x_3$
R = 0.401 (N. S.)
S.E. of b_1 = 0.1148 $R^2 = 0.1608$
S.E. of b_2 = 0.1422
S.E. of b_3 = 0.1248

* Significant at 5 per cent level.
N.S. = Not significant at 5 per cent level.

TABLE V—ANALYSIS OF VARIANCE TABLE

Taluka	Source	D. F.	S. S.	M. S.	Cal. F	Table F 5 per cent	Table F 1 per cent
1	2	3	4	5	6	7	8
Dholka	Regression	3	5954.7235	1984.9078	2.138	3.86	6.99
	Deviation	9	8353.2765	928.1418			
	Total	12	14308.0000				
Dhandhuka	Regression	3	1045.2583	348.4194	>1		
	Deviation	8	5453.7417	681.7177		4.07	7.59
	Total	11	6499.0000				
Matar	Regression	3	64.419	21.47	1.12	3.86	6.99
	Deviation	9	172.581	19.17			
	Total	12	237.000				
Cambay	Regression	3	1114.3991	371.4664	5.5387	3.86	6.99
	Deviation	9	603.6009	67.0667			
	Total	12	1718.0000				

Dholka

The coefficients of linear correlation between the annual rainfall and the area under cotton is significant at 5 per cent level. However, the coefficient of multiple correlation between monthly rainfall and the area under cotton is not significant. This can be explained from the fact that in this taluka out of a total of 117 villages only 46 villages are in the characteristic Bhal tract; the remaining enjoy normal conditions of soil and drainage. It is reported that water of the river Rohar used to get spread near Kesari village when no drainage was existing; now, when such a drain is provided, excess water drains off to the Nalsarovar—the big lake. In spite of this facility, when the drain gets flooded, water spreads out, affecting cultivation in the villages of Ragodar, Veri, Kantha, Talavdi, Shiyal, etc. Further, the combination of late rains in *kharif* and floods is known to affect even the wheat crop in the *rabi* season.

Dhandhuka

Out of 142 villages in the taluka, about 60 villages are situated in the Bhal area. Several shallow rivers, *viz.*, Bhadar, Bhogavo, Omkar, Nilaka and Utekali flow through or near this area. They are known to flood the area all around. Some of the villages which are so affected are Khodol, Khasta, Rajaka, Kashindara, Shela, Kodipur, Guaraf. Unabagadh, Sodhi, Sangasar, Hebatpur, Char, Zhanshi, Pachi, Kapadiav, Vaohel, Bavaliar, Navada, Dhodadar and Khamidana. The river water spreads out in the cultivated area even 5 to 6 times in the *kharif* season making the sowing of cotton risky and the growth of cotton crop difficult. It seems therefore that floods from the rivers may be the major cause for the variations of area under cotton and therefore. the effect of rainfall is not detectable in the analysis. Perhaps a more sophisticated technique or correlation of facts about river flow for sizable number of past years may help to further our understanding of the area.

Matar

Only 16 out of the 82 villages of the taluka are situated in the typical Bhal area. The river Vatrak flowing near the taluka does not pose any problem to this area and only rain water is known to stagnate in vast stretches. As the analysis is carried out on the data for the taluka as a whole and as a small percentage of villages are located in the typical Bhal area, the area under cotton has not been observed to be dependent on monthly rainfall. A further study of the taluka keeping in view only the villages under reference is therefore necessary. It may be also necessary to examine the weekly distribution of rainfall instead of the monthly rainfall. Further even though the floods in the rivers are not stated to be of any consequence, the study of the behaviour of the river water may be and will be useful for furthering our understanding of the tract.

Cambay

Fifty-three out of 105 villages can be said to be located in the typical Bhal area. Some of the villages are on the mouth of the Sabarmati river. It is clearly seen that in this taluka, 66 per cent of the variation of the area under cotton can be said to be due to regression. The finding that the regression coefficient (b_1) is just significant and that (b_2) is highly significant supports the common belief that more rainfall in July reduces the area under cotton as also heavy rains in August reduces the area under cotton significantly.

The income of cultivators growing cotton is always more than that of wheat growers. Even good wheat growers cannot get more than 200 kgs. per acre from 20 kgs. of seed rate. Cotton, which needs hardly 3—5 kgs. of seed per acre seriously competes even in areas where successful sowing is a gamble with weather and soil. Secondly, a very strict time limit is to be adhered to for wheat sowing, which results in heavy pressure on bullocks and other labour. Cultivators find it necessary even to change bullocks during sowing time so as to prevent over-exertion while cotton, particularly Kalyan variety can be sown and re-sown if necessary, without much difficulty and successful crop can be obtained even with delayed sowing. The wheat crop has also to be harvested in a specific period when acute labour shortage is experienced. Since cultivators have to invest in outside labour, wage rates also go high during wheat harvest. In the case of cotton, since the variety is a closed boll type, harvesting is not time specific.

It is, therefore, evident that steps will have to be taken to provide elaborate and controllable drainage facilities in the area which can enable cultivators to grow cotton and make more income per acre. It would also make it possible to have better crop of wheat, if parts of tract are found more suitable when drainage is provided. The engineering possibilities of such a project will have to be examined in relation to the benefit it will bestow on the cultivators of the Bhal tract.

Conclusions

(1) There is a very high negative correlation between the area under cotton and the area under wheat in all the talukas of the Bhal tract except Vallabhipur. It appears that the peculiar technical condition is one of the major factors for such behaviour of the area under cotton and wheat.

(2) There is correlation between the area under cotton and the monthly rainfall in Cambay taluka; heavy rainfall in July and August being detrimental to the area under cotton. In Dhandhuka taluka, probably it is the floods in the rivers passing through the area together with heavy rainfall which cause reduction in the area under cotton. In Matar taluka where river floods do not pose any problem, complete independence of area under cotton of monthly rainfall is rather difficult to explain and a further probe is necessary.

(3) If measures are taken to prevent floods in the river and provide controllable drainage for removing excess rain water, the entire area can probably be a potentially good cotton growing tract resulting in the economic uplift of the farming community. It would also help in defining areas which would be more suited for wheat cultivation.

R. L. SHAH
AND
G. A. PATEL*

* Deputy Director of Agriculture (Statistics) and Director of Agriculture, respectively, Gujarat State, Ahmedabad.

DIFFERENCES IN THE FORM AND INTENSITY OF INPUT-MIX AND YIELD LEVELS ON SMALL AND LARGE FARM ORGANIZATIONS IN THE I.A.D.P. DISTRICT LUDHIANA (PUNJAB) (A CASE STUDY)

Introduction

The major emphasis in the I.A.D.P. districts is on the intensive use of such non-conventional technological inputs as improved seeds, fertilizers, irrigation facilities and plant protection measures. Is the use of non-conventional inputs determined by the size of the farm? This question is generally raised but there is hardly any evidence to provide a conclusive answer to this question. This study is an attempt to examine the differences in the form and intensity of input-mix and output pattern on the small and large farm organizations in the Upper Dhaia region of I.A.D.P. district Ludhiana.

Design of the Study

The Dehlon Development block of Ludhiana was purposively selected for this study in 1965-66. A list of operational holdings was prepared in the five villages selected at random. These holdings were pooled and the distribution transformed to obtain small and large sized farm organizations. The frequency distribution of each size-group gave 10-acre and 22-acre size holdings as modal size-groups representing the small and large size-groups respectively. Twelve farm organizations were selected randomly from both the small and large size-groups. Data on input structure with respect to seed rate, quantity of manures and fertilizers, *viz.*, Calcium Ammonium Nitrate (C. A. N.), superphosphate, farmyard manure and yields per acre were collected separately for small and large farm organizations.

Deviations in the intensity of input-mix use and yield levels on the small and large farms were worked out by taking the average of input-output data and 't' test was used to test the significance of the differences.

Results and Discussion

Input-Mix

The form and the level of inputs used on the small and large farm organizations are indicated in Table I. The study showed that small farm organizations used higher doses of farmyard manure than the large farm organizations. These differences were significant at the 5 per cent level, in case of *desi* maize, *desi* cotton and sugarcane. Farmyard manure was, however, not applied to some crops such as groundnut and wheat.

Large farms used higher doses of such fertilizers as C.A.N. and superphosphate than the small farms (Table I). There were significant differences in the case of C.A.N. on almost all the crops grown on the small and large farms. The difference was significant in the case of hybrid maize and wheat sown after *kharif* crops at the 5 per cent level. In the case of irrigated groundnut, wheat and hybrid maize, the use of superphosphate was much higher on the large farms than on the small farms and the difference was significant at 5 per cent level.

The study indicated that seed rate per acre was higher on the large farms than on the small farms for almost all the crops (Table I). In the case of American cotton and wheat, the differences were significant at 5 per cent level.

In the case of irrigation use, there was hardly any difference in the number of irrigations used on small and large farms. The use of plant protection measures was almost absent on all the farm organizations.

Yields per Acre

Higher application of various chemical fertilizers such as C.A.N. and superphosphate and higher seed rate was reflected in higher yields per acre of *desi* maize, hybrid maize, American cotton, irrigated groundnut and wheat on the large farm organizations as compared with the small farm organizations (Table I). In the case of wheat after *kharif*, the difference was significant at 5 per cent level. It was apparent that the adoption of yield increasing technology on the large farms in recent years had reversed the trend in yield per acre on large farms. The Farm Management Studies conducted in 1954-57 had shown that yields per acre on the small farms were higher than those on the large farms. But this trend seems to have been reversed with the technological break-through coming up on the large farm organizations through the adoption of improved strains such as hybrid maize, hybrid bajra, Mexican wheat and intensive use of improved methods and improved practices.

A study conducted by Sinha and Singh[1] of I.A.D.P., Ludhiana also confirms these results. The authors observed that in the case of maize while comparing the average output per acre, the reported yield increased steadily with an increase in the size of holding, *e.g.*, the average yield per acre of the small operator, the medium operator and the large operator was 10.75, 11.88 and 13.40 maunds respectively. In the case of hybrid maize, the medium group operators were observed to have an average output per acre which is more than twice the yield of small farm operators. No observation was, however, recorded in the case of large operators' group. In the case of groundnut, the small operator group obtained on an average nearly one-fourth less output per acre when compared to the average yield of the two groups and the reported average yield per acre increased with the larger holdings. The per acre average yield of gram in the district was reported to be about 12.5 maunds of the three cultivator groups, large operators obtained the highest average yield per acre followed by the other two groups.

Similar trend of higher yield levels on large farm organizations was observed by Kaushik in a study conducted in district Hissar.[2] Rapid technological break-through and relatively intensive use of non-conventional inputs on large farm organizations have resulted in higher per acre yields on such farm organizations.

Conclusion

It is apparent from these studies that there was hardly any difference in the form of input use between small and large farm organizations. However, the inten-

1. Nirmal K. Sinha and R. S. Singh : An Agronomic Enquiry of Cropping Pattern and Input Practices in Ludhiana for the Year 1964-65—Research Report Series, July, 1966, pp. 19-20.
2. C. R. Kaushik : Farm Adjustments on the Introduction of New Irrigation Facilities in Canal Irrigated Area of Hissar district, unpublished M.Sc. Thesis, 1966.

TABLE I—DIFFERENCES IN YIELD LEVELS AND INTENSITY OF INPUT-MIX BASED ON THE TECHNOLOGY USED ON SMALL AND LARGE SYNTHETIC FARM ORGANIZATIONS, DEHLON BLOCK, I.A.D.P., LUDHIANA (1965-66) (ANALYSIS ON PER ACRE BASIS)

Crop enterprises	Seed rate				Calcium ammonium nitrate			
	Small farm (kgs.)	Large farm (kgs.)	Deviation (kgs.)	't' value	Small farm (kgs.)	Large farm (kgs.)	Deviation (kgs.)	't' value
1	2	3	4	5	6	7	8	9
1. *Desi* Maize	8.00	9.00	1.00	1.322	61.36	81.83	20.47	1.78
2. Hybrid Maize	7.50	7.20	0.30	0.416	90.00	136.20	46.20	2.35*
3. American Cotton	5.00	6.54	1.54	2.610*	12.82	20.75	7.93	0.707*
4. *Desi* Cotton	5.50	6.80	1.30	1.699	9.90	17.50	7.60	0.908
5. Groundnut Irrigated	25.00	26.28	1.28	0.760	37.50	54.28	16.78	0.826
6. Sugarcane Planted	2920	2800	120	1.387	81.25	114.54	33.29	0.869
7. Wheat after Fallow	38.50	35.00	3.50	2.595*	60.66	76.72	16.06	1.348
8. Wheat after *Kharif*	34.00	39.00	5.00	2.230*	63.00	85.00	22.00	2.673

* Significant at 5 per cent level.

(*Contd.*)

TABLE I—(*Concld.*)

Crop enterprises	Superphosphate				Farmyard manure				Yield per acre			
	Small farm	Large farm	Devia-tion	't' value	Small farm	Large farm	Devia-tion	't' value	Small farm	Large farm	Devia-tion	't' value
	(kgs.)	(kgs.)	(kgs.)		(tons)	(tons)	(tons)		(qtls.)	(qtls.)	(qtls.)	
	10	11	12	13	14	15	16	17	18	19	20	21
1. *Desi* Maize	10.00	20.00	10.00	1.32	8.84	4.70	4.14	5.507*	7.10	9.45	2.35	1.96
2. Hybrid Maize	10.00	71.4	61.4	2.839*	15.00	9.28	5.72	1.76	12.20	14.40	2.20	0.789
3. American Cotton	—	—	—	—	7.46	3.54	3.92	1.67	3.25	4.58	1.33	—
4. *Desi* Cotton	—	—	—	—	4.28	—	4.28	2.68*	3.75	3.43	0.32	—
5. Groundnut Irrigated	6.00	30.00	24.00	2.763*	—	—	—	—	4.50	5.75	1.25	1.749
6. Sugarcane Planted	10.00	32.00	22.00	—	6.37	2.25	4.12	2.267*	16.00	16.32	0.32	0.28
7. Wheat after Fallow	5.00	23.00	18.00	—	—	—	—	—	8.26	9.33	1.07	1.724
8. Wheat after *Kharif*	20.00	44.00	24.00	2.409*	—	—	—	—	6.63	8.25	1.62	3.04*

*Significant at 5 per cent level.

Assumptions :

Source	*Small farm*	*Large farm*
1. Land holding	10 acres	22 acres
2. Source of irrigation	P. well	Tube-well
3. Source of power	Bullocks	Bullocks

sity of use of the various non-conventional inputs was higher on the large farms than on the small farms which resulted in higher per acre yields on the former.

A. S. KAHLON
AND
TILAK RAJ KAPUR*

ECONOMICS OF TRACTOR CULTIVATION — A CASE STUDY†

The desirability and the possibilities of mechanization of Indian agriculture have been frequently debated. It is sometimes felt that such mechanization might aggravate the already difficult employment situation in rural areas. Besides considering mechanization undesirable for this reason, doubts are also expressed whether, in view of small holdings and meagre resources of the cultivators, it is possible to mechanize Indian agriculture to any appreciable extent. Notwithstanding these misgivings such machinery is finding favour with cultivators and is being employed by them on an increasing scale as evidenced by the following estimates of the number of tractors on agricultural holdings in the Punjab taken from the reports of livestock censuses:

Year	1951	1956	1961	1966
Number of tractors	980	3,809	7,804	15,000 (approx.)

Prima facie it appears that in spite of the difficulties involved in the operation of tractors under our conditions, advantages conferred by them are found worth the trouble by a number of cultivators presumably with large holdings which face labour difficulties as a regular feature. Attempts to study the advantages of mechanization have been made by a number of research workers/institutions, for example, the Punjab Board of Economic Inquiry.

The present paper has the same objective, *i.e.*, to assess the extent of benefits conferred by the use of tractor and to present farm economic data relating to the holdings using tractors as compared to others (non-users) in the villages under study. The data pertains to 4 districts in the (erstwhile) Punjab which leads the country in respect of the number of tractors per hectare in use.

The data were collected by survey method to study the cost of cultivation of cotton, principal oilseeds and food crops conducted by the Indian Council of Agricultural Research with the co-operation of respective Commodity Committees and the State Governments between 1960-61 to 1962-63. The survey was conduct-

* Dean, College of Basic Sciences & Humanities and Assistant Professor of Agricultural Economics (Farm Management), respectively, Punjab Agricultural University, Ludhiana.

† Thanks are due to Shri S. D. Bokil, Senior Statistician, Institute of Agricultural Research Statistics, New Delhi for guidance in the preparation of this paper and to Dr. D. Singh, Dy. Statistical Adviser for encouragement and advice. Thanks are also due to Shri V. C. Jain for his keen interest and help.

ed in the districts of Ludhiana, Bhatinda, Sangrur and Hissar. About 300 holdings were randomly selected from 40 villages for collection of cost data by cost accounting method. These came from three size classes, small, medium and large, the respective class limits being 0-15, 15-30 and 30 acres and above. Of these, 6 holdings possessed tractors in the year 1962-63. The distribution of these holdings according to district and size classes is as follows :

District	No. of villages	Size of holding	
		Medium	Large
Ludhiana	1	1	—
Sangrur	1	—	1
Hissar	3	—	4
Total	5	1	5

It is seen that with the exception of one, all holdings belong to large size as might be expected. The medium and large size holdings (22 in number) belonging to the same villages selected for the survey have been taken for the purpose of comparison. Table I gives an idea about the characteristics of these holdings in the two classes, *viz.*, 'tractor owners' and 'others.'

TABLE I—CHARACTERISTICS OF LAND HOLDINGS

Item	Tractor owners	Others (non-users)
No. of holdings	6	22
Average size of holding (acres)	58.86	21.08
Percentage of area irrigated	74.04	66.84
Average number of family workers per holding	2.83	2.45
Average number of permanent servants per holding	1.83	0.59
Percentage of casually hired labour :		
Male	26.42	7.26
Female	87.66	2.14
Bullock pairs per holding	1.17	1.48
Total investment per holding (Rs.)	27,015	4,563
Intensity of cropping	136.98	143.62

The average size of holding, the proportion of casually hired labour and the extent of investment in agriculture clearly show that the tractor owners are not only large size cultivators but are also financially much better off as compared with others. The average number of family workers devoted wholly to agriculture for tractor owners per holding was found to be higher than that for others; however, when considered with reference to the size of holding, family labour per acre for tractor owners is much less than that for others.

The intensity of cropping for tractor owners was found to be 136.98 (ranging from 118.3 to 189.9) whereas it is 143.62 (ranging from 99.9 to 163.4) for others. The difference is, however, small and hence needs no explanation.

The input pattern for human and bullock labour and the use of tractor have been studied according to operations. This study was confined to wheat alone as data for other important crops particularly cotton were found to be too scanty. The results for wheat are given in Table II.

TABLE II—PATTERN FOR LABOUR INPUTS FOR WHEAT IN HOURS PER ACRE FOR TRACTOR OWNERS AND OTHERS

Agricultural operations	Male		Female		Bullock		Tractor
	Tractor owners	Others	Tractor owners	Others	Tractor owners	Others	
Pre-sowing ..	9.5	34.8	—	—	3.8	34.1	5.4
Sowing	7.9	9.2	0.1	—	6.7	8.1	0.1
Post-sowing ..	8.6	21.1	3.6	1.6	—	—	—
Irrigation ..	14.6	12.6	—	0.1	4.3	3.9	—
Manuring	3.6	2.0	—	—	—	0.7	0.3
Harvesting ..	57.4	71.4	12.2	10.0	0.2	12.7	2.8
Miscellaneous ..	7.3	10.1	2.1	1.7	0.6	2.2	0.2
Total	108.9	161.2	18.0	13.4	15.6	61.7	8.8

It is clearly seen from Table II that tractor has been used mainly for pre-sowing and harvesting operations. As can be expected, it has resulted in reducing human and bullock labour inputs to a greater extent. This was indicated by Table I also. The input of male labour in post-sowing operation (hoeing and watching) is found to be 8.6 hours for tractor owners as compared to 21.1 hours for others though the tractor has not been used for this operation. It may be due to deep ploughing with the help of tractor which retards growth of weeds, etc., resulting in reduced hours of human labour required for weeding and larger hours are required for watching by non-tractor holdings due to scattered fields. It would also be seen that 8.8 tractor hours release male and bullock labour to an extent of 52.3 and 46.1 hours respectively from agricultural operation but the use of female labour has increased to an extent of 4.6 hours. Such a relationship when fitted on the basis of adequate data can provide estimates as to the extent of displacement of labour due to the use of tractors by the cultivators.

The effects of use of tractor on cost of cultivation of wheat and the income derived therefrom can be seen from Table III.

TABLE III—COST OF CULTIVATION OF WHEAT PER ACRE FOR TRACTOR OWNERS AND OTHERS

(*in Rupees*)

Components of Cost	Tractor owners	Others
Human labour	41.34	55.97
Bullock labour	15.27	41.20
Tractor	47.79	—
Seed	14.66	13.31
Irrigation (cash charges only)	9.42	5.87
Manure and fertilizers	1.79	3.89
Depreciation, repairs of implements and land taxes	16.56	11.42
Total	146.83	131.66
Production in maunds/acre		
Main product	13.90	12.67
By-product	19.39	19.50
Gross cost per maund	10.56	10.39
Net cost per maund	7.81	7.68
(basis 0.7394 of gross cost allowing for *bhusa*)		
Gross Income	280.57	261.22
Net income	133.74	129.56

Table III shows that the expenditure incurred on labour (human, bullock and tractor) per acre of wheat for tractor holdings is higher than that for others. The expenditure accounting for depreciation, repairs and land taxes is also more for the tractor holding. This is due to better equipment, farm structures and maintenance as compared to 'others' class of holdings. The cost of cultivation per acre of wheat for tractor holdings is somewhat higher than that for others but the higher production per acre brings down the cost of cultivation per maund and makes it quite close to the cost per maund for other holdings. The gross and net incomes[1] based on Cost[2] A_2 is found to be slightly higher for tractor owners than others.

1. Wheat grain has been evaluated @ Rs. 16 per maund, being the farm harvest price for the year 1962-63 and *bhusa* @ Rs. 3 per maund.

2. The concept of cost is that of Cost A_2 which comprises of paid and family human labour, bullock labour, cost of materials, *viz.*, seed, manures and fertilizers, irrigation charges (paid in cash), share of overheads such as land taxes and depreciation on machinery (other than tractor) and farm structures plus repair charges incurred thereon in proportion to area. It does not include interest on capital. The depreciation on tractor has been worked out separately on hourly basis taking life of the tractor to be 10,000 hours. The tractors in question have not undergone any major repairs during the period of inquiry. The costs of maintenance have, however, been accounted for. The rate for bullock labour has been worked out on the basis of livestock maintenance records. It includes depreciation on bullocks also.

While considering Tables II and III together the ratio of bullock labour and expenditure incurred thereon for tractor owners and others is found to be 1 : 4 and 1 : 3 respectively, the reason being better standard of feeding and maintenance of work animals in the former class of cultivators. The expenditure incurred on manuring operation by tractor owners is more than for others although the cost of manure for them is less. This is because tractor owners used farmyard manure in greater proportion than others who used more of chemical fertilizers. Application of farmyard manure involves use of more labour and explains for higher labour inputs in spite of lower cost of manure. From Table III it may be observed that the cost of irrigation for tractor owners is more than that for others whereas the cost of manure is much less for them which appears to be paradoxical. The reason for it is clearly the better irrigation facilities available to tractor owners. Such a paradox is tenable only when cultivators have adequate irrigation potential which is hardly the case.

The percentage of area under different crops for the two classes of cultivators is shown in Table IV.

TABLE IV—PERCENTAGE OF AREA UNDER VARIOUS CROPS FOR TRACTOR OWNERS AND OTHERS

Crop	Tractor owners	Others
Wheat	24.3	19.8
Gram	17.8	18.7
Wheat-gram	10.6	7.6
Sarson	4.4	3.8
Barley	0.8	1.4
Sugarcane	2.3	2.4
Cotton	14.3	8.5
Maize	2.0	5.3
Paddy	1.9	0.8
Bajra	1.4	9.0
Groundnut	1.1	—
Jowar	0.5	2.5
Fodder crops	17.9	19.1
Others	0.7	1.0

The figures in Table IV indicate that the area under wheat, wheat-gram and *sarson* (high value crops) in *rabi* season is more for tractor holdings than for others. It is widely known that crops like wheat need more intensive preparatory tillage than other crops. This is made possible due to the use of tractors. Similarly, during *kharif* season the proportion of area under cotton, paddy and groundnut (high value crops) is considerably more for tractor owners whereas the area under other crops, *viz.*, maize, bajra and jowar is less for them. The percentage area under fodder crops is also less for tractor owners. This decrease can be attributed partly to the reduction in fodder requirements and contributes to the increase in area under the high value crops.

The foregoing discussion leads to the conclusion that the use of tractors does not affect the cost of cultivation of wheat per maund appreciably. It might also be inferred that lower requirement of labour per acre would result in more unemployment. However, in areas in the neighbourhood of industrial centres hired labour is actually scarce and larger cultivators find it difficult to carry on their farming operations satisfactorily because of this scarcity. That is why in Punjab the cultivators have been inclined to use tractors more extensively even though the use of tractor does not necessarily result in reduced cost of cultivation.

BHAGAT SINGH*

* Institute of Agricultural Research Statistics (I.C.A.R.), New Delhi-12.