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NOTES

IMPACT OF RAINFALL ON CROP YIELD AND ACREAGE*

Introduction

A study of the effect of weather on crop acreages and yields is useful from a number of viewpoints. In the first place, it helps in formulating an estimate of a particular crop a few months in advance of the harvest of the crop. In a particular year, variations in acreage and yield, particularly the latter, are largely due to natural factors, rainfall being of overwhelming importance among them. If the relationships between rainfall in different time intervals (weeks, fortnights or months) and acreage/yield rate are known, the size of the crop can be anticipated on the basis of the rainfall data in different time intervals of the current year. Advance estimates of crops are considered important from the viewpoint of public policy. In the United States, special field surveys are conducted at different stages of the growth of a crop to formulate advance estimates of the crop. In India, too, information is collected from knowledgeable persons and through Government field staff in different parts of the country about crop conditions and on this basis advance estimates are made which are useful to Government, traders and manufacturers. For instance, Government's policy about procurement, distribution, imports and prices of foodgrains is determined to a considerable extent in the light of the advance estimates.

Another use of the weather-crop relationships, particularly in the developing countries, is that it makes it possible to know how much of the increase in production of different crops in a year is due to weather and how much to the developmental measures. The separation of the effect of weather is necessary to assess the progress due to planned agricultural development.

The work of supply analysis and projections, including the estimation of technical coefficients and price responses, has been seriously hampered and has not been able to make as much progress as the work of demand analysis and projections, mainly because the data on acreage, yield rate and production embodies the major influence of weather. Ar analysis of weather-crop relationship which helps in separating the effects of weather would remove an important obstacle in the way of supply analysis and projections. In the United States Department of Agriculture, interest in studying crop-weather relationships has been received as a step towards efficient and dependable supply analysis and projections in the agricultural sector.

It would be unrealistic to determine the rainfall-crop relationship in a single analysis for the country as a whole, unless the entire country constitutes a homogeneous region from the point of view of precipitation. Generally, it is necessary to divide the country into homogeneous tracts and analyse the rainfall-crop relationship for each tract separately. In this article, the analysis has been done for Punjab (India) and the commodity taken up is wheat.

* In the preparation of this Note, the author was assisted by Sarvashri Radhey Shiam and K. L. Kohli.

Effect of Rainfall on Crop Yield

Wheat requires cool and moist weather during the growing period and warm and dry weather at the time of ripening. The main growing period for wheat in the Punjab is in the months of January and February. In the month of March, or at least the second fortnight of March, the crop reaches the ripening stage and rainfall might have an adverse effect on yield. It would seem that rainfall in the months of December, January, February and March has a bearing on yield rate for wheat in the State. Accordingly, the following multiple regression equation was set up to determine the effect of rainfall on yield rate :

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + rT \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where

Y = Yield per acre of wheat in Punjab.
X_1 to X_4 = Average rainfall in millimeters in the State in the months of December, January, February and March, respectively.

T=Time variable.

The 'time' variable has been introduced to take account of the increasing trend in yield rate over time as a result of developmental effort and any other growth factors.

The data series for different variables related to the period from 1948-49 to 1960-61, a total of 13 observations.

The fitted equation worked out to be

$$\underset{}{Y=785.66} - \underset{(1.679)}{0.3534X_1}, + \underset{(1.090)}{1.8420X_2} + \underset{(0.4221)}{0.7120X_3} - \underset{(1.470)}{0.6821X_4} + \underset{(5.664)}{15.72\ T} \ldots(2)$$

$$R^2 = .775$$

(Figures in bracket denote the standard error of the respective coefficient.)

This result confirms the hypothesis stated earlier that rainfall in the months of January and February has a favourable effect on yield and that in the month of March has a harmful effect on yield. An increase of 1 millimeter of rainfall in January results in an increase of 1.8 lbs. in the yield rate, while an increase of 1 millimeter rainfall in February results in an increase of 0.71 lb. in the yield. In the month of March, a similar increase in rainfall results in a decrease of 0.68 lb. in yield. In the month of December, too, when the wheat plant is still taking firm roots, a unit increase in rainfall has some deleterious effect, resulting in a decline in yield rate of 0.35 lb. The coefficient of the 'time' variable is 15.72, which means that every year the yield rate tends to increase at an average rate of 15.72 lbs. due to factors other than rainfall.

The coefficient for the time variable is highly significant, while those for the months of December and March are insignificant, the standard error exceeding the respective coefficients. The coefficients for the months of January and February are significant but at a rather low level. R^2 being 0.78, about 78 per cent of the total variations in yield rate are explained by this equation. The equation is not very successful in explaining the variations in wheat yields in Punjab, but it at least serves to illustrate the method of approaching the problem of determining weather-crop relationships.

The low significance of the coefficients may be due to a number of reasons. The rainfall data and the data on yield rate may not be very accurate. Aggregation of the rainfall over the State may not be justifiable as the State may not be a homogeneous zone so far as the effect of rainfall on wheat yield is concerned. Similarly, aggregation over the whole period of a month may not be a correct procedure and it may be desirable to study the effect of rainfall in smaller time intervals (a fortnight or a week). The linear function assumed above may also not be the most appropriate one.

The failure of R^2 to be very high may be due, besides the factors enumerated above, to the exclusion of some factors from the analysis. For instance, temperature may have an important effect on yield as also the prices of wheat in relation to the prices of competing crops.

Equation (2) implies a constant marginal effect of rainfall on yield, *i.e.*, every successive unit increase in rainfall in a particular month will have the same effect on yield. An alternative assumption could be that rainfall would have a diminishing marginal effect on yield, every successive unit increase in rainfall having less and less effect on yield. To test this alternative hypothesis, a semi-log function of the type

$$Y = a + b'_1 \log X_1 + b'_2 \log X_2 + b'_3 + \log X_3 + b'_4 \log X_4 + rT \quad \ldots\ldots\ldots(3)$$

was fitted to the same data. In this equation, instead of the original rainfall data for different months, the logarithms of these data were used as independent variables. The time variable was kept the same as in equation (2). This semi-log function worked out to be

$$Y = 808.24 - \underset{(6.38)}{17.3433} \log X_1 + \underset{(25.13)}{29.1571} \log X_2 + \underset{(10.43)}{22.5707} \log X_3 - \underset{(16.65)}{28.6745} \log X_4 + \underset{(5.79)}{14.0170}\, T \quad \ldots\ldots\ldots(4)$$

$$R^2 = .75.$$

(Figures in bracket stand for the standard errors of regression coefficients.)

The effect of a unit increase in rainfall in the months of December, January, February and March is given by the partial derivatives with respect to X_1, X_2, X_3 and X_4 respectively.

$$\left.\begin{aligned}\frac{\partial Y}{\partial X_1} &= \frac{17.3433 \text{ lbs.}}{X_1}\\ \frac{\partial Y}{\partial X_2} &= \frac{29.1571 \text{ lbs.}}{X_2}\\ \frac{\partial Y}{\partial X_3} &= \frac{22.5707 \text{ lbs.}}{X_3}\\ \frac{\partial Y}{\partial X_4} &= \frac{28.6745 \text{ lbs.}}{X_4}\end{aligned}\right\} \qquad \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

These partial regression coefficients with X_1 as denominators show that as the amount of rainfall in any month increases, the effect on yield goes on decreasing.

R^2 for this equation is 0.75 and is no better than the R^2 of equation (2) which assumed constant marginal effect. But the standard errors of the co-efficients indicate that the significance of the coefficients has considerably improved over that in equation (2), which shows that rainfall has a diminishing marginal effect on yield and the semi-log function is more suitable. But the reasons explained earlier for R^2 being not very high, in the case of the linear function, apply to the semi-log function also.

As already mentioned, monthly rainfall data might involve too much aggregation for analysing factors influencing yield rate. The effect of rainfall in the first fortnight of December may be quite different from that in the second fortnight. Similarly, the rainfall in the first and second fortnight of March might affect yield even in the opposite direction. It is, therefore, desirable to analyse the effect of rainfall in each fortnight if not in every week. This means that rainfall in each of the 8 fortnights should represent an independent variable. The estimating equation would then be:

$$Y + b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + rT \ldots \quad (6)$$

where X_1 to X_8 represent the rainfall for different fortnights from December to March and T represents the trend variable. This function assumes constant marginal effect of rainfall on yield.

Now, there are theoretical objections to fitting an equation involving 10 constants from a series containing only 13 observations. This difficulty can be overcome by adopting certain transformations. In equation (6), the coefficients b_1 to b_8 represent the net effect of a unit change in rainfall in the relevant fortnight. It can be assumed that the effect of rainfall from one fortnight to the next would not be an abrupt or erratic change but an orderly one following some mathematical function. That means the values of $b_1 \ldots\ldots\ldots b_8$ could form a smooth curve when plotted against time with fortnightly intervals. The particular form of this function is not known but it is indicated by the monthly analysis that it would approximately be a second degree parabola. The values of different b's could then be expressed as a second degree parabolic function of time :

$$b_t = a_0 + a_1 t + a_2 t^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots(7)$$

The values of different b's would be given by

$$\left.\begin{aligned} b_1 &= a_o + 1a_1 + 1^2 a_2 \\ b_2 &= a_o + 2a_1 + 2^2 a_2 \\ &\cdots\cdots\cdots\cdots\cdots\cdots \\ &\cdots\cdots\cdots\cdots\cdots\cdots \\ b_8 &= a_o + 8a_1 + 8^2 a_2 \end{aligned}\right\} \qquad \ldots\ldots\ldots\ldots\ldots (8)$$

Substituting these values of b's, equation (6) can be written in the form

$$Y = b_o + (a_o + 1a_1 + 1^2 a_2) X_1 + (a_o + 2a_1 + 2^2 a_2) X_2 + \ldots\ldots + (a_o + 8a_1 + 8^2 a_2) X_8 + rT \qquad \ldots\ldots\ldots (9)$$

This can be re-written as

$$Y = b_o + a_o (X_1 + X_2 + \ldots\ldots\ldots + X_8) + a_1 (1X_1 + 2X_2 + \ldots\ldots + 8X_8) + a_2(1^2 X_1 + 2^2 X_2 + \ldots\ldots + 8^2 X_8) + rT \qquad \ldots\ldots\ldots (10)$$

or,

$$Y = b_o + a_o W_1 + a_1 W_2 + a_2 W_3 + rT \qquad \ldots\ldots\ldots (11)$$

Where

$$W_1 = (X_1 + X_2 + \ldots\ldots\ldots + X_8)$$
$$W_2 = (1X_1 + 2X_2 + \ldots\ldots\ldots + 8X_8)$$
$$W_3 = (1^2 X_1 + 2^2 X_2 + \ldots\ldots\ldots + 8^2 X_8)$$

Equation (11) has 5 constants b_o, a_o, a_1, a_2 and r. The new variables W_1, W_2 and W_3 are calculated from the rainfall data for the 8 fortnights, and the regression of yield on the three W's and T (time variable) is computed. The fitted regression equation works out to be

$$Y = \ldots\ldots\ldots 1.9196\ W_1 + 1.4785\ W_2 - 0.1852\ W_2 + 8.95\ T \ldots\ldots\ldots (12)$$

The values of a_o, a_1 and a_2 in equation (12) are used to derive the values of b's on the basis of relationships in (8). For instance, values of b_1 and b_2 work out to be

$$b_1 = a_o + 1a_1 + 1^2 a_2 = .6264$$

$$b_2 = a_o + 2a_1 + 2^2 a_2 = .296325$$

Similarly,

$$b_3 = .8486$$

$$b_4 = 1.0303$$

b_5 = .8415

b_6 = .2823

b_7 = .6475

b_8 =1.9477

These values of b's which are in lbs. represent the effect of a change of 1 millimeter of rainfall on yield in respective fortnights in equation (6) which becomes

$$Y=860.33-0.6264\,X_1+0.2963\,X_2+0.8486\,X_3+1.0303\,X_4+0.8415\,X_5+0.2823\,X_6-0.6475\,X_7-1.9477\,X_8+8.095\,T \quad \text{.....................(14)}$$

$$R^2=0.74.$$

In the analysis with monthly data of rainfall in equation (2), it was found that rainfall in the month of December had a deleterious effect on wheat yield. It is now brought out from the fortnightly analysis in equation (14) that rainfall in the second fortnight has a favourable effect on yield and that in the first fortnight has an adverse effect. It also shows that the most effective periods of rainfall are the months of January and the first fortnight of February. Rains in the second fortnight of February also have a favourable, though smaller, effect. But March rains in both the fortnights bring down wheat yields considerably in Punjab. These results by and large confirm the views of the agronomists.

R^2 for this function worked out to be 0.74 which was not better than the earlier analysis based on monthly data of rainfall. Nevertheless, this method does provide a way for estimating the effect of weekly or fortnightly rainfall without correspondingly increasing the number of variables in the function to be fitted directly from actual data. Even the effect of weekly rainfall, with 17 or 18 intervals, could be determined without involving more than 4 independent variables (including the time variable) in the equation to be fitted from actual data.

Effect of Rainfall on Acreage

Analysis similar to the regression equation (1) was also done to determine the effect of rainfall on wheat acreage in Punjab. Most of the sowing of wheat in the State is done in the months of September and October and, therefore, the acreage is assumed to be affected by rainfall in these two months. Accordingly, the following regression equation was estimated :

$$Y=a+b_1X_1+b_2X_2+rT \quad \text{...(15)}$$

Where

Y =Acreage under wheat in Punjab.
X_1=Rainfall in the month of September in millimeters.
X_2=Rainfall in the month of October in millimeters.
T =Trend variable.

This function assumes the constant marginal effect of rainfall on acreage. The fitted equation worked out to be

$$Y=3474 + 0.2711\ X_1 + 1.172\ X_2 + 158.66\ T \qquad \text{.......................(16)}$$
$$\qquad\quad (0.5588) \qquad\quad (0.6501) \qquad\quad (11.51)$$

$$R^2=0.95.$$

Thus an increase of 1 millimeter in the rainfall in the month of September in the State as a whole brings about an increase of 271 acres in the area under wheat. A similar increase in rainfall in October brings about an increase of 1172 acres in the area under wheat. Thus October rainfall has larger effect on acreage than September rainfall. The coefficient of the 'trend' variable shows that the area under wheat tends to increase by about 159 thousand acres annually as a result of factors other than rainfall. The coefficient of the trend variable is highly significant, that of X_1 (September rainfall) is insignificant and of X_2 (October rainfall) is significant at a rather low level. R^2, however, is 0.95, which is quite high. But the regression coefficients for rainfall in both months being not adequately significant, this equation cannot be used for projection purposes.

The semi-log function was tried, which assumes declining marginal effect of rainfall on acreage. But this function did not improve the result.

The effect of fortnightly rainfall can be estimated directly without going into the procedure involved in equations (7)—(10) in the case of yield analysis. However, when the effect of weekly rainfall is sought to be estimated, the number of variables involved in the direct estimation method becomes too large and the special procedure of equations (7)—(10) is helpful.

RAM DAYAL*

A STUDY OF SUBSIDISED INSECT PEST CONTROL MEASURES

Plant protection practices play an important role in increasing agricultural production. Pests and diseases cause heavy losses to field crops, vegetables and fruit trees. The annual losses inflicted by them have been estimated at over Rs. 18 crores for the Punjab State.[1] Protection of crops from pests is, therefore, a *sine qua non* of profitable agriculture.

To popularise plant protection among the cultivators, the State Department of Agriculture tried several measures. It arranged supplies of insecticides and plant protection equipment for the cultivators and provided technical guidance in using the supplies and equipment. To remove the shortage of equipment which was considered to be the main limiting factor to the popularity of plant protection measures, the Agriculture Department provided the plant protection

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1. These losses were estimated by the Entomologist to the State Government and published in *Government Agricultural College of Ludhiana Magazine*, Vol. IV, 1960.

equipment to the village panchayats and/or the co-operative societies at subsidised rates. It was hypothesised that with the availability of equipment with these institutions, the farmer would make increased use of the plant protection practices and these institutions would help popularise plant protection with the cultivators. To test this hypothesis, one operational study was conducted in 1963. Its specific objectives are :

(1) To examine the utilisation of plant protection equipment provided to village panchayats and/or the co-operative societies on subsidised rates.

(2) To examine the reasons of chemical control measures not becoming popular with the cultivators.

(3) To suggest measures that would popularise the chemical control measures with the cultivators.

DESIGN OF THE STUDY

The study was conducted in two parts :

Part I related to the use of plant protection equipment subsidised by the Government. Part II is concerned with the identification of factors that limited the popularity of plant protection measures.

Part I

The operational area of the study was limited to N. E. S. Block, Ludhiana. Of the 75 villages of the block, subsidy on plant protection equipment was given to 58 villages through panchayats and/or co-operative societies. The villages obtaining one spray pump were classified as group I, those getting either two spray pumps or a spray pump and a duster as group II, and others getting 3 pieces of equipment (spray pumps and dusters) as group III. The frequency distribution of the villages in each group and the villages selected at random from each group are shown as under :

Group No.	Frequency distribution of villages in the group	Number of villages selected
I	49	10
II	7	2
III	2	1
Total	58	13

Thus, 13 villages were selected for study, 10 from group I (20 per cent), 2 from group II (30 per cent) and one from group III (50 per cent). The relevant data were collected through personal interview with the village panchayats and/or co-operative societies which had obtained plant protection equipment on subsidised basis.

Part II

The scope of this part of the study was limited to the 13 villages referred to in Part I. Only such cultivators were selected in these villages, who were not carrying out any chemical control measures. The sample consisted of 5 per cent of such cultivators selected at random from each village and comprised 44 cultivators.

It is apparent that the size of the sample in this study was not large enough to justify statistical interpretation of the results, particularly in terms of the sampling error. The results of the survey can, however, be used to identify the weakness of the system and to promote policy action that will popularise adoption of plant protection measures.

PART I—UTILISATION OF PLANT PROTECTION EQUIPMENT

The plant protection equipment supplied on subsidised rates comprised foot sprayers, bucket pumps and dusters. The distribution of this equipment in the sampled villages was as under :

Frequency distribution of village	Foot sprayers	Bucket pumps	Dusters
10	10	—	—
1	2	—	—
1	1	—	—
1	1	1	2

Thus, out of a total of 17 pieces of equipment supplied to the sampled villages, two were dusting machines and one bucket sprayer. The remaining 14 pieces consisted of foot sprayers which were commonly used by the average farmer.

Life of the Equipment

The equipment purchased was one to four years old with the following details :

Year of purchase	Pieces of equipment purchased	Nature of the equipment
First half 1959	7	Foot sprayers
Second half 1959	1	Foot sprayers
First half 1960	1	Foot sprayers
Second half 1960	3	Foot sprayers
First half 1961	3	Two dusters + one bucket sprayer
Second half 1961	2	Foot sprayers

Most of the equipment was reported to be in use since it was purchased. But the more important question to be answered was how much it was used.

Under-utilisation of Plant Protection Equipment

In order to determine the extent of utilisation of the equipment, information was obtained from the village panchayats and/or co-operative societies regarding the acreage of different crops sprayed during *kharif* 1962. The *kharif* season was chosen because plant protection needs were greater during this period.

Table I shows the acreage of American cotton sprayed in each village and the total area of American cotton in that village along with the areas of other crops sprayed, if any.

It will be seen from Table I that excepting American cotton only a few acres of other crops were sprayed. Total area sprayed for maize hybrid, sugarcane, *desi* cotton and melons was 6 acres, 3 acres, 5 acres and 0.2 acre respectively.[2]

In case of American cotton, only 37 per cent of the total acreage was sprayed. As much as 73 per cent of this area was sprayed only once, the remaining 27 per cent was sprayed twice. Against this, the recommended schedule of American cotton was 3 to 4 sprays. It was apparent that the cultivators did not follow the recommended schedule of sprayings. They could not, therefore, obtain the full benefits of plant protection measures.

The extent of utilisation of equipment was assessed on the basis of number of days for which the equipment was used in spray operations. It will be seen from column 12 of Table I that only in one village Sangowal, the spray pump was used for about 55 days. In the remaining 12 villages, very little use was made of this equipment during the entire *kharif* season. In three of the villages (serial Nos. 5, 7 and 12) no area under American cotton was sprayed at all and the equipment was mostly unused.

The panchayat and co-operative society of one of the villages (serial No. 6) which possessed two sprayers felt that their needs could be served by one sprayer only. This was apparent from the little use they made of the equipment in that village. Only one acre was sprayed. The co-operative society of another village (serial No. 9) had a dusting machine in addition to the foot sprayer. But no use was made of the former and it was lying unused and packed in the form it was purchased. In one of the villages (serial No. 7) where the co-operative society maintained records regarding the utilisation of equipment, the spray pump was reported to have been used seven times during two and a half years.

Since little use was made of the equipment, it was apparent that the cultivators were not fully conscious of the benefits of plant protection measures. The extension education service need to educate the farmers on the importance and economic benefits of plant protection measures.

The rate of adoption of plant protection measures was further examined (Annexure 1). It was found that area under American cotton in the sampled village in 1956 (before the equipment was supplied) was 1,132 acres and it declined

2. Total acres sown under these crops were not available.

TABLE I—AREA OF AMERICAN COTTON AND OTHER CROPS SPRAYED, LUDHIANA BLOCK, 1962

Serial No.	Village	Position of equipment in the village			Total area American cotton (acres)	Area of American cotton sprayed (acres)	Per cent area sprayed	Number of times sprayed			Other crops sprayed	Total acreage of all crops sprayed (columns 5+8+9+10)	Number of days for which the spray pump was used
		Foot sprayer	Bucket	Duster				Once (acres)	Twice (acres)	Thrice (acres)			
1	2	3			4	5	6	7	8	9	10	11	12
1	Phullanwal ..	1	—	—	15	3	20%	3	—	—	—	3	1
2	Thakkarwal ..	1	—	—	20	10	50%	8	2	—	7	19	6½
3	Pamali ..	1	—	—	20	4	20%	4	—	—	—	4	1½
4	Threckey ..	1	—	—	20	10	50%	7	3	—	—	13	4½
5	Ayali Kalan ..	1	—	—	40	—	—	1	—	—	—	—	—
6	Baddowal ..	1	1	1	20	1	5%	1	—	—	—	1	½
7	Bhanor ..	1	—	—	8	—	—	—	—	—	0·2	0·2	¼
8	Mangliuchi ..	1	—	—	40	10	25%	8	2	—	—	12	4
9	Gahaur ..	1	—	1	3	3	100%	3	—	—	—	3	1
10	Sangowal ..	1	—	—	170	125	75%	85	40	—	1	166	55
11	Alamgir ..	2	—	—	150	20	13%	16	4	—	6	30	5
12	Lalton khurd ..	1	—	—	—	—	—	—	—	—	—	—	—
13	Daitwal ..	1	—	—	3	3	100%	3	—	—	—	3	1
	Total				509	189		138	51				

Note : The number of days for which the spray pump was used (col. 12) was estimated at 3 acres per day.

to 509 acres (45 per cent) in 1962. The decrease in acreage was mostly due to poor yields resulting primarily from heavy attack of insect pests and adverse climate. It was thus apparent that the supply of plant protection equipment did not solve the plant protection problem. Other factors were responsible for non-use or under-utilisation of the equipment and these might be examined carefully.

Lack of Technical Know-how

It was found that eleven of the thirteen panchayats/co-operative societies did not possess the requisite technical know-how for carrying out the chemical control measures. It is, therefore, important that trained extension workers impart the necessary technical know-how to the farmer and in particular to the institutions engaged in this work.

Conclusions

The study indicated that the supply of equipment to village institutions did not solve the problem of popularising plant protection measures. There were other limiting factors to the adoption of plant protection practices, that need to be examined rather carefully.

PART II—FACTORS LIMITING THE POPULARITY OF PLANT PROTECTION MEASURES

Adoption of chemical control measures was studied in this part. It was found that about 86 per cent of the selected cultivators did not carry out any chemical control measures. However, in one of the villages, about 75 per cent of the cultivators were reported to have carried out the spray operations. This relative popularity of the control measures in this village was reported to be the result of keen interest taken by the panchayat and *gram sevak*. It was apparent that success of plant protection measures depended upon the leadership provided by the village institutions and that great care has to be taken to ensure that these institutions are manned by persons who are devoted to development work and welfare of the cultivators.

The study indicated that the cultivators were particularly conscious of the damage done to American cotton by Jassids and whitefly, to sugarcane by borers, and to oilseed crops by aphids. They did not however adopt recommended schedule of chemical control measures for the following reasons.

Cost of Insecticides

Thirty-one cultivators (70 per cent) did not carry out the control measures because they felt insecticides were costly and they did not have the resources to pay for them. If the farmers were convinced that additional returns obtained from the use of plant protection measures more than compensated the additional cost of using control measures, they might have less hesitation to make such investments. Experiments conducted on the use of insecticides showed that it was economical for the farmer to carry out the chemical control measures (Tables II and III).

It will be seen from Table II that additional cost of treatment 1 and 2 was Rs. 28.80 and Rs. 21 respectively. The corresponding additional returns were

TABLE II—ECONOMICS OF SPRAYING COTTON AGAINST JASSIDS AND WHITEFLY (THREE SPRAYS) AT 28 DAYS' INTERVAL ON PER ACRE BASIS

Serial No.	Treatment	Added cost	Added yield of seed cotton over control	Value of additional return	Net gain or loss
1	DDT + BHC .1 per cent suspension of each	Rs. 28·80	70·92 Kgs.	Rs. 81·20	+ Rs. 52·40 (gain)
2	Endrin .02 per cent emulsion	Rs. 21·00	81·33 Kgs.	Rs. 87·21	+ Rs. 66·21 (gain)

Source : Derived from Annual Report 1960-61, Scheme for the Study of Insect Pests of Cotton and Their Control in Punjab.

Rs. 81.20 and Rs. 87.21 respectively. Thus there was a net gain of Rs. 52.40 and Rs. 66.21 per acre for treatments 1 and 2 respectively.

TABLE III—ECONOMICS OF APPLICATION OF DUST TO SUGARCANE CROP AT PLANTING FOR THE CONTROL OF WHITE ANT ON PER ACRE BASIS

Treatment	Added cost	Added yield over control	Value of additional returns	Net gain or loss
10 per cent BHC dust @ 30 lbs. per acre	Rs. 6·00	126·7 mds.	Rs. 190·05	+ Rs. 184·05 (gain)

Source : Derived from Annual Report, Sugarcane Research Scheme, Punjab, 1957-58.

It is apparent from Table III that in areas where white ant infestation is serious, application of 10 per cent BHC dust gave a net return of Rs. 184.05 per acre. The results of these experiments gave a clear indication that the use of control measures was economical and the Extension agency may use such economic information to convince the farmer about the importance of plant protection measures.

Lack of Knowledge

Sixteen cultivators (36 per cent) did not carry out the control measures because this practice was not used in their area. Demonstrations may be arranged to convince such farmers about the usefulness of plant protection measures. If some innovators or early adopters took up this practice, others might follow.

Insecticides Not Readily Available

Twenty-two cultivators (50 per cent) reported that supply sources of insecticides were not within their easy reach. They obtained such supplies from Ludhiana or Mullanpur markets and the average distance of these markets from the selected villages was about 5 miles. To make the supplies sure and within easy reach of farmers, insecticides may be stocked in adequate quantity with the co-operative societies in the village.

Lack of Guidance Regarding Technical Know-how

Eleven cultivators (25 per cent) did not possess the technical know-how for carrying out the control measures. They emphasised that they could not identify the attacking insect pests, and did not know their control measures. It was, therefore, important that the Extension agency provided the requisite technical know-how to the cultivators by developing close contacts with them.

Cultivators Not Convinced of the Efficacy of Control Measures

Five cultivators (11 per cent) felt that there was not much difference in the yields of sprayed and unsprayed American cotton crop. They had sprayed their cotton fields only once. The schedule of spray used in the table showed that 73 per cent of the cultivators used one spray and only 27 per cent sprayed it twice when the recommended schedule was 3 to 4 sprays for American cotton. Since a single spray was not effective and economical, the farmers gave up the control measures without fully appreciating the usefulness of such control measures.

Untimely Treatments

It was observed that cultivators generally treated the crop after the infestation became prominent. It was difficult to control the pest in advanced stages of its attack. And the treatments may not turn out to be economical to apply. To convince the cultivators of the efficacy of control measures, it was important for the Extension agency to educate the cultivators to follow recommended schedule of sprays and observe right timings of sprays rather scrupulously.

Neighbours Not Carrying Out Control Measures

Four cultivators (9 per cent) were of the view that there was not much use of carrying out the control measures unless the neighbouring cultivators followed this practice in the adjoining fields. They reported that the pests from untreated fields migrated to the neighbouring treated fields and rendered the treatments less effective.

It may be observed that some of the pests such as Jassids, Pyrilla, citrus psylla and grass-hoppers, etc., were capable of migrating to neighbouring fields to various degrees and in such cases the co-operation of neighbour cultivators was essential for satisfactory clean-up operations.

Non-availability of Insecticides in Containers of Required Size

Three cultivators (7 per cent) expressed the difficulty in obtaining the insecticides in containers of the required size. The cultivators' requirements were generally less than the quantities contained in these containers and they could not afford to purchase the whole quantity contained in them. For example, Endrin and Basudin were generally available in containers of one gallon capacity whereas the average cultivators needed them in smaller quantities. There was, therefore, a great need of designing packages of one-fourth to one-half gallon that the average farmer needed and its cost was within his easy financial reach.

Conclusions

The study indicated that the cultivators did not carry out the control measures for the following reasons :

(*i*) Most of the cultivators believed that the insecticides were too costly for their resources.

(*ii*) The insecticides were not readily available with co-operatives located in the villages.

(*iii*) Some of the cultivators were not fully convinced of the merit of plant protection practices.

(*iv*) The cultivators lacked the technical know-how for carrying out the control measures.

(*v*) The control measures were not effective when the neighbouring farmers did not use such measures in their fields.

(*vi*) Insecticides were not generally available in quantities required by the cultivators.

RECOMMENDATIONS

(1) It follows that the economic benefits of control measures should be brought home to the cultivators through practical demonstration in the cultivators' fields. Such demonstrations should educate the farmers to (*a*) follow recommended schedule of sprays, (*b*) observe right timings of spray and (*c*) impart the technical know-how necessary for the performance of these operations.

(2) Arrangements may be made to stock the insecticides with the village co-operative societies in adequate quantity so that the supplies do not run short and are within the easy reach of the cultivators.

(3) All the cultivators may be required to carry out the control measures over the infested areas by impressing upon them the necessity of co-operative action in fighting out the insect menace. The non-co-operative cultivators may be appraised with the provisions of the East Punjab Insect Pests and Obnoxious Weeds Act, 1949.

(4) The quantities contained in the insecticide packings may be adjusted to meet the requirements of average farmers.

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ANNEXURE 1

Serial No.	Village	Area under American cotton (1956) acres	Area under American cotton (1962) acres
1	Phullanwal	69	15
2	Thakkarwal	65	20
3	Pamali	45	20
4	Threckey	112	20
5	Ayali Kalan	133	40
6	Baddowal	95	30
7	Bhanor	106	8
8	Mangliuchi	75	40
9	Gahaur	67	3
10	Sangowal	130	170
11	Alamgir	102	150
12	Lalton khurd	71	—
13	Daitwal	61	3
		1,132	509

Source: Revenue Record, Tehsil Ludhiana and the information obtained from the village panchayats.

IRRIGATION FACTOR AND YIELD VARIABILITY IN RICE GROWING DISTRICTS IN INDIA

This note is a study of the yield variability of rice in some selected rice growing districts in the country. Using the national average yield rate of rice as the norm, the inter-district yield variations are analysed and an attempt is made to assess a few of the more important factors that may be taken to be influencing the yield variations.

Rice in India is grown under diverse soil and climatic conditions. Of the 311 rice growing districts in India, the first 177 districts (ranked in descending order according to their percentage share in the total rice production in the country) account for 93.21 per cent of the total rice production, having among them 92.35 per cent of the total area under rice in the country.[1] Among these 177 districts, the first 40 districts have been selected for the present study. Though an element of arbitrariness is inherent in the selection of the above number of districts for the purposes of study, the importance of these 40 districts lies in the fact that the share

1. *Agricultural Situation in India*, Vol. XIV, No. 5, August, 1959. The rice growing districts have been ranked on the basis of their contribution to the all-India rice production based on the averages of three years — 1955-56, 1956-57 and 1957-58.

of these 40 districts in the total area under the rice cultivation is 43.46 per cent, while their contribution to the total rice production is as much as 51.0 per cent. The remaining 271 districts, thus, put together, with a slightly more of rice acreage (56.54 per cent) among them, still contribute a proportion of total rice production which is slightly less than the production contributed by the above 40 districts.

For all the 311 rice growing districts in the country, the magnitude of the range in the yield rates (yield per acre) between the highest and the lowest is as much as 1,318 lbs., the highest yield being 1,600 lbs. in North Arcot district in Madras State (also in Salem district in the same State with 1,598 lbs. per acre), and the lowest being 282 lbs. in Rewa district in Madhya Pradesh. The national average yield rate based on the averages of the three-year period 1955-56 to 1957-58, works out to be 761 lbs. for the 311 districts. Among the 40 selected districts, the range of yields is narrower with the yield in Sambalpur district in Orissa being the lowest with a yield of 467 lbs.

An *Index of Yield Variability* has been constructed for the 40 districts by expressing the yield rate of each district as a percentage of the national average yield rate.[2] It has been observed that this index is above 100 for as many as 27 districts. (See Appendix).

Per acre yield is a function of many factor-inputs some of which are controllable in the sense that the quantity of some of the factor-inputs used can be controlled by the cultivators, while the others are uncontrollable, the weather-factor being the main uncontrollable factor-input. Of the factor-inputs determining the yield rates of rice, availability of irrigation facility has been chosen for detailed analysis as a factor determining the yield rate. This choice has been made primarily on the grounds of the ready availability of the data pertaining to the area under rice and the area under rice irrigated for all the districts. Secondly, as the I.C.A.R. study[3] points out, the main cause of low yields and uncertainty of rice harvests is the dependence of the crop on the rains. In India, the bulk of the rice crop depends upon rainfall for its water supply and only about 20 per cent of the rice area has irrigation facilities to supplement the water received from rainfall. It may be expected, therefore, that the extent of area under rice irrigated determines to a considerable extent, the yield rates in different districts. The above hypothesis, however, is beset with certain limitations which cannot be ignored. In a given region, the soil conditions and rainfall may be among the important physical factors that influence the yield rates considerably. Further, the other controllable factor-inputs, human as well as material, and the cultivation practices are equally important determinants of the yield rates. The consideration of the relationship between a single factor and the yield rates would give only a partial or incomplete relationship. Further, the relationship between the selected factor (the extent of irrigation) and the other factor-inputs (which are not considered for the analysis) may be neutral or their relationship may be one of complementarity or even substitutability.

2. However, the limitations of the " national average yield rate " cannot be ignored as pointed out by M. L. Dantwala : "...... a simple aggregation of area and production in all regions and calculation of all-India yields from the same does not give a base-weighted average of yields, with the result that the yield estimates would tend to be exaggerated." See " Trends in Yield Per Acre " in Changing India, edited by N. V. Sovani and V. M. Dandekar, 1961, p. 34.

3. Rice in India, Indian Council of Agricultural Research, New Delhi, 1960, p. 35.

The relationship between the percentage of area under rice irrigated and the yield rates in different districts is brought out using a simple regression analysis.[4]

The regression equation works out to be

$$y = 688.13 + 5.427x$$

where y = yield per acre (lbs.)
x = percentage of area under rice irrigated.

Coefficient of correlation : $r = 0.65$
It is significant at 1 per cent level.
Coefficient of determination : $r^2 = 0.42$.

Thus, it may be pointed out that 42 per cent of the variations in the yields are explained by the extent of availability of irrigation facilities. Though r^2 is low, it may be said that the results are not discouraging.

The conclusion that emerges is that yield rates can be stabilized and increased to a considerable extent with provision of irrigation facilities in areas depending entirely on rainfall for crop production. As the F.A.O. Report[5] points out, the main point seems to be established that while soil and climate greatly influence the yield of individual crops, current levels of productivity are by no means immutable. By improved methods of farming, which may necessitate irrigation as well as the provision of improved seeds, fertilizers and pesticides, the yields could be greatly increased. The availability of irrigation facilities—an adequate and assured supply of water—is one of the important factors influencing the yield rates as has been already noted.[6]

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4. For a similar study for Wheat in Pakistan, see S. K. Quereshi, " Rainfall, Acreage and Wheat Production in West Pakistan," *The Pakistan Development Review*, Vol. III, No. 4, 1963.

5. The State of Food and Agriculture 1963, Food and Agriculture Organization of the United Nations, Rome, 1963, p. 108.

6. A similar conclusion was reached by V. G. Panse : " An interesting conclusion derived ...was that irrigation can be introduced in some rice areas as a *positive measure* for increasing yield by supplementing the normal rainfall of the area and not merely as a protection against the vagaries of rainfall." (Italics ours) : See " Recent Trends in the Yield Rate of Rice and Wheat in India," *Indian Journal of Agricultural Economics*, Vol. XIV, No. 1, January-March, 1959, p. 19.

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APPENDIX

PERCENTAGE SHARE OF THE FIRST 40 DISTRICTS IN THE TOTAL PRODUCTION OF RICE AND AREA UNDER RICE IN INDIA (1955-56 TO 1957-58 AVERAGE)

District	Percentage share of production	Percentage share of area	Percentage area irrigated	Yield per acre (lbs.)	Index of Yield Variability
1	2	3	4	5	6
1. West Bengal					
1. Midnapore	3·11 (1)	2·59	29·62	913·0	119·9
2. 24-Parganas	2·38 (3)	1·92	6·12	943·0	123·9
3. Burdwan	2·11 (4)	1·37	36·41	1,168·0	153·5
4. Birbhum	1·47 (14)	0·98	61·18	1,142·0	150·1
5. Bankura	1·40 (16)	1·05	33·08	1,018·0	133·9
6. Purulia	0·96 (25)	0·95	N.A.	783·0	102·9
7. Murshidabad	0·93 (26)	0·85	25·57	831·0	109·2
8. Hooghly	0·98 (39)	0·57	37·66	1,043·0	137·0
2. Madras					
1. Tanjore	2·45 (2)	1·72	96·03	1,081·0	142·0
2. South Arcot	1·52 (11)	0·86	92·89	1,343·0	176·5
3. North Arcot	1·50 (12)	0·78	95·86	1,600·0	210·2
4. Tiruchirapalli	1·18 (18)	1·35	92·08	1,382·0	181·6
5. Chingleput	1·11 (20)	0·88	80·06	963·0	126·5
6. Tirunelveli	0·84 (30)	0·42	99·47	1,502·0	197·4
7. Madurai	0·82 (33)	0·45	99·53	1,399·0	183·8
3. Madhya Pradesh					
1. Raipur	1·88 (5)	2·14	18·53	669·0	87·9
2. Bilaspur	1·73 (6)	1·88	9·67	700·0	91·9
3. Durg	1·49 (13)	1·57	18·22	720·0	94·6
4. Bastar	1·00 (24)	1·09	5·33	702·0	92·2
5. Raigarh	0·89 (27)	0·99	0·65	680·0	89·3

(*Contd.*)

PERCENTAGE SHARE OF THE FIRST 40 DISTRICTS IN THE TOTAL PRODUCTION OF RICE AND AREA UNDER RICE IN INDIA (1955-56 TO 1957-58 AVERAGE)—(*Concluded*)

District	Percentage share of production	Percentage share of area	Percentage area irrigated	Yield per acre (lbs.)	Index of Yield Variability
1	2	3	4	5	6
	4. ANDHRA PRADESH				
1. West Godavari	1·67 (7)	1.03	90·80	1,226·0	161·1
2. Krishna	1·59 (8)	1·00	99·28	1,211·0	159·1
3. East Godavari	1·56 (9)	0·91	90·78	1,300·0	170·8
4. Guntur	1·12 (19)	0·64	93·44	1,341·0	176.2
5. Srikakulam	0·79 (37)	0·69	86·38	870·0	114·3
	5. BIHAR				
1. Santhal Parganas ..	1·41 (15)	1·44	21·23	737·0	96·8
2. Shahabad	1·21 (17)	0·65	70·66	681·0	89·5
3. Gaya	1·11 (22)	1·37	87.08	615·0	80·8
4. Ranchi	0·83 (31)	1·08	42·91	583·0	76.6
	6. ASSAM				
1. Kamrup	1·11 (21)	1·18	37·92	717·0	94·2
2. Sibsagar	0·82 (32)	0·68	10·57	928·0	121·9
3. Darrang	0·81 (34)	0·66	26·10	926·0	121·7
4. Goalpara	0·80 (35)	0·71	33·45	861·0	113·1
	7. ORISSA				
1. Cuttack	1·02 (23)	1·62	20·12	477·0	62·7
2. Sambalpur	0.86 (29)	1·39	41·05	467·0	61·4
3. Koraput	0·79 (36)	0·97	0·41	619·0	81·3
	8. MAHARASHTRA				
1. Bhandara	0·86 (28)	0·78	47·72	834·0	109·6
2. Thana	0·74 (40)	0·47	Neg.	1,199·0	157·5
	9. KERALA				
1. Malabar	1·56 (10)	1·25	6·68	944·0	124·0
	10. MYSORE				
1. South Kanara	0·79 (35)	0·53	15·79	1,160·0	152·4

Note : Figures in parenthesis indicate the rank of the district.

PRODUCTION FUNCTION FOR A SAMPLE OF FARMS IN ANKODIA VILLAGE*

The gross agricultural production can be considered as a function of certain input factors such as land, labour and capital. The variations in the levels of these inputs directly affect the gross agricultural production. Hence the input factors play a very important role in agricultural production.

An attempt is made in this paper to study the productivity of various input factors. The concepts of elasticity of production and marginal productivity of the different items of inputs have been made use of. In order to derive the values of the elasticities of production and marginal productivity, a production function is fitted to a sample of farms in Ankodia village of Baroda district. The data were collected by the Agro-Economic Research Centre for the States of Gujarat and Rajasthan, as a part of the programme of Continuous Village Survey. The information pertains to the agricultural year 1960-61.

CHOICE OF FUNCTION

An infinite number of functional forms are possible in productivity studies, *e.g.*, Cobb-Douglas power function, Spillman function, Quadratic forms and so on. Heady has given a fairly detailed discussion in his book.[1] From the various functions available, Cobb-Douglas function, which can be written as $Y = AX_1^{b_1} X_2^{b_2} \ldots\ldots X_k^{b_k}$,[2] was selected for the following reasons :

It is easy to see that on logarithmic transformation, the function becomes a simple linear one and the constants $b_i (i=1, 2\ldots\ldots k)$ and A can be evaluated following the principle of least squares.

Further it is implicit in the function that

(*i*) b_i is the elasticity of production of the factor x_i $(i=1, 2\ldots\ldots k)$.

(*ii*) $b_i \frac{Y}{X_i}$ is the marginal productivity of the factor X_i $(i=1, 2\ldots\ldots k)$.

Thus, having determined the numerical values of b_i, the values of elasticities of production and marginal productivity of the factor X_i $(i = 1, 2\ldots\ldots k)$ are easily computed. Since, the marginal productivity of X_i is $b_i \frac{Y}{X_i}$, we see that the marginal productivity of X_i is to be evaluated at particular values of X_i (in our study we have considered the geometric means of the sample values). It is also to be noted that elasticity b_i is independent of particular values of X_i. In other words, Cobb-Douglas function allows constant elasticity at all points. This is one of the unique characteristics of the Cobb-Douglas type function.

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* The author wishes to express his sense of gratitude to Dr. V. S. Vyas whose invaluable comments and suggestions at various stages proved very useful in the preparation of this paper.

1. E. O. Heady : Agricultural Production Functions, Iowa, 1961.
2. Y=independent variable, X_i= dependent variables. $i=1, 2\ldots.k$. A, b_i are constants.

Lastly, the sum ($b_1 + b_2 + \ldots\ldots\ldots\ldots + b_k$), provided $X_1\ X_2\ \ldots\ldots\ldots\ldots X_k$ are the only relevant inputs, indicates the nature of returns to scale. With the sum ($b_1 + b_2 + \ldots\ldots + b_k$) = 1, a given percentage increase in all k inputs will result in an equal percentage increase in output. With elasticity sums being more or less than 1, output will increase by a greater or smaller percentage respectively than inputs.

SELECTION OF SAMPLE

Out of farmers who were pursuing agriculture as the main occupation (102 families) in the village Ankodia, a purposive sample of 27 farmers was selected. The farmers represented by the sample are comparatively well-to-do. The farmers of this section are not severely handicapped in the use of most of the variable resources. The objective was to select that stratum of farms which has least "constraints" as far as variable factors are concerned. Table I gives the distribution of the sample families and that of all the farmers of the village Ankodia by the size of holdings and income groups.

TABLE I—DISTRIBUTION OF FAMILIES BY SIZE OF HOLDING AND INCOME GROUPS

Size-groups (acres)	Net Income Groups (Rs.)							Total
	Less than 300	301-600	601-1,200	1,201-2,400	2,401-3,000	3,001-5,000	5,000 and above	
0—5 ..	3	7	12	6	—	—	—	28
5—10 ..	1	3	8	11(5)	3	2(2)	—	28 (7)
10—15 ..	—	1	1(1)	5(2)	7(5)	3(2)	6(2)	23(12)
15—20 ..	—	—	—	3(1)	1(1)	3(1)	—	7 (3)
20—25 ..	—	—	—	—	—	3	8(4)	11 (4)
25 and above ..	—	—	—	1	—	—	4(1)	5 (1)
Total ..	4	11	21(1)	26(8)	11(6)	11(5)	18(7)	102(27)

Note : The values in brackets are sample values and the rest are population values.

It is evident from the above table that the sample represents the desired section of the class of farmers.

Further, the farmers included in the sample had the following characteristics in common :

(*i*) All belonged to the "owner-cultivator" group—*i.e.*, none of them leased in or leased out any land for cultivation. This was necessary because the information supplied by farmers with reference to the ownership of land and amount of rent paid or received for leased land is not always reliable.

(*ii*) All of them had irrigation. Though they did not own the well but got water from the adjoining wells and all paid water charges at a uniform rate.

(*iii*) All used cow-dung manure and in addition used fertilizer (ammonium sulphate) and/or oil cakes.

(*iv*) All possessed necessary agricultural tools and implements.

(*v*) All of them engaged at least one attached labourer more or less permanently apart from the casual labourers during the busy seasons.

(*vi*) All possessed at least one bullock. In fact all except one had more than one bullock with them.

NATURE OF VARIABLES

Six input factors are considered as responsible for the gross agricultural production, denoted by Y, in

$$Y = AX_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} X_6^{b_6}.$$

Here, A and b_i ($i = 1, 2 \ldots\ldots 6$) are constants, and X_1, $X_2 \ldots\ldots X_6$ are respectively land, agricultural implements, fertilizers and manures, water charges, hired labour and bullocks. 'Seeds' was not included because the variations in the observed values of seeds used per acre were insignificant. The inputs are measured in suitable units discussed below.

X_1 : Land in standardised acres.

The method used to standardise the land unit is based on the revenue paid by the farmer.

Thus $X = a.\frac{r}{R}$

Where a = acres operated by the farmer.

r = per acre revenue paid by the farmer.

R = average per acre revenue at village level.

It is assumed that more revenue is charged on better quality land. A standardised acre is comparable with another with respect to the quality.

X_2 : Depreciation of the agricultural tools and implements. This was arrived at by considering the price paid by the farmer for the implement divided by the average life (in years) of the implement.

Thus,

$$X_2 = \sum_{j=1}^{q} \frac{p_j}{n_j}$$

where p_j = price of the jth implement.

n_j = expected life of jth implement.

j = 1, 2........q.

The value of q varies from farmer to farmer.

The expected life was determined by the field investigators who visited the village for collection of data.

X_3 : Total charges paid by the farmer for the use of chemical fertilizers, oil cakes and cow-dung manure.

One may argue that these three inputs could be studied separately. But in measuring the output Y, we have taken together many crops and different types of fertilizers (chemical fertilizers, oil cakes and manure) are used for different crops. Also more than one of these are mixed, sometimes for certain crops by many farmers. Hence the three are taken as a combined input.

X_4 : Water charges paid by the farmers.

X_5 : Payment to agricultural labourers in cash and imputed value of payment in kind. This does not include the family labour.

X_6 : Number of bullocks owned by the farmer. This unit was also standardised as follows :

$$X_6 = B \frac{C}{V}$$

Where B = Number of bullocks, the farmer possessed.

C = Annual (per bullock) expenditure on concentrates incurred by the farmer.

V = Average annual expenditure on concentrates, at village level (per bullock). (An alternative method for the standardisation of bullocks would have been to consider the prices of the bullocks. But the bullocks are valued at different prices at different periods as per their age and general price level. In that case the age of the individual bullocks as well as the price for various categories of bullocks would have to be taken into account.)

As mentioned earlier, the gross output is measured by the money value of the total agricultural production. The prices used to evaluate the production were those prevailing at the time of harvest.

The levels of various input factors also depend on the variety of crops grown. These together with the areas under the crops for the sample as well as for the village as a whole are given in Table II.

TABLE II—CROPPING PATTERN OF THE VILLAGE ANKODIA AND THE SAMPLE

Crops	Per cent of land under the crop	
	Village	Sample
Tobacco	54	57
Paddy	16	14
Tur	7	6
Sundhia (Fodder)	7	9
Cotton	6	6
Bajra	5	4
Others (Jowar, *Kodra*, *Tal*, Vegetables, etc.)	5	4
Total	100	100

It will be observed that the cropping pattern is more or less the same for the sample and for the village.

NUMERICAL VALUES

The values of A, b_i (i = 1, 2.........6) marginal productivities, adjusted co-efficient of multiple determination $\bar{R}^2$ and the geometric means of the variables are given in Table III.

TABLE III—VALUES OF THE GEOMETRIC MEANS, ELASTICITIES OF PRODUCTION AND MARGINAL VALUE PRODUCTIVITIES OF THE SIX INPUT FACTORS

Variable	Unit	Geometric mean	Elasticity coefficient b_i	Standard error of b_i	M. V. P. at Geometric mean	"t" Values
X_1 Land	(acres)	13	0.23*	0.155	99.94	1.475
X_2 Agricultural tools and implements	(Rs.)	60	0.18*	0.110	17.40	1.653
X_3 Manures and fertilizers	(Rs.)	1,039	0.13*	0.099	0.73	1.335
X_4 Water charges	(Rs.)	311	0.25†	0.097	4.78	2.686
X_5 Hired labour charges	(Rs.)	869	0.22**	0.115	1.44	1.905
X_6 Bullocks	(Number)	2	0.02	0.163	51.94	0.197
Y Total gross output (in Rs.)		5,722	6	—	—	—
		$\sum_{i=1}^{6} b_i = 1 \cdot 04$				

A = 29.84, $\bar{R}^2 = 0.9994$ $\bar{R}$: (Adjusted Coefficient of Multiple Determination)

Note : The values marked with (†), (**) and (*) are significant at 1 per cent, 10 per cent and 20 per cent levels of significance respectively.

The elasticity coefficients b_i were tested by Student's "t" test. The value of "t" at 20 per cent, 10 per cent and 1 per cent levels of significance at 20 degrees of freedom are 1.325, 1.725 and 2.528 respectively.

RELATIVE EFFICIENCY AND MARGINAL PRODUCTIVITIES OF DIFFERENT ITEMS OF INPUTS

As mentioned earlier, the coefficients b_i ($i = 1, 2 \ldots\ldots\ldots 6$) measure the elasticities of production in respect to each variable and the sum ($b_1 + b_2 + \ldots\ldots + b_6$) indicates the nature of returns to scale, provided $X_1, X_2 \ldots\ldots\ldots X_6$ are the only relevant inputs. The value of $\bar{R}^2$ is 0.99 and shows that almost cent per cent of the variation observed in the sample values is explained by the fitted regression model. The value of ($b_1 + \ldots\ldots\ldots + b_6$) is 1.04 which is very nearly equal to unity and indicates constant returns to scale. Thus a given percentage increase in all the inputs will result in an equal percentage increase in output.

We now turn to the relative efficiencies of the individual inputs. Student's "t" test shows that b_4 is highly significant (at 1 per cent level of significance), b_5 is significant at 10 per cent level of significance, b_1, b_2, and b_3 are significant at 20 per cent level of significance, while b_6 is quite insignificant.

Considered from the point of view of statistical significance, the following is the order of inputs in which reliance can be put in the conclusions derived from the elasticity coefficients : (1) water charges, (2) hired labour, (3) agricultural implements, (4) land, (5) manure-fertilizers, and (6) bullocks.

We see that the elasticity of production is higher for the "water charges" input. We can say that one per cent increase in "water charges" results in 0.26 per cent increase in gross agricultural production. This is in agreement with the fact that tobacco and paddy which are dominating crops in Ankodia give good response to irrigation.

The elasticity of "hired labour input" is 0.22 which means that 1 per cent increase in this input results in 0.22 per cent increase in gross agricultural output. Similarly, one per cent increase in "land" input increases gross output by 0.23 per cent. Also one per cent increase in "agricultural implements" will result in 0.18 per cent more of gross production.

The "manure-fertilizers" factor has got the elasticity coefficient equal to only 0.13. This is in conflict with the popular belief that the use of fertilizers should be increased to raise agricultural production.

We shall give the probable reasons for this while discussing the marginal value productivity of this factor.

The last is the factor "bullock"—the elasticity of production is quite insignificant in this case. It is, however, not to be understood that this factor is unimportant as far as agricultural production is concerned. By standardising the bullocks on the basis of concentrates the number of bullocks had to be taken as less than the actual number in case where less concentrates were given. This can be justified if we can assume that those who gave more concentrates to bullocks utilised more of bullock services in agricultural operations. To the extent this assumption is not perfectly valid, this method of standardisation is less realistic. Furthermore, what we have taken into account is the number of bullocks standardised on the basis of the concentrates they are given but the relevant input is the actual hours for which the bullocks were used in agricultural operations rather than the number or quality of bullocks alone. If we consider simply the number of bullocks, we unconsciously include not only the non-agricultural activities performed with the help of bullocks but also the number of days the bullocks might have remained idle. This is why we do not get any significant elasticity for "bullock" inputs. Thus, it would be better to use, as in similar other studies, the "number of bullock hours" instead of "number of bullocks," provided, of course, such information is available (for the present study this was not available).

Finally, we consider the marginal productivities of various input factors. What is the return of an additional unit of a particular factor if the other factors are held constant at their respective geometric means ? (We take geometric means since we have fitted the Cobb-Douglas model—which is a multiplicative model. There is no objection, however, to taking any desired levels of independent variables). We shall examine this aspect for all the factors included in the model.

Let us first consider the water charges. From Table III, we find that the marginal value productivity of this input is 4.78. This means that the return of an additional rupee spent as "water charges" is as high as Rs. 4.78. The water is supplied to the farmers for irrigation purposes by a Co-operative Society and some private water-pump owners. In all there are 33 wells in Ankodia and 15 of them are fitted with water-pumps. One of these 15 equipments is owned by the Society. The rate at which the water was supplied is Rs. 5 per hour. This is, no doubt, higher in comparison with the rate charged for canal water irrigation. However, the existing facility proved quite profitable to the farmers and it can be said that any amount of efforts made in the direction of making the irrigation facility easily available will benefit the farmers and also raise the gross agricultural production.

Secondly, we consider the "hired labour" input. The marginal productivity for this factor is 1.44. The return of an additional rupee is more than one rupee. It is worthwhile to note that the average daily wage of a casual labourer is about Re. 1 and that of an attached labourer is about Rs. 1.50. The mean (weighted) wage rate is Rs. 1.12. Thus, the marginal productivity is comparatively more than average daily wage of a labourer.

It should be remembered that we have excluded family labour. But the proportion of family labour spent on the farms of the selected families is insignificant. For the sample, there were 45 active adult members of the families who supervised the agricultural operations but very few of them actually participated in the operations. Per acre availability of active adult family member (for supervision work) was $\frac{45}{376} = 0.12$. (Average number of persons available per farm was 1.6.) Thus, we can say that the exclusion of the family labour does not vitiate our results.

Thirdly, we take "land" input. The marginal value productivity of a standardised acre is Rs. 99.94. The average rent per acre paid by a tenant-cultivator in Ankodia is Rs. 163.[3] This is very high compared to the marginal value productivity. Though the variation in the rent values is considerable (standard deviation : Rs. 61, C.V. 35 per cent). One gets the impression that there is an element of "quasi" rent in the rent received by landlords. About 95 per cent of the tenant-cultivators paid average per acre rent to the extent of Rs. 140 to 188.

Fourthly, the marginal productivity of a unit of "depreciation of implements" is 17.40. This sounds absurd at first but a closer examination shows that the figure is quite convincing. The depreciation was calculated by dividing the price of the implement by its expected life. The effect of this was to reduce the actual investment in agricultural implements $\frac{1}{8.88}$ times, on an average. Thus, a unit of this input (depreciation) corresponds to the "investment" of Rs. 8.88 in the agricultural implements. The marginal return of a rupee "invested" in agricultural implements would be 1.96.

Again, if we consider the replacement value[4] in place of the investment for agricultural implements, we get the marginal productivity to be Rs. 1.89. Thus, we find that the return of an additional rupee invested in the form of agricultural implements is highly fruitful to the farmer.

Fifthly, we consider the popular input "manure-fertilizer". We have already seen that the elasticity of this input is only 0.13. We further find that the marginal productivity of this factor is 0.73, *i.e.*, the return of an additional rupee is 73 *Paise*. The probable reasons for this are the following :

(1) The farmers included in the sample are already aware of the use of chemical fertilizers. They use it to such an extent that the return of an additional rupee is less than one rupee. The geometric mean of this input, for the sample is Rs. 1,039. The solution of the equation $\frac{d}{dx_3}\ (AX_1^{b_1}\ X_2^{b_2}\ X_3^{b_3} \ldots\ldots X_6^{b_6}) = 1$ with X_i ($i = 1, \ldots\ldots 6$) at their respective geometric means gave $X_3 =$ Rs. 707. This means that after 707, a rupee invested gave return worth less than one rupee.

(2) The combination in which manure-fertilizer and oil cakes are used may not be a scientific one.

(3) It may also be suggested that the effect reflected here gives a partial picture. Fertilizers and manures are used, generally, for important crops only, whereas the gross agricultural production considered here includes some less important crops for which fertilizers are not used. But as we see in Table II, tobacco, paddy and *Sundhia* for which fertilizers and manures were used occupied nearly 80 per cent of the total land. Hence the first or the second reason should mainly explain this state of affairs.

Since, the elasticity of production of "bullock input" is quite insignificant, *i.e.*, it is highly probable that the observed value has arisen by chance—the marginal value productivity of this unit is not interpreted.

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3. Imputed value of the crop-share.
4. This was obtained by evaluating the implements at the respective prices prevailing during the reference year.

SUMMARY AND CONCLUSION

An attempt is made here to fit a production function linear in logarithm for a purposive sample of farms of Ankodia village of Baroda district. The sample is supposed to represent that section of farmers who had least constraints as far as variable resources are concerned. The study reveals the following interesting points :

(*i*) The "water charges" paid by the farmers turns out to be the factor with the highest elasticity. The marginal productivity of a rupee invested in this resource is also as high as Rs. 4.78. Thus, the farmers could have profitably invested more in this input.

(*ii*) The wages paid to agricultural labourers are considerably lower than the marginal productivity of the wage-paid labour.

(*iii*) Though the well-to-do farmers are supposed to possess the requisite implements but in fact they do not. As such investment in implements can be profitably increased. Since the term "implement" includes a wide variety of tools and implements it is difficult to indicate precisely the nature of desirable investment in this category of input.

(*iv*) There is an element of "quasi rent" in the rent received by landlords.

(*v*) About the "manure-fertilizer" input, we see that there is at least a class of farmers who is saturated with this particular input and for them the agricultural production will not increase much as a result of more fertilizer use. There is also a need to examine whether the combination in which the farmers use chemical fertilizers, manures and oil cakes, is a scientific one.

B. K. NAIK*

IMPACT OF INTENSIVE CULTIVATION SCHEME PROGRAMME OF I.A.R.I. IN DELHI VILLAGES[1]

INTRODUCTION

The Indian Agricultural Research Institute, New Delhi launched its Intensive Cultivation Scheme in 1950-51. The scheme took its initial stimulus from the Land Transformation Plan proposed by the then Minister for Food and Agriculture, Shri K. M. Munshi in 1950 and the scientific bases for the application of the Land Transformation principle as outlined by Dr. B. P. Pal.[2] These involved the

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1. Contribution of the Division of Agricultural Economics, Indian Agricultural Research Institute, New Delhi.

2. See Land Transformation, I.C.A.R. Bulletins (1955) : (i) A Consideration of the Scientific Bases for Land Transformation as Applied to a Particular Village. (ii) Land Transformation for Qamaruddin Nagar (A Preliminary Study).

realistic working out of food, manurial, hydrological and other cycles in regard to each area such that matter consumed in nature could be properly replenished and improved upon in an integrated approach to land development in relation to the well-being of men and animals supported by the land. In effect, the Intensive Cultivation Scheme was an attempt to extend the tested results of researches in different branches of agricultural science to farms covered by the nineteen villages comprising the Intensive Cultivation Block which served as the field clinic of the Institute. The 91 sq. km. area, with its headquarters at village Nangloi in the Union Territory of Delhi is roughly shaped like a triangle with the base-line running parallel and south of the Northern Railway line and the apex pointing toward the *mandi* and industrial township of Najafgarh. In 1962, after a little over ten years of this work, the need was felt for assessing its impact on the farmers of the area as distinct and separate from the impact and spread effect of the agricultural development programmes conducted by the National Extension Service under the Delhi Administration. The data reported herein were gathered during the latter part of 1962.

Bench-mark study of the needed kind could not, for lack of staff, be conducted at the time of initiation of the scheme, nor was any systematic effort made at any subsequent stage. As is well-known, farmers do not maintain records. As such, a direct study of changes over time was not possible. Also, the effect of pure extension education work done by the Institute without the aid of special motivating devices such as grants, loans and subsidies to farmers commonly associated with developmental programmes, had to be isolated from the other influences at work in the area. The study therefore aimed to observe matching samples drawn from the Intensive Cultivation Block and the Non-Block areas (hereinafter designated as S and NS areas respectively,) such that, by comparison and contrast, the directions in which change attributable only to the extension activities of the Institute could be mapped and the extent of change measured where it was possible to do so.

METHODOLOGY

A preliminary survey of the territory encompassing both S and NS areas showed that farm holdings in the size-groups of less than 2 hectares (ha.), 2-4 ha., 4-6 ha. and over 6 ha. were roughly distributed in the proportions of 4, 3, 2, 1, respectively. Six villages were randomly selected to constitute each of the two samples, S and NS. In each village ten holdings were selected at random from different size strata in the proportions indicated. All possible care was exercised in selecting the two groups to ensure comparability of agro-economic features such as soil type, irrigation, age and educational status of '*Kartas*' (chief farm executives) of the farm families. Some details are summarised in Table I.

TABLE I

Particulars	S	NS
Number of holdings	60	60
Cultivated area in the sample (ha.)	213·3	211·8
Average cultivated area per holding (ha.)	3·6	3·5
Proportion of cultivated area in the holding reported as irrigated	72·7%	71·9%
Number of draft animals per holding	1·6	1·8
Average size of farm family	9·8	10·0
Percentage literacy in families sampled	28·6	27·9

OBSERVATIONS

Irrigation Resources

The bulk of the area was irrigated by wells. Although the irrigated fraction of the cultivated area was reported to be more or less equal in S and NS samples, a closer look at the irrigational resources revealed that the number of wells and *rahats* (Persian wheels) was larger in the S area. This will be clear from Table II.

TABLE II

Size-group of holding	Cultivated hectares per irrigation well	
	S	NS
2 ha.	1·5	3·8
2-4 ha.	2·3	3·8
4-6 ha.	3·1	3·8
Over 6 ha.	4·2	7·6
Overall	2·6	4·5

In terms of actual possession of irrigational resources, the NS area appeared to have 'extensive' kind of irrigation whereas the S area enjoyed irrigation facilities of a somewhat 'intensive' character.

Irrigation and Other Improved Agronomic Practices

Effort was made to trace if any association existed between the better irrigational resources at farmers' disposal in the S area and the use to which these resources were put. Relevant information obtained on this subject is presented in Table III.

TABLE III

Size-group (ha.)		Average size (ha.)	No. of irrigation wells per holding	Hectares of land per irrigation well	Per cent of cultivated area under irrigated crop (wheat)	Average number of irrigations given to wheat
2	S	1·51	1·0	1·5	53·7	4·3
	NS	1·49	0·4	3·8	42·9	2·7
2-4	S	3·04	1·3	2·3	46·3	3·8
	NS	3·03	0·8	3·8	39·7	2·6
4-6	S	5·24	1·7	3·1	42·4	3·4
	NS	5·00	1·3	3·8	36·8	2·5
6	S	9·76	2·3	4·2	34·2	3·1
	NS	10·58	1·5	7·0	30·5	2·2
Overall	S	3·60	1·4	2·6	44·0	3·6
	NS	3·56	0·8	4·5	37·3	2·5

The percentage of total cultivated area sown to an important irrigated crop like wheat and the average number of irrigations given to it steadily declined with increase in land to well ratio and with increase in the size of holdings. In each size-group, the land to well ratio was lower and the other proportions were higher in the Intensive Cultivation Scheme area as contrasted with the NS area. Unfortunately, a chronological sequence of the developments over the decade of work done by the Institute leading to the present difference between Scheme and Non-Scheme farms could not be traced at this late stage.

Crop Pattern and Use of Improved Crop Varieties

Mention has been made in the preceding paragraph of the higher proportion of area sown to the important crop wheat and to the more liberal applications of irrigation to this crop in the Intensive Cultivation Scheme area. One of the important agronomic recommendations for the area is reductions in seasonal fallow in the *kharif* season and the application of liberal doses of nitrogenous fertilizers to the following wheat crop. In effect, this recommendation also amounts to a higher intensity of cropping. Evidence available with particular reference to wheat crop is cited in Table IV.

TABLE IV

Size-group (ha.)		*Kharif* fallow (percentage of cultivated area)	Intensity of cropping	Quantity of nitrogenous fertilizers used (Kgs. per holding)	Average yield of wheat (quintal per hectare)
2	S	34·5	151	27·2	17·8
	NS	42·0	140	19·2	17·1
2-4	S	34·9	145	31·3	18·3
	NS	38·6	135	23·5	16·4
4-6	S	36·3	139	41·4	18·9
	NS	36·4	128	32·8	17·2
6	S	33·8	137	66·0	20·8
	NS	30·5	125	38·1	15·0
Overall	S	34·9	143	41·5	18·8
	NS	36·9	132	28·4	16·7

For each size-group except the highest, the percentage of fallow land to total cultivated area during the preceding *kharif* season was larger on the S farms than on NS farms, the difference being more obvious in the two smallest size-groups. At the same time, the intensity of cropping, declining from small to large farms, was higher in the S group Farmers in the Scheme area used 26 to 70 per cent more nitrogenous fertilizers on wheat than their non-Scheme counterparts, the difference being remarkable in the highest size-group.

Between 67 to 83 per cent (average 74 per cent) of the wheat area on non-Scheme farms as against 82 to 100 per cent (average 85 per cent) on the farms in Intensive Cultivation Scheme area was reported to be under improved varieties (N.P. 718, C281, N.P. 823, N.P. 824 and C591 in order of spread). The areas sown to sugarcane, peas and vegetables although small, were all reportedly under improved varieties on both S and NS farms. In both types of sample farms, the percentage of area reportedly sown with improved varieties were small in the case of bajra and jowar in the *kharif* season and gram in the *rabi* season. The major difference noticed, as already indicated, related to wheat.

Use of Manures and Fertilizers

There is widespread recognition of the growing problem of salinity and alkalinity in the entire area and farmyard manure is the principal soil ameliorator on which the farmers rely. On an average, each S holding reported using 28 cartloads of farmyard manure annually as against 18 cartloads on the NS holding. As to the use of chemical fertilizers, nitrogenous fertilizers were the most in evidence. Some stray cases of use of phosphatic fertilizers were also noticed. The use of potassic fertilizers was not at all reported in either area.

Because of the large area under wheat and the importance attached to this crop as a source of food, fodder for cattle and cash, it claimed almost 85 and 80 per cent of the total farmyard manure used in the S and NS areas respectively. The quantities of nitrogenous fertilizers used for the crop have already been reported in Table IV. For the entire sample under S and NS respectively, the quantities of nitrogenous fertilizers applied to wheat constituted 86 and 90 per cent of the total quantities used on the farm. The remaining were used to fertilize small acreage of bajra, sugarcane and vegetables. Little mention was made of use of green manures in these areas. Apart from free supplies of materials and chemicals for plant protection work, there was hardly any mention made of expenses incurred on plant protection measures.

Crop Production Levels

As a consequence of the better use of irrigation resources often inter-linked with use of larger quantities of manures and fertilizers and the higher intensity of cropping presumably coupled with superior managerial ability and technological support from the staff of the I.A.R.I. in the S group of farms, production levels of almost all crops were found to be higher than what obtained in the NS group of farms. This will be clear from Table V.

TABLE V

Crop	Average yield in quintals			
	Per holding		Per hectare	
	S	NS	S	NS
Wheat	25·79	21·83	18·8	16·7
Wheat + gram	2·61	1·83	13·2	13·5
Gram	9·26	8·51	8·3	6·7
Barley	0·41	1·60	19·5	20·3
Jowar fodder (dry)	31·91	24·04	28·9	22·7
Mustard	1·01	0·86	Usually sown in lines with other crops	
Bajra	4·96	6·79	4·1	4·0
Sugarcane (*Gur*)	2·24	3·66	32·6	33·1

Livestock Improvement

The important directions in which farms serviced by the Intensive Cultivation Scheme of the Institute appeared to be superior to the non-Scheme farms were the higher area put under wheat and the higher per hectare yields obtained from wheat and jowar fodder. The superiority of the Scheme farms in fodder production seems to have stimulated a corresponding improvement in the livestock maintained on farms and their productive efficiency as will be evident from the following responses obtained.

Particulars of livestock production		S	NS
1. Average lactation yield per head of milch stock (Kgs.)	Buffalo	1,892	1,624
	Cow	963	829
2. Average annual production of milk per holding (Kgs.)	..	2,407	2,161
3. Average value of livestock sold off during the year (Rs.)	..	459	375

Farm Incomes

How beneficial has the scheme been to the farmers: Not all the benefits can be measured in terms of money. For instance, improvements in their decision-making ability, the superior ability to adjust to changing farm economies and better technical know-how which is theirs for good to help them reap greater gains from farming as superior inputs become more readily available in future, all these, cannot be assessed in terms of rupees. However, net income per holding should largely reflect the benefit that has accrued to the community from the working of the Intensive Cultivation Scheme since 1950-51. The following summary speaks for itself.

Particulars	S (Rs.)	NS (Rs.)	Difference (Rs.)
1. Average annual gross returns per holding from crop production : (a) Main products	1,932	1,851	
(b) By-products	958	868	
(c) Total crops	2,890	2,719	+ 171
2. Average annual gross returns per holding : (a) from milk production	1,291	1,158	
(b) from sale of livestock	61	100	
(c) Total livestock	1,352	1,258	+ 217
3. Total from crops and livestock	4,242	3,977	+ 265
Deduct annual cash expenses	354	327	— 27
Net annual farm business income	3,888	3,650	+ 238
Average net business income per hectare	1,080	1,043	+ 37

The Scheme farmer, it will be observed, ploughs into his business labour and materials worth Rs. 27 more than his counterpart in the non-Scheme area and obtains a net additional sum of Rs. 238 for this investment; a ratio of 8.8 to 1. For the 2,311 farming units in the nineteen villages under the scheme, the contribution measured in monetary terms of the extension activities of the I.A.R.I. aggregates to about Rs. 5½ lakhs annually.

Capital Formation on Individual Holdings

Due to the considerable difficulty involved in getting a reasonably correct picture of income, expense and equity position on individual farms, the above figures can merely be taken as rough indicators. Naturally, the superiority in farm business incomes of the holdings in the S group over a number of years have been written into a corresponding advantage enjoyed by them in respect of capital assets including quality of livestock and even buildings for residential-cum-farm purposes. This will be evident from the data presented below:

Details		S		NS
1. Estimated value of implements per holding :		Rs.		Rs.
(a) Ordinary		411		388
(b) Improved*		537		338
Total		948		726
2. Estimated value of irrigation wells per holding ..		2,079		1,252
3. Estimated value of livestock :				
Bullocks (a) per head of stock ..	(546)		(461)	
(b) per holding		874		830
Camels (a) per head of stock ..	(618)		(549)	
(b) per holding		105		165
She-Buffaloes (a) per head of stock ..	(547)		(488)	
(b) per holding		738		517
Milch-cows (a) per head of stock ..	(182)		(184)	
(b) per holding		84		147
Total		4,828		3,637

* inclusive of *rahat* (Persian wheel).

CONCLUSION

Sarvashri P. C. Raheja and A. R. Khan[3] have described the objectives with which the Intensive Cultivation Scheme was launched in 1951. These objectives were grouped as larger consumption of inputs contributing to increased output, control of wastes, conservation of resources and overall improvements in efficiency of production. While attention was no doubt devoted to items such as improvement of livestock through Key Village Scheme operation, the bulk of the programme aimed at improvements in crop production. Major items of work included were: (*a*) introduction of improved crop varieties; (*b*) maintenance of varietal purity; (*c*) adoption of improved cultural practices; (*d*) use of manures and fertilizers; and (*e*) use of improved implements.

The achievements narrated by these authors refer principally to improvements effected in crop production. However, as the present evaluation survey has revealed, the changes actually noticed have, in certain cases, gone beyond what was

3. P. C. Raheja and A. R. Khan, "I.A.R.I.'s Intensive Cultivation Scheme," *Extension Quarterly*, October, 1958, pp. 33-39 ; and "The Delhi Intensive Cultivation Scheme" *Indian Farming*, December, 1958, pp. 19-22.

conceived in the programme or reported until the end of 1958. Convinced with the crop demonstrations given on their fields, the local farmers presumably made efforts to strengthen their irrigational resources. Starting with the adoption of selected key practices for improved crop production such as use of better seeds, they blended varietal improvement with higher use of irrigation and fertilizers. Basing subsequent programmes on these changes, they proceeded to improve their livestock. As a consequence, feeding and management of livestock as well as the quality of the stock have undergone considerable improvement. As Mosher and Case[4] have put it, 'It is seldom possible to put into effect all the better practices at once.........The effects of some of the better practices are accumulative, they tend to become more pronounced from year to year.........' Judged by the results, the Intensive Cultivation Scheme of the I.A.R.I. has made a good impact. The results of the survey bear out the wisdom of the land transformation concept as outlined a decade earlier. The directions in which the farm economy in the area has developed indicate a material strengthening of the hydrological cycle, the milk production cycle and the food production cycle, one cycle re-inforcing another. One of the principal by-products of this work has been the improvement which has come about in the quality of research work conducted in the various Divisions and the problem-solving focus which most research programmes have received as a result of the extension activities in the villages.

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MARKETABLE SURPLUS IN MAIZE

The increased hoarding capacity of the producers is one of the important factors aggravating the recent economic crisis of spiralling prices of foodgrains. The hoarding capacity of the producer depends upon his financial position to retain the produce, the credit and storage facilities available to him, price level in the market, nature of the crop and his other obligations. "The marketable surplus represents the theoretical surplus available for disposal with the producer, left after his genuine requirements of family consumption, seeds, payments of wages in kind, fee and wastage having been met. This is distinguished from the marketed surplus which represents only that portion of the marketable surplus which is actually marketed and is placed at the disposal of non-producers. Marketed surplus may be less, equal to or, even more than the marketable surplus depending upon the external factors operating on the market economy."[1] The hoarding capacity of the cultivators increases with the consequent reduction in the size of the marketed surplus thereby affecting the total supply and the price level in the market.

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4. M. L. Mosher and H. C. M. Case : Farm Practices and Their Effects on Farm Earnings, University of Illinois A.E.S. Bull., 444/38.

* Division of Agricultural Economics, Indian Agricultural Research Institute, New Delhi-12.

1. P. C. Bansil, "Problems of Marketable Surplus," *Indian Journal of Agricultural Economics* Vol. XVI, No. 1, January-March 1961, p. 26.

The marketed surplus, of late, has been affected by the following factors : (*i*) The various land reform measures. (*ii*) Increased income of the cultivators. (*iii*) Increased facilities of cheaper institutional finance. (*iv*) Increased storage facilities provided by the Central and State Warehousing Corporations and the co-operative societies. (*v*) Speculative tendency due to uncertainty of prices.

Because of the abolition of intermediaries produce is now placed in the hands of large number of small cultivators who were previously not in a position to meet their home requirements from their total produce or wages in kind. The increased incomes of these cultivators and better facilities of cheaper institutional finance to them has increased their propensity to consume thereby reducing the marketed surplus.

Problems of marketable surplus have therefore received considerable attention of researchers in India and besides the estimates of the Directorate of Marketing and Inspection, Government of India, a considerable number of estimates of marketed surplus have been put up from time to time by researchers for the various agricultural commodities in their respective regions. An attempt is made here to present a broad picture of the pattern of disposal, marketable and marketed surplus in maize in Jaunpur district of Uttar Pradesh. The observations are based on the study of 80 randomly selected cultivator families from among 20 randomly selected villages of all the five tahsils of Jaunpur district. Survey method was used for the collection of primary data for which schedules were filled up by frequent personal visits to the cultivators.

Jaunpur district is situated in the eastern fringe of the State of Uttar Pradesh and is one of the four eastern districts of Uttar Pradesh which are supposed to be economically backward as compared to other districts of Uttar Pradesh. The normal rainfall of the district is about 38 inches. Out of the total area of 9,95,410 acres in 1962-63, about 74.53 per cent area was cultivated. A little more than half of the net sown area of the district was under irrigation, out of which more than 83 per cent was irrigated by wells. The soils of the district are mainly loam and clay, while sandy soils are also obtained in the areas adjoining the rivers Gomati and Sai. The total population of the district according to 1961 Census was 1,727,264 with 1,119 persons per square mile. More than four-fifth of the total working population comprises of agriculturists.

Rice, barley, maize, wheat, peas, sugarcane and gram, etc., are the major crops of the district, while out of the net cultivated area of 7,40,839 acres (1962-63) maize occupies 1,00,664 acres or about 13.58 per cent. Most of the maize grown is under rain-fed condition. Maize is commonly grown in one year rotation with potato, tobacco or onion, in two years rotation with potato and wheat and in three years rotation with jowar, *arhar*, barley, paddy and pea. Maize occupies quite an important place in the economy of the district, as the district is famous for the cultivation of good quality maize. Jaunpur has comparatively large acreage under maize and also occupies an important place in respect of maize production in Uttar Pradesh. Maize has obviously important place in the budgets of the Jaunpur cultivators. Any increase or decrease in the area and/or production of maize in Jaunpur will have a considerable effect on the agricultural economy of the district.

Area, Production and Yield per Acre of Maize

It may be noted that the average size of holding of the sample was about 3.1 acres out of which 0.8 acre was found to be occupied by maize during 1962-63. Maize thus occupied a little more than one-fourth of the total area of the holding. The average yield per acre of maize for the sample was 10.16 maunds of grain and 39.18 maunds of fodder. As regards the allocation of area under maize in relation to size of holding, it was observed that smaller size of holdings had comparatively larger proportion of area under maize.

The distribution of sample families according to area, production and yield per acre revealed that the modal size-group is below 0.5 acre having 36 families in that group. About one-fourth of the families were at a total production level between 5 to 10 maunds of maize. The maximum yield per acre recorded was 18.50 maunds, while the minimum was 6.75 maunds per acre. The modal group was 8 to 10 maunds per acre and the number of families reporting yield per acre in this modal group was 29. Hardly three families reported yield per acre of about 16 maunds, while hardly 10 per cent of the families reported yield per acre of about 14 maunds.

Pattern of Disposal, Marketable and Marketed Surplus in Maize

That the pattern of disposal has a definite relationship with the size of holding would be evident from Table I. The data in the table reveal the following broad features:

(1) The proportion of produce for home consumption to total production was found to be decreasing with the increase in size of holding.

(2) No definite relationship as regards retention for seed was observed.

(3) The proportion of maize disposal in the form of kind wages to total production showed a positive correlation with the size of holding. This was because of the predominance of family labour on small holdings and of hired labour (which is usually paid in kind) in the total labour inputs on larger holdings.

(4) The marketed surplus of maize also showed a positive correlation with the size of holding.

(5) The stocks of maize withheld by the farmer indicated an increase with the increase in size of holding.

(6) The marketable surplus too showed a positive correlation with the size of holding.

(7) The smaller cultivators (below 0.5 acre holding) had no marketable surplus at all.

Dr. P. C. Bansil[2] gave a theoretical estimate of marketable surplus to total production of maize to be 24 per cent in 1958-59 while Dr. M. Srinivasan[3] estimated

2. *Op. cit.*, p. 26.
3. *Op. cit.*, p. 106.

TABLE I—PATTERN OF DISPOSAL, MARKETABLE AND MARKETED SURPLUS

S. No.	Particulars	Size of holding (in acres)				
		Below 0·5	0·5 to 1·0	1·0 to 2·5	2·5 to 5·0	5·0 and above
1.	Number of holdings	5	15	20	20	20
2.	Total average production (in maunds)					
	(a) Total	1·10	2·35	6·38	10·51	16·08
	(b) Percentage	100·00	100·00	100·00	100·00	100·00
3.	Average disposal (in maunds)					
	(i) Home consumption :					
	(a) Total	1·10	2·19	4·23	5·29	5·85
	(b) Percentage	100·00	93·20	66·30	50·34	36·40
	(ii) Seed					
	(a) Total	Nil	0·02	0·38	0·57	0·84
	(b) Percentage	Nil	0·80	6·00	5·43	5·20
	(iii) Wage					
	(a) Total	Nil	Nil	0·4	0·92	1·82
	(b) Percentage	Nil	Nil	6·30	8·75	11·30
	(iv) Marketed surplus					
	(a) Total	Nil	0·07	0·62	2·40	4·85
	(b) Percentage	Nil	3·00	9·70	22·83	30·20
	(v) Stock					
	(a) Total	Nil	0·07	0·75	1·33	2·72
	(b) Percentage	Nil	3·00	11·70	12·65	16·90
4.	Marketable surplus = (Marketed surplus + Stock)					
	(a) Total	Nil	0·14	1·37	3·73	7·57
	(b) Percentage	Nil	6·00	21·40	35·48	47·10

the marketed surplus for maize to be 24.5 per cent. The marketed surplus in maize for the sample was found to be 22 per cent while the marketable surplus was about 35.5 per cent. Thus the fact that marketable surplus in maize for Jaunpur sample was much higher than the estimate given by Dr. Bansil (based on the various marketing reports) while the marketed surplus was comparatively less than the estimates of Dr. Srinivasan (also based on the marketing reports of the Directorate of Marketing and Inspection) indicates a comparatively higher hoarding capacity for maize of the sample cultivators from Jaunpur.

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AND
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