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# GREEN REVOLUTION AND BREAK-THROUGH IN FOOD PRODUCTION IN INDIA

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During the past few years there has been much debate on the 'Green Revolution' in Indian agriculture. The Government of India (Ministry of Food and Agriculture) claimed that India would become self-sufficient in food within a short span of time. The obvious question put before the agricultural scientists is whether India has really achieved a break-through in agriculture. Of late, the common man has been convinced that India is witnessing a green revolution in agriculture. Revolution or, say, break-through, is entirely different from self-sufficiency. A country may reach the self-sufficiency target but even then it may not pass through a 'revolution'. Then what is meant by 'revolution' in production ?

The present study aims at examining the behaviour of the food production data over the years, by calculating the percentage per annum compound growth rates and examining whether India has really achieved a break-through due to higher production or is just approaching it. By 'break-through' we mean a definite diversion from the general trend line in such a manner that a higher trend is established, In fact 'break-through' or 'revolution' can be claimed with certain probability. So, we may say that with 95 per cent confidence there is a revolution. We are not hundred per cent sure in claiming a 'revolution'. If the production points on a graph go beyond the upper or lower limits we say that they belong to different population. If they go beyond the upper line we say there is a break-through; if they fall below the lower limits we consider the years as abnormal or bad years.

Accepting the hypothesis that we have achieved a break-through, it is important to examine whether the revolution or break-through is confined to particular crops like wheat or jowar or that it is setting in the total foodgrain production also. Wheat may be experiencing a 'revolution' but rice may not. Then can we call it a break-through for the whole of the agricultural sector? This point is examined by taking various crops and studying their behaviour.

Sometimes the question of regional growth and imbalance also arises. Break-through may be true say, for example, in Punjab but not in other States. In this case can we generalise the performance of a particular State to that of the country as a whole ? To see this, Statewise analysis of crop-production data has been attempted. Important crops like rice, wheat, jower, etc., have been selected for analysis for various States depending upon the cropping

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pattern. Crops for which the total gross area sown is about one-tenth of the total foodgrain area in each State have been chosen for the analysis.

This study also examines the debatable point raised by B. S. Minhas and T. N. Srinivasan in an article.[1] In his article Ashok Mitra[2] analysed the fluctuating tendency of the food production data He concluded that the much talked 'green revolution' has not yet occurred in India. Minhas and Srinivasan criticised Mitra for including the two drought affected years, 1965-66 and 1966-67 in his study. According to them, except these two years the observations for the period 1950-51 to 1967-68 could be considered as coming from the same population. They claimed that for foodgrains as a whole the chances of observing a year like 1965-66 (or 1966-67) or worse are less than one in two-hundred years.[3] So these 'abnormal' years should be excluded from the analysis.

For this purpose we analyse the data for various periods as follows :

| | |
|---|---|
| Period I | 1949-50 to 1969-70. |
| Period II | 1949-50 to 1964-65. |
| Period III | 1949-50 to 1969-70 (excluding the abnormal years 1965-66 and 1966-67). |
| Period IV | 1949-50 to 1969-70 (expected production figures used for the two abnormal years). |

By doing this we are able to see the effect of inclusion of 'abnormal years' on the growth rate. Period IV tells us that if the growth rate of Period II is maintained and we get the production figures for the abnormal years on the basis of the growth rate of Period II, then a new series can be generated eliminating the effect of the abnormal years. Table I gives the Statewise coverage of important crops for the period 1949-50 to 1969-70.

TABLE I—STATEWISE COVERAGE OF IMPORTANT CROPS: 1949-50 TO 1969-70

| Crops | States |
|---|---|
| Rice .. .. .. | Andhra Pradesh, Assam, Bihar, Gujarat, Rajasthan, Kerala, Madhya Pradesh, Maharashtra, Mysore, Orissa, Tamil Nadu, Uttar Pradesh and West Bengal. |
| Wheat .. .. .. | Bihar, Madhya Pradesh, Rajasthan, Haryana, Punjab and Uttar Pradesh. |
| Maize .. .. .. | Bihar, Punjab and Haryana. |
| Jowar .. .. .. | Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu and Mysore. |
| Bajra .. .. .. | Gujarat and Maharashtra. |
| Foodgrains .. .. .. | Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Kerala, Madhya Pradesh, Maharashtra, Mysore, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. |

1. "Food Production Trends and Buffer Stock Policy," *The Statesman*, November 14, 1968.
2. "Bumper Harvest Has Created Some Dangerous Illusions," *The Statesman*, October 14 and 15, 1968.
3. Minhas and Srinivasan, *ibid*.

For all-India we have analysed all the five crops and also total foodgrains production.

For Maharashtra and Gujarat we have analysed the production data from the inception of the two States. The old State of Bombay has not been considered. So we have only one period of analysis for these two States.

In the case of Punjab and Haryana we have separate figures only from the year 1965-66 onwards. This five-year period is too short a period for regression analysis. We have the old Punjab figures till 1964-65. To extend the period backwards we assume that the proportions of production in the two States remain the same for the entire period. That means the shares of production of the two States to the combined total production are assumed to be constant. This may not be a very sound proposition but fairly good enough for the purpose of analysis. We have the figures for the five-year period. We get the proportions of production for both of the States for foodgrains, wheat and maize and get the simple average of the five proportions so obtained. This way we arrive at the figures 0.39 and 0.61 for Haryana and Punjab respectively for total foodgrains. That is, out of the total food production of the two States combined, Haryana contributed 39 per cent and Punjab 61 per cent. Similarly for wheat and maize, the figures for the two States are 0.30 and 0.70 respectively. Using these percentages we extend back upto 1949-50 and get the complete period 1949-50 to 1969-70. For these two States also we have analysed only one whole Period I.

*Methodology*

Linear regression models have been applied to the time-series data on total production and index of production of various crops under study. All the assumptions of regression analysis have been taken to be fulfilled which may not be true for a time-series. If $P_t$ denotes the production figures for the $t^{th}$ period then the fitted regression is of the type

$$P_t = ab^t u_t \quad .. \quad .. \quad .. \quad (1)$$

$$\text{or } \log P_t = \log a + t. \log b + \log u_t \quad .. \quad .. \quad .. \quad (2)$$

$$\text{or } Y_t = A + B_t + E_t. \quad .. \quad .. \quad .. \quad (3)$$

whole tolerance limits are given by

$$L_1 = \hat{Y}_t - ks$$

$$L_2 = \hat{Y}_t + ks$$

where k is a constant to be determined and s is given by equation (4).

This is simply a general trend fitting and may not be very much attractive. From here we get the per annum per cent compound growth rates. This is given by (antilog B—1) $\times 100$. We calculate the index of determination, $R^2$ for goodness of fit. We test the hypothesis that B=0 by using the t-test. The justification for the model used may be questioned right at the outset. Alternatives such as the Gompertz's curve or any other exponential model may be suggested for Indian agriculture. But the use of the simple model $P_t=ab^t$ may not be discarded. Indian agriculture has enough potential to higher growth with time. In Indian condition agricultural production is much affected by the weather conditions and the observed departure from the trend line could be ascribed to random disturbances.

It is always desirable to fit a production function if data on various inputs are available. But up-to-date data on the use of fertilizer for different crops, the area under high-yielding varieties, area irrigated, etc., are not easily available. The area irrigated for different crops are available, only upto 1964-65 and do not carry much meaning at all. Only the area sown and rainfall data can be used. That also for different crops the rainfall data need proper and cumbersome adjustments. Keeping all these in mind we have not attempted in fitting a production function to the production data. Here we are mainly interested in the 'break-through' aspect. The analysis of the production data has simply degenerated the study into a trend-fitting exercise. The determination of a level above which the production figures will fulfil the meaning of a break-through, is rather a difficult and subjective task. Statistical analysis will only ascertain the acceptance of break-through with certain probability. The purpose may be solved by finding out 'tolerance limits' for the regression line $Y_t=A+B_t$.

Pairs of limits within which a specified proportion of the observations in some population may be expected to lie are called tolerance limits. In general terms, let f(y) be density function, and on the basis of a sample of N values, it is desirable to determine two numbers $L_1$ and $L_2$ such that a proportion p of the area of f(y) is between $L_1$ and $L_2$. On the basis of a sample we cannot be certain that p say, 0.95 of the area of f(y) is between $L_1$ and $L_2$, but we may be able to ascertain that a proportion p of the population lies between $L_1$ and $L_2$ with a certain probability, say, which may be a specified confidence coefficient also. So, we want to find two functions $L_1=L_1\ (y_1,y_2,\ldots y_N)$, $L_2=L_2\ (Y_1,Y_2,\ldots\ldots Y_N)$ of the random $Y_1\ldots\ldots Y_N$.

If s is defined by

$$s^2 = \frac{\sum_{i=1}^{N} (Y_i - \hat{Y}_i)^2}{N-2} \qquad \ldots \quad \ldots \quad \ldots \quad (4)$$

then the tolerance limits are given by

$$L_1 = \hat{Y} - ks$$

$$L_2 = \hat{Y} + ks \qquad .. \quad .. \quad .. \quad .. \qquad (5)$$

for some constant k to be determined and $\hat{Y}$ is estimated value of Y.

The calculation of tolerance limits poses problems and for the sake of simplicity we assume that the Wald-Wolfowitz approximation[4] for the calculation of tolerance limits holds good. The approximation is useful in finding out the value of the constant k.

To find an interval within which we can assert with confidence coefficient that at least a proportion p of the population lies, we select some value of the independent variable, here time t, and calculate

$$N' = \frac{N \Sigma (t - \bar{t})^2}{\Sigma (t - \bar{t})^2 + N (t - \bar{t})^2} = \frac{1}{\frac{1}{N} + \frac{(t - \bar{t})^2}{\Sigma (t - \bar{t})^2}} \qquad .. \qquad (6)$$

If $K_p$ is the number which a unit normal deviate has probability (1—p) of exceeding in absolute value,

$$i.e., \text{ if } \quad \frac{1}{\sqrt{2\pi}} \int_{-Kp}^{Kp} e^{-u^2/2} \, du = p \qquad .. \quad .. \quad .. \qquad (7)$$

then, the constant k is given by

$$k = r. \frac{n}{\sqrt{\chi^2_r(n)}} \qquad \text{for } n = N - 2 \quad .. \quad .. \quad .. \qquad (8)$$

and, where r is given by

$$r = K_p \left(1 + \frac{1}{2N'} - \frac{2K_p^2 - 3}{24 N'^2}\right) \qquad .. \quad .. \quad .. \qquad (9)$$

4. "Tolerance Intervals for Linear Regression," W. Allan Wallis, Proceedings of the Second Berkely Symposium, University of California Press, Berkely, 1951, pp. 53-59.

Other references: (*i*) "Growth of Crop Output in India, 1951-54 to 1958-61—An Analysis of Component Elements," B. S. Minhas and A. Vaidyanathan, *Journal of the Indian Society of Agricultural Statistics*, Vol. XVII, No. 2, December, 1965, pp. 230-252, and (*ii*) Agriculture in Economic Development, Edited by Carl. K. Eicher and Lawrence W. Witt, McGraw-Hill Book Co., New York, 1964.

where N′ is given by (6)

$$\text{we have } K_p = 1.96 \text{ for}$$

$$p = 0.95$$

$$r = 0.95$$

We find out the 95 per cent tolerance limits and then can come to a conclusion regarding 'break-through' or 'green revolution.'

## RESULTS

The results have been summarised in the tables.[5] Table II shows the values of the linear regression coefficients of production of different crops for different States and for India for the periods. There are four parts of the table each giving the values for the four periods under study. Table III is just the reproduction of Table II except that it gives the per cent per annum compound growth rates. Blank cells show that the particular crop has not been taken for the concerned State. Table IV is a detailed table giving cropwise values of percentage per annum growth rates, values of $R^2$ and the values of Student-t for significance. The fit is very good as determined by the values of $R^2$ and we are justified in fitting the exponential model $P_t=ab^t$. Calculated t values are compared with the table values to see the significance of the regression coefficients some of them being significant at 1 per cent level also. Table V gives the information for the States of Gujarat, Maharashtra, and Haryana and Punjab for which only one period, *viz.*, 1949-50 to 1969-70 has been taken into account due to reorganization.

The index of agricultural production with base 1949-50=100 for the selected crops has also been analysed for India only and the results have been summarised in Table VI. Tables VII and VIII show the comparative picture of actual production (in log) and their upper and lower tolerance limits for a few crops for India, Punjab and Haryana. This gives an idea of deviation and its extent to cross the limits. Table IX gives the number of regressions for the States for total production.

Besides, the index of agricultural production for the six crops has been analysed for India only for the period 1949-50 to 1969-70. Thus in all we have 185 regressions and to plot all of them is a cumbersome job. For each of the 185 regressions the tolerance limits have been calculated separately.

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5. The source of data is Estimates of Area and Production of Principal Crops in India from 1949-50 to 1969-70, Ministry of Food and Agriculture, Government of India.

TABLE II—REGRESSION COEFFICIENTS OF PRODUCTION OF DIFFERENT CROPS

| States/Crops | India | Andhra Pradesh | Assam | Bihar | Kerala | Madhya Pradesh | Mysore | Orissa | Rajas-than | Tamil Nadu | Uttar Pradesh | West Bengal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Period—I | | | | | | |
| Foodgrains | 0.01194 | 0.01236 | 0.02161 | 0.01213 | 0.00638 | 0.01101 | 0.01562 | 0.02721 | 0.02283 | 0.01444 | 0.00780 | 0.00803 |
| Rice | 0.01295 | 0.01877 | 0.02282 | 0.01017 | 0.01540 | 0.00543 | 0.02346 | 0.02930 | | 0.02077 | 0.01158 | 0.00838 |
| Wheat | 0.02070 | | | 0.02559 | | 0.01584 | | | 0.02634 | | 0.01672 | |
| Maize | 0.02405 | | | 0.02907 | | | | | | | | |
| Jowar | 0.00998 | 0.00808 | | | | 0.02190 | 0.01584 | | | | | |
| Bajra | 0.01108 | | | | | | | | | | | |
| | | | | | | Period—II | | | | | | |
| Foodgrains | 0.01478 | 0.01690 | 0.02231 | 0.01572 | 0.00414 | 0.01836 | 0.01805 | 0.02871 | 0.03890 | 0.02010 | 0.00683 | 0.00532 |
| Rice | 0.01722 | 0.02402 | 0.02194 | 0.01790 | 0.01850 | 0.01361 | 0.02549 | 0.02737 | | 0.02791 | 0.00963 | 0.00822 |
| Wheat | 0.01837 | | | 0.01474 | | 0.02801 | | | 0.03961 | | 0.01781 | |
| Jowar | 0.01420 | 0.01237 | | | | 0.02632 | 0.01496 | | | | | |
| Maize | 0.02672 | | | 0.03106 | | | | | | | | |
| Bajra | 0.01109 | | | | | | | | | | | |
| | | | | | | Period—III | | | | | | |
| Foodgrains | 0.01484 | 0.01424 | 0.02268 | 0.01619 | 0.00702 | 0.01570 | 0.01876 | 0.02641 | 0.02932 | 0.01692 | 0.00974 | 0.00914 |
| Rice | 0.01612 | 0.02115 | 0.02271 | 0.01604 | 0.01795 | 0.01092 | 0.02718 | 0.02723 | | 0.02409 | 0.01561 | 0.00998 |
| Wheat | 0.02430 | | | 0.03023 | | 0.02290 | | | 0.03324 | | 0.01835 | |
| Maize | 0.02700 | | | 0.03182 | | | | | | | | |
| Jowar | 0.01241 | 0.00969 | | | | 0.02553 | 0.01746 | | | | | |
| Bajra | 0.01250 | | | | | | | | | | | |
| | | | | | | Period—IV | | | | | | |
| Foodgrains | 0.01379 | 0.01351 | 0.02172 | 0.01502 | 0.00625 | 0.01487 | 0.01737 | 0.02711 | 0.02815 | 0.01603 | 0.00877 | 0.00811 |
| Rice | 0.01510 | 0.01995 | 0.02184 | 0.01502 | 0.01674 | 0.01043 | 0.02510 | 0.02688 | | 0.02278 | 0.01473 | 0.00910 |
| Wheat | 0.02201 | | | 0.02660 | | 0.02179 | | | 0.03155 | | 0.01622 | |
| Maize | 0.02509 | | | 0.02954 | | | | | | | | |
| Jowar | 0.01172 | 0.00918 | | | | 0.02385 | 0.01548 | | | | | |
| Bajra | 0.01149 | | | | | | | | | | | |

TABLE III—COMPOUND GROWTH RATES OF PRODUCTION OF DIFFERENT CROPS

(*per cent per annum*)

| States/Crops | India | Andhra Pradesh | Assam | Bihar | Kerala | Madhya Pradesh | Mysore | Orissa | Rajasthan | Tamil Nadu | Uttar Pradesh | West Bengal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Period—I | | | | | | | |
| Foodgrains .. | 2.79 | 2.89 | 4.76 | 2.83 | 1.48 | 2.59 | 3.66 | 4.99 | 5.40 | 3.39 | 1.81 | 1.88 |
| Rice .. | 3.03 | 4.22 | 4.98 | 2.37 | 3.60 | 1.26 | 5.55 | 5.51 | | 4.90 | 2.70 | 1.95 |
| Wheat .. | 4.88 | | | 6.07 | | 3.71 | | | 6.25 | | 3.93 | |
| Maize .. | 5.69 | | | 6.92 | | | | | | | | |
| Jowar .. | 2.32 | 2.09 | | | | 5.17 | 3.72 | | | | | |
| Bajra .. | 2.60 | | | | | | | | | | | |
| | | | | | Period—II | | | | | | | |
| Foodgrains .. | 3.45 | 3.87 | 4.82 | 3.69 | 1.00 | 4.32 | 4.22 | 5.28 | 9.15 | 4.76 | 1.59 | 1.24 |
| Rice .. | 4.05 | 5.69 | 4.79 | 4.21 | 4.35 | 3.20 | 6.11 | 5.01 | | 6.65 | 4.19 | 1.91 |
| Wheat .. | 4.31 | | | 3.46 | | 6.66 | | | 9.55 | | 2.25 | |
| Maize .. | 6.35 | | | 7.41 | | | | | | | | |
| Jowar .. | 3.32 | 2.89 | | | | 6.25 | 3.51 | | | | | |
| Bajra .. | 2.59 | | | | | | | | | | | |
| | | | | | Period—III | | | | | | | |
| Foodgrains .. | 3.49 | 3.33 | 4.89 | 3.80 | 1.65 | 3.70 | 4.41 | 4.81 | 6.98 | 4.07 | 2.28 | 2.13 |
| Rice .. | 3.78 | 5.07 | 4.90 | 3.76 | 4.23 | 2.57 | 6.46 | 4.99 | | 5.70 | 3.66 | 2.34 |
| Wheat .. | 5.76 | | | 7.30 | | 5.42 | | | 7.99 | | 4.36 | |
| Maize .. | 6.41 | | | 7.60 | | | | | | | | |
| Jowar .. | 2.90 | 2.24 | | | | 6.06 | 4.10 | | | | | |
| Bajra .. | 2.92 | | | | | | | | | | | |
| | | | | | Period—IV | | | | | | | |
| Foodgrains .. | 3.23 | 3.16 | 4.77 | 3.53 | 1.45 | 3.48 | 4.08 | 4.98 | 6.70 | 3.76 | 2.03 | 1.89 |
| Rice .. | 3.52 | 4.70 | 4.78 | 3.53 | 3.93 | 2.43 | 6.06 | 4.83 | | 5.38 | 3.45 | 2.12 |
| Wheat .. | 5.20 | | | 6.31 | | 5.37 | | | 7.53 | | 3.81 | |
| Maize .. | 5.94 | | | 7.04 | | | | | | | | |
| Jowar .. | 2.75 | 2.14 | | | | 5.65 | 3.62 | | | | | |
| Bajra .. | 2.60 | | | | | | | | | | | |

TABLE IV—CROPWISE GROWTH RATES OF PRODUCTION

| Crop | Foodgrains | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Percentage growth rate per annum | | | | Significance of growth rate (value of Student-t) | | | | Index of determination (value of $R^2$) | | | |
| States/Period | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Andhra Pradesh | 2.89 | 3.87 | 3.33 | 3.16 | 8.64** | 10.45** | 10.20** | 9.77** | 0.99 | 0.99 | 0.99 | 0.99 |
| Assam | 2.76 | 2.82 | 2.89 | 2.77 | 1.37 | 1.98 | 2.09 | 2.42* | 0.90 | 0.89 | 0.90 | 0.90 |
| Bihar | 2.83 | 3.69 | 3.80 | 3.53 | 3.74** | 2.73* | 3.21** | 3.34** | 0.91 | 0.88 | 0.89 | 0.89 |
| Kerala | 1.48 | 1.00 | 1.65 | 1.45 | 1.66 | 2.07 | 3.03** | 2.39* | 0.93 | 0.94 | 0.87 | 0.82 |
| Madhya Pradesh | 2.59 | 4.32 | 3.70 | 3.48 | 2.15* | 8.25** | 6.94** | 5.86** | 0.89 | 0.89 | 0.91 | 0.88 |
| Mysore | 3.66 | 4.22 | 4.41 | 4.08 | 7.24** | 6.68** | 2.12* | 7.27** | 0.82 | 0.84 | 0.96 | 0.90 |
| Orissa | 2.99 | 3.28 | 2.81 | 2.98 | 1.78 | 2.14* | 3.45** | 2.81* | 0.91 | 0.90 | 0.91 | 0.91 |
| Rajasthan | 5.40 | 9.15 | 6.98 | 6.70 | 1.93 | 2.96** | 6.72** | 9.25** | 0.96 | 0.91 | 0.92 | 0.92 |
| Tamil Nadu | 3.39 | 4.76 | 4.07 | 3.76 | 2.33* | 4.74** | 1.32 | 3.84** | 0.76 | 0.82 | 0.89 | 0.89 |
| Uttar Pradesh | 1.81 | 1.59 | 2.28 | 2.03 | 2.09 | 3.61** | 4.20** | 3.27** | 0.92 | 0.96 | 0.91 | 0.97 |
| West Bengal | 1.88 | 1.24 | 2.13 | 1.89 | 1.46 | 2.58* | 3.42** | 2.53* | 0.83 | 0.85 | 0.92 | 0.84 |
| India | 2.79 | 3.45 | 3.49 | 3.23 | 10.28** | 9.76** | 13.48** | 14.64** | 0.99 | 0.99 | 0.99 | 0.98 |
| Crop | Wheat | | | | | | | | | | | |
| | Percentage growth rate per annum | | | | Significance of growth rate (value of Student-t) | | | | Index of determination (value of $R^2$) | | | |
| States/Period | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Andhra Pradesh | | | | | | | | | | | | |
| Assam | | | | | | | | | | | | |
| Bihar | 6.07 | 3.46 | 7.30 | 6.31 | 3.98** | 1.13 | 4.32** | 6.37** | 0.85 | 0.92 | 0.92 | 0.93 |
| Kerala | | | | | | | | | | | | |
| Madhya Pradesh | 3.71 | 6.66 | 5.42 | 5.37 | 1.27 | 5.08** | 3.89** | 3.97** | 0.95 | 0.98 | 0.98 | 0.97 |
| Mysore | | | | | | | | | | | | |
| Orissa | | | | | | | | | | | | |
| Rajasthan | 6.25 | 9.55 | 7.99 | 7.53 | 6.07** | 9.66** | 14.21** | 13.27** | 0.93 | 0.92 | 0.97 | 0.94 |
| Tamil Nadu | | | | | | | | | | | | |
| Uttar Pradesh | 3.93 | 2.25 | 4.36 | 3.81 | 3.62** | 3.67** | 3.08** | 6.21** | 0.91 | 0.96 | 0.92 | 0.98 |
| West Bengal | | | | | | | | | | | | |
| India | 4.88 | 4.31 | 5.76 | 5.20 | 10.10** | 8.64** | 8.03** | 6.63** | 0.99 | 0.99 | 0.98 | 0.97 |

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

*(Contd.)*

TABLE IV—(*Contd.*)

| Crop | Rice | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Percentage growth rate per annum | | | | Significance of growth rate (value of Student-t) | | | | Index of determination (value of $R^2$) | | | |
| States/Period | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Andhra Pradesh | 4.22 | 5.69 | 5.07 | 4.70 | 9.25** | 12.51** | 12.98** | 9.42** | 0.96 | 0.92 | 0.98 | 0.98 |
| Assam | 4.98 | 4.79 | 4.90 | 4.78 | 2.48* | 3.10** | 2.92** | 2.13* | 0.92 | 0.90 | 0.94 | 0.90 |
| Bihar | 2.37 | 4.21 | 3.76 | 3.53 | 2.31* | 2.57* | 2.17* | 2.50* | 0.80 | 0.83 | 0.87 | 0.91 |
| Kerala | 3.60 | 4.35 | 4.23 | 3.93 | 2.97** | 6.77** | 10.74** | 9.88** | 0.83 | 0.83 | 0.92 | 0.87 |
| Madhya Pradesh | 1.26 | 3.20 | 2.57 | 2.43 | 0.51 | 2.13* | 1.92 | 1.91 | 0.90 | 0.91 | 0.91 | 0.95 |
| Mysore | 5.55 | 6.11 | 6.46 | 6.06 | 4.36** | 5.39** | 6.71** | 4.06** | 0.93 | 0.96 | 0.90 | 0.98 |
| Orissa | 5.51 | 5.01 | 4.99 | 4.83 | 1.97 | 1.29 | 2.31* | 2.42* | 0.90 | 0.82 | 0.92 | 0.91 |
| Rajasthan | | | | | | | | | | | | |
| Tamil Nadu | 4.90 | 6.65 | 5.70 | 5.38 | 5.83** | 11.35** | 8.59** | 2.19* | 0.83 | 0.88 | 0.91 | 0.85 |
| Uttar Pradesh | 2.70 | 4.19 | 3.66 | 3.45 | 2.36* | 5.27** | 4.89** | 4.44** | 0.92 | 0.90 | 0.94 | 0.93 |
| West Bengal | 1.95 | 1.91 | 2.34 | 2.12 | 3.59** | 2.21* | 2.14* | 2.69* | 0.95 | 0.89 | 0.92 | 0.93 |
| India | 3.03 | 4.05 | 3.78 | 3.52 | 6.31** | 8.41** | 10.21** | 11.27** | 0.99 | 0.98 | 0.97 | 0.98 |

| Crop | Jowar | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Percentage growth rate per annum | | | | Significance of growth rate (value of Student-t) | | | | Index of determination (value of $R^2$) | | | |
| States/Period | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Andhra Pradesh | 2.09 | 2.89 | 2.24 | 2.14 | 3.89 | 4.59 | 4.60 | 1.67 | 0.94 | 0.83 | 0.91 | 0.83 |
| Assam | | | | | | | | | | | | |
| Bihar | | | | | | | | | | | | |
| Kerala | | | | | | | | | | | | |
| Madhya Pradesh | 5.17 | 6.25 | 6.06 | 5.65 | 2.45* | 2.76* | 2.89** | 2.83* | 0.88 | 0.94 | 0.90 | 0.93 |
| Mysore | 3.72 | 3.51 | 4.10 | 3.62 | 4.18** | 3.08** | 3.97** | 1.97 | 0.92 | 0.92 | 0.90 | 0.91 |
| Orissa | | | | | | | | | | | | |
| Rajasthan | | | | | | | | | | | | |
| Tamil Nadu | | | | | | | | | | | | |
| Uttar Pradesh | | | | | | | | | | | | |
| West Bengal | | | | | | | | | | | | |
| India | 2.32 | 3.32 | 2.90 | 2.75 | 3.21** | 6.08** | 5.87** | 5.41** | 0.90 | 0.88 | 0.90 | 0.92 |

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

(*Contd.*)

TABLE IV—(*Concld.*)

| Crop | Maize | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Percentage growth rate per annum | | | | Significance of growth rate (value of Student-t) | | | | Index of determination (value of $R^2$) | | | |
| States/Period | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Andhra Pradesh .. | | | | | | | | | | | | |
| Assam .. | | | | | | | | | | | | |
| Bihar .. | 6.92 | 7.41 | 7.60 | 7.04 | 8.00** | 6.71** | 5.36** | 7.27** | 0.90 | 0.86 | 0.97 | 0.91 |
| Kerala .. | | | | | | | | | | | | |
| Madhya Pradesh .. | | | | | | | | | | | | |
| Mysore .. | | | | | | | | | | | | |
| Orissa .. | | | | | | | | | | | | |
| Rajasthan .. | | | | | | | | | | | | |
| Tamil Nadu .. | | | | | | | | | | | | |
| Uttar Pradesh .. | | | | | | | | | | | | |
| West Bengal .. | | | | | | | | | | | | |
| India .. | 5.69 | 6.35 | 6.41 | 5.94 | 11.97** | 13.08** | 11.58** | 13.17** | 0.92 | 0.89 | 0.97 | 0.93 |

| Crop | Bajra | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Percentage growth rate per annum | | | | Significance of growth rate (value of Student-t) | | | | Index of determination (value of $R^2$) | | | |
| States/Period | I | II | III | IV | I | II | III | IV | I | II | III | IV |
| Andhra Pradesh .. | | | | | | | | | | | | |
| Assam .. | | | | | | | | | | | | |
| Bihar .. | | | | | | | | | | | | |
| Kerala .. | | | | | | | | | | | | |
| Madhya Pradesh .. | | | | | | | | | | | | |
| Mysore .. | | | | | | | | | | | | |
| Orissa .. | | | | | | | | | | | | |
| Rajasthan .. | | | | | | | | | | | | |
| Tamil Nadu .. | | | | | | | | | | | | |
| Uttar Pradesh .. | | | | | | | | | | | | |
| West Bengal .. | | | | | | | | | | | | |
| India .. | 2.60 | 2.59 | 2.92 | 2.60 | 2.92** | 2.87** | 3.08** | 3.23** | 0.79 | 0.84 | 0.90 | 0.90 |

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

TABLE V—REGRESSION COEFFICIENTS AND GROWTH RATES OF PRODUCTION OF DIFFERENT CROPS FOR SELECTED STATES

| States | Crops | Regression coefficients | Growth rate | Value of $R^2$ | Value of t | Period |
|---|---|---|---|---|---|---|
| Gujarat | Foodgrains | 0.01974 | 4.67 | 0.994 | 2.48* | |
| | Rice | 0.00721 | 1.69 | 0.978 | 1.42 | |
| | Jowar | 0.01032 | 2.47 | 0.981 | 2.06 | |
| | Bajra | 0.02592 | 6.13 | 0.980 | 3.21** | |
| Maharashtra | Foodgrains | 0.01831 | 4.31 | 0.924 | 2.96* | |
| | Rice | 0.01034 | 2.47 | 0.930 | 2.01 | |
| | Jowar | 0.01231 | 2.89 | 0.931 | 1.74 | |
| | Bajra | 0.00907 | 2.11 | 0.967 | 1.94 | |
| Haryana | Foodgrains | 0.02625 | 6.24 | 0.990 | 4.31** | |
| | Wheat | 0.03913 | 9.42 | 0.997 | 5.64** | 1949-50 |
| | Maize | 0.02768 | 6.58 | 0.981 | 5.92 | |
| | | | | | | to |
| Punjab | Foodgrains | 0.03018 | 7.20 | 0.999 | 6.92** | |
| | Wheat | 0.07415 | 18.62 | 0.994 | 8.23** | 1969-70 |
| | Maize | 0.02899 | 6.94 | 0.990 | 5.71** | |

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

Table values of t { at 5 per cent = 2.228. / at 1 per cent = 3.169.

TABLE VI—INDEX OF AGRICULTURAL PRODUCTION: INDIA

(*Base: 1949-50=100*)

| Crops | Regression coefficients | Annual compound growth rates | Value of $R^2$ | Value of t |
|---|---|---|---|---|
| Foodgrains | 0.010759 | 2.51 | 0.912 | 3.47** |
| Wheat | 0.019489 | 4.62 | 0.931 | 2.89** |
| Rice | 0.011735 | 2.78 | 0.901 | 2.13* |
| Jowar | 0.01003 | 2.39 | 0.899 | 2.49* |
| Bajra | 0.01089 | 2.59 | 0.941 | 2.78* |
| Maize | 0.001976 | 4.71 | 0.918 | 3.21** |

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

Table values of t { at 5 per cent level = 2.093. / at 1 per cent level = 2.861.

TABLE VII—PRODUCTION, ITS LOG, UPPER AND LOWER TOLERANCE LIMITS OF FOODGRAINS, RICE AND WHEAT FOR INDIA: 1949-50 TO 1969-70

| Crops | Foodgrains | | | | Rice | | | | Wheat | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | $P_t$ (000 tonnes) | $Y_t = \log P_t$ | $L_2$ | $L_1$ | $P_t$ (000 tonnes) | $Y_t = \log P_t$ | $L_2$ | $L_1$ | $P_t$ (000 tonnes) | $Y_t = \log P_t$ | $L_2$ | $L_1$ |
| 1949-50 | 54916 | 3.7397 | 3.8548 | 3.6332 | 23542 | 3.3718 | 3.4706 | 3.2277 | 6391 | 2.8055 | 2.9620 | 2.6314 |
| 1950-51 | 50825 | 3.7060 | 3.8656 | 3.6462 | 20576 | 3.3134 | 3.4824 | 3.2419 | 6462 | 2.8102 | 2.9811 | 2.6537 |
| 1951-52 | 51996 | 3.7160 | 3.8765 | 3.6592 | 21300 | 3.3284 | 3.4942 | 3.2559 | 6183 | 2.7910 | 3.0003 | 2.6759 |
| 1952-53 | 59201 | 3.7723 | 3.8876 | 3.6720 | 22899 | 3.3598 | 3.5062 | 3.2700 | 7501 | 2.8751 | 3.0196 | 2.6980 |
| 1953-54 | 69821 | 3.8440 | 3.8987 | 3.6848 | 28214 | 3.4504 | 3.5183 | 3.2837 | 8017 | 2.9042 | 3.0391 | 2.7198 |
| 1954-55 | 68035 | 3.8328 | 3.9100 | 3.6974 | 25219 | 3.4018 | 3.5305 | 3.2974 | 9043 | 2.9562 | 3.0588 | 2.7416 |
| 1955-56 | 66850 | 3.8251 | 3.9213 | 3.7099 | 27557 | 3.4403 | 3.5428 | 3.3110 | 8760 | 2.9425 | 3.0787 | 2.7631 |
| 1956-57 | 69855 | 3.8442 | 3.9328 | 3.7223 | 29037 | 3.4630 | 3.5553 | 3.3244 | 9403 | 2.9731 | 3.0987 | 2.7844 |
| 1957-58 | 64311 | 3.8083 | 3.9444 | 3.7345 | 25525 | 3.4069 | 3.5679 | 3.3377 | 7998 | 2.9031 | 3.1189 | 2.8056 |
| 1958-59 | 77141 | 3.8873 | 3.9562 | 3.7466 | 30847 | 3.4893 | 3.5806 | 3.3508 | 9958 | 2.9983 | 3.1393 | 2.8266 |
| 1959-60 | 76672 | 3.8846 | 3.9681 | 3.7586 | 31676 | 3.5008 | 3.5935 | 3.3639 | 10324 | 3.0137 | 3.1599 | 2.8474 |
| 1960-61 | 82018 | 3.9139 | 3.9801 | 3.7705 | 34574 | 3.5387 | 3.6065 | 3.3767 | 10997 | 3.0414 | 3.1807 | 2.8680 |
| 1961-62 | 82706 | 3.9176 | 3.9922 | 3.7823 | 35663 | 3.5522 | 3.6197 | 3.3895 | 12072 | 3.0817 | 3.2017 | 2.8884 |
| 1962-63 | 80151 | 3.9039 | 4.0045 | 3.7939 | 33217 | 3.5214 | 3.6330 | 3.4021 | 10776 | 3.0326 | 3.2229 | 2.9086 |
| 1963-64 | 80642 | 3.9066 | 4.0168 | 3.8054 | 36998 | 3.5682 | 3.6464 | 3.4146 | 9853 | 2.9934 | 3.2442 | 2.9287 |
| 1964-65 | 89356 | 3.9511 | 4.0293 | 3.8168 | 39308 | 3.5945 | 3.6600 | 3.4269 | 12257 | 3.0885 | 3.2658 | 2.9485 |
| 1965-66 | 72030 | 3.8575 | 4.0420 | 3.8280 | 30655 | 3.4866 | 3.6737 | 3.4391 | 10424 | 3.0179 | 3.2875 | 2.9682 |
| 1966-67 | 74231 | 3.8706 | 4.0547 | 3.8392 | 30438 | 3.4834 | 3.6875 | 3.4512 | 11393 | 3.0565 | 3.3094 | 2.9877 |
| 1967-68 | 95052 | 3.9780 | 4.0675 | 3.8502 | 37612 | 3.5753 | 3.7014 | 3.4631 | 16540 | 3.2185 | 3.3314 | 3.0071 |
| 1968-69 | 94013 | 3.9732 | 4.0805 | 3.8611 | 39761 | 3.5994 | 3.7155 | 3.4750 | 18651 | 3.2707 | 3.3536 | 3.0262 |
| 1969-70 | 99501 | 3.9978 | 4.0935 | 3.8720 | 40430 | 3.6067 | 3.7296 | 3.4867 | 20093 | 3.3030 | 3.3759 | 3.0453 |

TABLE VIII—PRODUCTION, ITS LOG, UPPER AND LOWER TOLERANCE LIMITS OF FOODGRAINS AND WHEAT FOR PUNJAB AND HARYANA

| | Punjab | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Crops | Foodgrain | | | | Wheat | | | | |
| Year | $P_t$ (000 tonnes) | $Y_t$= log $P_t$ | $L_2$ | $L_1$ | $P_t$ (000 tonnes) | $Y_t$= log $P_t$ | $L_2$ | $L_1$ |
| 1949-50 .. .. .. .. .. | 2371.5 | 3.3748 | 3.3987 | 3.2012 | 1040.4 | 3.0171 | 3.1027 | 2.8041 |
| 1950-51 .. .. .. .. .. | 2246·6 | 3.3515 | 3.4232 | 3.2417 | 910.0 | 2.9590 | 3.1226 | 2.8312 |
| 1951-52 .. .. .. .. .. | 2287.4 | 3.3593 | 3.4504 | 3.2607 | 1133.0 | 3.0542 | 3.1471 | 2.8591 |
| 1952-53 .. .. .. .. .. | 3060.1 | 3.4858 | 3.4961 | 3.2812 | 1173.6 | 3.0694 | 3.1684 | 2.8613 |
| 1953-54 .. .. .. .. .. | 3171.2 | 3.5012 | 3.5218 | 3.2981 | 1190.1 | 3.0756 | 3.1895 | 2.8876 |
| 1954-55 .. .. .. .. .. | 3178.2 | 3.5022 | 3.5534 | 3.3102 | 1260.1 | 3.1004 | 3.2104 | 2.9108 |
| 1955-56 .. .. .. .. .. | 3114.7 | 3.4933 | 3.5798 | 3.3421 | 1236.7 | 3.0922 | 3.2368 | 2.9374 |
| 1956-57 .. .. .. .. .. | 3512.0 | 3.5456 | 3.6108 | 3.3684 | 1400.4 | 3.1462 | 3.2608 | 2.9601 |
| 1957-58 .. .. .. .. .. | 3497.5 | 3.5437 | 3.6530 | 3.3921 | 1326.6 | 3.1227 | 3.2817 | 2.9812 |
| 1958-59 .. .. .. .. .. | 3875.3 | 3.5883 | 3.6801 | 3.4122 | 1561.3 | 3.1934 | 3.3041 | 3.0110 |
| 1959-60 .. .. .. .. .. | 3567.0 | 3.5523 | 3.7012 | 3.4247 | 1498.0 | 3.1755 | 3.3267 | 3.0312 |
| 1960-61 .. .. .. .. .. | 3921.1 | 3.5933 | 3.7261 | 3.4392 | 1778.8 | 3.2501 | 3.3518 | 3.0575 |
| 1961-62 .. .. .. .. .. | 3969.9 | 3.5988 | 3.7489 | 3.4507 | 1931.0 | 3.2858 | 3.3801 | 3.0821 |
| 1962-63 .. .. .. .. .. | 3812.2 | 3.5812 | 3.7698 | 3.4634 | 1886.4 | 3.2756 | 3.4114 | 3.1089 |
| 1963-64 .. .. .. .. .. | 3808.9 | 3.5808 | 3.8012 | 3.4801 | 1983.7 | 3.2974 | 3.4413 | 3.1301 |
| 1964-65 .. .. .. .. .. | 4334.2 | 3.6369 | 3.8241 | 3.5049 | 2417.8 | 3.3833 | 3.4802 | 3.1584 |
| 1965-66 .. .. .. .. .. | 3391.3 | 3.5303 | 3.8511 | 3.5231 | 1916.0 | 3.2824 | 2.4296 | 3.1816 |
| 1966-67 .. .. .. .. .. | 4216.8 | 3.6250 | 3.8805 | 3.5427 | 2493.9 | 3.3969 | 3.5621 | 3.2079 |
| 1967-68 .. .. .. .. .. | 5406.7 | 3.7329 | 3.9172 | 3.5623 | 3352.0 | 3.5253 | 3.6141 | 3.2381 |
| 1968-69 .. .. .. .. .. | 6252.1 | 3.7960 | 3.9408 | 3.5884 | 4520.0 | 3.6551 | 3.6594 | 3.2610 |
| 1969-70 .. .. .. .. .. | 6936.7 | 3.8412 | 3.9713 | 3.5971 | 4800.0 | 3.6812 | 3.6842 | 3.2897 |

*(Contd.)*

TABLE VIII—(*Concld.*)

| Crops | Haryana | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Foodgrains | | | | | | Wheat | | | | | |
| Year | $P_t$ (000 tonnes) | $Y_t$= log $P_t$ | $L_2$ | $L_1$ | $P_t$ (000 tonnes) | $Y_t$= log $P_t$ | $L_2$ | $L_1$ |
| 1949-50 .. .. .. .. .. | 998.1 | 2.9992 | 3.1218 | 2.7683 | 445.9 | 2.6492 | 2.8289 | 2.3843 |
| 1950-51 .. .. .. .. .. | 945.5 | 2.9756 | 3.1507 | 2.7994 | 390.0 | 2.5911 | 2.8513 | 2.4176 |
| 1951-52 .. .. .. .. .. | 962.6 | 2.9834 | 3.1741 | 2.8219 | 485.6 | 2.6857 | 2.8784 | 2.4481 |
| 1952-53 .. .. .. .. .. | 1289.9 | 3.1106 | 3.2038 | 2.8462 | 502.9 | 2.7015 | 2.9004 | 2.4773 |
| 1953-54 .. .. .. .. .. | 1614.1 | 3.2079 | 3.2206 | 2.8721 | 510.0 | 2.7076 | 2.9281 | 2.5002 |
| 1954-55 .. .. .. .. .. | 1618.8 | 3.2092 | 3.2512 | 2.9044 | 640.1 | 2.8062 | 2.9531 | 2.5271 |
| 1955-56 .. .. .. .. .. | 1576.5 | 3.1977 | 3.2843 | 2.9237 | 530.0 | 2.7243 | 2.9827 | 2.5512 |
| 1956-57 .. .. .. .. .. | 1841.3 | 3.2651 | 3.3127 | 2.9581 | 600.1 | 2.7782 | 3.0181 | 2.5791 |
| 1957-58 .. .. .. .. .. | 1936.7 | 3.2870 | 3.3481 | 2.9812 | 668.5 | 2.8248 | 3.0407 | 2.6084 |
| 1958-59 .. .. .. .. .. | 2083.6 | 3.3187 | 3.3721 | 3.0174 | 669.1 | 2.8255 | 3.0641 | 2.6304 |
| 1959-60 .. .. .. .. .. | 1878.0 | 3.2737 | 3.4089 | 3.0481 | 642.0 | 2.8075 | 3.0898 | 2.6527 |
| 1960-61 .. .. .. .. .. | 2113.4 | 3.3249 | 3.4407 | 3.0721 | 762.4 | 2.8820 | 3.1192 | 2.6781 |
| 1961-62 .. .. .. .. .. | 2146.7 | 3.3317 | 3.4781 | 3.0989 | 798.4 | 2.9022 | 3.1484 | 2.7001 |
| 1962-63 .. .. .. .. .. | 2041.5 | 3.3099 | 3.5042 | 3.1288 | 808.5 | 2.9077 | 3.1727 | 2.7239 |
| 1963-64 .. .. .. .. .. | 2039.2 | 3.3094 | 3.5381 | 3.1407 | 850.1 | 2.9295 | 3.1981 | 2.7556 |
| 1964-65 .. .. .. .. .. | 1899.4 | 3.2785 | 3.5607 | 3.1683 | 1037.2 | 3.0158 | 3.2107 | 2.7799 |
| 1965-66 .. .. .. .. .. | 2076.9 | 3.3174 | 3.5841 | 3.1971 | 902.2 | 2.9559 | 3.2337 | 2.8108 |
| 1966-67 .. .. .. .. .. | 2572.5 | 3.4103 | 3.6173 | 3.2212 | 1054.0 | 3.0228 | 3.2601 | 2.8379 |
| 1967-68 .. .. .. .. .. | 3992.0 | 3.6012 | 3.6418 | 3.2568 | 1466.4 | 3.1661 | 3.2812 | 2.8601 |
| 1968-69 .. .. .. .. .. | 3006.2 | 3.4780 | 3.6713 | 3.2321 | 1522.0 | 3.1824 | 3.3126 | 2.8812 |
| 1969-70 .. .. .. .. .. | 4567.4 | 3.6597 | 3.6948 | 3.3048 | 2119.5 | 3.3262 | 3.3481 | 2.9084 |

TABLE IX—NUMBER OF REGRESSIONS FOR THE STATES

*(Coverage: Total production)*

| State | No. of crops | No. of regressions |
|---|---|---|
| Andhra Pradesh .. .. .. .. | 3 | 12 |
| Assam .. .. .. .. | 2 | 8 |
| Bihar .. .. .. .. | 4 | 16 |
| Gujarat .. .. .. .. | 4 | 16 |
| Haryana .. .. .. .. | 3 | 3 |
| Kerala .. .. .. .. | 2 | 8 |
| Madhya Pradesh .. .. .. .. | 4 | 16 |
| Mysore .. .. .. .. | 3 | 12 |
| Maharashtra .. .. .. .. | 4 | 16 |
| Orissa .. .. .. .. | 2 | 8 |
| Punjab .. .. .. .. | 3 | 3 |
| Rajasthan .. .. .. .. | 2 | 8 |
| Tamil Nadu .. .. .. .. | 2 | 8 |
| Uttar Pradesh .. .. .. .. | 3 | 12 |
| West Bengal .. .. .. .. | 2 | 8 |
| India .. .. .. .. | 6 | 24 |
| Total .. .. .. .. | | 179 |

A number of graphs* have been drawn showing the behaviour of the output series of the crops along with the upper and lower tolerance limits. We have calculated the 95 per cent tolerance limits which give us confidence of 95 per cent that the output figures be within the limits. The tolerance limits do differ from all the four periods but the scatter of the production figures does not cross the limits. Limits for some periods come closer to the output figures but never they allow them to go beyond the limits. A few graphs for selected crops have been drawn to see the behaviour of the time-series. For most of the States and for all the crops there is a positive trend along which the series moves. The movements are marked by fluctuations and it is interesting to study the periodicity of such fluctuations. But it is not within the scope of this study.

We, therefore, see that the output figures belong to the same population. We can visualize three populations. The population which includes all the points between the tolerance limits may be termed as a 'normal'. One population may be visualized as a cluster of points above the upper tolerance limit. If the output figures fall in this area we are satisfied with the claim of a 'break-through' which, of course, is not seen here. A third type of population is the area between the x-axis and the lower tolerance limits. This gives an idea of abnormal production which was very much seen during the drought years

* Not included here for want of space.

1965-66 and 1966-67. For a few States this is true but for India no point falls below the lower tolerance limits as shown in the graphs. Even for wheat, the output points do not go beyond the limits. Of course, most of the growth rates are significantly high and there is a definite sign of progress and increase in production.

For example, Rajasthan presents an average of 8 per cent per annum growth rate of wheat. During 1949-50 to 1969-70 the growth rate is 6.25 per cent but for the Period II, *i.e.*, till 1964-65 it was as high as 9.55 per cent. Similarly in the case of maize, we find a growth rate of the order of 7.5 per cent in Bihar. On the other hand, the growth rates of rice and foodgrains in Uttar Pradesh, West Bengal, Assam, Orissa and Kerala are of the order of 1.5 to 2.0 per cent. For India, the growth rates for the selected crops in the four periods do vary, but not very much. The impact of drought years is there for crops like jowar and bajra. The growth rates of indices of agricultural production do not vary much from that of the growth rates of the gross production series.

For Punjab and Haryana the growth rates are high and significant. Table VII gives the comparative picture of the artificial production series with the tolerance limits which are much closer than in the case of India and other States. There would be a possible break-through in wheat production in Punjab in the coming years. The 1969-70 figures coincides with the upper tolerance limit. For Haryana also the same story can be observed for wheat. But the foodgrains production dose not give a picture of break-through.

So 'break-through' or 'green revolution' cannot be interpreted only as the increase in production. There are various aspects of the 'so-called' revolution. We have started a revolution in the technological aspect of agriculture. We have developed high-yielding varieties of a number of crops. But these varieties do need water and the state of irrigation has not improved even after a quarter century of Independence. The poor farmer cannot find the facilities for improvement unless proper distribution of fertilizer, seeds, water, machinery, etc., is assured. Break-through in agriculture can be viewed and claimed in isolated pockets of the country only and even a State is a big unit for the purpose. Also it cannot set in the total production of foodgrains. A few districts of Punjab may be taken as example of green revolution in wheat production.

The paper does not claim to be fool proof. The approach is not on the input side which certainly is of much importance. We have just attempted a simple statistical exercise to probe into the much claimed revolution in agriculture and to justify it. There should be statistical argument in declaring a 'break-through' in any field of production and the limits must be defined for its justification.