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AGRICULTURAL PRODUCTION TRENDS AND COMPONENTS*

S. A. Shetty

The purpose of this paper is two-fold: first, to analyse the trends in agricultural production at the all-India and regional levels and second to measure the contributions of three important components, *viz.*, area, yield per acre and crop pattern to the growth of agricultural production. The analysis relating to all-India covers the period 1920-21 to 1964-65 and that relating to regions covers the period 1920-21 to 1954-55. Agricultural production here comprises output of 15 principal crops—7 food crops (rice, jowar, bajra, maize, wheat, barley and gram) and 8 non-food crops (sugarcane, groundnut, rapeseed and mustard, sesamum, linseed, castorseed, cotton and jute). These 15 crops accounted for about 80 per cent of the total sown area in 1964-65. The choice of the crops and the period is mainly conditioned by the availability of relevant data. It is assumed that the exclusion of minor crops would not vitiate the main conclusions of the study.

In recent years attempts have been made to analyse the trends in agricultural production and to measure the relative contributions of various factors to the growth of agricultural production. Research wokers have employed two approaches to explain the growth rate in agriculture. Some have explained the growth of agricultural production in terms of the relative contributions of the following three components, *viz.*, (*i*) area; (*ii*) yield per acre; and (*iii*) crop combination. Minhas and Vaidyanathan were the pioneers in this approach.[1] Following Raj Krishna's study of agricultural growth in the Punjab[2] some researchers have adopted the production function approach to estimate the contributions of important factors like area, irrigation, fertilizers and technology to agricultural production. Ashok Parikh using both the approaches, namely, the decomposition of growth rate by components and the production function approach analysed the trends in agricultural production in important States.[3] In addition, a number of research workers have examined the trends in agricultural production for various States covering different periods by employing either of the approaches outlined above.[4]

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* This paper forms part of the author's dissertation entitled "Long-Term Trends in Farm Production in India," submitted for the award of Ph. D. degree of the University of Bombay in 1969. In this dissertation the author made an attempt to rebuild acreage and output series of 15 principal crops for the present Indian Union covering the period 1920-21 to 1964-65. Based on these adjusted series trends in production were examined at the all-India and regional levels.

The author is grateful to Dr. C. H. Shah for his valuable comments on an earlier draft of this paper.

1. B. S. Minhas and A. Vaidyanathan, "Growth of Crop Output in India : 1951-54 to 1958-61, An Analysis of Component Elements," *Journal of the Indian Society of Agricultural Statistics*, Vol. 17, No. 2, December, 1965, pp. 230-252.
2. Raj Krishna, "Growth of Aggregate Output in the Punjab," *Indian Economic Journal*, Vol. XII, No. 1, July-September, 1964, pp. 52-59.
3. Ashok Parikh, "Statewise Growth Rate in Agricultural Output—An Econometric Analysis, *Artha Vijnana*, Vol. 8, No. 1, March, 1966, pp. 1-52.
4. But the work of George Blyn however stands out distinctly from a number of other studies. After making the necessary adjustments for the gaps in the reported crop data, Blyn has examined the trends in agricultural production for British India and its constituent Provinces separately covering the period 1891 to 1946. For details of the method he had employed to estimate the growth of production, see Agricultural Trends in India, 1891 to 1946 : Output, Availability and Productivity, University of Pennsylvania Press, Philadelphia, U.S.A., 1966.

It may be noted that many of the studies referred to above relate to the recent post-planning period for which comprehensive crop production data are readily available. Such studies were inspired by the rapid increase in agricultural production resulting from several development measures undertaken during the planning period. However, research in factors accounting for the growth of agricultural production or lack of it covering a much longer period, including the pre-planning years, is rather meagre. No effort has been made except by Raj Krishna for the Punjab to measure the relative contributions of either the components or the factors to the growth of agricultural production in India and its regions covering a long period. This paper seeks to fill that lacuna by analysing the trends in agricultural production and its components encompassing a long period not covered by others.

The study of long-term trends in agricultural production covering the period 1920-21 to 1964-65 involved realignment of the reported crop data. Though the data on acreage and output are obtainable from different official sources they are not strictly comparable over a long period because of some deficiencies. The two major deficiencies which seriously impair comparability over time and space are (*i*) varying coverage and (*ii*) under-estimation of acreage in the erstwhile non-ryotwari regions. The crop data used in this study are not the reported data but the adjusted data which are reasonably comparable over the period 1920-21 to 1964-65. To realign the official data in a comparable mould several adjustments were carried out on the basis of adjustment methods evolved specially for this purpose. The principal adjustment methods used to rectify the above mentioned gaps are discussed in Appendix I.

Another development which affected comparability of crop output series over time was the replacement of *annawari* method by the crop-cutting method of yield estimation. The yield estimates based on the *annawari* method are known to have bias. The yield estimates prepared on the basis of crop-cutting method are free from subjective bias and hence are not strictly comparable with the *annawari* estimates. If crop output series free from subjective bias were to be constructed for the entire period of this study it is necessary to eliminate the bias in the *annawari* series. However, this refinement in the series could not be carried out for want of relevant data. Output series reasonably comparable over the period 1920-21 to 1964-65 was therefore obtained by linking the adjusted *annawari* series from 1920-21 to 1954-55 with the corresponding yield series based on the crop-cutting method readily available from 1955-56 to 1964-65. It is assumed that this limitation of the series would not distort the trends in production.[5]

After having carried out the necessary adjustments in the data in respect of each crop, an aggregate output series was constructed using 1924-25 to 1928-29 average prices as weights. Then index numbers of production of foodgrains,

5. The author has made an attempt in his thesis referred to earlier to find out if the trends derived from the *annawari* estimates are significantly different from the trends in crop-cutting estimates. For this he has relied on the data he had obtained for nine important crops in Maharashtra for the period 1945-46 to 1963-64. He compared the trends in *annawari* and crop-cutting yield series of these crops. In a large number of instances studied it was observed that the trends in *annawari* estimates were not significantly different from the trends in crop-cutting estimates for the same period.

non-foodgrains and all crops were constructed with 1935-36 as base.[6] The indices so derived are presented in Appendix II. The analysis of trends in production attempted in this paper with reference to all-India is based on these series.

I

TRENDS IN PRODUCTION : ALL-INDIA

We shall examine first the long-term movements in production at the all-India level. In order to ascertain the rate of growth of production semi-log trend of the following type was fitted : $Y = ab^t$. The percentage rate of change in output is estimated from the trend coefficient, log b of the above equation. In order to compare the movements in the production of foodgrains and non-food crops trends were fitted to each series separately. The results of the exercise are summarised in Table I. It can be seen from the table that the value of the trend

TABLE I—TREND CO-EFFICIENTS AND GROWTH RATE OF OUTPUT FOR THE PERIOD 1920-21 TO 1964-65

Series	Constant	Trend co-efficient	r^2	Growth rate (in percentage)
Foodgrains	3.8001	.00342* (0.0006)	.39	0.78
Non-foodgrains	3.2826	.00813* (0.0006)	.77	1.88
All crops	3.9153	.00470* (0.0006)	.57	1.09

* Significant at 5 per cent level.
Note : Figures in parentheses represent standard errors.

co-efficient with respect to gross output is positive and statistically significant. It indicates a significant upward trend in agricultural production during the period 1920-21 to 1964-65. The value of the trend coefficient with respect to foodgrains production, too, is positive and statistically significant, suggesting a growth in food production. Significant upward trend in production is also evident in respect of non-food crops. It may be noted that in the case of non-food crops as much as 77 per cent of the variations in production are explained by the semi-log trend equation.

Although the trend coefficients are positive and statistically significant the rates of growth have varied. It may be noted that what is of economic significance to us is not merely the statistical significance of the trend but also the

6. Similar series of crop production covering the period 1920-21 to 1954-55 were also constructed for each of the eight regions selected for the study. But the number of crops included in the aggregate series varied from five in the case of Assam to 12 in the case of Uttar Pradesh. The regional analysis of trends in agricultural production attempted in this paper is based on these series. However, for want of space the regional index numbers of agricultural production, area and yield per acre are not presented here.

annual rate of change of output over time. As the table indicates, the aggregate output of all crops has increased at a moderate rate of around 1.09 per cent per annum during the 45 years. The rate of growth of foodgrains production was relatively low being 0.78 per cent per annum and that of non-food crops was nearly 1.88 per cent per annum—twice that of food crops. The differential rates of growth of output between foodgrains and non-food crops point to a trend in favour of progressive commercialisation of Indian agriculture.

The implications of a low rate of growth of farm output are many. In a country like India where agriculture is a dominant sector engaging a major proportion of the labour force and accounting for over half of the national income the pace and pattern of economic development mainly hinges on the development of agriculture. The higher the rate of growth of agriculture the more rapid can be the economic development. In other words, a backward agriculture is a serious impediment to speedy industrialization. A low rate of growth of farm output, as noticed above, which reflects the low state of agricultural development implies low rate of increase in farm income, savings and capital formation.

II

TRENDS IN PRODUCTION DURING SUB-PERIODS

Over the 45 years many developments of far-reaching significance affecting the economic life of the people have occurred. The factors like population, per capita income, taste, etc., which determine the demand for agricultural commodities have also changed from time to time. An analysis of the long-term trend in production covering the 45 years as attempted above, encompasses within it several short-run trends which may not be the same for each period. Since a single trend equation tends to smooth out the short-term developments it is desirable to analyse the sub-period trends in production separately. On the basis of a broad classification of events we divided this period into the following three sub-periods: (*i*) Inter-war period, 1920-21 to 1938-39, (*ii*) War and post-war period, 1939-40 to 1950-51, (*iii*) Planning period, 1951-52 to 1964-65.

The results of the semi-log trends fitted to production series and the growth rates estimated from trend coefficients for the three sub-periods are presented in Table II.

It can be observed from Table II that as against stagnation in foodgrains production, the production of non-food crops increased at the rate of over 2 per cent per annum during the inter-war period. Because of the dominant weight of food crops, the trend in agricultural production turned out to be non-significant. However, during the war period, 1939-40 to 1950-51 the production of food and non-food crops tended to decline together. Both the coefficients were negative but not significant. This period was probably one of the worst periods for Indian agriculture as even the production of non-food crops which had been increasing in the inter-war period tended to exhibit a downward movement. As a marked contrast to the above feature the production of food and non-food crops increased rather rapidly during the planning period. All the trend coefficients turned out to be positive and statistically significant. It is important to note that the output of non-food crops continued to increase at a rate higher than that of foodgrains.

TABLE II—TREND COEFFICIENTS AND GROWTH RATES OF OUTPUT FOR DIFFERENT SUB-PERIODS

Series	1920-21 to 1938-39				1939-40 to 1950-51				1951-52 to 1964-65			
	Constant	Trend coefficient	r^2	Growth rate (in percentage)	Constant	Trend coefficient	r^2	Growth rate (in percentage)	Constant	Trend coefficient	r^2	Growth rate (in percentage)
Foodgrains	.. 3.8602	−.00093 (.0011)	.03	−0.21	3.8922	−.00246 (.0017)	.16	−0.57	3.3264	.01643* (.0020)	.85	3.85
Non-foodgrains	.. 3.2834	.00984* (.0016)	.69	2.28	3.4742	−.00127 (.0028)	.02	−0.33	2.7843	.02142* (.0019)	.91	5.05
All crops	.. 3.9612	.00176 (.0011)	.13	0.42	4.0336	−.00212 (0013)	.16	−0.48	3.4309	.01791* (.0015)	.91	4.10

* Significant at 5 per cent level.

Note : Figures in parentheses represent standard errors.

To sum up, we observe two important features in the development of agriculture in India during the period 1920-21 to 1964-65. First, the overall agricultural production was nearly stagnant during the early three decades ending 1950-51. The stagnation in agricultural production however concealed contrasting trends in food and non-food crops. Second, the growth in agricultural production was significant only during the planning period when the production of both food and non-food crops tended to increase rather rapidly. It is therefore clear that the trend in agricultural production observed for the period 1920-21 to 1964-65 was upward mainly because of the rapid increase in production of both food and non-food crops during the planning period.

III

TRENDS IN PRODUCTION OF INDIVIDUAL CROPS

The trend in aggregate crop production is determined by the behaviour of output of individual crops and their relative importance in the aggregate series. The aggregate output series conceals variations in the output of individual crops. We have already observed that the output of foodgrains and non-food crops has expanded at disparate rates. Besides, it is hardly likely that the output of constituent crops has increased at the same rate as that of the aggregate series. An analysis of the trends in the output of individual crops would also help our understanding of the behaviour of aggregate output series. An attempt is, therefore, made to analyse individually the long-term trends in the output of all the 15 crops.

It is clear from Table III that the trend coefficients of all food crops except barley are positive and significant. From the magnitudes of trend coefficients and their statistical significance it can be inferred that the output of principal food crops has been increasing during the period 1920-21 to 1964-65. The trend coefficient of barley is, however, negative but not significant. The production of barley was, therefore, stagnant. The rates of increase in output of such important crops as rice, jowar and wheat are low, being less than one per cent per annum. Maize alone among food crops recorded an increase in output at the rate of over one per cent per annum. Low increase in the output of inferior cereals like jowar and bajra and stagnation in barley mainly accounted for the low rate of growth of foodgrains production.

From among non-food crops, we find positive and significant coefficients for sugarcane, groundnut, rapeseed and mustard and jute. The output of all these crops except rapeseed and mustard increased at a rate of over 3 per cent per annum. The output of the remaining oilseeds declined at varying rates. The trend in the output of cotton was, however, sluggish. Thus, the major contribution to the growth of non-foodgrains production comes from only two crops, *viz.*, sugarcane and groundnut.

It is now clear from the foregoing analysis that though the output of food and non-food crops has increased, all the individual crops have not experienced growth in production. Some have expanded at a rate higher than the aggregate output, some at a lower rate while some have shown a downward trend. Such differences in trends as are demonstrated in Table III are of considerable economic significance. They represent shifting economic positions among growers of different crops and changes in the relative importance of crops.

TABLE III—TREND COEFFICIENTS AND GROWTH RATES OF OUTPUT OF INDIVIDUAL CROPS FOR THE PERIOD 1920-21 TO 1964-65

Series	*Constant*	Trend *coefficient*	r^2	Growth rate *(in per-centage)*
Rice	4.305	.0036* (.0006)	.39	0.83
Jowar	3.797	.0023* (.0007)	.17	0.53
Bajra	3.434	.0022* (.0008)	.15	0.51
Maize	3.297	.0053* (.0010)	.39	1.23
Wheat	3.771	.0042* (.0008)	.37	0.98
Barley	3.431	—.0010 (.0005)	.07	—0.24
Gram	3.549	.0036* (.0009)	.26	0.83
Sugarcane	3.350	.0143* (.0008)	.85	3.35
Groundnut	3.167	.0131* (.0011)	.75	3.06
Rapeseed and mustard ..	2.879	.0030* (.0001)	.28	0.69
Sesamum	2.748	—.0030* (.0006)	.32	—0.70
Linseed	2.671	—.0018* (.0007)	.13	—0.48
Castorseed	2.156	—.0031* (.0006)	.38	—0.71
Cotton	3.608	—.0008* (.0014)	.14	—0.20
Jute	3.020	.0151* (.0015)	.70	3.53

* Significant at 5 per cent level.
Note : Figures in parentheses represent standard errors.

IV

REGIONAL TRENDS IN AGRICULTURAL PRODUCTION

The analysis of regional trends in production here refers to the eight former British Provinces which are now known as States. They are Assam, Bihar-Orissa, Bombay Province, Madhya Pradesh (Central Provinces), Madras Province, the Punjab, West Bengal and Uttar Pradesh (United Provinces). The boundaries of these regions have been taken as obtaining in the pre-partition years. Bihar and Orissa have been treated as one region as the relevant crop data in respect of Orissa are not available separately for the years preceding 1935-36. The study relating to the regions, as mentioned earlier, covers the period 1921-55. The reorganization of the States in 1955-56 has placed serious obstacles in obtaining comparable regional crop data for the subsequent years and hence this limitation.

We may, to begin with, examine first the movements in aggregate crop production among the regions. In order to ascertain the long-term trends in aggregate crop production the semi-log trends as before were fitted to the series. The trend coefficients and the estimated growth rates in respect of each region are presented in Table IV. The semi-log trend fits give positive and significant coefficients for four out of the eight regions, *viz.*, Assam, the Punjab, Uttar Pradesh and West Bengal. All these four regions have, therefore, experienced upward trends in aggregate crop production during the period 1921-55. Though the trend coefficients for Bombay and Madras Provinces are positive, they are not significantly different from zero implying stagnation in production. Stagnation also characterized the long-term movements of aggregate crop production in Madhya Pradesh.

TABLE IV—TREND COEFFICIENTS AND GROWTH RATES OF AGGREGATE CROP OUTPUT FOR THE PERIOD 1920-21 TO 1954-55

Region	Constant	Trend coefficient	r^2	Growth rate (in percentage)
Assam	5.2772	.00752* (.0057)	.84	1.74
Bihar-Orissa	6.2253	—.00789* (.0007)	.76	—1.80
Bombay Province ..	5.8789	.00016 (.0008)	.006	0.05
Madhya Pradesh ..	5.7975	—.00058 (.0010)	.008	—0.14
Madras Province ...	6.2385	.00075 (.0005)	.05	0.16
Punjab	5.4882	.00430* (.0010)	.34	1.00
Uttar Pradesh	6.2526	.00172* (.0006)	.17	0.39
West Bengal	5.6880	.00588* (.0011)	.43	1.37

* Significant at 5 per cent level.
Note : Figures in parentheses represent standard errors.

The striking feature of the table is a sharp decline in aggregate crop production in Bihar-Orissa at the rate of 1.80 per cent per annum. It is significant to note that even in the regions which evinced significant upward trends, the aggregate crop production increased at a very low rate. The rates of growth varied from the highest 1.74 per cent per annum in the case of Assam to the lowest 0.39 per cent per annum in the case of Uttar Pradesh.

The uneven rates of change in agricultural production is partly the result of the differences in natural resources but mainly the outcome of the differences in the levels of agricultural development among the regions. Increase in production could be either due to one or two or several of the important factors such as

expansion of cultivated area, irrigation, changes in crop pattern, improvement in yield per acre, etc. The stagnation in production observed in some regions could be either due to decline or stagnation in area, or yield per acre or both. We shall explain the variation in the rates of growth of output among the regions by reference to the components of production, *viz.*, area, yield and crop combination.

V

TRENDS IN FOODGRAINS AND NON-FOODGRAINS PRODUCTION

Having observed that the production of aggregate crops increased in some regions, while it tended to stagnate in others, we shall now examine the trends in the production of foodgrains and non-food crops in different regions. Our attempt is to find out which regions witnessed commercialisation at a faster rate.

The results of the semi-log trends fitted to foodgrains and non-food crops series are presented in Table V. As with the aggregate crop production, the rates

TABLE V—TREND COEFFICIENTS AND GROWTH RATES OF OUTPUT OF FOODGRAINS AND NON-FOODGRAINS FOR THE PERIOD 1920-21 TO 1954-55

Region	Foodgrains				Non-foodgrains			
	Constant	Trend coefficient	r^2	Growth rate (in percentage)	Constant	Trend coefficient	r^2	Growth rate (in percentage)
Assam	3.9572	.00737* (.0006)	.49	1.71	4.4873	.00839* (.0013)	.55	1.95
Bihar-Orissa	6.1800	—.00837* (.0008)	.72	—1.91	5.2101	—.00391* (.0012)	.24	—0.91
Bombay Province	5.7325	—.00258* (.0009)	.41	—0.60	5.3458	.00507* (.0010)	.41	1.17
Madhya Pradesh	5.6661	.00107 (.0011)	.04	0.25	5.2188	—.00709* (.0016)	.36	—1.62
Madras Province	6.1198	—.00165* (.0005)	.22	—0.39	5.6199	.00650* (.0011)	.49	1.51
Punjab	5.3904	.00320* (.0011)	.19	0.74	4.7798	.00836* (.0012)	.58	1.96
Uttar Pradesh	6.1488	—.0003 (.0028)	.002	—0.07	5.6555	.00655 (.0013)	.43	1.51
West Bengal	5.6525	.00541* (.0013)	.34	1.25	4.5788	.01006* (.0013)	.62	2.33

* Significant at 5 per cent level.
Note : Figures in parentheses represent standard errors.

of change in foodgrains production are uneven among the regions. The trend coefficient for Assam, the Punjab and West Bengal turned out to be positive and significant. However, the rates of growth in production were moderate, the highest recorded was by Assam, it being 1.71 per cent per annum. The trend

coefficient for Madhya Pradesh is also positive but not significantly different from zero. The production of foodgrains was stagnant in Uttar Pradesh, too. In the remaining regions for which the trend coefficients are negative and significant, the production of foodgrains tended to decline at varying rates. It is significant to note that it has declined sharply in Bihar-Orissa, the decline being 1.91 per cent per annum during the period 1920-21 to 1954-55.

In contrast to foodgrains, the production of non-food crops increased in six out of the eight regions, the rates of growth varying from 2.33 per cent in West Bengal to 1.17 per cent per annum in the Bombay Province. For Bihar-Orissa and Madhya Pradesh the trend coefficients turned out to be negative and statistically significant. In both these regions the production of non-food crops declined at the rate of 0.91 per cent and 1.62 per cent per annum, respectively during the period 1920-21 to 1954-55.

Thus in contrast with foodgrains, the production of non-food crops increased in many regions during the period 1921-55. In many instances, it tended to increase at a relatively higher rate than foodgrains production. It is also clear that while non-food crops mainly accounted for the increase in aggregate crop production in Uttar Pradesh, both food and non-food crops contributed, the latter relatively more than the former, to the increase in aggregate crop production in Assam, the Punjab and West Bengal. In Bombay and Madras Provinces the stagnation in agricultural production was the result of two contrasting trends, the decline in foodgrains production matched by increase in non-food crops production. A trend in favour of gradual commercialisation of agriculture is thus a wider phenomenon but it was accompanied by varying position regarding foodgrains.

VI

DECOMPOSITION OF GROWTH RATE

So far we were concerned with the trends in agricultural production as a whole and in food and non-food crops both at the all-India and regional levels. The growth or lack of it can be attributed in the first instance to changes in the components of production. They are, as already mentioned (*i*) area, (*ii*) per acre yield, and (*iii*) crop combination. An attempt is made in this section to measure the contributions of these components to the growth of agricultural production. In order to estimate the contribution of each component it is necessary to construct two additional indices, *i.e.*, index numbers of agricultural production for constant crop pattern and index numbers of changes in crop pattern. The method of constructing these two indices is briefly discussed below.

The construction of these two indices involved the following steps. In the first instance a series of area under crops keeping crop pattern constant at 1920-21 level was evolved. This was done by reallocating the gross cropped area to individual crops on the basis of their proportions in the base year. Secondly, the area under individual crops was multiplied by their respective yield per acre to obtain the production of individual crops which when added gave aggregate production keeping out the effects of changes in crop pattern. For aggregation we used as before the 1924-25 to 1928-29 average prices. We have now two series:

(*i*) total production which includes the influence of changes in crop pattern (I_p) and (*ii*) total production which does not include the influence of crop pattern (I_o). We call the second series an index of production for constant crop pattern. Both these series, it may be noted, are composite of changes in area and yield per acre. Finally, by dividing the series I_p by the series I_o we obtained a new series which represents the influence of changing crop pattern (I_c). Together with the series of area (I_a) we now have four series: total production (I_p), total production for constant crop pattern (I_o) and changes in crop pattern (I_c). In order to measure the relative contribution of each of the components a simple method of decomposition is adopted.[7] By definition

$$G_p = G_o + G_c \qquad .. \quad .. \quad .. \quad .. \quad (1)$$

where

G_p = growth rate of total production,

G_o = growth rate of total production for constant crop pattern,

G_c = growth rate of changes in crop pattern.

The growth rate of each of these components is obtained by fitting the semi-log trend of the type described earlier.

It can be seen from the above equation that G_o is made up of growth of gross area and yield per acre. The growth of area may be denoted by G_a and that of yield per acre by G_y. Hence,

$$G_o = G_a + G_y \qquad .. \quad .. \quad .. \quad .. \quad (2)$$

G_y is obtained in our scheme as a residual as we have observations on G_o and G_a. Thus, we get $G_y = G_o - G_a$. Going back to our earlier equation, we can now write by substitution :

$$G_p = G_a + G_y + G_c \qquad .. \quad .. \quad .. \quad (3)$$

where G_y represents growth of yield per acre as a residual.

The above equation gives us a scheme of identifying contributions of area, yield per acre and changes in crop pattern to the growth of aggregate crop production. We assume that these elements have no interaction. Implicitly we assume that the double cropped or newly brought area under cultivation has the same productivity as that already under cultivation. This is a simplifying assumption since we do not have means to test empirically the interaction of growth of area and yield per acre. We can hypothetically visualize similar interaction between changes in crop pattern and yield per acre if we assume that the allocation of area to different crops in the base year was not only economically optimum but also technologically optimum. However, empirical testing of this hypothesis is also difficult due to lack of suitable data. In view of these difficulties we have

7. The method of decomposition of growth rates used here is adopted from Ashok Parikh's study already referred to.

made this simplifying assumption. However, this assumption does not disturb our equation which is an identity. Such interaction, if any, gets merged with one or the other component.[8]

The index numbers of gross production for constant crop pattern area, yield per acre and changes in crop pattern are presented in Appendix III. The growth rates of output and its components and the percentage contribution of each of the components are shown in Table VI. As indicated in the table, the contributions of area, crop pattern and yield per acre to the growth of gross output at the all-India level turned out to be 68 per cent, 22 per cent and 10 per cent, respectively. In other words, expansion of area and changes in crop pattern together accounted for about 90 per cent of the increase in gross output during the period 1920-21 to 1964-65.

TABLE VI—RELATIVE CONTRIBUTIONS OF DIFFERENT COMPONENTS TO THE GROWTH OF CROP OUTPUT

Growth rate of output (in percentage)	Percentage increase attributed to			Total
	Area	Yield per acre	Crop pattern	
1.09	67.9 (0.74)	10.1 (0.11)	22.0 (0.24)	100.0

Note : Figures in parentheses denote percentage growth rates.

Using the same method discussed above, we measured the contributions of different components to the growth of agricultural production in the regions. The analysis is confined to four regions, *viz.*, Assam, the Punjab, Uttar Pradesh and West Bengal which evidenced significant upward trend in agricultural production during the period 1920-21 to 1954-55. The percentage contribution of each component to the growth of agricultural production in different regions is worked out in Table VII. It can be seen from the table that nearly the entire increase in

TABLE VII—RELATIVE CONTRIBUTIONS OF COMPONENTS TO THE GROWTH OF AGGREGATE CROP OUTPUT

Region	Growth rate of aggregate output (in percentage)	Percentage increase attributed to			
		Area	Yield per acre	Crop pattern	Total
Assam	1.74	61.5 (1.07)	28.7 (0.50)	9.8 (0.17)	100.0
Punjab	1.00	9.0 (0.09)	91.0 (0.91)	—	100.0
Uttar Pradesh	0.39	112.8 (0.44)	—89.7 (—0.35)	76.9 (0.30)	100.0
West Bengal	1.37	108.0 (1.48)	—6.5 (—0.09)	—1.5 (—0.02)	100.0

Note : Figures in parentheses denote percentage growth rates.

8. B. S. Minhas and A. Vaidyanathan in their study referred to earlier have shown that the relative contribution of interaction element to agricultural production both at the all-India and State levels for the period they studied was negligible.

agricultural production in West Bengal was accounted for by expansion of area. The contribution of area was significant also in Assam and Uttar Pradesh. In other words, with the exception of the Punjab, the expansion of area was the major source of output growth in all the regions. In the Punjab improvement in yield per acre alone accounted for over 90 per cent of the increase in aggregate output. The contribution of crop pattern was negligible except in Uttar Pradesh.

SUMMARY

In the above analysis an attempt has been made to analyse the trends in agricultural production and to isolate the contribution of crop pattern from the effects of area and yield per acre. Some of the important findings of the study are summarised below.

The most important conclusion that emerges from the study is that the long-term trend in agricultural production has been a rising one during the period 1920-21 to 1964-65. The trends in production of foodgrains and non-food crops were also positive and significant though the rate of growth of the latter was twice as high as that of the former. It is clear from the analysis of trends for different sub-periods that the rather apparent stagnation in agricultural production during the pre-planning period concealed beneath it a perceptible increase in non-food crops production. It is also revealing that while almost all the crops except barley have contributed in varying measures to the increase in foodgrains production, only a few crops notably groundnut and sugarcane and to some extent rapeseed and mustard contributed to the increase in the production of non-food crops.

The analysis of trends in agricultural production among the regions presents a mixed picture. In four out of the eight regions studied agricultural production has increased while in three regions it was stagnant and in the remaining one region it declined during the period 1920-21 to 1954-55. A geographical pattern of agricultural growth is discernible in the increase in output in the northern and eastern regions with the exception of Bihar-Orissa and stagnation in output in the southern and western regions. Of special interest is the finding that agricultural production tended to increase in some regions even before the advent of planning in India.

It was further revealed that acreage expansion was the most important source of growth of production at the all-India level, the contributions of area and crop pattern accounting for nearly 90 per cent of the increase in agricultural production. The contribution of area was also significant in almost all the regions studied with the exception of the Punjab where nearly the entire increase in production was accounted for by improvement in yield per acre. The contribution of changes in crop pattern to the growth of production was negligible in all the regions except in Uttar Pradesh. Thus, the increase in agricultural production during the period covered seems to have been realized mainly through the expansion of area rather than through improvement in the productivity of land.

APPENDIX I

Principal Methods of Adjustment

The realignment of the reported crop data in a comparable mould involved several adjustments. Broadly they are of the following two types : (*i*) filling the gaps where the data were not reported; and (*ii*) removing the under-estimation bias in the acreage statistics of erstwhile non-ryotwari regions. The methods that were used to eliminate these deficiencies in the reported data are outlined below.

Methods of Computing Acreage and Yield for Non-reporting Regions

Where the gap in the yield series is small the projection of the trend in yield per acre observed for the reporting years was, in the first instance, considered. The form of the equation fitted is as follows :

$$Y_t = a + bt \quad .. \quad .. \quad .. \quad .. \quad .. \quad (1)$$

where Y_t is the yield per acre, a is constant, b is trend coefficient and t is time. The same method is employed to fill in the small gaps in acreage statistics, too. The results of the trend equation were used only if (*i*) the gap information is small, not exceeding five years and (*ii*) the trend coefficient is statistically significant (at 10 per cent level).

Where the gap in information is big, *i.e.*, the size of the non-reporting period is large (more than five years) and where method (*i*) did not provide a satisfactory solution to the problem of adjustment, the suitability of regression method was considered. The yield per acre of a crop, say rice, in a non-reporting region was regressed on the yield per acre of the same crop (rice) in an adjoining reporting region when both were reporting. The form of the relationship worked out is as follows :

$$Y_t = \propto + \beta R_t \quad .. \quad .. \quad .. \quad .. \quad (2)$$

where Y_t is the estimated yield per acre of a crop, $\propto$ and β are the regression parameters to be estimated, R is the yield per acre of the same crop in a neighbouring reporting region and t is time. This method was also used to compute acreage statistics for the non-reporting years. As in the case of trend projection method, only those regression coefficients which are statistically significant were used for adjustment purposes.

Where the above two methods did not provide a satisfactory basis for adjustment another method was considered. For many non-reporting regions yield estimates are readily available in respect of one or two principal crops for the entire period of this study. This limited information was also made use of for estimating the yield of other crops grown within the same region. The yield per acre of a crop, say gram, in a non-reporting region was regressed on the yield per acre of a similar crop, say wheat, or barley, grown within the same region. This relationship can be expressed as follows :

$$Y_t = \propto + \beta X_t \quad .. \quad .. \quad .. \quad .. \quad (3)$$

where Y_t, $\propto$, β and t are as in equation (2). X is the yield per acre of a similar crop grown in the same region for which the data are reported for the entire period of the study. Two criteria were applied in selecting a suitable independent variable.

Firstly, both the crops, *i.e.*, the crop for which the yield estimates had to be computed (dependent variable) and the crop for which the data are readly available (independent variable) should pertain to the same sowing and harvesting period. Secondly, they should be similar in production, like, grains, oilseeds, etc. As in the earlier methods, only significant coefficients were used for estimating yield for the non-reporting years.

For some reason or other but mainly statistical, the methods outlined above could not be employed for estimating acreage and yield for all the non-reporting regions. In such cases another method was used to complete the coverage. This method is based on an average of a few years'—not exceeding ten years—ratio of yield per acre of a crop in a non-reporting region to the yield per acre of the same crop in an adjoining reporting region. This method was also used to compute acreage where methods (1) and (2) failed to provide convincing basis for adjustment.

Thus, for small gaps in information the trend projection method (1) was found to be more suitable. In such cases this method was used without even considering the suitability of other methods provided it satisfied the aforesaid statistical criterion. Method (2) was extensively used for adjustment purposes. However, the suitability of alternative methods was considered, in turn, only when method (2) did not give satisfactory results for adjustment.

In addition, there were some non-reporting pockets within the reporting region which were brought under the orbit of reporting specially after Independence. But the comparable crop data for these pockets are not available for more than a year. Evidently, none of the above mentioned methods could be used to tackle this problem. In view of the limitations of the data the problem was resolved by a simple method. Acreage estimates were computed on the assumption that the proportion of area in a non-reporting pocket to the total reporting area is the same for all the non-reporting years as in the first reporting year. The same method was used for computing output estimats, too. In this way the major gaps in the reported data arising from varying coverage have been covered.

Method of Eliminating Under-estimation Bias in Acreage

Another adjustment related to erstwhile permanently settled regions like Bihar, Orissa and Bengal where the acreage statistics were known to have been under-estimated. Following Independence the *chowkidary* method of reporting acreage—the source of under-estimation bias—, was replaced by complete enumeration in Bihar and random sampling survey in West Bengal. The replacement of the *chowkidary* method of reporting had rendered the crop acreage series of these regions non-comparable over time. In order to restore comparability it was necessary to reduce, to the extent possible, the bias in the earlier acreage estimates based on the *chowkidary* method of reporting. But the extent of the bias as measured from the difference between the acreage estimates based on the *chowkidary* method and those based on the complete emuneration method could be known only for one year. As a result, the necessary adjustment for the bias in the acreage series had to be carried out with the help of this limited information.

In Bihar for which the relevant data are available the under-estimation bias in the acreage of rice, wheat and gram turned out to be 25.5, 45.8 and 26.5 per

cent, respectively. However, it appears unlikely that an under-estimation bias of such a high magnitude prevailed throughout the period covered by the study. A method which ensured at least the elimination of minimum bias was therefore preferred. The lower bound of the bias was worked out from the difference between the highest acreage reported by the *chowkidary* method a few years before its final replacement and the acreage estimates based on the complete enumeration method in the year of its commencement. The lower bound of the bias provided the correction factor to mark up the acreage series of rice, wheat and gram based on the *chowkidary* method of reporting. The yield estimates were subsequently revised with the help of yield per acre of crops in Bihar.

It may be mentioned that the necessary adjustments in the data were carried out in respect of each crop at the regional level. In many cases alternative methods had to be tried before making the final adjustment. The search for suitable procedure therefore entailed fitting more regressions than could be actually used in the reconstruction of acreage and production series.

APPENDIX II

INDEX NUMBERS OF CROP PRODUCTION

(*1935-36 = 100*)

Year	Foodgrains	Non-foodgrains	All crops
1920-21	92.0	58.0	81.9
1921-22	119.5	69.2	104.6
1922-23	121.9	77.8	108.8
1923-24	105.3	77.1	96.9
1924-25	109.1	78.8	100.1
1925-26	104.8	84.1	98.6
1926-27	105.9	81.8	98.7
1927-28	102.7	91.0	99.2
1928-29	108.1	89.4	102.5
1929-30	110.0	82.4	101.8
1930-31	111.6	89.2	104.9
1931-32	113.2	82.8	104.1
1932-33	103.2	97.3	101.5
1933-34	105.7	99.9	104.0
1934-35	106.1	86.6	100.2
1935-36	100.0	100.0	100.0
1936-37	109.7	110.4	109.9

(*Contd.*)

APPENDIX II (*Concld.*)

Year	Foodgrains	Non-foodgrains	All crops
1937-38	107.9	109.7	108.4
1938-39	98.2	88.2	95.3
1939-40	103.1	97.3	101.4
1940-41	100.1	115.5	104.6
1941-42	98.4	93.4	96.9
1942-43	108.1	93.1	103.6
1943-44	110.9	107.8	110.0
1944-45	108.8	97.6	105.5
1945-46	98.1	92.3	96.4
1946-47	99.6	96.1	98.6
1947-48	103.1	102.2	102.8
1948-49	97.5	87.8	94.6
1949-50	102.5	99.1	101.5
1950-51	93.2	105.7	96.9
1951-52	93.7	112.2	99.2
1952-53	107.3	102.8	105.9
1953-54	126.7	104.0	120.0
1954-55	122.3	120.1	121.7
1955-56	131.3	132.5	131.6
1956-57	139.1	148.5	141.8
1957-58	127.0	148.2	133.3
1958-59	151.1	157.9	153.0
1959-60	147.4	150.6	148.3
1960-61	159.5	178.0	164.9
1961-62	161.7	175.6	166.1
1962-63	151.6	169.2	156.9
1963-64	159.2	179.2	165.0
1964-65	173.5	203.3	182.5

APPENDIX III

INDEX NUMBERS OF COMPONENTS OF AGRICULTURAL PRODUCTION

Year	Index number of output for constant crop pattern (I_o) 1920-21=100	Index number of area (I_a) 1935-36=100	Index number of yield per acre (I_y) 1935-36=100	Index of crop pattern (I_c)
1920-21	100.0	90.0	91.0	81.9
1921-22	132.0	97.2	107.6	79.2
1922-23	134.8	98.8	110.2	80.7
1923-24	119.2	96.4	100.6	81.3
1924-25	124.7	99.0	101.6	80.3
1925-26	119.7	97.0	101.6	82.4
1926-27	120.0	96.3	102.4	82.2
1927-28	120.6	97.8	101.4	82.2
1928-29	124.7	101.1	101.4	82.2
1929-30	124.4	97.0	104.9	81.8
1930-31	126.3	100.0	104.8	83.0
1931-32	128.1	102.1	101.9	81.3
1932-33	124.3	100.1	101.3	81.6
1933-34	124.4	102.4	101.5	83.6
1934-35	120.7	98.8	101.5	83.0
1935-36	117.5	100.0	100.0	85.1
1936-37	128.1	102.4	107.3	85.8
1937-38	126.3	102.4	105.8	85.8
1938-39	111.7	100.6	94.6	85.3
1939-40	118.0	99.3	102.1	85.9
1940-41	119.5	102.2	102.4	87.5
1941-42	115.1	100.3	96.6	84.2
1942-43	126.7	106.0	97.7	81.8
1943-44	128.6	105.8	103.9	85.5
1944-45	124.0	105.9	99.6	85.1
1945-46	112.4	103.7	92.9	85.8

(Contd.)

APPENDIX III (*Concld.*)

Year	Index number of output for constant crop pattern (I_o) 1920-21=100	Index number of area (I_a) 1935-36=100	Index number of yield per acre (I_y) 1935-36=100	Index of crop pattern (I_c)
1946-47	112.0	103.0	95.7	88.0
1947-48	115.9	100.6	102.1	88.3
1948-49	106.2	100.8	93.8	89.1
1949-50	116.6	106.1	95.7	87.0
1950-51	108.3	107.3	92.0	89.5
1951-52	110.6	108.4	91.4	89.7
1952-53	123.3	111.9	96.4	85.9
1953-54	138.8	113.4	105.1	86.4
1954-55	145.3	119.7	101.6	83.7
1955-56	151.5	122.7	107.2	86.9
1956-57	161.0	124.2	114.2	88.1
1957-58	150.8	123.1	108.3	88.4
1958-59	174.5	125.6	121.8	87.7
1959-60	167.1	129.0	114.9	88.7
1960-61	185.9	129.4	127.6	88.7
1961-62	185.0	132.8	125.1	89.8
1962-63	177.4	131.3	119.4	88.4
1963-64	186.5	132.0	124.9	88.5
1964-65	201.2	133.3	136.9	90.7