SANKHYĀ

THE INDIAN JOURNAL OF STATISTICS

Edited by: P. C. MAHALANOBIS

Volume 1. Parts 2 and 3. May, 1934.

STUDIES IN THE VARIATION OF AGRICULTURAL PRICES IN INDIA.

For some time past, the Economic Section of the Statistical Laboratory has been engaged in the systematic study of Indian prices. Broadly, three aspects are being considered:—(*a*) the influence of supply on price, (*b*) the influence of price on consumption, and (*c*) the influence of price on subsequent production. The problem is so complex that it will take a long time to study even the more important crops of India. We have, therefore, thought it desirable to publish from time to time short reports on particular crops with a view to attract other workers to the field, and for discussion and criticism. It should be recognised that the results are of a tentative character.—*Editor.*

NO. 1. INDIAN CULTIVATORS' RESPONSE TO PRICES.

By AMULYA RATAN SINHA, M.A., HARIS CHANDRA SINHA, Ph.D., AND JNAN RANJAN GUHA THAKURTA, M.A.,

Statistical Laboratory, Calcutta.

It is an economic truism that prices influence subsequent production. In the case of agriculture, production is determined by (*a*) the area under cultivation, and (*b*) the yield per unit area. The yield rate is controlled to a very large extent by weather conditions. But this is only partly true in the case of the area, where economic considerations play their part. The previous investigators in this field in India, however, such as Jacob[1] (1910, 1916) and Unakar (1920) have considered only the meteorological factors both for area as well as for yield. This was done probably on account of the belief that Indian cultivators are guided mainly by customs and traditions, and not by economic motives. It is the purpose of this paper to examine how far this belief is justified.

Changes in crop area depend on two factors:—(*a*) the intention of the cultivator, and (*b*) his ability to carry out that intention in practice. The first, though purely psychological in character, is naturally influenced by economic considerations of price. As regards the second, although non-economic causes such as weather conditions about the time of sowing exert their influence, economic causes are also operative. When a plot is sown with a particular crop in preference to others, it is because the growers expect a better

[1] See Bibliography at the end of the paper.

return from that crop. This expectation is naturally influenced by the prices obtained for the crop during the last harvest. Thus, other things remaining the same, the acreage should rise or fall according as the last harvest price was high or low. Similarly, if the price at the sowing time is high, there is a natural incentive for the cultivator to increase the acreage. From the standpoint of the ability factor also, the prices at the time of the last harvest and during the present sowing are both important. For, an increased acreage means an increased cost, which the cultivator can meet better, if he has obtained good prices at the last harvest. Even when he has to borrow, as is frequently the case, the *mahajan* or the village moneylender will be better disposed to comply with his request when the *mahajan* finds that outstanding loans are less than before as a result of high prices obtained by the borrower, and further when prices show a rising tendency holding out a bright prospect for the crop for which finance is required. It should be remembered, however, that the high and low prices mentioned above are to be considered in relation to the prices of alternative crops. For, obviously, if the prices of *all* crops rise or fall to the *same* extent, the relative position is exactly the same as before, and there is no inducement for increasing or decreasing the acreage of any particular crop. It is, therefore, necessary to reduce the price of the crop under study by the prices of alternative crops, and work with such adjusted figures in studying the fluctuations in the acreage of that particular crop. The same object may also be attained by including the price of alternative crops in a scheme of multiple correlation. As this paper is a preliminary one, such refinements are reserved for more detailed consideration in future.

It is well-known that the food crops grown in India are largely consumed by the cultivators themselves. The influence of money economy is thus somewhat remote in in such cases.[3] It was therefore thought advisable to begin with important non-food crops. The non-food crops chosen for this preliminary study are Cotton, Linseed, and Groundnut. Jute was left out ; for, on account of permanent settlement in vogue in jute areas, no separate revenue staff is maintained there, and the acreage figures for jute are known to be less reliable than those for the other crops.

It should be remembered that relative rather than absolute changes form the basis of economic relationships. Various statistical devices are available for studying such relative changes. But it was thought advisable to make use of the method of percentage variation, in which each year's figure, whether for price or for area, is expressed as a percentage of the previous year's figure. This is a variant of the link relative method and seems to be peculiarly suited for studies of the present nature. For, in India new areas have been incorporated in the official reports from time to time. Owing to this gradual development, the early figures are not strictly comparable to the more recent ones, a fact which is clearly mentioned in every issue of the official publications relating to area and yield of crops in India. It is therefore difficult to determine the trend correctly. The trend being inaccurate, the trend-ratio method or any other method based on the trend is clearly inappropriate. The following example will show the difficulties of using a trend method. The officially reported area under Groundnut in India during the year 1907-08 was 87,000 acres, which included for the first time 14,000 acres for Burma. To find out the rate of variation during the next year, 1908-09, in which also Burma was reported, we should obviously work on the basis of 87,000, whereas in determining the rate of variation from 1906-07 to 1907-08, we should take 73,000, for Burma must be excluded from both. Similar difficulties occur in the case of other long series of crop data.

[3] In Bengal, "paddy loans," *i.e.*, loans incurred and paid off in terms of paddy, form a feature of the rural life. There are other examples of barter economy in Bengal and other parts of India.

The data for price also presented many difficulties. In the first place, the price *actually* obtained by the cultivator was not available for a long series of years.[3] Even the wholesale prices in the central markets during the sowing and harvesting seasons of early and late varieties of the different crops could not always be procured. Then there is the usual disparity between the prices in primary and central markets which is somewhat high in India, on account of the multiplicity of middlemen, who exploit the lack of knowledge and of bargaining power of the growers. But, as stated above, in the method chosen, the ratio of each year's price to the previous year's price has been taken, and the error due to this disparity has been largely eliminated.

In the next place, it is well known that the present century has passed through very large fluctuations in the value of money. Theory therefore calls for an adjustment for the variation in the purchasing power of money in the hands of the Indian *ryot*. This is a peculiarly difficult task ; for on account of the wide area and heterogenous ways of living in vogue in diverse parts of India, it is quite impossible to compile any satisfactory index number which would be suitable for the growers of all the crops in all the different provinces of India. In the case of industrial workers, whose conditions of living are less dissimilar than those of agriculturists, wide disparities are noticeable in the index number of cost of living from province to province, and even within the same province at different centres or in the same centre for different communities. On the other hand, it may be argued that the question of the changing value of the rupee is not of great importance to the Indian cultivator. He seems to be concerned mainly with the *nominal* price, for he grows commercial crops chiefly to meet his money obligations, such as the rent and debt charges, which do not change with changes in the purchasing power of money.

In view of the above facts as well as in the absence of the necessary data, the price of Cotton has not been adjusted, in this preliminary note, at all ; that of Groundnut has been deflated by the Department of Statistics Index Number of Wholesale Prices of exported articles, figures for which are available from 1861 ; and that of Linseed by the Index Number for all commodities in the same series.

1. Cotton.

The area data have been obtained from the '*Estimates of Area and Yield of Principal Crops in India.*' The price statistics have been taken from *Prices and Wages in British India*, and as the series were discontinued in 1923, the subsequent figures have been taken from market quotations which conformed to the series given in the Blue Book. The quotation for January was taken to represent the price during the previous harvesting season and that for July during the current sowing season.[4] The quotations are for Broach cotton, the most important variety of the crop, in Bombay, the principal market for the fibre. All these data for cotton are shown in Table I, the January and July prices having been paired with the acreage for the following crop season. Thus the prices in January and July, 1900 have been related to the area under cotton in 1900-01 and so on In column 5 of the same Table are shown the averages of January and July prices. In the next four columns are calculated the percentage variations as compared with the previous year of (1) the area under cotton (x_1), (2) the January price (x_2), (3) the July price (x_3) ;

[3] The harvest prices are being shown in Table VII of *Agricultural Statistics of India*, Vol. I only from the issue for the year 1919-20.

[4] This is not strictly accurate, as sowings of late varieties, which are grown principally in certain parts of Southern and Western India, continue till December and harvesting till July of the following year.

and (4) the average of January and July prices (x_3). The influence of January and July prices on the subsequent acreage was obtained by the method of multiple correlation ; the regression equation[6] is given below.

$$x_1 = 1{\cdot}4877 + 0{\cdot}1391\ (x_2) + 0{\cdot}1212\ (x_3) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1{\cdot}1)$$

The coefficient of multiple correlation,[6] $R_{1{\cdot}23} = 0{\cdot}57$.

To judge the relative importance of the two variables—x_2 and x_3, it is necessary to transform the above equation in such a manner that each variable is expressed in terms of its own standard deviation. If this is done, the coefficients of x_2 and x_3 are found to be nearly equal. This means that the January and July prices exert almost equal influence on the subsequent acreage under cotton. We are therefore justified in taking the averages of the two prices, and in correlating such averages with the area figures. The following equation results :—

$$x_1 = 1{\cdot}6562 + 0{\cdot}2607\ (x_4) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1{\cdot}2)$$

with a correlation coefficient of nearly 0·6 with a probable error of 0·09, showing that the relationship is significant.[7] The percentage changes derived from this equation have been transformed into actual acreages and are shown in column 10 of Table 1. The estimated and actual acreages (col. 2, Table 1) have been plotted for comparison in Fig. 1.2. It will be seen that with the exception of the disturbed war period,[8] the concordance between the two curves is fairly satisfactory.

In the above, it is tacitly assumed that when the price rises by, say, ten per cent., the area cultivated increases at an invariable rate, no matter whether the level of price under consideration is high or low. For example, the assumption is, that when the price rises from Rs. 20/- to Rs. 22/- by ten per cent. the effect on acreage is the same as when the price rises from Rs. 300/- to Rs. 330/- by ten per cent. again. This hypothesis is not theoretically tenable, and we may try to improve the fit by using a parabola of the second degree. The following equation is obtained :—

$$x_1 = 3{\cdot}7995 + 0{\cdot}3633\ (x_4) - 0{\cdot}0042\ (x_4)^2 \ldots\ldots\ldots\ldots\ldots\ldots (1{\cdot}3)$$

The acreages as estimated from the above equation are shown in column 11 of Table 1, and plotted in Fig. 1.2. It will be seen that within the range of observation there is no substantial improvement in the estimate made from the more complex equation. As a matter of fact, the standard error in terms of percentages is reduced to only 8·9 in the case of parabolic relationship against 9·4 for the linear relationship.

---

[6] The observed statistical constants are :—

$\bar{x}_1 = 2{\cdot}762$; $\bar{x}_2 = 5{\cdot}872$; $\bar{x}_3 = 3{\cdot}838$; $\bar{x}_4 = 4{\cdot}25$

$\sigma_1 = 11{\cdot}7$; $\sigma_2 = 29{\cdot}8$; $\sigma_3 = 25{\cdot}1$; $\sigma_4 = 24{\cdot}5$

$r_{12} = +0{\cdot}53$; $r_{13} = +0{\cdot}50$; $r_{23} = +0{\cdot}66$ $N = 29$ in all cases

[6] The one per cent. values of multiple correlation co-efficients for no association are 0·55 ($n = 25$), and 0·51 ($n = 30$). See Wishart's Table.

[7] If a properly weighted average of x_2 and x_3 are taken, the correlation coefficient should theoretically be 0·57 as before.

[8] If the five years of the war, which are abnormal, be excluded, the correlation coefficient improves to 0·7, showing a closer correspondence between actual and estimated acreages.

FIG. (1·1) LINEAR EQUATION

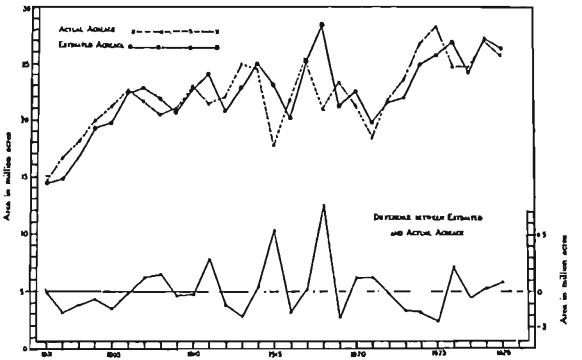

FIG. (1·2) PARABOLIC EQUATION

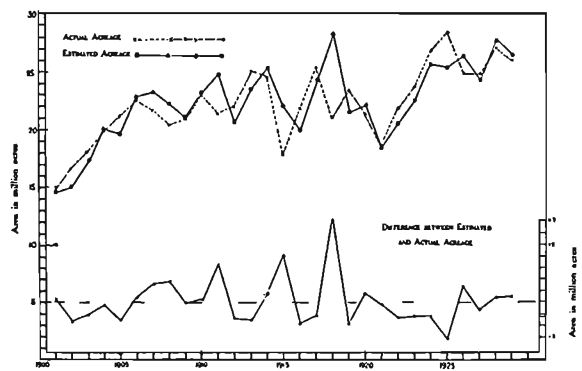

FIG. 1. Actual and Estimated Acreage for Cotton.

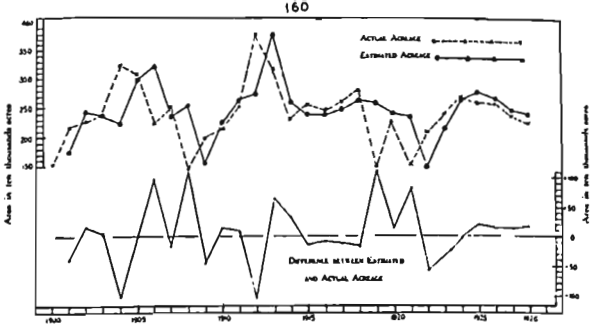

Fig. 2. Actual and Estimated Acreage for Linseed.

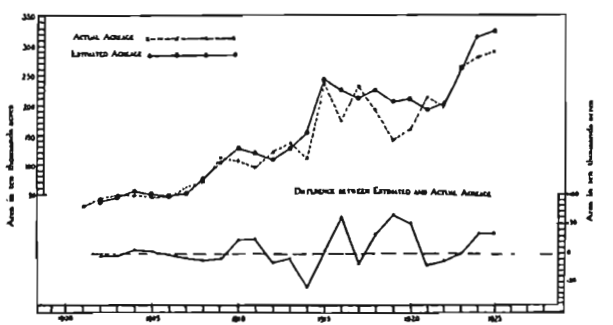

Fig. 3. Actual and Estimated Acreage for Groundnut

TABLE 1.—DATA FOR COTTON.

Years	All-India Cotton Area (in million Acres	Price of Broach Cotton (Rs. per Candy of 784 lbs.)			Percentage variation as compared with preceding year of				Estimated Acreage	
		January	July	Average of January and July	Cotton Area x_1	January Price x_2	July price x_3	Average of January and July price x_4	Equation (1'2)	Equation (1'3)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1900	11'2	213	223	219	...	...	...	...	..	...
1901	11'3	225	205	215	+ 2'1	+ 4'7	- 9'0	- 1'8	11'4	11'6
1902	10'6	205	219	212	+11'5	- 8'0	+ 7'0	- 1'4	11'7	15'0
1903	18'0	192	222'5	207'25	+ 8'4	- 6'3	+ 1'6	- 2'2	16'8	17'1
1904	19'0	261	235	248	+10'6	+35'0	+ 5'6	+19'7	19'2	19'7
1905	21'1	195	236	215'5	+ 6'0	-25'3	+ 0'4	-13'1	19'6	19'6
1906	22'5	253	249	252	+ 6'6	+30'8	+ 5'5	+16'0	22'4	22'0
1907	21'6	238'5	259	248'75	- 4'0	- 6'5	+ 4'0	- 1'3	22'8	23'2
1908	20'4	267	226	246'5	- 5'6	+11'0	-12'7	- 1'0	21'0	22'3
1909	21'0	221	263	242	+ 2'9	-17'2	+16'4	- 1'8	20'6	21'0
1910	23'0	316	290	303	+ 9'5	+43'0	+10'3	+25'2	22'7	23'2
1911	21'4	369	315	342	- 7'0	+16'8	+ 8'6	+12'9	21'1	21'8
1912	22'0	261	305	283	+ 2'8	-29'3	- 3'2	-17'7	20'8	20'6
1913	25'0	323	295	309	+13'6	+23'8	- 3'3	+ 9'2	22'0	23'5
1914	24'6	292	287	289'5	- 1'6	- 9'6	- 2'7	- 6'1	23'0	25'3
1915	17'8	193	217	205	-27'6	-33'9	-24'4	-29'2	23'1	22'0
1916	21'8	300	284	292	+22'5	+55'4	+30'9	+42'4	20'1	19'9
1917	25'3	412	509	461	+16'1	+37'3	+79'2	+57'9	25'4	24'2
1918	21'0	594	712	653	-17'0	+44'2	+39'9	+41'6	28'5	28'2
1919	23'4	676	594	635	+11'4	+13'8	-16'6	- 2'8	21'2	21'5
1920	21'3	519	456	502'75	- 9'0	-18'8	-27'2	-20'9	22'5	22'1
1921	18'5	320	326	323	-13'1	-41'7	-28'5	-35'7	19'7	18'4
1922	21'8	483	542'5	512'75	+17'8	+50'9	+66'4	+58'7	21'6	20'5
1923	23'6	481	518	499'5	+ 8'3	- 0'4	- 4'4	- 2'6	22'0	22'1
1924	26'8	658'5	506	582'25	+13'6	+36'9	- 2'3	+16'6	25'0	25'6
1925	28'4	450	460	455'5	+ 6'0	-30'3	- 9'1	-21'1	25'8	25'3
1926	24'8	360	372'5	346'25	-12'7	-21'6	-27'7	-24'6	27'0	26'2
1927	24'8	253	339	296	0	+29'7	+ 2'0	-14'5	24'3	24'2
1928	27'1	378	417	397'5	+ 9'3	+49'4	+23'0	+34'3	27'4	27'6
1929	25'9	339	320	329'5	- 4'4	- 5'0	-23'3	-11'6	26'5	26'4

2. Linseed.

In the case of linseed, such a detailed study was not attempted. It is grown largely as a "mixed" (companion) crop, specially in the United Provinces, where the area under the mixed crop variety[9] as given in *Estimates of Area and Yield of Principal Crops in India* is stated to be largely conjectural. The acreage data were therefore taken from *Agricultural Statistics of India*, Vol. I. The averages of January and July prices in Calcutta were taken from the Index Numbers of Indian Prices, as "proper prices" during the sowing and harvesting seasons were not readily available. This was also necessary as the index numbers of prices for all commodities with the help of which the raw prices are to be adjusted were available only for the prices recorded in the Blue Book. In columns 2, 3 and 5 of Table 2 are shown respectively the acreages under linseed, the prices of linseed, the index numbers of prices of all commodities, and the deflated prices of linseed. The percentage variations in acreages y_1 and in deflated prices y_2 are given in columns 6 and 7 of the same Table. The regression equation[10] between the two is

$$y_1 = 4{\cdot}2 + 0{\cdot}57\ y_2 \qquad \ldots\ldots(2{\cdot}1)$$

with a correlation coefficient of 0·53, which is above the five per cent. level of significance for $n = 28$.

The acreages estimated from this equation are given in column 8 of Table 2, and are shown plotted in Fig. 2. Comparing with the actual values (given in column 2 and plotted in Fig. 2) it will be noticed that there is a fair amount of correspondence between the two sets of figures.

3. Groundnut.

Groundnut has become an article of export of increasing importance only in recent years, and its price quotations were not available from official publications. They were therefore obtained from the Prices Current issued by the Madras Chamber of Commerce. Only the January prices, that is prices during the harvesting season, have been used in this paper. As sowing and reaping are carried on at different time in different parts of India, it is difficult to obtain 'proper prices.' As stated above, these raw prices have been adjusted by the Index Number of exported articles. The acreage data have been taken from the *Estimates of Area and Yield of Principal Crops in India*. All these figures are

[9] On the average of the five years ending 1931-32, the area under the mixed linseed crop in the United Provinces represents about 30 per cent. of the total linseed area in the British India.

[10] The observed statistical constants are :— $\bar{y}_1 = 5$; $\bar{y}_2 = 1.4$; $\sigma_1 = 26.4$; $\sigma_2 = 24.4$ $N = 28$

TABLE 2.—DATA FOR LINSEED.

Years	Area of Linseed in British India (in tens of thousands Acres)	Calcutta Price of Linseed (in Rupees per bazar maund of 82⅔ lbs.)	General Index Number of prices	Deflated Prices	Percentage Variations		Estimated Area of Linseed in British India (in tens of thousands Acres)
					in Acreage y_1	in deflated Prices y_2	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1899-1900	153	4·42	96	4·61	..	...	...
1901	215	6·34	116	5·47	+41	+19	176
1902	227	6·03	110	5·32	+ 6	+16	243
1903	234	6·72	106	6·34	+ 3	0	236
1904	323	5·20	99	5·25	+38	−17	221
1905	305	4·11	101	4·07	− 5	−22	207
1906	223	4·58	110	4·16	−27	+ 2	321
1907	251	5·41	129	4·19	+13	+ 1	234
1908	140	5·33	137	3·89	−44	− 7	251
1909	198	5·83	138	4·22	+41	+ 8	153
1910	212	6·13	126	4·84	+ 7	+17	226
1911	251	7·88	122	6·46	+18	+31	250
1912	376	8·04	129	6·03	+50	+ 7	271
1913	313	8·81	137	6·43	−17	− 7	376
1914	227	5·69	143	3·98	−27	+38	258
1915	253	5·97	147	4·06	+11	+ 2	238
1916	245	4·04	152	3·25	− 3	−20	235
1917	256	5·56	184	3·02	+ 4	− 7	245
1918	278	5·58	196	2·84	+ 9	− 6	259
1919	143	5·03	225	2·24	−48	−21	256
1920	223	12·63	276	4·56	+55	+104	238
1921	150	12·44	281	4·43	−33	− 3	231
1922	205	0·13	236	3·87	+37	−13	146
1923	237	0·00	232	3·88	+16	0	213
1924	265	0·25	215	4·30	+12	+11	262
1925	256	0·50	221	4·20	− 3	0	276
1926	252	0·53	227	4·20	− 2	− 2	264
1927	233	8·00	216	3·70	− 8	−12	244
1928	221	7·16	202	3·54	− 5	− 4	239

quoted in Table 3, columns 2 to 5. The percentage variations in acreages (z_1) and in deflated prices (z_2) are shown in the next two columns, the regression equation[11] reducing to

$$z_1 = 12{\cdot}2 + 0{\cdot}45\ (z_2) \qquad \ldots\ldots(3{\cdot}1)$$

with a correlation coefficient of 0·52, ($n = 24$) which is significant. The acreages as estimated from the equation are given in column 8 and in Fig. 3 are shown the actual and estimated acreages plotted together.

Conclusion.

From the above analysis, it is clear that in the case of at least three commercial crops, there is a significant relation between the price and the subsequent acreage. Fairly high correlation coefficients (of the order of 0·6) have been obtained even for a period of great economic disturbance, although 'proper prices' have not always been available. It follows therefore that in estimating crop areas by statistical methods it is necessary to take both the meteorological and economic factors into consideration.

BIBLIOGRAPHY.

Jacobs, S. M. Correlation of Areas of Matured Crops and Rainfall. *Memoires of the Asiatic Society of Bengal*, Vol. II, No. 11 (1910), pp. 347-429.

— On the Correlation of Rainfall and the Succeeding Crops with special reference to the Punjab. *Agricultural Journal of India*, Science Congress number, 1916, pp. 86—102. Also published as *Memoires of the Indian Meteorological Department*, Vol. XXI, Part XIV.

Smith, Bradford B. Forecasting the Acreage of Cotton. *Jour. Amer. Stat. Soc.*, March, 1925, pp. 31-47.

Unakar, M. V., Rao Sahab. Correlation between Weather and Crops with special reference to Punjab Wheat. *Memoires of the Indian Meteorological Department*, Vol. XXV, Part IV, (1929).

Wishart, John. Table of Significant Values of the Multiple Correlation Coefficient. *Quart. Jour. Royal Met. Soc.*, Vol. LIV, No. 227, 1928, pp. 258-259.

Indian Official Publications.

Agricultural Statistics of India, Vol. I. Published annually by the Govt. of India, Calcutta and Delhi.

Estimates of Area and Yield of Principal Crops in India. Published annually by the Govt. of India, Calcutta and Delhi.

Prices and Wages in British India. Published annually by the Govt. of India, (discontinued since 1929).

Prices Current issued weekly by the Chamber of Commerce, Madras.

(Paper received July, 1933).

[11] Statistical constants are :—

$\bar{z}_1 = 14$; $\bar{z}_2 = 4$; $\sigma_1 = 21.4$; $\sigma_2 = 25.6$; $N = 24$.

TABLE 3.—DATA FOR GROUNDNUT.

Years	Area of Groundnut (in tens of Thousand Acres)	January price of Groundnut in Madras (in rupees) per candy of 500 lbs.	Exported Index No. of prices	Deflated prices	Percentage variations		Estimated area of Groundnut in India
					in Acreages	in deflated prices	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1900-1901	29	2·80	124	2·26	...	..	...
1902	43	3·43	116	2·96	+48	+31	37
1903	49	3·00	113	2·65	+14	−10	46
1904	47	2·83	103	2·77	− 4	+ 5	56
1905	46	2·50	104	2·40	− 2	−13	50
1906	49	2·38	116	2·05	+ 7	−15	48
1907	62	2·68	139	1·93	+27	− 6	53
1908	87(73)*	3·40	145	2·34	+18	+21	76
1909	111	3·00	151	2·38	+28	+10	102
1910	105	3·65	133	2·74	− 5	+ 6	128
1911	93	3·43	127	2·70	−10	− 1	118
1912	121	3·75	136	2·76	+27	+ 2	107
1913	137	3·58	143	2·47	+13	−11	129
1914	210	3·70	134	2·40	+53	− 3	152
1915	241	4·30	160	2·69	+15	+12	216
1916	166	2·35	133	1·65	−31	−39	227
1917	233	3·63	163	2·23	+40	+35	212
1918	194	2·55	170	1·50	−17	−33	226
1919	141	2·66	199	1·31	−27	−13	206
1920	159	6·65	277	2·40	+13	+83	210
1921	213	8·20	281	2·92	+34	+22	193
1922	214(198)**	4·30	239	1·80	− 7	−38	202
1923	263	5·50	245	2·24	+23	+24	253
1924	280	5·85	224	2·61	+ 6	+17	316
1925	289	6·23	222	2·81	+ 3	+ 8	325

* The figure within bracket represents the area after excluding Burma which was included for the first time in the series.

** The figure within bracketa represents the area after excluding Hyderabad which was included for the first time in the series.