A STUDY OF RECENT CHANGES IN COTTON PRODUCTION PATTERN AND TECHNIQUES IN THE UNITED STATES AND THEIR APPLICABILITY TO INDIAN CONDITIONS

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T. Y. Patil

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A STUDY OF RECENT CHANGES IN COTTON PRODUCTION PATTERN AND TECHNIQUES IN THE UNITED STATES AND THEIR APPLICABILITY TO INDIAN CONDITIONS

by

T. Y. Patil

AN ABSTRACT

Submitted to the College of Agriculture of
Michigan State University of Agriculture
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ment of the requirements
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1955

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T. Y. Patil

ABSTRACT

A Study of Recent Changes in Cotton Production Pattern and Techniques in the United States and their Applicability to Indian Conditions

This study represents an attempt to evaluate recent changes responsible for improvements in United States cotton production and to find possible application of these factors to Indian conditions.

In the last 30 years cotton production in United States increased in spite of the considerable decrease in acreage. (Many developments were responsible for it.) India is the second largest cotton producing country in the world following the United States. Yet in India similar improvements to those in the United States have not been made. It was believed that the study of different factors responsible for recent increased cotton yields in the United States would be helpful as a guide to recommend improvement of Indian cotton production.

Data used for this study were obtained from various sources reporting United States Agricultural Statistics and different bulletins of the United Nations. Most of the data show acreage, yield and production of cotton in the United States and India for the period of 1910 to 1952. Statistics required to study technological changes, costs returns and efficiency were collected for different periods from different studies and bulletins. This period was one of contrasting changes in acreage and yield in these two countries.

Qualitative analyses were made. The basic notion here is that production of cotton is a function of acreage and yield.

It was found that the increase in yields irrespective of decline in acreage was responsible for increased production. Different factors such as improved varieties, fertilizer, tillage techniques and land selection seemed to have a significant influence in increasing yield; mechanization also had a great influence on production efficiency. Increase in yield and decrease in labour requirement were significantly responsible for increases in production efficiency. Mechanized large farms and intensively cultivated small farms both increased production per man hours. Returns per acre appeared to be higher on the small scale farms than the large scale farms. Larger capital expenditures and higher cost caused lower returns on large-mechanized farms.

An analysis of the role and applicability of these factors to Indian cotton production, indicated that the use of improved varieties, fertilizer and tillage are the most feasible possibilities to increased cotton yield in India. Use of labour saving devices such as mechanization though necessary and desirable as a long run of objective do not appear to represent an immediate source of improvement.

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The author assumes full responsibility for any errors which may be present in this manuscript.

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CHAPTER I

INTRODUCTION

I. Agriculture in India

1) Importance of Agriculture in the Economy -

Agriculture is India's most important industry and has always occupied an important place in India's economy. That role it retains even today despite the fact that the economy is being steadily industrialized. It is the main occupation of the people, but more important than this is the rise in proportion of population dependent on agriculture. This proportion has risen from 61 percent in 1891 to 66 percent in 1901 to 73 percent in 1921. According to the census of 1951, 71 percent of the population depends directly on agriculture at the present time.

There has been a steady increase in the population in India and the additional population instead of being absorbed into industry has actually remained on agriculture. "The indigenous cottage industries were driven to the wall by the competition of mass produced, machine made cheap goods imported from abroad, and their decline drove the small artisans to seek their livelihood from land. Thus, whereas industrialisation provided more and more employment in western countries, for India it meant the destruction of all indigenous industries with no

offsetting increase in employment at home."[1] Of the rural population nearly 90 percent is directly or indirectly connected with agriculture.

Agriculture contributed 49.9 percent to the national income of India for the year 1915-52.[2] A large amount of capital is invested in agriculture. Agricultural holdings represent perhaps the largest fixed capital investment in the country.

Furthermore, agriculture provides the bulk of India's exports and helps in earning a considerable amount of foreign exchange necessary for the planning of different schemes of social and economic development.

Again, agriculture forms a basis for India's various industries including trade and transport. Some of the biggest industries such as sugar and textiles depend on agriculture for the supply of raw materials. Besides, agriculture is the main source of revenue for the state governments. Above all domestic agriculture is the main source of food and fibre for the vast and growing population of the country.

The significant place of agriculture in the country's life and economy is thus quite evident. India is primarily an agricultural country and agriculture is the basis of India's national economy.

2) Present Position of Agriculture -

The change in number of people engaged in agriculture and industry for different periods is illustrated in Table I. It shows

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[1] Narayauswani, B. V. and P. S. Narsiguham, The Economies of Indian Agriculture, Richouse and Sons, Ltd., Madrass, India, 1946, p. 9.

[2] "The Special Budget Number for 1955-56," The Eastern Economist, New Delhi, March 5, 1955, p. 361.

TABLE I

THE NUMBER AND PERCENTAGE OF PEOPLE OCCUPIED IN AGRICULTURE AND INDUSTRIES IN INDIA, 1911-1952 (by census year)[1]

People employed in	1911		1921		1931		1941		1951	
	Number (1000)	Per-cent	Number (1000)	Per-cent	Number (1000)	Per-cent	Number (1000)	Per-cent	Number (1000)	Per-cent
Agriculture	218.7	72.2	223.0	73.0	253.0	75.0	291.75	75.0	249.0	69.8
Industries	16.6	5.5	14.9	4.9	14.5	4.3	16.3	4.2	32.8	9.2
Total Population	303.0		330.6		338.0		389.0		356.8	

[1]Source: Compiled from the United Nations Publications, Year Book of Food and Agricultural Statistics, Food and Agriculture Organization of the United Nations, Rome, Italy, 1948-1953.

that industries provide employment to about 4 to 9.2 percent of the total population of the country. The total volume of industrial employment has increased during recent years. Agriculture, however, is—and probably will remain for many years to come—India's largest single industry.

Unfortunately it is also one of her most depressed industries. The outstanding features of the Indian rural economy is the appalling poverty of the cultivators. "Average annual per capita net income of the Indian farmer in 1952 was not more than Rs. 110 or $24.00"[1] as compared with that of $930.00 of the farmer in the U.S.A.[2] in the same period. The contrast is alarming; many factors are responsible for it.

One of these factors is the small size of holding; the average unit of cultivation being less than five acres. A farm of this size fails to give employment to the farmer throughout the year. These holdings usually are not compact but in fragments scattered throughout the village area.

Another reason is that the Indian farmer is extremely dependent on monsoon rainfall which is proverbially irregular. The frequent crop failures which result, have the effect of making Indian farmers fatalistic and hence have reduced the incentive to improvement.

Extremely low yields per acre on small size farms mean a very low per capita income from farming and because of the absence of subsidiary occupation the farmer is completely dependent on the produce from land.

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[1] "Records and Statistics"- Quarterly Bulletin, The Eastern Economist, New Delhi, 1954, Vol. VI, No. 1, p. 36.

[2] The Farm Income Situation, A.M.S., U.S.D.A., 1955 Outlook Issue, p. 23.

A defective marketing system adds to the woes of the Indian farmer. A marketing system often built around repayment of production debts by delivery of farm products often compels him to sell cheap when he has bought dear.

For these and many other reasons, the cultivator often does not earn enough to maintain himself until the next harvest. This inadequacy of income plus expenditures on social ceremonies demanded by custom forces farmers to borrow. Thus being a debtor, his right to the land becomes precarious. The loss of the liberty to dispose of his crop except to the lender to repay his debt tends to reduce the incentive for improvements. These troubles are aggrevated by illiteracy which prevents the rapid adoption of improvements.

3) Food Problem -

These conditions affect agricultural production. From 1915 through 1925, the food supply of the country did not keep pace with the increase in population even though the number of people engaged in agriculture increased. Though statistics regarding food production are not current, some available information gives a rough picture of the situation. Table II shows the index number of change in population and food supply in India from 1910 through 1935.

The table shows that though food production remained above population growth in this period, the margin between these two indices was narrowing. "Mr. P. K. Wattal in his presidential address at the All-India population conference of 1938 pointed out that during 1913-14 to 1935-36 population increased at the rate of nearly one percent per

TABLE II

INDEX NUMBERS OF CHANGE IN POPULATION AND FOOD SUPPLY IN INDIA, 1910-11 to 1937-38[1]

Year	Population	Food production (weighted)	Food supply available for consumption (unweighted)	Excess or deficit of food supply index in relation to population index
1910-11 to 1914-15	100	100	100	
1915-16	103	129	125	+22
1916-17	104	135	126	+22
1917-18	104	130	122	+18
1918-19	105	91	87	-18
1919-20	100	130	113	+13
1920-21	99	99	99	0
1921-22	100	127	120	+20
1922-23	101	144	125	+24
1923-24	101	126	109	+ 8
1924-25	101	121	103	+ 2
1925-26	101	121	113	+12
1926-27	102	126	117	+15
1927-28	102	117	111	+ 9
1928-29	103	118	120	+17
1929-30	104	123	122	+18
1930-31	107	126	123	+16
1931-32	114	126	122	+ 8
1932-33	117	124	123	+ 6
1933-34	118	123	122	+ 4
1934-35	120	125	123	+ 3
1935-36	121	115	122	+ 1
1936-37	123	123	128	+ 5
1937-38	125	110	118	- 7

[1]Source: Mukerjee Rashakamal, Food Planning for Four Hundred Millions, Macmillan and Co. Ltd., St. Martin's, St. Londar 1938.

annum whereas crop production increased by only 0.65 percent per annum."[1] Extrapolation of the above trends by using recent figures of food imports in India will give a picture of the unbalanced situation of the population and food. Table III shows the imports of food grains in India. The solution of India's food problem, chronic and grave as it has become, is urgent from every point of view. It affects seriously the life and efficiency of both the present and future generations. Food shortages cause certain diseases by lowering vitality. The general depression of health and lack of efficiency in work are important national problems.

II. Partition

1) Effect of Partition on Food and Fibre

The partition of India into the union of India and Pakistan took place on August 15, 1947. The economy of the country received a violent shock by partition. It resulted in an uneven distribution of area when related to agricultural resources and population. India had nearly 77 percent of the total area with 81 percent of total population of undivided India. The area under irrigation is another important factor. The proportion of irrigated area to net sown area is larger in Pakistan than in India. The Republic of India has under irrigation 20.2 percent of the net sown area, while Pakistan has 45.0 percent. Table IV shows these changes in absolute figures for different crops. Irrigated land provides higher and more consistent yields than those from non-irrigated land. The loss of irrigated facilities has made Indian agriculture poorer and more dependent on monsoon rains.

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[1] Jathar and Beri, Indian Economies, Oxford University Press, 1948, Vol. I, p. 78.

TABLE III

IMPORTS OF FOOD GRAINS IN INDIA 1944-52

Year	Quantity in tons (millions)	Value in dollars (millions)
1944	0.649	4.48
1945	0.850	7.03
1946	2.250	26.24
1947	2.330	32.31
1948	2.840	44.65
1949	3.700	51.03
1950	4.400	119.04
1951	4.720	102.82
1952	3.900	62.85

[1] Wadia and Merchant, Our Economic Problem, New Book Company Ltd., Bombay, 1948 and "The Eastern Economist," Quarterly Station Bulletin, Vol. VI, No. 1, New Delhi, India, Oct. 1954.

1 Re. = 21¢ - after September 1949
1 Re. = 29¢ - before September 1949

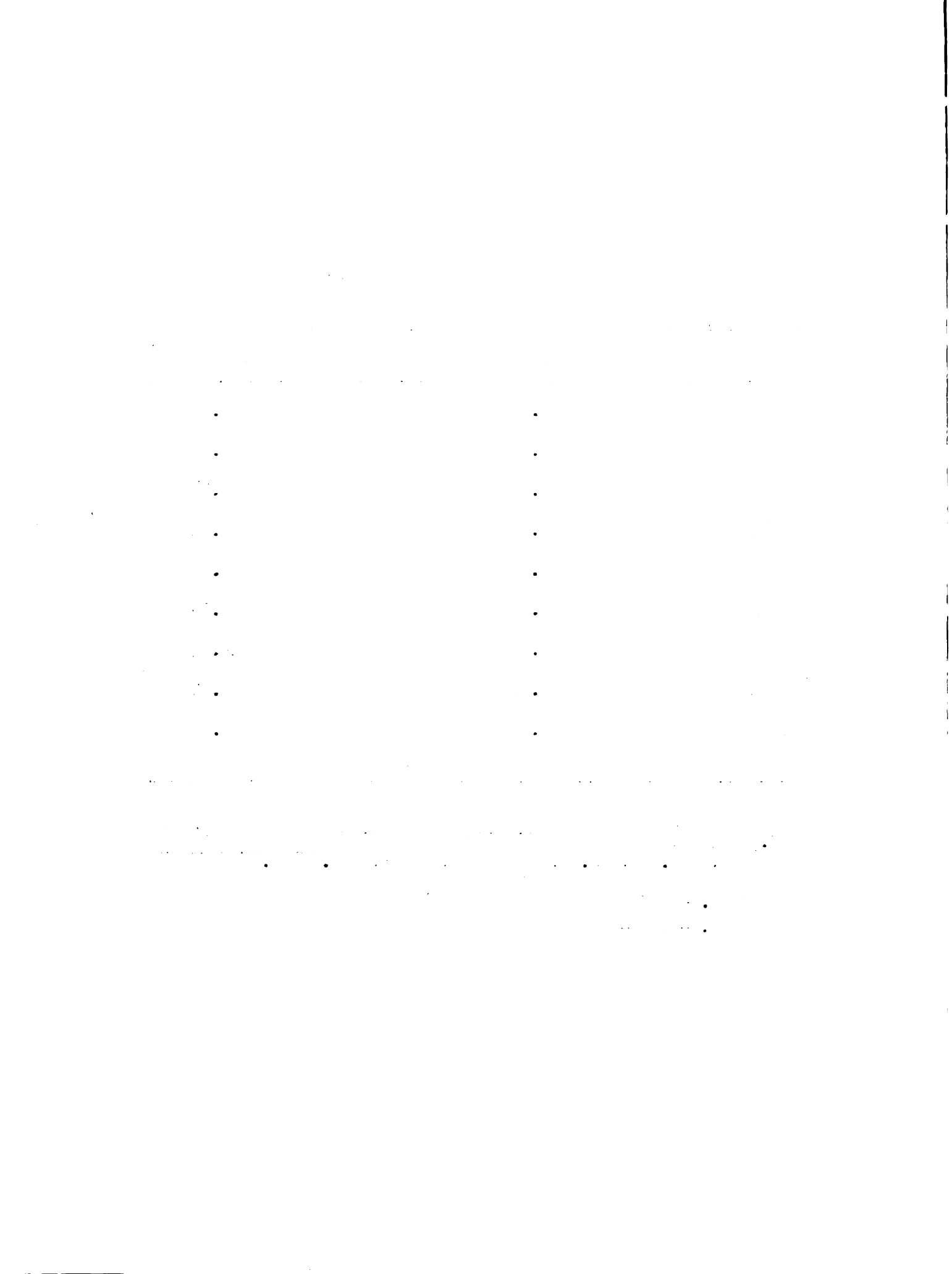

TABLE IV

TOTAL AND IRRIGATED AREA UNDER SOME IMPORTANT CROPS AND PRODUCTION IN INDIA AND PAKISTAN—AFTER PARTITION (BASE 1945-46)[1]

Crops	India			Pakistan		
	Total area	Irrigated area	Production	Total area	Irrigated area	Production
	—1,000 acres —		1,000 tons	—1,000 acres —		1,000 tons
Rice	58,013	20,375	18,208	22,720	2,535	8,488
Millets (sorghums)	61,383	1,581	8,320	3,449	2,134	713
Wheat	24,480	7,582	5,907	10,497	7,703	3,131
Maize	7,772	802	2,060	1,002	708	429
Barley	6,237	3,116	1,962	507	253	125
Sugarcane	3,201	2,447	4,552	624	432	864
Cotton	11,360	1,068	2,124	5,308	3,001	1,406
All crops	236,808	48,228	n.a.[2]	49,418	22,482	n.a.[2]

[1] Sources: Agricultural Statistics, U.S.D.A., Washington, D. C. and Year Books of Food and Agricultural Statistics, Food and Agriculture Organization of the United Nations, Washington, D. C.

[2] n.a. = not available.

Partition thus increased India's food shortage by .5 to .7 million tons per year.[1] This necessitates an increase in the production of food crops and has created even greater pressure towards increased productivity of land.

If the food shortage were the only problem in Indian agriculture, it could have been faced fairly well, but partition created other problems. It has aggrevated the problem of disequilibrium between agricultural production and requirements of both food and fibre crops. India has become a heavy importer of cotton. The cotton story is similar to that of food crops. Undivided India utilised 14.9 million acres in the production of cotton. Of this amount Pakistan received 3.3 million acres. Pakistan received nearly 80 percent of the total irrigated cotton area in undivided India. This explains the larger productivity per acre in Pakistan than in India. Yields per acre in both the nations are low but averaged 170 pounds in Pakistan and 100 pounds in India. Thus 40 percent of the cotton production of undivided India went to Pakistan. Table IV shows the change in acreage and production of cotton in India and Pakistan after partition.

2) Importance of Cotton in the National Economy and Related Problems -

The cotton textile industry is by far the largest and the most important non-farm industry in India. According to the Eastern Economist in 1953 it provided employment directly and indirectly to 1,007,000 people. The total value of the output estimated was over Rs. 300 million

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[1] Wadia and Merchant, Our Economic Problems, New Book Company Ltd., Bombay, 1948, p.

(nearly $60 million) producing nearly 4,500 million yards of cloth at installed capacity.[1] But the partition caused serious dislocation in the distribution of raw cotton required for the Indian textile industry. Pakistan has less than five percent of the total cotton mills of undivided India, but produces 40 percent of the total raw cotton of the best varieties. The Indian Central Cotton Committee estimated that 25 percent of the total consumption of the Indian textile industry in 1947-48 was from Pakistan.

The change in production pattern of cotton obviously raised the important question of the extent of dependence of the Indian textile industry on Pakistan cotton. The government of India at an Inter-Cominion conference for Exchange of Essential Commodities in May 1948 asked for a supply of 900,000 bales. Between May 1948 and May 1949 it was found that the government of Pakistan could supply only about 400,000 bales. The problem of price and custom duty did not receive any recognition in terms of the Agreement of May 1948. Pakistan decided to levy an export duty of $12.00 per bale on raw cotton despite the fact that the government of India exempted from any custom duty all imports from Pakistan. This increased the cost of production of cotton textiles in India. The problem was aggravated more after September 1949, when India followed Great Britain in devaluation of currency. Since Pakistan did not devalue, cotton from Pakistan became more expensive. This, again,

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[1] "Records and Statistics"- Quarterly Bulletin, The Eastern Economists, Vol. VI, No. I, New Delhi, Oct. 1954, pp. 15-48.

increased the cost of production of cotton textiles in India. Pakistan was an important consumer for Indian textile, but Pakistan tried to purchase more and more cloth from other countries even though Indian textile was comparatively cheaper.[1]

Cotton is also important in India's trade. Before 1933 the total volume of Indian cotton export appeared to be very closely related to United States export. It occupied one-fifth of the world's total.[2] "More than 50 percent of total production was exported in normal times before World War II."[3] After partition imports of cotton had a very adverse effect on India's foreign exchange position. Table V shows that with reduced imports of raw cotton and increased exports of textiles India barely maintained a balance in 1949-50.

Unfortunately the cotton control administration in India is defective. The prices of ginned cotton are controlled but the prices of raw cotton are not. The mill-owners have, from time to time, been agitating for a control over prices of both raw and manufactured cotton. The prices offered by mill-owners did not cause the cotton farmers to increase cotton production. In part, as a result of the price policy in the country and the politics in the cotton export-import market the textile

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[1] "The Sterling Area - An Analysis," Economic Cooperation Administration Special Mission to the U.N., London 1951, The Supt. of U. S. Govt. Printing Office, Wash., D. C., pp. 313-339.

[2] "Cotton Production in Pakistan," Foreign Agricultural Report No. 42, U.S.D.A., Oct. 1949, p. 18.

[3] Wadia and Merchant, op. cit.

TABLE V

FOREIGN EXCHANGE POSITION DUE TO CHANGES IN COTTON TEXTILE INDUSTRY
1947-48 to 1949-50 (IN MILLION RUPEES)[1]

Items (export-import)	Year		
	47-48	48-49	49-50
Imports of raw cotton	312.0	642.2	632.6
Imports of cotton yard and manufactures	95.1	176.0	184.1
Total Foreign Exchange (import) payments	407.1	818.3	816.7
Export of cotton, yarn and many manufactures	205.2	398.6	722.3
Export of raw cotton, waste	396.8	191.5	193.4
Total Foreign Exchange (export) receipts	602.0	590.1	915.7
Net loss (-) or gain (+) in Foreign Exchange	+194.9	-228.2	+ 99.0

[1] Source: The Eastern Economist, April 1953, New Delhi, India.

industry of India, being largely dependent on imports of raw material became depressed. Table VI shows the changes in exports and imports of cotton cloth and yard in India since 1938-39.

All this indicates that unless production—based on workable price policy—improves, any farther pushing up exports of cloth would create a scarcity and black-market of textile in the country.

III. Organization of the Thesis

1) Nature of the Problem -

In summary cotton production has a unique importance in India's national as well as in the social economic life of the country. It gives subsidiary employment as a cottage industry. Also as a cash crop it helps farmers to finance their daily expenditure. Partition has seriously dislocated the distribution of cotton and has led to heavy import of raw cotton. It has created an unbalanced situation in the countries trade and foreign exchange position. All these have necessitated a program of self-sufficiency in cotton. The government of India with the help of the Imperial Council of Agricultural Research and the Indian Central Cotton Committee is making a determined effort to increase cotton production. The limitations are determined by the extent to which such efforts come in conflict with the schemes which have been implemented to increase the food production such as the grow-more-food-scheme. As India has deficits both in food grains and raw cotton, great caution is necessary in the alternative utilization of cultivated area as between the production of raw cotton and that of food grains. In problems like this it may be found, for example, that

TABLE VI

EXPORT AND IMPORT OF COTTON CLOTH AND YARN:
INDIA 1938-39 TO 1948-49[1]

Year	Export		Import	
	Cloth	Yarn	Cloth	Yarn
	1,000 yds.	1,000 lbs.	million yds.	1,000 lbs.
38-39	176,992	37,980	647	36,459
39-40	221,405	36,943	579	41,132
40-41	390,144	77,509	447	19,334
41-42	772,355	89,320	182	8,173
42-43	817,991	34,240	16	945
43-44	461,337	10,078	4	630
44-45	423,021	16,918	5	192
45-46	440,510	14,497	3	123
46-47	318,318	3,791	16	217
47-48[2]	192,422	42	28	8,803
48-49	340,865	7,407	47	11,071

[1]Source: "Cotton Production in Pakistan," Foreign Agricultural Report, No. 42, U.S.D.A., Oct. 1949.

[2]Pakistan treated foreign destination since March 1, 1948.

the same area if devoted to the production of food grains, would be less advantageously used both in terms of internal cost and in terms of foreign exchange than if devoted to the production of cotton. India has to decide if it is worth while to carry production of cotton to the maximum capacity and if so what steps should be taken to assure steady production of the necessary quality and quantity.

2) Purpose of the Study -

In the last five years progress has been made in improving the cultivation and hence the production of rice. India looked to the countries producing rice with the highest possible yield with maximum efficiency for assistance in this effort. By adopting a simple Japanese method of rice production Indian farmers achieved yields ranging from 8,000 to 17,500 pounds per acre. An additional million tons of rice was produced.

As with the recent improvement in rice production it may be possible to improve cotton production. It is natural to look to other cotton producing countries and especially to the United States as India for a long time has been second only to the United States in world cotton production.

So the purpose of this study is to observe changes in cotton production in the United States to determine the main elements contributing to improved production, to analyze and find the contribution made by different factors responsible for improving production, and to evaluate the possibility of applying these factors to the cotton production in India.

3) Form of the Study -

The relevant analysis of change in production as it is affected by change in acreage under cotton and yield per acre of cotton for the period of the last 40 years will be covered in Chapter II.

The factors contributing to improvements in the production of cotton, changes in those factors over a period of time, and their role in cotton production will be discussed in Chapter III.

Chapter IV will be an analysis of changes in cotton production in India relative to that of the United States and an evaluation of the possibility of applying those factors responsible for improved cotton production in the United States to Indian conditions.

A summary and general conclusion will be presented in Chapter V.

CHAPTER II

RECENT CHANGES IN UNITED STATES COTTON PRODUCTION

I. Introduction

1) History and Importance -

Though cotton is a major crop only south of the thirty-seventh parallel, it is one of the most important cash crops in the United States. During the last 40 years, United States production has been relatively constant but there has been a change in the relative importance of the United States as a cotton producer. The United States ranged up to 72 percent by producing 15,694,000 bales in 1911, and did not fall below 50 percent of the total world's production until the 1933 season. Subsequent to that time, the trend of United States production has been generally downward, with the exception of a record breaking crop of 18,946,000 bales in 1937. The trend of foreign and world production has, meanwhile, been gradually upward. Yet, the United States continues as the world's leading cotton producing country. In 1950 it produced one-third of the world's total supply, more than three times as much as India, the second largest cotton producer. Table VII shows the production of cotton in the principal countries of the world by decades from 1910.

For many years, cash income from cotton lint in the United States has been greater than that of any other farm crop. The relative importance of cotton in the agriculture of the United States may be observed from the data in Table VIII. During the period of 1942-52

TABLE VII

COTTON PRODUCTION: WORLD AND LEADING COUNTRIES BY SPECIFIED YEARS[1]

Country	Years				
	1910	1920	1930	1940	1950
World	18,400,000	21,350,000	26,230,000	30,440,000	35,370,000
United States	11,609,000	13,429,000	13,932,000	12,566,000	10,012,000
India	3,254,000	3,013,000	4,373,000	5,090,000	2,720,000
China	n.a.[2]	2,406,000	2,615,000	2,354,000	2,430,000
U.S.S.R.[3]	592,000	58,000	1,587,000	4,000,000	3,500,000
Egypt	1,555,000	1,251,000	1,715,000	1,900,000	1,754,000
Brazil	357,000	476,000	483,000	2,506,000	1,800,000
United States percent of total	63	63	53	41	36

[1]Source: Agricultural Statistics and Statistical Abstracts, U.S.D.A., Wash., D.C.

[2]n.a. = not available.

[3]U.S.S.R. figures not comparable.

TABLE VIII

AVERAGE ACREAGE AND FARM VALUE OF MAJOR CROPS IN THE UNITED STATES 1943-52[1]

Crops	Acreage cultivated	Total farm value
Corn	87,408	4,364,293
Hay	74,650	2,199,123
Wheat	73,032	2,107,269
Oats	43,845	1,016,662
Cotton and cotton seed	22,390	2,202,613

[1]Source: Agricultural Statistics, 1953.

cotton was fourth among the crops in acreage, being exceeded only by corn, hay, wheat and oats. In value, however, cotton was even more important than the acreage and was second only to corn in that period, having an average annual farm value of over two million dollars.

2) Cotton Regions -

The cotton producing region of the United States is one of the most specialized farm regions of the world. Bounded on the north by the frost line which marks the northern limit of 200 day frost free growing season and a mean summer temperature of not less than 70°F, the belt dips irregularly to the south around the higher altitudes of the southern appalachian to the north again in the low levels of the Mississippi and then tends to the southwest in response to both inadequate rainfall and low temperatures. On the east and south the cotton belt is fringed by sub-tropical border, beginning in the Carolinas and following around the gulf and includes practically all of Florida.[1]

There are several fairly distinct sections of the cotton belt in the U.S.A. Cotton is produced, in sufficient quantities to be statistically recorded, in 16 states. An area extending from southern Virginia through North and South Carolina, Georgia, Florida and Alabama is usually referred to as the Southeast Region. Proceeding westward from the broad delta or river bottom areas along the Mississippi River through Tennessee, Missouri, Arkansas, and Louisiana

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[1] Holley, William C. and Lloyd E. Arnold, Cotton, Work Progress Administration, National Research Project; Philadelphia, September, 1938, Chap. I.

is another area known as the Delta Region. Cotton has been produced here for many years. During the 20's additional land was drained and cleared and cotton acreage in this region increased from seven to nine million acres. The Southwest Region includes Texas and Oklahoma. The greatest recent relative increases have occurred in Arizona, California and New Mexico where cotton is grown on irrigated land. In these areas an average of 4,000 acres was reported for the years 1907-11 as compared with 2,402,000 acres in 1953. Figure 1 shows different cotton regions in the United States. As will be seen later, these changes are highly important in their effects on production, acreage and yield per acre for the country as a whole and go far in explaining trends in the total amount of inputs used in the crop production.

II. Analysis of Changes in Acreage, Yield and Production in the United States, 1910-52

1) Acreage -

Cotton acreage, yield and production in the United States for the years 1909-52 as shown in Table IX. Acreage steadily increased from 30,555,000 acres in 1909, reaching about 35,038,000 acres in 1918. A decrease occurred during the period of heavy boll weevil infection from 1919-24. Meanwhile, acreage in the western region was increasing but acreage for the country as a whole did not increase because the increase in the western region was less rapid than the decrease in the eastern cotton region. Then came a sharp increase in total United States acreage, largely through expansion in the western areas. "The acreage harvested in the western cotton region increased from 11.8 million acres in 1909 to 22.6 million acres in 1926. The greatest

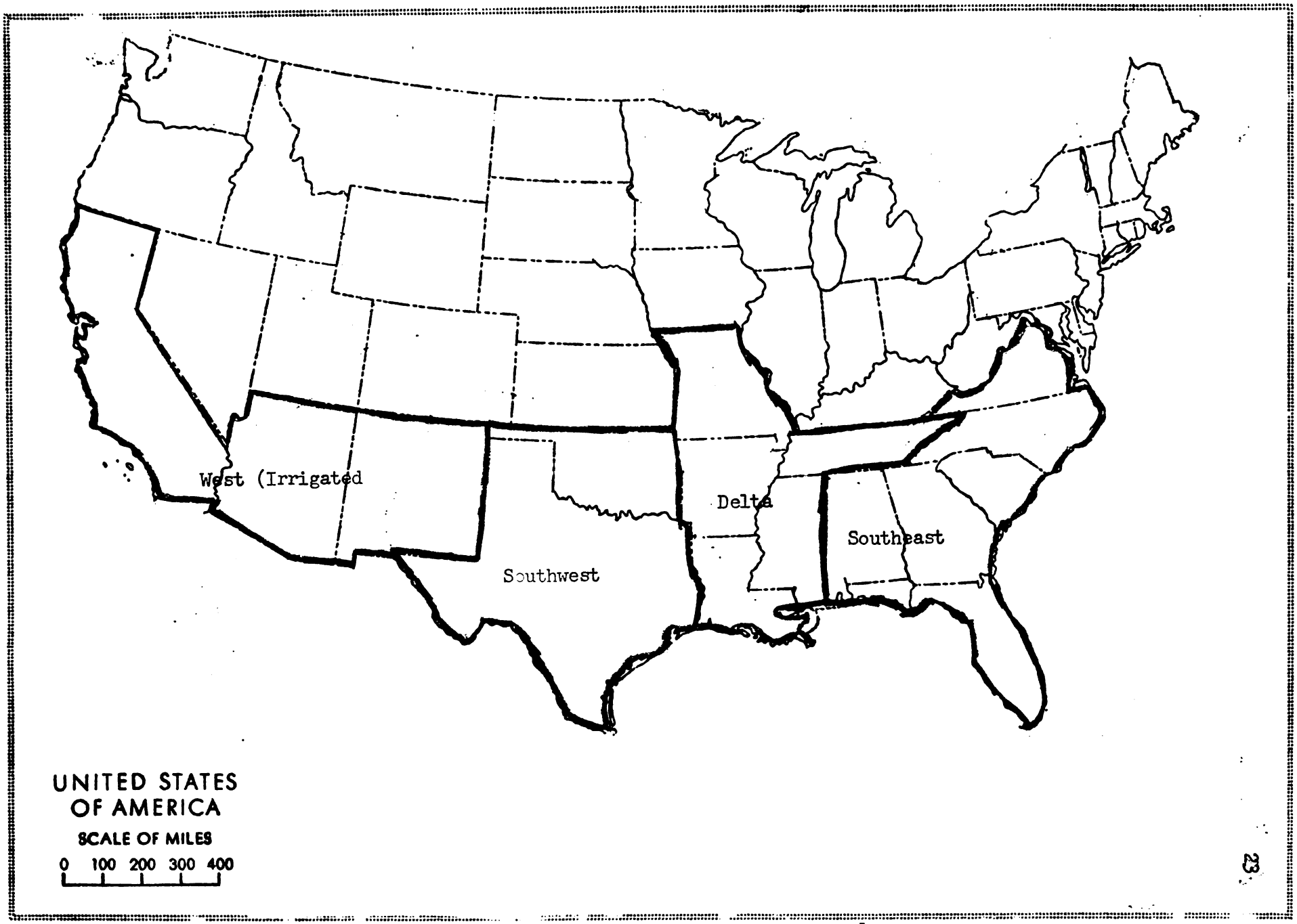

Figure 1. Cotton Regions, United States[1]

[1]Source: Cotton Situation, U.S.D.A., A.M.S., August, 1951.

TABLE IX

ACREAGE, YIELD PER ACRE AND PRODUCTION OF COTTON
UNITED STATES 1909-52[1]

Year	Acreage harvested 1,000 acres	Yield per acre pounds	Production 1,000 bales
1909	30,555	156.5	10,005
1910	31,508	176.2	11,609
1911	34,916	215.2	15,694
1912	32,557	201.4	13,703
1913	35,206	192.3	14,153
1914	35,615	216.4	16,112
1915	29,951	178.5	11,172
1916	33,071	165.6	11,448
1917	32,245	167.4	11,284
1918	35,038	164.1	12,018
1919	32,906	165.9	11,411
1920	34,408	186.7	13,429
1921	28,678	132.5	7,945
1922	31,361	148.8	97,515
1923	35,550	136.4	10,140
1924	39,501	165.0	13,630
1925	44,386	173.5	16,105
1926	44,608	192.9	17,978
1927	38,342	161.7	12,956
1928	42,434	163.3	14,477
1929	43,232	164.2	14,825
1930	42,444	157.1	13,932
1931	38,704	211.5	17,079
1932	35,891	173.5	13,003
1933	29,383	212.7	13,047
1934	26,866	171.6	9,636
1935	27,507	185.1	10,638
1936	29,755	199.4	12,399
1937	33,623	269.9	18,946
1938	24,248	235.8	11,943
1939	23,805	237.9	11,817
1940	22,861	252.5	12,566
1941	22,106	231.9	10,744
1042	21,602	272.4	12,817
1943	21,610	254.0	11,427
1944	19.619	299.4	12,230
1945	17,029	254.1	9,015
1946	17,584	235.7	8,640
1947	21,330	266.6	11,860
1948	22,911	311.3	14,877
1949	27,439	281.8	16,128
1950	17,843	269.0	10,012
1951	26,867	271.7	15,144
1952	25,664	282.0	15,136

[1]Source: Agricultural Statistics, 1952, U.S.D.A. Gov't Printing Office, Wash., D.C., 1952, p. 76.

relative increase was found in California where there was a rise from 8,000 acres in 1910 to 368,000 acres in 1936. Acreage in New Mexico and Arizona increased from 41,000 acres in 1917 to 353,000 in 1929."[1] United States acreage reached a peak during 1926 when 44,608,000 acres were harvested. This represents an increase of 46 percent over that of 1909 or approximately 14,000,000 acres. Following this peak, acreage began to decrease in all areas. The decrease is probably attributed to lower price conditions at least through 1933. Though declining gradually, acreage remained more than 40,000,000 acres annually except for a sudden fall to 38,704,000 acres in 1927.

After 1933, there was a continuous decline in acreage as the Agricultural Adjustment Administration took steps to bring production down to an amount which would sell at support price levels. In 1933, the first year of the Agricultural Adjustment Programs, about 29,383,000 acres were harvested and the trend continued downward with acreage dropping to 17,029,000 acres in 1945 - the lowest in recent history. This represented a 71.61 percent decrease from 1926. From 1945 onward there has been a steady increase in acreage to the point where the average acreage is approximately 26,561,000 acres at the present time.

Figure 2 shows the trend in acreage harvested for the United States from 1910-52. It can be seen from this Figure that the trend in Cotton acreage from 1909 to the present time can be divided into three distinct linear patterns as illustrated in Figure 2.

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[1] Ibid.

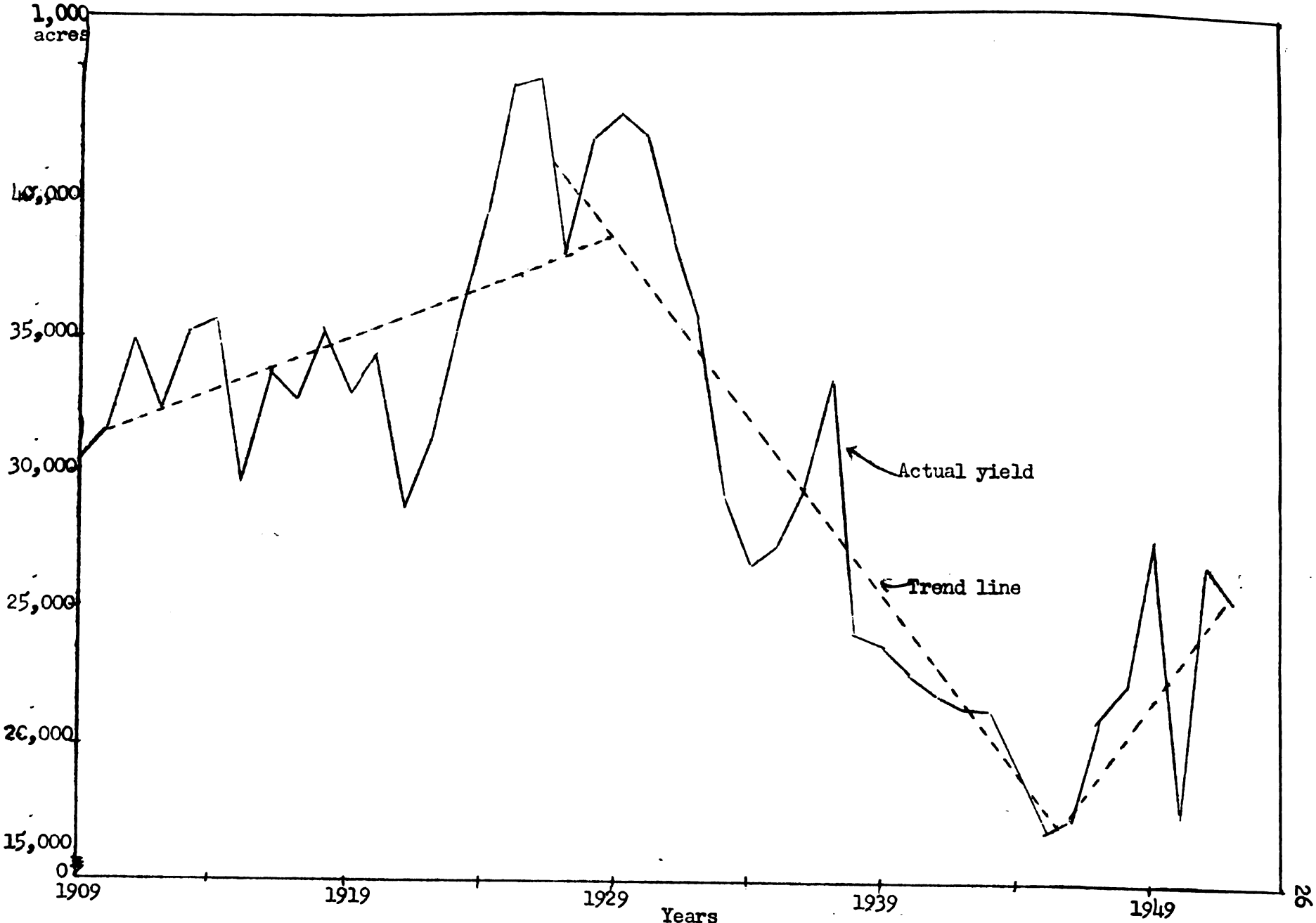

Figure 2. Trend in Cotton Acreage Harvested, U.S., 1909-52[1]

[1] Source: Agricultural Statistics, 1952, U.S.D.A., Washington, D. C.

The first period is from 1910 to 1926. The trend during this period was upward with a moderate slope. The least square line of the best fit rises at the rate of 482,770 acres per year.[1] The fluctuations about trend were relatively small as compared with the other periods.

The second distinct period begins in 1927 and runs to 1945. Throughout this period the trend was downward at the rate of 1,394,860 acres per year.[2]

The third period is from 1946 through 1952. Through this period the average again increased by 1,077,130 acres per year.[3]

While acreage reduction was attained, production was not reduced as much as intended. An all-time record crop was grown in 1937 with a production of 18,252,000 bales. This was 89 percent greater than in 1909 and was grown on but nine percent greater acreage. A yield of 270 pounds per acre was attained. As shown in Table X, this was a 50 percent increase in yield as compared to that of 1926.

2) Yield -

Average United States cotton yield per acre remained approximately constant from 1909 to 1914. From 1914 to 1923 there was a downward adjustment largely because of boll weevil damage in the humid areas and a westward movement of cotton mainly to low yielding arid non-irrigated regions. From 1924 onward the trend turned upward as boll

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[1] $Y_1 = 347,944.11 + 4827.7X$

[2] $Y_2 = 29,588.40 - 1,394.86X$

[3] $Y_3 = 22,803.57 + 1,077.13X$

TABLE X

CHANGES IN ACREAGE AND YIELD OF COTTON IN THE UNITED STATES FOR 1926 AND 1937[1]

Year	Acres harvested	Yield/acre pound	Percent changes in acreage	yield
1926	47,087,000	180	-28.5	+50
1937	33,623,000	270		

[1] Source: Agricultural Statistics, U.S.D.A., Washington, D.C., p. 76.

weevil damage was reduced and as acreage declined in some low yielding areas and increased in some of the higher yielding areas.

From 1933 onward, when acreage was reduced as a measure adopted by the Agricultural Adjustment Administration to reduce production so as to sell it at the support price, yields have shown a very definite upward trend. Many acres of low yielding land were thrown out of production, support prices encouraged farmers to increase production from the reduced acreage by using better land and larger inputs of fertilizer. Beginning in 1934 and through 1949, the trend has been decidely upward. It attained an all-time average of 258 pounds with a high of 311.3 pounds per acre in 1948.

On the basis of a nine year moving average "the yield of cotton per harvested acre in the United States has tended to increase steadily since the middle of the 1920's. The yield in 1952 of 282.7 pounds per acre was about four pounds below that indicated by a projection of the trend line, (Figure 3). From 1870 to 1948 actual yields were within 20 pounds of the trend about 70 percent of the time."[1]

Yield varies not only for the country as a whole from time to time but also varies from state to state. Year to year fluctuations in yield were mainly due to drought, floods and insect attacks. The principal reason, however, for the marked increase in recent years is that production has been shifted to better and higher yielding lands among the regions or within the cotton acreage of a given region. Farmers have

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[1] Cotton Situation, U.S.D.A., A.M.S., August, 1951, p. 1.

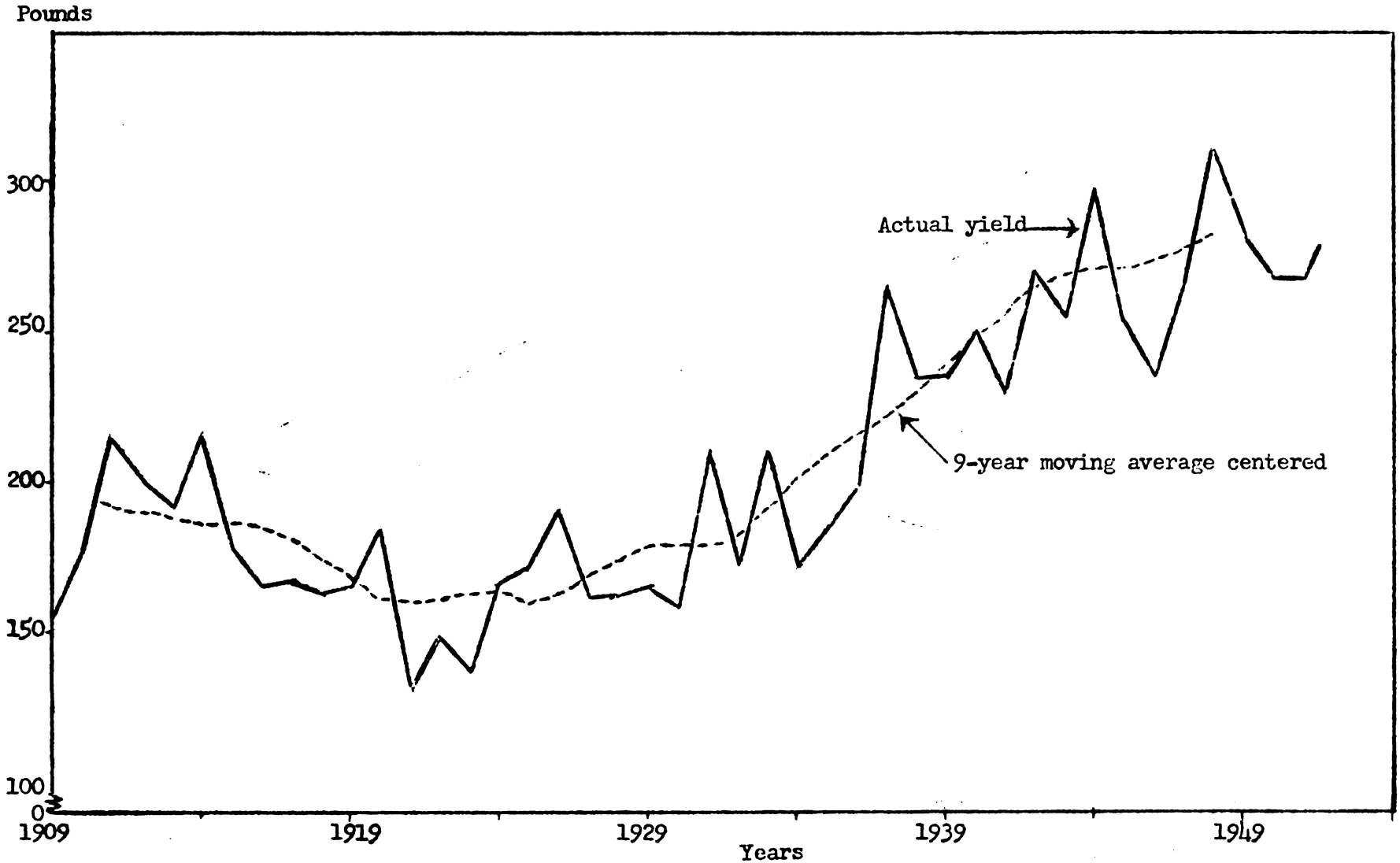

Figure 3. Average Yield Per Harvested Acre of Cotton in U.S., 1910-54[1]

[1]Source: Cotton Situation, U.S.D.A., B.A.E., Washington, D. C., April 1955.

devoted more attention to cultivation, insect control, and have used more fertilizers per acre. These and several other factors have been directly or indirectly important in increasing yield. These factors are highly important in their effects on production and on the average man hours employed per acre for the different regions and the country as a whole. They go far towards explaining the production efficiency as measured by labor productivity and in determining production costs for the crop. The role of these factors and their effects on cotton production is shown later.

3) Production -

Acreage harvested, yield per acre and cotton production in the United States by years from 1909 to 1952 have been shown statistically in Table IX and graphically in Figure 4. There have been fairly regular five year to six year intervals between the peak of successive upswings in production.

Since 1909 cotton production has always remained above 10,000,000 bales annually, with the exceptions of 1921 and 1922 when there was a severe boll weevil attack and in 1934 and 1945-46 when there was a sharp reduction in acreage.

During the period of 1909 to 1952, production averaged 12,770,000 bales per year. The steady increase in acreage associated with somewhat constant level of yield during the period of 1909 to 1914 caused production to rise steadily to an average of 13,546 bales. From 1915 to 1922 production averaged 11,057,000 bales a year. This lower production compared with the previous period was caused by low yield which prevailed in that period. The lowest production of cotton since

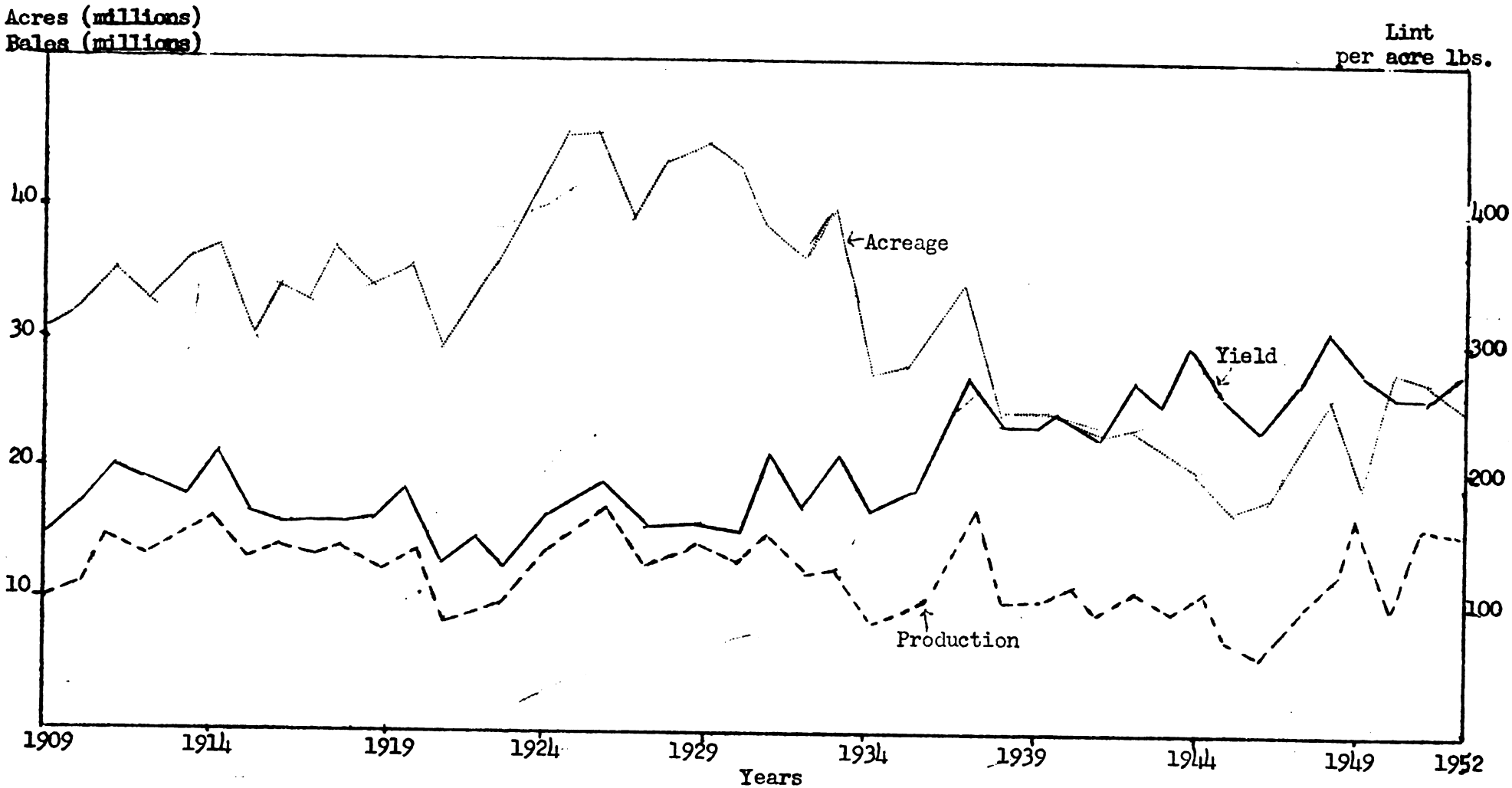

Figure 4. Acreage, Average Yield and Production of Cotton, U.S., 1909-52[1]

[1]Source: Agricultural Statistics, 1952, U.S.D.A., Washington, D. C.

1909 took place in 1921 when eight million bales were produced. This was caused principally by the severe boll weevil infestation which reduced cotton yields to 132.5 pounds per acre--a reduction of 31 percent of the yield in the previous year.

From 1923 onward to 1931, with a steady annual average increase in yield and moderate increase in acreage, average cotton production increased to 14,571,000 bales, the highest peak for this period was nearly 18 million bales observed in 1926.

A downward trend in production began in 1932 largely as a result of steps taken by the Agricultural Adjustment Administration to bring production to a level which would sell at support prices. Production ranged from 9,636,800 bales in 1934 to 15,136,000 bales in 1952 with a high of nearly 19 million bales in 1937 and a low of 8,640,000 bales in 1946.

III. Analysis of Changes by Production Regions

Although both acreage and yields for the cotton belt as a whole have shown a rather definite trend, the changes have not been uniform as between different parts of the belt. According to the soil, climate, geographical changes and changes in production pattern, the cotton belt can be divided into different regions of production. These different regions show different changes in acreage and yield of cotton and show well explained characteristics of cotton production. An examination of changes by areas is, therefore, desirable.

Table XI shows the changes in acreage, yield and production of cotton by regions by periods 1908 to 1952. An analysis and discussion of the situation in each area follows.

TABLE XI

AVERAGE ACREAGE, YIELD AND PRODUCTION OF COTTON FOR UNITED STATES BY PERIODS[1]

Regions	1908-12	1918-22	1928-32	1938-42	1948-52
	Average Acreage (in 1,000 acres)				
Southeast	12,231	10,427	10,050	5,893	4,780
Delta	7,078	7,478	10,634	6,708	6,685
Southwest	12,803	14,343	19,044	10,043	10,911
West (irrigated)		217	531	676	1,706
United States	32,117	32,478	40,541	23,350	24,142
	Average yield per acre (in pounds)				
Southeast	212	193	206	215	291
Delta	215	200	216	323	361
Southwest	167	133	143	172	201
West		232	372	507	656
United States	190.58	159.6	173.9	246.1	283.0
	Average production per year (in 1,000 bales)				
Southeast	5,447	4,127	4,183	3,054	2,784
Delta	2,850	2,751	4,363	4,522	5,032
Southwest	4,544	3,919	5,689	3,634	4,394
West		108	418	745	2,239
United States	12,850	10,675	14,666	11,977	14,253

[1] Source: Cotton Statistics, U.S.D.A., B.A.E., Statistical Bulletin No. 99, Washington, D. C., June, 1951.

1) Southeast Region -

The southeast region includes that part of the cotton belt in the states of Virginia, North and South Carolina, Georgia and Florida,[1] namely the costal plain areas, Piedmont areas and eastern hilly areas of southeast United States.

The acreage under cotton in the southeast region declined almost continuously between 1909-52 from an average of 12,231,000 acres per year in the period of 1908-12 to 4,780,000 acres in the period 1948 through 1952. This represents a decrease of 61.2 percent. Many factors were responsible for this continuous decline. Advent of the boll weevil and its severe and continuous attack during the 1920's and the 1930's, low prices, uninterupted cotton cropping leading to accelerated erosion and finally the inauguration of the Agricultural Adjustment Administrator's programs, were all contributing factors. Whenever opportunities were available for the substituting of other crops, like peanuts, vegetables and field crops, their acreage increased. Especially during World War II prices for peanuts and vegetables were sufficiently attractive to compete favorably with cotton for the use of land and labor and, in this region, acreage of these crops increased materially while cotton acreage continued to decline. Afterward acreage under feed crops were increased at the expense of cotton acreage because a given labor force would handle a large acreage. This meant higher net returns per man--resulting in a greater total net farm income.[2]

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[1] Cotton Situation, U.S.D.A., A.M.S., p. 39.

[2] Cotton: Hearing before Subcommittee of Committee on Agriculture, House of Representatives, 78th Congress, Second Session, 1944, p. 735.

Yield trends for this area followed the same pattern of change as shown by the country as a whole. It declined from 212 pounds in the period of 1908-12 to 193 pounds in 1918-22, or by 11 percent. There was a small but steady increase totaling 11.5 percent from 1918-22 to 1938-42 along with a 51.9 percent decrease in acreage in the same period. The most influential factors in this increase in yield was the increased use of fertilizer and selection of better land. The same relation of change between acreage and yield was continued from then with a different degree of change from 1938-48 to 1948-52. Acreage decreased by 19.9 percent while yield per acre increased by 35.3 percent. Table XI shows the changes in absolute figures by periods. On the whole, this region showed a very clear pattern of change in acreage and yield of cotton. There was a 60 percent decrease in acreage in 1948-52 as compared with that in the period of 1908-12. The increase in yield was not adequate to compensate for the decrease in acreage; hence, production declined by 49 percent from 5,447,800 bales a year in the period 1908-12 to 2,784,000 bales a year in 1948-52.

2) Delta Region -

This region includes delta areas, sandy land areas and the mountains and valley areas in the states of Missouri, Arkansas, Tennessee, Mississippi and Louisiana.[1]

The trend in acreage under cotton in this region was upward from 1909 to 1930. Acreage increased from an average of 7,078,000 acres a year in the period 1908-12 to 10,634,000 acres in 1928-32 with the peak of

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[1] Cotton Situation, U.S.D.A., A.M.S., Sept.-Oct., 1953, p. 31.

11,105,000 acres in 1930. With the advent of the Agricultural Adjustment Administration Program, acreage began to decline reaching an average of 6,708,000 acres a year in 1938-42. Little change in acreage has occurred since then. Because the main source of family farm income of this region is cotton, farmers try to plant up to their acreage allotment. Land is highly productive in cotton and being level is adaptable to mechanical equipment.

The major portion of land under cotton in this region, produced higher and higher yield per acre in each period and on the average it was next in yield to irrigated cotton farms in the western region.

Even though there was a 40 percent decrease in the acreage in 1938-42 as compared with the 1928-32, production increased by 177 percent.

During the early period of 1918-22 this region produced 22.1 percent of the total production of the United States. In 1938-42 it accounted for 38 percent of the total. In 1948-52 as compared with 1938-42, production has increased by more than 5,000,000 bales; but inspite of this, there was a reduction in percentage of the country's total production. It was mainly due to a proportionately larger increase in production in the southwest and west in recent years. Production in the Delta region was nearly 33 percent of the total in 1948-52.

3) Southwest Region -

The southwest region includes cotton farms in the Blackland, low and high plains, prairie, and sandy land areas in the states of Texas and Oklahoma.[1]

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[1] Ibid.

The pattern of change in acreage under cotton in this area was somewhat similar to that of the country as a whole. During the period of 1908-12, annual acreage was 12,803,000 acres. In 1928-32, this increased to 19,044,000 acres contributing nearly half of the United States acreage. After 1933, as a result of the action taken by the Agricultural Adjustment Administration, acreage declined to 10,043,000 acres.

Yield per acre in this region coincided with the change for the country as a whole but at a lower level. Continuous croppings of cotton and erosion have reduced the fertility of soil in many parts. Disease and insect attacks played their part in preventing large yield increases; furthermore, cotton does not appear to respond to commercial fertilizers in this area, hence very little is used.

The yield per acre therefore increased by only 31 pounds from 1908-12 to 1948-52 as compared to more than 400 pounds increase in the western region in the same period. A moderate but constant increase in yield did not result in any appreciable increase in production except in a few years due to an offsetting decline in acreage. Production was largest in the period 1928-32 when this region contributed 40 percent of the country's total. By 1948-52 it had declined to 30 percent.

Even though yields per acre were relatively lower and total acreage was declining in this region, acreage per farm was increasing as large scale highly mechanized farms were found profitable. However, in some areas relationships between cotton and other crops, like grain-sorghum and feed crops, have tended to replace cotton. This was largely true during the war years and when there was a shortage of labor.

4) Western Irrigated Region -

This region included cotton areas from the states of California, Arizona and New Mexico. Cotton in this region is almost all under irrigation.[1]

Since 1919, acreage has increased continuously from 217,000 to 1,706,200 acres in the period of 1948-52. In absolute figures cotton increased from nothing and now it represents more than 10 percent of the total United States cotton acreage.

Yields have also increased materially from an average of 232 pounds per acre in 1918-22 to 656 pounds per acre in 1948-52. This increase is largely due to irrigation. Other causes are the adoption of better varieties, an internal shift in acreage to land which is better adapted to cotton production and good response to fertilizer because of irrigation.

Rapid increases in acreage as well as in yield continuously contributed to higher and higher production per year. Production increased from 108,600 bales a year in 1918-22 to 2,239,000 bales a year in 1948-52. This represents an increase from near zero to 20 percent of the total United States production. The irrigated areas probably have expanded cotton acreage to nearer the limit of land and water resources and of profitable competition with other crops. Therefore, cotton acreage in these areas may remain at about the levels of recent years unless new land is brought into production or unless the relationship between the prices of cotton and prices for competing crops change materially.[2]

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[1] Ibid.

This discussion has been primarily in terms of rather large areas. The more important differences in the changes of cotton production among these regions have been mentioned. An analysis involving different areas within the regions might show other variations within each of the production regions discussed. It should be emphasized that even though they are not brought out in this comparison, important differences undoubtedly exists amongst the farms, and localities within each of these broad regions. Changes in acreage, yield and production of cotton by regions by periods have been shown in Table XI and in Figures 5, 6 and 7. With the help of the above analysis some contrasting observations can be made here about the shift in acreage related to yield and hence production.

1) There was a continuous shift in acreage from the east to the west in the cotton belt for the country as a whole.

2) Acreage in states in the southern region declined continuously even though yields were increasing.

3) States in the southwestern region, Texas and Oklahoma, grow a greater percentage of total United States acreage even though yields were lower than that of any other region.

4) Yield, acreage and production all have increased continuously in the irrigated cotton region in California, Arizona and New Mexico.

As previously mentioned it appears that the shift towards irrigated production is almost completed in the western region. Further shift and increase in acreage may be anticipated in the Delta and southwest regions.

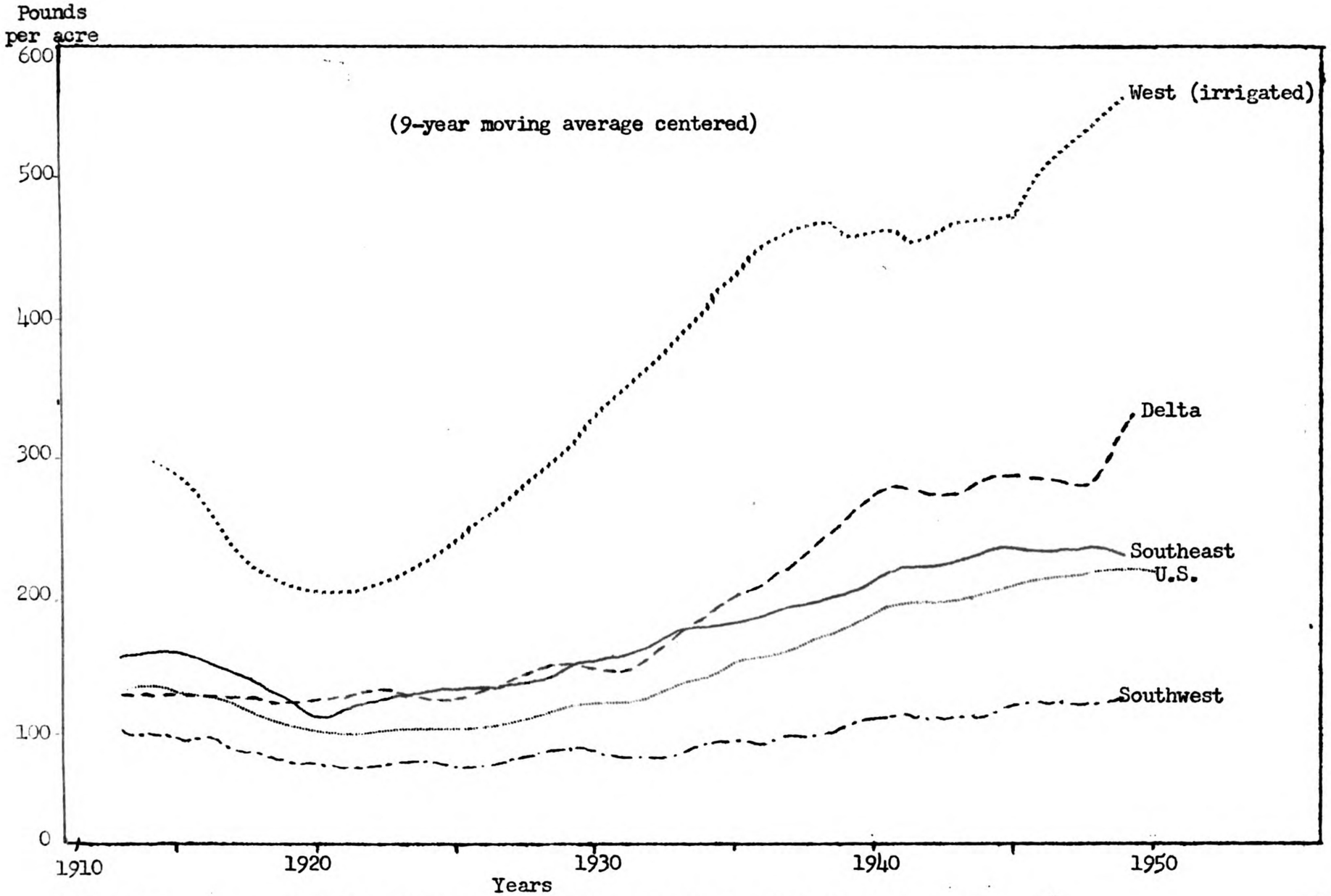

Figure 5. Average Yield Per Acre Harvested of Cotton in the U.S. by Regions, 1910-52[1]

[1]Source: Cotton Situation, U.S.D.A., B.A.E., Statistical Bulletin 99, Washington, D. C., June 1951.

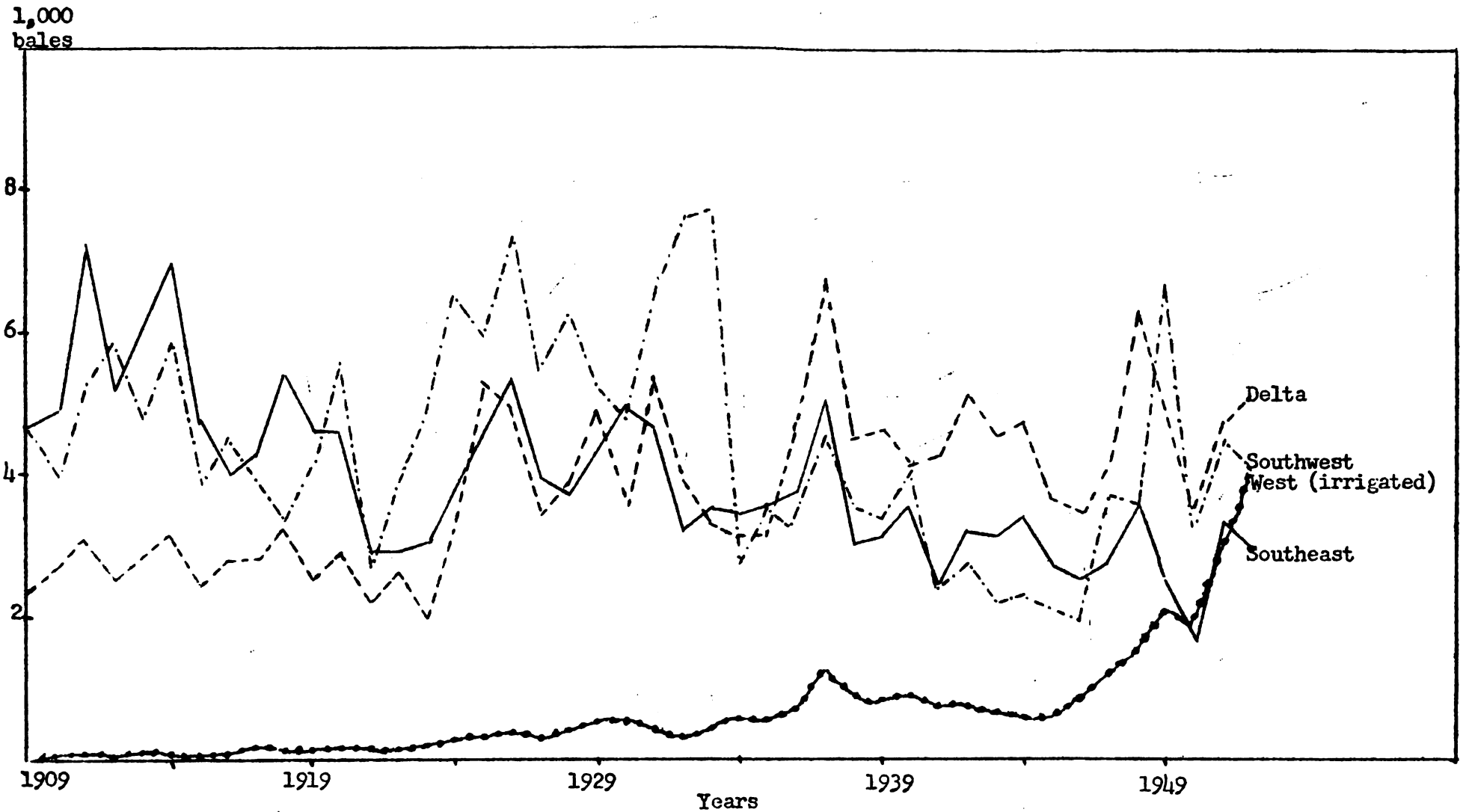

Figure 6. Changes in Cotton Production by Regions, 1909-52[1]

[1]Source: Cotton Statistics, U.S.D.A., B.A.E., Statistical Bulletin 99, June 1953.

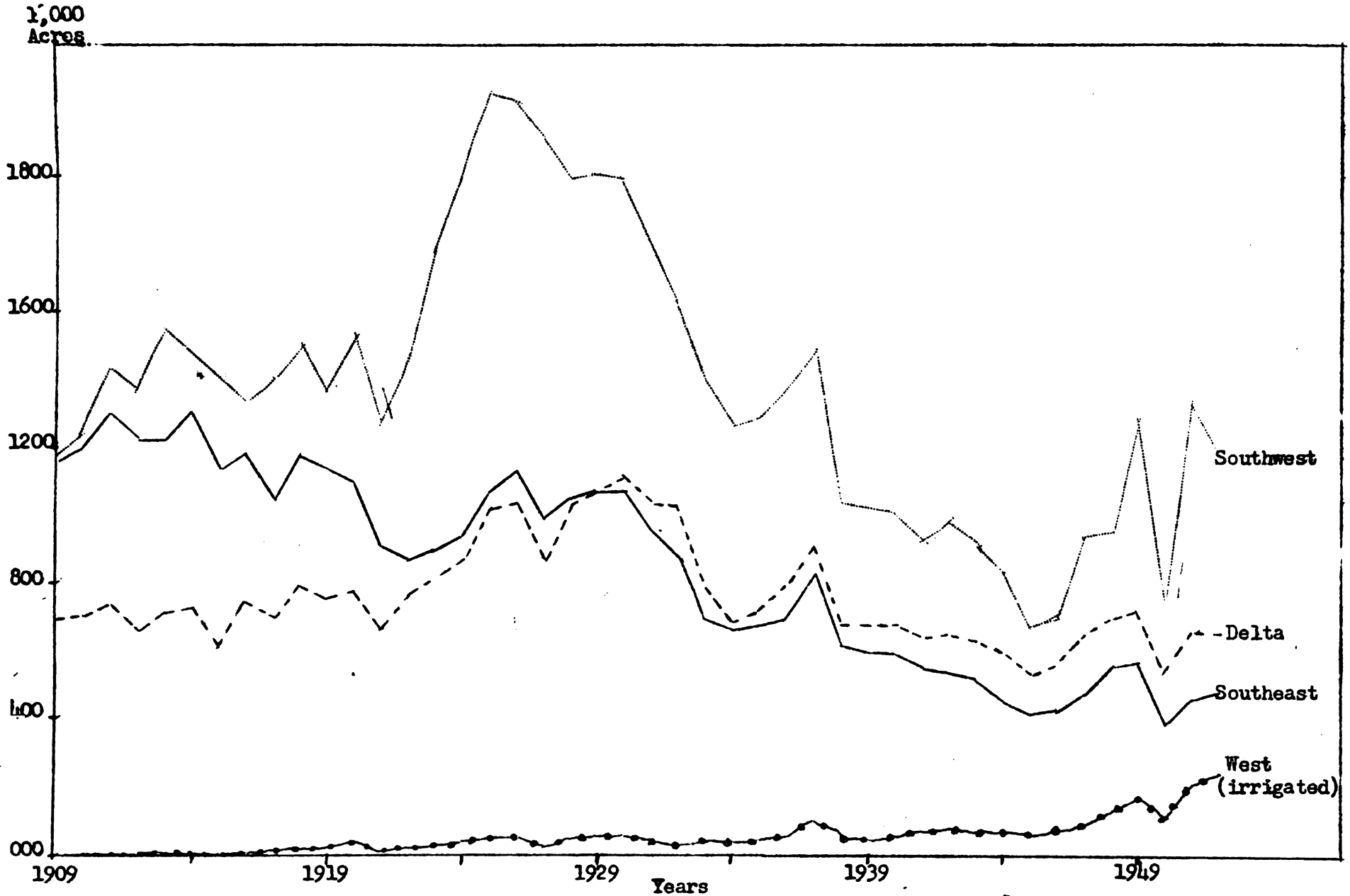

Figure 7. Changes in Cotton Acreage by Regions, 1909-52[1]

[1]Source: Cotton Statistics, U.S.D.A., B.A.E., Statistical Bulletin No. 99, Wash., D. C., June 1953.

As will be seen later these changes are highly important in their effects on production and can be considered further as they relate to the influence of natural, biological and economical factors affecting production of cotton.

IV. Production and Price Relations

It may be said that production shifts were along the lines of comparative advantage. Furthermore, it has been observed that shifts occurred after the inaguration of the price support program. Cotton production shifted from the southeast to relatively lower yielding regions of southwest and to western irrigated areas. It was found that in some cases that price relationships between cotton and alternative crops have tended to reduce cotton production. This was especially true during the war years. It, therefore, becomes important to evaluate the effect of the price change on production of cotton.

There are two principal methods that can be used to illustrate changes in comparative production advantage. First, if accurate cost data are available, comparison of production costs and related returns can be used to analyze changes in comparative production advantage either between regions or between crops within an area. Secondly, inferences regarding changes in comparative production advantage can be drawn from a trend analysis of production and price data.[1] Because of the nature

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[1]Gray, Roger W., V. L. Sorenson and Willard W. Cochrane, An Economic Analysis of the Impact of Government Programs on the Potato Industry of the United States, Tech. Bul. 211, University of Minnesota, June 1954, p. 138.

of costs on the farms other than single crop-farms, a limited amount of data are available. The major reliance is this analysis if placed on the second method. However cost data included in the next chapter will be supplementary evidence.

Permanent shifts in farming practices may not occur immediately in response to change in price-cost relationships. The rate of shift would to a great extent depend on the amount of long term specialized capital required. Shift into or out of production of any commodity may be more or less rapid. These shifts are also influenced by the cost of production for the commodity concerned and for the nearest possible alternatives available to the farmer.

From 1933 onwards changes in cotton production appear to have been influenced by price support and production control programs designated to reduce the production so as to sell the commodity at the support price levels. Generally relative price levels for different crops change as production costs change. These changes require some time to complete.

1) Production Price Trend -

Figure 8 shows the relation between cotton prices deflated by the index of prices received for all farm products and cotton production for United States, 1909 to 1952. It indicated that before the Agricultural Adjustment Act of 1933, there were relatively wider fluctuations between prices and production. After production control programs of 1933, there were relatively less fluctuations in price and production. These data indicate that at least two to three years are needed to expand or contract production in response to the corresponding change.

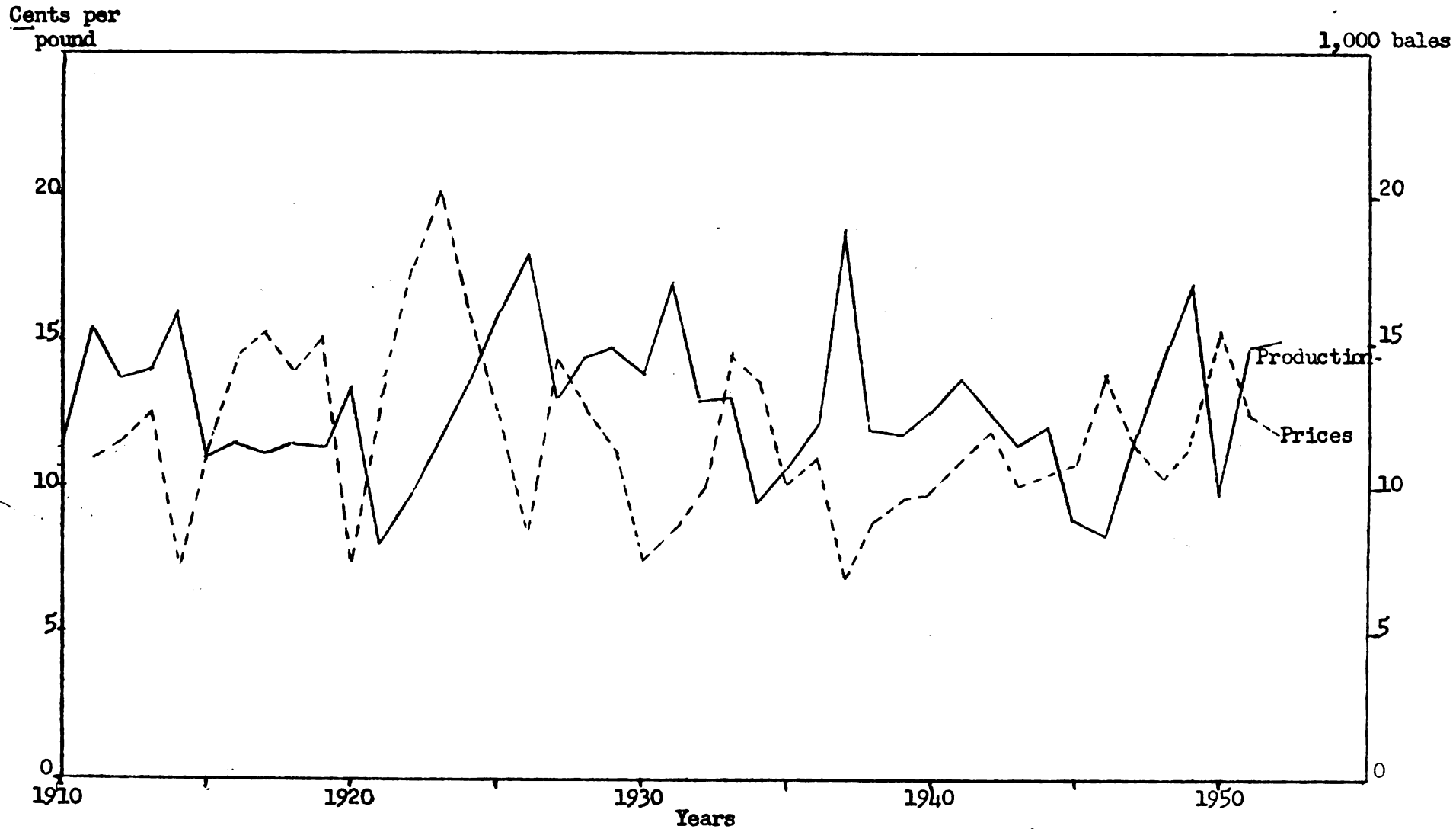

Figure 8. Deflated Seasonal Average Prices and Production of Cotton, U.S., 1910-52[1]

[1] Source: Agricultural Statistics, 1952, U.S.D.A., B.A.E., Washington, D. C.

2) Prices, Alternative Crops, Income -

Any emperical determination of responses of cotton growers to price supports and its effects on the level of income of cotton grower is beyond the scope of this study. Some general conclusions regarding this effect may, however, be drawn from observations already made regarding the role of cotton in the production pattern of different cotton producing regions. It was observed that the role of cotton in the agricultural economy is different in different regions depending upon the number and types of alternatives available to cotton producers and the proportion of producers' income from cotton production. Theoretically, the total effect of price change can be broken down into an income and a substitution effect due to alternatives. A lower price of cotton would make the producer worse off and a reduction in his welfare would have an effect on his inclination to produce alternative crops. But it depends upon the availability of alternatives and the importance of crop in the farm income.

On the farms in the Delta of Mississippi, cottin is all important as 80 percent of the farm income is from cotton and there is no good alternative to cotton open to farmers. The response to change in the price of cotton appears to be very small and may be said to bo of an inelastic nature. In the southeast region, the production of cotton has been established as an adjacent to vegetables, peanuts and feed crops. The place of cotton therefore in this region as a cash crop has been limited to small acreage even in the absence of acreage restriction. Another type of movement has been observed in other regions. Under the price relationship existing during the war years, in the states

of Oklahoma and Texas, wheat, grain, sorghum and the feed crops appear to have had an income advantage over cotton and hence some cotton acreage was diverted to these crops. In the irrigated cotton region, having many and varied alternatives to cotton, cotton acreage and production declined proportionately more than any other region. This was more pronounced during the war years. Most of the vegetables showed relatively favourable prices, acreage in vegetables increased while cotton acreage declined. There are some implications arising from factors other than alternatives to cotton. These are changes in natural resources, biological factors, technological changes, production control programs and other factors which mitigate changes in cotton production as a response to change in price. A more meaningful conclusion can be brought by a comparison on state level or at the actual farm level.

V. Conclusion

The analysis presented in this chapter can be summarized as follows: cotton production in the United States increased from 10 million bales to 15 million bales from 1910 to 1952. Of the two elements affecting production, acreage went down while yield per acre of cotton increased. Acreage in the southeast region declined while it increased in the southwest and especially in the western irrigated region. Yields per acre increased at different rates for different regions. These different changes in acreage and yield in various regions resulted in different changes in production. In the eastern region production declined because reduction in acreage was proportionately larger than increases

in yields per acre. In the remaining regions production increased because of either proportionately larger increases in yield than in acreage decline, or increases both in acreage and yield. A decline in production continued in the eastern region in the face of higher prices after 1933. These changes can be evaluated again with reference to the criteria of perfectly competitive conditions. With perfect knowledge, full employment, complete mobility and rational adjustment it is logical to assume that any change in the quantity of cotton produced at different prices at different periods and in different regions was an effort to maximize producers' profit. Hence it seems reasonable to conclude that farmers increased or decreased cotton production and maximized their profit by diverting resources towards or away from cotton whichever the case may be.

As observed previously and inferred before, the major increase in production has resulted from increased yield per acre, it may, therefore, be generalized that production shifted to and increased in regions having greater production efficiency. Evidence of changes in efficiency with which resources are used cannot be conclusive unless the contribution of different factors to increase efficiency are determined and a comparison of cost are made. Since data are not available for this kind of comparison on either an interemporal or interspatial basis this further refinement must be foregone.

CHAPTER III

ANALYSIS OF FACTORS AFFECTING UNITED STATES COTTON PRODUCTION

I. Introduction

It has been observed that increase in cotton production resulted mainly from increase in yield. There are many factors affecting yield and production and changes in these factors contributed to increased production. Technological development includes both invention and innovation, the latter meaning application of the former. Some of the developments contribute directly to increased yields and hence production, while others indirectly contribute to increased production and hence efficiency. Accordingly they have divided into two groups. The first group deals mainly with developments which contribute directly to increased yield as for example improved fertilization and better varieties. The second group deals mainly with developments which were responsible for and helped to increase production indirectly. This group consists mainly of innovation which reduce labour requirements and includes such things as capital, machinery, etc. All of these factors do not operate with equal effectiveness at the same time in all cotton producing areas. They have made their contribution differently in different areas and in different parts of the same area. Recent changes in production of cotton in different region and states has not been uniform. The following discussion will analyze the relevant factors affecting production and their relative importance in different regions of the United States.

II. Factors Affecting Cotton Production

A) Factors contributing to increased yield

1) Insects, Diseases and Weather -

Insects - Cotton have had an important effect upon the agricultural and industrial life of the South. Boll worm, boll weevil, cotton hopper, and leaf worm are among the most important. The boll weevil has been one of the most serious insect pest of cotton in the United States for the last 40 years. In some years it causes millions of dollars of damage and threatened to wipe out cotton production over large areas. Table XII shows that the estimated average reduction from the calculated full yield per acre caused by boll weevil damage was 40.4 pounds more during 1948-52 than during 1918-22. Damage has varied for different periods. In general, the available data suggest the recurrence of the boll weevil by five year cycle. "From 1909 to 1922 the weevil moved from the east to the north and brought about reductions in the acreage planted to cotton in the affected regions."[1] In some cases recovery was brought about by better adapted varieties; improved methods of combating boll weevil were available by the time the weevil reached these areas again.

Cotton leaf worm and the boll worm also attack and damage cotton but not as seriously as the boll weevil. "The estimated loss caused by these insects amounted to two to four percent of the cotton crop

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[1] Holley, W. C. and L. E. Arnold, Cotton, Work Progress Administration Natural Research Project, Report A-7, Philadelphia, (Penn.) Sept. 1938, p. 93.

TABLE XII

COTTON ACREAGE, PRODUCTION, YIELD PER ACRE AND REDUCTION FROM FULL YIELD DUE TO SPECIFIED CAUSES, UNITED STATES FOR DIFFERENT PERIODS[1]

	1909-12 Average	1918-22 Average	1928-32 Average	1938-42 Average	1948-52 Average
Acreage, million acres	32.384	30.478	40.451	23.550	24.142
Production, million bales	12.753	10.912	14.667	11.977	14.259
Reported yield per acre, lbs.	164.0	148.8	192.80	247.00	283.00
Full yield per acre, lbs.	243.2	261.97	310.46	356.83	426.46
Reduction from full yield per acre, lbs.	79.2	113.17	117.6	109.83	143.46
All specified causes, lbs.					
Weather - climatic, lbs.	53.06	50.94	68.00	56.79	80.05
Boll Weevil - insects, lbs.	18.91	59.06	42.57	46.80	58.65
Diseases	8.02	3.19	6.88	6.21	4.68

[1] Source: Statistics on Cotton, U.S.D.A., B.A.E., Statistical Bulletin 99, Washington, D.C., June 1951, pp. 67.

amounting to some 32 million dollars during the period of 1910-1920."[1] "Entomologists have developed methods of combating insects; plant breeders developed cotton varieties able to resist the insects attack. Agronomists developed improved methods of planting and cultivating the crop which reduced insect damages; chemists developed dusts and insecticides and engineers used airplanes filled with new mechanism for dusting."[2]

Diseases - The cotton plant in most areas is subject to attack by disease, some of which causes serious losses. Soil born fungus and bacterial diseases from the air are the most important. Of the soil born fungus diseases "root rot has been estimated to cause a loss of 10 to 15 percent of the cotton crop under normal conditions in the Southern states; while under severe conditions in the costal plain area it reduced the yield by as much as 75 to 90 percent."[3]

Effective controls have been secured against various cotton diseases by selection of disease free seeds, by avoidance of susceptible varieties, by development of better methods of controlling cotton diseases by treating seeds with chemicals, etc.

Weather - Weather and climatic conditions affect cotton yields because of either excessive moisture, lack of moisture or other climatic abnormalities which affect the physiological condition of the cotton

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[1] Falson, J. W., Insect Enemies of the Cotton Plant, Agri. Farmers Bul. No. 1688, U.S.D.A., 1932, p. 3.

[2] Ibid., p. 20.

[3] Neal, D. C. and W. W. Gilbert, Cotton Diseases and Methods of Control, U.S.D.A., Farmers Bulletin 1745, May 1953, pp. 8-12.

plant. Unusual weather and climatic conditions reduce yields by as much as 50 percent of the possible yield. Since the weather is unpredictable; it is the most important uncontrollable factor affecting cotton yields. Greater consistency in yields have been observed in irrigated areas where the moisture content in the soil is at least partly under control.

Table XII gives more information about the role played by different factors in reduction of the cotton yield. The reduction from estimated full yield of cotton due to various causes was varied from period to period. Weather conditions were not favourable during 1948-52 when climate and weather reduced yield per acre by 23.26 pounds. This reduction was greater than any other period, largely because of deficient moisture and other unfavourable climate conditions during 1951 and 1952 when it is estimated that weather damage reduced yields by about 15 and 22 percent respectively. This was much above the average damage by weather and climatic conditions. Table XII also shows that diseases were less harmful in 1948-52 but the net reduction due to all causes was larger by 36.63 pounds in 1948-52 than in 1938-42. In other words average yield would have been 70.63 pounds more in the years 1948-52 than in 1938-52, if weather and boll weevil damage had been at comparable levels.

2) Fertilizer -

The use of fertilizer is very important in the production of cotton. Throughout the greater portion of the cotton belt, production would be less profitable without the use of commercial fertilizers year after year, but in several sections fertilizer is not required, notably in the Mississippi Delta and in much of Texas and Oklahoma. The percentage of

the acreage fertilized, the quantity of fertilizer applied per acre and the yield per acre by states and the United States as a whole for different periods are presented in Table XIII.

The use of fertilizer was nearly universal in the southeast region where in 1948-50 more than 95 percent of the cotton acreage was fertilized. An average of 75 percent of the cotton acreage was fertilized in the Delta region during this period. On a state basis, during this period, Georgia was at the top having nearly all of the cotton acreage fertilized. Only 11 percent of the cotton acreage in Texas was fertilized in 1948-50. As far as rate of application is concerned, North and South Carolina were high using 550 pounds per acre in the period 1948-50, while Oklahoma was lowest applying 221 pounds per acre on 15 percent of the total acreage. For different periods Table XIII shows that there has been a wide variation in percentage of acreage fertilized and average application per acre by states. "Rather wide fluctuations have occurred in the tonnage of fertilizer used from year to year. These are closely associated with the price of cotton in the preceding year and the cost of fertilizer."[1] It was observed that in some states the use of leguminous green manuring crops has caused some saving to the farmer in the purchase of his fertilizer.

Table XIII also shows that increased application of fertilizer has generally increased the yield of cotton. It indicates that for the country as a whole, percentage of acreage fertilized and yield

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[1]Holley, W. C. and L. E. Arnold, op. cit., p. 68.

TABLE XIII

PERCENTAGE OF ACREAGE FERTILIZED, FERTILIZER PER ACRE AND YIELD PER ACRE OF COTTON BY STATES AND UNITED STATES BY PERIODS 1928-52[1]

	Percent acreage fertilized			Average fertilizer per acre (pounds)			Average yield per acre (pounds)		
	28-30	38-40	48-50	28-30	38-40	48-50	28-30	38-40	48-50
Virginia	96.15	97.22	92.31	391	395	548	273	239	367
North Carolina	98.05	98.2	97.87	434	428	556	238	313	283
South Carolina	92.37	97.01	98.87	328	401	560	205	322	267
Georgia	95.99	98.65	99.68	265	301	456	187	226	229
Florida	87.08	94.20	98.24	247	260	405	135	130	206.33
Alabama	92.32	32.00	99.80	264	313	471	176	209	262.66
Missouri	17.01	12.88	48.20	136	198	196	234	486	367.33
Arkansas	41.36	39.99	75.71	186	168	265	166	324	345
Tennessee	58.57	53.99	83.28	217	201	260	197	321	367
Mississippi	53.41	71.73	96.03	220	223	265	192	287	339
Louisiana	48.42	61.37	70.17	183	173	220	185	267	321
Texas	6.65	6.98	11.15	185	173	203	125	172	216.66
Oklahoma	1.66	1.00	15.5	181	135	121	127	171	178
United States Total	39.04	44.4	52.67	263	280	340	161	242	286.8

[1] Statistics on Cotton, U.S.D.A., B.A.E., Statistical Bulletin No. 99, Washington, D. C., June 1951.

per acre have increased through time. Considering the increases in fertilizer and yield from 1938-40 to 1948-50, the average application of fertilizer increased by 60 pounds per acre whereas average yield increased by 44.8 pounds per acre or a relationship of .75 pounds increase in yield for each pound of fertilizer. Different experiments on different experiment stations have shown that fertilizer increases yield considerably. "It has been estimated that on an average for the country as a whole, a tone of fertilizer will increase production by 1.7 bales which is equivalent to 0.2425 pounds of lint per pound of fertilizer. Experiments conducted in North Carolina, South Carolina, Georgia and Mississippi showed an application of 200 pounds of 4-8-4 fertilizer in bands of different depths under seeding level, increased yield to as much as 1220 pounds per acre when with no fertilizer the yield was only 527 pounds."[1] A part of this increase may be due to the fact that fertilizer now contains much more quickly soluble materials than it did when used years ago. Considering these new techniques in application of fertilizer and change in fertilizer itself, it appears reasonable to assume that between the periods of 1938-48 to 1948-50, the average increase in lint per pound of fertilizer was much more than 425 pounds which was estimated in experiments conducted 25 years previously. Figure 9 shows the relationship between yield and fertilizer application per acre of cotton for the United States 1928-52.

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[1] Smalley, H. R., "Practical Side of Fertilizer Application Investigation," The American Fertilizer, LXXXIV, No. 7 (1936), pp. 7-10.

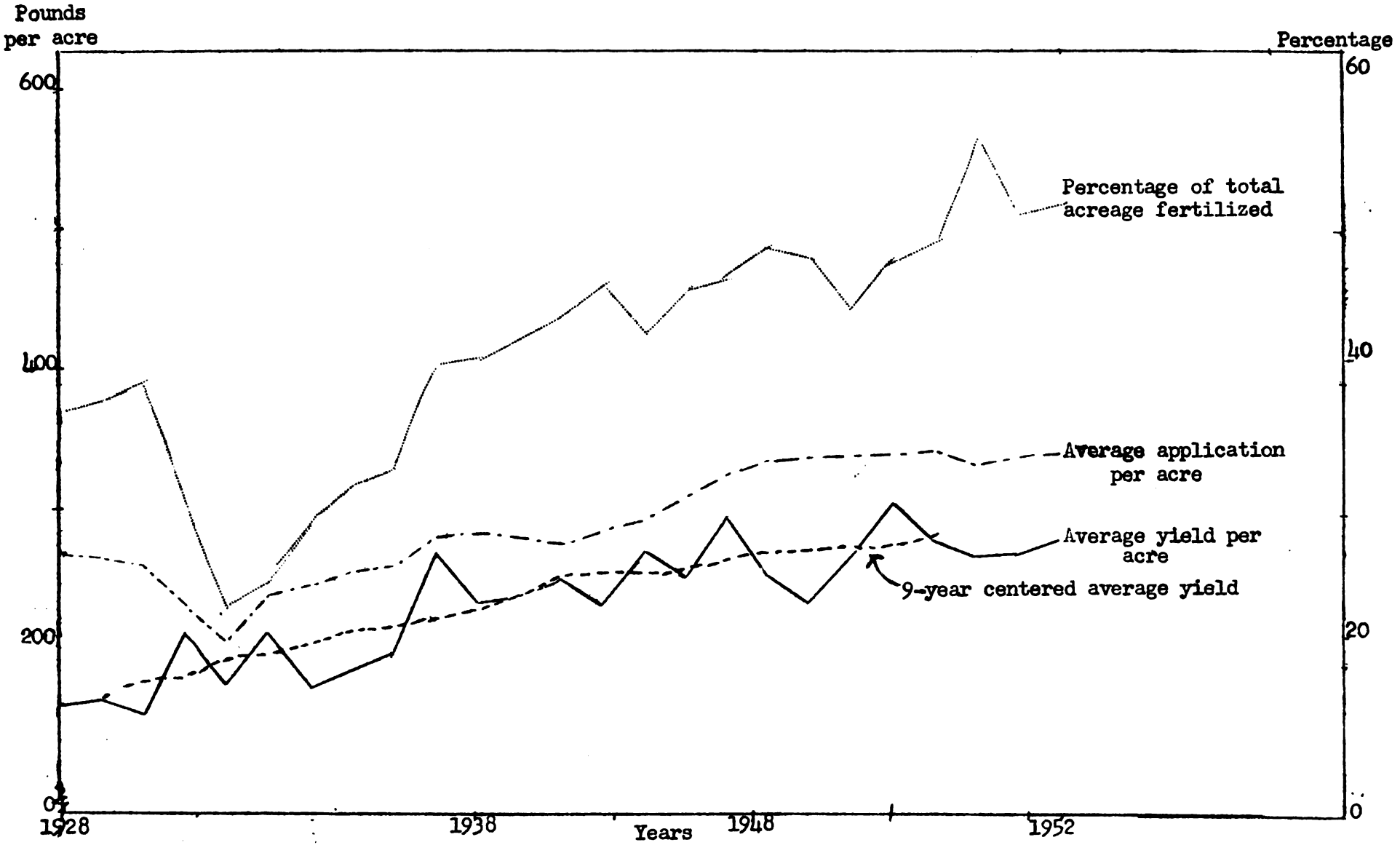

Figure 9. Percentage of the Total Cotton Acreage Fertilized, Average Fertilizer Per Acre and Yield Per Acre of Cotton in U.S., 1928-52[1]

[1]Source: Cotton Statistics, U.S.D.A., B.A.E., Statistical Bulletin No. 99, June 1953.

3) Better Varieties -

The migration of the boll weevil from Mexico to Texas in the early years and its subsequent spread to all important cotton producing regions by 1920 led to radical changes in the varieties of cotton grown in most areas. Many excellent varieties of long stable length and nearly all better varieties of medium staple were hard hit by the weevil. These were replaced by early maturing varieties with short staple length. With this setback, it took years of cotton breeding in state experiment stations to produce and make available new varieties with long staple and resistance to the weevil and insects. It was observed that ". . . in 1936, the acreage planted with improved cotton varieties represented approximately 82 percent of the total cotton acreage. By 1937, there were more than 500 one variety communities growing upward of two million acres of selected varieties of cotton."[1] "The Bureau of Plant Industry developed good varieties producing long fibre, larger bolls and a high lent percentage. Premiums of one to two cents a pound were given for the higher quality cotton. This helped to improve the demand for quality cotton and to increase the acreage under improved varieties."[2]

Emergence of new varieties increased cotton yields, improved quality, and acted as major weapons against insect pests and diseases.

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[1] Johnson, Sherman E., "Changes in American Farming," Misc. Publication No. 707, B.A.E., U.S.D.A., Washington, D. C., 1949, p. 25.

[2] Hopkins, John A., "Changing Technology and Employment in Agriculture," U.S.D.A., B.A.E., May 1941, p. 81.

In addition some varieties have been developed to permit production under different climatic conditions. It is difficult to measure net effect of varietal changes in cotton production as effects do not lend themselves to quantitative treatments.

4) Land Selection, Tillage, Techniques -

It has been observed that with the decline in total acreage production has increased. It is probable that the shift between regions, within the regions or within the boundaries of individual farms was towards land better suited for cotton. This was especially true in the Delta region and in the southwest.

The principal experimental developments in tillage techniques and cultural practices affecting cotton production are changes in:

1) Rotation and cropping practices

2) The amount and type of fertilizer used

3) Methods of planting with regard to spacing and methods of cultivation.

Some of the recent developments in cultural practices have been discussed previously. It has been observed that throughout the cotton belt, except in the high plains of Texas and Oklahoma, there is a continuous need to supply additional organic matter to the soil other than that supplied by cash and feed crops. A failure to furnish the organic matter reduces the efficiency of any commercial fertilizer which may be applied to the soil. Decaying organic matter assists greatly in this process and thus is the fundamental reason for the increasing emphasis on the use of green manuring in the cotton belt. Extensive experimental data are available which emphasizes the value of green manuring

in the cotton production. When leguminous green manuring is used the yield of seed cotton increased between 20 to 200 percent in many instances.

Crop rotation systems are often not used largely because of the difficulties in adapting them to the commercial agriculture of the region. Research is being conducted which may develop more adaptable crops for the types of conditions most often encountered. Systematic crop rotations which improves soil structure, soil productivity and are thus effective soil conservation practices are under study in different areas.

It is difficult to evaluate the role of changed cultural practices in increasing cotton yield. There is wide variation in the cultural practices employed in different areas principally due to differences in climate, topography of the soil, size of the farm, size and character of the implements and power used, insect pests and diseases, available labor supply and institutional factors. These factors are all interrelated and cannot be assessed. A complete and accurate description of the general process of production for any one section would have to be modified in many details for other areas.

Some factors discussed above do not lend themselves to quantitative analysis. In other cases measurable results are obtainable. Some available empirical results indicating the contribution of different periods are summarized in Table XIV.

Thus weather, insects, diseases, fertilizer, tillage techniques affect the yield of cotton directly, but there are other factors which are responsible for and helped to increase production. Analysis and discussion of these are as follows:

TABLE XIV

YIELD CHANGES IN POUNDS PER ACRE DUE TO DIFFERENT FACTORS AFFECTING CHANGES IN YIELD FOR DIFFERENT PERIODS IN UNITED STATES[1]

Factors causing yield change	1928-32 to 1941-42	1935-39 to 1941-53
Increased use of fertilizer	25	15
Shifting of acreage among regions	20	9
More favourable weather	6	3
Less damage by causes other than		1
Damage by weather and boll weevil		
More damage by weather and boll weevil	-5	
Land selection, better varieties of seed	38	12
More legume, conservation—other practices		
Decrease caused by boll weevil	-5	-12

[1] Source: Langsford, E. L., Cotton Production in War and Peace, F.M. 45, U.S.D.A., B.A.E., Washington, D. C., December 1944, p. 21.

B) Factors responsible for increasing production

1) Size of the Farm -

"Size of the farm is important in determining the degree of application of labor saving equipment and production methods. The factors which are responsible largely for the increase in production also have had considerable influence on changes in number and size of the farms. This is particularly true of specialized cotton farms where mechanical equipment and the cotton picker are used. A part of the change in size of cotton farms since 1920 resulted from factors related to development of new arable land in the west and abandonment of land in the east."[1]

Table XV shows the cotton farms as a percentage of all farms in the cotton states and in the United States for 1930, 1940 and 1950. It indicates that except in the irrigated cotton growing states of California, Arizona and New Mexico, the majority of the farms in the cotton states are cotton farms. The number of cotton farms in each cotton state and for the country as a whole has declined steadily. According to the agricultural census,[2] this has resulted in a 20 percent increase in the number of farms having large acreage during this decade. This has resulted in larger acreages per farm for all cotton states in general except in the southeastern area. Table XVI shows changes in average cotton acreage per farm for different states by periods. The greatest increase shown is in the western states where acreage per farm increased from an average of 13 acres in 1909 to 133 in 1949.

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[1] Wilcox, W. W. and W. W. Cochrane, Economics of American Agriculture, Prentice Hall, Inc., New York, 1951, pp. 196-201.

[2] Census of Agriculture, 1950, Vol. VI., pp. 707-775.

TABLE XV

COTTON FARM PERCENTAGE OF ALL FARMS,
UNITED STATES, 1930-40 and 1950[1]

States	Cotton farm percentage of all farms		
	1930	1940	1950
Virginia	8	4	5
North Carolina	54	37	36
South Carolina	83	81	67
Georgia	81	77	56
Florida	20	14	10
Alabama	90	87	69
Missouri	7	6	7
Arkansas	79	70	55
Tennessee	36	31	29
Mississippi	90	89	76
Louisiana	80	76	52
Texas	80	65	46
Oklahoma	61	48	27
New Mexico	12	8	14.6
Arizona	24	11	16
California	3	4	6
Cotton States	61	52	44
United States	32	26	20.6

[1]Source: Census of Agriculture, U.S.D.A., 1950, pp. 775-785.

TABLE XVI

CHANGES IN ACREAGE UNDER COTTON FOR DIFFERENT STATES AND UNITED STATES, BY PERIODS[1]

	1909	1919	1929	1939	1949
	- - - - - - - - - - Acres - - - - - - - - - -				
Virginia	4.8	5.2	6.3	4.3	4.8
North Carolina	9.8	9.0	10.8	6.9	8.0
South Carolina	16.2	14.6	15.0	10.5	12.8
Georgia	20.1	17.5	16.5	11.1	14.1
Florida	12.7	9.1	10.1	6.6	7.7
Alabama	16.6	11.9	15.4	9.6	12.7
Missouri	13.2	14.3	21.9	23.4	36.3
Arkansas	14.5	14.8	17.9	13.7	25.7
Tennessee	11.6	10.6	11.8	8.7	13.2
Mississippi	14.8	12.3	14.2	9.4	14.5
Louisiana	12.9	13.1	15.1	9.4	14.3
Texas	31.4	33.2	42.6	27.5	69.0
Oklahoma	22.4	24.8	33.6	20.8	32.2
New Mexico	13.4	31.6	61.3	27.3	82.6
Arizona	9.5	40.4	69.8	56.9	224.4
California	18.0	70.0	56.9	56.9	103.1
United States	18.7	17.7	21.8	13.9	23.9

[1]Source: Census of Agriculture, 1950, U.S.D.A., B.A.E., Washington, D. C., 1951.

Comparing changes in number of farms with changes in the acreage per farm, in the eastern states a constant decrease in acreage as well as in number was apparent. Except in the southeast region, cotton farms are tending to become larger in size at different levels depending upon the degree of reduction in the number of farms and corresponding increase in acreage under cotton. Large size farms have made it possible to operate mechanical equipment which helps farmers to operate additional acreages efficiently.

2) Mechanization: Changes in Equipment -

The amount of labour used per acre in producing cotton and therefore, the acreage a man or a family can care for varies among areas and localities. On farms in the southern Piedmount and Mississippi Delta, one family usually raises 15 to 18 acres of cotton. In the High Plains of Texas one farmer with mechanical equipment grows from 100 to 200 acres of cotton. In these highly mechanized sections cotton production has been increasing. Accurate measurement of the affect of farm mechanization on cotton production is difficult, nevertheless it appears that the direct results of it have been substantial.

The rapid shift from animal power to mechanical power constituted one of the most important changes that has ever taken place in the American agriculture. It started with the substitution of tractors for horses and mules. This substitution has not taken place at a uniform rate over the entire cotton belt. The rate of adaption has been more rapid in the west and southwest cotton regions than in the southeast and Delta. Small farms with irregular shapes, in later regions, means small units of power and more difficulty in using

larger equipment advantageously. Other factors like hilly farms tended to prevent more general mechanization in these regions. Moreover there are numerous farms on which the advantage arising from adaption of mechanical equipment appears to be nil; on such farms there was little motivation to shift towards mechanization.

The number of tractors in cotton states has increased rapidly in recent years. It is difficult to determine how much of this equipment is actually used for cotton production. An attempt has been made to collect available information from different sources which will give a partial evaluation of the process of mechanization in cotton production. Table XVII shows the percentage of indicated operations on cotton acreage worked with tractor power by geographic divisions in 1939 and 1946. It shows that in 1946 three-fifths of the land planted to cotton in the United States was worked with tractor-drawn implements as against half the percentage seven years earlier. The proportion of cotton planting and cultivating done with tractors likewise has more than doubled during these seven years. In 1939, the Mountain and Pacific regions were far ahead of the others in the extent to which tractors were used for these operations, but the West-North Central States made the greatest gains from 1939 to 1946.

Although considerable progress has been made in mechanization, it has had little effect on the peak labour requirements during picking. A stripper type harvester removing the entire boll from the plant has been developed for use in areas where snapping was practiced. The picker picks the lint from the boll leaving the boll on the stalk. It is not unreasonable to believe that the mechanical cotton picker could affect

TABLE XVII

PERCENTAGE OF INDICATED OPERATIONS ON COTTON ACREAGE WORKED WITH TRACTOR POWER, BY GEOGRAPHIC DIVISION, 1939 and 1946[1]

Geographic division	Breaking land		Planting		Cultivating	
	1939	1946	1939	1946	1939	1946
West North Central	24	76	4	30	13	55
South Atlantic	11	40	1	12	1	10
East South Central	14	36	4	15	6	15
West South Central	40	74	33	62	32	65
Mountain	75	90	56	75	64	83
Pacific	85	97	71	85	73	90
United States	30	60	21	43	21	45

[1]Source: Hetch, Reuben W. and Glen T. Barton, Gain in Productivity of Farm Labor, Technical Bulletin 1020, U.S.D.A., B.A.E., December 1950, p. 75.

cotton production as much as the adoption of mechanical harvesting methods affected wheat production. Because of differences in climatic conditions, soil and other factors which differentiate production practices in one area from another, the rate of mechanization has varied in different areas in different periods. However, the rate of mechanization will largely be dependent upon the stage of improvement in mechanical equipment adaptable to different conditions and the volume in which equipment is available for widespread use.

The following discussion and Table XVIII should be considered only a rough approximations of probable results from use of these machines. "The use of tractors along with other machinery has advanced rapidly in the western semi-arid sections. Tractor equipment has tended towards larger units from the mostly two row size units. The use of two row tractor equipment instead of horse power results in a saving of approximately one to two hours of man labor per acre in operations preceding harvest. The use of four row equipment would make possible the production of an acre of cotton with only four to five hours of man labor prior to harvest."[1]

The Bureau of Agricultural Economics in cooperation with several State Agricultural Experimental Stations has made studies to develop a rough approximation of probable results from use of tractors by obtaining information on performance of mechanical equipment used in cotton production. It showed that when the equipment is mechanically satisfactory, one row units can be expected to cover six to eight acres per day. Two row units can cover 10 to 15 acres per day. Using these

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[1] Looking Ahead with Cotton, Misc. Bul. 584, U.S.D.A., 1945, p. 6.

TABLE XVIII

ESTIMATED MAN HOUR LABOR NEEDED PER ACRE AND PER BALE TO PRODUCE COTTON WITH DIFFERENT TYPES OF POWER AND EQUIPMENT AND VARIOUS METHODS OF HARVESTING IN SPECIFIED PRODUCTION AREAS[1]

Production area	Type of equipment	Method of harvest	Per acre			Per bale
			Total preharvest	Pick or snap	Total all operations[2]	Total man labor[2]
			hours			
High plains	2 row tractor	snapped by hand	5.6	17.0	22.6	54
High plains	4 row tractor	snapped by hand	4.4	17.0	21.4	51
High plains[3]	4 row tractor	2 row mech. snipper	4.4	2.0	6.4	15
Black Land	2 row tractor	picked by hand	15.0	30.0	45.0	143
Sandy Land	1 row mule	picked by hand	44.0	33.0	74	235
Delta	1 row mule	picked by hand	56.0	85.0	141.0	160
Delta	4 row tractor	picked by hand	42.0	85.0	127.0	143
Delta[3]	4 row tractor	1 row mech. picker	42.0	4.0	46.0	52
Delta	4 row tractor & flame cultivator	1 row mech. picker	21.0	4.0	25.0	28
Costal Plains	½ row mule	picked by hand	71.0	50.0	121.0	230
Costal Plains	1 row mule	picked by hand	59.0	50.0	109.0	208

[1]Source: Looking Ahead with Cotton, Misc. Bul. 584, U.S.D.A., 1945, p. 7.

[2]Does not include hauling to gin.

[3]It should not be inferred that tractors, mechanical harvesters, and flame cultivators can or will be used only in the high plains and delta. These areas are used to illustrate the effect of these machines on labor needs.

assumptions, estimates of man labour requirements for pre-harvest operations, estimates of man labour needs for producing cotton with different sizes of equipment, and harvesting methods have been estimated and are given in Table XVIII.

These estimates indicate that "large reductions in man-labor requirements would be possible with the use of these machines. On the basis of these assumptions total man-labor requirements in the high plain area would be only about one-third as great with the use of the two row stripper as with hand snapping. In the Delta areas the percentage reduction would be even greater. With the use of a one row mechanical picker and flame cultivator, the estimated man labor requirements would be less than one-fifth as great as when one row mule equipment was used and picking was done by hand."[1] Although specific production areas used in Table XVIII illustrate the effect of those machines on the labour needed to produce cotton, it should not be inferred that the high plain and Delta areas are the only areas in which mechanical equipment is used. They were among the first to adopt the new machines. But, in general, reduction in labour requirements would be observed with different degrees, corresponding to the amount of mechanical equipment used in different cotton producing regions with the prevailing conditions and equipment there.

Table XVII shows that the percentage of tillage work done by tractor power on cotton acreage is increasing as time goes on. Some studies have

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[1]Various Methods of Harvesting Cotton in Specified Production Areas, Misc. Bulletin 548, B.A.E., U.S.D.A., 1945.

shown that "The annual increase in pounds of cotton produced per hour is to some extent associated with mechanization."[1] Table XIX shows the effect of change in yield per acre and mechanization and other factors, on pounds of cotton lint produced per 100 man hours by geographic divisions in the periods 1919-1946. It indicates that "from 1919-21 to 1944-46 the effect of greater yields was almost double than that of increases in mechanization in all geographic divisions, except in the West South Central. The increase in yield was less in this area than in any other geographic division and it is among the areas in which the most progress has been made in mechanizing the production of cotton."[2]

3) Changes in Capital -

"The higher yields obtained in recent years are in a fundamental sense, the results of changes in production methods. The changes in the process of production, on or off the farm, imply corresponding changes in the instruments used. In agriculture, this general principal has been doubly true because the change in process often originates in improvements in the power units or in the farm equipment when technological changes call for new equipment it requires more capital investment than did older methods."[3] It has been

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[1] Hecht, Ruben W. and S. T. Barton, Gains in Productivity of Farm Labor, Tech. Bul. 1020, B.A.E., U.S.D.A., Dec. 1950, pp. 23-24.

[2] Ibid., p. 74.

[3] Hopkins, John A., Changing Technology and Employment in Agriculture, B.A.E., U.S.D.A., (CWPA;NRP) May 1941, p. 35.

TABLE XIX

EFFECT OF CHANGE IN YIELD PER ACRE AND MECHANIZATION AND OTHER FACTORS ON POUNDS OF COTTON LINT PRODUCED PER 100 MAN HOURS, BY GEOGRAPHIC DIVISION, INDICATED PERIODS, 1919-1946[1]

Geographic Division	Production per 100 man hours			Change in production per 100 man hours 1919-21 to 1937-39			Change in production per 100 man hours 1937-39 to 1944-46			Change in production per 100 man hours 1919-21 to 1944-46		
	1919 to 1921	1937 to 1939	1944 to 1946	Associated with change in		Total	Associated with change in		Total	Associated with change in		Total
				Yield per acre	Mech. & other factors		Yield per acre	Mech. & other factors		Yield per acre	Mech. & other factors	
	pounds											
West North Central	207	268	275	43	18	61	1	6	7	44	24	68
South Atlantic	101	202	231	27	14	41	23	6	29	50	20	70
East South Central	135	222	237	76	11	87	9	6	15	85	17	102
West South Central	172	256	267	45	39	84	-2	13	11	43	52	95
Mountain	243	362	359	99	20	119	-7	4	-3	92	24	116
Pacific	305	460	464	129	26	155	-8	12	4	121	38	159

[1]Source: Reuben W. Hetch and Glen T. Barton, Gains in Productivity of Farm Labor, Technical Bulletin No. 1020, U.S.D.A., B.A.E., Dec. 1950.

observed that cotton production has shifted from horse drawn to tractor drawn equipment and has resulted in tremendous labour savings. This shift from horse to mechanical source of power has also caused one of the most important change in the make-up of the capital requirement in cotton production.

Studies have been made on commercial family operated cotton farms in the areas of Delta Mississippi, Black Prairie and Southern Plain from 1930 onwards. Though the data are limited to these three areas, these areas are characteristic in their operation, production and return. The Southern Plains are characterized by large scale highly mechanized production. Delta farms are small in terms of acres, income, and total output while the Black Prairie cotton farms represent in many respects a transition between the other two. Table XX shows changes in capital investment in machinery and equipment on cotton farms by specific areas in the United States 1930-50.

a) The Mississippi Delta -

Capital investment in machinery and equipment per cotton farm in this area has been smaller than those of other areas during the period of 1930-52. The increase in investment for this period was not proportionate to other areas. Capital investment on machinery and equipment per farm was $130.00 in 1930 and increased to $290.00 in 1950. This was less than one-third of the capital investment per farm in the Black Prairie and less than one-fourth of that in the Southern Plainsarea in 1930 and these proportions decreased to less than one-fifth and one-sixth respectively in 1950. This shows that there was very little investment on machinery and equipment on farms

TABLE XX

CHANGES IN CAPITAL INVESTMENT IN MACHINERY AND EQUIPMENT ON COTTON FARMS BY SPECIFIED AREAS IN THE UNITED STATES, 1930-1950[1]

Year	Southern Plain	Black Prairie	Delta Area
1930	$ 562	$ 439	$130
1931	526	428	123
1932	447	393	108
1933	395	356	97
1934	395	360	92
1935	551	399	101
1936	612	417	107
1937	739	471	115
1938	815	510	137
1939	838	511	144
1940	836	501	147
1941	915	607	149
1942	1,040	746	165
1943	1,157	788	179
1944	1,150	821	182
1945	1,289	909	200
1946	1,376	965	210
1947	1,625	1,170	228
1948	1,814	1,372	250
1949	1,920	1,496	275
1950	1,979	1,498	290
1951			310
1952			320
1953			330

[1]Source: Farm Costs and Returns, Commercial Family-Operated Farms, 1930-51, F.M. 55, 70 and 82, U.S.D.A., B.A.E., Washington, D. C.

in this area. Many factors are responsible: family operated farms in this area are small in terms of average production and income. Resident labour is used to meet even peak period labour requirements. Each family's scale of operation is limited to about 15 to 20 acres. As the area is not well adapted to mechanization, these small farm operators have understandably stayed with mule drawn equipment and hand labour.

b) Southern Plains -

Capital investment in machinery and equipment per cotton farm in the Southern Plains has always been larger than that of any other area. Investment amounted to $562.00 per farm in 1930 and increased to $1979.00 per farm in 1950 or an increase of 350 percent as compared in 1930. Comparatively level and large scale farms in this area are more suitable than those in any other area for the use of tractor-drawn mechanical equipment and hence more investment is found on these farms.

c) The Black Prairie Area -

The make-up of the capital investment in mechanical equipment in this area has shown the same pattern of change as in the Southern Plains cotton area in all respects except the absolute amount. Investment increased from $439.00 per farm in 1930 to $1498.00 in 1950. Investment has always been less per farm than in the Southern Plains but always more per farm than in the Mississippi Delta. This relationship may be attributed to the fact that Black Prairie cotton farms are in many respects a transition from the small farm type of organization in the east to the large scale mechanical cotton farms of the Southern Plains. The topography makes this area well adapted to the use of mechanical equipment for cotton harvesting and production

and hence there has been a substantial increase in the amount used. Table XX shows changes in capital investment in machinery and equipment on cotton farms for these areas from 1930 to 1950. It should be remembered that these data do not indicate the investment in cotton machinery only—they are for the farm as a whole, cotton being the major enterprise.

The process by which this change in investment occurred followed a definite pattern. As farmers found an opportunity for its profitable adoption, they invested more capital in farm machinery and equipment. It has already been shown that mechanization resulted in a large saving of labour. This is one of the opportunities for the profitable adoption of mechanical power. Similar generalization can be drawn from all these discussions, i.e. that the larger the farms, the more profitably machinery can be used and total investment per farm will be greater.

Because of unavailability of data showing changes in expenditures for labour used for cotton production, it is impossible to show conclusively to what extent the increase in investment in machinery and equipment caused a reduction in expenditure on labour. It can be generalized from the observation made so far, however, that increasing capital investment is one of the factors of production which has profoundly affected the use of labour.

III. Production Per Man Hour

"The rise in man hour productivity during the last 40 years has resulted in a sharp increase in farm output and moderate decrease in

total man hour requirement for farm work."[1] A number of factors are responsible for the increase in yield and for reducing the amount of labour required to produce cotton. These factors already have been discussed.

Output per man hour of labour or production per worker is a commonly used measure of production efficiency, though neither production per man hour nor production per worker is an ideal measure. Both are ratios of total production to labour inputs. Ratios of this kind do not measure the net contribution of labour or of capital or of any other factor of production. The change in ratio reflects the joint efforts of all factors of production such as substitution of machinery for labour and increased production by the development of higher yielding, more disease resistant varieties and hybrids, more effective methods of disease and insect controls, different tillage techniques, fertilizers, etc. However, since labour is the most important input in cotton production the change in labour requirement provides a useful measure of change in production efficiency.

Year to year fluctuations in yield results from different factors. When changes in man hour and crop production per acre are converted to an average annual rate of change the change in production per man hour is more clearly seen. Table XXI shows the average annual rate of change in cotton production per man hour, and man hours and crop production per acre of cotton for the United States by periods 1910-53.

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[1] Hecht, Reuben W. and Glen T. Barton, "Gains in Productivity of Farm Labor," U.S.D.A., B.A.E., Tech. Bul. 1020, Dec. 1950, p. 2.

TABLE XXI

AVERAGE ANNUAL RATE OF CHANGE IN CROP PRODUCTION PER MAN HOUR AND MAN HOUR AND CROP PRODUCTION PER ACRE OF COTTON UNITED STATES BY PERIODS, 1910-1953[1]

	1910-14 to 1920-24	1920-24 to 1930-34	1930-34 to 1940-44	1940-44 to 1950-53
	percent			
Man hours per acre	-1.72	+0.104	+ 0.206	-2.62
Production per acre	-2.28	+1.88	+ 4.130	+1.019
Production per man hour	-0.529	+1.78	+ 3.86	+5.305

[1]Source: Calculated from: Reuben, Witt, and U. R. Vice, Labor Used for Field Crop, Statistical Bulletin 144, A.R.S., U.S.D.A., June 1954.

It shows that the decrease of 1.72 percent per year in labour requirement per acre was associated with a decrease of .529 percent in crop production per man hour from 1910-14 to 1919-24. This occurred because cotton yield declined during this period. But during the period from 1920-24 to 1930-34 a small increase in man hours per acre associated with a substantial increase in average yield, resulted in an increase in production per man hour of 1.78 percent per year. Man hours per acre increased 0.104 percent and yields increased 1.88 percent during this period. In the period of 1930-34 to 1940-44, a 3.86 percent increase in production per man hour was associated with a 0.206 percent increase in man hour per acre and a yield increase of 4.13 percent per year. From 1910-44 to 1950-53 a 5.305 percent increase per year in production per man hour was associated with a 2.62 percent decrease in man hours per acre and a 1.019 percent increase in yield annually.

This indicates that cotton yield increased greatly during and after World War II and was influential in raising total production at a high rate. Thus during these periods, changes in yields were chronologically, less effective, equally effective and more effective than were changes in labour requirements in raising cotton production per man hour. The many factors which affect cotton production and changes in labour productivity have seldom had a uniform effect in all the cotton areas. As seen above, reduction in man hours per acre and greater yield were largely responsible for the increase in production per hour of labour used not only for cotton but for all crops. The importance of each factor varies, however from crop to crop from area to area and from one period to another. Cotton production per hour

of labour decreased during the early part of the last 40 year period. The boll weevil was advancing over the cotton belt and its ravages severely reduced cotton yields and more labour was needed to fight the scourge. Since 1921, however, production of cotton per man hour has increased almost as much as the average for all crops. During the interwar periods it advanced more than the average increase for other crops except food grains. The greater yields which have been attained, are the results of several factors which have already been discussed.

There has been a rather slow but steady increase in mechanization of cotton production which has helped to reduce the labour employed on cotton farms and thus increased the productivity of labour spent on cotton production. Table XVII shows the percentage of indicated operations on cotton acreage done with tractor power by geographic division while Table XVIII, the effect of different types of mechanical equipment as labour saving device on a per acre and a per bale basis. These indicate that use of such machines have resulted in more reduction in labour requirements and thus in an increase in labour productivity. But such machines have not yet been used on an extensive scale in all states, therefore their effect on labour productivity has not yet been fully exploited. Table XIX summarizes the effect of mechanization and other factors on the amount of cotton lint produced per 100 man hours for geographic divisions by indicated periods, 1919-46. It also shows their effect on labour productivity. It indicates that if mechanical farming is more widely adopted in the future its effect on labour productivity in the cotton belt will be significant.

The available data permits a partial evaluation of changes in efficiency by the criterion of man hour of labour required to produce a pound of cotton. Table XXII shows production per man hour of labour for the United States and the geographic divisions by periods, 1920-48. Areas which are characterized by large mechanized farms and farms producing cotton under irrigation have the highest output per man hour of labour. The Pacific and the Mountain divisions consisting of irrigated cotton producing farms in California, New Mexico and Arizona have had constantly greater output per hour of labour than other divisions. Among these California was highest followed by Arizona and New Mexico. Production in the West South Central division dominated by mechanized farms in Texas and Oklahoma has followed a somewhat different pattern. Average production per labour hour in this area was relatively low compared to all other divisions during the early years but has steadily increased in each period because of continuous reductions in labour requirements caused by the rapid progress in the shift from mule drawn to tractor drawn equipment on the family operated farms in this area. The East South Central area consisting of the Delta states shows a slow but steady increase in production per man hour of labour and this may be due to concentration of cotton production on higher yielding rich soils of the Delta area. The South Atlantic division consisting of the eastern cotton states demonstrated somewhat the same pattern. Production per hour of labour increased while total acreage was declining. This may be accounted for by the elimination of inefficient farms.

TABLE XXII

POUNDS OF COTTON PRODUCED PER MAN HOUR OF LABOR FOR THE UNITED STATES AND BY GEOGRAPHIC DIVISIONS, 1920-1948[1]

Years	United States	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific
1920-24	8.45	9.91	8.16	7.07	9.06	13.75	17.50
1925-29	9.32	12.06	8.63	8.94	9.61	15.51	19.37
1930-34	9.91	9.65	9.45	8.64	10.38	16.27	21.79
1935-39	11.95	13.40	10.50	11.12	12.39	18.42	23.81
1940-44	13.17	14.61	11.31	11.97	14.11	18.01	24.62
1945-48	10.99	11.42	9.56	10.08	11.38	15.95	19.93

[1]Source: Hetch, Reuben W. and Glen T. Barton, Gains in Productivity of Farm Labor, U.S.D.A., B.A.E., Technical Bulletin 1020, December 1950.

It seems well to mention, at this point, that three influences are responsible for this change. One was a general shift towards specialized and high yielding areas, the other mechanized cotton production causing reduction in labour requirement and the third importance of crop among divisions and within the crop enterprise. These all significantly affected total cotton production per man hour at different levels.

IV. Production Cost

Change in production per man hour or per worker must be interpreted in the light of changes in capital inputs and hence the consideration of production costs is essential. Although output per man hour of labour represents one measure of production efficiency, low cost of production is usually associated with high labour productivity. In some cases, however, this measure does not give a clear indication of production efficiency. Geographical differences in the relationship between wages and of other factors of production may in many cases, prevent direct comparisons. For example, in the Delta area on the small family operated farms where mule drawn equipment and hand labour is used, wage costs are always higher especially during the picking season than on a larger and specialized tractor drawn power unit farms in Texas and Oklahoma. In this latter area little labour required. Investment in machinery and equipment is, however, much higher. Because of these differences, unequivocal generalization cannot be made on the basis of labour input alone. In general, production cost is least in areas of specialized production and on the farms having relatively large acreage and where labor saving equipment is used.

Additional evidence concerning changes that have occurred in the efficiency with which resources are used in the production of cotton could be obtained by comparing cost data. However, unavailability of this type of data either on a state or regional basis is the limiting factor. Studies have, however, been made on a year to year basis from 1930 onwards for typical family operated farms in the area of the Mississippi Delta, the Black Prairie Region, and the Southern Plains. A summary of data showing cost on a per acre and per pound basis by periods are given in Table XXIII. Returns per acre and per pound have been calculated from the receipts obtained from cotton lint and seed. Unavailability of cost data in such form has necessitated the allocation of costs with some assumptions. Suppose 80 percent of the total receipt is from cotton lint and seeds, the total cost for the farm enterprise as a whole has been allocated on the same basis and has been assumed to be the cost for cotton production in that particular case. In this way costs per acre and per pound of cotton have been calculated. With these assumptions reasonable comparison can be made. An analysis and discussion of the situation follows.

1) Southern Plain -

Returns and cost per acre and per pound of cotton in this area were smaller than in other areas. Returns are smaller because yields per acre for the period under consideration were relatively lower than other areas. Costs were lower because of large scale mechanized cotton production. "The recent increase in cost came from building material and machinery, increased wage rates and cotton snapping rates. The latter two increased by five to eight percent while the investment

TABLE XXIII

PER ACRE AND PER POUND COSTS AND RETURNS FOR COTTON PRODUCED ON FARMS IN SOUTHERN PLAIN, BLACK PRAIRIE AND DELTA OF MISSISSIPPI BY PERIODS, 1930-1952[1]

	Southern Plains				Black Prairie				Mississippi Delta			
	cost		returns		cost		returns		cost		returns	
	acre	lbs.	acre	lbs.	acre	lbs.	acre	lbs.	acre	lbs.	acre	lbs.
	$	¢	$	¢	$	¢	$	¢	$	¢	$	¢
1930-34	3.14	2.71	11.8	8.94	4.33	2.65	16.82	10.20	7.16	3.45	25.78	11.67
1935-39	3.39	2.37	15.9	10.38	4.45	2.52	19.73	11.44	8.28	2.18	49.66	13.51
1940-44	5.05	2.54	37.09	17.92	5.72	3.53	30.90	18.59	8.92	2.11	98.21	23.20
1944-49	8.24	4.34	52.83	29.54	11.89	7.55	49.30	32.45	15.32	3.85	158.35	36.27
1950-52	n.a.[2]	n.a.[2]	57.80	41.12	22.41	16.19	60.90	42.98	16.24	4.28	170.70	44.55

[1] Source: Typical Family Operated Farms, F. M. 55, 82 and 70, U.S.D.A., B.A.E., Washington, D. C., 1946-51.

[2] n.a. = not available.

in machinery increased by 16 to 26 percent from 1946-1948."[1] Comparing these changes in costs to those of returns the percentage change was the same in both cases. In absolute figures gross profit has been definitely increasing.

2) The Black Prairie Region -

These farms showed a continuous increase in cost per acre and per pound. Absolute cost increases are not large but percentage-wise costs increased by more than 500 percent from 1920 to 1951, on a per acre and on a per pound basis. At the same time fairly stable yields presented an increase in returns that was proportionately as great as the increase in costs. For the period of 21 years from 1930 to 1951 the ratio of returns to costs increased from 4:1 to 6:1 in the first half and decreased to less than 3:1 in the later half of the period. In the second half of the period prices of cotton did not advance enough to offset the effect of increases in cost. Hence with stable yields the ratio of returns to capital declined. "Cost rates in this region increased by 12 percent from 1945 to 1950 compared with an increase of only six percent in prices received."[2]

3) Mississippi Delta -

The pattern of change in cost and returns in this area is peculiar. Cost per acre and per pound increased in all regions from 1928 to 1952, but the pattern of change in this area and that observed in the other

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[1] Source: Farm Costs and Returns, 1950, Commercial Family-Operated Farms, F.M. 82, U.S.D.A., B.A.E., Washington, D. C., pp. 9-18.

[2] Farms Costs and Returns 1945-47 for Commercial Family Operated Farms, U.S.D.A., B.A.E., Washington, D. C., FM 70, pp. 13-14.

two areas were different. Cost per acre increased from $7.16 to $16.24 while cost per pound increased from 3.45¢ to 4.28¢. The increase in cost per pound was less than in any other area. Percentage-wise a comparison of this change with those of other areas would show a very significant difference. Returns per pound increased by four times while the increase in returns per acre was near to seven times. This relationship between returns per acre and per pound was due to increasing yields and decline in acreage. From 1928-51 the acreage under cotton declined by 25 percent while yield increased by 275 percent.

V. Summary

These changes in costs and returns in different regions help to explain changes in production efficiency. To get the exact picture of production efficiency from the pattern of changes in costs and returns, cotton production should be observed in the light of changes in yield, labour requirements, and capital used for labour saving devices. The high value of cotton obtained from 12 to 20 acres in the Delta area probably resulted in large part from the fact that more yields could be obtained by using more family labour which was available without additional cash expenditures. That is why these small scale farms showed the greatest net profit per acre.

Second lower yielding farms in the Southern Plains were profitable as mechanized production in that area enabled farmers to add more acreage to their large scale farms and thus helped to increase production with decreasing costs per acre. There efficiency is associated with mechanical production which saves labour.

The Black Prairie farms are shifting from horse drawn to tractor equipment and are neither fully mechanized nor intensively specialized. Resulting costs in the Black Prairie are somewhat higher than in any other area.

This pattern can be summarized in the statement efficiency in cotton production has resulted from reduction in labour requirement and increase in yields. One is associated with costs while the other is associated with output.

CHAPTER IV

DEVELOPMENTS OF TECHNOLOGICAL POSSIBILITIES TO IMPROVE INDIAN COTTON PRODUCTION

I. Introduction

For the last forty years India[1] has been second to the United States in the production of cotton. Thus attention should naturally be directed to the United States to find possible ways of improving production methods in India. In the first part of this chapter an attempt is made to compare the nature of some important developments in the Indian cotton situation during the last forty years with those of the United States in order to evaluate the possibilities of improving production in India. The second part will discuss and appraise possibilities and implications of adopting and applying different technological advances which helped to increase production in the United States.

II. Comparative Changes in Indian and United States Cotton Production

1) Acreage, Yield, Production -

Table XXIV shows the cotton acreage, yield per acre and production for the United States and India, 1912 to 1952. Indian cotton production

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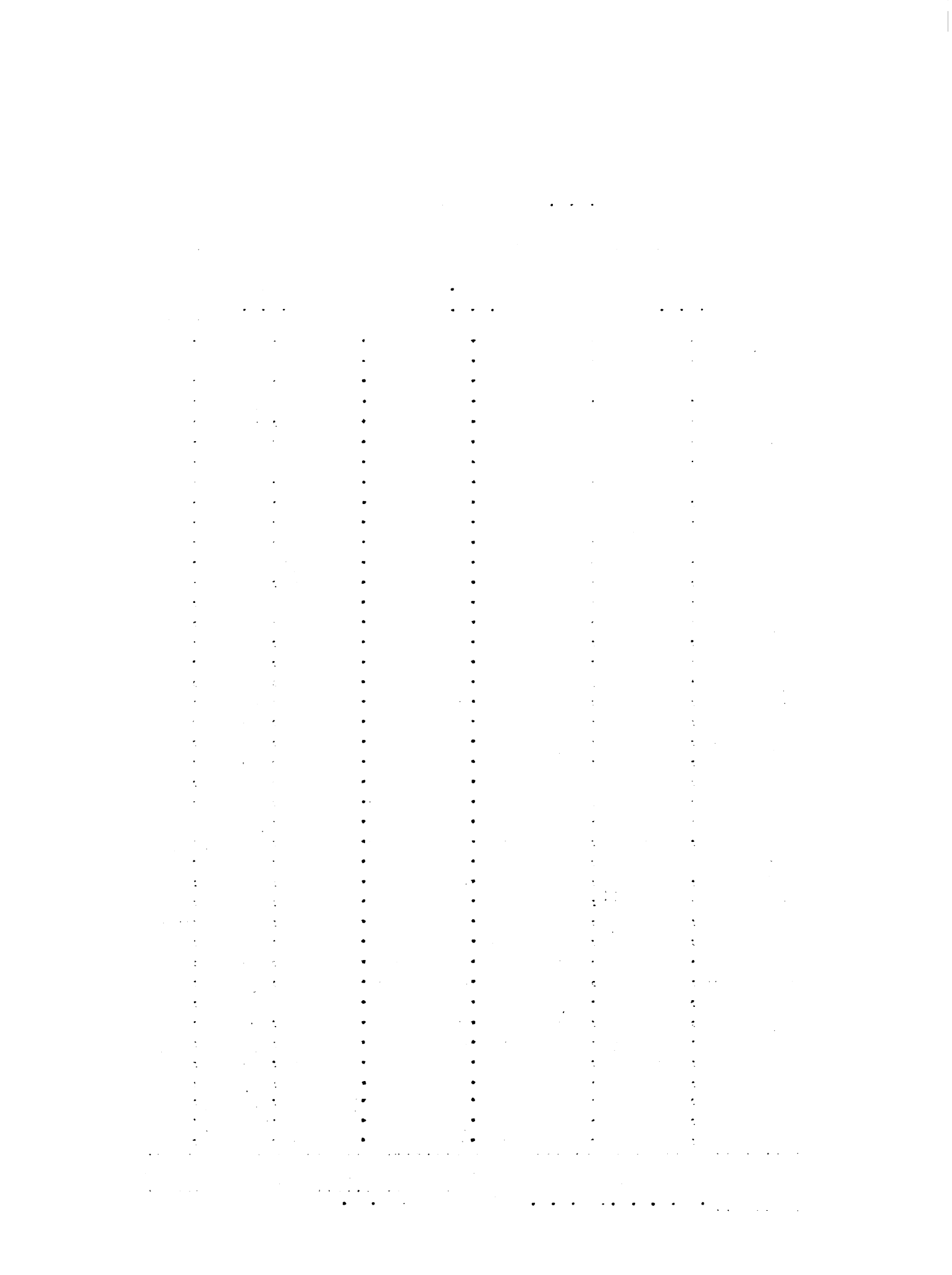
[1]Unless otherwise specified 'India' and 'Indian' will refer to pre-partition India, thus including Pakistan, but excluding Burma, separated from India in 1937.

TABLE XXIV

COTTON - ACREAGE, YIELD PER ACRE AND PRODUCTION FOR U.S.A. AND INDIA, 1912-1952[1]

Year	Total acreage (1,000 acres)		Yield (lbs. per acre)		Production (1,000 bales)	
	U.S.A.	India	U.S.A.	India	U.S.A.	India
1912	32,557	23,166	201.4	76.7	13,703	3,702
1913	35,206	23,500	192.3	86.5	14,153	4,239
1914	35,615	24,595	216.4	85.0	16,112	4,359
1915	29,951	17,746	178.5	84.6	11,172	3,128
1916	33,071	21,745	165.6	82.9	11,448	3,759
1917	32,245	25,188	167.4	64.6	11,284	3,393
1918	35,038	21,037	164.1	75.9	12,018	3,328
1919	32,906	22,353	165.9	99.7	11,411	4,853
1920	34,408	21,341	186.7	67.7	13,429	3,013
1921	28,678	18,451	132.5	97.6	7,945	3,752
1922	31,361	21,792	148.8	93.5	9,755	4,245
1923	35,550	23,626	136.4	87.7	10,140	4,320
1924	39,501	26,801	165.6	91.2	13,630	5,095
1925	44,386	28,491	173.5	101.9	16,105	5,201
1926	44,608	24,822	192.9	81.3	17,978	4,205
1927	38,342	24,761	161.7	96.7	12,956	4,990
1928	42,434	27,053	163.3	85.8	14,477	4,838
1929	43,232	25,922	164.2	81.2	14,825	4,387
1930	42,444	23,812	157.1	88.1	13,932	4,373
1931	38,704	23,772	211.5	67.8	17,097	3,353
1932	35,891	22,483	173.5	83.2	13,003	3,898
1933	29,383	23,739	212.7	86.4	13,047	4,274
1934	26,866	23,907	171.6	81.6	9,636	4,065
1935	27,509	25,999	185.1	91.6	10,638	4,962
1936	29,755	25,219	199.4	101.1	12,399	5,312
1937	33,623	25,746	269.4	91.6	18,946	4,914
1938	24,248	23,482	235.8	88.2	11,963	4,315
1939	23,805	21,356	237.9	94.2	11,817	4,195
1940	23,861	22,902	252.5	108.6	12,566	5,182
1941	22,236	24,151	231.9	101.8	10,744	5,127
1942	22,602	19,203	272.4	98.3	12,817	3,935
1943	21,610	21,086	254.0	100.1	11,427	4,401
1944	19,617	14,843	298.9	119.4	12,230	3,693
1945	17,029	14,668	253.6	115.4	9,015	3,529
1946	17,584	14,861	235.3	114.8	8,640	3,557
1947	21,330	14,222	266.3	115.0	11,860	3,410
1948	22,991	14,600	311.3	93.3	14,877	2,840
1949	27,439	12,173	281.8	92.6	16,128	2,350
1950	17,843	14,556	269.0	89.6	10,012	2,720
1951	26,854	16,213	270.2	91.7	15,144	3,100
1952	25,664	16,175	282.7	84.5	15,136	2,850

[1]Sources: Compiled from Statistical Abstracts and Agricultural Statistics, U.S.D.A., B.A.E., Washington, D. C.



was not controlled by the government until the middle of World War II. During the period of 1912 to 1943, Indian cotton production was much more stable than that of the United States. Production reached a peak in 1936 when 5.3 million bales were produced. From 1943 on the Indian Government's "Grow More Food" campaign and later on the effect of the political partition of the country, which was aggravated by a nation-wide famine in 1948, resulted in immediate restrictions on cotton acreage and production declined. Production in 1949, was the lowest of the entire forty year period totaling only 2.3 million bales. This resulted from a sharp and sudden decrease both in acreage and yield after the partition. Government restrictions were not in effect in 1936 or 1949 either.

United States production on the other hand reached its peak in 1937 when almost 19 million bales were produced. The low point in cotton production for the forty year period of 1912 to 1952 was in 1946 when 8.6 million bales were produced. Governmental restrictions on acreage which applied intermittently from 1933 onward were not in effect in either year.

Table XXIV shows that production in the United States for 1952 exceeded by 18.08 percent of the average for the period 1912 to 1952 while Indian cotton production in the same year was only .56 percent of the average for the period. It indicated that United States cotton production has made a strong recovery from the war time slump. Indian cotton production, on the other hand, was declined steadily. Unless India can reverse the present downward trend in production by using different methods of production she will not be able in the future to improve her cotton economy, which was seriously disturbed after partition.

Cotton acreage is a better measure of farmers reaction to changing economic conditions than production since production is a function of both acreage and yield and the latter is to a considerable degree affected by non-economic factors such as weather and insect infections. In the United States, change in cotton acreage, in the absence of governmental control, reflect changes in farmers estimate of the profitability of using land for cotton production rather than for some alternative use. When cotton acreage remains stable for a considerable period of time as was the case in India in the thirties, the meaning is not so clear. Stability in acreage planted to cotton may reflect stability in the relative profitability of cotton compared to other crops but it may also be due to inertia on the part of farmers who are often bound by customs and unwilling to change rotations of cropping system even when it would be economical to do so.

Experience of the last forty years indicates that Indian cotton acreage and to a lesser extent, production is relatively stable and is significantly responsive only to very powerful influences such as war and governmental pressure such as the "Grow More Food" scheme. Even strong economic force such as sharp reductions in cotton prices in the United States and artificial high prices for American cotton did not greatly change the pattern of land use in India. It appears reasonable to conclude that cotton acreage in India will not deviate significantly in the next few years unless India is able to win the present and future food war which is the first and the most immediate problem of the country.

Table XXV shows the changes in acreage, yield per acre and production of cotton for India and the United States for 1932 and 1953. The decline in Indian cotton production of 26.88 percent from 1932 to 1952 was associated with a fall in acreage of 28.07 percent. For the same years, United States cotton production increased by 16.40 percent despite a decline in acreage of 28.49 percent. Production is a function of both acreage and yield. In the same years, yield in the United States increased by 62.93 percent or by more than 100 pounds while in India it increased by 1.56 percent or by 1.3 pounds per acre. Actually yields in both countries have increased absolutely. Production being the function of acreage and yield this confirms that the increase in United States cotton production despite a decline in acreage is mainly due to increase in yields. Figures 10, 11 and 12 show the changes in acreage, yield per acre and production of cotton in the United States and India from 1912 to 1952.

This long run increase in yield in the United States is due to many factors. One group of factors includes development and propagation of higher yieldings, disease resistant varieties, improvement in cultural practices through improved tillage techniques to fight diseases and adverse conditions, shifting cotton production from low yielding to high yielding irrigated areas. This group of factors has contributed directly to increased yield. The other group consists of factors which helped to increase efficiency mainly by reducing labour requirement. These consist of such things as machinery, capital, etc. Some of these factors operate in India but not to a sufficient degree to keep yields from falling relative to United States yield. Since economic, social

TABLE XXV

CHANGES IN ACREAGE, YIELD PER ACRE AND PRODUCTION OF COTTON IN U.S.A. AND INDIA, 1932 and 1952[1]

	U.S.A.				India			
	1932	1952	Changes from 1932 to 1952		1932	1952	Changes from 1932 to 1952	
			total	percent			total	percent
Acreage	35,891	25,664	10,227	-28.49	22,483	16,175	6,300	-28.07
Yield	173.5	282.7	109.2	62.93	84.5	83.2	1.3	1.56
Production	13,003	15,136	2,133	16.40	3,898	2,850	1,048	-26.88

[1] Source: Agricultural Statistics 1934 and 1953, U.S.D.A., B.A.E., Washington, D.C.

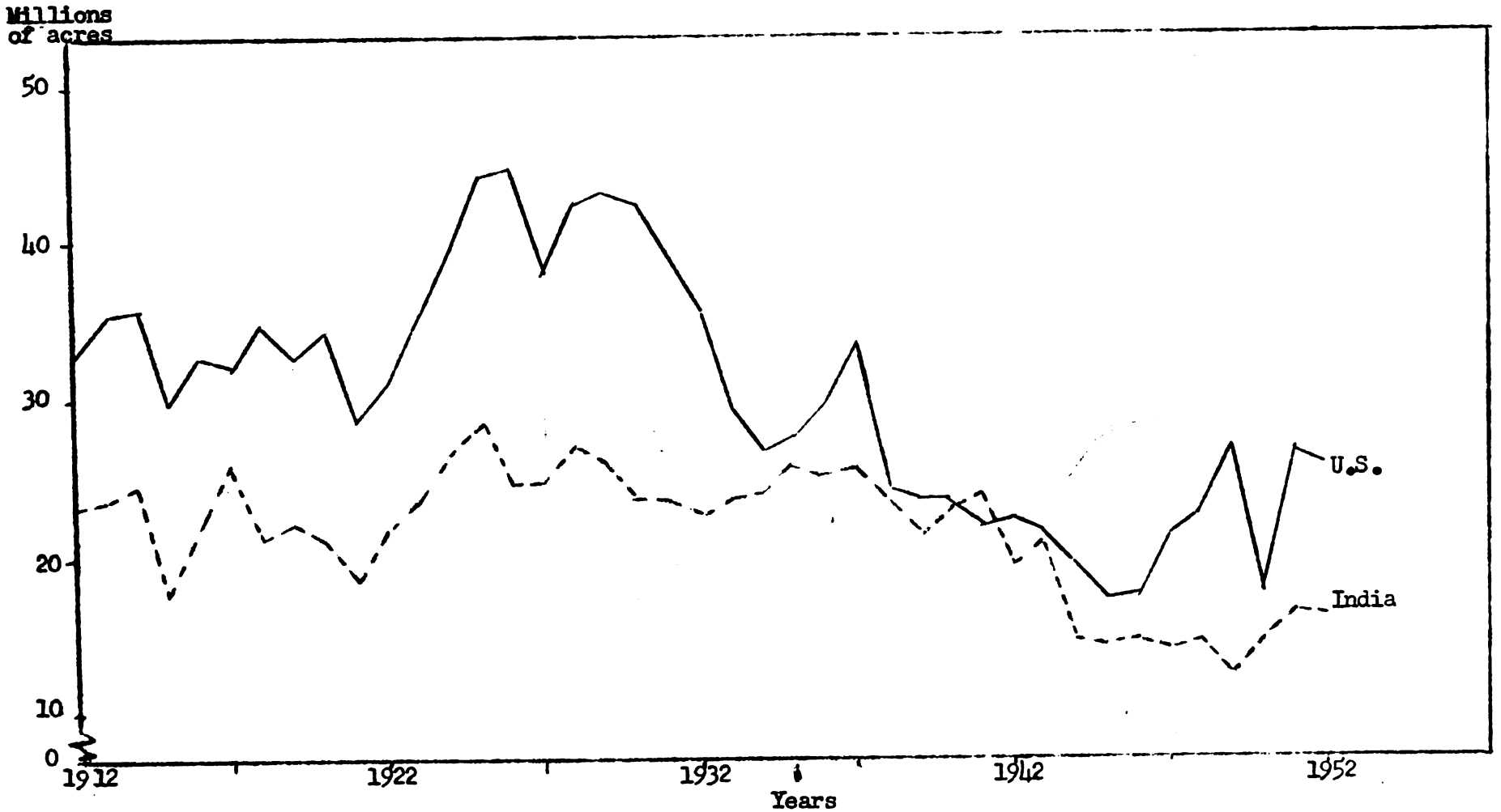


Figure 10. Cotton Acreage, U.S. and India, 1912-52[1]

[1]Sources: Compiled from Agricultural Statistics and Statistical Abstracts, U.S.D.A., B.A.E., Washington, D. C.

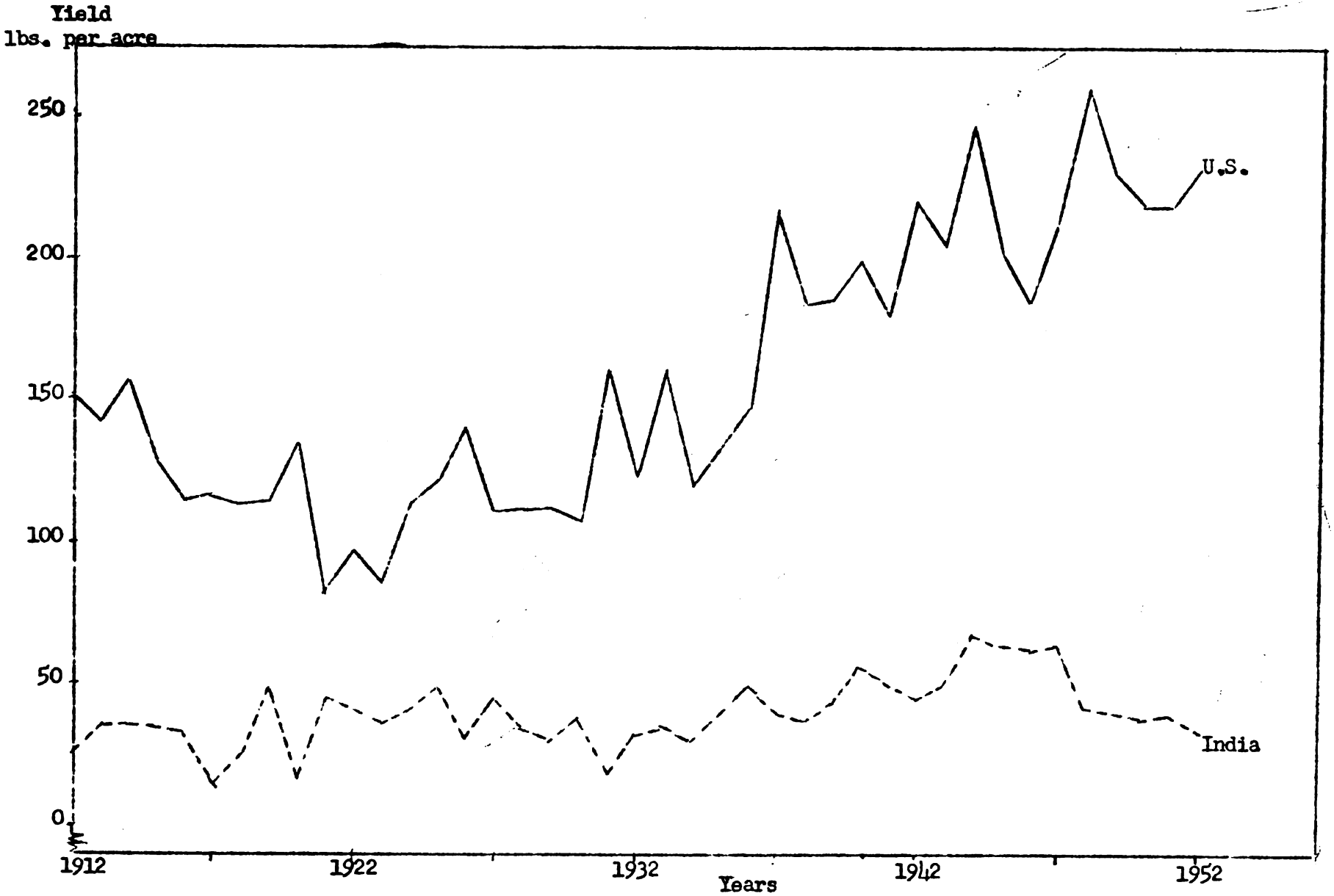


Figure 11. Yield of Cotton Per Harvested Acre in U.S. and India, 1912-52[1]

[1]Sources: Compiled and calculated from Statistical Abstracts and Agricultural Statistics, U.S.D.A. B.A.E., Washington, D. C.

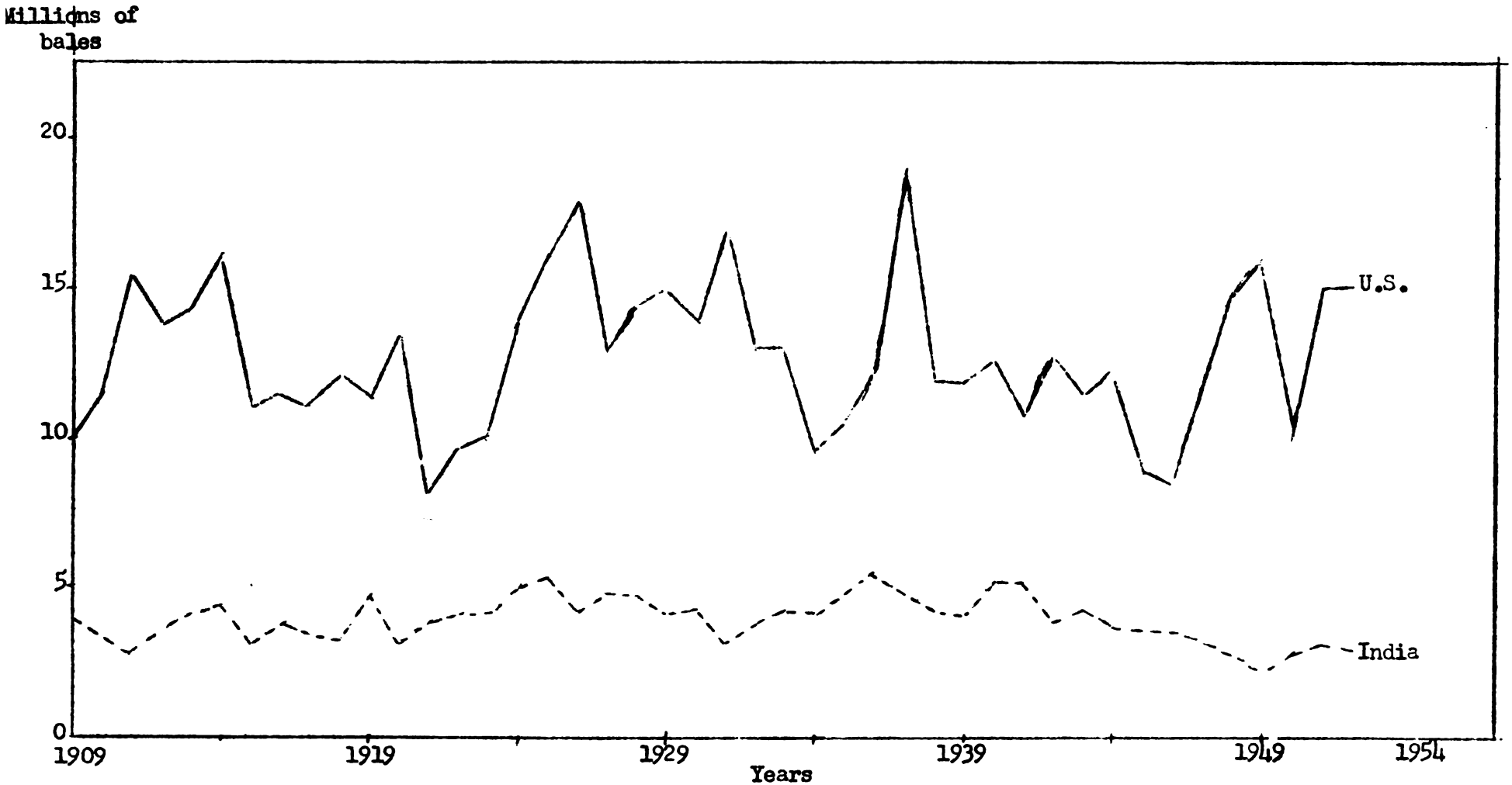


Figure 12. Cotton Production, U.S. and India, 1909-52[1]

[1]Sources: Compiled from Statistical Abstract and Agricultural Statistics, U.S.D.A., B.A.E., Washington, D. C.

and institutional conditions in India and in United States differ widely, it would be expected that the applicability of each group of factors differs widely between the two countries.

In the first chapter a survey of agricultural problems in India indicated the nature of problems faced there. Agricultural policy occupies an important place in India's national economy, because of the problem of producing adequate food and fibre for a growing population. India has used a policy of intensive development of a certain line of production aiming at high degree of self-sufficiency.

The importance of the food problem has forced itself upon the attention of the people during the last decade. No agrarian reform in India has any likelihood of success unless the question of agricultural indebtedness is settled. This means examination and proposal of a sound agricultural credit policy. The second question is of small and scattered holdings. It requires to change the tenure system and the law of inheritance. Such a radical transformation would involve redistribution of land. These problems represents the result of accumulated neglect and blunders of generations. Some of them are the product of institutional forces. Their solution requires a firm political body prepared to achieve ends at the cost of reshaping the foundation of social stability.

Apart from these, there are other problems. If the country is to enter upon agricultural production by new technologies and use of scientific application, it would appear that the government has to provide all requirements such as seed and fertilizer and accompany their

distribution with intensive propaganda and educational programs to familiarizing the farmer with new methods and techniques.

However it must be remembered that the problem of agriculture cannot be solved by agricultural policy alone. There can be no large scale development in agriculture unless it is correlated to the development of non-agricultural industries. Both agriculture and industry in turn are dependent on well organized and well planned fiscal and monetary policy as well as efficient transportation and communication facilities.

This shows that the problem of improvement of cotton or agricultural production in India is not purely technological. It is primarily a social, economical and political problem. It is beyond the scope of this study to analyze these problems in detail. In facing the problem of cotton production, policy should be oriented both to the short run and a long run point of view. The short run policy should include programs which help to increase yield. Immediate needs should be given first priority. Long run policy should include such programs as mechanization and redistribution of land.

Some of the factors which helped to increase cotton production in the United States are already operating in India. The following section will investigate the role of those factors which might prove to be useful if adopted in India. The economic goal is to increase yield and thus help to reorganize the country's disrupted economy.

III. Technological Development and Possibilities in Indian Cotton Production

1) Disease, Pest, Varieties -

Insect pests and plant diseases are sources of serious loss to cotton and food crops in India. Insects causing the greatest damage are boll worms and leaf insects which destroy plants and bolls and lower the quality of lint. Of the cotton diseases found in India only wilt and root disease are important.

Research into the disease and insect pests of cotton is being conducted both by the Imperial Council of Agricultural Research and the State Departments of Agriculture. Methods of controlling diseases and pests in general use are:

1) Destroying the insect fungus by chemical and biological means
2) Obviating the attack by some changes in tillage techniques
3) Adoption of better and resistant varieties of cotton.

This is one of the most outstanding achievements of cotton improvement work which has been done by Indian cotton breeders.

The Indian Central Cotton Committee with state governments maintain cotton experiment stations in major cotton producing areas. Many varieties suitable to particular areas and resistant to cotton disease prevailing in that area have been developed. Cotton experiment stations have done an outstanding job in convincing the farmers to use improved seeds, but even so improved cotton is seeded only on 30 percent of the area. Indifference by the majority of the farmers to the improved varieties is due partly to inadequate education and partly to the absence of organized agencies for the production and

distribution of seeds of improved varieties at reasonable prices. The absence of private agencies in this area is a great handicap. The agricultural departments have, therefore, had to undertake supplying seed of the improved varieties through the agency of seed farms, seed store and cooperative socieities.

2) Tillage Techniques -

The yield from land can be increased by a good system of crop rotations. Though the practice of crop rotation has been known to Indian farmers for a long time, the use of proper rotational system has been declining in recent years. Farmers have concentrated more on certain commercial crops. This is particularly true of cotton. The attention of the Agricultural Research Stations have been centered on rotations connected with cotton. Systems of crop rotations based on the soil and climatic conditions suited to each particular area have yet to be evolved and popularized.

As regards to actual method of cultivation, although some areas are highly developed, there is much possibility for improvement in processes like cultivation, seeding and harvesting. Methods of cultivation in India today are what they were centuries ago. There is a need to examine different practices and to select and popularize the best ones.

3) Manure and Fertilizer -

Scientific manuring based on needs of the crop and type of soil, which will increase the supplies of plant food available in the soil, will greatly increase the yield. Soils in India are not naturally

poor but are deficient mainly in nitrogen as most lands in India have been under constant cultivation for centuries. Indian farmers are not, of course, ignorant of the value of manuring and in irrigated areas artificial manures are being used increasingly. But there is lack of expert guidance advising farmers to use the proper manure at the right time and to apply it correctly under widely differing crop, soil and climatic conditions.

One of the causes of the present low yields per acre of cotton is the tremendous waste of farm yard manure. Results of experiments have shown that yields of cotton when two and one-half tons of farm yard manure was applied, increased to 532 pounds per acre from 318 pounds per acre with no manure. To restore organic matter and nitrogen to the soil and to maintain soil fertility, different measures have already been sought and farmers have been encouraged to use compost and farm yard manure, green manures and oil cake manures.

The yield of cotton can also be increased by the use of commercial fertilizers. The present consumption is inadequate to maintain soil fertility. As a result of the five year plan, the production capacity of the National Fertilizers Projects is expected to fulfill the needs in 1955-56. Cotton, however, is hardly considered in this program. Fertilizer is scarce and therefore used on food crops only. In a way cotton benefits indirectly from fertilizers used on previous crops since not all of the plant food would be used or leached out of the soil before cotton is planted. Existing yields of cotton should be increased by increased application of fertilizer, but because of the

lack of purchasing power, it is not possible unless large scale advances to farmers are made available for the purchase of fertilizer either through cooperative credit associations or by direct governmental advances through the Department of Agriculture.

Indian farming is extremely dependent on seasonal rainfall which is proverbially irregular; the surest way in which agricultural production can be increased is through the development of irrigation potentials. At present very little cotton is irrigated. It may contribute considerably to increased cotton production in the future when the number of irrigation schemes and dams under construction start operating.

These different factors, namely, development of improved disease resistant varieties, improvements in tillage techniques and cultural practices, use of manures and fertilizers, are operated and practiced through State Departments of Agriculture. Ultimately no government can succeed in helping the farmer unless farmers are willing to help themselves. Indifference of the farmers and their poverty and illiteracy are the obstacles in the way of rapid adoption of these improved varieties and techniques. Cooperative societies working in villages with illiterate farmers should act as a local agent of the Agricultural Departments and should educate and advise the farmer in adopting the improvements suggested by the Agriculture Departments. The cooperative societies should also undertake the supply of improved seeds, manures on credit at reasonable rates and prices.

The second group of factors which affected cotton production indirectly and helped to increase United States production are: land, size of farm, mechanization and capital. Differences in institutional, social and especially in economic life of the two countries create different problems and they not only affect cotton production but affect all agricultural production differently.

4) Land Selection -

The possibility of bringing new acreage into cultivation to increase cotton production is limited. Limited increase may be obtained by irrigating dry land and reclaiming swamp land through extensive drainage. Some such projects are underway, some are planned. Whether these projects can be brought to completion in time to allow increased production of either food or cotton in the near future is doubtful. If cotton can be advantageously traded for food, some of the new land should be used to produce cotton. The shifting of cotton production to higher yielding areas which contributed to increased yields and production in the United States has received very little attention. The problem of size of cotton farms is closely related to mechanization and therefore will be discussed under mechanization.

Since there is very little scope for increasing the acreage under cotton increased production must come from increased output per acre through new technological improvement oriented towards this goal.

5) Capital -

Production requires capital and in a country like India where agriculture produces nearly 50 percent of the national income[1] and where subsistance farmers have little capital reserved for future production, agricultural finance must necessarily be a problem of interest. The small holding which is prevalent is in most cases not a sufficient security to get required loans from cooperative credit or land mortgage banks. This is the case for agriculture in general and cotton does not escape from it. It is beyond the scope of this study to delve deeply into this matter. Even though the government and the Reserve Bank of India have given serious thought to it, the problem of agricultural finance has not been solved. The unavailability of credit and inherited poverty on the part of the farmer, prevents him from taking the initiative in agricultural improvement. Such initiative has to come from the government.

6) Mechanization and Problems Arising from It -

The production per worker is primarily a function of the tools and power with which he works. In this respect India is still in a primitive stage using crude and inadequate farm equipment. It is one of the chief causes of low agricultural productivity. Implements that are used by the Indian farmers are in keeping with their standard in general, but are far from the best that should be utilized for efficient

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[1] The Eastern Economist, New Delhi, India, September 1954, p.

and successful cultivation. They yet rely on primitive plows to cultivate land, crude sickles to harvest crops, natural wind to winnow grains and hands for picking cotton. The scope for mechanization should be explored with the progress of education in better farming methods.

It is clear that the adoption of machinery is partially determined by the price of substitutable animal or man power and the prices of farm products. Proper conditions can come into existence only after industrialization in industry has been attained to a sufficient degree. Only then will labour become relatively costly in agriculture because of transfer into and absorption by industry. In the United States where labour is scarce there is a sharp contrast with India where labour is excessive and cheap. In addition, some technical and social requirements must be fulfilled. Most important of them are the size of farm, which should be large enough to make it economically advantageous to introduce machinery and a large amount of capital must be provided for mechanization of agriculture.

These conditions raise a very important question: What is the role of mechanization in the fight against agricultural inefficiency and poverty? Unfortunately, on this issue one finds a good deal of confused thinking. Such conflicting view-points are a very great hinderance in arising at any definite conclusion. In general, the problems with which the mechanization of Indian agriculture is faced are as follows:

a) Uneconomic Holding -

It was observed previously that mechanization goes hand in hand with large scale farming. It, therefore, requires a large farm as a prerequisite for its application. The United States, where mechanized cotton production is followed, average cotton acreage is between 60 to 70 acres. The prerequisite is clearly lacking in India where average cotton acreage per farm is notoriously small and widely scattered. The average size varies from a patch of land to three to four acres. On such size mechanization is out of the question. These holdings are uneconomical even for wooden plow and a pair of bullocks. Tractor mechanization would increase cost and reduce output. On such small farms mechanization has no place.

This necessitates a change in the land tenure policy of the country. Fragmentation of farms under the law of inheritance should not be allowed below an optimum size of holding. The only feasible and effective way in the short run is to try mechanization through joint farming societies on a cooperative basis with the use of small tractors designed to meet economic and technical needs of small acreage.

b) Scarcity of Capital Resources -

The general question of capital has been discussed previously in detail. Mechanization of agriculture requires a large amount of capital. In the underdeveloped economy of India, savings are very small and government has either to supply capital by postponing or abandoning other developments and schemes. As a result progress in some other direction will be stopped. The other alternative is to take the risk of borrowing foreign capital.

c) Question of Unemployment -

Mechanization of agriculture in India has been regarded as highly undesirable on the grounds that it will result in tremendous displacement of labour. Assuming that one worker will be required instead of four, with mechanized farming 75 percent of the workers employed in agriculture or nearly 53 million workers will be thrown out of employment. It is very difficult to find alternative jobs for persons on such a large scale. In support of this, attention may be drawn to the amount of employment provided by the development of industries in India. Though the development of large scale industries has been rapid, particularly during the last decade, the number employed in industries has increased by 16.5 million or by a small fraction of 4.6 percent of the total population. On this grounds well known Gandhian Economists regarded mechanization of cotton production as undesirable. They argued, "Mechanization is good when the hands are too few for work intended to be accomplished. It is an evil when there are more hands than required for the work. As the case in India the problem is how to utilize their idle hours which are equal to the working days of six months in a year."

On this opinion there is no unanimous agreement. It need not necessarily follow that fewer men per occupation would mean lesser men employed. It may create more opportunities for work in other directions. Mechanization of agriculture will help in stepping up

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[1] Agranal, A. N., The Gandhian Plan, Padma Publication Ltd., Bombay, 1944, p. 24.

the economy of the country to a higher level. As a consequence secondary and tertiary occupation will multiply offering adequate employment to the surplus worker. Increased cotton production with reduced labour requirement would require more and more people to work in the textile industry and thus the problem of displaced labour could possibly be solved within the cotton economy of India.

Bullocks are used for cultivation. They in turn aggrevate the food problem as they require large amount of produce of the soil. Thus there is a need for a reduction in their number. It has been observed in the United States that about 33 million acres of land have been made available for production after replacing draft horses and mules by tractors.[1] This is a very important possibility for India.

d) Attempts at Mechanization -

The analysis within various limits shows that there are no doubt, a number of difficulties in the way of mechanization. Under the stress of these and other difficulties the progress of mechanized farming in India is bound to be slow. As an immediate need there exists wide scope for the improvement in the farm implements that are commonly used as well as for the manufacture of improved implements and machinery suited to requirement of Indian conditions. Central and state governments have made limited attempts to encourage production of improved implements suitable to existing conditions of Indian farmers and farms. Also by gradually developing the system of cooperative and joint farming, it is possible to benefit from the use of machines and tractors owned or hired from the government station.

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[1] Johnson, Sherman E., Changes in American Farming, Misc. Publication No. 707, U.S.D.A., B.A.E., Wash., D. C., Dec. 1949, p. 15.

The increase in the use of tractors for general purpose has been increased as shown in Table XXVI.

TABLE XXVI

IMPORTS OF TRACTORS, INDIA, 1949-52[1]

Year	No. of tractors imported
1949 - 50	3,318
1950 - 51	4,950
1951 - 52	7,400

[1]Source - The Eastern Economics, Quarterly Bulletin, New Delhi, India, Sept. 1953.

IV. Conclusion

The problem of cotton production in India should be examined from the short run immediate needs and from the long run point of view. To meet the immediate needs, the short run program deals with improving cotton production by using fertilizer, different rotations, improved varieties while the second is related mainly to labour saving devices such as machinery. The long run planning has serious implication, arising out of unemployment, finance and land tenure system. These problems can never be solved unless considered as a part of wider planning that extends its activities to all aspects not only of our economic life but also of social, cultural and political thoughts. Agricultural planning must be related to planning of industrial production and these two again can be successful only if they rest upon the foundation of planned credit organization

and technical education. The evolution of new technique should be pushed more vigorously. The system of farming practiced should be examined from the point of view of the economic situation of the farmer and his capacity to make the use of technical know-how as it becomes available.

CHAPTER V

SUMMARY AND CONCLUSIONS

This study represents an attempt to observe:

1) Changes in cotton production in the United States;

2) To study the main factors responsible for improvement of production in the United States; and

3) To evaluate the possible application of these factors to cotton production in India.

Data used were obtained from United States Agricultural Statistics and different United Nations bulletins. Data on acreage yield and production of cotton in the United States and India were collected for the period from 1910 to 1952. Statistics for fertilizer application, mechanization costs and returns were collected from different statistical and research studies, bulletins and publications.

An analysis of changes in acreage yields and production from 1910 to 1952 is presented in Chapter II. It was observed that cotton production in the United States increased by one and one-half times in the period under consideration. Of the two elements affecting production acreage decreased while yield per acre increased. On the regional basis a contrasting and peculiar pattern of change in yield and acreage was observed. There was a continuous shift in cotton acreage from the Southeast to the Southwest and Western regions. This shift continued in the face of higher cotton prices after 1933 and a relatively higher yield in

the Southeast. With the criteria of perfect competitive conditions a reasonable conclusion is that farmers changed their pattern of cotton production to maximize profit by diverting resources towards or away from cotton depending on the availability of the alternatives available to and the importance of the cotton in the farm income.

Technological developments on the farm appears to be responsible for increases in yield and production. Due to the unavailability of statistical data and a suitable unit for measuring technological change, qualitative analysis of the factors affecting cotton production was necessary. This is done in Chapter III. Technological factors were divided into two groups; one group includes factors contributing directly in increasing yields and another group which included factors which contributed increasing production efficiency through the reduction of labour requirements. It was found that the developments of new high yielding and disease resistant varieties, developments of chemicals and insecticides to fight disease and pests, increased use of fertilizer and the new tillage techniques have to a large extent contributed to increased yields.

The second group of factors indicated that the important mechanical inovations like cotton pickers and harvesters permitted the development of larger sized farms and increased production per worker. Thus an increase in yields per acre and a reduction in labour required for production increased production efficiency.

The analysis indicated that different regions improved production efficiency in accordance with the level of increase in yield per acre and the amount of the labour saving equipment in use.

It was found that small but intensively cultivated, man-mule operated farms in the Delta improved production efficiency substantially. At the same time highly mechanized low yielding, large size farms in the South-west were also producing cotton efficiently as measured by output per man hour. Thus efficiency in the first case was due to high yields per acre while in the second it resulted from a reduction in labour requirements.

Because of the unavailability of data in the required form, no quantative estimates of the contribution made by different factors were obtained in this study.

Chapter IV is devoted to an analysis of the role and the application of these factors to Indian conditions. Primary developments and the applicability of different factors are discussed, the analysis indicated that yield increasing factors such as improved varieties, disease controls, fertilizer applications and tillage technique are also already in practice, but not on a very large scale. Illiteracy is a main obstacle to improvement. Government and especially village cooperatives encourage the farmers to use new varieties and apply new methods. It is hoped that newly formed National Extension Service will benefit a large number of farmers.

Applicability and use of other factors responsible for increasing production efficiency by reducing the amount of labour required, especially mechanization, have different economic implications. Small holdings, lack of capital and unemployment are among the most important obstacles to their adaption. Pro and con views on these implications

indicated that mechanization is both necessary and possible. The progress of farm mechanization in India is slow at the present time. The central and state governments have taken steps to divert and eliminate these difficulties within a reasonable period.

It may be pointed out at this point that through technological development in Indian agriculture is necessary and desirable, its course should be determined by efforts to obtain economic use of available resources.

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