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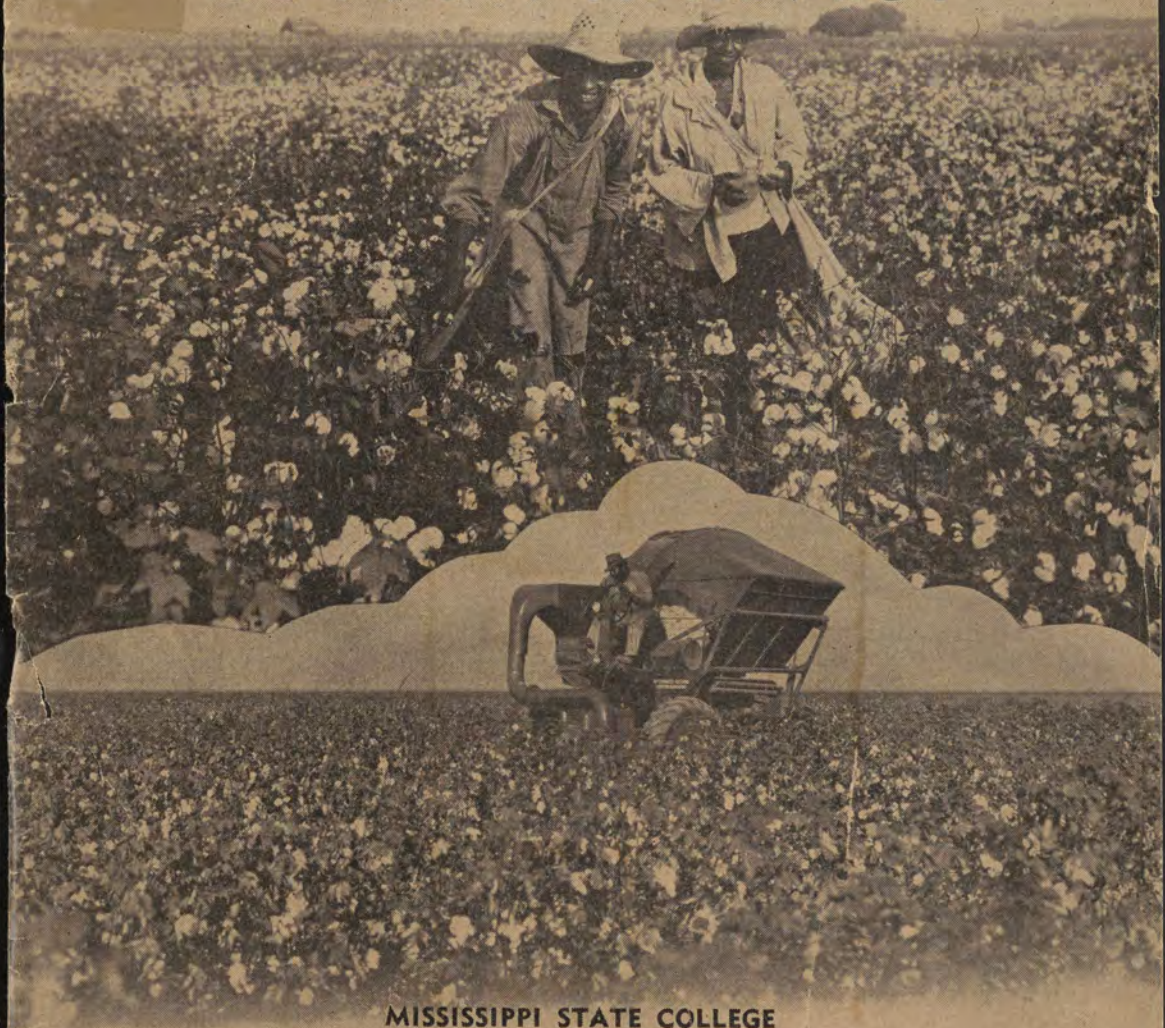

MISSISSIPPI STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION

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MECHANIZATION OF THE COTTON HARVEST[1]

By

FRANK J. WELCH and D. GRAY MILEY[2]

Man in his tireless search to find more efficient and effective ways of doing things has made great progress through the centuries in the fields of science, technology, and operational techniques. His material progress started with the utilization of tools; it has progressed as the quantity and quality of these tools have progressed. In the final analysis, therefore, the quantity and quality of the goods and services produced depend in large measure upon the effectiveness of man's tools and the efficiency with which these tools are used.

Technical Progress in Agriculture

The most phenomenal technological progress has perhaps been made in the broad general field of industry, but great progress has also been made in the field of agriculture. The number of workers required to produce the food supply in our own country has dropped precipitously every decade since the beginning of the 19th century. In 1840, for instance, more than three-fourths of all workers in the United States were on farms as contrasted with slightly less than one-fifth a century later.

Starting around 1850 and continuing to the present time, such patented farm implements as the chilled steel plow, power reaper, power thresher, disk harrow, haying machines, combine, twine binder, disk plow, and the modern tractor with its wide range of attachments, have all contributed materially to the increased unit output per agricultural worker and the reduction decade by decade of the relative percentage of workers on farms. See figure 1.

It should not be assumed, however, that increased efficiency in agricultural production is due solely to improved machinery and power. In addition to more power and increased numbers and efficiency of machines, production efficiency has increased significantly as a result of the introduction, adaptation, and improvement of plants and livestock; the increased ability to meet the challenge of insects, pests, and diseases; the increase in knowledge relative to the use and replenishment of soils; and finally, the improvement in managerial and marketing techniques. Continued progress may be expected in these fields as well as in the field of technology.

For whatever cause, the fact that the American farmer is able to produce the food and fiber to meet the needs of approximately five persons in addition to his own needs, accounts in large measure for the very high standard of living that now prevails in the United States. Those nations the world over that have made the greatest economic progress are those that have been able to produce their food and fiber supply with a decreasing percentage of total workers engaged in agriculture.

Cotton Production Inefficiencies and Exchange Penalties

Less progress has perhaps been made in the application of machine labor-saving devices to the production and harvesting of cotton than to any other major crop in American agriculture. Prior to World War I, about the same amount of labor was required to produce a pound of cotton as in 1860. Since then, some progress has been made in utilizing power equipment and improved machinery in seedbed preparation and in the cultivation of cotton, which has reduced the total man hour labor requirements for cotton production. The fact,

[1] A subsequent report will deal with mechanization and other labor saving practices as they relate to the planting and cultivation of cotton.

[2] Dr. Frank J. Welch is Head, Department of Agricultural Economics, and Dr. D. Gray Miley is Associate Economist, both of the Mississippi Agricultural Experiment Station.

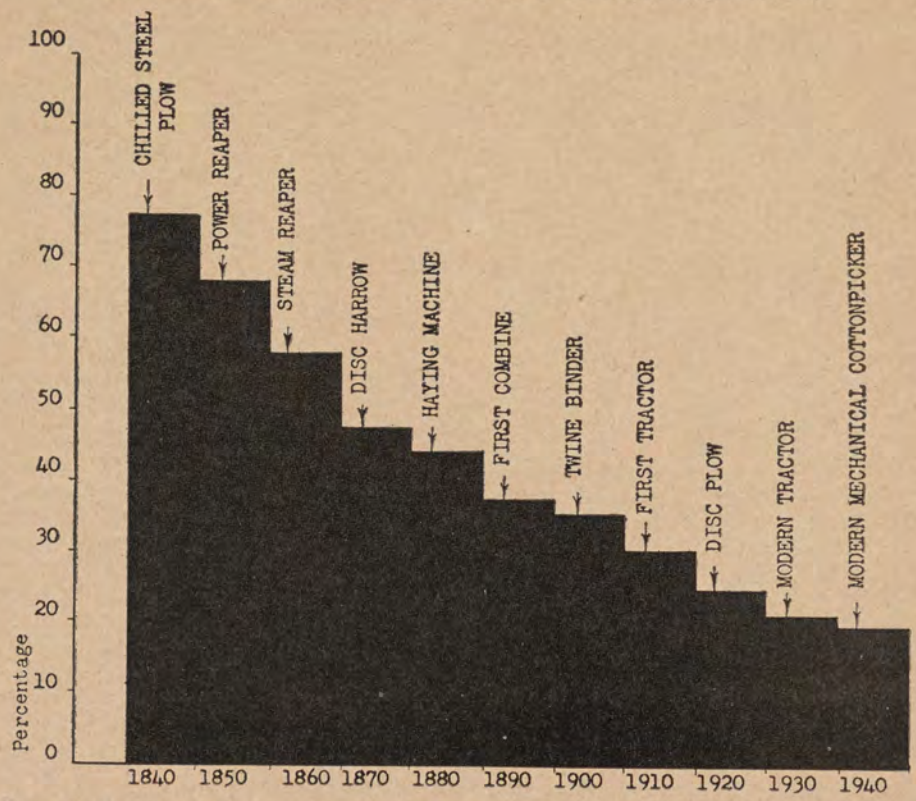

Figure 1. Percentage of the total gainfully employed workers in the United States that were engaged in agriculture in relation to the development of labor saving farm machinery, by decades, 1840-1940.

however, that a large amount of hand labor is still required to harvest the crop has hampered progress in the application of improved tools and techniques in the planting and cultivation of cotton. Consequently, much of the cotton crop is still produced with hand labor, which accounts in large measure for the low output per worker in cotton production.

The income status of the vast army of cotton field workers is adversely affected by the fact that the product of their toil is exchanged in the market place with goods much of which have been produced by skilled workers using tools that have multiplied their efficiency manyfold. A man cultivating with a hoe or working with his bare hands in the harvesting of cotton is not a competitive equal in terms of earning power with a man working with a tractor or other farm power equipment.

As a means of further complicating the American cotton producer's already unfavorable economic position, he has been forced to sell his product in the competitive world market and buy many of the products he uses and consumes on the farm in a sheltered tariff protected market at home.[3] In more recent years monopoly prices have also taken additional toll from his already meager income. In addition, credit has, generally speaking, been scarce and expensive.

[3]Tariffs are not effective on surplus agricultural products.

Thus, production inefficiencies, high credit costs, the sale of cotton in an erratic and unstable world market, and the purchase of many of the products used in the home and on the farm in a tariff sheltered and/or otherwise partial monopoly market, explain in large measure why the cotton producers of the South receive the lowest real, as well as monetary income, of any group of workers in America. The amelioration of some of these problems is within the reach of the cotton producers themselves; whereas. other important causal factors can be dealt with only from a national or international level.

Ever since the rapid development of cotton production in the Southern colonies, there has been a reasonably adequate supply of unskilled cheap hand labor available in the Cotton Belt for the production and harvesting of the American cotton crop by simple direct hand methods. While the income to the cotton field worker, whether tenant or operating owner, has been extremely low, he has managed to eke out a tolerable existence and more than reproduce himself[4] and hope that the following year would bring about improved conditions. Even though his economic and social status has been deplored from time to time, little or nothing has been done that would induce self improvement or advance significantly the low income position of the cotton producer except temporarily as a result of wars and crop failures or other general economic dislocations.

Cotton Outlook Unfavorable

The current outlook for cotton is such that apparently something definite and tangible will have to be done in the post war period to safeguard even the present unsatisfactory economic position of the cotton producer. The ever increasing competition of producers in other countries and the phenomenal increase in synthetic and substitute products for cotton in both the domestic and foreign markets will no doubt complicate the cotton situation immeasurably.

During the period between World War

[4]The population increase in the Cotton Belt is higher than for any other major farm area in the country.

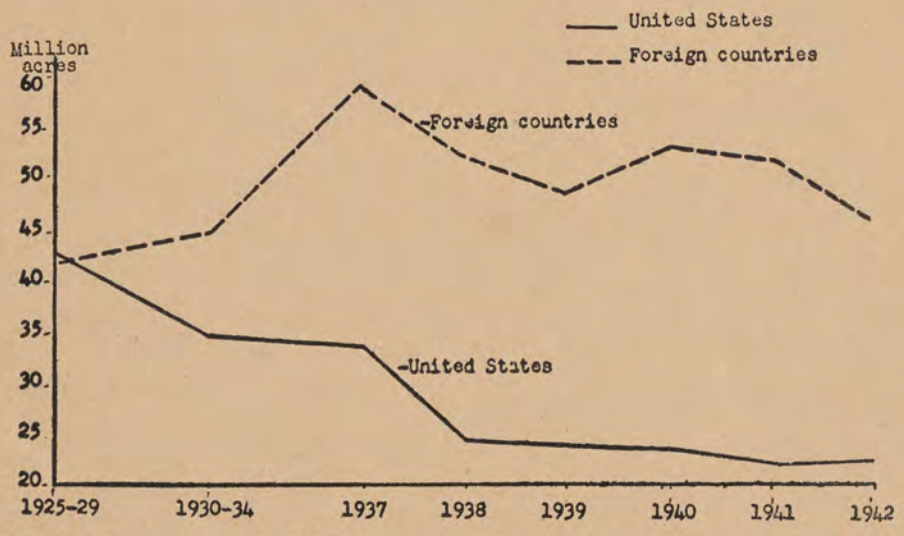

Figure 2. Cotton: Acreage in United States and all foreign countries, average for periods 1925-29, 1930-34, and by years 1937 to 1942.

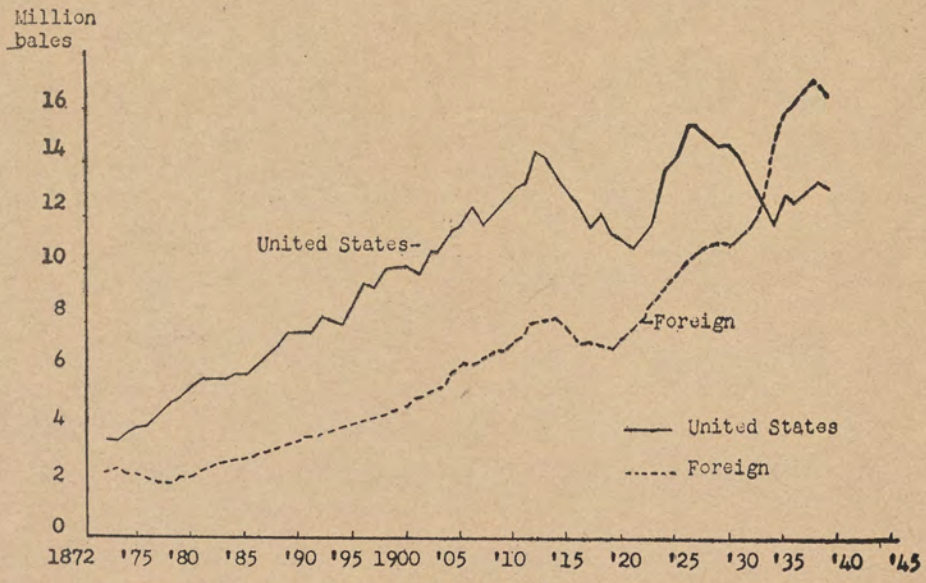

Figure 3. Cotton production in the United States and foreign countries, 5-year moving average, 1870-1940.

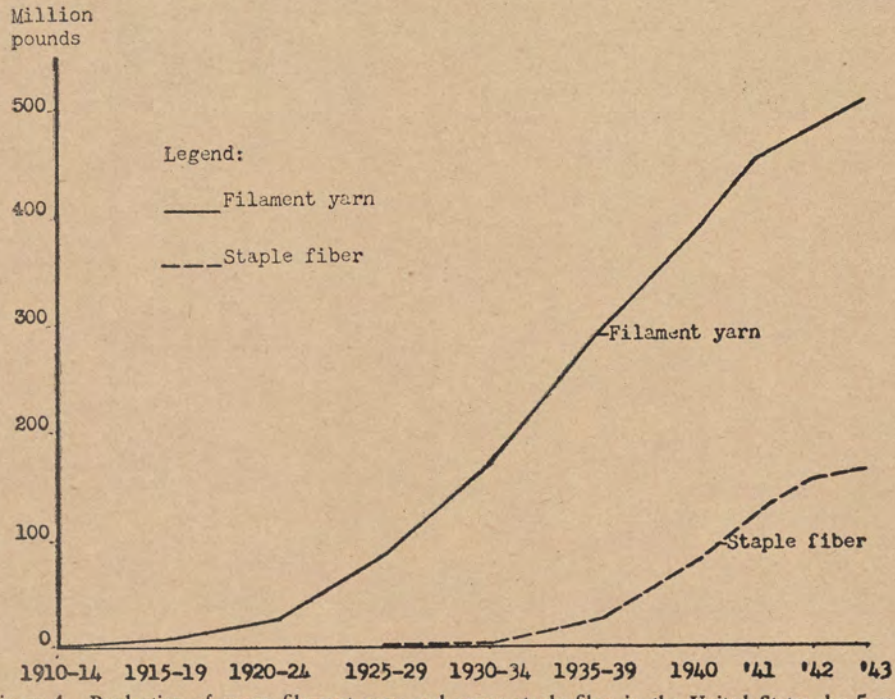

Figure 4. Production of rayon filament yarn and rayon staple fiber in the United States, by 5-year periods, 1910-1939, and by years 1940-1943.

I and World War II, the general trend of acreage planted to cotton in foreign countries was upward; whereas, cotton acreage in the United States was reduced sharply during the latter part of this same period. See figure 2. Cotton yields have been much lower in most foreign countries than in the United States, but distinct progress is being made with respect to improved yields and, as a consequence, foreign production exceeded United States production in 1934 and has been above total domestic production since that time. See figure 3.

A number of substitute and synthetic products such as paper, nylon, casein, spun glass, and rayon, have entered the market as serious competitors of cotton. The most important of these is rayon, a synthetic product made from fibrous cellulose. The production of rayon filament yarn and rayon staple fiber has been phenomenal within recent years. In 1943 there was a total of 663 million pounds of both rayon filament yarn and rayon staple fiber produced in the United States. This is equivalent to 1,560,000 bales of cotton. The world production of rayon in 1942 was 3,473 million pounds or the equivalent of 8,172,000 bales of cotton. The increased production of rayon in the United States in 1944 over 1943 was the equivalent of approximately 500,000 bales of cotton. See figure 4.

The price relationship between cotton and rayon as competitive products is extremely important. The price of rayon filament yarn decreased sharply from approximately $2.00 per pound in 1925 to about 60 cents per pound by around 1932, and has fluctuated between 52 cents and 60 cents per pound since that time. Rayon staple fiber entered the marketing field

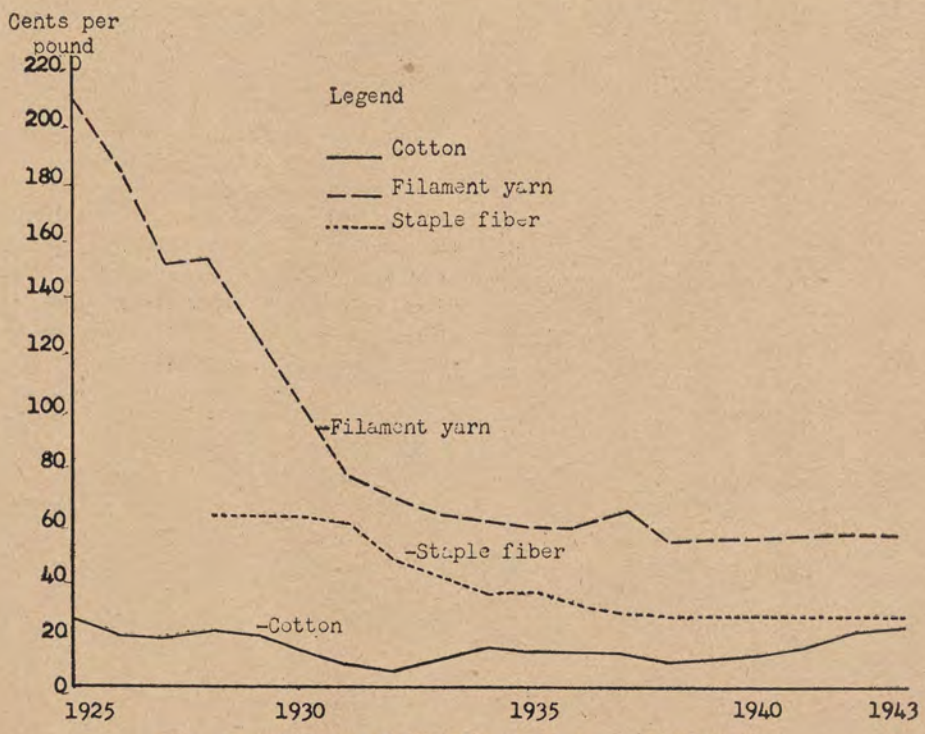

Figure 5. Average spot prices of cotton and rayon, 1925-1943.

around 1928 at 60 cents per pound and by 1938 had declined to 25 cents per pound, at which approximate level it has since remained. See figure 5.

It is predicted that the price of rayon will be still further reduced following the war. Due to losses of fiber in the processing and utilization of cotton, it must sell for approximately one-tenth less than rayon in order to be on a competitive price basis with rayon. See table 1.

Table 1. Estimated grade and manufacturing waste of cotton.

Grade	Percentage waste
Good middling	6.3
Strict middling	7.2
Middling	8.0
Strict low middling	9.2
Low middling	11.8
Strict good ordinary	14.0
Good ordinary	16.5

Source: "Cotton Fiber and Spinning Testing Service," War Food Administration, United States Department of Agriculture, September 1944, p. 10.

Reduced Production Cost Needed

Considering the low economic status of cotton producers generally, a possible reduction in the relative price of cotton means that cotton will have to be produced more cheaply, and that as a matter of equity and economic necessity the exchange penalties previously mentioned will have to be removed. Reduced cost of production can be effected through the use of better tools, more efficient practices, and through the production of better quality cotton. The improvement of the exchange status of the cotton producer will be accomplished through appropriate public policy and programs.

Cotton Harvest Labor Requirements

The amount of hand labor required to harvest an acre of cotton varies with the yield, stand, prevalence of weeds, variety of cotton, and physical characteristics of the soil on which cotton is grown. For the country as a whole, approximately 57 percent of the unweighted man hour labor requirements for the production of an acre of cotton is required for harvesting. In the Mississippi Delta Area, from 60 to 65 percent of total labor is required for harvesting, depending on the degree of mechanization; and for the irrigated areas of the West, 67 percent of total labor is for harvesting. It is thus obvious that the perfection of a mechanical cotton harvesting machine would make possible a drastic reduction in the man labor required for the production of an acre of cotton. See table 2.

Low Farm Machinery Ratio

The amount of machinery on Southern cotton farms is considerably less than that found in other farming areas of the country. Comparisons are indicated in table 3. Even though farm machinery value ratios to crop acreage and to farms are slightly higher for the Delta plantation areas than for non-plantation areas of the Cotton Belt in the Southeast, the resultant labor efficiency within the plantation area has been largely with crops other than cotton.

Increased use of power and machinery in seedbed preparation and in cultivation have resulted in somewhat higher cotton yields per acre and more efficient utilization of land and labor in these processes. So long, however, as labor must be kept on the plantation for hoeing and picking regardless of labor efficiencies in the other production processes, neither labor nor management can take full advantage of such efficiencies. They merely tend to aggravate the already rather acute underemployment problems[5].

The successful harvesting of cotton with machinery will give added impetus to mechanization and improved practices for the total production process. Such an adjustment will certainly increase very

[5] Welch, Frank J., **The Plantation Land Tenure System in Mississippi,** Mississippi Agricultural Experiment Station Bulletin Number 385, pp. 22-23, June 1943.

Table 2. Approximate man hour labor requirements per acre for selected crops.[1]

Selected crops	Man hour labor requirements per acre
Alfalfa	20.0
All hay	4.7
Barley	9.6
Beans, snap	131.0
Corn	27.3
Cowpeas	19.0
Cabbage	109.0
Cotton[2]	133.0
Irish potatoes	68.0
Lespedeza	8.9
Oats	9.0
Peanuts	63.0
Soybeans	16.0
Sweet sorghum	14.0
Sweetpotatoes	114.0
Sorgo sirup	130.0
Tomatoes	114.0
Watermelons	59.0

[1]Adapted from **Labor Requirements for Crops and Livestock,** M. R. Cooper, W. C. Holley, H. W. Hawthorne, and R. S. Washburn, Bureau of Agricultural Economics publication, F. M. 40, 1943.

[2]Man hour labor requirements taken from Mississippi Agricultural Experiment Station Bulletin 387, "Farm Labor Requirements in Mississippi," Paul S. McComas and Frank J. Welch, 1943.

significantly the per unit labor output on cotton farms, reduce unit cost, and should, at least in the short run, tend toward an increase in cotton farm labor income.

The only remaining serious bottleneck with reference to hand labor requirements will be that of chopping and weeding the cotton. Less progress has perhaps been made to date in eliminating hand labor in thinning the cotton to a stand and eliminating the grass, weeds, and vines that cultivators will not get than in any other phase of the production process. This is the next big problem in the way of complete mechanization. However, some progress is being made through cross-cultivation and check-rowing of cotton, and experiments conducted at the Delta Branch Experiment Station indicate that the flame cultivator shows some promise as a possibility for filling this gap.[6] (Figure 7).

Cotton Harvesting Machinery

Despite the many attempts that have been made to develop a satisfactory mechanical cotton harvesting machine, most of the cotton produced today throughout the world is still harvested by the time-wasting, back-breaking methods used thousands of years ago when the Pharaohs reigned in the valley of the Nile. There has been no lack of persistent effort through the years to develop a mechanical cotton picking machine. The disappointing results of such persistent effort attest to the many difficulties associated with the problem. As early as 1850, S.

[6]Neely, J. Winston, and Brown, Sidney G., **Control of Weeds and Grasses in Cotton by Flaming,** Mississippi Agricultural Experiment Station Circular 118, 1944.

Table 3. Farm machinery value ratios for selected areas, 1940.

Item	Value farm machinery per capita	Value farm machinery per crop acre	Value farm machinery per farm
Mississippi Delta[1]	$ 47.55	$ 7.68	$211.00
Mississippi	28.97	5.80	138.00
Southern States[2]	28.92	5.65	163.00
Midwestern States[3]	179.81	11.05	795.00
United States[4]	129.66	10.12	614.00

Source: United States Census.

[1]Includes following counties: Bolivar, Coahoma, Humphreys, Issaquena, Leflore, Quitman, Sharkey, Sunflower, Tunica, and Washington.

[2]Includes Alabama, Arkansas, Georgia, Louisiana, Mississippi, North Carolina, and South Carolina.

[3]Includes Indiana, Illinois, Iowa, Ohio, Wisconsin, and Kansas.

[4]Exclusive of 7 Southern states indicated above.

Figure 6. Preparing land (above), planting seed and cultivating cotton (on adjoining page) with three- and four-row equipment. Pictures furnished by the International Harvester Company.

S. Rembert and J. Prescott of Memphis. Tennessee, were issued a patent on a mechanical cotton picking machine. Since that time, hundreds of patents covering many kinds of mechanical cotton harvesting devices have been issued.[7]

Even though a very wide range of devices have been used experimentally in an effort to find a satisfactory cotton harvesting machine, most of the efforts can be grouped into five general classes as follows: (1) picker type, designed to pick the cotton from the open bolls by means of spindles, fingers, or prongs, (2) thresher type, which severs the stalk and takes the entire plant into the machine where the cotton and vegetative matter are separated, (3) pneumatic type, which attempts to remove the cotton from the bolls either by suction or blasts of air, (4) the electric type, designed to attract the cotton fiber to a statically charged belt to remove the cotton from the boll and, (5) the stripper type, designed to remove the cotton bolls by combing the plant with teeth or by drawing it between stationary slots or revolving rolls.

Considerable progress has been made in the development of the picker type and stripper type machines during the past decade. The stripper machine is better adapted to the sub-humid regions of Texas and Oklahoma; the picker type machine is being used in the Mississippi Delta and other relatively level cotton producing areas where the plant growth is relatively rank and the yield high.

[7]Smith, H. P., Killough, D. T., Byrom, M. H., Scoates, D., and Jones, D. L., **The Mechanical Harvesting of Cotton,** Texas Agricultural Experiment Station Bulletin Number 452, August, 1932.

Figure 7. The flame cultivator. Picture furnished by Delta Branch Experiment Station.

Since the data for this report were obtained in Mississippi, and since the stripper has been used only to a very limited extent and largely on an experimental basis in this State, only the picker type machine will be included in this report[8]. Two general type pickers employing combinations of spindles and doffers have been developed. These two types are known as high-drum pickers and low-drum pickers. The former operate successfully in cotton growing up to 5 feet; whereas, the latter is used where the cotton stalk is 2½ feet or less in height. The low-drum machine is not adapted to Mississippi Delta conditions where the cotton plant usually grows rank.

[8]Records were kept on International Harvester machines. The Rust machine was also operated on an experimental basis within the State, but data are not available on its operation.

The high-drum machine is described by the International Harvester Company as follows:

"The high-drum picker (known as No. H-10-H) is mounted on the rear of the modified Farmall-H tractor, which provides power to operate the picker and propel it through the fields. The rear of the tractor, however, becomes the front. Modifications include a high-clearance axle which provides the means of reversing the travel of the tractor from forward to rearward and lowers the gear ratios for proper picking speeds.

"The pickers are provided with two vertical and parallel revolving drums between which the cotton plants pass as the machine moves forward along the rows. Each drum is equipped with cam-actuated picker bars on which are mounted rotating spindles having numerous tiny

needles or barbs which catch the lint. The rotative speed of the picker drums is synchronized with the traveling speed of the tractor so that the projecting rotating picker spindles enter and withdraw from the plants without any raking action and without disturbing the unopened bolls or otherwise injuring the plants. As the rotating spindles penetrate the plants and contact the lint in the open bolls, the barbs catch the cotton and extract it. As the cam-actuated picker bars carry these cotton-laden spindles around, they are withdrawn from the plants and the cotton is removed by rubber doffers which rotate in close proximity to the spindles and thus remove the cotton. Before the spindles contact the open bolls, they pass under moistened rubber pads which moisten the spindles to assist in doffing the cotton. There is a water tank and metering system which supplies water to the rubber pads in uniform amounts controlled by the operator to give best results.

"After removal from the spindles the cotton is conveyed by vacuum to a separating chamber where considerable trash is removed. It is then blown up into the storage basket by air pressure produced by fan equipment. As the cotton enters the basket it passes along a grating

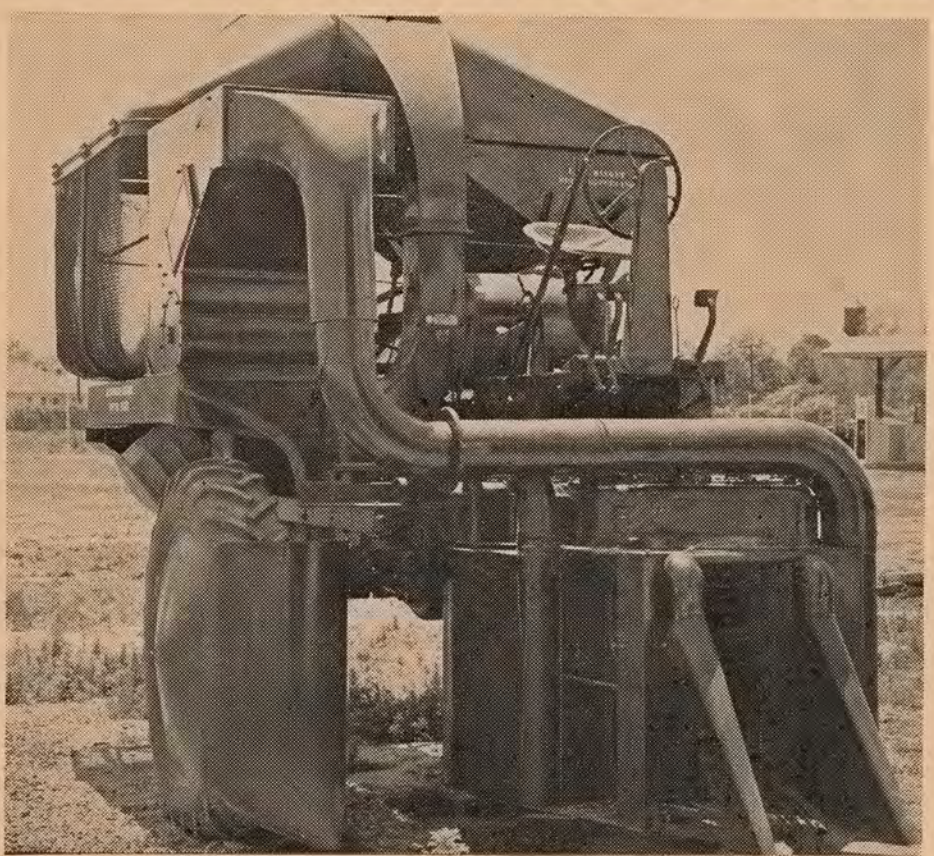

Figure 8. The International Harvester high-drum mechanical cotton picker. Picture furnished by United States Cotton Ginning Laboratory.

which further assists in removing trash. The basket holds approximately one-half bale of seed cotton. When the basket is filled, the cotton is dumped into wagon or truck by a mechanism powered by the Farmall hydraulic lift.

"The driver is the only attendant required to operate the machine. He sits comfortably above the drum box where he has a full view of the row of cotton plants being picked, which flow continuously through the drum box." See figure 8.

No doubt, considerable improvement will be made in the present cotton picking machines and the present retail price can probably be reduced when the machines are produced on assembly-line basis. Sufficient progress has been made to date, however, to demonstrate the feasibility of the mechanical harvester both from the operational and cost viewpoints, at least under current conditions of relatively high wages and scarce labor supplies.

Mechanical Operation, 1944

Detailed operational records were kept on the mechanical pickers that were used on a practical farm basis in 1944. There was a total of 12 of these machines. Records were also kept on the operation of two additional experimental machines, which data were used largely as a check against actual field data.

In addition to machine operation data, information was collected on the effect of machine on grade and the amount of cotton left by the pickers in the fields. On all of the plantations using mechanical pickers, cotton was also picked by hand. The comparative grades and prices of machine-picked cotton and hand-picked cotton were compiled for each day of harvest throughout the season in such a way as to make daily comparisons from the same plantations as well as a seasonal comparison.

Figures were also compiled by actual boll count on one plantation and by estimates on all plantations on the amount of cotton left in the field by machines. The effect on income of grade reduction and loss of cotton in the field will be indicated later.

Cost of Mechanically Picked Cotton, 1944

A total of 2,229 bales of cotton was picked during the 1944 season by the 12 machines studied, or a seasonal average of 186 bales per machine. The number of days which a machine can operate during a season, the topography of cotton fields, length of cotton rows, prevalence of weeds, and variety of cotton, are factors that influence the amount of cotton that can be picked in a day or during the season. A single machine will cover from 4 to 8 acres per day, which means, on the average for Delta conditions, from 4 to 10 bales of cotton per day can be harvested per machine.[9] During the 1944 season, the 12 machines for which records are available operated an average of 430 hours, or 43 ten-hour days. The machines actually picked an average of 4.3 bales for each 10 hours they were in operation.[10]

The average cost, not including grade loss or value of cotton left in the field, for mechanically picking a bale of cotton in 1944 was $7.38. This cost was divided as follows: direct operating cost, $3.84; depreciation, and interest cost, $3.54. See table 4 for detailed cost items.

Some of these cost figures should be regarded as tentative, especially those for maintenance and repairs. The manufac-

[9] See **Mechanization of Delta Cotton Plantation,** by H. H. Hopson, Jr., Hopson Planting Company, Clarksdale, Mississippi.

[10] Detailed information as to the actual acres covered by the machines is available for only one plantation. This machine operated during a part or all of 49 days and averaged operating 9.8 hours per day, a part of which was at night. A total of 228 acres was covered and 202 bales were picked. An average of 4.1 bales of cotton was picked from 4.7 acres each day the picker operated.

Table 4. Cost of operating 12 cotton pickers in the Mississippi Delta during the 1944 harvesting season.

Item	Total cost	Average per picker	Average per bale for 2,229 bales
Direct operating costs:			
Fuel	$ 1,096.79	$ 91.40	$ .492
Oil (motor and picker)	366.72	30.56	.165
Labor	3,801.13	316.76	1.705
Repairs (tractor and picker)	2,069.53	172.46	.928
Miscellaneous	1,230.69	102.56	.552
Total	$ 8,564.86	$ 713.74	$3.842
Depreciation and interest:			
Depreciation (tractor)	750.00	62.50	.336
Depreciation (pickers)	6,417.89	534.82	2.879
Interest (tractors)	75.00	6.25	.034
Interest (pickers)	641.78	53.48	.288
Total	$ 7,884.67	$ 657.05	$3.537
Total cost	$16,449.53	$1,370.79	$7.38

turers are still experimenting with the machine, consequently, some replacement parts and some repairs made by the Company were not included in the cost items. Only normal repair and upkeep charges, as nearly as these could be judged to be normal, were included in the cost items. Also, depreciation charges are rough estimates due to lack of actual experience with reference to length of life of the machines. Pickers were depreciated at the rate of 20 percent per annum "straight line," and tractors at the same rate but for only one-fourth the time since tractors are normally used for other farm work the other three-fourths of the year.

Major adjustments for tractors are necessary when pickers are attached.[11] The average cost for parts at the time of conversion was $100, which amount was added to the cost of pickers. Installation labor cost was approximately $50 and this was included with the miscellaneous items, which also included some other minor costs such as service costs for trailers used in servicing machines in the field and a few other very minor miscellaneous items.

The average cost of the pickers delivered to the plantations was $3,924, including $1,250 for the tractors on which the pickers were mounted. Thus the average cost of the pickers including conversion kit was $2,674. The interest rate on investment was calculated at 4 percent per annum on one-half the value of the pickers and one-half of the proportion of the tractor investment charged to the picking operation.

Grade Loss

Despite the excellent progress that has been made and continues to be made, both with respect to the operation of the picker and for cleaning equipment at gins, cotton picked with mechanical harvesters is given a lower grade and thus sells in the market place at a discount over that of hand-picked cotton.

The machine-picked cotton averaged 1.4 grades lower than cotton picked by hand on the same plantation on the same days for the 1944 season. The average grade for 3,506 bales of hand-picked cotton was slightly above strict low middling; whereas, the average grade for 2,229 bales of machine-picked cotton was slightly below low middling, or a difference of 1.4 grades. The range of grade differences ran from 0.8 grade on one plantation to 2.2 grades on another plantation. There was a difference of 0.2 of one staple length in favor of machine-

[11] See page 12 of this bulletin.

picked cotton, which may or may not be a significant difference in fiber length. The Delta Branch Experiment Station at Stoneville reports a comparable difference from unpublished data gathered in 1944.[1 2]

The average price for the grade of hand-picked cotton for the period September 1, 1944, through January 31, 1945, on the Memphis market was 21.73 cents per pound; whereas, the average price of the grade of machine-picked cotton in the same market during the same period of time was 18.05 cents per pound. The difference is equal to 3.68 cents per pound or an average of $18.40 per bale in favor of the hand-picked cotton. See table 5.

Spinning Quality

The Department of Agriculture, War Food Administration, Cotton and Fiber Branch, Stoneville, Mississippi, in preliminary tests have found that machine-picked cotton is slightly superior (stronger yarn) to that of hand-picked cotton. This is probably due to the fact that the shorter, weaker staple that constitutes the more undesirable cotton is left in the field under machine picked conditions; and when the market comes to recognize this factor, the income loss as a result of excess grade penalty will be less than it is at the present time.

Defoliation

Most of the machine-picked cotton had been defoliated by dusting the plants with calcium cyanamide dust. This cost was not added as an extra item for machine-picked cotton, since much of the hand-picked cotton was also defoliated in the same way.

By thus ridding the stalks of leaves the bolls are exposed to the sun rays which hasten the opening of the cotton and facilitate somewhat the harvesting of cotton by both hand and machine methods.

Variety Influence

There is some indication that cotton variety may be important in terms of adaptation to mechanical harvest. Additional studies are now under way at the Delta Branch Experiment Station, Stoneville, Mississippi, and further evidence will be secured from actual field experience, but sufficient data are now lacking from which to draw any definite conclusions with reference to the importance of variety on machine harvest.

Cotton Gin Cleaning Equipment

Considerable progress has been made in the development and installation of driers and cleaning equipment on modern cotton gins. Further progress is needed, however, as evidenced by loss of grades as previously indicated. Significant progress, however, appears to have been made during the past season. A newly designed cleaner called the "impact cleaner" was installed late in the season, and the results obtained on late season, very trashy hand-picked, machine-picked, and snapped cotton were striking. Cotton that would have undoubtedly been classed as strict good ordinary was raised to as high as strict low middling as a re-

[1 2]See also Mississippi Agricultural Experiment Station Service Sheet No. 364, P. W. Gull, July, 1943.

Table 5. Comparison of grades and staple lengths of machine and hand picked cotton, Mississippi Delta, 1944.

Item	Grade	Staple length	Average price (cents)	Value per bale
Machine picked	7.15	34.1	18.05	$ 90.25
Hand picked	5.75	33.9	21.73	108.65
Difference	1.4	.2	3.68	$ 18.40

Figure 9. Comparison of very late season seed cotton (on right) that was "pulled" and the ginned lint (on left) after going through the "impact" cleaner.

sult of the usage of this cleaner. See figure 9.

There is also some question as to whether this cleaner will give the same results on early picked cotton as on late picked cotton.

The successful development of satisfactory cleaning equipment will eliminate the most significant single item of cost associated with the mechanical harvester. An approach to the solution of this problem is being made through breeding of varieties better adapted to mechanical harvesting, through establishment of cleaning equipment on pickers, and through development of better drying and cleaning equipment at the gin.

Cotton Left in Field

The amount of cotton left in the field as a result of machine operation over that which would have been left by hand picking, is a loss that needs to be considered along with the other cost items.

A detailed daily record on the basis of actual boll count was kept on one plantation throughout the season and the results showed that 91 percent of the open cotton at the time of harvest was picked by machine. Thus 9 percent of the cotton was left either on the stalks or on the ground. Estimates were made on other plantations, and it would appear, even though objective data were secured from only one plantation, that this percentage loss is about average for all the plantations studied. The losses were apparently higher in some instances and lower in others. Progress is being made in this respect through breeding and machine improvement.

Some cotton will be left in the field even when hand-picked. If we assume, therefore, that with hand labor approximately 2 percent of the cotton will be left, then there is a net loss of 7 percent of cotton due to machine operation. On

the basis of current prices for hand-picked cotton and cottonseed, and after allowing for the cost of picking, this is the equivalent of about $7.62 per bale. However, from the standpoint of the producer, the loss of cotton in the field is partly offset by the additional weight of machine-picked cotton which is due to foreign matter added in the picking process. Tests show that machine-harvested cotton has about 7 percent more foreign matter than hand-picked cotton. The cotton left in the field, however, is an economic loss and should therefore be considered in any general comparisons of the two methods of harvesting cotton.

Machine vs. Hand Picking Costs

All items of operating cost and losses associated with machine-picked cotton considered, the actual direct cost of operating the picking machine is one of the smallest items involved. See table 6. Total costs and losses, including cost of picking, loss in grade, and loss of cotton left in field, was $33.40 per bale in 1944.

The cost of hand picking averaged $2.36 per hundred pounds or $37.76 per bale (1600 pounds of seed cotton) on the plantations included in this study for 1944. Comparisons at different picking rates can be readily made by the reader. See table 6.

Favorable Factors in Shift to Mechanization

Under conditions of stringent labor shortages, such as existed in 1944, there are certain advantages associated with machine operation that may not be reflected in comparative cost figures. The timeliness of harvest is an important factor, since the quality and grade of cotton usually deteriorate rather rapidly as the season advances due to weather conditions. The worry and uncertainty of getting the cotton picked under any conditions is also an important factor. See figure 10.

There are also certain other factors, not reflected in the comparative cost figures in this report, that are significant in terms of a shift to machine harvest. On the large plantations there is a heavy capital investment in living quarters and a recurring upkeep cost that is quite heavy. Moreover, seasonal labor is usually required even under the sharecropper system, the recruitment of which is bothersome and expensive under conditions of a relatively adequate labor supply. Adoption of the mechanical picker would, as has already been suggested, make feasible more complete mechanization in the whole production process and would reduce or practically eliminate the cost of maintaining a large number of tenant houses and the bother and expense of labor recruitment and labor management problems.

The relative over-all cost of mechanical harvesting versus hand picking will, of course, be the major factor in determining the rate and extent at which shifts are made to machine harvest. Such a shift, however, will involve a rather drastic reorganization of plantation operation. A careful over-all analysis, therefore, of operation under a system of machine operation compared with operation under the hand labor system will be required before all the cost factors can be considered for comparative purposes. Further studies will make such comparison possible.

Table 6. Comparative cost of machine and hand picked cotton, Mississippi Delta, 1944.

	By machine	By hand
Cost of picking	$ 7.38	$37.76
Loss in grade	18.40	—
Loss of cotton	7.62	—
Total	$33.40	$37.76

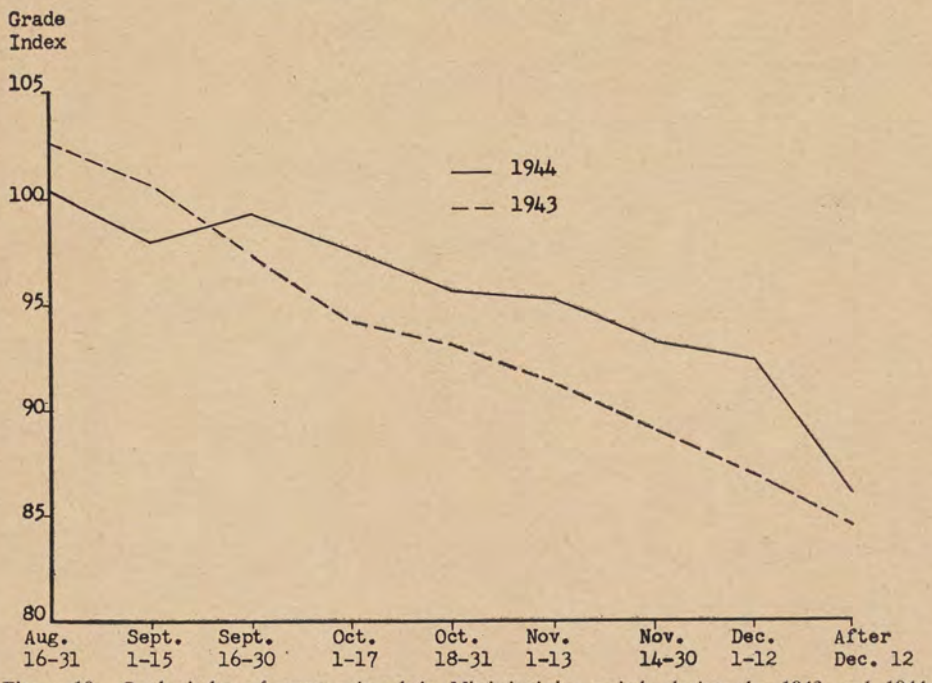

Figure 10. Grade index of cotton ginned in Mississippi by periods during the 1943 and 1944 seasons.

Retarding Factors in Shift to Mechanization

Even though there is evidence that the key to complete mechanization of the cotton industry is closer to reality today than ever before, any assumption that there will be a rapid and extensive shift to complete mechanization should be examined carefully. Had the mechanical picker been at the technological stage of development at the outbreak of the war that it is now, and had these machines been available during the war period, there can be little doubt that extensive utilization of mechanical harvesters would have resulted.

Distinct progress in mechanized cotton production will, no doubt, continue to be made in the postwar period, but the rate and extent of mechanization may be at a slower tempo than many people now anticipate. In the first place, agriculture continues to stand face to face with the problem of an increasing potential capacity to produce out of proportion to its capacity to gain outlets for its products. Secondly, some of the rural farm labor that will be displaced have had almost no experience with industrial discipline and complicated machinery, and some of them have had little experience in independent self direction as a result of the paternalistic character of the plantation system.

These special handicaps, coupled with the distinct possibility that there will be an increase generally in the number of rural persons hemmed in by limited opportunities in both city and country, may further retard the shift to complete mechanization. It should not be forgotten, furthermore, that less than a decade ago the leading newspapers in this area were advocating the junking of all mechanical cotton pickers in the Mississippi River as anti-social instruments and economically detrimental to the people with-

in the area. Also the Agricultural Adjustment Administration was following a policy of restricting or attempting to restrict farm labor displacements. In case of rather widespread unemployment, it is quite probable that certain social and administrative restraints will again be used to discourage further farm labor displacement.

Finally, the shift to mechanical operation will all but destroy the old plantation system as it has existed since shortly after the Civil War. The large operating units under a single management will continue, but the existing paternalistic relationship between management and labor, the "furnish" system, the sharecropper pattern of operation—in short the very heart and soul of an economic and social institutional system that has become a distinctive symbol and traditional agrarian way of life in the Cotton Belt of the South, will have passed out of existence. Vested economic interest in the operation of phases of the old system, sentiment, and the heavy hand of inertia, will delay and hinder rapid shifts even assuming favorable economies associated with such shift.

Influence of Technological Advance to Producers

The assumption that widespread shift to mechanical production of cotton will automatically solve the income problem of cotton producers seems to be rather widely accepted. Such assumption needs critical examination.

As a result of the existence of a large number of independent production units and intense competition, most of the gains in more efficient production in agriculture are, sooner or later, passed on to the consumer. Furthermore, the gains that do accrue to the producer are usually capitalized into increased land values. If improvements were adopted by producers simultaneously, consumers would undoubtedly get most of the benefits of increased efficiency quickly, but one of the most significant impacts of technological advancement in agriculture, however, is that farmers do not and cannot apply at equal rates the results of science and invention. New and old techniques continue side by side—the one-horse plow and the tractor operate in adjacent fields; one-horse wagons and modern trucks transport cotton to the same market; and very likely, the power harvester and the laborer armed only with his bare hands and a sack across his back will both continue to harvest the American cotton crop for some time to come.

As a result of uneven adoption of new machinery, scientific knowledge, and new techniques, farmers who first adopt these undoubtedly gain while others are following at an uneven pace. As more and more farmers follow in more efficient production, there is always a tendency for prices to fall or other adjustments to be made that tend to reduce or eliminate the direct economic gain to the producers. Furthermore, there is usually a significant number of farmers who, for one reason or another, cannot take advantage of the new efficient techniques, and consequently, their already low standard of living may be still further reduced as price is reduced or as they are forced to make farm adjustments that bring lower returns than did the old system under the old price level. In the long run of course, it must be assumed that those not needed on the farms as a result of production efficiencies will find alternative employment either on or off the farm.

The areas that will receive the greatest direct benefit from economies growing out of mechanization will be those areas in a position to first take advantage of the opportunity. And ultimately, of course, whatever efficiencies that may accrue will be reflected in either higher returns to producers or lower costs to consumers, or both, and the standard of living of people generally will be raised even though many individuals may find

it difficult to make the necessary adjustments. In no other way can society make economic progress.

There is still another benefit that will flow from production efficiency at this particular time. And this benefit needs special emphasis. The current and prospective competitive position of American cotton is the most hazardous and precarious in its long history. Lower production costs reflected in lower selling price will strengthen the competitive position of cotton and result in a larger volume of consumption in both the domestic and foreign markets. The wide disparity between income from an acre of cotton and the next best alternative enterprise in the major cotton producing areas makes it highly desirable to maintain as large a market for American cotton as possible.

Social and Economic Effect of Mechanization

A shift to mechanization of the cotton harvest will have its effects on both the cotton plantation and the "family size" farm unit, but the repercussions will be of a different nature. Mechanization will, of course, come first in the plantation areas, which will in turn tend to force changes in farm organization and operation in the non-plantation areas. Despite certain gains that may accrue to certain producers, and despite the long-time gains to society in more efficient production and the improved competitive position of cotton, the immediate resultant economic and social dislocations and changes may be painful for both type areas unless off-farm employment is available. If so, they as well as those that remain on the farms will be benefitted.

Displacement in Plantation Areas

Complete mechanization of cotton production in the plantation areas is not expected in the near future. But assuming relatively complete mechanization of the cotton harvest together with fuller mechanization of the other production processes, this will mean a significant displacement of labor in the cotton plantation areas. Even though the population density within the plantation areas is little, if any, higher than that for the non-plantation areas of the Southeast, cotton not only plays a much more important part in the economy of the plantation area than it does in other areas, but the plantation is much better adapted to more complete mechanization. See table 7 for comparative densities for farm population.

As indicated earlier in this report, the resultant displacement of labor with mechanization will eliminate the need for plantation commissaries or stores and the plantation furnish system and in fact, destroy the established plantation system as is. This possibility emphasizes the very great need for developing alternative employment opportunities within the area either on the farms, in industry, or in other types of employment.

Under relatively complete mechanization it is difficult to forecast the probable displacement numbers, but such displace-

Table 7. Crop acres per farm person and crop acres per farm for selected areas, 1940.

Area	Crop acres[1] per farm person	Crop acres per farm
Mississippi Delta	6.19	27.49
Mississippi	5.00	23.89
Seven Southern States[2]	5.12	28.91
Six Midwestern States[3]	16.27	71.93
United States[4]	12.81	60.71

[1] Acres harvested in 1939.
[2] The states of North Carolina, South Carolina, Georgia, Alabama, Mississippi, Arkansas, and Louisiana.
[3] The states of Ohio, Indiana, Illinois, Wisconsin, Iowa, and Kansas.
[4] Excluding 7 states above.

ment obviously will be high. The labor required to produce an acre of cotton using a mechanical picker is only 37 percent of the labor required to produce an acre of cotton using hand labor for harvesting, the equivalent of a 63 percent reduction in total man hour requirements. This percentage change assumes the usage of multiple-row planters and cultivators, but even with multiple-row equipment, already in use, there is little doubt that still further reductions will be made in man hour requirements in planting and cultivating when mechanical pickers can be introduced. Thus a conservative estimate of labor displacement runs from 55 to 65 percent.

A few plantations are already operating on a ratio of about one family for each 100 acres of cropland by utilizing seasonal labor for chopping and picking. In 1940 there was one family for each 27 acres of cropland in the Delta area. On the assumption that widespread adoption of the picker would make possible adjustment of the labor force to 100 acres of cropland for each family instead of 27 acres per family as in 1940, then 73 percent of the present families would not be needed.

In 1940 there were 64,683 farm families, or a total farm population of 287,111 in the 10 all-Delta counties. A 73 percent reduction would mean that these counties alone would lose 47,218 families and 209,591 in rural-farm population. But, as a matter of fact, the area has probably already lost from 30 to 35 percent to the Selective Service and to war industries since 1940. If postwar conditions are such that few agricultural workers return to the area, then obviously the effect of mechanization will be correspondingly less severe.

Even though society will gain little or nothing in the short run from technological advancement in agriculture if displaced labor go to swell the relief rolls or are forced to find employment on made-work projects, such a contingency does not justify the discouragement of more efficient techniques of production. To do so would hamper or prevent economic progress and the gradual improvement in standards of living for everyone. However, inasmuch as society benefits from such progress in the long run, society should contribute to cushioning the shock of technological unemployment and general economic and social dislocations that result from such progress.

Adjustments in Non-Plantation Areas

Relatively complete mechanization of the cotton harvest (and in turn, cotton production) will have its effect on the non-plantation areas of the Cotton Belt even though the adjustments will be somewhat of a different nature. The ratio of farm population to cropland indicates a relative dependence on intensive crop production equal to that in the plantation areas. See table 7.

The non-plantation areas of the Southern cotton states are characterized by small operating units. Despite the fact that most of these units have only a small acreage of cotton, cotton and cottonseed products constitute the major cash income crop, and in fact, there is no alternative crop outside the concentrated tobacco, peanut, and a few high specialty crop areas that will provide acreage or labor returns anywhere nearly equal to that of cotton.

The vast majority of these farms are too small to shift to mechanized operation; the topography of many others hinders or precludes shift to mechanized operation; many of them, equipped as they are now with little farm machinery and equipment, provide even less under these conditions than full employment the year round; and finally, the landscape is characterized by extensive erosion and poor management practices. The availability, therefore, of effective cotton picking machines and other mechanized equipment

provides little or no opportunity for improved practices and increased income in the absence of drastic reorganization and enlargement of operating units.

The contention that these small "upland" operators can take advantage of mechanized operation either through cooperative purchase or custom service overlooks the fact that such an arrangement guarantees neither increased production nor cheaper production. As a matter of fact, if mechanized operation merely displaces hand labor without providing alternative employment opportunities, cash costs may move up without corresponding increase in income. With income already normally near the subsistence level, any such adjustment might be intolerable. In other words, any labor income on these small units—whether from women and children or whatever it might be—that would otherwise run to waste, is just that much additional income. The cotton picker would cut down sharply on practically the only source of employment for women and children on these small farms, which is desirable from both a social and economic viewpoint, provided of course some other means of maintaining or increasing the present income can be found.

With the coming of mechanized cot ton production and its concomitant eco nomies in the areas adapted to mechanized operation, the areas of small cotton farm operation, under the impact of assumed lower cotton prices, may be forced to shift more to livestock and other crops. Such an adjustment will mean a more extensive type of agriculture, which in turn means that operating units will have to be enlarged and more machinery. equipment, buildings, and other operating facilities provided. This will involve a very considerable reduction in farm population within these areas, change in ownership patterns, additional credit, and significant adjustments in the whole range of service institutions. There is no reason to believe that these adjustments will be any less painful or disturbing than those taking place in the plantation areas.

General Summary and Conclusions

There is evidence that the key to the successful mechanical harvesting of cotton and in turn the complete mechanization of cotton production, is closer to reality today than ever before. Actual farm experience with a sufficient number of machines during the past two or three seasons in the Yazoo-Mississippi Delta has demonstrated the technical and economic feasibility of harvesting cotton with machinery. With the advent of a successful cotton picking machine, the only serious bottleneck to complete mechanization of cotton production will be that of properly thinning and weeding the cotton.

The average cost per bale of machine-harvest of 2,229 bales of cotton by 12 machines during the 1944 season was as follows: direct operating cost, $3.84; depreciation and interest cost, $3.54; grade loss as a result of mechanical harvest, $18.40; value of cotton left in field that would have been picked by hand labor, $7.62; totals, $33.40.

The cost of hand picking a bale of cotton on the plantations using machines at prevailing wages in 1944 was $2.36 per hundred pounds, or $37.76 per bale, with 1600 pounds seed cotton per bale.

The rate and extent of shift to mechanical harvest in the immediate future will depend upon a number of unpredictable influences such as the following: supply and cost of hand labor; alternative employment opportunities for displaced farm labor; realization of anticipated progress in technical improvement of picking machine and of cleaning devices at the gin, and in the breeding of varieties better adapted to mechanical harvest; and finally, the discovery of ways and means of utilizing machines for harvesting cotton in the rolling upland, small farm, small field areas of the Southeast.

The assumption that widespread shift to mechanical production of cotton will automatically solve the income and market outlet problems of cotton producers merits critical appraisal. Past experience has demonstrated that production efficiency gains are, for the most part, sooner or later passed on to consumers, or that whatever gains do accrue to producers are capitalized into increased land values. Society would, however, gain as a result of any efficiencies associated with shift to mechanization, and the competitive position of cotton as well as the cotton producer would be distinctly improved.

A shift to mechanization of the cotton harvest will leave its impact on both the cotton plantation and the "family size" farm unit. Relatively complete shift to mechanized operation will mean a heavy displacement of labor in both types of areas. The traditional plantation system as such will undergo significant changes. The whole institutional arrangement within the plantation areas will be subject to drastic change and the farm population may shrink some 60 to 75 percent.

In the small or "family size" farm areas of the Cotton Belt where the pressure of farm population against land resources is equal to or greater than in the plantation areas, adjustments looking towards a more extensive agriculture and a displacement of farm population only slightly less than in the plantation areas may take place. Such adjustments would mean the enlargement of operating units with more machinery, equipment, buildings, and other operating facilities and a greater amount of capital investment. In the absence of other employment opportunities either on the farms with some other intensive enterprise or combination of enterprises or off the farms within the areas, the whole range of institutional service patterns may undergo significant change within these areas.

American cotton production must be made more efficient if it is to compete successfully in the market place with foreign grown cotton and synthetic and substitute products and at the same time bring the producer anything like an adequate income. The economic and social dislocations and adjustments as well as the ultimate benefits that rather complete mechanization of cotton production and harvesting will inevitably bring, must be shared by society as a whole.