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Farm Mechanization Research in the South

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Economic research and some of the findings in regard to farm mechanization in the South are here summarized. Somewhat similar research now under way in the cotton fields of California is not included.

SOUTHERN FARMERS have seldom been lazy but they have experienced low per capita production and income compared with farmers in other major agricultural regions. The South has a long history of methods which use a great deal of labor in relation to other factors of production. Historically the major reasons for this intensive use of labor and for the lag in farm mechanization have been the large available supplies of unskilled labor and the fact that machines to meet the peak labor needs of the South's major cash crops had not been perfected. The magnitude of the lag in farm mechanization in the South is well illustrated by the fact that as late as 1945 the value of equipment per worker was less than one-half the national average. With considerably less investment in land, buildings, and machinery, the average southern farm worker was able to produce only three-fifths as much as the average farm worker throughout the Nation.

The fact that cotton, the most important farm enterprise on many farms in the South, requires five times as much labor as wheat and twice as much labor as corn to produce a given value of product illustrates the labor-intensive nature of cotton. In fact, man labor accounts for more than half of the cost of producing cotton. Because of the importance of the crop most of this discussion of farm mechanization research is centered around the cotton enterprise but the principal supplemental and companion crops are considered if they influence the mechanization processes.

Southern cotton farmers are faced with double-barrelled competition from synthetic fibers and foreign-grown cotton. The problem of altering to some extent the labor-intensive nature of cotton production is urgent if cotton producers are to meet price competition, without a further reduction of already relatively low returns to labor.

A rational appraisal of this problem brings with it the realization that this competition must be met both price-wise and quality-wise. One of the best-bet approaches to lowered production costs, and thus the chance to meet price competition, is the introduction of new methods and new machines in cotton production. Already the need for increased production efficiency in cotton, along with temporary labor scarcities caused by the war, has greatly accelerated the search for new techniques and labor-saving machines. Mechanical cotton pickers, mechanical strippers, flame cultivators, multiple-job tractor equipment, anhydrous ammonia as fertilizer, and chemicals for weed control, are examples of new machines and new techniques that have become realizations during the last decade.

As never before, cotton farmers are confronted

with the necessity to make almost immediate decisions as to whether they should mechanize their farming operations. Once the decision is made, a host of problems must be faced. How complete is the mechanization to be? Which of the new machines and new techniques fit best? Since most of the machines, the notable exceptions being harvesting equipment, are well adapted to the production of companion crops to cotton, these decisions obviously cannot be made on the basis of the cotton enterprise alone. Rather, the full appraisal of the benefit of machines must be made within the framework of the complete farming system. This is the reason mechanization becomes so complex a problem and in its ultimate effort must be recognized as a social as well as an economic revolution.

The Need for Research

Unfortunately, many decisions at the farm level relative to the adoption of new techniques are being made on a costly trial and error basis. To prevent this lost motion, research should (1) provide cost and performance evaluations of these new production techniques and furnish farmers with guides for their use and (2) develop an appraisal of how these new techniques fit into existing and potential farming systems. The second is probably the more important of the services research should provide.

The long-run objective of technological research on Southern farms is to improve the competitive position of the farm commodities produced by pointing the way for the development of a more efficient agriculture—an agriculture in which returns to production factors approach the returns to similar factors in other farming areas or in other economic endeavors. This objective is not an end in itself. The first test of any farm adjustment is its effect on the net income of the farmer, but the ultimate ends of mechanization must be viewed in terms of their influence on the social and economic structure of the farm economy, of the area and later of the Nation. For example, such questions as labor displacement and population shifts, associated with technological progress, must be studied and answered within the framework of the national economy rather than at the local or regional level.

Framework of the Research Effort

Recognizing the needs set forth in the preceding paragraphs, the Bureau of Agricultural Economics in cooperation with State Experiment Stations initiated a regional project dealing with the economics of cotton mechanization across the Cotton Belt. Cotton will receive major attention in this regional project, but the mechanization of other crops is an integral part of the study and it is planned that the final appraisal will cover the entire production system of the region.

Because of the complexity of the economic problem associated with mechanization, and the fact that new machines and improved methods are constantly entering the picture, the project is being conducted in two phases. Phase 1 deals with economic evaluations of new machines and new production practices on the basis of their individual merit. Phase 2 will evaluate their position in existing and potential farming systems by appraising the effect of new techniques on the organization, operation, and income of farms in the Cotton Belt.

To cover the full range of conditions existing in the Belt, studies were located at points where findings would be generally applicable to broad areas. Conditions in both North and South Carolina are generally representative of those in the Southeast; conditions in Mississippi represent those of the Middle-south and the alluvial areas; Texas is representative of the Southwestern part of the Belt. Work is under way in these States to appraise the tractor as a source of farm power, to evaluate defoliation and mechanical picking and stripping as harvesting methods, and to measure other significant components of the mechanized process.

In some of these areas, as in the Mississippi Delta and the Texas High Plains, where conditions are rather favorable to mechanical farming, progress toward mechanization is taking place at a rapid rate. In such areas, the research is naturally somewhat more intensified.

Results from the studies being conducted in these sample areas will provide the basis for a regional summary and appraisal of mechanization and its implications on southern cotton farms.

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Economic Appraisals of New Techniques

THE ALL-PURPOSE TRACTOR.—Before the introduction of the all-purpose tractor during the late

1920's, the primary economic consideration on cotton farms was the most efficient use of mule power and man labor in relation to the acres of cotton which a family could chop, hoe, and pick. At that time, cotton was produced largely with mule power and either half-row or full-row equipment. Under these conditions, the labor requirements were high. The introduction of the tractor with its higher performance rates offered possibilities of greatly increasing efficiency in the production of this crop.

Recent studies conducted in the Delta show that the average annual operating cost for a medium (2-row) tractor is $518 and for a large (4-row) tractor $736 and the average annual cost, based on efficient feeding practices, for a single head of workstock is $142[1]. Since a medium tractor, in terms of performance rates, is equivalent to 6 mules, and a large tractor to at least 10 mules, it is readily seen that tractors are a more economical source of power.

The shift to tractor power also influences the costs of labor and machinery, making it necessary to take these two items into consideration. Table 1, which covers one cultivation operation on a large farm, is illustrative of the effect of tractor power on the costs of labor and equipment. Thus, on farms that are large enough to employ these power units at the levels of average use, it is clear that the mechanical power units are cheaper from the standpoint of costs.

The situation on small farms where tractors cannot be used at average levels presents a somewhat different problem. The Delta study[2] compares mules and tractors as a source of power on a 30- and a 60-acre crop unit in terms of costs of preharvest labor, power, and equipment. On farms of this size, tractor costs are adjusted to take into account the longer life resulting from less use. On 30-acre crop units, mules are a cheaper source of power if family labor is considered to have no alternative opportunities of employment and is not charged as a production cost. But if family labor is considered a cost of production, the tractor becomes the cheaper source of power. On 60-acre crop units, the tractor is cheaper regardless of how family labor is considered. This treatment is entirely in terms of cost. Other factors affecting mechanization on small farms are discussed later.

TABLE 1.—*Costs of power, labor, and equipment per day and per unit of work accomplished, one cultivation, large cotton farm, three levels of equipment, Yazoo-Mississippi Delta* [1]

Source of power, level of equipment, and items of cost	Cost per day	Work accomplished per day	Cost per acre	Percent of total costs
	Dollars	*Acres*	*Dollars*	*Acres*
One-row mule:				
2 mules	3.64		.52	50.0
Labor	3.00		.43	41.3
Equipment	.62		.09	8.7
Total	7.26	7.0	1.04	100.0
Two-row tractor:				
Medium tractor	6.87		.31	49.0
Labor	4.50		.20	32.0
Equipment	2.70		.12	19.0
Total	14.07	22.2	.63	100.0
Four-row tractor:				
Large tractor	7.04		.17	46.0
Labor	4.50		.11	30.0
Equipment	3.83		.09	24.0
Total	15.37	41.2	.37	100.0

[1] Based on average annual use of the various types of power and equipment and 1949 price relationships.

FLAME CULTIVATION AND CHEMICAL WEED CONTROL.—Weed and grass control is the sole remaining obstacle to the complete mechanization of cotton. Accordingly, the need for labor-saving methods in weed control, in order to bring balance to the over-all mechanization program, has resulted in the development of many machines designed for this purpose. Probably the most important of these to date is the flame cultivator. This machine is a tractor-mounted unit using as fuel one of the liquid petroleum gases, propane or butane. Killing action on weeds and grasses is obtained by directing a jet of intensively hot flame into the drill-row at the base of the cotton plants. Cultivation of row middles with sweeps is usually carried out simultaneously with flaming. The cotton plants must be 6 to 8 inches high and 3/16 of an inch in diameter at the ground level before the initial flaming operation takes place. At this stage the cotton plants are tough enough to withstand the flaming heat.

Flame cultivators studied in the Delta covered, during the season, an average of 110 acres of cotton 4.2 times, or an equivalent of 462 acres once

[1] Based on an average annual use of 75.3 days for medium tractors, 104.7 days for large tractors, and 78 days for mules and 1949 price relationships.

[2] See GAINES, JAMES P., and CROWE, GRADY B. WORKSTOCK VS. TRACTORS IN THE YAZOO-MISSISSIPPI DELTA. Miss. Agr. Expt. Sta. Bul. 470. March 1950.

over per machine. The average cost of operating a four-row flame cultivator, exclusive of labor and power, was $0.60 per acre per flaming, or $2.54 per acre for the season. When labor and power are included as costs, these figures are $0.96 and $4.04 respectively.[3] Unfortunately, the costs of flaming do not represent the entire seasonal outlay for weed control since some hand labor is usually necessary to control weeds and grasses during the period between planting and the time the cotton is large enough to be flamed. On the average, farms using flame cultivation and hand labor, compared with farms using hand labor alone, effected a savings of approximately $3 per acre on weed-control operations in 1947.

The fact that flame cultivation has not proved to be the full solution to the problem of grass and weed control in cotton has spurred researchers to increased efforts along other lines. One of the most promising approaches to the solution at present lies in the use of herbicidal oils as weed-killing sprays. These oils are sprayed into the row at the base of the cotton plants. They kill young weeds and grasses by a differential contact action. One of the most promising features of this method is that early applications of oil may be made immediately after the emergence of the cotton plants in the spring. It is too early to generalize from research findings to date, but a preliminary economic evaluation of this method of control, both alone and in conjunction with flame cultivation, is being made jointly by researchers in chemical weed control and economists, on field-size tests in Mississippi, during the current year.

MECHANICAL HARVESTING.—Harvesting cotton by hand has long been a tedious and time-consuming operation, accounting, in high-yielding areas, for 65 percent or more of the total labor requirements. The recent development of practical machines for picking and stripping cotton has provided farmers with an opportunity to make great reductions in the labor requirements for this crop. These machines are often described as the greatest labor-saving devices in cotton production since Eli Whitney invented the cotton gin. Studies are under way across the Cotton Belt to ascertain the economic feasibility of harvesting cotton mechanically under different production situations.

In the Southwest and some of the Hill areas of the Belt, where the small stalk growth is conducive to the use of mechanical strippers, these machines are rapidly gaining favor. Results of a study in the Texas High Plains indicate a high economic potential for the use of strippers. These machines cannot be used satisfactorily until the leaves have dropped from the plant. Perhaps the greatest single hinderance to rapid expansion of this harvesting method is the need for a practical and economical defoliant which will remove the leaves earlier than would be done by frost.

In the alluvial and irrigated areas, where stalk growth is rank and yields are high, the spindle-type mechanical picker seems better adapted. Preliminary studies of the operation of this machine have been made in North and South Carolina, Mississippi, and Texas.

A total of 26 machines was included in the Mississippi Delta study in 1947. These machines operated an average of 308 hours and harvested 109 bales per machine. Bales harvested per picker for the season ranged from a low of 27 where the machine was used entirely for scrapping, to a high of 180 where used throughout the picking season. Time expended by machine operator and helpers amounted to 5 hours per bale of machine-picked cotton, in 1947. This compares with a usual hand-picking labor requirement of from 90 to 100 hours per bale.

Generally, three categories of cost are associated with mechanical harvesting: (1) machine operating costs, (2) waste or cotton left in the field, and (3) loss-in-grade. Machine-operating cost in 1947, adjusted to 1948 prices for machines, was $18.23 per bale; this cost consisted chiefly of depreciation and interest, 52 percent; repairs 22 percent; and labor, 17 percent. These costs are based on the 109 bale-picking volume mentioned earlier; they would be somewhat lower if the machine were operated at its estimated seasonal picking capacity of 150 bales.

Some waste is incurred in harvesting cotton mechanically as compared with hand picking. Picker efficiency tests conducted on plantations in 1947 reveal that machines are about 92 percent as effi-

[3] There are good arguments for excluding the costs of labor and power since flaming is usually done in conjunction with sweep cultivation, an operation which would be performed regardless of whether flame was used. The addition of the flaming unit to the tractor adds little if any to the regular labor and power cost. The figures are shown here to cover those cases in which only the flaming is done.

cient as hand pickers from the standpoint of clean picking. Picker efficiency varies greatly with crop conditions, yield, period of the picking season, and machine adjustment. Efficiently operated machines, under good conditions, may be as high as 95 to 97 percent as effective as hand harvesting. The 92-percent picker efficiency found in 1947 reflects a field waste of 8 percent. Valued at 1947 prices, this amounts to $13 per bale and is charged against the machine as a cost, for cotton left in the field is an economic loss to the producer.

Loss-in-grade has probably been the most troublesome factor in machine harvesting of cotton. Early attempts to use the machine resulted in quality losses of from two to three grades—an almost prohibitive differential, when compared with hand-harvested cotton. But better cultural practices, defoliation, and the use of more and better cleaning and ginning equipment, have reduced this quality differential to approximately one grade. Results of the Mississippi study indicate that the quality differential between hand and machine-picked cotton was approximately one full grade in 1947 which meant a difference of $7.90 per bale. Further improvements in cultural practices, machine operation, and ginning facilities, offer a prospect of reducing this cost still further.

The total cost of harvesting cotton mechanically, then, amounted to $39.13 per bale in 1947, when capital charges were calculated on the basis of 1948 prices for machines. This is equivalent to a hand-picking rate of approximately $2.65 per hundredweight of seed cotton. According to these calculations, machine-operating costs account for less than half the total cost of machine harvesting. This means that opportunities for increasing picker efficiency and removing quality differentials between machine- and hand-picked cotton offer a broad field in which to make improvements pointed toward reducing costs.

The Pilot Field Approach

Preliminary economic appraisals of new machines and new techniques are valuable both as an indication of their individual merit and as a basis for fitting them into an orderly scheme of production. Regardless of the starting point, whether it is a chemistry laboratory or an alley machine shop, if a technological finding is to be used on the farm it must become part of the adopted farming system.

TABLE 2.—*Yield per acre, man and tractor hours required per acre and per bale produced under two production systems, Delta Experiment Station, 1947*

Field	System	Yield per acre (seed cotton)	Hours per acre		Man hours per bale
			Tractor	Man	
1	A	2,184	3.15	146.55	100.7
	B	1,934	3.82	21.43	16.6
2	A	2,835	3.67	216.43	114.5
	B	2,487	6.13	47.45	28.6
3	A	2,922	4.90	198.25	102.0
	B	2,601	6.43	23.68	13.7

The technique of a pilot field or proving ground offers a constructive approach to the problem of fitting new techniques into a farming system. In Mississippi, proving-ground tests of field size have been set up in cooperation with the agricultural engineers. They serve as a basis for approximating costs and performance of particular machines and practices when these are fitted into a production system. Plot findings and previous experience are used as a basis for the selection of particular operations to be included. Careful testing and analyses of combinations of machines and methods in pilot fields will provide guides for the development of low-cost farming systems, and will help to bridge the gap between plot findings and farm conditions.

In 1948, two production systems were tested. System A approximates the conventional method of cotton production with considerable hand chopping for weed control, and hand harvesting. System B was a high-speed, mechanized system, including flame cultivation and mechanical harvesting, with just enough hand labor to "get by." The systems were tested on three fields ranging from 5 to 15 acres, each being of a different soil type. Seed, fertilizer, and programs for insect control were the same for each system.

As shown in table 2, System B compared with System A reflects some significant reduction in man-labor requirements in all fields, ranging from one-fourth as much in field 2 to one-seventh as much in field 3. Per acre yields are higher under System A in all fields. Preliminary analysis of costs and returns indicate that, with 1948 cost-price relationships, both gross and net returns over direct expenses per acre were higher under System A than under System B. But the returns per hour

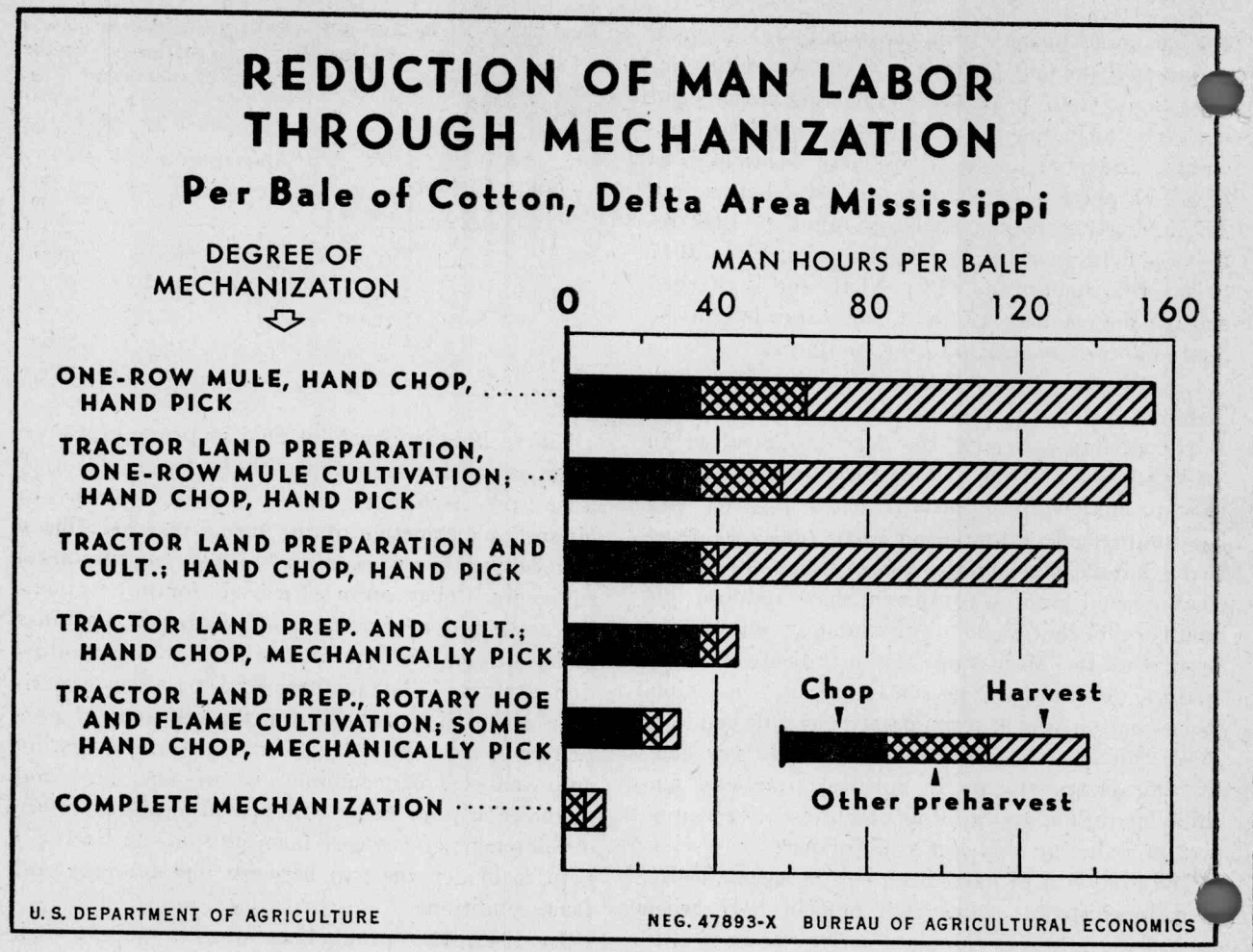

FIGURE 1.

of labor are much higher under System B. It may be that one of the important advantages in mechanization will lie in the possibility of shifting cotton production from a labor-intensive to a labor-extensive enterprise. It is probable that further modification of production system B could result in higher yields without materially affecting the level of inputs. In fact, attempts at such modifications are already under way in subsequent tests.

Mechanization and the Farms

In spite of the progress that has been made in mechanization, cotton is still produced with technology ranging from mule power and half-row equipment to tractor power and four-row machines, and with almost every conceivable combination of these and intermediate levels of equipment.

Mechanized practices have been adopted, on a few more advanced farms, about as far as tested experimental results would indicate as practicable. This has resulted in tremendous reductions in requirements for labor. Under a system of mule power and half-row equipment, 160 hours of man labor were necessary to produce an acre of cotton. By mechanizing as completely as possible with present equipment, only 20 to 35 hours of man labor are required, depending on the amount of hand labor that is necessary for the control of weeds. If and when the weed-control problem is solved, it is not inconceivable that cotton will be produced in some areas with as little as 10 hours of man labor per acre (fig. 1).

Scale of operation has a decided effect upon the rate of adoption of mechanized practices. Many machines used in cotton production are too large to be owned by small operators for use exclusively

on their own farms. This means that, for the present, mechanization of cotton will tend to be carried out on larger units. There is little doubt that mechanization will "pay" on large cotton farms

The opportunities for profitable mechanization that are apparent on large commercial farms become severely restricted as smaller farm acreages are considered. Cotton Belt farms of 30 acres of cropland or less—and there are a great many of these—are too small to be completely mechanized profitably. The use of machines on a custom basis has not proved to be a solution to this problem as yet. Ownership of tractors on small farms can be justified from a cost standpoint, but costs do not provide the complete answer. In general, neither the capital structure nor the credit facilities that are available to operators of small farms would allow them to make relatively large expenditures for machinery and equipment. A set of practical, difficult problems is involved in mechanizing of small farms. These problems form an especially fertile field for research. But it is not one to be approached along subject-matter lines. The solution will no doubt require the concerted and cooperated effort of engineers, economists, agronomists, entomologists, and other production specialists.

Mechanization and the Southern Farm Economy

As progress in the mechanization of agriculture in the Cotton South, thus far, is due largely to labor scarcities growing out of the conditions of World War II, no serious social effects have been felt as yet. If this substitution of capital equipment for labor—conditioned by the development of new skills and managerial capacity—is carried to the point of providing an efficient agriculture in the South, then a great many of the workers who are now on Southern farms would not be needed. These people cannot be considered as "economic extras." In order for the full social and economic benefits of mechanization to be realized, displaced human resources must be utilized in other segments of the economy, and as total society will be the ultimate benefactor, it would seem that that society should contribute to cushioning the shocks growing out of such progress.

For those people who remain in agriculture, with their increased skills and improved managerial ability, there is little doubt that greater production efficiency would enhance their opportunities for financial betterment. The size of the net product that will accrue to any given area will depend upon the proportion of the farms that are able to take advantage of new techniques and the speed with which such adjustments are made.

There can be little doubt that mechanization will affect the size of Southern farms. As it greatly increases labor's capacity for land, the old family-size cotton farm is likely to be too small for an efficient, economic unit. In addition to the increased need for capital to buy machinery and technical services, there will be a need for capital to buy additional land.

The South, with its vast stores of raw materials and undeveloped resources, is provided the opportunity, through mechanization and other technological advancements, to increase its productive capacity greatly, to provide new and higher levels of living for its people, and to overcome the disparity in income between it and other agricultural areas. It is the job of research to assist in pointing the way.