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MECHANIZATION IN RELATION TO THE ORGANIZATION
OF FARMS
(Northern Coastal Plains Area)

By

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INTRODUCTION

The mechanization of agriculture has far reaching implications and is closely associated with changes in the agricultural pattern. The substitution of tractors for animal power has been by far the most important technological change affecting farming systems in recent years. In most instances, where tractors have supplanted mules, substantial reductions have been realized in man labor requirements, and in workstock numbers. These changes have made the farm organization more flexible and increased the farm's capacity for producing other kinds of livestock.

Increased demands for agricultural products during wartime has focused attention on economy in the choice of power. The loss of farm labor has been only one of many factors that encouraged the rapid adoption of mechanical power. The demand for tractors during the war has been so great that restrictions on manufacture as well as rationing and price control were necessary in order to secure the best possible distribution of available supplies.

^{1/} This is the second publication dealing with mechanization in the Northern Coastal Plains. The first bulletin covered specifically the cost of power and production requirements for mechanized and non-mechanized methods of farming. See "Power Costs and Production Requirements for Mechanized and Non-mechanized Methods of Farming in the Northern Coastal Plains."

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With conversion from war to peace-time conditions, restrictions on production, prices, and purchases of farm machinery will very likely be eliminated. This means that, in the next few years, most farmers will have an opportunity of mechanizing their farm operations. The purpose of this report is to discuss some of the important economic considerations that apply to eastern North Carolina and particularly to the Northern Coastal Plains Type-of-Farming Area.

This bulletin presents two situations in which tractor power may be substituted for mules. In one, the conditions for lowest per acre costs are examined. This entails the maximum use of the tractor within the practical limits of the representative farm. In the other case, minimum requirements for successful tractor operation are considered. The problem in this situation is to determine how small a farm may be and yet find mechanical power practical.

The importance of price level variations is extremely important in the relative economy of tractors and mules. In periods of high prices, mules are relatively expensive as a source of power and vice versa. These questions are discussed in detail in the section on price level fluctuations.

It is misleading to infer that changes in the organization of farms are the result of mechanization. There is no such simple relationship. The changing organization of farms is the result of numerous conditions, and the importance of any one is difficult to assess. It is the purpose of the final section to discuss these issues and to enumerate some of the apparent problems of mechanization.

EXTENT OF MECHANIZATION IN NORTH CAROLINA

The extent of mechanization in North Carolina is indicated by the rapid adoption of tractors as a source of farm power. There was little change in the number of tractors reported on farms from 1930 to 1940. Approximately three times as many tractors were reported on North Carolina farms in April, 1944 as in 1925. The number of tractors almost doubled from 1940 to 1944. The reported number of tractors on farms for census periods and for 1944 by type-of-farming areas are presented in table 1.

Table 1. The number of tractors in North Carolina by type-of-farming areas, 1925 - 1944.

Type-of-farming areas	Year			
	1925 ^{1/}	1930 ^{1/}	1940 ^{1/}	1944 ^{2/}
Area I	137	339	725	1,441
Area II	334	548	799	1,861
Area III	434	869	1,267	2,702
Area IV	406	684	855	2,350
Area V	379	772	779	1,950
Area VA	268	372	427	936
Area VB	1,361	1,728	1,776	3,076
Area VI	1,467	1,890	1,680	2,513
Area VII	2,659	3,395	3,630	5,761
Area VIII	355	643	640	1,068
Area VIIIA	109	186	178	311
Total	7,909	11,426	12,756	23,969

^{1/} U. S. Census.

^{2/} Reported by the Agricultural Adjustment Administration and the Agricultural Statistics Division of the North Carolina Department of Agriculture, as of April, 1944.

The rate of tractor adoption was not uniform through the State but varied with type-of-farming, physical conditions, and other causes.

Concentration is evident in certain parts of the Coastal Plains, particularly in the Northern Tidewater Area. In the Piedmont there is evident concentration in

the Central and Southern Piedmont Areas, figure 1. In 1944 there were approximately 18 tractors per 100 farms in the Northern Tidewater Area, 18 in the Central Piedmont, 15 in the Northern Coastal Plains, and 12 in the Southern Piedmont. The State average was 7.7 tractors per 100 farms or about one tractor for every 13 farms.

Since the size of farm varies somewhat from area to area, the intensity of tractors per 1,000 acres of cropland is probably more meaningful than the number per 100 farms. The intensity of tractors per 1,000 acres of cropland, however, followed a pattern similar to the distribution of tractors per 100 farms, figure 2.

In the Central Piedmont (Area VII) there were on the average 7 tractors for each 1,000 acres of cropland in 1944, or 143 acres for each tractor. This is the area of greatest intensity of tractors and is followed by the Northern Tidewater Area (Area I) with 5.2 tractors for each 1,000 acres of cropland, or 192 acres for each tractor. The Northern Coastal Plains (Area III) had 4.7 tractors for each 1,000 acres of cropland, or 213 acres for each tractor, and the Southern Piedmont (Area VE) had 4.6 tractors for each 1,000 acres of cropland, or 217 acres for each tractor. The State average in 1944 was 3.5 tractors for each 1,000 acres of cropland, or approximately one tractor for every 286 acres.

In the Coastal Plains

The soils and topography of the Tidewater and Coastal Plains Areas (Areas I, II, III, IV, V, and VA) of the State are suitable to the use of mechanical power and the complementary machinery.

Crop production in this part of the State with the exception of tobacco and some of the truck crops can be mechanized--that is, the prevailing production operations may be done equally as well or better with mechanical as with animal

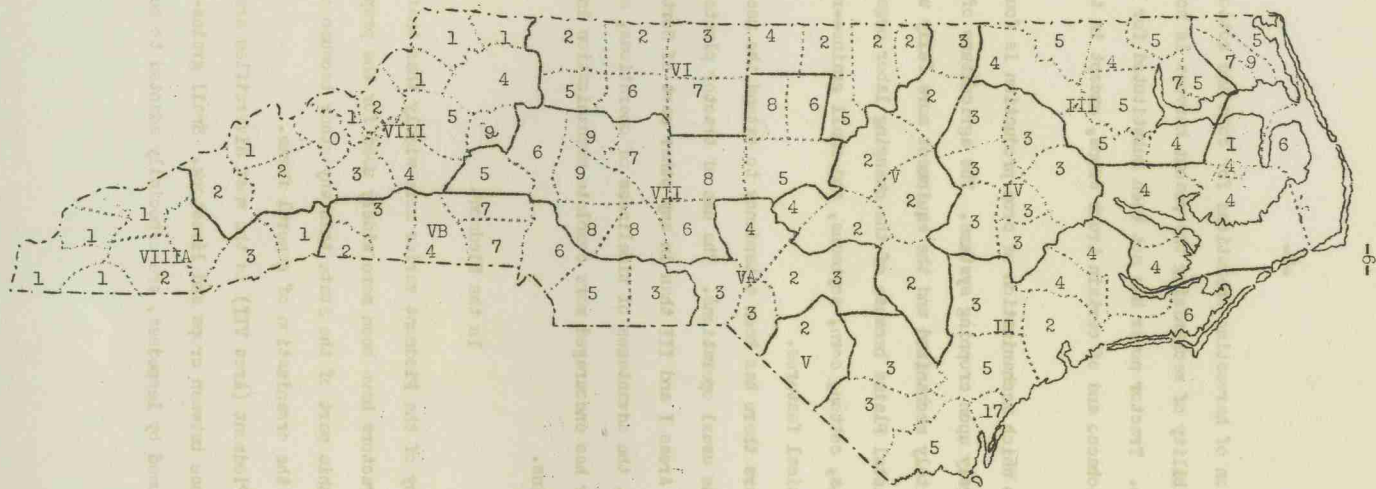


Figure 2. Number of Tractors per 1000 acres of Cropland
1944

power. Mechanization of harvesting operations for corn and cotton are yet to be adopted. The possibility of mechanizing the peanut harvest is not as bright as for corn and cotton. Tractor power has not been substituted for animal power in the production of tobacco and of certain truck crops, except in the preparation of land.

The degree to which mechanization of crop production is found in the Coastal Plains depends largely upon cropping systems. The agriculture of Areas I and III is much more completely mechanized and the equipment more fully used than in other sections of the Coastal Plains because of the changing labor organization and the crops grown--peanuts, cotton, corn, soybeans, and small grains--rather than to differences in physical features.

In recent years there has been a tendency to extend the use of mechanical power to more of the usual operations. The use of tractor planters and cultivators is more general in Areas I and III than in any other part of North Carolina. The loss of farm labor, the advantages of timeliness of operations, as well as economy in the use of power has encouraged more complete mechanization in these sections of the Coastal Plains.

In the Piedmont

The topography of the Piedmont varies more widely than that of the Coastal Plains; however, tractors have been more widely used for the preparation of land and harvesting in this part of the State than any other because of the importance of small grains in the organization of general farms.

The Central Piedmont (Area VII) is the most diversified area of the State, having a good balance between crops and livestock. Small grains--wheat, oats, and barley--often followed by lespedeza, are especially adapted to mechanization and

account primarily for the great intensity of tractors in that area. The large number of tractors in this section of the Piedmont are used primarily for land preparation, grain harvest, and belt work and not for planting and cultivation of intertilled crops.

The Southern Piedmont Area (Area VB) is the principal cotton area, but here also mechanized power is used mostly for land preparation, grain harvest and belt work on general farms. The planting and cultivation of intertilled crops with mechanical power has not been extensive in this area.

Tobacco is predominant in cropping systems of the Northern Piedmont (Area VI) and as a consequence the trend toward complete mechanization has been slower than in either of the other Piedmont Areas.

In the Mountains

Extreme variations in topography, together with small farms and small fields, have discouraged the mechanization of agriculture in the Mountain Areas of North Carolina (Areas VIII and VIIIA). However, many tractors are found on small farms with as little as 50 acres of cropland and are used mainly for land preparation.

TRACTORS VERSUS WORKSTOCK AS A SOURCE OF POWER

Farmers in selecting the type of power to be used will be influenced by (1) its cost, (2) the amount of labor required to operate it, and (3) the cost of the complementary equipment required by each type of power. These considerations on the part of farmers are interdependent. It is conceivable that the cost of operating a given type of power might be relatively low, yet the labor and complementary equipment cost may be such as to make the total production cost for power, labor, and equipment higher than the alternative type of power.

There are other factors in addition to the cost of operation and the labor required which will affect the choice of power. Farmers must consider the matter of timeliness of performing operations or the time required to get certain critical jobs done. It is frequently the case that the cost of a given type of power may be relatively higher than another, yet the actual cost is secondary to the income derived from getting the job done at the right time.

It is the purpose in this section of the report to compare the cost of tractors and mules in performing various farm operations. The comparative costs presented are the results summarized from the previous publication on the cost of power and production requirements for mechanized and non-mechanized methods of production in the Northern Coastal Plains.

Cost of operating tractors. The average cost of operating 125 tractors in the Northern Coastal Plains in 1943 was 54 cents an hour. This includes the cost of fuel, grease, repairs, service labor, depreciation, and interest. The tractors were operated on an average of 90 ten-hour days in 1943. The average horsepower rating for the 125 tractors was 21.02. The average purchase price was \$1,028 a tractor, and the average life of all tractors was 10 years.

Variations in the cost of operating tractors due to amount of use. The cost of operating tractors per unit of time or per hour varies inversely from \$5.00 a day when the tractor is used 121 days to \$9.51 a day when it is used only 20 days, table 2. There is very little change in operating cost per day to use, especially when the use exceeds 50 days per year. Overhead cost, which includes interest and depreciation, declines rapidly per unit of time as the amount of use increases.

Table 2. Estimated variations in the cost of operating medium-size tractors due to amount of use.

Days used per year	Cost of operation on per 10-hour day		
	Operating Dollars	Overhead ^{1/} Dollars	Total Dollars
20	3.45	6.06	9.51
30	3.41	4.36	8.77
40	3.38	3.67	7.03
50	3.33	3.31	6.64
62	3.27	2.86	6.13
91	3.27	2.08	5.35
121	3.27	1.73	5.00

^{1/} Does not include a charge for shelter and taxes.

Cost of operating tractor machinery. The average investment in tractor equipment, excluding combines and peanut pickers, per farm for 17 one-tractor farms studied in the Northern Coastal Plains was \$826. For this equipment, depreciation amounted to \$79; repairs, \$97; and interest \$21 per farm annually. Thus the total annual cost per one-tractor farm for tractor equipment, other than the combine and peanut picker, was \$197. The average cost per hour of use was 22 cents.

The average annual cost of operating 49 six-foot power take-off combines in the Northern Coastal Plains in 1943 was \$178.06. This includes repairs, depreciation, and interest. The average six-foot combine harvested 144 acres of grain, soybeans, and lespedeza at a cost of \$1.24 an acre.

The average annual cost of operating 56 peanut pickers was \$115.60. This includes repairs, depreciation, and interest. The average machine was used to pick 124 acres of peanuts at a cost of 93 cents an acre.

Estimated variations in machinery cost with use. Machinery cost per day or per hour varies inversely with the amount of use. The estimated average machinery cost for one-tractor farms, excluding tractors, combines, and peanut pickers, varied from \$1.82 a day when used 121 days to \$5.70 a day when used only 20 days, table 3.

Table 3. Estimated variations in average machinery cost with use 1/

Days used per year	Cost per 10-hour day of use			
	Repairs Dollars	Depreciation Dollars	Interest Dollars	Total Dollars
20	2.70	1.95	1.05	5.70
30	2.00	1.43	.70	4.13
40	1.65	1.23	.52	3.40
50	1.42	1.10	.42	2.94
62	1.27	1.03	.34	2.64
82	1.06	.88	.26	2.20
90	1.04	.86	.23	2.13
121	.89	.76	.17	1.82

1/ Estimates for one-tractor farms, excluding tractors, combines, and peanut pickers.

Cost of keeping workstock. The average annual net cost of keeping a mule on 58 large farms in the Northern Coastal Plains in 1943 was \$185.87. This includes the cost of feed, depreciation, chore labor, harness repairs and replacements, interest, veterinary fees, medicine, and shoeing. No charge was included for shelter and taxes. The net cost of mule work per hour based on 800 hours of use per year was 23 cents.

Cost of operating workstock equipment. The estimated average investment in mule equipment on farms working four mules in 1943 was \$457.00 or an average of \$114.25 a mule. The annual equipment cost per mule for depreciation, interest, and repairs was \$17.72. Based on 800 hours of use per year, workstock equipment cost on an average amounted to 2.2 cents an hour.

Rates of performance for tractors and mules. The average rates of performing some of the more important field operations with tractors and mules in the Northern Coastal Plains are shown in table 4.

The rate of performance varied with the kind and amount of power and size of implement used. The average rates of performance shown in table 4 may be used in calculating power requirements for crops in this area of the State.

Table 4. Time required to perform specific operations with tractor and mule power per 10-hour day in the Northern Coastal Plain.

Operation	Tractor 1/			Mule 2/		
	Size of Implement	Hours per acre	Acres covered per 10 hour day	Size of Implement	Hours per acre	Acres per 10-hour day per mule
Breaking	5 disc. (tiller)	0.8	12.5	1-mule	7.1	1.4
Breaking	-	-	-	2-mule	10.6	0.9
Disking	6 ft.	0.5	20.0	2-mule	5.0	2.0
Harrowing (spike tooth)	12 ft.	0.3	33.3	2-mule	2.0	5.0
Running rows	-	-	-	1-mule	1.7	5.9
Distributing fertilizer	-	-	-	1-mule	1.9	5.3
Ridging or listing (cotton)	-	-	-	1-mule	3.5	2.9
Ridging or listing (peanuts)	-	-	-	1-mule	2.0	5.0
Planting (average all crops)	-	-	-	1-mule	1.6	6.2
Planting (corn & soybeans)	2-row	0.7	14.3	-	-	-
Planting (cotton & peanuts)	2-row	0.8	12.5	-	-	-
Cultivating (all crops)	2-row	0.6	16.7	1-mule	2.8	3.6
Cultivating (all crops)	-	-	-	2-mule	2.9	3.4
Drilling grain	8 ft.	0.5	20.0	-	-	-
Combining (grain & beans)	6 ft.	0.8	12.5	-	-	-
Cutting hay (lespedeza)	7 ft.	0.7	14.3	-	-	-
Digging peanuts	2-row	0.8	12.5	1-row	2.5	4.0

1/ Average for 61 mechanized farms, 1943.

2/ Average for 128 farms operated with mules, 1941.

Labor and power requirements for specified crops. Labor and power requirements by type of power used are shown in table 5 for five crops commonly grown in the Northern Coastal Plains.

The comparison in table 5 is made for tractor power and mule power methods of production. Both types of power were available on most of the farms studied, and it is obvious that both sources of power were used in performing various production tasks. Tractors are normally used for combining and peanut picking on farms where mules are the main source of power, while mules are normally used for hauling corn and cotton from the fields on farms where tractors are the chief source of power.

Table 5. Labor and power required to produce an acre of crops with tractor power and mule power, Northern Coastal Plains.

Crop	Tractor power Hours per acre			Mule power Hours per acre		
	Man	Mule	Tractor	Man	Mule	Tractor
Cotton	107.9	2.0	7.1	134.5	42.4	-
Peanuts	51.0	7.5	10.3	67.0	44.5	1.6
Corn	16.4	3.0	4.7	34.5	27.8	-
Soybeans	7.2	-	5.5	20.0	25.6	0.8
Small grains	6.1	-	3.1	14.3	20.6	0.8

Mechanized methods of farming required fewer hours of man labor to produce the principal field crops, table 5. The largest relative reduction in labor requirements was obtained for soybeans, small grains, corn, peanuts, and cotton in the order enumerated. The largest absolute reduction in labor required per acre was for cotton, followed by corn, peanuts, soybeans, and small grains.

Summary of operating expenses by different methods of production for specified crops. The comparison of operating expense by type of power used is made with the idea of further exploring the economy of the two methods of production and not for the purpose of determining the cost of producing crops. The comparisons include only operating expenses for labor, power, seed, fertilizer, and supplies used in the production of the various crops, but do not include the cost of land and management. The operating expense for producing five of the crops commonly grown in the Northern Coastal Plains is shown in table 6.

Crops were produced with less expense per acre where tractor power was used. The percentage reduction in operating expense was largest for soybeans, followed by small grains, corn, peanuts, and cotton. The largest absolute difference in operating expense was for peanuts, where the difference amounted to \$11.65 an acre.

Table 6. Gross operating expense per acre with tractor power and mule power for specified crops, Northern Coastal Plains, 1943

Crop	Gross operating expense	
	Tractor power	Mule power
	Dollars	Dollars
Cotton	38.45	47.07
Peanuts	32.71	44.36
Corn	11.96	17.30
Soybeans	8.71	16.56
Small grains	10.51	17.07

Significant variations in expense items for different methods of production.

Labor and power costs were larger where mules were used as the chief source of power. Equipment costs were less where mules were used. Other expenses were approximately the same for both methods of production with the exception of contract work. Where mules were used, combining grains or soybeans and peanut picking were usually hired at contract rates. The cost per acre of combining small grains and soybeans and of picking peanuts was larger where it was performed on a contract rate basis.

EFFECTS OF SUBSTITUTING MECHANICAL FOR ANIMAL POWER
ON FARMING SYSTEMS

The mechanization of farming raises many different problems in the organization of the farm. It must be remembered, however, that in the area to which this study applies, the substitution of tractors for animal power is only one of several causal factors that have influenced production patterns. For instance, during the past decade the program of the Agricultural Adjustment Agencies has had a pronounced effect on production of intensive row crops. Since 1941 the wartime food production program has encouraged adjustments in crop and livestock production in such a way as to most effectively meet national needs. Nevertheless, the

mechanization of farm operations has had an effect on the production of certain crops, especially those that are adapted at least in part to mechanization.

The over-all effect of substituting mechanical for animal power on farming systems may be shown by comparing the distribution of crops found on 61 highly mechanized farms with the average for the area as a whole. Such a comparison, though not strictly valid because small farms have a higher proportion of row crops, is shown in table 7. This comparison is indicative of the possibilities of

Table 7. Distribution of crop acreage for the 61 highly mechanized farms in the Northern Coastal Plains Area, 1943, with comparisons.

Crop	Distribution as percent of total crop acreage for		
	61 Highly mechanized farms ^{1/}	Halifax County ^{2/}	Northern Coastal Plains Area ^{2/}
	Percent	Percent	Percent
Corn	19.2	20.8	27.2
Cotton	12.8	19.9	11.9
Peanuts	21.7	23.9	27.5
Tobacco	2.9	4.5	4.3
Soybeans for beans	11.3	3.4	4.2
Soybeans for hay	.4	1.6	1.7
Wheat for grain	2.1	.7	.5
Oats for grain	4.1	1.7	.9
Barley for grain	1.7	.3	.2
Rye for grain	1.0	.1	.1
Small grain hay	.8	1.1	.8
Lespedeza hay	2.7	- ^{3/}	- ^{3/}
All tame hay ^{4/}	-	4.4	4.9
Lespedeza seed	4.1	1.4	.5
Cover crops	13.6	11.0	11.1
Other	1.6	5.2	4.2
Total	100.0	100.0	100.0

^{1/} Distribution as percentage of the average crop acreage for the 61 highly mechanized farms surveyed in the Northern Coastal Plains.

^{2/} Distribution as percentage of the reported acreage for 1943, North Carolina Department of Agriculture.

^{3/} Included in all tame hay.

^{4/} Except soybeans, cowpeas, peanuts, and small grains.

increasing certain crops which are particularly adaptable to mechanized methods of production for those less adaptable and requiring greater relative amounts of hand labor.

The highly mechanized farms had approximately 58 per cent of the crop acreage in row crops, 28 per cent in small grains, hay, and soybeans, and the remaining 14 per cent in cover crops. In 1943 the distribution of crop acreage in Halifax County on all farms was 78 per cent in row crops, 12 per cent in small grains, hay, and soybeans, and 10 per cent in cover crops. For the Northern Coastal Plains Area approximately 75 per cent of the total acres was in row crops, 14 per cent in small grains, hay, and soybeans, and 11 per cent in cover crops.

The conclusions drawn in this section are based upon the records of the 61 mechanized farms. The average crop organization for these farms is presented in table 8. Although the average cropping system may not be identical with any particular farm, it does provide a basis for a quantitative analysis of the relative economy of farming methods. The kind of power as well as the combination of tractor and mule power that is employed in crop production affects the requirements for man labor, mule power, tractor power, operating expense, and capital investment.

The analysis of production requirements under mechanized and non-mechanized methods of farming indicates that the substitution of tractors for mules usually accomplishes the following: (1) A reduction in the cost of power, (2) a reduction in the amount and consequently the cost of labor, and (3) an increase in output per worker. Some other effects of shifting from animal to tractor power are higher capital requirements, additional opportunities for changing the cropping system and the livestock organization, and finally a greater managerial responsibility.

The following statements as to the comparative economy and operation with mule and tractor power are based upon the average mechanized farm in this study-- a farm with 515 acres in crops, including cover crops and double cropping, table 8. Production requirements and other related data are compared for both methods of production in table 9. It was estimated by the farmers in this study that one

Table 8. The average acres in crops for 61 highly mechanized farms in the Northern Coastal Plains, 1943.

Crop	Acres	Crop	Acres
Tobacco	15	Barley for grain	9
Corn	99	Rye for grain	5
Cotton	66	Small grain for hay	4
Peanuts harvested	111	Lespedeza for hay	14
Peanuts hogged	1	Lespedeza for seed	21
Soybeans for beans	58	Cover crops	20
Soybeans for hay	2	Cover crops, small grains	50
Wheat for grain	11	Garden	8
Oats for grain	21		
		Total acres in crops	515

Table 9. Comparison of production requirements and related data for mechanized and non-mechanized methods of farming in the Northern Coastal Plains, 1943.

Item	Tractor power	Mule power
Acres in crops <u>1/</u>	515	515
Investment <u>2/</u>	\$ 8,233	\$ 6,752
Number of mules	2	19
Number of tractors	3	0
Number of men (man equivalent)	11	14
Hours of mule work	1,987	14,926
Hours of tractor work	2,773	302
Hours of man labor	21,513	28,491
Bushels of corn required to feed mules	120	1,140
Tons of hay required to feed mules	6	57
Total operating expense	\$11,010	\$14,473

1/ See table 8 for the crop organization.

2/ Includes tractors, mules, machinery, and equipment.

medium tractor could accomplish as much work as 3 teams of mules or 6 mules. This estimate was not based upon physical limits of accomplishment alone, but also upon the practical limits of substitution which are determined by the normal distribution of work. Since it was determined that 3 medium tractors could accomplish as much work as 18 mules in this illustration, the comparison of production requirements for mechanized and non-mechanized methods is made for the average farm when mules are used exclusively and when 3 tractors are substituted for 17 mules, leaving 2 mules on the farm for odd jobs.

Tractors are a cheaper source of power. The cost of power for producing crops in 1943 on the average farm of 515 acres was less with tractors than with mules. The operating expense for this farm using 19 mules is estimated to be \$14,473 at 1943 prices. If three tractors were substituted for 17 mules, the total operating cost would be \$11,010 or \$3,463 less where 3 tractors were substituted for 17 mules.

The labor organization of farms varies with the type of power used. When tractors replace mules as the source of power there must be corresponding adjustments in the farm labor force to achieve maximum efficiency in the use of labor. Quantitative estimates of labor needs for this large peanut, cotton, and tobacco farm indicate that less labor is required under mechanized conditions.

Approximately 28,491 hours of labor are required to produce the crops for the cropping system shown in table 8, when 19 mules are the source of power. When 3 tractors were used to replace 17 mules on the same crop organization, only 21,513 hours of man labor are required. The mechanization of this farm results in a reduction of 6,978 hours of man labor required or about 24 per cent.

The distribution of labor throughout the year is materially changed with mechanization. Where mules are used entirely, there exists two distinct labor

peaks; one occurring in May, June, and early July during planting, cultivating, and small grain harvest; and the other occurring in the fall during the harvest season, figure 3. As tractor power is substituted for mules, the early labor peak is reduced, figure 4, because of the higher accomplishments per man and because modern tractors and equipment have been adapted to practically all important farm operations during this period. The number of workers required during the spring and summer months was reduced approximately 50 per cent where tractors were used to replace mules. However, since the harvesting of the important crops--cotton, peanuts, and corn are as yet not mechanized in the Northern Coastal Plains, the mechanization of agriculture has not materially reduced the hours of unskilled hand labor necessary to harvest the crops. ^{3/} Therefore, the problem is one of "partial mechanization." Unless the harvesting of major crops is mechanized, there will persist serious limitations to the mechanization of agriculture in the Northern Coastal Plains.

The limitations of partial versus complete integral mechanization are obvious. The individual farmer has found it possible to reduce the number of workers 50 per cent or more during the pre-harvest season by substituting tractors for mules. Until the harvesting operations are mechanized, approximately the same amount of unskilled hand labor is required on tractor farms as on mule farms. There are several alternative ways in which this problem may be handled. In each of the following cases it is assumed that full and efficient utilization of the farm resources will be had.

- (1) The tractor farmer may continue the present cropping system and utilize the "on farm" labor efficiently provided there is sufficient seasonal labor

^{3/} It has been shown previously that the largest relative and absolute reduction in man labor requirements under mechanized conditions was obtained in pre-harvest operations.

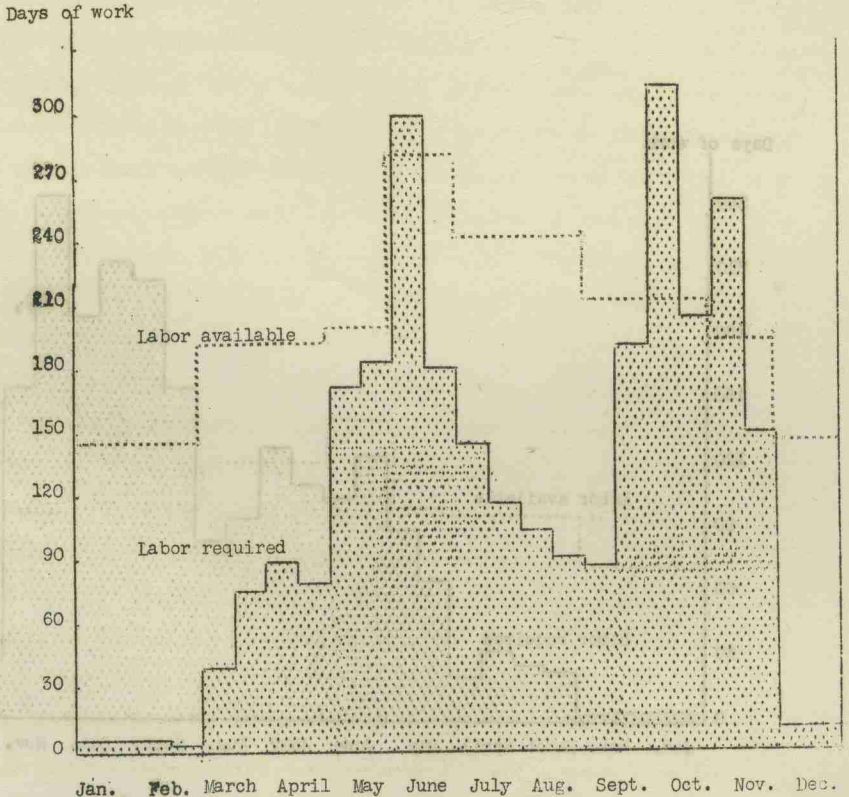


Figure 3. The semi-monthly distribution of man-labor required and the total labor available on a typical farm with 515 acres in crops that is operated with mules. The total labor available is based upon an average of 10 cropper families.

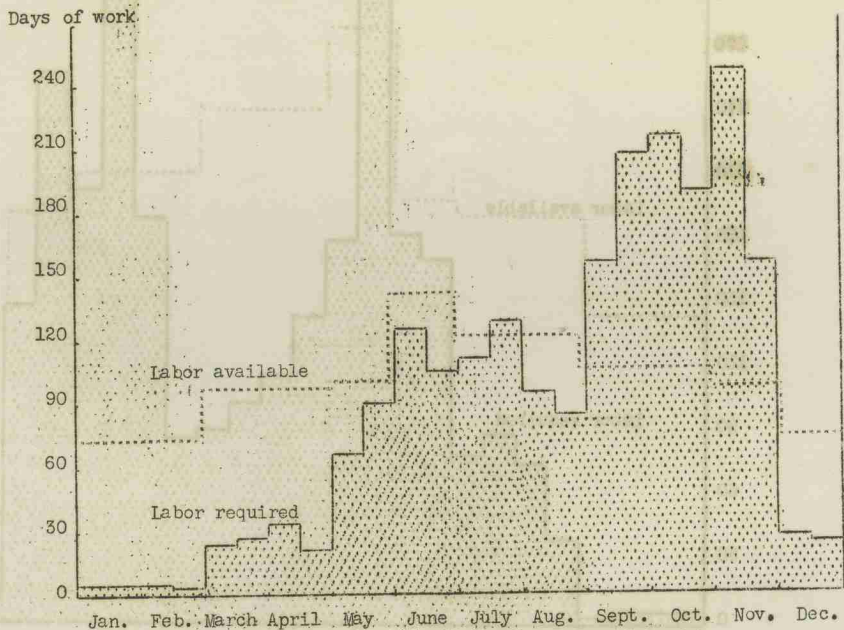


Figure 4. The semi-monthly distribution of man labor required and the total labor available on a typical mechanized farm with 515 acres in crops. The total labor available is based upon an average of 5 crop-per families.

available for agricultural employment during the harvesting season.

(2) The tractor farmer may make adjustments in the cropping system, reducing those crops with high labor requirements at harvest time and increasing those that can be harvested with machinery. The extent of these adjustments would depend upon the composition of the farm labor force and the price relationship of the various commodities.

(3) The degree to which labor-intensive and high profit crops will be maintained in the cropping system will depend finally upon the development, perfection, and adoption of harvesting machinery for cotton, corn, and peanuts that will reduce the labor requirements during the harvesting season. That is, if the farm labor is to be efficiently utilized, the harvesting of crops must be mechanized proportionally to pre-harvest operations. Until the labor required for harvest is reduced by mechanization, farmers will be confronted with the decision of whether sufficient harvest labor is to be maintained on the farm throughout the year for only two to three months work. The development of a cotton picker and corn harvester adapted to local conditions will do much to remove this maladjustment in labor distribution.

The output per hour of work is greater with mechanization. When 3 tractors displaced 17 mules on this 515 acre farm, the hours of man labor required to produce the crops enumerated was reduced from 28,491 to 21,513. There is no evidence that there are significant variations in yield when different types of power are used provided other production practices are the same. With this assumption it is possible to calculate the increased output per hour of man labor. The reduction of 24 per cent in the man labor required results in an increase in output per hour of man labor of about 32 per cent.

Larger capital outlays are required on mechanized farms. Assuming that capital requirements, other than for power and equipment, would be the same whether or not the farm was mechanized, it is possible to compare the capital outlay for power and equipment on mechanized and non-mechanized farms. The investment in mules and equipment when the farm was operated entirely with mules is estimated to be \$6,752. After 17 mules are replaced with 3 tractors and the complementary equipment, the capital outlay is estimated to be \$8,233 or an increase of \$1,481. This increase in capital outlay is due entirely to the larger investment in tractors and equipment.

The reduction of workstock makes it possible to increase commercial livestock enterprises. If workstock are reduced in number from 19 to 2 head, the amount of corn needed for workstock is reduced 1,020 bushels and hay requirements are reduced 51 tons. The 1,020 bushels of corn is sufficient to produce approximately 15,000 pounds of pork or 75 hogs weighing 200 pounds, assuming that sufficient supplements are available. The 51 tons of peanut hay is sufficient to winter approximately 51 head of beef cattle according to the feeding standards practiced in the area.

The mechanization of farms and the consequent reduction in workstock makes it possible for the individual farmer to increase the sale of feed crops, or to develop commercial livestock enterprises as an important source of farm income. An increase in livestock would probably result in a better distribution and more complete utilization of farm labor and management.

Mechanization as related to adjustments in crop acreages. At the beginning of this section the average crop organization for 61 highly mechanized farms was compared with the over-all crop organization of Halifax County and the Northern Coastal Plains Area. Again emphasis is necessary to prevent misunderstanding that

mechanization dictates changes in crop acreages. More frequently mechanization is the result of changing crop patterns, changing labor conditions, changing cost structure, and other factors. In discussing adjustments in cropping systems, it is expedient to think of mechanization of farming as interrelated with various factors affecting farm organizations, such as, the composition of the farm labor force, governmental programs as they affect crop patterns and other organizational factors.

Some of the more significant adjustments that appear feasible as farming becomes more highly mechanized are as follows:

- (1) There is a tendency toward larger farm operating units. The business is usually enlarged by buying more land or renting additional land.
- (2) Cash crops such as peanuts, cotton, and tobacco are maintained at levels near the allotment, depending more upon the availability of farm labor than any other factor. The increase in labor extensive crops, such as soybeans, small grains, and corn are dependent primarily upon the possibility of obtaining additional cropland or the loss of farm labor.
- (3) There is a tendency to use farm land more completely throughout the year when tractors are used. Land which might otherwise remain idle during part of the year is more likely to be planted to cover crops, small grains, lespedeza, or soybeans.
- (4) As long as the labor supply is adequate, it is not likely that the more profitable labor intensive crops will be abandoned in favor of the more extensive crops--soybeans, small grains, and lespedeza--even though the latter are more adaptable to mechanized methods of production.

Data are not available to show detailed changes in cropping systems that were the direct result of substituting tractors for mules. The causes of the

principal changes that are apparent are so complex and closely interrelated that it is extremely difficult to separate the influence of mechanization.

The mechanization of farming has increased the responsibilities of management. More of the farm labor is hired on a cash wage basis on tractor farms than on farms operated with mules. The use of tractor equipment requires more skilled management for the adjustment, repairs, and operation of the equipment. The average wage hand has had very little training in the care of modern machinery, therefore, more supervision is usually required by the management.

CONDITIONS FOR LOWEST PER ACRE COSTS

The combination of crops on an individual farm reflects price and cost relationships and the choice of crops is made with the view of maximizing net income. It is important to obtain the most efficient utilization of power that is possible within the limits of the farm organization and, of course, without reducing the net farm income. The maximum use of the tractor and the complementary machinery is essential for lowest cost operation. This section sets forth an example of a typical cropping system representing the maximum acreage which can be handled with one medium tractor and one mule, table 10.

Table 10. Typical cropping system representing the maximum acreage which can be handled with one medium-size tractor and one mule.

Crop	Acres	Crop	Acres
Tobacco	5	Small grain hay	1
Corn	33	Lespedeza hay	5
Cotton	22	Lespedeza seed	7
Peanuts	37	Cover crops	23
Soybeans for beans	19	Garden & other	3
Small grains	15		
		Total	170

The acreage which can be handled with one medium-size tractor and one mule depends upon the distribution of tractor work throughout the year, which in turn depends upon the cropping system. The combination of enterprises on a given farm is determined by the relative prices of farm products, the relationship between and among enterprises, cultural practices, type of equipment used, and the price of cost items. It is the interaction of all of these forces which determine, at any given time, the combination of crop and livestock enterprises. The acreage which can be operated with one tractor will be determined by the nature of the cropping system or enterprise combinations. For instance, if the principal crops do not require intensive cultivation as in the case of small grains, lespedeza, soybeans, and corn a much larger acreage can be handled with a given power unit. Where cotton and peanuts predominate, the acreage that can be adequately cared for is relatively less as these crops are usually cultivated from five to seven times during the growing season.

The distribution of tractor work determines the maximum acreage of crops that can be grown with any given power unit. This distribution of work is necessarily dependent upon the combination of crops but, assuming a given cropping system, either crop acreages must be kept in line with peak requirements for a given period, or the power unit must be increased.

The semi-monthly distribution of tractor work for the representative cropping system is shown in figure 5. ^{4/} Assuming a ten-hour working day and weather permitting 20 suitable days for field work a month, the peak tractor work

^{4/} In determining the amount of tractor work which would be available, it was assumed that with usual weather conditions tractors would be used on an average of about 20 ten-hour days a month. Since tractors do not tire as do workstock it is possible, with the use of improved lights, to extend the working day in rush seasons to nearly 24 hours of working time. If this were done, the maximum acreage per tractor could be increased materially.

Days of work

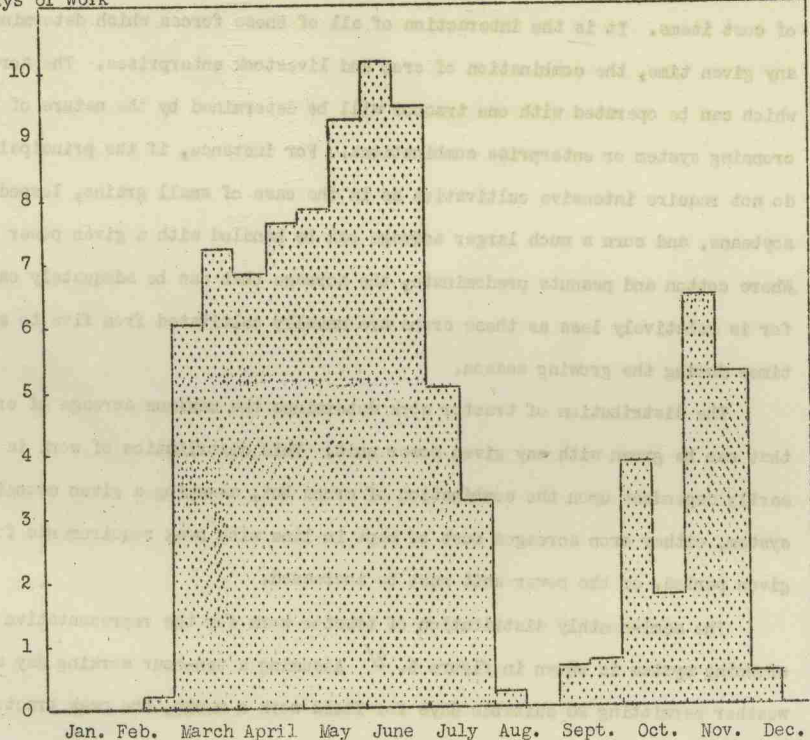


Figure 5. The semi-monthly distribution of tractor work for a typical cropping system of 170 acres that represents the maximum acreage which can be adequately handled with one medium-size tractor and one mule. It is assumed that 20 days of tractor work a month is the practical maximum.

requirements for this crop organization occur during the last half of May and the month of June. Since the peak requirements and the cropping system prevent the tractor from handling a larger acreage of crops, it is obvious that the tractor must remain idle during most of the year unless other suitable work can be found. The cropping system in this illustration requires only 913 hours of tractor work, but it would be impractical to assume that the average tractor would be used much more than this in a normal season.^{5/}

In special cases, where farm labor has become scarce and cropland is not being utilized, it is possible as well as desirable from the farm income aspects to adjust the crop pattern in such a way as to increase the total acreage handled with a given unit. That is, when sufficient labor is not available to produce tobacco, cotton, and peanuts, the farm operator may utilize his resources more effectively by increasing the acreage of crops that require less man labor and less power in their production. Even though per acre returns would be lower for the crops that replaced tobacco, cotton, and peanuts, it is likely that in this situation the net farm income would be greater than if part of the cropland remained idle. Mechanization adds more flexibility to farming systems and provides farm operators with the opportunity of meeting adverse conditions more easily. In addition to being adaptable to changes in the cropping system, tractors can be operated at night in order to meet increased and concentrated needs for cultivation and other operations which may have been caused by unfavorable weather conditions.

Even though the main purpose of this section is to set forth the conditions for lowest per acre operating costs, it should be helpful to compare the cost of power and labor for the two kinds of power. The cropping system in this illustra-

^{5/} Farm belt work and custom work on nearby farms would increase the use of the tractor but the amount of this work available to the average tractor operator is not sufficient to utilize the tractor to full capacity.

tion could be operated with one tractor and one mule or six mules. The cost of power and labor vary considerably depending upon the power unit employed. A summary of power and labor requirements and other related data for mechanized and non-mechanized methods of operating this farm is given in table 11.

Table 11. Comparison of power and labor requirements and related data for mechanized and non-mechanized methods of farming in the Northern Coastal Plains

Item	Tractor power	Mule power
Acres in crops ^{1/}	170	170
Number of mules	1	6
Number of tractors	1	0
Number of men (man equivalent)	3.6	4.7
Hours of mule work	660	4,916
Hours of tractor work	913	99
Hours of man labor	7,147	9,450
Power and labor costs ^{2/}	\$2,203	\$3,040

^{1/} See table 10 for the crop organization.

^{2/} 1943 prices.

If mules are used as the main source of power, the total cost of power and labor at 1943 prices is estimated to be \$3,040.00 or \$18.20 an acre in crops. Approximately 4,917 hours of mule work and 9,450 hours of man labor would be required to produce the crops enumerated.

If one tractor replaced five mules, the total cost of power and labor at 1943 prices would be \$2,203.16 or \$13.19 an acre. To produce the crops enumerated, it is estimated that 660 hours of mule work, 913 hours of tractor work, and 7,147 hours of man labor would be required.

The reduction of \$836.84 or \$5.01 an acre in the power and labor cost on this farm through the substitution of mechanical for animal power reflects the economy of farm mechanization. This change in cost reflects the reduction in power cost and the reduction in labor cost. There is no reason to believe that

crop yields would be different on mechanized and non-mechanized farms, provided production practices were the same. Since the cropping system was identical for both situations, it may be inferred that the reduction in power and labor costs realized when one tractor replaced five mules on this farm represented an addition to the net farm income. Furthermore the grain and hay that would normally be fed to workstock could be used to feed other kinds of productive livestock and should result in an addition to gross farm receipts as well as to net farm income.

MINIMUM REQUIREMENTS FOR SUCCESSFUL TRACTOR OPERATION

The problem of choosing between the use of animal power and tractor power is more difficult on farms with less than 100 acres of crops than on larger farms. If mule power can be dispensed with completely, the comparative economy of mechanical power is greater, consequently the minimum size of farm that could be operated with a tractor would be smaller. If mule power cannot be dispensed with entirely, as in the case where tobacco is found in the cropping system, the minimum size would be larger than where mule power is completely eliminated.

A typical three-mule farm in Halifax County is used to compare power and labor costs with animal or mechanical power, table 12. On this farm it would be necessary to keep one mule for the tobacco crop. This illustration, in which one medium-size tractor replaces only 2 mules, is considered to be representative of marginal cases. Prices prevailing during 1943 were used in comparing the cost of power and labor. Power and labor requirements and other related data are compared for this farm for mechanized and non-mechanized methods of farming in table 13.

The power and labor cost for operating this 60 acre farm with three mules is estimated to be \$1,339.92 or \$23.72 an acre. With animal power, 4,381 hours of man

labor, 1,865 hours of mule work, and 19 hours of hired tractor work are required.

Table 12. Typical cropping system representing the minimum conditions for successful tractor operation ^{1/}

Crop	Acres	Crop	Acres
Tobacco	3.4	Soybeans for beans	2.7
Corn	19.2	Cover crops	9.1
Cotton	11.2	Garden & other	3.5
Peanuts	10.9		
		Total	60.0

^{1/} This cropping system is typical of Halifax County farms that are operated with 3 mules. The illustration represents the minimum acreage in which it would be economical to replace 2 mules with a medium-size tractor.

If one-medium-size tractor is substituted for 2 of the mules, the power and labor cost for this farm is reduced \$196.71. Thus the power and labor cost of \$1,143.21 results in a cost of \$20.23 an acre. With this power complement, 3,456 hours of man labor, 297 hours of mule work, and 315 hours of tractor work are required to produce the crops grown.

Table 13. Comparison of power and labor requirements and related data for mechanized and non-mechanized methods of farming in the Northern Coastal Plains

Item	Tractor power	Mule power
Acres in crops ^{1/}	60	60
Number of mules	1	3
Number of tractors	1	0
Number of men (man equivalent)	1.7	2.2
Hours of mule work	297	1,865
Hours of tractor work	315	19
Hours of man labor	3,456	4,381
Power and labor costs ^{2/}	\$1,143.21	\$1,339.92

^{1/} See table 12 for the crop organization.

^{2/} 1943 prices.

Even though the tractor and the mules on a 60 acre farm are used very little during the year, and much below usual standards the total cost of power and labor

is \$196.71 less where one medium tractor replaces only 2 mules. On the other hand man labor is used much more efficiently and accounts primarily for the cost reduction. The amount of man labor required on this farm was reduced slightly over one-fifth--the result of shifting to mechanical power.

No evaluation has been made in this illustration of the possible effects of reducing per acre power costs by obtaining fuller use of mechanical power on a custom basis. The hourly cost of operating tractors and tractor machinery is reduced when it is more fully utilized (tables 2,3;pages 10,11). Many farmers with only 60 acres in crops would have the opportunity of using mechanical power on other farms. Furthermore, it would be possible to eliminate the third mule provided it was possible to trade tractor work for 297 hours use of a mule. This would mean further economies in the use of power, and would result in lower per acre costs. The minimum acreage for successful tractor operation would be somewhat lower if the third mule could be eliminated.

THE EFFECTS OF PRICE LEVEL FLUCTUATIONS ON THE COST OF MECHANICAL AND ANIMAL POWER

The purpose of this section is to illustrate and discuss the effects of price level fluctuations on the cost of mechanical and animal power. To accomplish this the price level for three periods, 1933, 1935-39, and 1943 was used to compute power and labor costs by type of power used for typical farms with 60 and 170 acres in crops.

Fluctuating price relationships have a pronounced effect upon the relative cost of animal and tractor power. Changes in the general price level are usually accompanied by changes in the relative prices of various commodities. Some commodity prices are more volatile than others--that is, certain raw material prices fluctuate more violently than other prices. Feed prices more than doubled from

1933 to 1943 while farm machinery prices increased about 22 per cent, and equipment and supplies increased about 30 per cent, table 14.

Table 14. Index numbers of prices paid by farmers for selected commodities, United States 1/

(1910-14 = 100)

Year	Feed	Farm Machinery	Equipment and Supplies
1933	77	138	103
1935-39	108	152	111
1943	162	169	134

1/ Agricultural prices, U.S.D.A., B.A.E.

The annual cost of keeping a mule is considerably higher in years of relatively high prices as compared with years of low prices. The annual cost of keeping a mule is compared for three different price levels in table 15. At 1933 prices the net annual cost is \$108.73 as compared with \$185.87 at 1943 prices. When the five year average prices that prevailed in the period 1935-39 are used, the annual cost is \$121.74. Feed is the largest single cost item for each of the price situations; however, the relative cost of feed is greater during periods of high prices than of low prices.

Since general price changes have little or no effect upon the amount of work done per mule annually, it may be assumed that per hour cost of mule work varies proportionally with the annual cost of keeping the mule. Mules were worked on an average of 800 hours in the year. The net cost per hour would be 23.2 cents at 1943 prices, 15.2 cents at 1935-39 average prices, and 13.6 cents at 1933 prices. The cost per hour of mule work varies widely depending upon the number of hours worked per year.

Table 15. The average annual cost of keeping a mule in the Northern Coastal Plains Area. ^{1/}

Cost items	Cost at					
	1943 prices ^{2/}		1935-39 prices ^{3/}		1933 prices ^{4/}	
	Dollars	Percent	Dollars	Percent	Dollars	Percent
Corn	83.40	42.0	46.20	35.0	40.80	35.0
Hay (peanut)	60.00	30.0	42.93	33.0	37.41	32.0
Salt	.42		.35		.32	
Shoeing	1.43	1.0	1.17	1.0	1.08	1.0
Veterinary fees	1.79	1.0	1.46	1.0	1.35	1.0
Medicine	.69		.56		.52	
Chore labor	16.80	9.0	7.06	5.0	5.26	4.0
Harness (gear) cost	7.22	4.0	5.89	5.0	5.47	5.0
Total variable cost	171.75	87.0	105.62	80.0	92.21	78.0
Depreciation ^{5/}	19.96	10.0	19.96	15.0	19.96	17.0
Interest ^{6/}	6.16	3.0	6.16	5.0	6.16	5.0
Total overhead cost	26.12	13.0	26.12	20.0	26.12	22.0
Total cost	197.87	100.0	131.74	100.0	118.33	100.0
Less value of manure	12.00		10.00		9.60	
Net annual cost per mule	185.87		121.74		108.73	

^{1/} Adjusted to average prices for 1943, 5-year average 1935-39 and 1933.

^{2/} Average of prices reported by months for North Carolina used for corn and hay. Other items based on survey of 61 farms in Northern Coastal Plains Area.

^{3/} Average of corn and hay prices reported for North Carolina by years 1935 to 1939. Chore labor adjusted on the basis of wage rates reported by B.A.E. for all states. Salt, shoeing, veterinary fees, medicine, and harness cost adjusted on the basis of prices paid by farmers for equipment and supplies, B.A.E. all states for 5 years--1935 to 1939.

^{4/} Average of corn and hay prices reported for North Carolina for 1933. Chore labor adjusted on the base of wage rates reported by B.A.E. for all states, 1933. Salt, shoeing, veterinary fees, medicine, and harness cost adjusted on the basis of prices paid by farmers for equipment and supplies, B.A.E. all states.

^{5/} Average purchase price of mules 246.38; years of useful life 12.3.

^{6/} Interest figured at 5 per cent on one-half of the purchase price of mules.

Tractor cost varies less with changing price levels than workstock cost.

The reason for this is the fact that operating expense items for tractors fluctuate less than the expense items for keeping workstock. Also, variable costs are a smaller proportion of the total cost in the operation of tractors than in the

case of mules.

Since the cost per hour of tractor operation is so closely related to annual use, variations in the cost of operation due to price changes are shown in table 16, by hours used per year. In this cost comparison for different price levels, no attempt was made to adjust the average purchase price of tractors. Obviously, it would be misleading to adjust the purchase price of a late model tractor to that of an old model. Even though there have been increases in the purchase price of tractors, improvements in design and increased capacity in many cases have been off-setting in their effect. Therefore, the variations presented in this illustration for different price levels are due entirely to changes in the operating cost, and not to depreciation and interest.

Table 16. The effect of price level changes on the per hour cost of operating medium-size tractors, by hours used per year. ^{1/}

Hours used per year	Cost per hour at		
	1943 prices	1935-39 prices ^{2/}	1933 prices ^{3/}
	Dollars	Dollars	Dollars
200	.951	.892	.871
300	.777	.718	.698
400	.703	.647	.627
500	.664	.607	.587
620	.613	.557	.537
910	.535	.479	.459
1210	.500	.444	.424

- ^{1/} In adjusting for price level changes only the operating costs were adjusted. The average purchase price as reported by farmers, represents prices for different years and was not adjusted for changes in machinery prices; inasmuch as price increases during this period were associated with technical improvements of the tractor, thus reducing the reliability of the possible comparisons.
- ^{2/} The operating cost was adjusted to the 1935-39 period, by applying the 5-year average index of prices paid for equipment and supplies to the 1943 data.
- ^{3/} The operating cost was adjusted to the 1933 period by applying the 1933 index of prices paid for equipment and supplies to the 1943 data.

The per acre cost of power and labor varies with the price level, the size of farm, and the type of power used. Price level changes cause greater variations

in per acre cost of power and labor where mules are the main source of power, table 17. When mules were used as the main source of power in the production of 60 acres of crops, the per acre cost for power and man labor at 1933 prices was \$11.34; for the five year average 1935-39, \$13.41; and for 1943, \$23.72. When one tractor was substituted for two mules the per acre power and labor cost was \$11.68 at 1933 prices; \$13.15 for the five year average 1935-39; and \$20.23 for 1943. The variation in per acre cost for power and labor from 1933 to 1943 prices was \$12.38 where mules were used and only \$8.55 where one tractor replaced two of the mules.

Table 17. The effect of price level changes on per acre power and man labor costs for tractors and mules.

Price level	Cost of power and man labor per acre in crops			
	60 acres in crops 1/		170 acres in crops 2/	
	One tractor and one mule	Three mules	One tractor and one mule	Six mules
	Dollars	Dollars	Dollars	Dollars
1933	11.68	11.34	7.37	9.03
1935-39	13.15	13.41	8.41	10.60
1943	20.23	23.72	13.19	18.20

1/ Cropping system shown in table 12, page 31.

2/ Cropping system shown in table 10, page 25.

Price level changes brought about similar variations when applied to farms having 170 acres in crops; however, the per acre cost of power and labor was lower as a result of greater efficiency in the use of power on the larger farms. When six mules were the source of power for the production of 170 acres of crops, the per acre cost of power and labor varied from \$9.03 at 1933 prices to \$18.20 at 1943 prices. When one tractor was substituted for five mules, the per acre costs for power and labor varied from \$7.37 for 1933 to \$13.19 for 1943. Thus, the variation in per acre cost of power and labor due to change in price level where six mules were used was \$9.17 and only \$5.82 where one tractor replaced five mules.

On the farm having 60 acres in crops, which was used to illustrate the minimum size farm suitable for tractor operation, the cost of power and labor at 1933 prices was 34 cents less per acre where mules were used. On the farm having 170 acres in crops, which was used to illustrate the maximum acreage one tractor could handle, the cost of power and labor at 1933 prices was \$1.66 more per acre where mules were used. Thus, it is evident that the farmer must consider size of business along with general price level in determining the type of power that should be used.

MECHANIZATION IN RELATION TO ADJUSTMENTS IN AGRICULTURE

The trend toward mechanization in agriculture may be indicated by (1) the substitution of tractor power for animal power, (2) the use of specialized equipment such as combines and other implements that are associated with tractor use, (3) the use of automobiles and trucks for transportation, and (4) the use of electricity on the farm. This combination of technological improvements is what is usually meant by the broad term mechanization. It is impossible to separate the influence of the different phases of technological improvements as they are all part of the broad impact of mechanization in agriculture. For instance, the tractor at the present time is usually required in conjunction with the use of most specialized items of farm equipment; and since the development of rubber tires and trailer equipment for tractors, it is frequently used for transportation both on and off the farm.

This study has been limited to the use of tractors as a source of power and to the use of tractor equipment. The influence of automobiles and trucks and the use of electric power on adjustments in agriculture are recognized but no detailed attempt was made in this report to separate their influence. In fact, this treat-

ment of mechanization is gauged principally by the adoption of tractors for farm use and it is believed that this serves as a meaningful index of the extent of mechanization in North Carolina. The adoption of tractors in the South has lagged far behind that of other farming areas throughout the United States, and in most southern areas the adoption of tractors for farm use has lagged behind the adoption of improved means of transportation.

The consequences of mechanization in agriculture not only affect the economic organization of society in general, but its impact is carried to nearly every phase in the organization of individual farms. From the economic viewpoint the influences of mechanization increase the choices among combinations of the factors of production--labor, management, and capital. Also mechanization widens the choice in enterprise combinations.

This section elaborates upon desirable adjustments that stem from the adoption of tractors and the subsequent reduction in labor required for farming and the displacement of workstock. It is not sufficient to appraise mechanization only as it exists today, for with new improvements in implement and machine design the adjustments in agriculture must be fluid. To achieve fully the advantages offered by mechanization, farming systems must be adjusted to most effectively utilize the productive capacity of the farm. Finally, it should be helpful to enumerate some of the problems that are apparent with the mechanization of farming and the accompanying adjustments in farming systems. Suggestions are offered for facilitating adjustments in the agricultural pattern and the use of productive resources with the purpose of maximizing the benefits to be gained from technological improvements in agricultural production.

The mechanizing of farm operations affects the economic organization of the farm. The substitution of modern mechanized methods of production for the prac-

tices normally associated with the use of mule power creates additional opportunities for choice on the part of the farmer in the use of productive resources. Improvements in mechanical power and implements tend to strengthen the position of machinery relative to labor in the farm organization. Thus, farm operators are finding it increasingly profitable to substitute machinery for labor.

During periods when job opportunities in industry are plentiful for relatively unskilled labor, farm wage rates tend to increase. It is in these periods that farm operators strive to mechanize farm operations and reduce the cost of farm labor. Since farm wage rates are determined by alternative job opportunities, the reduction in farm labor cost can be accomplished only by reducing the amount of farm labor required.

Prior to the war the supply of farm labor on most coastal plain farms was large in relation to that required for the normal farming operations. Consequently, labor was the relatively cheap resource, a condition which was not favorable to rapid mechanization as it is to the advantage of the farmer to make full use of the cheaper resources in production.

The substitution of machinery for labor is only one of several mutually related points to consider. One of the major considerations is the comparative cost of mechanical and animal power. When mule power is high in relation to mechanical power, as it usually is in periods of high industrial employment and high farm prices, the effect of substituting mechanical for animal power is usually cost reducing.

Other considerations such as the timeliness of performing farm operations, the utilization of farm land, the possibilities of increasing the size of the farm business either by adding additional acreages or substituting a productive livestock enterprise for workstock, and the problems inherent in partial mechan-

ization are of extreme importance in applying the principle of substitution in the organization of productive resources.

Mechanization of agriculture widens the choice of enterprises and affects the combination of enterprises on the individual farm. The relative economies concomitant with mechanization vary for different crops depending upon the resulting reduction in man labor and power costs--that is, some crops are more adaptable to mechanized conditions than others. For example, the greatest relative reduction in man labor for mechanized methods as compared with non-mechanized methods is obtained for small grains followed by soybeans, corn, peanuts, and cotton in the order enumerated. As for power cost, the greatest relative reduction is for small grains, followed by soybeans, peanuts, cotton, and corn.

The choice of alternative enterprises is not based on the cost aspects alone but depends on both cost and price relationships for the various commodities produced. The relative profitableness of enterprises varies from time to time depending on price and cost relationships.

In order to most effectively organize the farm business and make the allocation of resources to the various farm enterprises that will maximize the net farm income, every farm operator must estimate the probable price of farm products, the probable cost outlays for producing them and lastly the most profitable combination of enterprises. In determining the most profitable combination of enterprises additional considerations are necessary; such as spreading the use of man labor throughout the year, the utilization of farm by-products, the risks prevalent with specific enterprises, the maintenance of soil productivity as a conservation measure, and the advantages of diversification and specialization.

The adoption of tractors for farm power reduces the amount of farm labor required and displaces workstock. In recent years many farmers have substituted

tractors for mules because farm laborers have left the farm for other jobs and it was necessary to increase the accomplishments per worker if the usual cropland was to be utilized. Where labor becomes scarce and mechanical equipment has been adopted, there is usually some shift in enterprises in which those crops which are particularly adapted to mechanization are increased. Since the reduction in labor required has occurred only in pre-harvest operations for some crops--cotton, peanuts, and corn--the substitution of mechanical equipment for mules does not reduce labor requirements evenly throughout the season. In fact, peak requirements during the harvesting season are proportionally greater (see figure 4, page 21). This point will be considered further under problems of mechanization.

One of the most significant changes occurring with the transition from animal to mechanical power is the displacement of workstock. This reduction in workstock offers promising possibilities of substituting productive livestock enterprises on the farm and consequently adding an additional source of farm income. The reduction of workstock releases land that was formerly needed to produce feed for mules. If average yields are assumed for the area, the acreage required to produce grain for one mule ranges from about 3 to 3.5 acres. Usually mules are fed about 3 tons of peanut hay in this area and this hay could be used for other livestock. The particular enterprise to be chosen on any individual farm will, of course, depend upon special conditions such as the relative prices of the livestock products and upon the facilities available on the specific farm.

Progress in the development of new improvements in mechanical equipment will very likely increase the advantages of mechanized farming. If agriculture is to make the most of available opportunities, it will be necessary to make desirable adjustments in the utilization of farm resources as speedily as possible.

The development of the general purpose tractor is one of the outstanding factors which made mechanical power readily substitutable for animal power. Other

improvements such as the power-take-off and the power-lift have made the tractor more useful in performing farming operations. Improvements also have been made in tractor machinery. The size of machines have been made flexible to fit special circumstances and other improvements have increased their effectiveness.

With the development of smaller tractors and smaller implements the economy of mechanization has been extended to smaller farms. A continuation of this trend will very likely result in economical substitution of mechanical for all animal power on some farms with as little as 40 to 50 acres in crops, depending to a large extent on the cropping system.

In general improvements in machine design that reduce the cost of power and labor and increase the effectiveness can be expected in the future as in the past. These will tend to make mechanical methods of production adaptable to more farm jobs and feasible on smaller farms which should result in an increased output per unit of farm labor employed.

Many new problems in the organization of farm resources are resulting from the mechanization of agriculture. Mechanizing of farm operations in the Northern Coastal Plains of North Carolina has proceeded rapidly in recent years and without doubt the impacts of war have stimulated the use of mechanical methods. Smaller than normal supplies of farm labor have encouraged more complete use of available tractor power than ever before. The transition from animal to mechanical power is being made so rapidly in this area and certain other areas throughout the South that numerous problems have become apparent. Some of the more important problems associated with a mechanized agriculture are enumerated as follows:

1. Farmers that have adopted tractors are frequently not reducing the cost of power as they should. This results from the fact that when tractors are purchased, there is a reluctance to reduce the number of mules. Conse-

quently, per acre power costs are not decreased as much as they should be because mule power is only partially utilized.

2. Much of the farm labor left on farms is relatively unskilled in the use of mechanical equipment. This, of course, is a short-run problem in that with experience over a period of time this unskilled labor will be educated to the proper ways of using the new machinery. Until this experience is gained the cost of mechanical power will be higher than it normally should be.

3. Mechanization in the Northern Coastal Plains as in most parts of the South is only partial. Where mechanical power is used, the preparation of land, planting, and cultivating is completely mechanized for most crops, but the harvesting of cotton, peanuts, and corn is still performed mainly by hand labor. Not until satisfactory harvesting equipment is developed for these crops will it be possible to obtain the full economy offered by mechanization. Tractors and tractor equipment reduce the peak labor problems during the pre-harvest season, but until harvesting equipment is adopted for corn and perfected for cotton will it be possible to solve the peak labor problems occurring during the harvest season. Because of the importance of quality and the curing of peanuts for the edible trade, the possibilities of completely mechanizing the harvest operation for this crop are not bright in the eastern producing areas where rainfall is likely to be heavy during the harvest season.

4. The impact of mechanization has far reaching implications on the choice of crops and the expansion of the farm business. The use of tractors and tractor machinery often change the relative profitableness of the crops grown. This, together with changes in price relationships, usually calls for a reorganization of the cropping system to most effectively allocate

productive resources.

5. Where workstock have been displaced, many farmers have **not fully developed** the potentialities of increasing productive livestock enterprises that would increase the size of the farm business. Productive livestock enterprises, particularly, beef cattle, poultry, and to some extent hogs, could utilize farm by-products and thereby increase the net farm income on many farms.
6. Extending the use of modern mechanized methods of farming increases the productivity of farm labor. Under normal peace-time conditions this would tend to increase the surplus of farm labor. It has been shown that man labor requirements per unit of production are much less where farm operations are mechanized. The surplus farm labor on farms would be confronted with the problem of finding jobs outside of agriculture or in other agricultural areas. This is an important social problem and emphasizes the need for maintaining a high level of industrial employment.

The problems that were enumerated are not insurmountable. In fact, most problems relating to mechanization are short run in nature and exist only because it is difficult to make adjustments speedily. The following suggestions are offered as a means of improving efficiency in the use of resources on mechanized farms.

1. When tractors are purchased, reduce the number of mules. One medium-size tractor is capable of replacing about 6 mules throughout the year.
2. Farm laborers should be trained in the proper use and care of tractors and farm machinery. This training will rest principally upon farm operators, but should result in more efficient work at lower cost.
3. The harvesting operations must be mechanized in order to reduce the peak

labor requirements during the harvest season. This applies particularly to cotton and corn.

4. Farm operators should continually explore price and cost relationships with the purpose of substituting more profitable crops for less profitable ones.
5. Add a productive livestock enterprise to the farm business when mules are displaced. This should afford utilization of farm by-products and increase the farm income.
6. Increase the use of farm machinery by using it to do more jobs. Labor requirements will be reduced but the productivity of labor will be increased. Surplus farm labor must find employment in industry, therefore, it is necessary for society to maintain a high level of industrial activity.

SUMMARY

1. The number of tractors on farms in North Carolina remained about the same from 1930 to 1940, but almost doubled from 1940 to 1944.
2. The average cost of operating the 125 tractors studied was 54 cents an hour.
3. The cost of operating tractors varies with the amount of use, ranging from \$5.00 a day when used 121 days a year to \$9.51 when used only 20 days.
4. The average annual cost of operating 49 six-foot combines was \$178.06. The average six-foot combine harvested 144 acres of grain, soybeans, and lespedeza at a cost of \$1.24 an acre.
5. The average annual cost of operating 56 peanut pickers was \$115.60. The average machine was used to pick 124 acres of peanuts at a cost of 93 cents an acre.
6. The average annual gross cost of keeping workstock, excluding the cost of shelter and taxes, was \$197.87 per head; the average annual net cost was \$185.87 per head.

7. On the basis of the average work performed, one medium-size tractor replaces approximately six mules.
8. Mechanized methods of farming required fewer hours of man labor to produce the principal field crops in 1943. The largest relative reduction in labor requirements was obtained for soybeans, small grains, corn, peanuts, and cotton in the order enumerated.
9. Crops were produced at lower cost where tractor power was used. The relative reduction in per acre operating expenses in 1943 was largest for soybeans, followed by small grains, corn, peanuts, and cotton.
10. The substitution of tractors for mules on large farms usually means (1) a reduction in the cost of power, (2) a reduction in the amount and consequently the cost of labor, and (3) increase in output per worker.
11. Where 3 tractors were assumed to replace 17 of 19 mules on the average mechanized farm with 515 acres in crops, the operating expense was reduced from \$14,473 to \$11,010.
12. A reduction in the number of workstock makes it possible to increase productive livestock enterprises.
13. The distribution of labor throughout the year is materially changed with mechanization. All important labor peaks are reduced; however, the harvesting operations for cotton, peanuts, and corn have not, as yet, been mechanized, and represent a serious labor problem where tractor power is used. Adjustments in the cropping system and the development of new harvesting equipment for the important cash crops will help to eliminate this problem.
14. Lowest per acre costs for power and labor are obtained when maximum use is made of the tractor and equipment.
15. Based on a typical cropping system for mechanized farms, 170 acres of crops

- represent the maximum acreage which can be handled with one medium-size tractor and one mule.
16. The maximum acreage which can be handled with a given power unit depends upon the distribution of tractor work throughout the year, which in turn depends upon the cropping system.
 17. If mule power can be dispensed with completely, the minimum requirements for successful tractor operation will be considerably lower.
 18. Power and labor costs were slightly less where one medium-size tractor was used to replace two of three mules on a typical small farm with 60 acres in crops.
 19. Fluctuating price relationships have a pronounced effect upon the relative cost of animal and tractor power.
 20. Changes in the general price level are usually accompanied by changes in the relative prices of various commodities. Feed prices normally fluctuate more violently than do prices for machinery, equipment, and supplies.
 21. The cost of mule power varies more with the general price level than does the cost of tractor power.
 22. During periods with a low general price level, the cost of man labor and mule power are relatively lower than the cost of man labor and tractor power for an individual cropping system. For example, the cost per acre in crops for man labor and power on a typical 60 acre farm in 1943 was \$20.23 where tractor power was used as compared with \$23.72 where mules were used. Comparable figures for 1933 are \$11.68 and \$11.34 respectively.
 23. Mechanization of farm operations affects the economic organization of farms, widens the choice of enterprises and affects the combination of enterprises, reduces the amount of farm labor required, and displaces workstock.

24. The development of new and improved mechanical equipment will very likely increase the advantages of mechanized farming.
25. Partial mechanization of production operations for important crops, such as cotton, peanuts, and corn make adjustments in the farm labor organization more difficult. Improved harvesting machinery, the use of seasonal labor, and adjustments in the cropping system will help to alleviate this difficulty.
26. The following suggestions are offered as a means of improving efficiency in the use of resources on mechanized farms:
 - (a) When tractors are purchased, reduce the number of mules.
 - (b) Train farm laborers in the use and care of modern farm machinery.
 - (c) Mechanize harvest operation as soon as practical in order to reduce peak labor requirements during the harvest season.
 - (d) Study price and cost relationships and consider the advisability of adding new crops or increasing the acreage of those crops which are more profitable.
 - (e) Increase productive livestock when mules are displaced. This should afford better utilization of farm by-products and increase the farm income.
 - (f) Increase the use of farm machinery by using it to do more jobs, thus reducing labor and mule power requirements.