Tung
Processing and Marketing Practices and Costs

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CONTENTS

PREFACE

Under authority of the Agricultural Marketing Act of 1946 (RMA, Title II), a marketing research project was organized to analyze the methods and practices of oilseed mills in relation to costs and margins, and their effects on return to growers. A study of tung milling is one part of that project. Tung oil is classified by the Munitions Board as one of the six strategic oils. Production from domestic tung groves is roughly equivalent to a fifth of normal domestic requirements.

This study is an attempt to analyze the methods, practices, and economic efficiency of the processing mills through which the domestic tung crop passes to the industrial users of tung oil. At the time mill data were obtained the industry was composed of 14 mills. The smallness of this number put stringent limitations on the analysis.

Search for comparable data to check against the tung information revealed little material of use. No such data are available on the processing of other drying oils. Similar analysis was made for the cottonseed-oil processing industry, however, and pertinent data from that analysis are here compared with the tung data despite the many dissimilarities in the situations in the two industries, the sources of their materials, and the uses of their products.

Information was collected through interviews with officials of tung mills and supplemented from such governmental sources as the Commodity Credit Corporation, Bureau of Agricultural Economics, Farm Credit Administration, Bureau of Plant Industry, Soils, and Agricultural Engineering, Bureau of Agricultural and Industrial Chemistry, and the Bureau of the Census. Mill officials, in general, spent considerable effort in supplying actual figures or estimates from their records, and although such records are not well suited to the purpose of comparative cost allocation, the figures were the main source of data for this study.

This report was planned and developed under the general supervision of C. B. Gilliland, Chief of the Research Division of the Fats and Oils Branch. The study was carried out and the report written under the immediate supervision of Donald Jackson. J. C. Eiland collected and tabulated the major part of the field information and interpreted his field notes for use in preparing the manuscript. Thomas B. Smith took part in the exploratory field work. George W. Kromer contributed to completion and checking of the report.

Both the American Tung Oil Association and the Tung Growers Council of America gave helpful suggestions.

SUMMARY

During the marketing season of 1948-49, millers processed most of the tung fruit in the United States on a toll or custom basis. Their mill operating costs, as reported in this study, averaged $17.13 per ton of tung fruit processed. Their average return was: (1) A processing charge of $12.69 per ton plus (2) value of meal and hulls to which they obtained title of $7.19 per ton, or a computed average total of $19.88. In the preceding year most tung fruit had been bought outright by the mills.

Operating costs of processing tung fruit varied greatly among the 14 mills that comprised the industry in the processing years 1947-48 and 1948-49. For those two seasons mill costs varied as much as $17.93 per ton of fruit and the average cost was divided between current and fixed costs in about a 57-43-percent ratio.

Current costs not only averaged higher than fixed costs but also were responsible for well over one-half the variation in total costs. They consequently offer management the greatest opportunity for reducing costs in a high-cost mill. It will pay most managers of average, or high-cost, mills to work toward increased efficiency in those operating functions that vary directly with the volume of fruit processed.

Improvements in this respect will pay in lower direct, or current, costs per ton of fruit processed, and in a majority of instances will contribute indirectly to a better utilization of invested capital and other overhead costs, such as salaries and office expense. Nearly every management decision affects both current and fixed (direct and overhead) costs.

Fixed costs for processing a ton of tung fruit appear by various tests to be a higher percentage of total cost than is desirable from an efficiency viewpoint. Facts developed by this survey suggest that the average cost for the industry, covering both high- and low-cost mills, can be lowered significantly through improved management of fixed items.

Most tung mills operate for short seasons, the average for the two seasons studied being 136 days. Present techniques of storage do not permit holding the fruit later than about July 1. Until these techniques, or the methods of extraction, are improved in a way to overcome this difficulty, this factor will limit the maximum length of the potential crushing season. Some mills operated as many as 127 more days per season than did other mills, and costs decreased as season lengthened. The small number of days the mills were operated is partly due to the custom of leaving the fruit in the orchard until needed for processing. This practice often results in congestion of receiving facilities in good weather and shortage of mill stock of fruit in bad weather, thus interrupting mill operation. Moisture content of the fruit will also vary with the weather, thus increasing the operating problems.

Direct effect of the small number of days operated and its attendant problems is upon the fixed, or overhead, costs of the mill. Labor cost also is increased, however, by the brevity and irregularity of operations.

Any major saving in fixed costs must come from raising the ratio of tonnage processed to plant valuation, rather than from better scheduling of the same volume. Improvement in this ratio should automatically come about through increased production as new trees come into bearing and through careful planning of mill expansions; otherwise it would be a most difficult process. Any question of additional equipment should be scrutinized to avoid investing in mill expansion while present capacity is utilized at less than the optimum, or best practicable, rate.

Even if a manager feels that his mill is currently operating at the optimum seasonal rate, good business requires that he plan to absorb some increase in the crop by constantly improving his operating methods and practices, and thereby, his business efficiency. For example, it may have been necessary to slow down, or shut down, a mill from time to time in bad weather when fruit could not be hauled from the orchards. Any way to lessen or avoid these stoppages (such as by more storage) at less cost than to accept them obviously will increase mill efficiency. In some cases more and better storage might do this.

Mechanical harvesting of tung fruit promises a saving in harvesting cost. It also promises movement of the fruit from the orchard as harvested. This would make the fruit more regularly available to the mills but would require solution of several storage problems either at the mill or at the farm. Such development might also increase the maximum milling season somewhat. Furthermore, if field hulling is more fully adopted, obviating the hauling of hulls to the mill, the hulled nuts can be stored in much less space than the whole fruit, but storage conditions will require even closer attention than at present. The Federal tung laboratories and the Federal tillage laboratory are devoting constant experimental work and study to these problems, but it must remain largely for the industry and the individual mill management to coordinate the technical processes into an efficient and continuously improving enterprise.

Another way to economize on "fixed and administrative" cost is to increase the integration of tung milling with other enterprises that will utilize the same fixed or administrative facilities. This method of operation has been employed by some of the tung mills, notably those integrated with tung orchards. One supervisory and office force and, in many instances to a considerable degree one labor force, can operate both enterprises. The tung mills integrated with industrial plants that use tung oil are following a customary business expedient to avoid "middlemen" in marketing the oil, are assuring themselves an oil supply and an oil market to a certain extent, and perhaps are furnishing financial backing for their tung mills. Many cottonseed and peanut mills have gone much further than most tung mills in developing enterprises that use plant, power, office or management facilities jointly with the oil mill. Fertilizer mixing, feed mixing, ice manufacturing, and the selling of farm machinery and equipment, fertilizer, feed, and fuel are among such enterprises. Various unpublished data and informed opinion in the industry indicate that such joint use of facilities can economize directly on fixed and administrative costs and can economize on labor cost by retaining a better labor force.

A serious need of the tung mills is a better accounting of costs and returns. In the independent mill such accounting is needed principally to help control costs by type. For example, such accounts will indicate whether or not office or salary costs are unusually high and if so, may suggest how they may be reduced. For the orchard-mill concern, detailed cost accounting is one of the major methods of determining the extent to which the several operations involved in each enterprise are carrying fair or unfair shares of the cost and receiving credit for proper shares of the joint returns. This, of course, is a first major step in cost and managerial control.

To be most effective, cost control must have trustworthy standards for reference, but in tung processing both the newness of the industry and the small number of mills make such a standard especially difficult to attain. From interviews with tung mill operators, and from parallel experience of cottonseed-oil mills, it is evident that widely varied ideas of average and permissible levels of any specific type of costs in an industry are held by plant officials. To the extent that this is true, some unbiased record of usual costs (if no more than industry averages) will serve as an improved standard of comparison for management. There is, in fact, serious need of an impartial collection and analysis of industry-wide costs integrated with returns, for mills and orchards together.

Occasionally figures on cost of tung production have been presented but they have neither been on a uniform basis nor have they adequately met objective accounting or economic standards. Although the mills integrated with orchards are the ones that require accurate knowledge of tung fruit production costs in order to segregate their mill costs and revenue, both the tung mills and the tung growers would benefit by including other types of producers in such analysis.

It is to the advantage of the processors to assist in cooperative or independent study and effort toward improvement in the marketing schedule and processing practices, and to anticipate as well as possible any likelihood of significant changes before embarking on improvement projects that involve expansion. Improvement in a mill's operating schedule without expanding the mill will at least economize in current costs, and usually will increase potential capacity without added fixed cost.

TUNG PROCESSING AND MARKETING PRACTICES AND COSTS

Prepared in the Fats and Oils Branch, Production and Marketing Administration

INTRODUCTION

The production of tung oil is a new industry in the United States, having had its commercial beginning in the late 1920's. Its establishment undoubtedly was stimulated by the growing use of tung oil in the drying oil industries and the erratic imports that resulted in an unstable supply and fluctuating prices. Other incentives to its establishment were the cheap cut-over land, compatible climate, and plentiful labor supply along the Gulf coast of the Southern States.

Because the only commercial use of tung fruit was in the production of oil, the oil mill was at once recognized as an integral part of the industry. Thus, as production developed successively in Florida, Mississippi, Louisiana, Georgia, and Alabama, mills were built locally as a means of marketing the crop. Capacities of these mills were small compared with mills processing other oilseeds, but were excessive for the quantity of tung fruit available. Most of the mills were not started as commercial ventures but as adjuncts of extensive orchards planted either by individuals or organized groups. Around these integrated orchard-mill enterprises, and dependent on them for milling services, grew up smaller "independent" orchards. The attitude of the mill owners toward these independent producers appears not to have been uniform. Most mills do crush some tung fruit grown by independent producers; some of them, at least, compete for such business; a few do practically none of it. Some managers who do buy fruit or crush for others on a toll basis to keep their mills more fully employed, nevertheless, feel an inconvenient competition for precedence between the two types of business.

According to industry information, the planting of tung orchards has increased greatly since 1940, and this should improve the utilization of mill capacity. Actually, the production of tung oil indicates practically a constant rate of growth since 1932, when records were first kept. As time passed and the industry grew, however, this constant increase applied to a bigger and bigger base and represented an even larger absolute quantity. Furthermore, because of the limited area suited to tung culture, any increase in plantings comes to represent more and more an increased concentration around established mill locations.

Two closely related questions are involved in the influence of volume of business on costs. One concerns the most favorable volume for a mill of a given capacity and the variation in costs as the ratio of tonnage to plant-capacity changes. The other concerns the scale of costs for mills of different sizes, each handling its most favorable volume. Neither problem can be worked out with desirable precision for the tung mills because of both the newness of the industry and the small number of mills.

In this study, operating information has been requested of tung millers in order to analyze mill practices and costs as a basis for distinguishing the more efficient practices from the less efficient ones. The resulting data are neither as adequate in coverage nor as precise in classification as required for a complete examination of efficiency in this step of the marketing process. They yield facts that are important to the marketing of the tung crop, nevertheless, and on which opinion in the industry has differed.

The analysis has been amplified by comparisons of the tung-mill data with corresponding data for cottonseed-oil mills. At the time the comparison was made all of the tung mills and 24 of the cottonseed-oil mills used only screw-presses for oil extraction and they used closely comparable methods.

CHARACTERISTICS OF THE TUNG INDUSTRY AND THEIR ECONOMIC SIGNIFICANCE

The area of commercial tung production in this country extends along the Gulf of Mexico from central Florida to southeastern Texas in a belt about 100 miles wide. The States in the order of their production are Mississippi, Louisiana, Florida, Alabama, Georgia, and Texas (Table 1).

Only in this belt have the climatic conditions been found to be favorable for tung production. North of an indefinite line about 100 miles inland from the Gulf, both winter temperature and spring frosts make tung tree growth precarious. The southern limit for tung production is a line through central Florida; south of this line, fewer than 400 hours below 45° F., are expected during the dormant season, as required for uniform growth and full crops of tung fruit (3).[1] The western boundary of the area is an approximate line west of which the average annual rainfall is less than 40 inches; although winter temperature and soil type undoubtedly influence this boundary.

Development of Tung Production in United States

The industry dates back to about 1905, when, it is reported, the first seed were received in this country for planting purposes. Until the late 1920's, however, production was altogether experimental. This new American industry was encouraged by the paint and varnish manufacturers with the object of "making us less dependent upon foreign sources and of preventing violent price fluctuations" (5). In fact, some of the first commercial tung orchards were started by paint and varnish interests.

In the spring of 1929, the first tung oil mill began operation, processing the 1928 crop (5). Until about 1940, many aspects of domestic production were largely experimental. By 1940, production began to assume commercial significance. It increased significantly in 1940 and has shown a continuous growth since. (See table 1.) Figure 1 shows the growth in production to vary around a straight line, indicating that it has been fairly constant. Variations in production are largely accounted for by the biennial bearing tendencies of the trees, and occasional cold and frost damage.

The number of trees also has shown an increase except from 1940 to 1945. However, the number of trees reported in Mississippi in 1940 included some duplication. Judging from the number of farms and trees for other years, it appears that 6,000,000 trees would be nearer correct than the figure given for Mississippi in 1940[2]. (See tables 2 and 3.)

The rapid growth of the industry during the last decade is further emphasized in table 4, which shows total oil production by crop years, 1943 through 1949, and in table 5, which gives production and farm value of fruit for the crop years 1939 through 1950.

It is obvious that during the early growth of the industry there was need for a more dependable supply of tung oil. Shipments from China were erratic due to political and military disturbances. Consequently, the supply and price of tung oil fluctuated widely from time to time.

There was need also, for some new crop in this area of the South. Cotton production was on the wane[3], and the once seemingly inexhaustible supply of timber was being rapidly exhausted.[4] These factors caused land and labor to be comparatively plentiful and cheap in this area, which was conducive to the establishment of this new agricultural crop.

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[1] Underscored numbers in parentheses refer to Literature Cited, p. 32.
[2] The figures were correspondingly adjusted by the Bureau of the Census.
[3] Brewster, John M., Cottonseed Supply Areas U.S. Dept. Agr. Stat. Bul. No. 90, 1950. See p. 22, fig. 8, "Percentage change in average production of cottonseed, by counties, 1928-32 to 1943-47. Tung Belt counties showed a decrease in cotton production ranging from 30 to 100 percent."
[4] Behre, Edward C., Gaging the Timber Resources of the United States, U.S. Dept. Agr., July 1947, revised, table 8, p. 18, shows that for Alabama, Georgia, Florida and Mississippi the stand of saw timber declined 22 billion board feet or 15 percent from 1932-36 to 1945. A comparable decline was also indicated for Louisiana, the other main tung producing state.

Harvesting and Marketing the Crop

Tung fruit begins falling from the trees in late September or early October, and harvest operations are started soon thereafter. It is desirable to have the fruit picked up as soon as possible to keep deterioration at a minimum. It is necessary to have it off the ground before the first spring cultivation and application of fertilizer, recommended by the laboratories for late February.[5] Therefore, the period of harvest runs about 3 to 4 months and comes at a time when general farm operations in the area are not pressing.

The fruit is picked from the ground by hand. When hired labor is used, it is done on a piecework basis. The price per unit varies, depending upon the amount of fruit per acre, availability of labor, and how much weed growth and trash are in the worker's way. In Louisiana in 1948, picking, including sacking and placing the sacked fruit in the crotches of the trees for further drying, was paid for at an average rate of 9 cents per bushel (about 25 pounds) for the first picking (36 bushels) and 21 cents for the second picking (8 bushels) (8). The operation required an average of 12 man-hours of labor per acre or 21.8 hours per ton of fruit. The computed average cost for this harvest operation was $4.92 per acre, yielding 1,100 pounds of fruit, or $8.95 per ton of fruit.

In recent years, effort has been made to perfect a mechanical harvester that would gather the fruit from the ground or a combined harvester-huller that would harvest and hull the fruit in one operation. The United States Department of Agriculture Farm Tillage Laboratory at Auburn, Ala., as well as private concerns and individuals, has been actively engaged in this work. A mechanical harvester would save a great amount of labor, and a harvester-huller would include a further essential process in the one operation and at the same time (1) save the expense of hauling the hulls to the mill and (2) leave them distributed in the orchards where their fertilizing value might be realized.

Portable hullers, used by some producers to hull fruit in the orchards, provide some of the benefits of mechanical harvester-hullers. One problem that results from farm hulling is the storing of the hulled fruit, because it deteriorates more readily than the whole fruit. Hulled fruit must be stored under more closely controlled temperature and moisture conditions than whole fruit. This fact tends to offset the advantages of orchard hulling.

Holding of part of the crop in farm storage buildings has been practiced and storage facilities at the mills are too limited to hold the whole crop. It is impossible to state the extent to which either of these facts is responsible for the other. There obviously are two requirements that storage must meet: It must preserve the quality of the fruit and it must be economically feasible. Several types of farm storage structures have been used. The corn-crib-type house with wire-mesh side walls has apparently been most popular. A common method of keeping fruit without a storage structure is that of suspending it in bags in the crotches of the trees. This method is limited to whole fruit. Before all the crop could be harvested with a mechanical harvester-huller, more and better storage and drying facilities or more processing capacity would have to be built. A recent survey of storage facilities at oil mills in the United States by the Production and Marketing Administration shows that the tung industry in 1951 had the capacity to store 15,000 tons of tung fruit. This is enough to keep the existing mills running about 35 days at their customary rates.[6]

The milling season for the fruit extends from about November 1 until about July 1, the bulk of the crop being marketed from November through May. (See table 6) The Maximum practical length of the milling season is dependent upon how late in the summer it is feasible to store the fruit.

Transporting the fruit from farm to mill is almost all done by truck. The exceptions are rail shipments from a few isolated locations. One exception is Texas fruit moving to Louisiana or Mississippi mills. Some producers have their own trucks. Others have their tung fruit hauled by commercial trucks, mill trucks, or by the trucks of other farmers.

The mills buy tung fruit on a "delivered basis," and so transportation costs are paid by the producer. The best available information on cost of hauling from farm to mill indicates that the

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[5] U.S. Dept. of Agr. Field Laboratories for Tung Investigations, Bogalusa, La. A Letter to Tung Growers Council of America, dated April 1, 1949.

[6] Daily milling capacity is variously estimated from a minimum little above actual production to a maximum of 800 or 1,000 tons in 1951.

average cost was about $2 per ton of fruit for the 1947 and 1948 crops. The usual charge was by zones. An area of a 30 to 50-mile radius from the mill was considered as zone one, and a new zone was added for each 50-mile increase in radius. A usual charge per ton was from $1.50 to $2 for zone one and $1 extra for each additional zone. In 1946, the maximum distance from farm to market in the four eastern tung belt States and eastern Louisiana was about 50 miles. There has been some cross hauling or movement of fruit to mills a greater distance away than the nearest mill but this has not been significantly large.

Until recently, growers were usually able to sell outright most of the fruit to the oil mills but they did not do so in 1948-49, and have not done so in subsequent years except on a limited scale. Table 7 indicates that about 96 percent of the 1947 crop but only about 29 percent of the 1948 crop was sold outright. The remainder each year was toll-processed for the grower's account.

Reason given by mill operators for low cash purchases in 1948-49 was the uncertainty of the tung oil price for that season. In 1947-48 there was a Government support price of 25 cents per pound for the oil, but the 1948 crop had no such support. For the latter year, the mills reported being unable to sell oil for future delivery when fruit was purchased. This resulted in most mills hesitating to buy fruit but preferring to "toll" process it at a set charge per ton and to assist the producers in marketing the oil.

The price the mills pay for fruit varies by the oil content, the oil being by far the most valuable product recovered. (See table 10) The price of fruit purchased from the 1947 crop by mills that signed contracts with the Commodity Credit Corporation under the price support program was $72 per ton on a basis of 20-percent oil content.[7] The average price paid for all purchases of fruit for each crop year by mills surveyed is shown in table 7.

Oil content of most of the fruit is determined by laboratory analysis. Several of the mills maintain their own laboratories for this purpose. Others that do not have such facilities send the samples of fruit to commercial laboratories where the job is done for a fee of $7.50 for each sample analyzed.

There are instances when analysis of the raw product is done visually by someone who has had experience in tung mill operations. This method is used principally for small lots when a $7.50 charge for oil-content analysis appears impracticable.

The arrangements between mills and growers for toll milling are set up in contract form. The mills agree to process the fruit and perform other marketing services for the producer. It has been customary for several of the mills to guarantee to recover a fixed percentage (usually about 85 percent) of the analyzed oil content for the producer's account, but the percentage has varied considerably by mills and by season. Some mills contract to credit the producer's account with any oil recovered in excess of the guarantee. The mills gain title to the meal and hulls unless provision is made for the producers to retain them, in which case a different charge is made for processing. The mills perform such other services as analyzing the fruit for oil content or providing for laboratory analysis, storing the oil, insuring the oil against physical loss, serving as agent to sell the oil, providing containers, and loading the oil for shipment. There have been some exceptions to the mills' acting as agents, however, in which cases pool managers usually have been designated by the producers to perform this service. The tung price-support program of the Commodity Credit Corporation has made specific provision for the pooling of oil processed for and controlled by growers.

A small part of the crop is processed and marketed through cooperative mills. The principal differences between the producers' arrangements with cooperatives and their toll-milling contracts with other mills are that: (1) Cooperatives operate on a cost basis, whereas other mills have a set charge per ton of fruit, and (2) cooperatives market the meal and hulls recovered for the growers' accounts, wereas other mills gain title thereto.

In 1947-48, when the Commodity Credit Corporation was supporting the price of tung oil, mills were in a position to buy the fruit without great price risks. The support was contingent on the mills' paying a specified minimum to the grower for tung fruit. In 1948-49, when there was no price-support program, the mills, in the face of lower prices for tung oil, were not inclined to

[7] Premiums and discounts were provided for computing the price of fruit above and below 20-percent oil content. In more recent years premiums and discounts have been made for oil content above and below 17.5 percent, which is approximately the average oil content of whole tung fruit as delivered to oil mills.

make heavy purchases of fruit.[8] This left producers no satisfactory alternative to custom milling the fruit and selling the oil. The volume of fruit toll-processed from the 1947 crop was determined largely by the producers who were in a position to hold title to oil, as they were assured of the support price. In 1948-49, the producers wanted to sell the fruit but the price outlook for the oil, as seen by most millers, was for a downward movement. As a result, the mills were unwilling to pay a price for fruit in line with the day-to-day oil prices, and the producers were unwilling to sell for less.

Table 7 shows the total value of the fruit at the mill, total value of the fruit being based on prices for cash purchases made by the mills.

Toll processing as the alternative of cash sale of the fruit gave the producer a slightly higher net return from the 1947 and 1948 crops. The average value of the oil per ton of fruit from the 1947 crop was $77.40 at mill locations. After deducting the average processing charge of $17.06, the net value of the oil was $60.34, compared with an average of $59.79 for cash sales of the fruit. In toll processing, the oil is the only product to which the producer customarily retains title. The producers thus obtained a net gain of $0.55 per ton of fruit marketed by toll processing in 1947-48. The average value of the oil per ton of fruit from the 1948 crop was $64.05 at mill locations. The average processing charge was $12.69. The net value of the oil was $51.36, compared with an average of $48.12 for cash sales of the fruit. The producer averaged a net gain of $3.24 per ton of fruit marketed by this method in 1948. There was significant variation, however, in the quantity of oil recovered per ton, the charge for processing, and the cash price that mills paid for the fruit. These factors cause the advantages of toll processing to vary from one mill to another. Also, the market price of oil fell in 1947-48 after the peak of the season and rose in 1948-49 during the corresponding period. Another season the picture might be reversed, if the price of oil were to drop rather than rise during the season. Because the grower in recent years has had most of his fruit toll milled, he has taken over from the miller the risk of price change.

Tung Mills and Mill Operation

Under the contracts usually written by the tung mills for the toll processing of fruit, the processing charge can well be considerably less than the mill cost or "factory cost," of processing since the contract now in use gives the hulls, meal, and foots to the processor.[9] These byproducts are likely to receive scant recognition, however, except under active competition between the two methods of marketing.

Before 1947, toll processing of tung fruit was uncommon, and no particular inducement was offered the growers by most mills for marketing their tung crops in that manner. As this practice would suggest, average mill cost and average toll-processing charge in 1947-48 were practically identical. The average toll charge reported was $17.06 per ton of fruit and the average mill cost reported was $17.09 per ton, before allowing credit for the meal and hulls customarily retained by the crushers.

In 1948-49 the mill managements were more aggressive in seeking toll-processing contracts. For that season, reported figures averaged $12.69 per ton for toll processing and $17.13 for mill costs, before credits.

Normally, the byproducts of processing a ton of tung fruit, according to reports obtained from mills, will include about 400 pounds of meal and about 10 pounds of foots. The 1,000 pounds or more of hulls may have a small but uncertain value. Some are sold, some are burned as fuel in the mills, and some are spread on the orchards or are ground into fertilizer. Any net value above their cost of utilization is difficult to demonstrate, however, and no significant value can be assigned to them as a normal figure. Most contracts guarantee recovery of 85 or 86 percent of the oil content of the fruit for the grower's account. An 86-percent recovery from fruit containing 17.5 percent of oil would give approximately 301 pounds of oil from a ton of fruit. Calculated from figures reported to the Production and Marketing Administration by the tung mills, oil recovery was 308 pounds a ton in 1947-48 and 314 in 1948-49. Average price of tung oil a pound at mills was 25.13 cents in 1947-48 and 20.43 cents in 1948-49. Foots were valued at 12.5 cents a pound. Meal was valued at $22.50 a ton in 1947-48 and at $16.41 in 1948-49.

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[8] The price of tung oil in drums, carlots, New York City, January 1947, averaged 39.5 cents per pound; August 1948, it was 22.0 cents.

[9] In tung oil processing the term "foots" refers to the residue from the filter press or the settling tank.

On the basis of these quantities and prices of byproducts and the quantity of oil left in the possession of the processor, the average mill costs, byproduct values, and toll charges in processing tung fruit for the two seasons appear to be as follows:

		1947-48 Dollars		1948-49 Dollars
Toll Charge		17.06		12.69
Value of products retained by crusher:	Dollars		Dollars	
Hulls	0		0	
Meal, 400 lb	4.50		3.28	
Foots, 10 lb	1.25		1.25	
Excess oil, 7 lb. and 13 lb.	1.76		2.66	
Total		7.51		7.19
Gross return to mill from toll processing		24.57		19.88
Deduct processing cost, before credits		17.09		17.13
Net return from toll processing		7.48		2.75

In 1948-49 there were 12 tung mills in operation in the Belt, including two cooperatives. Their locations with respect to source of fruit are shown in figure 10. Their greatest concentration was in the Mississippi-Louisiana area where roughly two-thirds of the tung trees in the United States are located. Production of fruit in this area shows a more rapid rate of increase in the past decade than is shown in any other area of comparable size (See table 1.)

The period from 1928-29, when the first mill began operation, until our entry into World War II in 1941, saw the most rapid growth in number of mills. In 1941-42, there were 11 mills in operation (5) compared with 12 mills in 1948-49. Several were built during the latter period, but as a number were destroyed by fire, there was a net increase of only one mill. Increase in total capacity of the mills is calculated from 1943 only, because of limitations of data. The increase in milling capacity since 1943-44 has not been as rapid as the corresponding increase in production. (See fig. 3.) This has resulted in lengthening the milling season. (See table 8) Assuming that monthly milling capacity is that volume of production attained by the industry during the high-production month each year, one can readily see that the milling industry has not utilized its facilities fully.

The length of the milling season is limited by the storability of the fruit. Biological changes in the fruit are accelerated by increased temperatures as the summer months approach. This makes the oil more difficult to recover late in the season. As July 1 is about the latest practical date of storing the fruit under present methods of handling the fruit, and with present knowledge of methods of processing, the milling season is limited to about 8 months beginning around November 1, shortly after harvesting begins. However, as the season is shorter for most mills and as the processing rate is below capacity, the short-time problem in the milling industry is not one of lengthening the potential season. It is rather that of attaining fuller utilization of present milling facilities by increasing both rate of operation and length of actual operating season to more nearly the maxima now feasible.

Screw-press extraction of the oil is the method used now, and is the only mechanical method that has been used. Considerable effort has been made towards developing a solvent method, but at present this method is confined primarily to recovering the oil from foots. Some mills sell their foots for solvent extraction rather than extract the oil from them by the screw-press method. The solvent method apparently has some advantages but at present not a net advantage, and it is not clear that it would be any more successful than the screw-press method in extracting oil from fruit stored a long time in summer weather.

The products recovered from tung fruit are: Oil, meal (press cake or pomace), and hulls. The yield of each product per ton of fruit varies considerably, depending upon such factors as original oil content of fruit, portion of oil content that is recovered, and loss of moisture and other nonrecoverable matter.

A ton of air-dry fruit (fruit with 15-percent moisture content) will yield, under average oil-mill operation, 40 to 45 percent of hulled fruit, or 800 to 900 pounds, leaving 55 to 60 percent of hulls, or 1,100 to 1,200 pounds (13). Considering the midpoint as representative, a ton of air-dry fruit will yield 850 pounds of hulled fruit, and 1,150 pounds of hulls. The hulled fruit will contain about 8 percent moisture, or 68 pounds,[10] and the hulls will contain about 20 percent, or 230 pounds. As the moisture content of the fruit varies the pounds of hulled fruit a mill gets from a ton of whole fruit also varies because of the different amounts of moisture which the kernel and the various segments of hull absorb (8).

Tables 9 and 10 show the average yield of each product per ton of fruit processed and the total volume and value of products utilized from the 1947 and 1948 crops. From these tables it can be seen that the oil is by far the most valuable product. If fruit has an average oil content of 17.5 percent (4), and recovery runs about 86 percent, the increase in oil yield per ton of fruit with perfect recovery would be about 49 pounds. According to the best analysis available, the 49 pounds of oil represents about 14 pounds in the hulls, 5 pounds in the foots, and 30 pounds in the meal. According to these assumptions, the meal has a 7.5 percent oil content. If the oil content of the foots is required to make up the 86 percent of oil content guaranteed to the grower, however, 35 of the 49 pounds residual oil would be represented by an 8.75 percent oil content in the meal. In soybeans and cottonseed crushing by screw presses, the oil content is usually reduced to a level well below the 7.5 percent figure. So complete a recovery of oil from tung fruit is widely recognized as especially difficult. Recovery of one-half of this residual oil would have added $5.19 per ton to the product value of the 1947-48 and 1948-49 crush. (This figure is based on approximate values per pound for those years of 1.1 cents for meal and 22.2 cents for oil.)

Integration in the Tung Industry

All the tung mills have been built by tung fruit producers, and in many cases they have been built and maintained primarily to process the owner's production. However, the relative importance of mill-integrated production shows a downward trend.

As a result of integration with tung orchards the mills have been integrated with other farm enterprises. These usually have been specialties, and one that has been very popular is livestock and especially beef cattle and sheep production. Nonfarming integration of tung milling has occurred with saw milling, naval stores production, piling treating, sirup production, and processing other oilseeds. Processing of other oilseeds, however, has been of very minor importance to the tung industry as a whole.

Integration has occurred also with various businesses utilizing tung oil, such as paint and varnish and electric motor manufacturing, and with fertilizer mixing in which meal and sometimes hulls are used. During the period studied there were only two mills in the industry that were not integrated with some other business activity.

Advantages offered an integrated mill are: (1) Better use of labor and other facilities such as office space and equipment, office force, power plant, storage space, credit contacts, and management and (2) transfer of tung mill products to an industrial user essentially without buying or selling cost.

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[10] Consensus of opinions of mill operators and officials at the U.S.D.A. Field Laboratory for Tung Investigations, Bogalusa, La.

ANALYSIS OF PROCESSING COSTS

Economic analysis of tung processing is handicapped by the prevalent integration of the tung-oil mills with other enterprises, particularly the production of tung fruit. Various joint costs and services have to be divided between the mill and some other enterprise. In the case of intergration with tung orchards or tung-oil-using enterprises, it is also necessary to estimate values of commodities that are at the same time products of one part of the business and raw materials of another part. Today not more than three or four nonintegrated mills exist from which such costs and values might possibly be judged. Very useful estimates can nevertheless be calculated for purposes of analyzing oil-mill practices and costs.

Processing costs were studied under the present project on the basis of average cost per ton of fruit processed. They were broken down into types of costs, and the variations and interrelations of these types were studied. The major items segregated, in order of importance, are (1) labor; (2) fuel, power, and light; (3) salaries; (4) supplies and repairs; (5) miscellaneous and administrative; (6) plant depreciation; (7) insurance; and (8) taxes and licenses. Average costs by type are shown in figure 3.

The average moisture content of tung fruit as received at the mills, computed from mill reports, was more than 23 percent. In order to express cost in terms of processing a standardized ton of fruit the tonnage has been adjusted to an "air-dry" basis, that is, 15 percent moisture content.[11] This adjustment results in showing costs per ton 9.8 percent higher than they would be if based on the moisture content of the fruit when received by the mills.

Variation was great in processing cost figures for tung mills in 1947-48 and 1948-49. The average for the 2 years for the mills surveyed was a little more than $17. (This cost figure cannot properly be compared with the toll charge for extracting the oil until by-product value has been deducted from total cost.) The range of costs between the highest-cost and lowest-cost mills was nearly $18 as reported by the mills. Two-thirds of the mills had costs within about $5, or 30 percent, of their average. Costs in some mills, however, were nearly three times what they were in others. From these facts it seems obvious that there is opportunity for many of the mills to increase their efficiency and reduce their costs. Table 11 summarizes the variation in tung processing costs and cost items between the individual mills for the 1948-49 season.

The best indications are that, although average costs rose by roughly $1.90 from 1947-48 to 1948-49, the range of costs for individual mills did not change significantly. The pattern of variation in processing costs indicated that costs tended to vary with size of operation but the correlation between the two was not close. Also, as volume of production increased the variation of costs among mills became less. Costs appear to become more erratic as the volume of business of a given tung mill decreases. This suggests that the mills are operating at less than their most favorable volume--sometimes at far less. This tendency is seen in comparisons of identical mills for 2 years as well as in comparisons of different mills for 1 year.

Variations in total costs agreed more closely with variations in current costs than with those in fixed costs. This may appear logical because current costs on the average make up 57 percent of total processing costs, whereas fixed costs make up 43 percent. However, the more erratic variation of higher costs seems to result mostly from the behavior of fixed costs. Even at relatively low cost levels, the fixed-cost category shows more variation than do current operating costs. The 43-57 ratio between these two cost categories suggests a greater opportunity to lower processing costs by lowering current costs than by lowering fixed costs.

[11] Tung fruit with 15 percent moisture is considered "air-dry." According to the concensus of members of the milling industry and the USDA Field Laboratories for Tung Investigations at Bogalusa, La., a ton of air-dry fruit, on the average, contains 15 percent moisture by weight, from which mills average a recovery of 800 to 900 pounds of hulled nuts which contain about 8 percent moisture by weight. In crushing, cooking, and conditioning the fruit for oil extraction, the moisture content is reduced to an average of 4 percent moisture. These weights and weight losses calculated against the pounds of products recovered by the oil mills was the basis for adjusting production to tonnage of fruit at 15 percent moisture content. More recent research at the laboratory seems to indicate that the moisture content of "air-dry" fruit may be around 12.5 percent.

A mill operator may more frequently find ways to lower current costs as they are committed for shorter periods, and some of them can be controlled from day to day. The wider variation of fixed costs, in relation to total costs, is somewhat misleading because it can result from changes in current and total costs as well as in the fixed costs themselves. As volume of fruit crushed varies, gross current costs obviously tend to vary likewise, and as total cost thus changes, the ratio of fixed costs to total costs changes in the opposite direction.

Comparison of Current and Fixed Costs

The average current cost chargeable to a ton of tung fruit in 1947-48 and 1948-49 was $9.33. The range between the two extreme mills was $12.43, two-thirds of all mills falling within 35 percent of the average. For fixed costs, the corresponding figures are: Average $7.09 and range $8.49, two-thirds of all observations falling within 38 percent of the average. Thus average current costs appear to be nearly a third larger than fixed costs, and the two show a similar degree of variation.

There is further similarity between the current and fixed cost categories in that their variations fail to correlate with variations in certain major mill characteristics. Size of mill is one such characteristic. The nature of the two classes of costs is so different, however, that one must expect many divergencies in relationship. And that does prove to be the case.

The volume of fruit processed showed no consistent effect on either current or fixed costs per ton. This is a point of considerable importance. Furthermore, it is supported by other measurements that greatly increase the trustworthiness of this finding. It might be expected that some very small mills would operate with too small a volume of business to utilize their equipment economically. These is a size below which commercial equipment simply is not available. Such an explanation cannot properly apply in the case of a mill larger than the smallest. For example, when a mill operator has installed two presses instead of one, he obviously is not holding his total fixed costs to a minimum. Yet, these larger mills seem on the whole to have fitted the size of mill to the tung fruit supply no better than have the smallest mills. A partial cause undoubtedly is the fluctuation in size of the tung crop. Not only does the crop vary greatly from season to season but research and experimentation are continually teaching both how to increase production and how to decrease the number of crop failures. Experience has justified the expectation of an increased supply as a result of the application of this increasing knowledge. Probably even more important is the fact that most mills have been built on the assumption that the crop would be greatly enlarged by continual expansion of tung growing. To date experience has also justified this assumption. (See figure 1 for increase in production.)

Larger mills and fewer hours of operation per season reduce storage requirements and permit greater physical flexibility in the use of mill labor. Regardless of size of mill, however, there has existed the necessity to process the fruit when available. That often has meant maximum operation in good weather and little or no operation in protracted periods of bad weather because of lack of fruit.

A major factor in the cost of processing tung fruit has been the short operating season. It was stated earlier that with present techniques of storage it appears impractical to store the fruit later than about the end of June. That makes the maximum length of processing season about 8 months. Most of the mills do not, in fact, operate nearly that long. The length of season was estimated by mill operators for 1947-48 and 1948-49 in days, and averaged 136 days. Converting this average to months is a matter of judgment, and depends on the number of operating days assumed per month. On the basis of cottonseed-mill operation as reported to the Bureau of the Census, 136 days is the equivalent of about 5 3/4 months.

Comparison of fixed costs with tons of fruit processed per press during the season showed a decrease of 20 cents in fixed cost per ton with each 100-ton increase in fruit processed per press unit. A part of this variation will result from differences in daily operation, both through (1) efficiency of equipment and labor utilization, and (2) the degree of completeness with which the oil is removed from the cake. Another important part is due, however, to variation in the length of actual operating time per season. Either longer seasons (with improved storage) or managerial ingenuity to operate more days per month or more hours per day will help most mills to absorb any likely increase in supply of fruit without adding to the amount of major equipment. Success in this task will bring corresponding decrease in fixed costs per ton.

In relation to varying lengths of season, practice is not uniform as to either the number of hours (or shifts) operated per day or the number of days operated per week. From interviews with mill operators it appears that most of these variations are considered and intentional.

Except for special circumstances, such as unusual weather, they depend mostly on an economical balance of fixed and current costs. When other conditions remain unchanged, the fixed capital and administrative outlays make the most economical contribution if they are spread over continuous full production. But increase in current cost may prevent this. In some cases the rates and terms of Sunday work are such that any saving in fixed cost per ton is more than offset by increased labo cost. This comparison is less important but not discredited if the supply of fruit for the season is already set. Also, cases were reported where the unwillingness of labor to work over week ends and holidays so greatly decreased the production per man-hour that again the higher current cost per ton of fruit processed more than offset any economy in fixed and administrative costs.

Although current costs for individual mills were scattered less widely than fixed costs, relative to their respective averages, their range in dollar terms was much greater--$12.43 for current costs and $8.18 for fixed costs. Labor cost was by far the most important single category of current cost, and in many instances it appeared to vary quite independently of other current costs

Volume of Fruit Processed

In any attempt to increase efficiency a vital question is which particular costs tend to cause or indicate high, or low, total costs. The accountant wishes to classify costs in the two groups: (1) Those direct, or current, costs that apply to each unit of production, and (2) those indirect, or overhead, costs that have to be met regardless of production. But because not all indirect costs are absolutely "fixed," the manager's interest obviously is to examine every individual cost in relation to over-all efficiency.

Because of the small number of mills, data could not be classified here to show the effect of all these different practices on costs without disclosing information for some individual mills. Furthermore, physical costs are not in practice broken down and accounted for by each job. Nevertheless, a great deal can be learned regarding the important factors.

Processing costs per ton and volume processed were correlated negatively[12] with each other, but not closely. Of course, the factor of volume encompasses mill size, operating rate, and length of operating season. Substituting the volume processed per press during the season disposes of size of plant, and shows a considerable dependence of cost on the volume that each press handles during the season. When data for only the mills that were under the same management were compared there appeared a still greater reduction in costs with increased production. The latter comparison is made on the basis of fewer data, but is presumed to eliminate a major part of the management variable.

Several types of measurements have been used. One is the volume of fruit processed per dollar (or per $1,000) of plant value. It was found that with higher volume relative to plant value, costs decreased. Despite the rather rough proximation that it was necessary to use for plant value, the resulting correlation coefficient between volume per $1,000 of plant value and cost per ton was 0.717 indicating statistically that variation of volume was responsible for perhaps 50 percent of the variation in costs. Volume of fruit processed per $1,000 of plant value average 35 tons, and its variation indicates that with each increase of 1 ton in fruit processed per $1,000 in plant value cost of processing decreased by 16.5 cents per ton.

Additional factors examined included the following in various combinations and variations: (1) Number of days operated per season, (2) tons processed per day, (3) number of press units, (4) tons processed per press unit per day and total, and (5) tons processed per man-day and total.

Production per day operated varied in 1947-48 and 1948-49 by about 90 tons, about 3 times th average daily production. This factor covers both size of mill and its rate of operation, however and to eliminate size, production per press-unit per day was substituted for total daily productio

There was no clear indication of variation in cost with number of press units. Such a relation ship is suggested in certain parts of the data but the small number of mills studied permits no definite indication. Also, the number of days operated during the season affects the average daily productivity of each press. In other words, the production per press-unit per day decreased somewhat as the operating season was lengthened. It is clear that for these mills the degree to which each press was utilized was more important than was the number of units operated.

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[12] Costs and volume varied in opposite directions.

In fact, the data analyzed here fail to show that total processing costs vary in any significant way with size of mill. Such measures include value of plant and number of presses (or press units). The rate of operation, on the other hand, determines to a very important extent the efficiency with which the plant is utilized, and its costs.

There is, of course, a close limitation on the extent to which the rate of operation can be varied at will in tung milling. With the accelerated rate of planting in recent years, it is to be expected that a greater volume will become available to the mills as the orchards come into bearing. Except, or until, that happens, however, an increased rate of operation can only mean fewer days of operation per year.

As the data stand, it seems probable that even with the season's crush already determined it still would pay the mills to concentrate their processing into shorter seasons, thereby gaining an advantage from a higher rate while actually running the mills. The extent to which this represents a practical possibility cannot be determined from information now available. If the entire crop could be made available early in the season, the plants might simply be closed down earlier in the spring. That, in turn, would require better storage than has been available. A shorter season could be obtained by closing down periodically during the winter. Ordinarily, however, that would result in great inefficiency of labor. In brief, the mill managers may have found as good a balance of operating rate and operating time as the current limitation on supply permits. Fixed costs remain the same regardless of moderate shifts in rate of operation and length of season. Insofar as new plantings increase the fruit supply, it appears that the increased efficiency of a higher rate and a longer season may be attained, provided the plant capacity is not expanded.

Another major factor in the processing cost is the efficiency of labor. For the mills studied the volume of tung fruit crushed per man-day in 1947-48 and 1948-49 combined average 1.22 tons. Measured statistically, each processing increase of 100 pounds per man-day accompanied a cost decrease of 39.6 cents per ton. Something of the ways in which the production per man-day is controlled or influenced, is indicated by the factors with which man-days are correlated. The most important of these are: Daily volume of production, production per $1,000 of plant value, number of days per operating season, and tons processed per press-unit per day. Each of these factors increases or decreases as production per man-day increases or decreases. It means that the hours of labor per ton, and in a great majority of cases, the labor cost per ton, decreased as more production was gotten out of each press each day, the mills operated more days per season, and--reflecting both of these in a general way--more production was obtained per season from each $1,000 of plant value. In the data studied here the size of mill did not show any effect on either the amount of labor or the cost of labor per ton of fruit processed.

These factors that influenced (or varied with) labor costs, similarly influenced other important cost categories and the total of processing costs. For both years together average mill labor cost was $4.48 per ton, representing 48 percent of current costs, and 26 percent of total costs. It varied about its average in such a way that two-thirds of all cases fell within $1.62 of the average. Furthermore, the variation in mill labor costs accounted for 24 percent of the variation in total processing cost. (See table 15.)

Number of Days Operated Per Season

Number of days operated and operating costs were negatively correlated, but only slightly. The coefficient of correlation was -0.29. Statistically, this degree of relationship is considered "nonsignificant." The statistical test of significance, however, takes no account of the repetition of occurrences (or similar occurrences) with parallel results. When these occurrences are considered, the correlation of number of days operated and operating costs does appear to acquire some significance. There are many parallel findings in cottonseed-oil mills and elsewhere. Figure 4 shows that in the year of higher production, costs were lower. In the year of higher production the mills also operated a longer period. The greater production for an individual mill resulted largely from the longer season's operation and obviously the number of days operated and production were positively correlated and both were negatively associated with costs. Days operated were negatively correlated with all cost categories except salaries and taxes and licenses.

Number of Press Units and Daily Production Per Unit

There was no clear indication that number of presses or press units was correlated significantly with costs. This result was about the same as for other measures of size. How fully the press units were utilized was a more important factor affecting costs than was number of press-units.

Production per press-unit per day operated and costs were negatively associated, that is, as production increased, costs decreased. One ton increase in production per press-unit per day was associated with a decrease of 88 cents per ton in processing costs. For an increase of 100 tons in the season's production per press-unit there was a decrease of 60 cents per ton in processing costs.

Production Per Man-Day

Production per man-day and costs were negatively associated. For an increase of 1 ton in production per man-day there was a decrease of $7.91 per ton in total processing costs, and for each change of 1 ton in the total tons processed per worker per season there was a decrease of 8 cents per ton in total processing costs. These factors are significantly correlated with all items of processing costs.

Oil Outturn Per Ton of Fruit

Amount of oil recovered per ton of fruit tended to increase as processing costs decreased, but this trend is not supported by other analysis. In fact, most of the statistical comparisons made indicated that the amount of oil recovered and the total processing costs increased and decreased together. When other factors are held constant, this result is to be expected. In fact, it is so surely to be expected that this statistical comparison is important principally as a check on the data used. Except as the results depend on varying oil content in the fruit, or on varying degree of moisture, grind, and other physical characteristics of the prepared kernels, cost must vary with oil obtained.

A 20,000-ton sample of tung fruit representing 52.2 percent of the tonnage marketed in the Texas-Louisiana-Mississippi area from the 1947 crop averaged 17.6 percent oil content, most of the tonnage ranging from 15 to 20 percent. However, the over-all range was from 8 to 24 percent (4). It is apparent, then, that oil recovered per ton will vary independently of efforts and costs.

Hulling experiments (9) have shown that a significant percentage of the oil can be lost by hulling when the fruit is too dry. This loss ranged from 0.63 percent of the oil when fruit contained 15.4 percent moisture to 3.13 percent when the fruit contained 12.9 percent moisture.

Early experiments (13) showed that the pressure during mechanical oil extraction operations could be varied, and screw-presses commonly are adjusted to what the superintendent considers the most favorable cost-yield relationship. These adjustments undoubtedly result in variation of effort and costs. Also the fineness and uniformity of preparation of the kernels before oil extraction is an important factor affecting the efficiency of oil recovery (10).

When the more important comparisons are brought together tung-processing costs appear to depend largely on the volume processed per day by each press and by each mill worker. Length of season also has an important effect, but not entirely in addition to the influence of daily production rate. This is because, on the average, each lengthening of season is accompanied by a slight decrease in the daily rate of operation, both per press and per man.

Either an increase in rate of production or a longer season should be advantageous. Improvement in both directions at the same time would be the ideal way to lower current costs, and there is reason to believe this can gradually be brought about. A major need is for more careful plant management particularly as to the integrated use of labor in the mill and affiliated enterprises. Lowering of fixed cost will not be accomplished, however, without increased economy in administrative costs, including salaries, and increased resistance to the tendency to expand plant in advance of requirements. These lines of economy or increase in efficiency are bound together. Little can be expected in increased plant economy without greater efficiency in the use of labor, which in turn requires improved efficiency in the planning and management of operations.

Current cost represents 57 percent of total cost for the average mill and its variations influence the total cost more than does fixed cost. Current cost is influenced more by labor cost than by any other type. Fixed cost varies relatively more than current cost, presumably because many of its items are "uncontrolable" except over somewhat extended periods of time. Throughout the analysis little evidence has been found that size of mill has any significant influence on costs per ton of fruit.

To test further the reliability of the tung data studied and the conclusions drawn, several comparisons have been made between the tung mill data and corresponding data for cottonseed oil mills of parallel mechanical construction.

COMPARISON OF TUNG AND COTTONSEED PROCESSING INDUSTRIES

The small number of tung oil mills has made statistical analysis difficult. Furthermore, comparable data are not available on the processing of other oilseeds in the drying oil field, such as flaxseed and castor beans. However, comparable data are available on the processing of cottonseed by the screw-press type of mill located in the same general region as the tung mills. The comparison of these two processing industries, although limited, gives a better understanding of the tung industry and its problems.

The tung processing industry differs from the cottonseed industry in size, location, and age; and these differences affect the levels, the composition, and the variations of processing costs. The tung industry, only a small fraction of the size of the cottonseed industry, is restricted to a far smaller geographical territory, and has a lesser variation in size and age of mills. These differences can be expected in general to give the tung industry narrower variations among individual mills but at the same time less stability of industry-wide averages.[13]

Both of the industries are seasonal and they are affected somewhat similarly by this factor. Actually the tung industry has been more seasonal than the cottonseed industry. Reports to the Bureau of the Census show that tung oil is produced in each of about 8 months of the year, whereas there is some production of cottonseed oil every month of the year (12). Indications in both industries are that increases in length of season usually decrease the cost per ton for processing.

An expensive operation performed by the cottonseed-oil mills for which there is no parallel in tung processing is the removal of linters (2). Whether or not this delinting operation increases the year-to-year cost variations in cottonseed processing is not certain.

Tables 12 through 16, show several of the more pertinent characteristics and interrelations found in the tung data, together with similar data for cottonseed-oil mills.[14]

For all practical purposes the only method of extracting tung oil is by the use of the screw-press, but in the cotton seed industry three methods are used, namely, hydraulic, screw-press, and solvent. The method of preparing the meats for the oil extraction process is closely comparable for tung oil mills and screw-press cottonseed-oil mills.

Yield of hulled fruit per ton of tung fruit is approximately 850 pounds, as compared with more than 1,200 pounds of hulled seed per ton of cottonseed. Average screw-press capacity figures for tung fruit and for cottonseed, as given by two leading manufacturers of screw-presses, correspond approximately with these yield figures. However, the mills recover approximately the same average quantity of oil per ton of tung fruit and cottonseed. These facts check with the common assumption that the time required to extract the oil from oilseeds is principally dependent upon the quantity of material put through the press rather than upon the quantity of oil recovered.

For comparison of cost variations between the tung and cottonseed processing industries, rather than comparison of actual costs, it appears justifiable in many instances to use information for the cottonseed processing industry as a whole, rather than for the screw-press mills only.

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[13] For a comparison of size and location of the industries see table 1 and figure 1 of this report and Brewster, John M., Cottonseed-Supply Areas, table 2 and fig. 4, pp. 9 and 13; PMA, Washington, D. C., May 1950. For our purposes here, location of seed production and of mills is the same.

[14] Table 13 compares several characteristics and costs for tung-oil and screw-press cottonseed-oil mills. Table 13 narrows the cost comparisons to tung and cottonseed-oil mills geographically, by using cottonseed-oil mill data for the Southeast. Table 15 shows data used in comparing variation of cost items with total processing cost within the tung and the cottonseed industries. Table 16 shows statistical coefficients indicating the extent to which each of the individual cost items can be expected to contribute to the variation in processing costs.

The general similarity of the figures for the two industries has the appearance of closely related series, and comparison of individual pairs of items shows the degree of divergence in specific respects. It is apparent that differences between sectors of the cottonseed industry are as great as those between the cottonseed and tung industries.

Variations in processing costs as found here for tung mills appear to be distributed between current and fixed costs in about the same proportions as among all cottonseed oil mills in the United States.

Current-cost variations comprised 57 percent of the variation in total costs for tung mills in 1947-48 and 1948-49 and for cottonseed-oil mills in 1947-48. In 1948-49 the figure for cottonseed-oil mills rose to 58 percent.

The current-cost variations themselves for both industries are made up in major part by labor and fuel.

Labor Costs

Man-hours of labor per ton of fruit or seed as reported to the Bureau of the Census for the calendar year 1947 varied much less in the tung mills than in the cottonseed-oil mills. This variation appears to be largely accounted for by the fact that the cottonseed-oil mills are located over a much wider area. An examination of data for cottonseed-oil mills of all types shows that the mills in the Southeast and the Valley required more man-hours of labor per ton of seed than mills in the Southwest but that the labor costs were somewhat equalized by differences in wage rates paid. The range in labor cost was less in each of the three major areas than it was for the Cotton Belt as a whole.

Difference in labor cost between high-cost and low-cost cottonseed-oil mills contributes well above one-half of the whole current-cost variation; in the tung mills it contributes little more than one-fourth. Most of the correlation between labor cost and total processing costs for the tung series is due to one or two observations and appears in only 1 of the 2 years studied. In tung milling the high-cost operators appear to have paid out but little more for labor than did other members of the industry, whereas the cottonseed-oil mill managers who operated on a low cost relative to the rest of the industry saved on labor cost in about the same proportion as they did on total cost. There was a variation in labor costs for the tung mills, it is true, and furthermore, it corresponded to a considerable extent with the variations in total current cost. On the average, however, it had little influence on the systematic variation of total processing costs.

In the cottonseed-oil mills using screw presses, the average wage rates and labor costs were higher than in the tung-oil mills (table 13). Despite the difference in level, however, the variation in wage rates was similar for the two series. The man-hours of labor required to process cottonseed and tung fruit in screw-press mills are about the same when compared on the basis of quantity of material actually crushed. One explanation for higher wage rates in the cottonseed-oil mills appears to be the extension of the industry into the high-wage area of the Southwest and California. Labor-cost variation contributed 15 percent of total variation in tung processing cost, but contributed 30 percent to the variation in cottonseed processing in 1947-48 and 41 percent in 1948-49. As percentages of the variation in current costs these figures become 32, 53 and 70, respectively.

Length of Season

The difference in average length of milling seasons of these industries, and in variation in length of season within each was important because in each of the two industries length of season and costs vary in opposite directions. The fact that the season was longer and varied more in the cottonseed industry tended to cause lower costs and more variation in costs in that industry than in the tung industry (table 13).

Both number of presses and tons of seed processed (total, per press per season and per press per month) averaged higher and showed wider variation in the screw-press cottonseed-oil mills. These factors represent size of mill, length of operating season, and rate of operations, and each varied inversely with cost. Some indication of how these factors, and others, varied similarly in the tung and cottonseed industries is shown in table 16.

Salaries

The tung-mill data indicate decidedly less influence of either labor costs or salaries on total processing costs than existed in cottonseed milling. They suggest, furthermore, that salary costs are less uniformly "managed" in the tung mills than in the cottonseed mills. Management, supervision, and office costs covered by salaries often are too great or the mill accounts do not indicate what these costs actually are. Average salary charge per ton of material processed for the tung industry over the 2-year period 1947-48 and 1948-49 was $0.98 (64 percent) higher than for cottonseed. The average ratio of salaries to total cost is higher for tung processing than for cottonseed and no reason appears in the data to explain the difference. Furthermore, in the tung mills salaries fluctuate widely from mill to mill without much regard to the level of other costs. Statistically, salaries accounted for less than one-tenth of the variation in total processing cost for tung fruit in the 2 years 1947-48 and 1948-49 but in cottonseed processing accounted for more than one-fourth in 1947-48 and about one-sixth in 1948-49. Volume of cottonseed processed increased from the former to the latter year with an accompanying decrease in salary costs. Some cottonseed mills actually lowered salaries in addition to spreading them over a greater volume of business and these mills were largely from among those that formerly had salary costs higher than average.

Fuel, Power, and Water

Fuel, power, and water cost was a less constant percentage in the tung mills than in the cottonseed mills. In the tung mills the item increased percentagewise as total costs increased--just the opposite from labor costs. It accounted for nearly one-third of the cost variation in tung processing but for less than one-tenth in cottonseed processing. Furthermore, the influence that fuel cost had on current cost on tung processing was passed on to total cost. In other words, there was an observable tendency for higher fuel costs to show up in total costs rather than to be offset by savings elsewhere.

Other costs for which comparable data are available on variations in line with total processing costs are (1) supplies and repairs, and (2) depreciation. For cottonseed the fluctuation of each of these factors contributes more to variations on total cost than does fuel; in tung they are far less significant than fuel, but each is perhaps as important in this respect as salaries. Available data indicate that when a tung mill manager finds ways to reduce processing costs he can be expected, on the average, to reduce supplies, repairs, and depreciation together by perhaps one-fifth as much as total costs are reduced.

Differences pointed out here between these variations in costs (and practices) as they influence or make up total processing are believed to be significant comparisons of conditions in the cottonseed and tung-processing industries.

A significant comparison between the two industries can be made with respect to variations in the percentage of total processing costs that is contributed by each type of cost (table 14). Some items remained roughly a constant percentage of total costs when total costs changed. For example, in the cottonseed industry in the Southeast labor costs remained a fairly constant percentage of total costs as the latter increased or decreased; whereas in the tung industry there was a decrease in this percentage as total cost increased. This indicates less variation in labor cost in the tung industry than in the cottonseed mills.

Size of Mill

Relative to the cost effects of size of mill, data for the two industries do not agree. Cottonseed data as summarized from mill reports to the Bureau of the Census indicate decreasing costs with increasing size of mill. The same phenomenon is widely experienced in most lines of business. That is to say, up to some certain size, not necessarily known, a plant can gain technical advantages that will lower its operating costs by increasing in size. Eventually, however, if growth continues, a point will be reached where cost per unit will increase and net return per unit will decrease.

The relatively small size of the individual tung mills compared with other vegetable-oil mills makes it doubtful that any of the tung mills has reached such a point of least cost. Yet the tung data available show practically no suggestion that operating costs decline with increase in size of plant. This showing may be due in part to the relatively small range of difference in size of tung mills. Insofar as this is true the small number of mills and the severely limited data for each preclude showing the influence of mill size. Failure to show any influence of mill size on mill cost very probably is due in part, however, to the fact that some of the mills are larger than their tung-fruit supply warrants and for this reason have inefficiencies both in use of plant and in operation that actually increase with size of mill. This is illustrated by comparison of costs in identical mills for the two seasons covered. The data show, for instance, that a 32-percent average increase in volume of fruit processed resulted in very little increase in total fuel cost. This is a clear indication that the average tung-mill fuel plant was too large to operate most efficiently with the volume of fruit available. Also, total processing cost decreased 24 percent with this 32-percent increase in volume.

These comparisons of some of the more important relationships shown by the mill data for tung and cottonseed aid the tung-mill analysis in two respects. They demonstrate by repeated similarities (of measurements or movements) the consistent and reasonable composition of the tung data. They increase the doubt concerning one relationship that already was in question, that is, the failure of costs to decrease with increases in size of mill. In view of the small number of tung mills such comparisons are especially useful. Information from the tung-oil mills and from the mill reports to the Bureau of the Census describes the situation that existed in the processing industry, and that would be most likely to be found in another survey. The examination of tung and cottonseed processing jointly lends added support to this conclusion.

In summary, one of the greatest planning problems in the tung industry results from the shortness of its history and the consequent uncertainty as to the best engineering and management practices. Much of the mill engineering to date has been too optimistic as to the rate of expansion to expect in tung fruit production. As a result one of the greatest present opportunities to improve operating efficiency of the tung mills lies in taking advantage of the current expansion of tung orchards to improve the ratio of volume of fruit processed to investment and fixed costs. To realize the fullest benefits from such an opportunity, the temptation to mill expansion must be resisted and improvements in operating techniques must be constantly developed. The industry seriously needs a thorough and uniform study of orchard and mill costs, scientifically made on an industry-wide basis and analytically summarized. Such a study, made cooperatively by the industry and some unbiased agency, preferably in the tung States, is necessary as a guide to improvements in capital structure and operating efficiency of the mills.

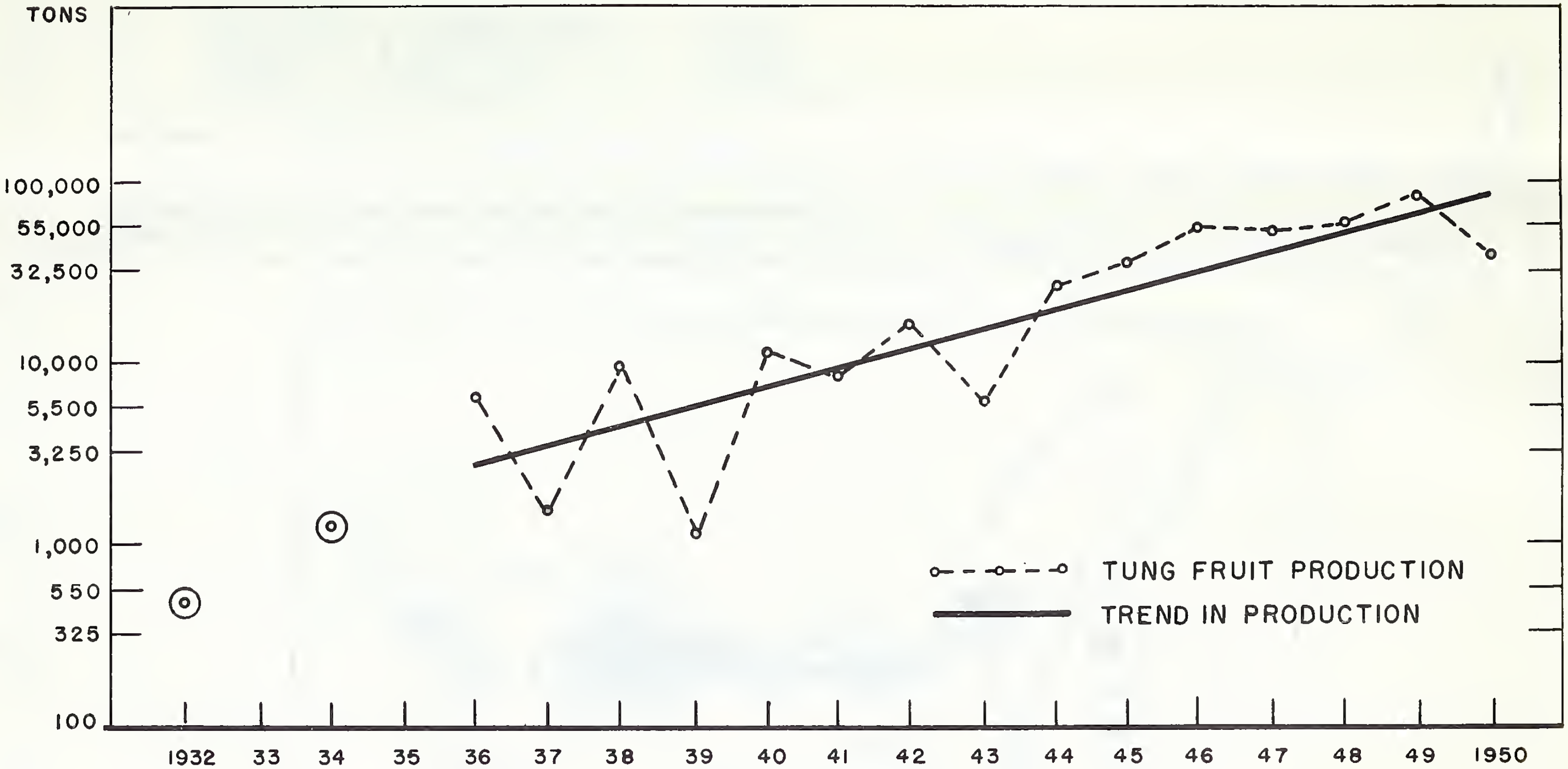

Figure 1.--Tung fruit production by years, 1932-50, and trend since 1936. The straight line trend shown on the chart represents an equal percentage change from each year to the next, or a constant rate of growth. A "logarithmic" scale is used for this purpose. Commercial production in 1933 and 1935 was zero but actual production may have been considerable. Spread of production over a wider and more diverse area undoubtedly has resulted in more stable averages. Also, with scientific study of varieties, planting, cultivation, pruning, fertilization, soils, and environment, improved production and reduced frequency and extent of crop losses became quite evident by 1940. Source: 1932-38, Tung Oil, R. S. McKinney, AIC, USDA, 13 pp. illus., Nov. 1946 (AIC-94). 1939-50, BAE, USDA.

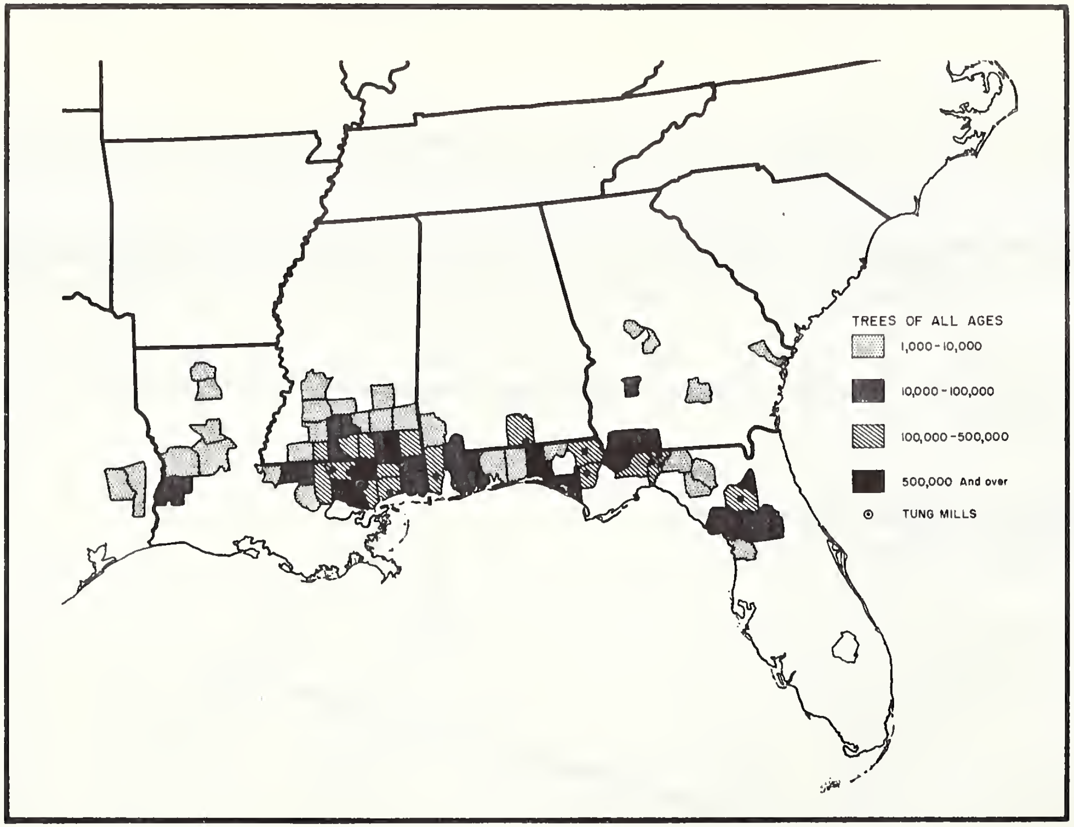

Figure 2.--Location of the tung industry in the United States: (1) Number of tung trees by counties with more than 1,000 trees each, and (2) location of tung oil mills in 1950. The tung oil mill at Monticello, Jefferson County, Fla., started operations in 1951, and is not included in the present analysis.

Within the group 100,000-500,000 trees the distribution of counties by number of trees is fairly regular. Within the group 500,000 and over, distribution is as follows:

Mississippi,	Perry County.........	675,000 trees
Florida,	Walton County	813,000 "
Louisiana,	St. Tammany Parish ..	2,163,000 "
Mississippi,	Pearl River County ...	3,408,000 "

Source: Data on number of trees from 1950 Census of Agriculture, Bureau of the Census. Information on the number of trees for the States of Georgia and Texas taken from unpublished data of the Bureau of the Census. Data on tung oils mills from Fats and Oils Branch, PMA, USDA.

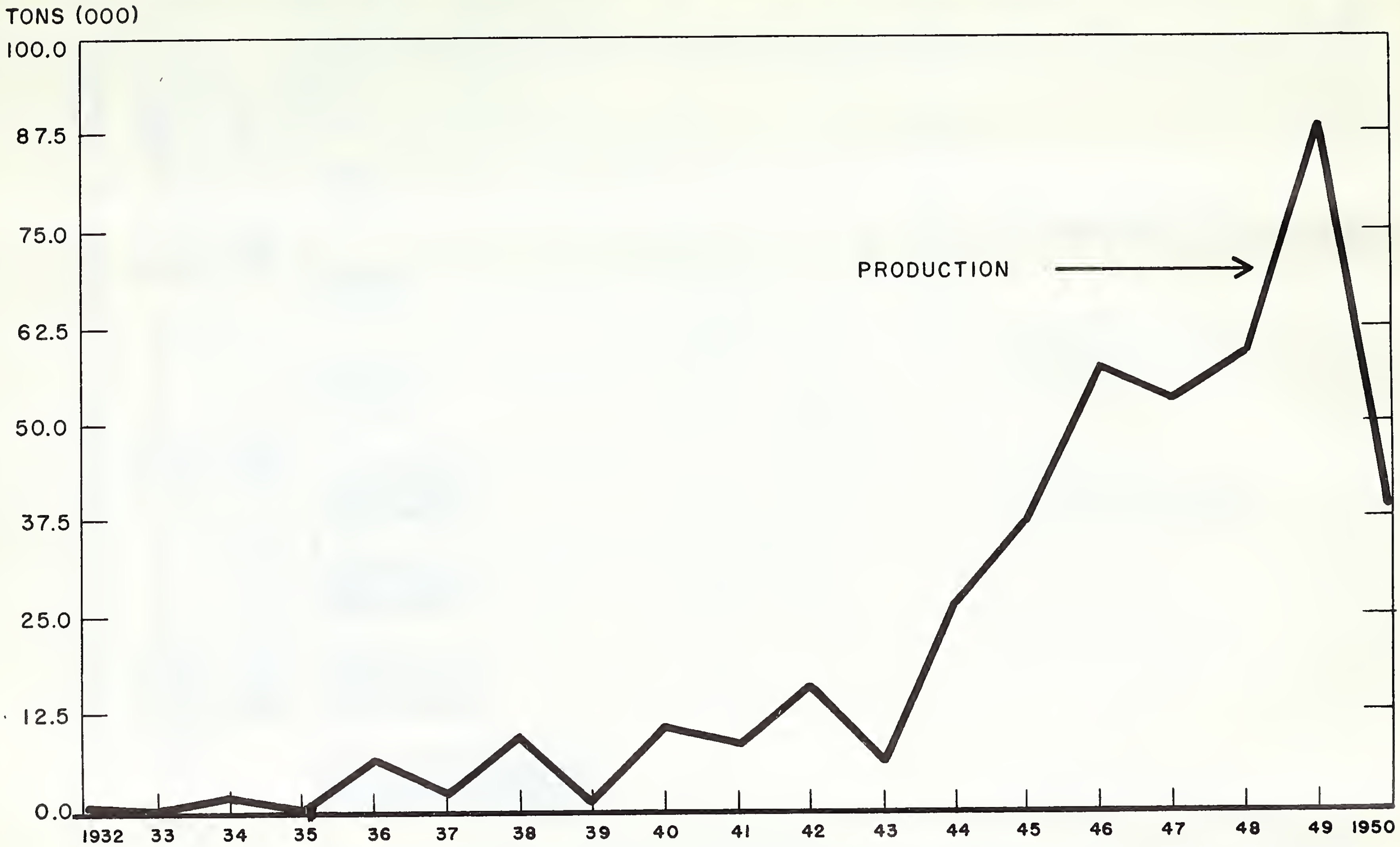

Figure 3.--Production of tung fruit in the United States, 1932-50. Tung production for the years 1932-38 compiled from Tung Oil, R. S. McKinney, AIC, USDA. Nov. 1946 (AIC-94). 1939-50 from BAE.

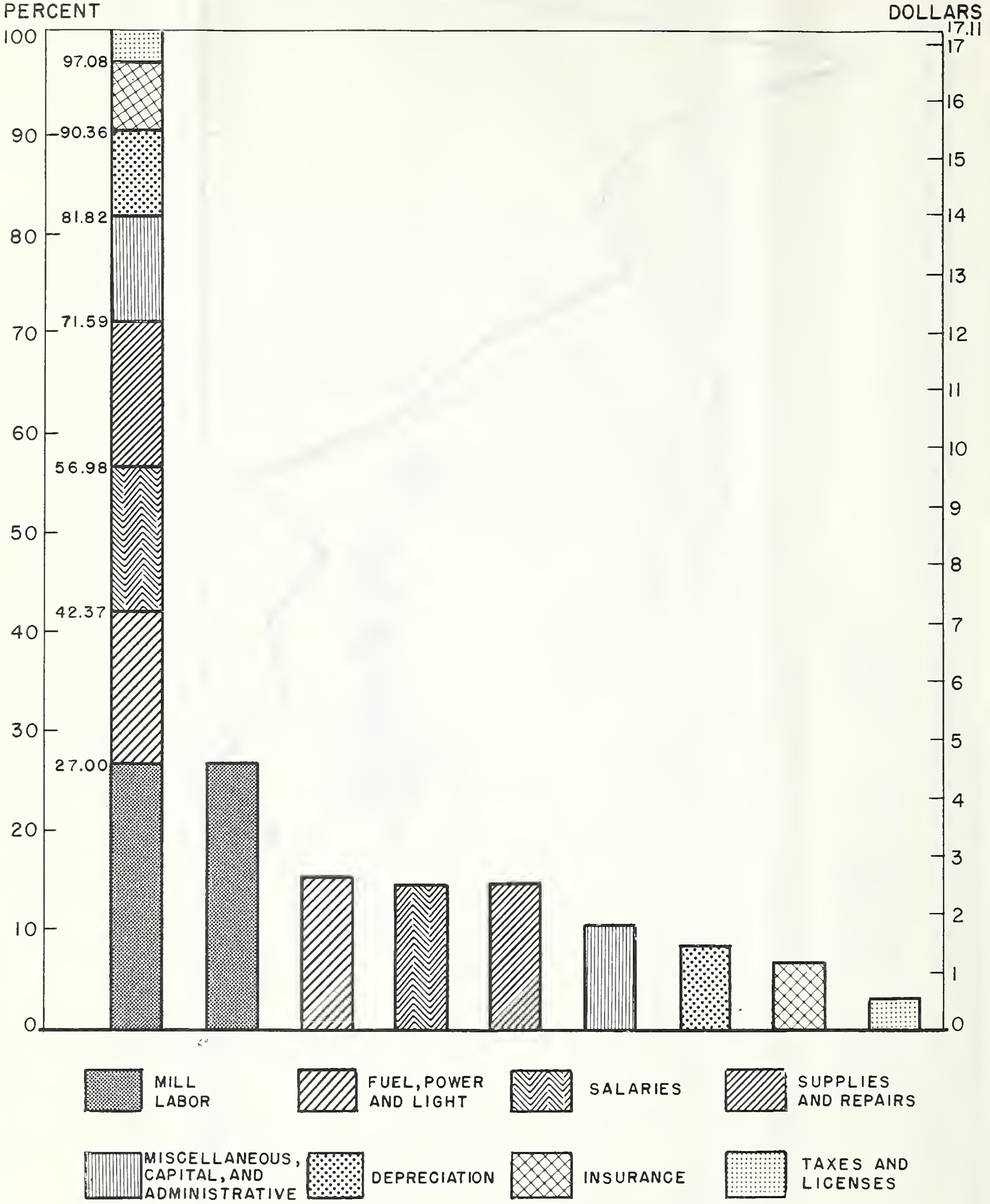

Figure 4.--Major processing costs per ton of tung fruit crushed by oil mills in the United States, in dollars, and the percentage that each item of cost is of total cost, 1947-48 and 1948-49.

Table 1.--Tung fruit production, by States and United States, 1939-51

Year	Mississippi	Louisiana[1]	Florida	Alabama	Georgia	United States
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
1939.........	425	150	550	20	15	1,160
1940.........	3,700	1,200	4,700	200	1,200	11,000
1941.........	3,700	1,800	2,250	350	650	8,750
1942.........	7,200	4,000	3,700	500	950	16,350
1943.........	1,940	3,260	700	100	200	6,200
1944.........	10,630	7,550	7,000	700	800	26,680
1945.........	15,690	10,750	8,400	1,140	1,100	37,080
1946.........	23,800	15,200	15,000	1,600	1,800	57,400
1947.........	25,000	15,500	11,000	800	900	53,200
1948.........	25,300	14,000	17,500	900	800	58,500
1949.........	43,600	25,200	16,200	1,900	1,000	87,900
1950[2]........	20,800	6,100	8,200	1,000	400	36,500
1951[3]........	37,000	2,200	15,000	800	500	55,500

[1] Includes small quantities produced in Texas.
[2] Frost severely damaged the 1950 crop.
[3] Estimate, December 1951.

Crop Reporting Board, Bureau of Agricultural Economics.

Table 2.--Number of tung farms and trees reported, by States and United States, 1930,1935, 1940, 1945, and 1950

State	1930			1935			1940		
	Farms	Trees		Farms	Trees		Farms	Trees	
		For the State	Avg. per farm		For the State	Avg. per farm		For the State	Avg. per farm
	Number	*Thousands*	*Number*	*Number*	*Thousands*	*Number*	*Number*	*Thousands*	*Number*
Alabama.........	23	9	378	104	63	609	207	103	498
Florida.........	85	301	3,539	174	1,065	6,118	367	1,209	3,294
Georgia.........	7	3	452	101	216	2,138	283	80	284
Louisiana.......	8	5	581	41	213	5,195	373	1,759	4,715
Mississippi.....	20	33	1,673	192	2,068	10,771	831	[1]9,481	11,409
Texas...........	1	--	15	15	7	497	204	35	172
United States.	144	351	2,436	627	3,632	5,793	2,265	[1]12,667	5,593

State	1945			1950		
	Farms	For the State	Avg. per farm	Farms	For the State	Avg. per farm
Alabama.........	634	318	501	539	357	662
Florida.........	575	2,291	3,985	800	2,656	3,320
Georgia.........	642	180	281	([2])	([2])	([2])
Louisiana.......	666	2,067	3,103	874	3,274	3,746
Mississippi.....	1,599	4,718	2,951	2,811	6,027	2,144
Texas...........	44	9	215	([2])	6	([2])
United States.	4,160	9,583	2,304	[3]5,024	[4]12,319	[3]2,452

[1] It has been officially recognized that there was a duplication in 1940. The amount of this duplication has been estimated by the Bureau of the Census to be approximately 3,000,000 trees.
[2] Information not available as yet.
[3] Excludes Georgia and Texas.
[4] Excludes Georgia.

Source: Census of Agruculture, Bureau of the Census.

Table 3.--Tung trees in the United States, by States and counties, 1940, 1945, and 1950[1]

State and county	Trees of all ages--		
	1940[2]	1945	1950[3]
	Number	*Number*	*Number*
United States	12,669,341	9,583,087	[4] 12,318,952
Alabama	103,072	317,530	356,497
Autauga	---	1,133	---
Baldwin	30,226	101,935	49,733
Barbour	1,800	2,711	---
Bibb	1,200	---	---
Bullock	---	1,051	---
Choctaw	2,051	---	---
Coffee	1,021	---	---
Covington	---	98,859	164,969
Dale	---	1,542	---
Dallas	---	1,355	---
Houston	7,018	4,551	---
Mobile	57,257	101,592	135,791
Washington	---	---	2,199
Florida	1,208,764	2,291,232	2,656,434
Alachua	197,606	470,909	409,270
Bay	---	---	13,383
Bradford	---	80,000	75,026
Calhoun	---	183,359	121,614
Citrus	16,000	13,663	9,951
Escambia	59,325	13,896	36,902
Gadsden	31,123	280,085	90,484
Hillsborough	4,632	---	---
Holmes	---	3,003	1,497
Jackson	98,561	117,132	332,907
Jefferson	258,054	177,999	209,777
Lafayette	6,302	5,601	9,563
Leon	110,397	165,649	326,477
Levy	119,716	130,473	96,048
Madison	---	4,599	2,517
Marion	171,913	321,700	88,326
Okaloosa	63,683	---	5,869
Putnam	4,062	2,748	---
Santa Rosa	29,444	19,848	8,241
Suwannee	1,464	1,085	3,579
Volusia	29,811	---	---
Walton	4,392	296,137	813,382
Georgia	80,360	180,479	([5])
Baker	2,744	20,739	
Brooks	5,435	1,179	
Bryan	5,032	5,425	
Calhoun	---	1,836	
Colquitt	---	2,307	
Decatur	1,626	25,310	
Dougherty	2,000	1,000	
Grady	19,896	56,350	
Lanier	3,502	---	
Lee	27,007	23,850	
Lowndes	---	1,978	

Footnotes at end of table.

Table 3.--Tung trees in the United States, by States and counties, 1940, 1945, and 1950[1]--Continued

State and county	Trees of all ages in--		
	1940[2]	1945	1950[3]
	Number	*Number*	*Number*
Georgia--Continued			
Mitchell	1,459	10,227	
Peach	---	2,000	
Telfair	1,630	1,483	
Thomas	4,046	16,490	
Tift	---	3,431	
Wayne	1,966	---	
Louisiana	1,758,819	2,066,531	3,273,581
Acadia	3,706	---	---
Allen	3,045	---	---
Beauregard	53,846	50,985	95,862
East Baton Rouge	1,151	---	---
East Feliciana	23,555	12,052	46,208
Grant	---	---	4,182
Jackson	---	---	2,450
Lafayette	---	1,247	---
Lincoln	---	---	1,516
Livingston	---	3,961	1,306
Rapides	1,705	---	6,766
St. Helena	150,022	117,976	91,121
St. James	1,018	---	---
St. Tammany	876,449	1,102,839	2,162,646
Tangipahoa	147,664	523,045	486,621
Vernon	1,126	1,391	2,428
Washington	493,301	247,107	369,086
West Feliciana	---	2,527	1,000
Mississippi	9,481,143	4,717,873	6,026,850
Amite	5,534	6,760	7,004
Copiah	---	---	6,003
Covington	---	---	1,237
Forrest	36,382	87,634	98,975
George	33,239	79,861	89,827
Greene	66,364	109,632	105,339
Hancock	34,490	99,063	254,049
Harrison	127,034	145,254	301,530
Hinds	---	1,100	1,116
Jackson	24,007	36,953	30,381
Jasper	---	---	1,108
Jefferson Davis	---	---	13,218
Jones	3,341	2,442	5,652
Lamar	5,401	61,755	274,925
Lawrence	---	---	12,088
Lincoln	---	---	3,298
Marion	8,256	34,467	173,479
Newton	4,003	10,710	---
Pearl River	8,276,344	2,847,228	3,408,275
Perry	421,714	747,272	675,304
Pike	86,215	78,269	103,528
Simpson	---	3,730	1,175
Stone	340,918	353,015	419,898
Walthall	6,418	11,991	27,021
Wayne	---	---	1,917

Table 3.--Tung trees in the United States, by States and counties, 1940, 1945, and 1950[1]--Continued

State and county	Trees of all ages in--		
	1940[2]	1945	1950[3]
	Number	*Number*	*Number*
Texas	37,183	9,442	5,590
Hardin	24,707	---	
Harris	1,188	---	
Jasper	4,081	---	1,233
Montgomery	2,030	---	
Navarro	---	2,180	
Tyler	---	---	4,001
Walker	---	3,701	---

1 County figures do not add to State total for counties with less than 1,000 trees excluded.
2 It has been officially recognized that there was a duplication in 1940. The amount of this duplication has been estimated by the Bureau of the Census to be approximately 3,000,000 trees.
3 Preliminary.
4 Does not include Georgia.
5 Information not available as yet for the State of Georgia.

Source: Census of Agriculture, Bureau of the Census.

Table 4.--Tung oil: Production and value in the United States, 1932-33 through 1949-50

Year	Production[1]	Price per pound[2]	Value
	Pounds	*Cents*	*Dollars*
1932-33	150,000	6.40	9,600
1933-34	(3)	-	-
1934-35	400,000	14.00	56,000
1935-36	(3)	-	-
1936-37	2,000,000	14.70	294,000
1937-38	500,000	14.20	71,000
1938-39	3,000,000	17.80	534,000
1939-40	371,200	25.40	94,285
1940-41	3,520,000	29.90	1,052,480
1941-42	2,800,000	39.30	1,100,400
1942-43	5,232,000	[4] 36.00	1,883,520
1943-44	2,032,784	[4] 37.50	762,294
1944-45	8,766,660	[5] 37.32	3,271,718
1945-46	10,597,729	[6] 37.74	3,999,583
1946-47	14,399,056	[7] 31.88	4,590,419
1947-48	16,012,398	[8] 25.13	4,023,916
1948-49	17,031,127	[8] 20.43	3,479,459
1949-50	27,985,000	[9] 24.43	6,836,736

1 Production through 1938 from Tung Oil, R. S. McKinney, AIC-U.S.D.A. 13 pp. illus. Nov. 1946 (AIC-94). 1939-42, production was calculated from tung fruit production BAE (320 pounds of oil per ton of fruit). 1943 and since, production is from Bureau of the Census, monthly reports.
2 Price through 1941 is the annual average price (Oct.through Sept.) in drums, carlots, New York, BAE price series.
3 No data available
4 CCC purchased total production, f.o.b. mill location, cars or drums.
5 CCC Purchased 1,980,000 pounds at 36.00 cents, remainder of crop valued at ceiling price, New York City, drums (39.13), less drum differential and freight from mill locations to New York City, (0.81 and 0.62 cents respectively in 1945 when most of 1944 crop was marketed.
6 BAE price less drum differential (0.89 cents) and freight to New York City (0.62 cents).
7 BAE price less drum differential (1.31 cents) and freight to New York City (0.89 cents).
8 Average price per pound by mills surveyed calculated by date of sale.
9 BAE price less drum differential (1.20 cents) and freight to New York City (1.02 cents).

Table 5.--Production, price, and value of tung fruit in the United States, 1939-40 through 1950-51

Year	Production	Price[1]	Value
	Tons	*Dollars*	*Dollars*
1939-40	1,160	42.20	48,952
1940-41	11,000	60.00	660,000
1941-42	8,750	88.30	772,625
1942-43	16,350	91.80	1,500,930
1943-44	6,200	99.00	613,800
1944-45	26,680	102.00	2,721,360
1945-46	37,080	98.90	3,667,212
1946-47	57,400	96.90	5,562,060
1947-48	53,200	64.90	3,452,680
1948-49	58,500	49.10	2,872,350
1949-50	87,900	63.70	5,599,230
1950-51	35,300	110.00	3,883,000

[1] Season average price received by growers.

Crop Reporting Board, BAE.

Table 6.--Deliveries of tung fruit to mills in the United States, by months, 1943-44 through 1948-49

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Total[1]
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
1943-44	--	--	1,291	91	1,829	1,438	696	125	--	--	5,470
1944-45	--	1,628	2,905	4,858	3,031	4,032	6,904	3,952	(2)	(2)	27,416
1945-46	(2)	4,041	4,096	7,018	6,635	5,289	3,111	1,260	(2)	(2)	32,354
1946-47	--	4,679	9,008	7,114	12,365	3,098	5,268	2,312	(2)	(2)	45,094
1947-48	--	(2)	(2)	11,440	11,213	10,511	8,562	3,496	(2)	(2)	50,589
1948-49	--	2,878	4,052	14,357	12,634	8,638	4,698	2,420	(2)	(2)	(2)

[1] When total given is not same as total of months, the difference is the sum of figures not reported by months to avoid disclosure of individual operations. In August and September 1949, small deliveries were reported, apparently from the 1948 crop.
[2] Not shown to avoid disclosure of individual operations.

Compiled from Monthly Reports of the Bureau of the Census.

Table 7.--Tung fruit marketed, by method, average cost for toll processing, average price, and total value, 1947-48 and 1948-49[1]

Year	Quantity marketed[2]			Charge per ton for toll processing[4]	Price per ton for sales[5]	Total value
	Sold[3]	Toll processed	Total			
	Tons	*Tons*	*Tons*	*Dollars*	*Dollars*	*Dollars*
1947-48	27,240	1,182	28,422	17.06	59.79	1,699,357
1948-49	13,790	[6] 32,917	46,707	12.69	48.12	2,247,536

[1] Seven mills covered by survey in 1947 and nine in 1948.
[2] Hulled nuts delivered to mills are included on whole-fruit basis.
[3] Includes tonnage from orchards owned partially or entirely by mills; consistent treatment of this tonnage could only be accomplished by treating as sales.
[4] Mill charges weighted by tons.
[5] Discrepancies between these prices and prices for the same seasons in table 4 occur because of incomplete coverage of production in this table.
[6] Includes a small tonnage from orchards described in footnote 3 which could not be segregated.

Compiled from PMA records.

Table 8.--Tung fruit crushed in the United States, annually and by months, 1943-44 through 1948-49

Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Total[1]
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
1943-44	--	--	--	732	1,112	1,210	1,032	1,384	--	--	5,470
1944-45	--	--	([2])	3,071	3,675	5,529	7,089	5,138	1,122	([2])	27,333
1945-46	([2])	([2])	3,601	5,524	7,306	5,343	3,424	2,072	933	([2])	32,354
1946-47	--	2,804	5,309	7,340	8,459	7,545	6,167	4,546	([2])	([2])	45,094
1947-48	--	--	2,871	9,536	9,700	9,883	10,465	6,104	([2])	([2])	50,589
1948-49	--	1,673	3,259	10,935	10,509	10,415	7,299	4,726	900	([2])	50,252

[1] When total given is not same as total of months, the difference is the sum of figures not reported by months to avoid disclosure of individual operation. Small crushings were reported apparently from the 1948 crop.
[2] Not given in order to avoid disclosure of individual mill operations.

Compiled from monthly reports of the Bureau of the Census.

Table 9.--Average yield of products per ton of tung fruit processed in the United States, 1947-48 and 1948-49[1]

Year	Products[2]			Total
	Oil	Meal	Hulls[2]	
	Pounds	*Pounds*	*Pounds*	*Pounds*
1947-48	308	372	1,045	1,725
1948-49	314	378	1,052	1,744

[1] Average of seven mills for 1947 and nine mills for 1948 covered in survey.
[2] Products per ton of fruit as delivered at mills. Hulls are partially estimated and include those from fruit hulled in orchards. The difference between the total and 2,000 pounds represents moisture loss and foreign matter.
Compiled from PMA records.

Table 10.--Quantity and value of tung products at oil mills, 1947-48 and 1948-49[1]

Year	Weight of products			Value of products			
	Oil	Meal	Hulls[2]	Oil	Meal	Hulls[3]	
	Lb.	*Lb.*	*Lb.*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1947-48	8,734,522	10,577,400	29,286,000	2,199,749	118,973	75,851	2,394,579
1948-49	14,644,000	17,672,000	41,427,000	2,991,769	145,004	97,133	3,233,906

[1] Seven mills for 1947 and nine for 1948.
[2] Excludes estimates of 405,000 pounds of hulls in 1947-48 and 7,707,000 pounds in 1948-49 from nuts hulled in orchard and hulls not sold or used for fuel.
[3] Value of hulls for fuel was estimated by applying average fuel cost per ton of fruit for mills burning other fuel to tons fruit processed by mills burning hulls for fuel. Only hulls sold or used for fuel included.

Compiled from PMA records.

Table 11.--Costs in processing a ton of tung fruit, and the distribution of individual mill's costs, average of 1947-48 and 1948-49, United States

Cost item	Average for mills	Distribution about the average	
		Standard Deviation[1]	Coefficient of Variation[2]
	Dollars	*Dollars*	*Percent*
Total processing	16.42	5.12	31.18
Current	9.33	3.31	35.48
Fixed	7.09	2.72	38.36
Mill labor	4.48	1.62	36.16
Salary	2.37	1.05	44.30
Fuel, power, and water	2.64	1.92	72.73
Supplies and repair	2.24	1.04	46.43
Miscellaneous capital and administrative	1.63	1.23	75.76
Depreciation	1.94	1.01	52.06
Insurance	1.10	0.55	50.00
Taxes and licenses	0.40	0.20	50.00

[1] The standard deviation measures the distance (plus and minus) from the average within which approximately 2/3 of all the individual observations can be expected to fall.
[2] The coefficient of variation is the ratio of the standard deviation to the average.

Computed from PMA records.

Table 12.--Percentages of weight and value of specified products from cottonseed and tung fruit, 1947-48 and 1948-49

Year	Oil		Meal		Hulls[1]		Linters		Weight Loss	Total	
	Weight	Value	Weight	Value	Weight	Value	Weight	Value		Weight	Value
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
1947-48:											
Cottonseed.....	15.4	59.04	46.01	29.09	22.4	2.55	9.2	9.32	6.9	100	100
Tung...........	15.4	91.70	19.0	5.07	52.5	3.23	-	-	13.1	100	100
1948-49:											
Cottonseed.....	16.0	56.86	44.8	32.77	23.1	1.75	9.1	8.62	7.0	100	100
Tung...........	15.6	92.54	18.8	4.47	50.2	2.99	-	-	15.4	100	100

[1] Value assigned to hulls applies to those burned or sold which represents a small proportion of hulls produced.

Source: Cottonseed product weights from Cotton Production and Distribution, Bul. 186, Bureau of the Census, 1949. Product values calculated by using average prices received; oil crude, tanks, f.o.b. mills, BAE; meal 41 percent protein, bagged, Memphis; hulls, loose, carlots, Atlanta; linter prices, Weekly Cotton Linters Review, PMA.

Table 13.—Tung-oil mill and screw-press cottonseed-oil mill characteristics and operating costs, United States, 1947-48

Item	Unit	Average for mills	Distribution about the average	
			Standard Deviation[1]	Coefficient of Variation[2]
				Percent
Size of mill				
Tung	Press	2.1	0.9	45
Cottonseed	Press	4.5	2.6	56
Length of season				
Tung	Month	5.7	1.2	21
Cottonseed	Month	7.0	1.9	27
Seed Processed				
Tung	Ton	3,985	3,384	85
Cottonseed	Ton	10,763	11,806	110
Seed processed per press				
Tung	Ton	1,749	826	47
Cottonseed	Ton	2,161	1,406	65
Seed processed per press month				
Tung	Ton	302	116	38
Cottonseed	Ton	304	154	51
Hourly labor wage rate				
Tung	Dollar	0.66	0.25	38
Cottonseed	Dollar	0.89	0.35	39
Labor per ton of seed				
Tung	Hour	6.8	1.9	28
Cottonseed	Hour	9.9	6.8	69
Labor costs per ton of seed				
Tung	Dollar	4.41	1.61	37
Cottonseed	Dollar	7.52	3.18	42
Fuel costs per ton of seed				
Tung	Dollar	1.45	1.18	81
Cottonseed	Dollar	2.18	1.61	74

[1] The standard deviation measures the distance (plus and minus) from the average within which approximately two-thirds of all the individual observations can be expected to fall.
[2] The coefficient of variation is the ratio of the standard deviation to the average.

Source: 1947 Census of Manufactures.

Table 14.--Percentage distribution of processing costs of tung oil mills, 1947-48 and 1948-49, and of cottonseed-oil mills in the Southeast region, 1947-48[1]

Type of cost	Mill group with average processing cost[2]															
	80% and under		80.1% to 90%		90.1% to 100%		100.1% to 110%		110.1% to 120%		120.1% to 130%		130.1% and over		Area average 100%	
	CS	Tung	CS	Tung	CS	Tung	CS	Tung	CS	Tung	CS	Tung	CS	Tung	CS	Tung
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Current operating cost:																
Labor[3]..........	37.0	39.2	35.3	41.4	36.9	24.6	30.4	25.0	28.4	21.3	41.3	21.2	33.8	21.1	33.5	27.0
Fuel, power, and water..........	10.8	11.0	9.9	9.8	7.6	10.8	8.8	18.3	10.6	8.5	9.4	18.1	10.6	25.4	9.2	15.4
Supplies and repairs........	12.4	11.9	16.3	17.9	12.4	15.4	18.3	15.1	15.1	12.5	17.4	14.8	13.9	16.5	15.8	14.6
Total..........	60.2	62.1	61.5	69.1	56.9	50.8	57.5	58.4	54.1	42.3	68.1	54.1	58.3	63.0	58.5	57.0
Fixed and general costs:																
Salaries........	16.7	12.6	14.4	6.5	17.3	20.3	19.6	14.6	18.4	19.3	11.1	15.2	20.0	11.2	17.8	14.6
Miscellaneous, capital and administrative.	8.4	7.3	10.2	7.0	10.4	7.4	8.8	11.0	7.0	11.4	5.7	12.9	5.1	7.8	8.4	10.2
Depreciation....	5.9	10.8	5.8	10.2	5.5	12.9	6.5	6.0	15.9	17.5	6.2	6.2	8.1	10.2	7.1	8.6
Insurance, all kinds..........	5.2	4.6	4.6	4.4	5.6	5.9	3.9	7.3	1.9	8.0	4.9	8.0	4.4	6.0	4.4	6.7
Taxes and licenses[4]......	3.6	2.6	3.5	2.8	4.3	2.7	3.7	2.7	2.7	1.5	4.0	3.6	4.1	1.8	3.8	2.9
Total..........	39.8	37.9	38.5	30.9	43.1	49.2	42.5	41.6	45.9	57.7	31.9	45.9	41.7	37.0	41.5	43.0
Total bulk cost...	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

1 Processing costs expressed as percentage of group average cost.
2 Weighted by tons crushed.
3 Includes night superintendent in cottonseed-oil mills.
4 Except Federal income tax.

Source of cottonseed-oil mill data taken from "Distribution of Marketing and Processing Costs of Cottonseed-oil Mills, 1947-48" by Donald Jackson and Calvin Spilsbury, USDA, table 1, p. 29, May 1950, and Tung-oil mill data from PMA records.

Table 15.--Tung-oil mill and cottonseed-oil mill processing costs per ton, United States, 1947-48 and 1948-49

Cost	Average[1]	Distribution about the average	
		Standard Deviation[2]	Coefficient of Variation[3]
	Dollars	*Dollars*	*Percent*
Total cost:			
Tung	16.42	5.12	31
Cottonseed			
Southeastern	17.32	4.18 2	24
Valley	15.38	2.66	18
Southwestern	16.70	3.60	22
Current costs:			
Tung	9.33	3.31	35
Cottonseed			
Southeastern	11.08	2.77	25
Valley	9.82	1.92	20
Southwestern	10.46	2.09	20
Fixed costs:			
Tung	7.09	2.72	38
Cottonseed			
Southeastern	6.24	2.56	42
Valley	5.56	1.46	26
Southwestern	6.24	3.12	50
Labor costs:			
Tung	4.48	1.62	36
Cottonseed			
Southeastern	4.64	1.22	26
Valley	4.38	1.05	24
Southwestern	4.50	1.23	28

[1] Average of mills of the 2 years.
[2] The standard deviation measures the distance (plus and minus) from the average within which approximately two-thirds of all the individual observations can be expected to fall.
[3] The coefficient of variation is the ratio of the standard deviation to the average.

Computed from PMA records.

Table 16.--Relationships of selected factors for tung-oil and screw-press cottonseed-oil mills combined and for cottonseed-oil mills only, 1947[1]

Independent factor	Dependent factor	Tung and cottonseed mills		Cottonseed mills	
		Regression coefficient[2]	Correlation coefficient[3]	Regression coefficient[2]	Correlation coefficient[3]
Length of season mill operated, in months[4]	Dollar fuel cost per ton	- 1.50	- 0.39	- 0.65	- 0.20
Length of season mill operated, in months[4]	Man-hours of labor per ton	- 0.17	- 0.04	- 0.38	- 0.11
Monthly production per press, in tons	Man-hours of labor per ton	- 1.08	- 0.54	- 1.31	- 0.60
Monthly production per press, in tons	Dollar fuel cost per ton	- 1.30	- 0.56	- 1.21	- 0.63
Wage rates per hour of labor	Man-hours of labor per ton	- 0.59	- 0.35	- 1.43	- 0.53
Man-hours of labor per ton	Dollar fuel cost per ton	1.30	0.76	1.58	0.78

[1] 1947 Census of Manufactures.

[2] This indicates the unit change in the dependent variable for each unit increase in the independent variable. For example, under tung and cottonseed mills the first regression coefficient indicates that for an increase of one month in the length of season operated there is a $1.50 decrease in the fuel costs per ton of seed crushed.

[3] This indicates how closely the variation was between the independent and dependent variables. The minus signs indicate that the variation was in opposite directions. The possible maximum coefficient is one (plus or minus, depending upon whether the variation is together or in opposite directions in the series), so the nearer it approaches one, the closer the variation in the two series.

[4] The relationship is not indicated to be significant here but the comparison of the industries is significant.

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