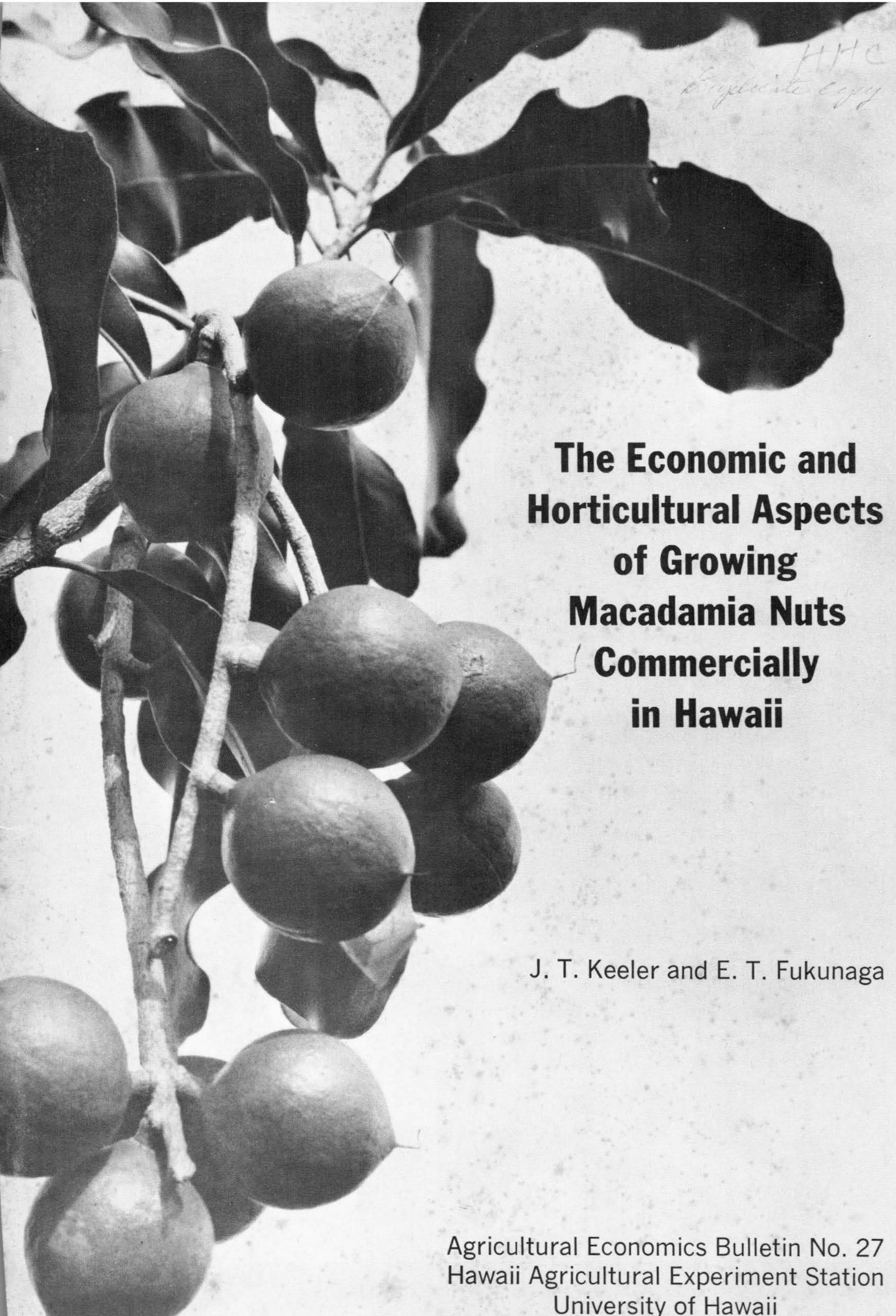

The Economic and Horticultural Aspects of Growing Macadamia Nuts Commercially in Hawaii

J. T. Keeler and E. T. Fukunaga

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SUMMARY

The growing of macadamia nuts is one of the most profitable farm enterprises in Hawaii. After a slow beginning, the industry has shown considerable economic strength due mainly to improved varieties, improved cultural techniques, better processing machinery, and, last but not least, market development. At the present time, the demand for macadamia nuts greatly exceeds the supply.

The success of a macadamia planting depends on the selection of a suitable site and the judicious application of sound management practices from the very beginning. Trials at different branch stations of the College of Tropical Agriculture, University of Hawaii, have shown that attainable yields and quality differ markedly with location and environment. In general, yields have been much higher at the Kona Branch Station than in other areas.

The new producer must decide what planting system to use, the extent of land preparation, whether supplemental windbreaks are needed, and if inarching is desirable. He must also determine what herbicides to use and the kind and amount of fertilizer to apply. There is no single answer to the above problems facing the producer which will satisfy all environmental conditions or economic situations. A producer with limited capital, for example, will want a large number of trees per acre in the early stages of the orchard's growth and would be well advised to use a square planting system with filler trees. Someone with more capital could logically select the equidistant planting system which would give him 15 percent more permanent trees than the square system but not as many in the beginning as the square system with fillers.

The choice of herbicides will depend on what weeds are present. In former pasture lands the producer will need to use herbicides selective to grasses, like dalapon, in his weed control program. Also, his initial expenditures on herbicides will need to be much greater than those of a producer located on cleared forest land.

Experiments on aa lava lands have demonstrated the need for considerably more phosphorus than has customarily been applied in the past. Important as these findings are, they are not directly applicable to all soils where macadamias are grown. Even though the producer has recommended guidelines to follow regarding fertilization and weed control, it is still necessary for him to make periodic observations and evaluations in adapting them to his particular conditions.

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THE AUTHORS

J. T. KEELER is Associate Agricultural Economist at the Hawaii Agricultural Experiment Station, University of Hawaii.

E. T. FUKUNAGA is Agriculturalist and Superintendent, Kona Branch, Hawaii Agricultural Experiment Station, University of Hawaii.

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INTRODUCTION

The smooth-shell variety of macadamia (*Macadamia ternifolia* var. *integrifolia*) was introduced into Hawaii from Australia in the 1880's.[1] Since that time, there have been numerous attempts to establish macadamia on a commercial scale. Both the local government and the Federal government have attempted to encourage producers and attract potential producers. In 1927, for example, the Hawaii Territorial Legislature exempted commercial macadamia planting from taxes for 5 years.[2] Since 1915, research and extension work has been devoted to the crop to make it more economically competitive. In spite of these early efforts, it was not until after World War II that the industry became firmly established on a commercial scale.

There are numerous reasons why it took so many years for macadamia to become a commercially important crop in the diversified agriculture of Hawaii, but primary among these has been the lack of suitable varieties. Until 1947 when the Hawaii Agricultural Experiment Station made available superior varieties, macadamia trees were relatively low yielding and lacked uniformity. Unfavorable economic factors also explain early fluctuations in acreages. Small increases in production brought low prices because few people were familiar with macadamia nuts and merchandising methods were poor. Because of the low volume of production and lack of uniformity in the nuts, modern efficient processing machinery was not developed. Since processing costs were high, the farmer received a low price for his nuts.

Most of the problems which plagued early attempts to establish a macadamia industry have been solved. The planting of seedling orchards has given way to grafted trees of superior varieties which yield uniformly high quality nuts. Efficient processing, packaging, and distribution methods have been developed. The demand for macadamia nuts has steadily increased as more people have become familiar with them. With the development of a large-scale tourist industry in Hawaii, people have been introduced to such macadamia delights as chocolate-coated nuts, macadamia ice cream, and chopped nuts in pastries. Macadamia nuts are presently being sold in many

1 Perry F. Philipp, *Diversified Agriculture of Hawaii*, University of Hawaii Press, Honolulu, 1953, p. 102.

2 David L. Crawford, *Hawaii's Crop Parade*, Advertiser Publishing Company, Honolulu, 1937, p. 162.

of the major cities on the Mainland, principally through supermarkets. Demand for the nuts at present prices exceeds supply. The transition from the high priced luxury item market to the lower priced mass sales of the supermarkets has been successfully accomplished. Currently, macadamia nuts are selling for 89 to 99 cents in 6-ounce cans, while a similar can of mixed nuts sells for 63 cents. The big problem for the industry at present is that of getting enough nuts to satisfy its markets.

Increasing the supply of macadamia nuts in order to meet market demand is a slow process since it takes 6 to 8 years for the trees to start bearing. At the present time in the State of Hawaii, there are 2,460 bearing acres of macadamia and 2,370 acres nonbearing.[3] Thus approximately half of the total acreage of the State has yet to come into bearing. Heavy plantings were made about 5 years ago so a substantial increase in the total supply of nuts should be forthcoming in the next few years. Even considering this potential increase, however, the supply will still fall far short of the demand.

The future of the macadamia industry is one of the most promising of the agricultural industries of the State. The climatic and soil conditions of Hawaii are more favorable for the growth of the trees, than are those of most potentially competitive areas. With the superior varieties we now have and the knowledge of cultural techniques, the newer orchards should prove more productive than those presently bearing. Should the demand for the nuts continue to expand, and this appears likely since so many people are unfamiliar with them, large areas of land exist which are suited to macadamia production. If unfavorable economic pressures continue to be exerted on crops like coffee, the production of macadamia nuts may provide an excellent alternative.

PURPOSE OF THE STUDY

The purpose of this study is to bring together in one publication the economic and horticultural aspects of successful macadamia production. It is written primarily for the prospective grower or for those who desire the basic fundamentals regarding production techniques and their input-output relationships. For the prospective producer this study will serve as a guide in determining how much capital will be needed, and how long the waiting period will be before a substantial return from the crop can be expected. Cultural recommendations are based on information derived from experiments or practices having shown good results in the field. There is still much to learn about the growing of macadamias.

For those who wish a more intensive treatment of such practices as weed control, fertilization, and training of the trees, Hawaii Agricultural Experiment Station Bulletin No. 121[4] or publications of the Department of Plant Physiology of the University of Hawaii's College of Tropical Agriculture are available.

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[3] *Statistics of Hawaiian Agriculture 1965*, Department of Agriculture, State of Hawaii, 1966.

[4] R. A. Hamilton and E. T. Fukunaga, *Growing Macadamia Nuts in Hawaii*, Hawaii Agricultural Experiment Station, Bulletin No. 121, January 1959, 51 pp.

The cost figures shown in this report do not emphasize the historical cost patterns of the small producers. The costs of present producers differ from one another, depending on the state of technology reached when the planting was made. Many earlier plantings were of the rough-shell variety or seedling trees which required grafting over to the newer superior varieties. Variations exist also in many of the older orchards with regard to intercropping, spacing, pruning, and other cultural practices. All of these variations would tend to give a distorted picture of projected costs if an average cost of production were derived from existing plantings. Also the cost evaluation for each farm or planting will vary from the one shown in this report depending on the physical and management factors involved. In good areas of Kona, for example, macadamia trees will develop more rapidly than in other areas having less desirable soil and climatic conditions. The objective here is to project the cost pattern to coincide with what prospective medium to small planters are likely to encounter who follow recommended cultural practices and locate in an area having good quality land and other resources.

In terms of acreage, it describes a planting of from 1 to 100 acres in size.

It is recognized that much larger acreages running into thousands of acres would have a different cost pattern than the one depicted here.

HOW THE STUDY WAS MADE

The information contained in this report was obtained from a number of sources, including the branch experiment stations of the University of Hawaii, cooperative experiments on private farms carried on by the University, and from farmers who have plantings of their own.

The materials and methods employed in carrying out such cultural practices as weed control, fertilization, and pruning are based on the experience of the agricultural experiment stations. The labor and machinery inputs are based on the experience of growers on the island of Hawaii.

The unit costs of materials are based on those which existed in the Kona area in 1966. Such unit costs may be slightly higher than those existing in other areas. The reason for selecting this area as a basis for material costs is that it is better to depict slightly higher costs to allow for price increases over time, and to provide a cost pattern which would adequately cover costs experienced in any area.

In all likelihood, there will be considerable expansion of macadamia plantings of the family-farm type in Kona. Kona has large areas of land which are suitable for macadamia production, and grower interest in the crop is high. The precarious economic position of present coffee planting also serves to create interest in alternative crops such as macadamia nuts.

Typical yields are more difficult to determine than are most cost factors because they can be subject to the adversities of weather and the cultural practices. Yields as expressed in this study are based on the performance of trees at the experiment stations and the results of farm plantings where acceptable varieties were planted and records were kept.

Land costs are based on typical lease agreements as found on the island of Hawaii.

Typical vegetation as found on aa lava lands in South Kona.

Aa lava land after rough clearing.

LAND PREPARATION

The costs of land preparation will vary depending on vegetation, slope, and type of soil. Also, growers planning to clear larger acreages will have lower costs than those planting just a few acres.

Land preparation in some cases will require smoothing out with a dozer, rolling, and even contouring. In all cases where raw land is cleared, the existing vegetative cover should be either windrowed or pushed to the edges of the fields. In cases where the brush is piled or windrowed, time should be allowed for burning and general clean-up before further layout and planting of the trees is undertaken. While many vegetative covers will be dry enough to burn immediately after clearing, others will burn much more readily if allowed to dry out for several months. Where cleared vegetation consists of large ohia logs, burning is started by igniting old rubber tires or by using kerosene burners to assure that the fire gets a good start. In burning forest debris, compactness of the debris is essential. Loosely piled debris will not burn well.

In situations where windrowed vegetation does not form a barrier to field operations and layout of the planting, it may not be necessary to burn. Even though vegetative materials will decay over time, burning to assure clean fields is recommended.

The several different types of land preparation together with the costs are shown below.

I. *Type of land:* Aa lava.
Vegetation: Primarily large ohia trees with guava and other types of underbrush.
Slope: Moderate with irregular surface, some large rocks.

Smoothing out and burying rocks prior to rolling.

Rolling cleared land. Note how this smooths land surface, making orchard accessible to vehicles.

	Operations needed:	a) Clear and windrow vegetation. b) Smooth out irregular surface with dozer. c) Roll land.
	Cost per acre:	$250.00.
II.	*Type of land:*	Soil with some rocks.
	Vegetation:	Large guava, lantana, other types of underbrush.
	Slope:	Gentle to moderate, surface reasonably smooth.
	Operations needed:	a) Clear and windrow vegetation. b) Windrow large rocks.
	Cost per acre:	$150.00.
III.	*Type of land:*	Soil with some rocks.
	Vegetation:	Large guava, lantana, other types of underbrush.
	Slope:	Steep.
	Operations needed:	a) Clear and windrow vegetation. b) Contour.
	Cost per acre:	$350.00.

The above land conditions are commonplace in many parts of the island of Hawaii; however, there are other types of land not covered by the above descriptions.

Most land suitable for macadamia trees located in areas available to the family type farmers would cost about $250.00 per acre to clear and prepare for planting. It is recognized that there are variations in cost both above and below these quoted figures.

ORCHARD LAYOUT

The first job after land clearing is to lay out where the trees are to be planted, roads are to run, and in some cases where windbreaks will be put in. It is very important that the layout of these items be carefully considered in relation to the overall management of the planting. Decisions made at this time will affect the efficiency of the whole enterprise for many years to come or require elaborate and expensive changes. Provision should be made for the maximum accessibility of machinery throughout the orchard. Since macadamia trees will last many years, it is quite possible that mechanical harvesters or other types of labor-saving equipment will be developed which will afford an opportunity to reduce the cost of production.

On lands where slopes are moderate, where the land has been rolled, or where soil exists, roads do not constitute a major problem since all parts of the orchard will be accessible to jeeps or similar vehicles. Most areas where macadamia trees are likely to be planted will require careful provision for roads. As much as possible, roads should follow the contour of the land and be spaced approximately 200 feet apart. Such a spacing makes it possible to reach any point in the orchard with a power sprayer for weed control, using 100 feet of hose. On aa lava land where soil erosion is not a problem, the roads may run up and down the slope with the rows running across the slope, provided the slope is not too steep for vehicular travel.

In many locations the establishment of windbreaks will be an essential operation. The kind of trees, the planting pattern, and the need for windbreaks will depend upon how exposed the particular site is to both prevailing and abnormal wind conditions.[5] In providing for windbreaks, it is recommended that farmers consult the Soil Conservation Office in their area. Under certain conditions part of the cost of providing windbreaks may be borne by the Federal government.

Before the clearing operations are begun, provisions can be made to leave strips of the forest uncleared to provide a natural windbreak. Windbreaks of this kind can be reinforced by selected planting if the forest strips left after clearing are not adequate.

There are a number of different planting systems which can be used in laying out a macadamia orchard. The particular system selected will depend on a number of factors, among which are: (1) the contour and slope of the land, (2) whether the grower is planning to practice intercropping, (3) whether filler trees will be used, (4) the degree to which cultural operations such as weed control will be mechanized, and (5) the personal preference of the grower.

On steep slopes it may be mandatory that the planting be made following the contour of the land. In such cases it may also be necessary to terrace, which often requires a high initial investment in land preparation. Even though the investment is high for terracing, the cost will be amortized over a long period of time. If terracing is needed to prevent soil erosion or to promote

[5] *Ibid.*

efficiency by allowing more access of machinery in the orchard, this added expense may be justified. The ease of harvesting the nuts should also be considered in this regard.

On some lands having very steep slopes or rock outcroppings, it may be impractical to provide accessibility for machinery in the orchard. It is recognized that on some lands such operations as terracing will be prohibitively expensive. While lands like these have certain disadvantages from the standpoint of keeping operational costs to a minimum, in favorable climatic areas with good management they still can be economically planted. In orchards where the access of machinery is impractical and filler trees are not used, the hexagonal or triangular planting system is to be recommended. This system provides for the maximum number of permanent trees per acre, 15 percent more than when the square system is used. The disadvantages of this system are that it does not work well with fillers and it is awkward where machinery is used because the rows are diagonal.[6] Since every tree in the hexagonal system is equidistant from every other tree, the shade from the mature trees is ideally distributed, which reduces the cost of weed control. However, when the orchard is young, there are other planting systems which provide more shade through the planting of a large number of filler trees which are later removed when the orchard matures.

On lands of moderate slope where the accessibility by machinery is practical, the square planting pattern offers many advantages. This system allows machinery to pass between the rows and within the rows. Next to the hexagonal system the square system provides the largest number of *permanent* trees per acre and has the important advantage of being ideal for the use of machinery. When planted quincunx with filler trees the square system provides the largest number of trees per acre of any system. The quincunx arrangement is created by planting a filler tree in the center of each square. Converting to quincunx by using fillers will make the orchard somewhat less accessible to machinery, since it reduces the width of the rows by one-half of the original distance. This is not necessarily a serious problem, providing the original square spacing is relatively wide as it generally is with macadamia. A square spacing of 35 feet will leave rows 17½ feet wide after the fillers are planted forming the quincunx arrangement. By using diagonal rows with or without fillers, the row width is 25 feet. As the orchard matures, some pruning of the lower hanging branches should provide adequate accessibility for machinery.

Planting filler trees to form a quincunx arrangement doubles the number of trees in the orchard. This provides for higher yields from the time the trees start to bear up to the time that the fillers are removed, an important consideration where capital is limited. The presence of filler trees will also reduce the cost of weed control through shading. All things considered, the square system using fillers to form a quincunx pattern is the most economical and efficient planting system to use.

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[6] Joseph Harvey Gourley and Freeman Smith Hawlett, *Modern Fruit Production*, The Macmillan Co., New York, 1947, p. 107.

In using filler trees the grower should prune them back periodically so that they will not interfere with the permanent trees. In practice, one of the limitations of using filler trees has been that growers are very reluctant to remove them, allowing them to compete with the permanent trees.

The alternative to the square system is the rectangular planting pattern. Under this system, trees in the rows are closer together than the trees between rows. The advantage of this system is that it provides excellent access for machinery between rows. The rectangular pattern is well suited to fillers when trees are planted closely within rows, alternate trees within rows being removed later. The disadvantages of this system are that when the fillers are removed, there are fewer trees per acre than when the square system is used, and the extra wide spacing between rows encourages weed growth. At the present time, experiments are being conducted to determine whether nets can be economically used for harvesting. Should nets prove feasible, then the rectangular system of planting might be the most suitable in spite of its other disadvantages.

Below are listed some of the advantages and disadvantages of various planting patterns:

Rectangular

Advantages

(1) Provides best access for machinery, but in one direction.
(2) Works reasonably well with fillers.
(3) Lends itself well to technical innovations such as harvesting nets.

Disadvantages

(1) Rows widely spaced—has poor shade distribution.
(2) When fillers removed, has fewer trees per acre than other systems.

Contour with terracing

Advantages

(1) Can use machinery even on steep slopes.
(2) Reduces soil erosion, conserves moisture.
(3) Facilitates the use of irregular or steep lands.
(4) Excellent where intercropping is permanent to semipermanent.
(5) Can be used with other patterns to fill in valleys and steep slopes.

Disadvantages

(1) Can be very expensive, large initial outlay of capital required.
(2) Expensive to lay out properly.

Hexagonal, Triangular, Equidistant

Advantages

(1) Fifteen percent more permanent trees per acre than other systems; highest yield.

(2) Best distribution of shade and exposure of leaves to sunlight; minimizes weed control problem.

Disadvantages

(1) Not as well suited to the use of machinery as other systems.

(2) Does not lend itself to intercropping or use of filler trees.

Square

Advantages

(1) Allows for machinery accessibility in two directions.

(2) Next to hexagonal, has the largest number of permanent trees per acre.

(3) Well suited to the use of fillers.

(4) Provides good shade distribution, thus reduces weed growth.

(5) Easy to lay out.

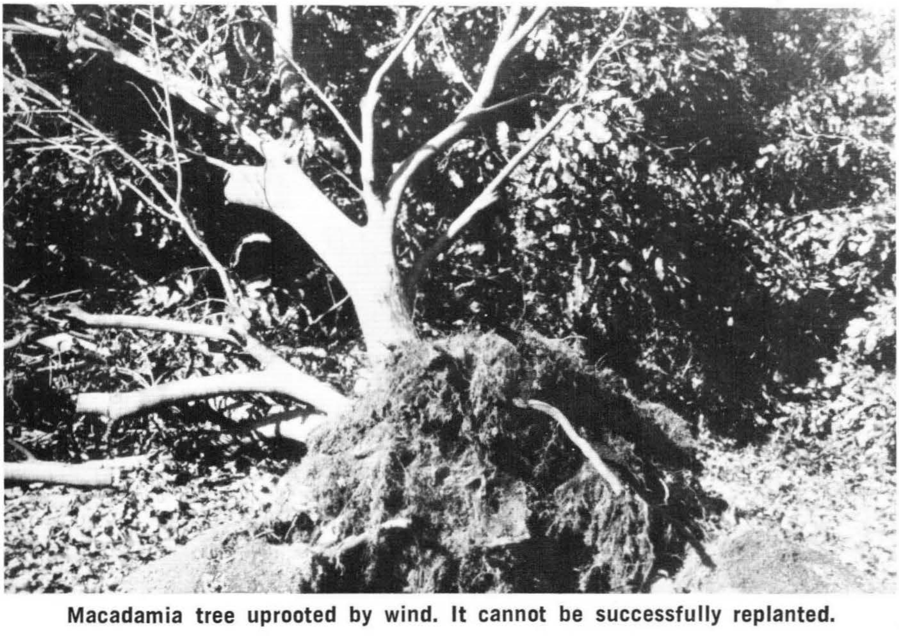
Disadvantages

None.

WINDBREAKS

Macadamia trees are particularly susceptible to wind damage since a large part of the root system is close to the surface of the ground. There are two kinds of winds which cause damage to macadamia trees: (1) the unusual or storm type winds of unpredictable occurrence, and (2) the prevailing or "trade" winds.

The storm type winds occur almost everywhere in Hawaii, even in areas like Kona where air turbulence is at a minimum. They generally last for short



Macadamia tree uprooted by wind. It cannot be successfully replanted.

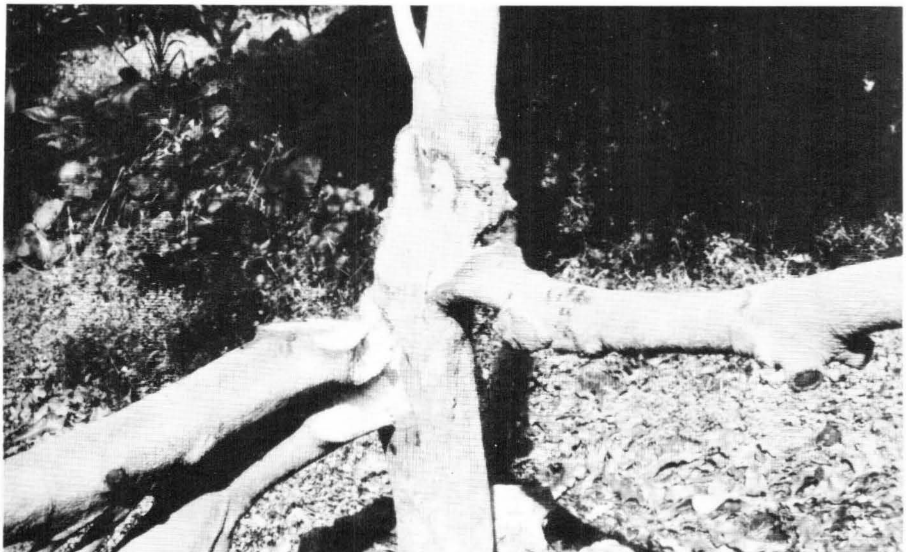
periods of time, the longest being for several days, but are severe in intensity. Storm winds when severe often knock over trees or break off limbs.

The prevailing winds tend to deform the trees but are not as dynamic in their devastation as the storm winds; nevertheless, they can, and often do, cause serious damage. A typical example of prevailing winds is the so-called "trades," which vary in intensity but blow most of the time in the windward sections of all the islands. Even when these winds do not seriously deform the trees, they often cause poor growth and low yields.

There are three things which the potential grower can do to protect against wind damage. The first and most obvious solution is to select a planting site which is relatively well protected, as in Kona. The second is to leave strips of uncleared forest surrounding each planting site. The third method is to plant a windbreak prior to planting the orchard.

Assuming that a suitable site has been selected for planting the macadamia orchard, then the most economical method of obtaining wind protection is by selective clearing. The orchard sites should be rectangular shaped, separated by strips of uncleared forest. A width of about 15 to 20 feet of uncleared forest should be sufficient to provide adequate protection. Where winds are likely to be severe, the rectangular planting sites should be narrower in width, and the uncleared areas should completely surround the planting site.

In areas where natural forest cover is not available, or insufficient to provide protection, windbreaks should be planted. Trees and shrubs should be alternated in rows and should vary in height in order to provide a complete



Wind damage caused by failure to train the macadamia tree with one dominant vertical limb.

barrier to wind. Trees for windbreaks can be obtained from State Department of Agriculture nurseries at minimal cost. Certain expenses incurred in planting windbreaks qualify for reimbursement under the Agricultural Conservation Program of the Federal government.

TRAINING YOUNG TREES

Fortunately, macadamia trees require a minimum of training, yet it is important that a thorough and timely job be done.

Macadamia trees should be trained to a single leader tree with branches forming wide-angled crotches with the trunk. This is accomplished by pruning off undesirable branches, or by pruning off the leader itself when necessary in order to force the tree to start a new leader and branch whorl.

Training should start the first year after planting. At this time it should consist of snipping off side branches which seriously compete with the main shoot. Once the training method is understood, a man should be able to cover 1 acre in an hour or less, depending on the terrain. For details on how to train macadamia trees, the reader is referred to Hawaii Agricultural Experiment Station Bulletin No. 121.[7]

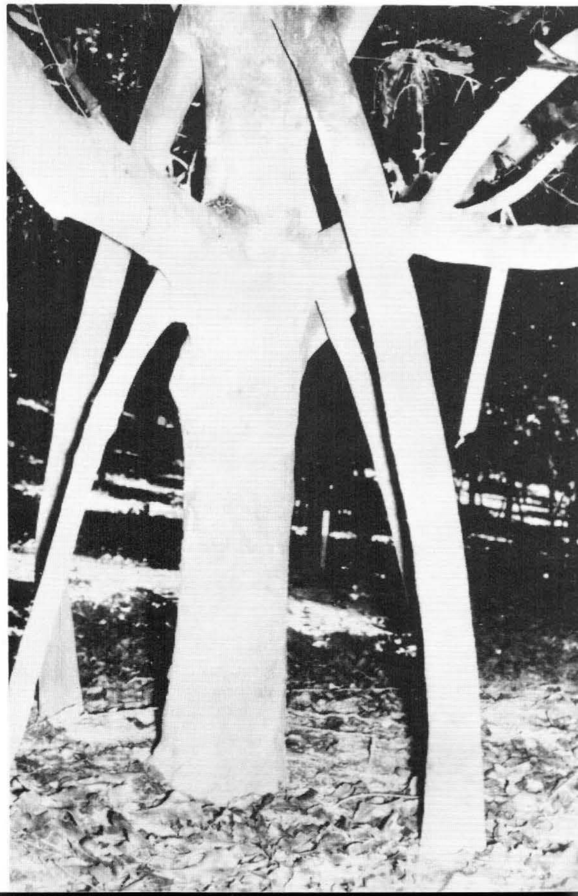
Training the macadamia orchard is accomplished in the first 3 years of the orchard's growth. Once the trees are properly started, the only additional work would be the removal of dead limbs and low vegetation to promote better access.

INARCHING

Inarching consists of planting three or four young macadamia seedlings 3 feet from the trunk of a growing tree and then grafting them onto the trunk. The young seedlings are planted in the orchard during the third year and are grafted to the main tree when 3 to 4 feet high 2 or 3 years later.

The purpose of inarching in macadamia is primarily to provide additional support for the trees as protection against possible wind damage. Inarching is also a means of saving an orchard tree when the trunk is girdled through physical damage or by splitting.

[7] Hamilton and Fukunaga, *op. cit.*



Inarching provides macadamia trees with additional structural support.

It is possible that the original stock may not have been the most vigorous. When four more root systems are added to the root system of the original tree, it is possible that one or more may be more vigorous. There are many cases where the inarched "braces" have outgrown the original trunk below the graft union.

WEED CONTROL

Cultural Management

Historically the cost of weed control in macadamia orchards is second only to harvesting. This is because many growers have not practiced clean culture from the start, but have sought to control the weeds only after access to the orchard has become difficult or when the weeds interfere with field operations.

Failing to control weeds from the initial planting results in a serious weed problem later and retards the growth of the young macadamia trees. Even the practice of controlling the weeds around the base of the trees while letting those in the interrows grow, results ultimately in a costly control program. Practicing clean culture only around the individual trees does result initially in a lower cost for weedicides and labor. The main disadvantage of this practice, however, is that there is a constant source of weed seed continually reinfesting the area around the base of the young macadamia trees. Other disadvantages are that weeds impede the passage of machinery and labor through the orchard, and the area beneath the trees is constantly increasing as the orchard matures. A more serious limitation of partial weed control is that certain weeds, such as perennial grasses, sedges, wood sorrel, and vines like wild yam, are almost impossible to eradicate except with heavy applications of weedicides once they become well established. Such heavy applications of weedicides can damage the macadamia trees.

Recent technological advances in the chemistry of weed control make it even more advantageous to practice completely clean culture from the very beginning. The advent of effective preemergence herbicides such as diuron, atrazine, and simazine has made it much easier to achieve eradication of weeds from the orchard. These herbicides are not only effective in killing growing

Failure to control weeds from the beginning, results in slow growth of the trees and increases the overall cost of the weed control operation.

weeds but can be sprayed on the ground to kill weeds germinating from the seeds. Considerable care must be exercised in spraying diuron lest a residue remain that will affect the young macadamia trees when they are planted. In wet areas where the rain will leach away the residue, planting can be done safely 4 to 6 months after spraying, but in drier areas a longer time will be required.

Even though many of the herbicides presently on the market are not approved by the Federal government for use in mature macadamia orchards, it is permissible to use them prior to planting and for a few years after planting. This is not true, of course, for herbicides such as sodium arsenite where the residue left by spraying may last many years. It is possible to use contact sprays such as pentachlorophenol, diquat, and paraquat for several years after planting.

The recommended program for the most economical weed control will begin with an intensive spraying after the land has been cleared but before planting. It is highly desirable for the cleared land to remain idle for at least 3 months after clearing so that a thorough eradication of weeds and seeds can be made with a potent herbicide such as diuron.

There is another good reason for waiting 3 months or longer before planting after the land is cleared. There will be a considerable amount of fresh organic matter in the soil such as leaves, twigs, and especially the roots of the original vegetation. When these begin to decompose, the presence of microorganisms in the soil will increase considerably. Some of these microorganisms will compete with the macadamia plants for nutrients, thus slowing the rate of growth. However, if the organic material is allowed to decompose and the microorganisms die, the nutrients they have originally absorbed will become available to the macadamia trees.

It is recognized that a waiting period of 3 months between clearing and planting is not always practical, in which case a less potent herbicide having less residual action (such as pentachlorophenol) must be used.

The importance of preplanting weed control cannot be overemphasized. A substantial investment in control measures at this time will pay big dividends later on. There are certain very tenacious weeds, both grasses and brushes, such as perennial grasses, vines, guava, and honohono. These should be eradicated from the orchard prior to planting lest they become a serious problem. Once the macadamia trees are planted, and particularly when they are young, great care must be used in applying certain of the very effective herbicides like 2,4,5-T, for fear of injuring the trees.

If a thorough job of preplanting weed control has been done, light applications of preemergence herbicides such as diuron and atrazine, made periodically, will take care of the major weed problem. These herbicides have "contact" properties when used with surfactants. Other herbicides like paraquat and dalapon may be necessary to control weeds resisting diuron and atrazine. An excellent management practice in this regard is to set up a calendar of operations for weed control coupled with periodic inspections to make sure weeds do not gain a foothold. Most herbicides are quite effective when sprayed on very young weeds whereas even heavy application on older hardy

Once the orchard has filled in, shading greatly reduces weed growth.

weeds may fail to kill them. The more potent herbicides such as diuron may be used in the interrows away from the young macadamia trees during the first year after planting if care is used to keep them away from the roots and trunks of the trees. The base of the trees can then be sprayed with a contact spray such as pentachlorophenol. Some follow-up weed control measures should be taken on a spot-spray basis. This will generally involve spraying dalapon if grasses are a problem, or a 2,4,5-T and oil mixture if ti plants are present. Spot spraying may be done with a knapsack sprayer.

Providing a thorough job of weed control has been done during preplanting and followed up in the first few years, weed control should be neither time-consuming nor expensive by the time the orchard starts to bear. From the first year on, the number of sprayings and the amount of herbicides used can be reduced. Another factor which will reduce the need for control will be the shading of the trees as they mature. In the mature orchard, spot spraying will most likely be sufficient.

Once harvesting starts, considerable care must be taken not to spray herbicides while any nuts are on the ground. This means that all weed control should be done immediately after harvest, which will also avoid peak labor requirements. It is important that no nuts be left on the ground after harvest lest they become contaminated with herbicide and picked up in the following harvest. Nuts left on the ground after harvest will spoil if left too long, and they also tend to attract rats.

Chemical Control

Just as land clearing will differ in cost depending on location and type of vegetation, the measures necessary to control weeds will also vary. Many herbicides are very specific with respect to the types of weeds they control; therefore, the macadamia grower should possess a general knowledge of how various herbicides work and what weeds they can destroy most effectively.

Herbicides can be divided into three major groups as follows: (1) contact, (2) systemic, and (3) preemergence. Such a classification is not rigid, for there are herbicides that have some of all three of the characteristics mentioned above. In addition to the above classifications, there are fumigant and soil-sterilizing herbicides which in general would not be used in macadamia orchards. Fumigants are not used, except for very small areas, because they are expensive and difficult to apply. A small area of nut grass (*Cyperus rotundus*) might be eradicated by using methyl bromide tarp fumigation.

Soil-sterilizing herbicides such as arsenicals are outlawed for use in macadamia orchards because of the danger of their contaminating human food.

Surfactants

The name surfactant comes from "surface-acting agent," and its purpose is to reduce the surface tension of aqueous sprays.

The incorporation of a surfactant in the herbicide mix promotes the formation of emulsions as when pentachlorophenol oil mixture is emulsified in water. Surfactants also overcome the waxy layer on the leaves and stems of weeds, allowing the herbicide to adhere and spread over the surface. Common examples of surfactants are soaps and detergents.

For use with preemergence herbicides like diuron and atrazine, the so-called nonionic surfactants are recommended. When used with a nonionic surfactant, the above-mentioned herbicides exhibit contact properties. Nonionic surfactants form an adhesion between the tissue of the weed and the herbicide. By staying wet, they allow the weed to absorb the herbicide.

A typical example of nonionic surfactant is "Turgitol MDX," which sells for $3.40 per gallon (Kona, Hawaii). This surfactant is added in the proportion of ½ gallon per 100 gallons of water.

Contact Herbicides

Contact herbicides, as the name implies, kill by destroying the tissue of the plant on or near the area on which it is sprayed. The contact properties of a herbicide are thus restricted to destroying the above-ground portion of the weed through corrosive action. They are most effective in killing weeds which are true seed plants having no underground rhizomes. Young plants which have not had time to build up a regenerating root system are also effectively killed with these herbicides.

Since the action of contact poisons is largely physical, they are nonspecific with respect to the weeds they will kill.

Contact poisons do their major damage to weeds shortly after they are applied, and are particularly effective during warm sunny weather.

Contact herbicides are relatively safe to use from the standpoint of damaging the macadamia trees since they destroy only the plant tissue they are sprayed on. In general they are *locally absorbed* but not translocated through the plant, hence are not a source of human food contamination as long as the edible portion of the plant is not sprayed. As mentioned previously, however, care must be exercised not to spray nuts on the ground with any herbicide. This word of caution is particularly true for oils for they are readily *absorbed* by macadamia nuts.

The cost of contact herbicides per gallon tends to be much lower than that of other weed poisons. This is largely offset, however, by the need to apply much larger dosages to achieve the necessary killing power. Some of the contact herbicides such as aromatic oils or pentachlorophenol are sprayed on weeds as emulsions and, therefore, require continuous agitation.

Examples of Contact Herbicides

NAME:	Aromatic oil.
CLEARANCE:	Is cleared for use in macadamia orchards.
ADVANTAGE:	Repels water, therefore good in rainy areas.
DISADVANTAGE:	Low toxicity requiring large dosages to kill weeds.
DOSAGE:	Normally used straight requiring approximately 50 to 100 gallons per acre to kill a good stand of weeds.
COST:	20 cents per gallon (Kona, Hawaii).
REMARKS:	Generally used as a vehicle for other herbicides like pentachlorophenol. 1 to 2% pentachlorophenol in oil increases the killing power 10 times. Straight aromatic oil is safe to use around humans and animals. Will contaminate nuts if sprayed on them.

NAME:	Pentachlorophenol.
CLEARANCE:	Is *not* cleared for use in macadamia orchards. Is restricted to preplanting weed control or during first few years of the orchard's growth.
ADVANTAGES:	Emulsions made with pentachlorophenol are the most inexpensive contact poisons considering their effectiveness. Is readily available on all islands. Has some residual effect.
DISADVANTAGES:	Is quite toxic and will penetrate into macadamia nuts if it comes in contact with them. Requires agitation.
DOSAGE:	A concentrate containing 50 pounds of pentachlorophenol dissolved in 50 gallons of aromatic oil is prepared at the farm. An emulsion is then prepared as follows: 8 gallons of concentrate/100 gallons of water/acre.
COST:	50 pounds for $12.25 (Kona, Hawaii).
REMARKS:	Care should be exercised in working with pentachlorophenol as it is very toxic to humans.

NAME:	Paraquat.
CLEARANCE:	Is not cleared yet. Clearance has been requested for use in macadamia orchards.
ADVANTAGE:	Is a water-soluble liquid, hence is very easy to prepare.
DISADVANTAGES:	Is relatively expensive since price will probably be $38 per gallon; however, it is not on the market at the present time. Has no residual effect.
DOSAGE:	1 to 2 quarts/100 gallons of water/acre.
REMARKS:	Is relatively safe to use around humans and animals.

Systemic Herbicides

Systemic herbicides are very complex chemically as to their action within the plant. They are sometimes called translocated herbicides because they are absorbed into the circulatory system of the plant, destroying its ability to carry on the normal physiological processes. Two of the most commonly used systemic poisons are dalapon and 2,4-D. Dalapon is a very effective herbicide for killing grasses while at the same time being relatively harmless to broadleaf plants. 2,4-D is particularly effective in killing broadleaf plants while being relatively harmless to grasses. The ability of these two herbicides to kill weeds varies considerably even within their areas of specific use. Thus there are some broadleaf plants and some grasses which neither 2,4-D nor dalapon are effective in controlling.

Systemic poisons are extremely lethal to certain plants even in relatively small concentrations. A mist or drift containing 2,4-D can be very injurious to young macadamia trees. For this reason, caution must be used in applying these herbicides. Equipment used for weed control should not be used for spraying insecticides and fungicides.

In spite of the care which must be exercised in their use, systemic poisons are very effective and economical. Even in very small concentrations, poisons like 2,4-D will effectively kill weeds. Systemic herbicides are able to kill the roots of many weeds, and hence preclude the regrowth of the plant. They are most effectively applied when weeds are actively growing, generally in warmer weather.

The Federal government has been somewhat cautious in approving a number of systemic herbicides for use in macadamia orchards because of the possibility that traces of them may reach the nuts. At the present time, dalapon is cleared for use but 2,4-D is not. The use of 2,4-D in macadamia orchards is, therefore, restricted to preplanting weed control and the first few years of the orchard's growth.

Examples of Systemic Herbicides

NAME:	2,4,5-T.
CLEARANCE:	Has not been cleared for use in macadamia orchards. Use restricted to preplanting weed control or first few years of the orchard's growth.

ADVANTAGE: Is very effective at low dosage on certain broadleaf weeds such as honohono, Wandering Jew, wild vines such as wild morning glory, wild yam, and many shrubs such as guava, Christmas berry, etc., not effectively killed by other herbicides.

DISADVANTAGE: Is very toxic to macadamia trees as well as other beneficial plants even in very small quantities.

DOSAGE: 2 pounds of 2,4,5-T/100 gallons of water/acre.

COST: $10.65 per gallon (Kona, Hawaii).

REMARKS: Is relatively safe to use around humans and animals.

NAME: 2,4-D. Has the same general characteristics as 2,4,5-T but differs in that it has a narrower spectrum of weeds that it will control and is adequate for eradicating honohono, air plant, and other herbaceous broadleaf plants. 2,4-D is also less expensive as the following prices show:

Water-soluble amine salt of 2,4-D:
1 gallon, $3.10 (Kona, Hawaii).
5 gallons, $15.00 (Kona, Hawaii).

NAME: Dalapon.

CLEARANCE: Is cleared for use in macadamia orchards.

ADVANTAGES: Is the most effective herbicide for perennial grasses. Is water soluble, hence is easy to prepare.

DISADVANTAGES: Is very specific to the kinds of weeds it will kill, mainly restricted to monocotyledons. Has no residual effect.

DOSAGE: 10 pounds/100 gallons of water/acre/application. The maximum number of applications that can be applied per year is two.

COST: 50 pounds for $50.90 (Kona, Hawaii).

REMARKS: Very safe for use around humans and animals.

Preemergence Herbicides

Preemergence herbicides are sprayed on the soil surface and kill the weeds as they germinate from the seed. Contrary to popular notion, these herbicides do not kill seed *per se*. Weed seeds must first germinate and develop some kind of a root system before they are killed, since these herbicides are absorbed through the roots when used as preemergence herbicides. When freshly plowed weedy fields are treated with preemergence herbicides, the surface of the soil will turn green with germinating weeds within a few days and the first impression one gets is that the herbicides are not working. But these weeds will gradually die after a few days. Weeds will keep on germinating and dying until the supply of weeds close to the surface in position for germination will be exhausted or the efficacy of the herbicides wears out (by bacterial action, by physico-chemical reaction with the soil, or by leaching).

Preemergence herbicides are very slightly soluble in water. Some, like simazine, have a solubility of only 3.3 ppm. The solubility of diuron is 40 ppm. Atrazine is 70 ppm. However, the weed-killing abilities of these herbicides are so powerful that weeds can be killed with very little of the chemical in solution. This low solubility also explains their long-lasting nature.

All of the preemergence herbicides are wettable powders or emulsions. They remain on the soil surface or near it for long periods. Normally the least soluble ones last longest and are used in rainy areas or during rainy seasons. Preemergence herbicides are not very effective in low-rainfall areas or during low-rainfall periods unless the soil can be kept moist by irrigation.

At one time the slightly soluble powder type preemergence herbicides were thought to be effective only by absorption through the roots of the plants. However, when they were incorporated with certain types of (nonionic) surfactants it was found that weeds can be killed by spraying on the foliage. In this case, the herbicide acts like a systemic poison. It is not known why the incorporation of certain types of surfactants will make these herbicides into systemic herbicides. It is not merely the wetting ability of the surfactant, since simple wetting agents are not very effective. One thing we know is that these nonionic surfactants are all liquids and when dried form a gel-like semiliquid which is hard to wash off. It is possible that these surfactants keep a small amount of the herbicide in solution all the time, since it does not dry in the air, giving the plants a chance to absorb the dissolved herbicide slowly.

Preemergence sprays are easy to use and constitute the most economical method of controlling a large variety of broadleaf weeds and grasses normally encountered in macadamia orchards. The lasting qualities of these herbicides lengthen the spraying intervals necessary to maintain adequate weed control. For certain resistant weeds and grasses more specific herbicides, namely the systemics, can be applied on a spot-spray basis.

Examples of Preemergence Herbicides

NAME:	Diuron.
CLEARANCE:	Cleared as of September 1, 1965.
ADVANTAGES:	Has long residual action. Has a broad spectrum of weeds which it will kill. Is relatively nontoxic to macadamia trees. Has systemic properties when used with a surfactant.
DISADVANTAGE:	Is relatively insoluble in water (40 ppm); must be made into a suspension requiring agitation.
DOSAGE:	For a preemergence spray: 2 pounds/acre in any amount of water required for even application, generally 50 gallons. For use as a combination systemic and preemergence herbicide: 4 pounds (actual)/100 gallons of water with surfactant/acre.
COST:	50 pounds of 80%, \$156.90 (Kona, Hawaii).
REMARKS:	Has the broadest spectrum of herbicides in this group. Is relatively safe to use around humans and animals. Is

the most economical method for weed control in macadamia orchards, requiring the least frequent applications. Two applications of 4 pounds (actual) per acre are sufficient to keep orchard clean of weeds diuron is effective against.

NAME:	Atrazine.
CLEARANCE:	Has been cleared for use in macadamia orchards.
ADVANTAGE:	Can be used as a systemic herbicide with a surfactant.
DISADVANTAGE:	Not effective against grasses except as a preemergence herbicide.
DOSAGE:	As a combination preemergence and systemic herbicide: 4 pounds (actual)/100 gallons/acre).
COST:	50 pounds of 80%, $128.15 (Kona, Hawaii).
REMARKS:	Solubility (70 ppm) higher than either diuron or simazine, good under fairly dry conditions. Is relatively safe to use around humans or animals. Residual effect does not last as long as diuron or simazine.
NAME:	Simazine.
CLEARANCE:	Has been cleared for use in macadamia orchards.
ADVANTAGES:	Very low solubility (3.5 ppm); is long lasting in wet areas.
DISADVANTAGE:	Has very little systemic effect because of low solubility.
DOSAGE:	4 pounds (actual)/acre in enough water to spread evenly, generally 15 to 100 gallons per acre with a knapsack or 50 gallons per acre with a boom (more pressure).
COST:	50 pounds of 80%, $137.75 (Kona, Hawaii).
REMARKS:	Used only under wet conditions. Is strictly a preemergence herbicide. Is relatively safe to use around humans or animals.

General Remarks on Herbicides

No one herbicide is effective on all of the common weed species found in areas suitable for macadamia production. This is especially true of systemic herbicides and preemergence herbicides used as systemics with surfactant. Thus diuron, which has a very wide spectrum (kills a large number of species of weeds), will not kill many common weeds such as the fire weed (*Erechtites hieracifolia*), Flora's paint brush (*Emilia sonchifolia*), broadleaf plantain (*Plantago major*), and others, except very young seedlings of these species just emerging from seed. If diuron is used exclusively, these resistant weeds will eventually dominate and cover the entire orchard. Hence all of the herbicides now cleared for use in macadamia orchards must be used as necessary.

There are some weeds against which there is no effective herbicide known. The most common of these in Hawaii are torpedo grass (known on the island of Hawaii as Wainaku grass, *Panicum repens*), and purple nutsedge (commonly called nut grass, *Cyperus rotundus*). Hence precautions must be taken to prevent these grasses from being brought into the orchard, and if accidentally introduced, to prevent them from becoming established, either by digging them out of the orchard or by fumigating the spot with methyl bromide under tarp.

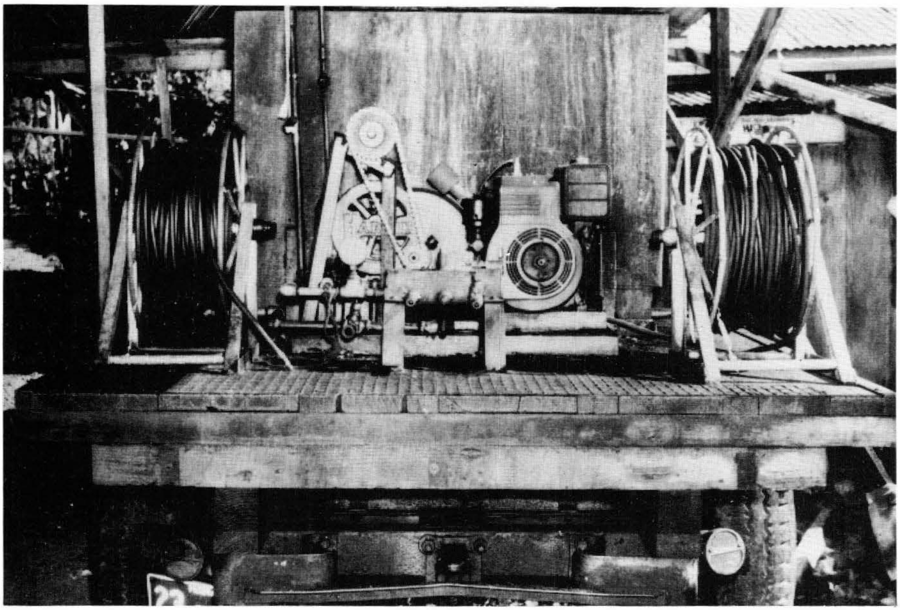
Spraying Equipment

Methods of applying the herbicides will vary depending on the slope, rockiness, planting pattern, and size of the orchard. In orchards where accessibility is practical, the use of a boom sprayer will reduce the labor requirement for weed control. Boom sprayers vary greatly in their cost and complexity. The least expensive boom sprayers make use of one or two 55-gallon drums which are integral-mounted on the three-point hitch of a tractor or on the rear end of a ½-ton pickup truck. The tractor-mounted sprayers use the power takeoff as a source of power, while the truck types have a small auxiliary gasoline engine. Boom sprayers of this kind sell for approximately $200. Tractor- or truck-mounted sprayers can also be used for spot spraying by disconnecting the boom and connecting hoses and wand sprayers.

For large acreages, truck- or trailer-mounted sprayers which include tanks having a large capacity (400 to 1,000 gallons) may prove the most economical. The cost of large sprayers with tanks will depend on the size of the tank, the material used in construction, and the equipment desired by the grower.

In very rough terrain, which precludes the use of vehicles, portable pumps run by small gasoline engines which can be carried by two men may be used. On smaller farms, knapsack sprayers may be used especially for spot spraying.

This two-man power sprayer is used in conjunction with 55-gallon drums spaced throughout the orchard.



Truck-mounted power sprayer with agitation tank and hoses.

The small portable engines and pumps which are carried by two men may be used in conjunction with 55-gallon drums with lids removed. The drums are placed strategically through the orchard with a galvanized iron sheet inserted in the top to increase the rain-catching capacity of the drum. The chemicals to be added to the water in the drums are placed beside them in the orchard. This system avoids having to transport heavy spray materials and is the most efficient system to use where the orchard is inaccessible to vehicles and where more than 2 or 3 acres are being farmed. Portable pumps with small gasoline engines can be purchased for approximately \$150. Fifty-five-gallon drums with iron sheets will cost around \$2 apiece. In addition the grower will need hoses and wands costing about \$60.

FERTILIZATION

The guiding principle in fertilization, assuming the profit-maximizing objective, is to increase the application of fertilizer up to the point where the last unit applied is just paid for by the value of the added yield. While this principle is a sound guide practice, the complete achievement of equating the marginal cost of the fertilizer with the marginal revenue from the nuts generally cannot be accomplished. The major reason for this is that weather cannot be predicted in advance. Thus, in practice, the grower either applies too little or too much fertilizer to maximize his profits.

More complicated perhaps than how much fertilizer to apply is what kind. It is particularly important that the macadamia tree receive the correct proportion of the elements nitrogen, phosphorus, and potassium. Recent studies conducted by the Plant Physiology Department of the College of Tropical Agriculture at the University of Hawaii have shown that phosphorus is much more important in macadamia metabolism than was originally supposed.[8] On the basis of experiments on aa lava lands, it has been found that for a mature orchard, a fertilizer with the balance of 2 parts N, 4.5 parts P_2O_5, and 2 parts K_2O is recommended. A formula with this balance can be made by combining 5 parts of ammonium phosphate (21-48) with 2 parts sulfate of potash, thus yielding a formula of 15-34-15. Regardless of spacing, approximately 1,000 pounds per acre per year of formula 15-34-15 should be applied in the mature orchard. For trees on aa lands showing symptoms of phosphorus deficiency a supplemental application of superphosphate (22.2% P_2O_5) should be applied at the rate of 630 pounds per acre per year for 2 years; this should correct the deficiency.

Just prior to when the trees close in, more of all fertilizer elements may be required than that suggested above for maintenance. At this time the trees will be in an active growth stage and at the same time will be yielding nuts. The period prior to closing-in will be longer for orchards with wider spacing and hence will require heavier applications of fertilizer over a longer period of time.

Once the trees have closed, the application per individual tree can best be arrived at by dividing the recommended applications per acre given previously by the number of trees per acre. Thus, if the mature orchard has a spacing of 25 feet × 25 feet, or 69 trees per acre, the application per tree per year should be 14.5 pounds of 15-34-15 (1,000 pounds ÷ 69 trees).

Table 1 gives the recommended fertilizer applications for the developing orchard with a spacing of 25 feet × 25 feet.

TABLE 1. Recommended applications of 15–34–15 in an orchard with a spacing of 25 feet × 25 feet where trees close in the 11th year

Age in years	Diameter, inches	Pounds of phosphorus per tree per year	Pounds of 15-34-15 per tree per year	Pounds of 15-34-15 per acre per year
1	0.5	0.06	0.4	27.6
2	1.3	0.31	2.1	144.9
3	2.1	0.78	5.3	365.7
4	2.9	1.51	10.2	703.8
5	3.7	2.44	16.4	1,131.6
6	*	*	*	*
7				
8	*	*	*	*
9	*	*	*	*
10	*	*	*	*
11	7.8	2.15	14.5	1,000.5

* Fertilizer applications for the 6th year through the 10th year have not been determined by experimentation. It is recommended that the grower use the 5th-year fertilizer application and supplement this if deficiency symptoms occur.

[8] Bruce J. Cooil, Yoshio Watanabe, and Shigeru Nakata, *Relationships of Phosphorus Supply to Growth, Yield, and Leaf Composition in Macadamia,* Hawaii Agricultural Experiment Station, Technical Bulletin No. 66, December 1966, 71 pp.

Applications of fertilizer should be made about four times per year. The recommended method is to broadcast the fertilizer as evenly as possible under the trees to the point where the root system extends. The extent of the root system can be estimated by observing the extent of the branching.

HARVESTING

In the mature macadamia orchard, harvesting requires more labor than all other operations combined. It is the most expensive operation where the labor must be hired. For this reason, and to maintain quality, considerable care and attention should be devoted to this operation.

On one large corporate farm in Hawaii a mechanical harvester has proven practical, but for the small farmer or those located on steep or rocky lands, hand harvesting will probably remain a necessity. Without exception, macadamia nuts are harvested from the ground. Once the nuts have fallen to the ground, deterioration can take place fairly soon, especially in rainy areas. It is quite important, therefore, to harvest the nuts as soon as possible. During the months of heaviest fall, it may be necessary to harvest every 2 weeks, tapering off to once a month as yields diminish. Harvesting at frequent intervals will help considerably in improving quality.

One of the important operations supplemental to harvesting is the raking and burning of leaves. The presence of leaves makes it difficult to locate nuts, and decaying moist leaves will cause the fallen nuts to deteriorate more rapidly. In some locations, it is possible to break up leaves with a mower having a mulching attachment which will hasten their decomposition; however, in most orchards, shattering leaves mechanically will be prevented by the steep terrain or the presence of rocks.

RAT CONTROL

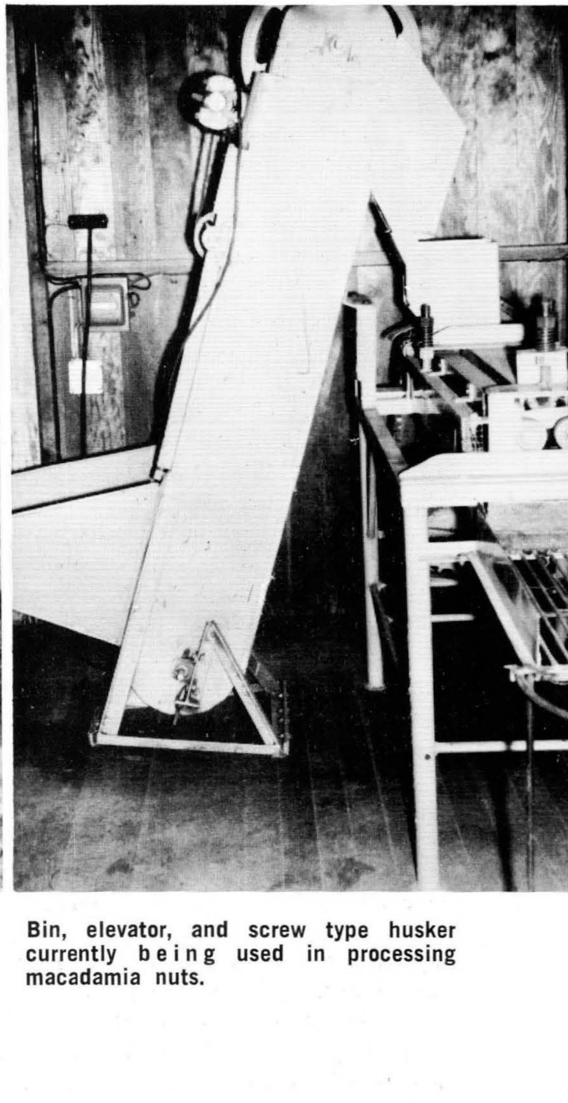
A program for rat control should begin when the orchard starts to bear at about 5 to 6 years. Aside from the public health menace they create, rats can do a considerable amount of damage if allowed to go unchecked in macadamia orchards. The main objection to rats is that they seriously reduce yield through eating and storing nuts and by destroying immature nuts on the tree.

A very effective way of controlling rats is by inserting poisoned bait in plastic sleeves placed strategically throughout the orchard. As the bait is eaten from the bottom of the sleeve, more bait slides down to take its place; thus, a constant supply is available to the rats. Warfarin-treated cull nuts or oats make an effective poison bait for use with the plastic containers. Periodic inspection and refilling of containers will guard against reinfestation.

FARM PROCESSING FOR SALE

The major jobs to be accomplished by farm processing are: (1) removal of the husk, (2) drying the nuts, and (3) sorting out the bad nuts.

Two kinds of poisoned bait dispensers used in controlling rats. The sleeve type requires less filling.



Bin, elevator, and screw type husker currently being used in processing macadamia nuts.

Nuts harvested from the orchard should be husked within 24 hours to prevent serious deterioration. Unhusked nuts left for any time in the bag tend to heat up due to decomposition. The bagged unhusked nuts coming from the orchard are dumped into a hopper from which they are conveyed into the husker. For many years the most popular type of husking method consisted of running the unhusked nuts between a rubber car-tire and a plate; however, this method has given way to the screw type husker.

The screw type husker consists of two rollers about 2½ inches in diameter and 3 feet long. Heavy wires are welded on the rollers in spirals, then the two rollers are placed parallel to each other and rotated in opposite directions, pushing the nuts from one end to the other. A space is provided between the rollers just sufficient to clear the spiral wires.

A long narrow metal plate, lined with heavy rubber (a strip of rubber tire is used at present), is placed directly above the center of the two rollers. This long plate is spring mounted and the clearance between the rubber lining and the two rollers is adjustable.

As the rollers rotate, the nut in the husk is pushed from one end into the space between the rollers and the rubber-lined plate. The clearance becomes smaller as the nut is pushed farther from the entrance end. Thus the nut is forced through a progressively narrowing space and, in the process, the husk is rubbed off. The husk drops through the space between the rollers while the nut emerges at the end of the pair of rollers.

The principle of the screw type husker is similar to the old rubber-tire husker, but in the tire husker, the nut is propelled through the husker by the rotating tire itself. However, when the nuts are wet, the tire becomes very slippery, thus the propelling action of the tire is nullified and the nuts will not be forced into the effective part of the husker. But the new husker depends upon spirals acting as screws, hence the action is more positive, regardless of whether the nuts are wet or dry.

Two bags of unhusked nuts typically yield one bag of nuts in the shell.

The primary reason for drying the nuts after husking is to prevent their deterioration until they can be sold or shipped to the processor. It also becomes easier to sort out bad nuts after drying, because some defects are not readily apparent until the nuts are at least partially dried.

When nuts come out of the husker, they are normally about 20 to 25 percent moisture. They should be dried to around 10 percent prior to delivery to the processor. After husking, the nuts are conveyed to a drying bin where air is continually passed through them by a blower. If the nuts are kept in the bin longer than 5 days, then intermittent drying such as blowing air through them only in the daytime will be sufficient. Heated air or sun drying should never be used for drying freshly husked macadamia nuts as this will cause uneven drying and cracking. Heat may be employed after the kernel has shrunk somewhat after shade drying.

Sorting nuts should be done just before they are sold to the processor since defects will be most noticeable at this time. Blemishes include very light nuts indicating immature kernel, and discolorations due to spoilage. The percentage of bad nuts will vary tremendously with the time of year (out of season), the location of the orchard, and the care exercised in processing. In some areas at certain times of the year, as much as 50 percent of the nuts may be bad. On the average, one would expect about 15 to 20 percent of the nuts to be culls. Not all defects are detected at the farm; normally about 10 percent of the sorted nuts sold to the processor will be bad.

To husk and dry 300 pounds of unhusked nuts will require approximately 1 man-hour. Under normal conditions (15 to 20 percent cull nuts), one man can sort about 290 pounds of husked nuts in 1 hour.

PRICES

The price which producers receive for their macadamia nuts will be determined by three factors: (1) percentage moisture, (2) quantity sold, and (3) quality of the nuts. In order to realize the premium paid for quantity, many farmers elect to market through a cooperative which in turn sells to the processor. Below is an example of a processor's price quotations and other conditions of sale.

I. MACADAMIA NUT BASE PURCHASE PRICE SCHEDULE[9]

Percent Moisture	*In-shell Weight Price Per Pound Grafted and Seedling*
5.0–5.6	0.1850
5.7–6.9	0.1825
7.0–8.1	0.1800
8.2–9.4	0.1775
9.5–10.6	0.1750
10.7–11.9	0.1725
12.0–13.1	0.1700
13.2–14.4	0.1675
14.5–15.6	0.1650
15.7–16.9	0.1625
17.0–18.1	0.1600
18.2–19.4	0.1575
19.5–20.6	0.1550
20.7–21.6	0.1525
22.0–23.1	0.1500
23.2–24.4	0.1475
24.5–25.0	0.1450

II. KERNEL QUALITY BONUS

A premium will be paid for higher quality kernels received at factory under the following terms:

Bonus on Roasted Kernel quality suitable for jar and tin pack:

Based on Net In-shell Weight

80% or more Top Quality	—1½¢/lb	in-shell	weight
70–79% " "	—1¼¢/lb	"	"
60–69% " "	—¾¢/lb	"	"
50–59% " "	—¼¢/lb	"	"
49% Quality or less	—Regular price		

This bonus reflects the savings in inspection costs at our factory when the percentage of top quality nuts is high. Only top quality macadamias are used in jar and tin packages.

9 Price list furnished by processor in 1966.

III. DELIVERY BONUS

A bonus will be paid for deliveries received in one lot of 2,000 lbs. or more as follows:

2,000 lbs. to 4,999 lbs.—1¢/lb
5,000 lbs. and over —1½¢/lb

IV. ANNUAL QUANTITY BONUS

A direct shipper will receive an additional retroactive bonus for all nuts delivered based on the following schedule:

0–25,000 lbs. —Regular price
25,000–49,999 lbs. —Regular price plus bonus of ½¢/lb
50,000–99,999 lbs. —Regular price plus bonus of 1¢/lb
100,000–199,999 lbs.—Regular price plus bonus of 1½¢/lb
200,000–300,000 lbs.—Regular price plus bonus of 2½¢/lb

TERMS AND CONDITIONS

a. All prices F.O.B. factory.
b. The above prices apply to the net weight of incoming shipments after the deduction of spoilage as measured by samples drawn by the buyer.
c. Any or all of the shipment with more than 25% spoilage may be rejected.
d. All bags will be returned to the grower.
e. All macadamia nuts purchased must be husked.

COST AND RETURN PROJECTION FOR A 10-ACRE FARM

Each grower will be faced with a different situation with regard to the buildings and equipment he will need. Many potential macadamia growers will be engaged in growing a crop other than macadamia and will therefore possess many of the capital items needed. In making up this budget it is assumed that the grower is starting from scratch, that he is located on land that is smooth enough to traverse with a jeep, and that the intended planting is 10 acres in size.

Equipment and Buildings

$ 600	Quonset hut 20 feet by 50 feet: drying nuts, husking nuts, storage area for fertilizer, weedicide, hand tools, packing shed
1,000	Husker and motor[10]
500	Drier (drying bin, blower, and motor)[10]
600	Jeep, used military type
400	Farm trailer
450	Power sprayer with hoses and small detachable boom, for jeep mounting
70	Knapsack sprayers, 2 @ $35 apiece

[10] Husker and drier not purchased until 6th year.

200 Miscellaneous, including hand tools: pruning shears, sickles, boots, raincoats, gloves, water containers, picks, shovels

———

$2,320 TOTAL COST

Depreciation and Interest Schedule

Per Year Per Acre		
$ 3.00	*Quonset*	depr., $600 ÷ 20 yrs. = $30/yr ÷ 10 acres = $3
1.80		int., $300 × 6% = $18/yr ÷ 10 acres = $1.80
6.67	*Husker*[10]	depr., $1,000 ÷ 15 yrs. = $66.67 ÷ 10 acres = $6.67
3.00		int., $500 × 6% = $30 ÷ 10 acres = $3
3.33	*Drier*[10]	depr., $500 ÷ 15 yrs. = $33.33 ÷ 10 acres = $3.33
1.50		int., $250 × 6% = $15 ÷ 10 acres = $1.50
10.00	*Jeep*	depr., $600 ÷ 6 yrs. = $100/yr ÷ 10 acres = $10
1.80		int., $300 × 6% = $18/yr ÷ 10 acres = $1.80
2.67	*Farm trailer*	depr., $400 ÷ 15 yrs. = $27.67 ÷ 10 acres = $2.67
1.20		int., $200 × 6% = $12 ÷ 10 acres = $1.20
4.50	*Power sprayer*	depr., $450 ÷ 10 yrs. = $45/yr ÷ 10 acres = $4.50
1.35		int., $225 × 6% = $13.50/yr ÷ 10 acres = $1.35
1.40	*Knapsack*	depr., $70 ÷ 5 yrs. = $14/yr ÷ 10 acres = $1.40
.21	*sprayers*	int., $35 × 6% = $2.10/yr ÷ 10 acres = $0.21
5.00	*Miscellaneous*	depr., $200 ÷ 4 yrs. = $50/yr ÷ 10 acres = $5
.60		int., $100 × 6% = $6/yr ÷ 10 acres = $0.60

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$33.53 Total depreciation and interest per acre per year

Establishing the Planting

The topography of the land, soil type, climatic factors, and vegetative growth will determine to a considerable extent the cost of land preparation and the labor performance rates on the various jobs to be done. In this case it is assumed that the land is of the small aa lava type and that the vegetation is composed of ohia trees, guava, and other types of underbrush. There is a moderate slope to the land with some surface irregularities which will require smoothing out with a dozer. To provide reasonably good access for a jeep and power sprayer, the land must be rolled.

Cost Per Acre

$250.00 *Land clearing:* Smoothing out irregularities, rolling, piling, and burning brush; done on contract.

44.38 *Preplanting weed control:*

After clearing:

5 lbs. of 80% diuron @ $3.14 in 50 gals. of water	$15.70
Jeep and power sprayer, 2 hrs. @ $1.10	2.20
2 man-hrs. @ $1.35	2.70

6 weeks after clearing (spot spraying):

10 lbs. of dalapon @ $1.02 in 30 gals. of water	10.20

Jeep and power sprayer, 2 hrs. @ $1.10 — 2.20
2 man-hrs. @ $1.35 — 2.70
½ gal. of 2,4,5-T @ $10.65/gal. in 10 gals. of aromatic oil @ $0.20 — 7.33
1 man-hr. @ $1.35 (knapsack sprayer) — 1.35

Total — $44.38

6.75 *Lay out and dig planting basins:* Using the triangle or equidistant system of planting without filler trees and a spacing of 33 ft. requires 46 basins to be dug per acre: 5 man-hrs. @ $1.35 = $6.75.

108.85 *Planting nursery stock:*

6 months after clearing:

46 young macadamia trees @ $2 = $92
Fertilizer 0-22-0 @ ¼ lb/basin, 11½ lbs. @ $3.06/100 lbs = $0.35
5 man-hrs. hauling soil, manure, and trees @ $1.35 = $6.75
3 jeep-hrs. (operation expense only) @ $1 = $3
5 man-hrs. planting trees @ $1.35 = $6.75

None *Windbreaks:* In clearing, the natural forest cover will be left in strips.

6.75 *Indirect labor:* Labor expended in bookkeeping, going after supplies, banking, repairing equipment, etc.
5 man-hrs. @ $1.35 = $6.75

$416.73 TOTAL COST

First-Year Costs Per Acre

$ 35.00 *Land rental* including taxes

76.86 *Weed Control*

2nd month after planting — *Costs*

5 lbs of 80% diuron @ $3.14 plus ½ gal. of non-ionic surfactant @ $3 and 10 lbs. of dalapon @ $1.02 in 100 gals. of water — $ 27.40
Jeep and power sprayer, 2 hrs. @ $1.10 — 2.20
2 man-hrs. @ $1.35 — 2.70
Note: Dalapon necessary only if perennial grasses are present. Do not use diuron spray close to trees. Spot spray around base of trees with: 1 gal. of PCP concentrate @ $0.44 in 12 gals. of water — .44
1 man-hr. @ $1.35 (knapsack sprayer) — 1.35
If ti plants are present, direct spray with: ¼ gal. of 2,4,5-T @ $10.65/gal in 5 gals. of aromatic oil @ $0.20 — 3.66
½ man-hr. @ $1.35 (knapsack sprayer) — .68

8th month after planting
Same as 2nd month after planting — 38.43

Total — $ 76.86

12.29 *Fertilizing*
Materials:
(15-30-15) 4 applications @ ¼ lb. = 1 lb/tree × 46 trees = 46 lbs. @ $6.28/100 lbs = $2.89
Labor:
4 applications @ 1 man-hr. = 4 man-hrs. @ $1.35 = $5.40
Equipment:
Jeep, 4 applications @ 1 hr. = 4 hrs. @ $1 = $4

.68 *Pruning:* ½ man-hr. @ $1.35

6.75 *Indirect labor:* Labor expended in bookkeeping, going after supplies, banking, repairing equipment, etc.
5 man-hrs. @ $1.35 = $6.75

33.53 *Depreciation and interest on investment* in buildings and equipment (see Depreciation and Interest Schedule, page 33)

$165.03 Total First-Year Costs Per Acre

Second-Year Costs Per Acre

$ 35.00 *Land rental* including taxes

49.16 *Weed control*

	Costs
2nd month of 2nd year	
2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	$ 15.75
Jeep and power sprayer, 2 hrs. @ $1.10	2.20
2 man-hrs. @ $1.35	2.70
1 lb. of dalapon @ $1.02 in 10 gals. of water (spot spraying)	1.02
½ man-hr. @ $1.35	.68
2 gals. of PCP concentrate @ $0.44 in 25 gals. of water (spot spraying)	.88
1 man-hr. @ $1.35	1.35
8th month of 2nd year	
Same as 2nd month of 2nd year	24.58
Total	$ 49.16

15.18 *Fertilizing*
Materials:
(15-30-15) 4 applications @ ½ lb. = 2 lbs/tree × 46 trees = 92 lbs. @ $6.28/100 lbs = $5.78
Labor:
4 applications @ 1 man-hr. = 4 man-hrs. @ $1.35 = $5.40

Equipment:

Jeep, 4 applications @ 1 hr. = 4 hrs. @ $1 = $4

.68 *Pruning:* ½ man-hr. @ $1.35

6.75 *Indirect labor:* Labor expended in bookkeeping, going after supplies, banking, repairing equipment, etc.
5 man-hrs. @ $1.35 = $6.75

33.53 *Depreciation and interest on investment* in buildings and equipment (see Depreciation and Interest Schedule, page 33)

$140.30 Total Second-Year Costs Per Acre

Third-Year Costs Per Acre

$ 35.00 *Land rental* including taxes

42.96 *Weed control*

	2nd month of 3rd year	*Costs*
	2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	$ 15.75
	Jeep and power sprayer, 2 hrs. @ $1.10	2.20
	2 man-hrs. @ $1.35	2.70
	8th month of 3rd year	
	2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	15.75
	Jeep and power sprayer, 2 hrs. @ $1.10	2.20
	2 man-hrs. @ $1.35	2.70
	Note: Edges of entire 10-acre field should be sprayed with: 10 lbs. of dalapon @ $1.02 plus ½ gal. of nonionic surfactant @ $3 in 100 gals. of water = $11.70 Jeep and power sprayer, 2 hrs. @ $1.10 = $2.20 2 man-hrs. @ $1.35 = $2.70 Total cost for 10 acres = $16.60 Cost for 1 acre	1.66
	Total	$ 42.96

23.84 *Fertilizing*

Materials:

(15-30-15) 4 applications @ 1¼ lbs. = 5 lbs/tree × 46 trees = 230 lbs. @ $6.28/100 lbs = $14.44

Labor:

4 applications @ 1 man-hr. = 4 man-hrs. @ $1.35 = $5.40

Equipment:

Jeep, 4 applications @ 1 hr. = 4 hrs. @ $1 = $4

22.00 *Inarching and pruning*

At this age 4 seedlings are planted 3 ft. from the trunk of the main tree on 4 sides.

46 trees × 4 seedlings = 184 seedlings @ \$0.05 = \$9.20
8 man-hrs. @ \$1.35 = \$10.80
Jeep, 2 hrs. @ \$1 = \$2

6.75 *Indirect labor:* Labor expended in bookkeeping, going after supplies, banking, repairing equipment, etc.
5 man-hrs. @ \$1.35 = \$6.75

33.53 *Depreciation and interest on investment* in buildings and equipment (see Depreciation and Interest Schedule, page 33)

\$164.08 Total Third-Year Costs Per Acre

Fourth-Year Costs Per Acre

\$ 35.00 *Land rental* including taxes

43.00 *Weed control:* Note: Spraying should be done before and after harvesting.

	Costs
2nd month of 4th year	
2½ lbs. of 80% diuron @ \$3.14 plus 2½ lbs. of 80% atrazine @ \$2.56 and ½ gal. of nonionic surfactant @ \$3 in 50 gals. of water	\$ 15.75
Jeep and power sprayer, 2 hrs. @ \$1.10	2.20
2 man-hrs. @ \$1.35	2.70
8th month of 4th year	
2½ lbs. of 80% diuron @ \$3.14 plus 2½ lbs. of 80% atrazine @ \$2.56 and ½ gal. of nonionic surfactant @ \$3 in 50 gals. of water	15.75
Jeep and power sprayer, 2 hrs. @ \$1.10	2.20
2 man-hrs. @ \$1.35	2.70
1 lb. of dalapon @ \$1.02 in 10 gals. of water (field edges)	1.02
½ man-hr. @ \$1.35 (knapsack sprayer)	.68
Total	\$ 43.00

38.29 *Fertilizing*
Materials:
(15-30-15) 4 applications @ 2½ lbs. = 10 lbs/tree × 46 trees = 460 lbs. @ \$6.28/100 lbs = \$28.89
Labor:
4 applications @ 1 man-hr. = 4 man-hrs. @ \$1.35 = \$5.40
Equipment:
Jeep, 4 applications @ 1 hr. = 4 hrs. @ \$1 = \$4

6.75 *Indirect labor:* Labor expended in bookkeeping, going after supplies, banking, repairing equipment, etc.
5 man-hrs. @ \$1.35 = \$6.75

33.53 *Depreciation and interest on investment* in buildings and equipment (see Depreciation and Interest Schedule, page 33)

\$156.57 Total Fourth-Year Costs Per Acre

Fifth-Year Costs Per Acre

$ 35.00 *Land rental* including taxes

43.00 *Weed control:* Note: Spraying should be done before and after harvesting.

		Costs
	2nd month of 5th year	
	2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	$ 15.75
	Jeep and power sprayer, 2 hrs. @ $1.10	2.20
	2 man-hrs. @ $1.35	2.70
	8th month of 5th year	
	2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	15.75
	Jeep and power sprayer, 2 hrs. @ $1.10	2.20
	2 man-hrs. @ $1.35	2.70
	1 lb. of dalapon @ $1.02 in 10 gals. of water (field edges)	1.02
	½ man-hr. @ $1.35 (knapsack sprayer)	.68
	Total	$ 43.00

60.32 *Fertilizing*

Materials:
(15-30-15) 4 applications @ 4 lbs. = 16 lbs/tree × 46 trees = 736 lbs. @ $6.28/100 lbs = $46.22

Labor:
4 applications @ 1½ man-hrs. = 6 man-hrs. @ $1.35 = $8.10

Equipment:
Jeep, 4 applications @ 1½ hrs. = 6 hrs. @ $1 = $6

34.05 *Inarching:* Seedlings for inarching should be 3 to 4 ft. high before grafting to the main trunk.
23 man-hrs. @ $1.35 = $31.05
Materials: Nails, wax = $3

6.75 *Indirect labor:* Labor expended in bookkeeping, going after supplies, banking, repairing equipment, etc.
5 man-hrs. @ $1.35 = $6.75

33.53 *Depreciation and interest on investment* in buildings and equipment (see Depreciation and Interest Schedule, page 33)

$212.65 Total Fifth-Year Costs Per Acre

Sixth-Year Costs Per Acre

$ 35.00 *Land rental* including taxes

43.00 *Weed control:* Note: Spraying should be done before and after harvesting.

	Costs
2nd month of 6th year	
2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	$ 15.75
Jeep and power sprayer, 2 hrs. @ $1.10	2.20
2 man-hrs. @ $1.35	2.70
8th month of 6th year	
2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	15.75
Jeep and power sprayer, 2 hrs. @ $1.10	2.20
2 man-hrs. @ $1.35	2.70
1 lb. of dalapon @ $1.02 in 10 gals. of water (field edges)	1.02
½ man-hr. @ $1.35 (knapsack sprayer)	.68
Total	$ 43.00

60.32 *Fertilizing*

Materials:

(15-30-15) 4 applications @ 4 lbs. = 16 lbs/tree × 46 trees = 736 lbs. @ $6.28/100 lbs = $46.22

Labor:

4 applications @ 1½ man-hrs. = 6 man-hrs. @ $1.35 = $8.10

Equipment:

Jeep, 4 applications @ 1½ hrs. = 6 hrs. @ $1 = $6

9.20 *Rat control*

Materials:

26 plastic dispensers @ $1.25 = $32.50

52 lbs. warfarin oats @ $15.75/75 lbs = $10.92

36 man-hrs. filling dispensers @ $1.35 = $48.60

Cost for 10 acres = $92.02. Cost for 1 acre = $9.20

111.65 *Harvesting*

60 lbs. (unhusked) nuts/tree × 46 trees = 2,760 lbs/acre picking rate, 35 lbs/hr = 79 man-hrs. @ $1.35 = $106.65

Jeep and trailer, 5 hrs. @ $1 = $5

21.44 *Husking and drying* 2,760 lbs. (unhusked) nuts

300 lbs. husking and drying rate per hr. = 9.2 man-hrs. @ $1.35 = $12.42

Husker and drier operation cost = $5.52

Materials: 10 bags @ $0.35 = $3.50

6.48 *Sorting* 1,380 lbs. (in shell) nuts

290 lbs. sorting rate per man-hr. = 4.8 man-hrs. @ $1.35 = $6.48

6.75 *Indirect labor:* Labor expended in bookkeeping, going after supplies, banking, repairing equipment, etc.

5 man-hrs. @ $1.35 = $6.75

48.03 *Depreciation and interest on investment* in buildings and equipment[11] (see Depreciation and Interest Schedule, page 33)

$341.87 Total Sixth-Year Costs Per Acre

$222.87 Total Sixth-Year Gross Returns Per Acre, 2,760 lbs. unhusked nuts = 1,380 lbs. nuts in shell, minus 15% bad nuts = 1,173 lbs. saleable nuts in shell × $0.19/lb = $222.87

$ −119.00 (negative) Total Sixth-Year Net Returns Per Acre

Seventh-Year Costs and Returns Per Acre

$ 35.00 *Land rental* including taxes

43.00 *Weed control:* Note: Spraying should be done before and after harvesting.

	Costs
2nd month of 7th year	
2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	$ 15.75
Jeep and power sprayer, 2 hrs. @ $1.10	2.20
2 man-hrs. @ $1.35	2.70
8th month of 7th year	
2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	15.75
Jeep and power sprayer, 2 hrs. @ $1.10	2.20
2 man-hrs. @ $1.35	2.70
1 lb. of dalapon @ $1.02 in 10 gals. of water (field edges)	1.02
½ man-hr. @ $1.35 (knapsack sprayer)	.68
Total	$ 43.00

60.32 *Fertilizing*

Materials:

(15-30-15) 4 applications @ 4 lbs. = 16 lbs/tree × 46 trees = 736 lbs. @ $6.28/100 lbs = $46.22

Labor:

4 applications @ 1½ man-hrs. = 6 man-hrs. @ $1.35 = $8.10

Equipment:

Jeep, 4 applications @ 1½ hrs. = 6 hrs. @ $1 = $6

5.95 *Rat control*

Materials:

5.2 lbs. warfarin oats, cost $1.09

3.6 man-hrs. filling dispensers @ $1.35 = $4.86

13.50 *Raking and burning leaves:* 10 man-hrs. @ $1.35 = $13.50

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[11] Reflects purchase of husker and drier in the 6th year.

163.95 *Harvesting*

140 lbs. (unhusked) nuts/tree × 46 trees = 6,440 lbs/acre picking rate, 55 lbs/hr = 117 man-hrs. @ $1.35 = $157.95

Jeep and trailer, 6 hrs. @ $1 = $6

45.43 *Husking and drying* 6,440 lbs. (unhusked) nuts

300 lbs. husking and drying rate per hr. = 21½ man-hrs. @ $1.35 = $29.03

Husker and drier operation cost = $12.90

Materials: 10 bags @ $0.35 = $3.50

14.99 *Sorting* 3,220 lbs. (in shell) nuts

290 lbs. sorting rate per man-hr = 11.1 man-hrs. @ $1.35 = $14.99

6.75 *Indirect labor:* Labor expended in bookkeeping, going after supplies, banking, repairing equipment, etc.

5 man-hrs. @ $1.35 = $6.75

48.03 *Depreciation and interest on investment* in buildings and equipment[11] (see Depreciation and Interest Schedule, page 33)

$436.92 Total Seventh-Year Costs Per Acre

$520.03 Total Seventh-Year Gross Returns Per Acre, 6,440 lbs. unhusked nuts = 3,220 lbs. nuts in shell, minus 15% bad nuts = 2,737 lbs. saleable nuts in shell @ $0.19/lb = $520.03

$ 83.11 Total Seventh-Year Net Returns Per Acre

Eighth-Year Costs and Returns Per Acre

$ 35.00 *Land rental* including taxes

43.00 *Weed control:* Note: Spraying should be done before and after harvesting.

	Costs
2nd month of 8th year	
2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	$ 15.75
Jeep and power sprayer, 2 hrs. @ $1.10	2.20
2 man-hrs. @ $1.35	2.70
8th month of 8th year	
2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	15.75
Jeep and power sprayer, 2 hrs. @ $1.10	2.20
2 man-hrs. @ $1.35	2.70
1 lb. of dalapon @ $1.02 in 10 gals. of water (field edges)	1.02
½ man-hr. @ $1.35 (knapsack sprayer)	.68
Total	$ 43.00

[11] Reflects purchase of husker and drier in the 6th year.

60.32 *Fertilizing*

Materials:

(15-30-15) 4 applications @ 4 lbs. = 16 lbs/tree × 46 trees = 736 lbs. @ \$6.28/100 lbs = \$46.22

Labor:

4 applications @ 1½ man-hrs. = 6 man-hrs. @ \$1.35 = \$8.10

Equipment:

Jeep, 4 applications @ 1½ hrs. = 6 hrs. @ \$1 = \$6

5.95 *Rat control*

Materials:

5.2 lbs. warfarin oats, cost \$1.09

3.6 man-hrs. filling dispensers @ \$1.35 = \$4.86

20.25 *Raking and burning leaves:* 15 man-hrs. @ \$1.35 = \$20.25

214.55 *Harvesting*

200 lbs. (unhusked) nuts/tree × 46 trees = 9,200 lbs/acre picking rate, 60 lbs/hr = 153 man-hrs. @ \$1.35 = \$206.55

Jeep and trailer, 8 hrs. @ \$1 = \$8

63.95 *Husking and drying* 9,200 lbs. (unhusked) nuts

300 lbs. husking and drying rate per hr. = 31 man-hrs. @ \$1.35 = \$41.85

Husker and drier operation cost = \$18.60

Materials:

10 bags @ \$0.35 = \$3.50

21.47 *Sorting* 4,610 lbs. (in shell) nuts

290 lbs. sorting rate per man-hr. = 15.9 man-hrs. @ \$1.35 = \$21.47

6.75 *Indirect labor:* Labor expended in bookkeeping, going after supplies, banking, repairing equipment, etc.

5 man-hrs. @ \$1.35 = \$6.75

48.03 *Depreciation and interest on investment* in buildings and equipment[11] (see Depreciation and Interest Schedule, page 33)

\$519.27 Total Eighth-Year Costs Per Acre

\$744.61 Total Eighth-Year Gross Returns Per Acre, 9,220 lbs. unhusked nuts = 4,610 lbs. nuts in shell, minus 15% bad nuts = 3,918 lbs. saleable nuts in shell @ \$0.19/lb = \$744.61

\$225.34 Total Eighth-Year Net Returns Per Acre

Ninth-Year Costs and Returns Per Acre

\$ 35.00 *Land rental* including taxes

43.00 *Weed control:* Note: Spraying should be done before and after harvesting.

[11] Reflects purchase of husker and drier in the 6th year.

		Costs
	2nd month of 9th year	
	2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	$ 15.75
	Jeep and power sprayer, 2 hrs. @ $1.10	2.20
	2 man-hrs. @ $1.35	2.70
	8th month of 9th year	
	2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	15.75
	Jeep and power sprayer, 2 hrs. @ $1.10	2.20
	2 man-hrs. @ $1.35	2.70
	1 lb. of dalapon @ $1.02 in 10 gals. of water (field edges)	1.02
	½ man-hr. @ $1.35 (knapsack sprayer)	.68
	Total	$ 43.00

60.32 *Fertilizing*

Materials:

(15-30-15) 4 applications @ 4 lbs. = 16 lbs/tree × 46 trees = 736 lbs. @ $6.28/100 lbs = $46.22

Labor:

4 applications @ 1½ man-hrs. = 6 man-hrs. @ $1.35 = $8.10

Equipment:

Jeep, 4 applications @ 1½ hrs. = 6 hrs. @ $1 = $6

5.95 *Rat control*

Materials:

5.2 lbs. warfarin oats, cost $1.09

3.6 man-hrs. filling dispensers @ $1.35 = $4.86

27.00 *Raking and burning leaves:* 20 man-hrs. @ $1.35 = $27

238.50 *Harvesting*

240 lbs. (unhusked) nuts/tree × 46 trees = 11,040 lbs/acre picking rate, 65 lbs/hr = 170 man-hrs. @ $1.35 = $229.50

Jeep and trailer, 9 hrs. @ $1 = $9

75.65 *Husking and drying* 1,040 lbs. (unhusked) nuts

300 lbs. husking and drying rate per hr. = 37 man-hrs. @ $1.35 = $49.95

Husker and drier operation cost = $22.20

Materials: 10 bags @ $0.35 = $3.50

25.65 *Sorting* 5,520 lbs. (in shell) nuts

290 lbs. sorting rate per man-hr. = 19 man-hrs. @ $1.35 = $25.65

6.75 *Indirect labor:* Labor expended in bookkeeping, going after supplies, banking, repairing equipment, etc.

5 man-hrs. @ $1.35 = $6.75

48.03 *Depreciation and interest on investment* in buildings and equipment[11] (see Depreciation and Interest Schedule, page 33)

$565.85 Total Ninth-Year Costs Per Acre

$891.48 Total Ninth-Year Gross Returns Per Acre, 11,040 lbs. unhusked nuts = 5,520 lbs. nuts in shell, minus 15% bad nuts = 4,692 lbs. saleable nuts in shell @ $0.19/lb = $891.48

$325.63 Total Ninth-Year Net Returns Per Acre

Tenth-Year Costs and Returns Per Acre

$ 35.00 *Land rental* including taxes

43.00 *Weed control:* Note: Spraying should be done before and after harvesting.

	2nd month of 10th year	*Costs*
	2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	$ 15.75
	Jeep and power sprayer, 2 hrs. @ $1.10	2.20
	2 man-hrs. @ $1.35	2.70
	8th month of 10th year	
	2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	15.75
	Jeep and power sprayer, 2 hrs. @ $1.10	2.20
	2 man-hrs. @ $1.35	2.70
	1 lb. of dalapon @ $1.02 in 10 gals. of water (field edges)	1.02
	½ man-hr. @ $1.35 (knapsack sprayer)	.68
	Total	$ 43.00

60.32 *Fertilizing*

Materials:

(15-30-15) 4 applications @ 4 lbs. = 16 lbs/tree × 46 trees = 736 lbs. @ $6.28/100 lbs = $46.22

Labor:

4 applications @ 1½ man-hrs. = 6 man-hrs. @ $1.35 = $8.10

Equipment:

Jeep, 4 applications @ 1½ hrs. = 6 hrs. @ $1 = $6

5.95 *Rat control*

Materials:

5.2 lbs. warfarin oats, cost $1.09

3.6 man-hrs. filling dispensers @ $1.35 = $4.86

33.75 *Raking and burning leaves:* 25 man-hrs. @ $1.35 = $33.75

[11] Reflects purchase of husker and drier in the 6th year.

258.40 *Harvesting*

280 lbs. (unhusked). nuts/tree × 46 trees = 12,880 lbs/acre picking rate, 70 lbs/hr = 184 man-hrs. @ $1.35 = $248.40

Jeep and trailer, 10 hrs. @ $1 = $10

87.35 *Husking and drying* 12,880 lbs. (unhusked) nuts

300 lbs. husking and drying rate per hr. = 43 man-hrs. @ $1.35 = $58.05

Husker and drier operation cost = $25.80

Materials: 10 bags @ $0.35 = $3.50

29.97 *Sorting* 6,440 lbs. (in shell) nuts

290 lbs. sorting rate per man-hr. = 22.2 man-hrs. @ $1.35 = $29.97

6.75 *Indirect labor:* Labor expended in bookkeeping, going after supplies, banking, repairing equipment, etc.

5 man-hrs. @ $1.35 = $6.75

48.03 *Depreciation and interest on investment* in buildings and equipment[11] (see Depreciation and Interest Schedule, page 33)

$608.52 Total Tenth-Year Costs Per Acre

$1,040.06 Total Tenth-Year Gross Returns Per Acre, 12,880 lbs. unhusked nuts = 6,440 lbs. nuts in shell, minus 15% bad nuts = 5,474 lbs. saleable nuts in shell @ $0.19/lb = $1,040.06

$431.54 Total Tenth-Year Net Returns Per Acre

Eleventh-Year Costs and Returns Per Acre

$ 35.00 *Land rental* including taxes

43.00 *Weed control:* Note: Spraying should be done before and after harvesting.

	Costs
2nd month of 11th year	
2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	$ 15.75
Jeep and power sprayer, 2 hrs. @ $1.10	2.20
2 man-hrs. @ $1.35	2.70
8th month of 11th year	
2½ lbs. of 80% diuron @ $3.14 plus 2½ lbs. of 80% atrazine @ $2.56 and ½ gal. of nonionic surfactant @ $3 in 50 gals. of water	15.75
Jeep and power sprayer, 2 hrs. @ $1.10	2.20
2 man-hrs. @ $1.35	2.70
1 lb. of dalapon @ $1.02 in 10 gals. of water (field edges)	1.02
½ man-hr. @ $1.35 (knapsack sprayer)	.68
Total	$ 43.00

[11] Reflects purchase of husker and drier in the 6th year.

60.32 *Fertilizing*

Materials:

(15-30-15) 4 applications @ 4 lbs. = 16 lbs/tree × 46 trees = 736 lbs. @ $6.28/100 lbs = $46.22

Labor:

4 applications @ 1½ man-hrs. = 6 man-hrs. @ $1.35 = $8.10

Equipment:

Jeep, 4 applications @ 1½ hrs. = 6 hrs. @ $1 = $6

5.95 *Rat control*

Materials:

5.2 lbs. warfarin oats, cost $1.09

3.6 man-hrs. filling dispensers @ $1.35 = $4.86

33.75 *Raking and burning leaves:* 25 man-hrs. @ $1.35 = $33.75

258.40 *Harvesting*

300 lbs. (unhusked) nuts/tree × 46 trees = 13,800 lbs/acre picking rate, 75 lbs/hr = 184 man-hrs. @ $1.35 = $248.40

Jeep and trailer, 10 hrs. @ $1 = $10

93.20 *Husking and drying* 13,800 lbs. (unhusked) nuts

300 lbs. husking and drying rate per hr. = 46 man-hrs. @ $1.35 = $62.10

Husker and drier operation cost = $27.60

Materials: 10 bags @ $0.35 = $3.50

32.13 *Sorting* 6,900 lbs. (in shell) nuts

290 lbs. sorting rate per man-hr. = 23.8 man-hrs. @ $1.35 = $32.13

6.75 *Indirect labor:* Labor expended in bookkeeping, going after supplies, banking, repairing equipment, etc.

5 man-hrs. @ $1.35 = $6.75

48.03 *Depreciation and interest on investment* in buildings and equipment[11] (see Depreciation and Interest Schedule, page 33)

$616.53 Total Eleventh-Year Costs Per Acre

$1,114.35 Total Eleventh-Year Gross Returns Per Acre, 13,800 lbs. unhusked nuts = 6,900 lbs. nuts in shell, minus 15% bad nuts = 5,865 lbs. saleable nuts in shell @ $0.19/lb = $1,114.35

$ 497.82 Total Eleventh-Year Net Returns Per Acre

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[11] Reflects purchase of husker and drier in the 6th year.

AMORTIZATION OF INVESTMENT IN A MACADAMIA PLANTING

One of the features of macadamia production is that the grower must wait, in some cases up to 8 years, before receiving a substantial return from his crop. During this waiting period he is constantly pouring capital into the planting in the form of fertilizer, herbicide, and other costs. One of the costs which is often overlooked by the individual grower but not by the corporate type business is the interest on the monetary inputs. Another feature of this periodic investment is that after the first year the grower is paying interest on his previous interest, or in other words paying compound interest.

Table 2 shows how the investment in a macadamia orchard would gradually be amortized by the income from the sale of the nuts. The investment and return figures shown in table 2 are taken from the cost and return projection given earlier in this bulletin, slightly modified by adjusting the depreciation schedule.

Starting with a first year's interest of $50.71 the yearly interest climbs to a maximum of $172.20 in the eighth year. From the maximum the interest declines until the investment in the orchard is completely repaid in the fifteenth year. The accumulated investment schedule follows a similar rise and fall as one would expect since the interest is computed from it.

In brief, if a grower were to borrow all of the money required to initiate a macadamia orchard, at 6½ percent interest, it would take 15 years for him to retire his loan.

TABLE 2. Amortization of investment for 1 acre of macadamia nuts

Year	Yearly investment without interest	Accumulated investment at beginning of year	Interest on accumulated investment at 6½%	Accumulated investment at end of year	Gross returns from sale of nuts
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
First	780.23	—	50.71	830.94	—
Second	106.77	937.71	60.95	998.66	—
Third	130.55	1,129.21	73.40	1,202.61	—
Fourth	123.04	1,325.65	86.17	1,411.82	—
Fifth	199.12	1,610.94	104.71	1,715.65	—
Sixth	450.84	2,166.49	140.82	2,307.31	222.87
Seventh	448.89	2,533.33	164.66	2,697.99	520.03
Eighth	471.24	2,649.20	172.20	2,821.40	744.61
Ninth	517.82	2,594.61	168.65	2,763.26	891.48
Tenth	560.49	2,432.27	158.10	2,590.37	1,040.06
Eleventh	613.50	2,163.81	140.65	2,304.46	1,114.35
Twelfth	568.50	1,758.61	114.31	1,872.92	1,114.35
Thirteenth	568.50	1,327.07	86.26	1,413.33	1,114.35
Fourteenth	568.50	867.48	56.39	923.87	1,114.35
Fifteenth	568.50	378.02	24.57	402.59	1,114.35
Sixteenth	608.50	− 103.26	− 6.71	− 109.97	1,114.35

UNIVERSITY OF HAWAII
COLLEGE OF TROPICAL AGRICULTURE
HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII

THOMAS H. HAMILTON
President of the University

C. PEAIRS WILSON
Dean of the College and
Director of the Experiment Station

G. DONALD SHERMAN
Associate Director of the Experiment Station