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A PRODUCTION COST ANALYSIS OF EUPHORBIA LATHYRIS

Final Report

By
David Alan Mendel

August 1979

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SRI International
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Prepared by:

David Alan Mendel

Frederick A. Schooley, Project Leader
Ronald L. Dickenson, Project Supervisor

Prepared for:

Fuels from Biomass Systems Branch
Division of Distributed Solar Technology
The United States Department of Energy

SRI Project 7877

SRI International
333 Ravenswood Avenue
Menlo Park, California 94025

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SUMMARY AND CONCLUSIONS

The purpose of this study is to estimate costs of production for Euphorbia lathyris (hereafter referred to as Euphorbia) in commercial-scale quantities. Selection of five U.S. locations for analysis was based on assumed climatic and cultivation requirements. The five areas are:

- Nonirrigated areas
  - Southeast Kansas and Central Oklahoma
  - Northeast Louisiana and Central Mississippi
  - Southern Illinois.
- Irrigated areas
  - San Joaquin Valley, California
  - Imperial Valley, California and Yuma, Arizona.

Cost estimates are tailored to reflect each region's requirements and capabilities. Variable costs for inputs such as cultivation, planting, fertilization, pesticide application, and harvesting include material costs, equipment ownership, operating costs, and labor. Fixed costs include land, management, and transportation of the plant material to a conversion facility. The variable, fixed, and total production costs for each region are shown in Table 1.

Euphorbia crop production costs, on the average, range between $215 per acre in nonirrigated areas to $500 per acre in irrigated areas. Extraction costs for conversion of Euphorbia plant material to oil are estimated at $33.76 per barrel of oil,[1] assuming a plant capacity of 3,000 dry ST/D. These results are summarized in Table 1.

Table 2 suggests that estimated Euphorbia crop production costs are competitive with those of corn. Alfalfa production costs per acre are less than those of Euphorbia in the Kansas/Oklahoma and Southern Illinois site, but greater in the irrigated regions. This disparity is accounted for largely by differences in productivity and irrigation requirements.

Table 1

ESTIMATED EUPHORBIA PRODUCTION COSTS
IN FIVE U.S. LOCATIONS
(Fourth Quarter 1978 Dollars)
(Includes Transportation and Extraction Costs)

Region	Crop Production Costs				Total Cost per Barrel of Oil
	Variable Costs	Fixed Costs	Total	Yield $/Ton per Year	
Nonirrigated					
Kansas/Oklahoma	138.35	67.54	205.89	30.00	89.40
Louisiana/Mississippi	158.45	74.55	233.00	34.00	96.23
Southern Illinois	160.75	103.70	264.45	39.00	105.23
Irrigated					
San Joaquin Valley	380.80	121.70	502.50	49.00	169.57
Imperial Valley/Yuma	376.30	156.33	532.63	47.00	177.71

Table 2

ESTIMATED PRODUCTION COST PER ACRE
FOR CORN, ALFALFA, AND EUPHORBIA
(Fourth Quarter 1978 Dollars)
(Does Not Include Transportation Costs)

Region	Euphorbia	Corn	Alfalfa
Nonirrigated			
Kansas/Oklahoma	186.00	180.00	150.00
Louisiana/Mississippi	214.00	202.00	--
Southern Illinois	245.75	210.00	122.00
Irrigated			
San Joaquin Valley	483.80	506.16	536.00
Imperial Valley/Yuma	514.00	--	520.00

Yields produced under experimental conditions would be difficult to replicate in a commercial-scale operation. Spacing would be changed from the 1 sq. ft. grid currently used, to a conventional row crop spacing of 2.5 sq. ft. This spacing would permit both post-emergence cultivation and pesticide application, which are not afforded by a 1 sq. ft. grid. Given this additional space, commercial yields per plant can be expected to attain experimental levels. Commercial yields per acre, however, probably will not reach the 17 dry tons predicted by previous experiments. Rather, commercial production would yield approximately 6.8 dry tons, or an equivalent of 3.7 barrels of oil.

Yields and costs are responsive to variations in inputs. Experiments at the University of California South Coast Field Station have shown that an additional 50 lbs of nitrogen per experimental plot induces additional growth of 12-18 inches per plant. It has not been determined whether the use of additional nitrogen would be cost effective for large-scale commercial operations. As economies of scale for Euphorbia production are developed, current seed costs of $60 per acre could be reduced to $10-20 per acre. Conversely, pesticide costs can be expected to increase as a greater understanding of the agronomic characteristics of Euphorbia is advanced. The net reduction in overall production costs could be $20-30 per acre. As additional experiments are conducted, more precise estimates will be developed.

I INTRODUCTION

During the past 150 years, industrialized nations have become increasingly dependent on coal, petroleum, and natural gas for energy and chemicals. Mushrooming energy consumption is ensuring the rapid depletion of these energy sources. Some experts expect that more than half of proven world resources of petroleum and natural gas will be consumed within the next 25 years.[2] Severe economic and environmental problems will be encountered in utilizing coal reserves. The use of other fossil fuels, such as those found in oil shales, appears to be even more difficult.

It has been suggested that the use of biomass--organic materials generated by photosynthesis--may provide an alternative energy source. Through the mechanism of the photosynthetic carbon cycle, a green plant captures the carbon dioxide from the atmosphere and, with the aid of sunshine, separates hydrogen from the water to reduce the carbon dioxide to carbohydrate (such as sugar), in which there is only one oxygen atom on each carbon atom. Some plants can take the carbohydrate and reduce it to hydrocarbons, with no oxygen at all on the carbon atoms. This is essentially what petroleum is.

One plant that is rich in hydrocarbon is the latex-producing plant, Euphorbia. A member of the family Euphorbiaceae, Euphorbia is one of 300 species of latex-bearing plants that produce an isoprenoid similar to rubber. Although data concerning the agronomic and economic characteristics of Euphorbia are limited, field experiments are currently being conducted.

The purpose of SRI's study was to estimate the costs of producing Euphorbia in commercial quantities in five regions of the United States, which include both irrigated and nonirrigated areas. The study assumed that a uniform crop yield could be achieved in the five regions by varying the quantities of production inputs. Therefore, the production costs estimates, which are based on fourth quarter 1978 dollars, include both fixed and variable costs for each region.

Doane's Machinery Custom Rates for 1978[3] were used to estimate all variable costs except materials, which were estimated separately. Custom rates are determined by members of the Doane Countywide Farm Panel, a group of farmers specifically selected to represent the various sizes and types of commercial farms found throughout the country. The rates reported are the most recent rates the panel members had either paid, charged, or known for certain a second party had paid or charged. Custom rates for any particular operation include equipment operating costs (fuel, lubrication, and repairs), equipment ownership costs (depreciation, taxes, interest), as well as a labor charge for the operator. Custom rates are regionally specific and thereby assist the accuracy of this analysis.

Fixed costs include land, management, and transportation of the plant material to a conversion facility. When appropriate, fixed costs were regionally specific. Changes in total production costs over future time periods were not addressed. The total estimated production costs of Euphorbia in each region were compared with production costs for corn and alfalfa in the same regions. Finally, the effects on yield and costs of changes in the production inputs were estimated.

II PRODUCTION REQUIREMENTS

This section describes the major factors in Euphorbia production, including climate, soil preparation, planting, fertilization, pesticide application, harvesting and drying, land and management expenses, and transportation to a conversion facility. The yields per acre obtained under experimental conditions are also discussed. The estimated production costs described in this section are substantiated by the tables presented in the Appendix, which list estimated costs by region.

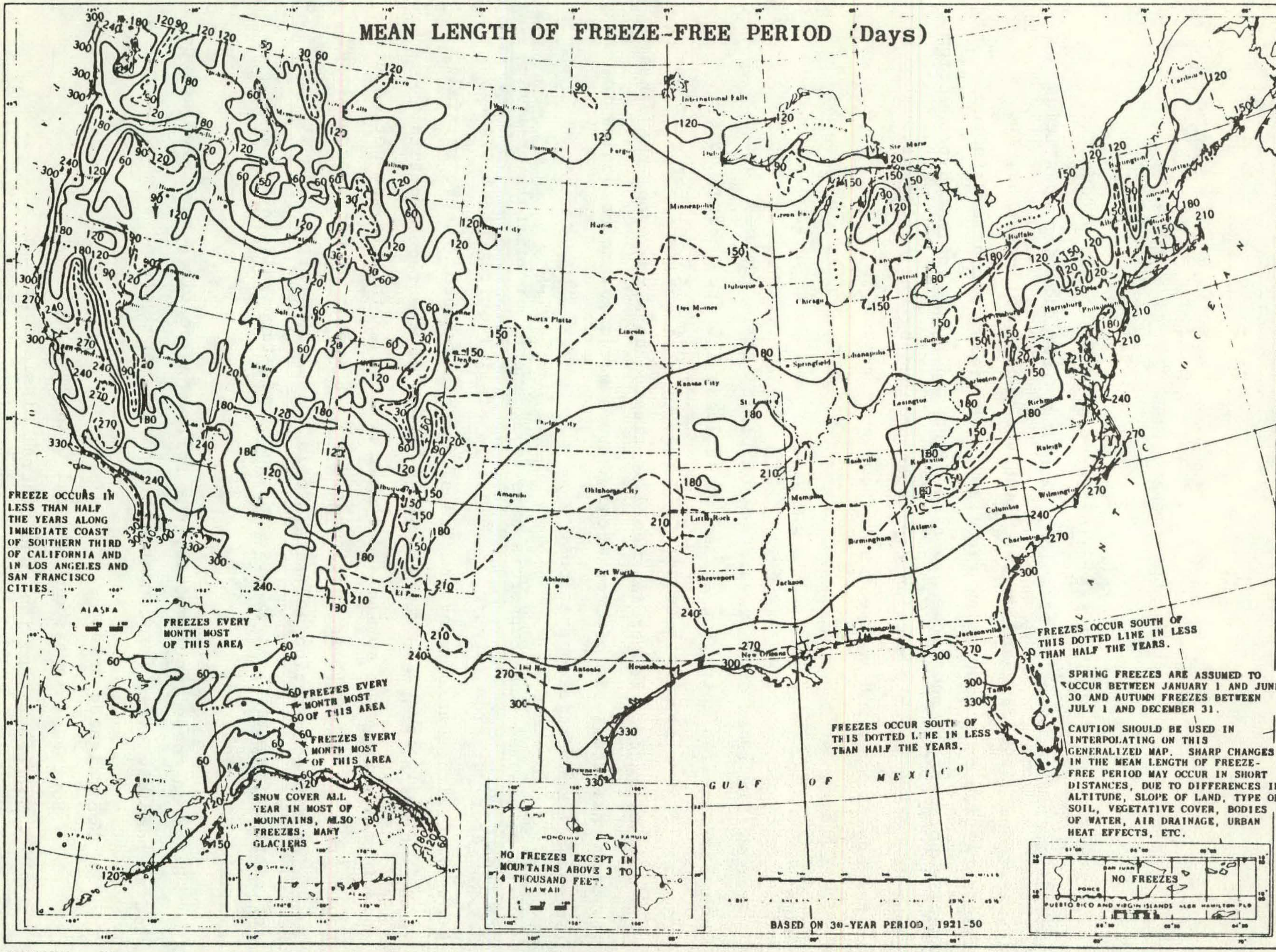
Climate

Euphorbia is an annual, warm season plant. It is assumed that Euphorbia requires a growing season of at least 180 freeze-free days per year (Figure 1). Soil temperature must be 60°F (15.5°C) for germination and emergence. Euphorbia should be treated as a row crop; the denser planting characteristic of close-growth crops would not be conducive to large-scale commercial operations.

It is assumed that Euphorbia uses 24-30 inches of rainfall or irrigation water per crop (Figure 2). This rainfall requirement is closely associated with that of many row crops, especially corn. Where rainfall is the principal source of water, 18-20 inches of the required total should fall during the spring and summer months, as this is the period of rapid growth. Rainfall is supplemented by 4-6 inches of water accumulated from winter precipitation and retained in the plant profile. In areas deficient in rainfall, it is assumed that irrigation water would be available as required.

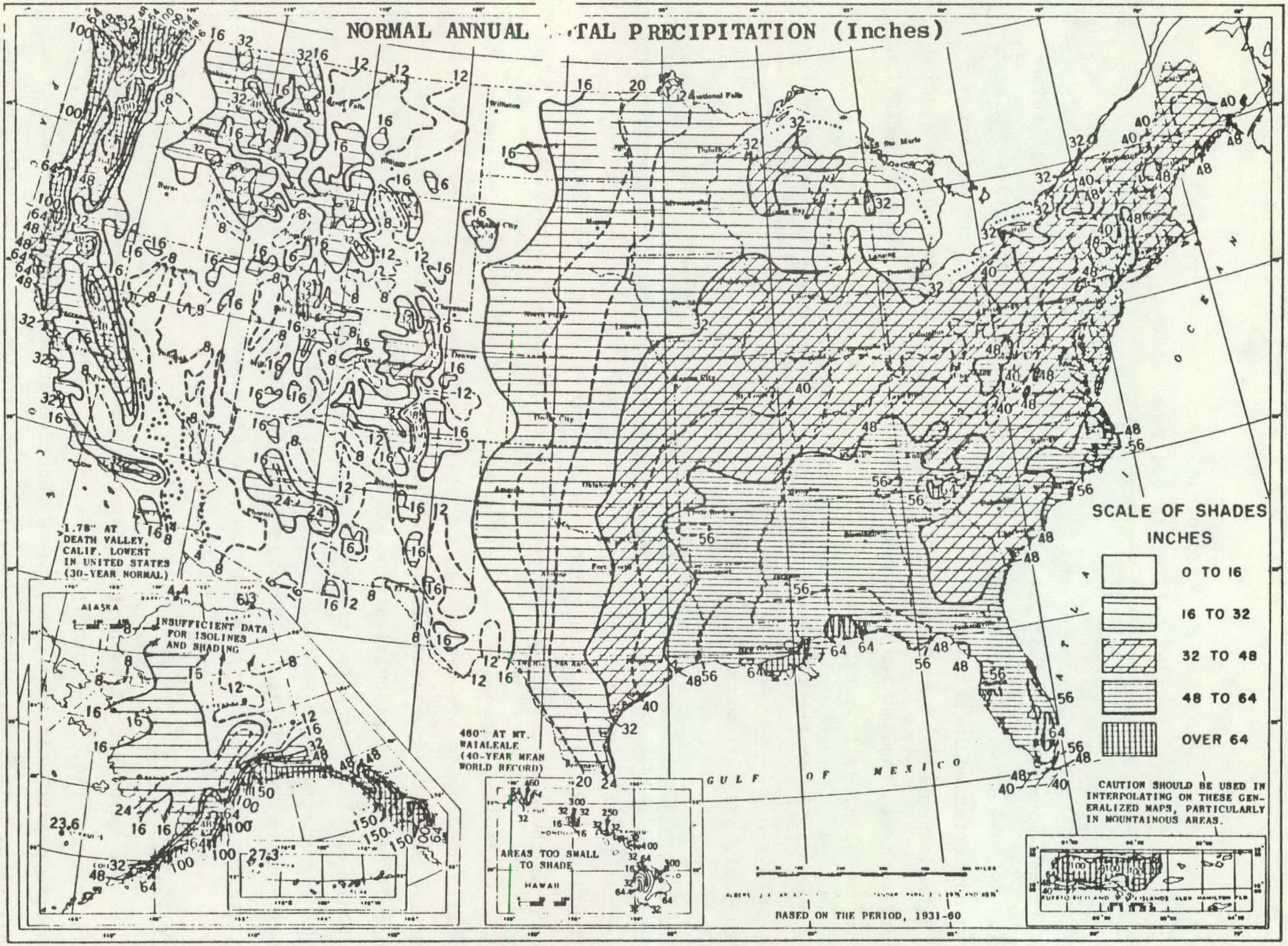
Based on these requirements, the following locations have been selected as possible sites for commercial Euphorbia production:

- Nonirrigated areas
  - Southeast Kansas and Central Oklahoma
  - Northeast Louisiana and Central Mississippi
  - Southern Illinois



SOURCE: "Selected Climatic Maps of the United States," Environmental Data Service, U.S. Department of Commerce (1966)

FIGURE 1 MEAN LENGTH OF FREEZE-FREE PERIOD



SOURCE: "Selected Climatic Maps of the United States," Environmental Data Service, U.S. Department of Commerce (1966)

FIGURE 2 NORMAL ANNUAL TOTAL PRECIPITATION

Irrigated areas

- San Joaquin Valley, California
- Imperial Valley, California and Yuma, Arizona.

Soil Preparation

The amount and kind of pre-plant soil preparation will vary in relation to soil type, previous crop, and general management practices. In the nonirrigated locations, soils are relatively sandy in composition and lend themselves to minimum tillage preparation. This analysis assumes that discing (tandem) and harrowing (spike tooth) operations are sufficient for pre-plant soil preparation.

The soils of the irrigated areas are somewhat more compacted. Soil preparation in these regions will require plowing (moldboard), discing (tandem), and harrowing (spiketooth).

Planting

As previously stated, Euphorbia should be treated as a row crop. Planting would be done using plate type or singulating seed planters, such as those used for planting other row crops such as corn.

Currently, Euphorbia seeds are produced for experimental purposes only. Seed costs are estimated from current costs and therefore do not derive benefits from economies of scale. Should Euphorbia be designated for commercial cultivation, seed costs can be expected to drop significantly. Estimates of the quantity of seed required assume a 90% germination rate and a 2.5 square foot planting grid (30 inches between rows and 12 inches between plants). This spacing arrangement is taken from optimal yield results produced under test conditions.

Fertilization

The responses of Euphorbia to varying fertilizer levels are still largely unknown. The quantity of extractable hydrocarbons produced by the plant could vary widely as a function of the relative amounts of nitrogen, potassium, phosphorous, and micronutrients available to the plant. Estimates of fertilizer requirements have been prepared from fertilizer application levels presently associated with row crops cultivated in the locations selected, as well as from fertilizer information obtained from experimental plots of Euphorbia.

The irrigated valleys of California and Arizona typically are deficient in nitrogen. In addition, irrigated soils facilitate the plants' utilization of larger quantities of nitrogen. Potassium is needed in few if any irrigated soils. The need for phosphorous is limited to selected areas of the Imperial Valley. Agricultural lime is not used in California and Arizona.

In contrast to the fertilizer needs of irrigated soils, nitrogen deficiency is not encountered in the nonirrigated regions. Response to both potassium and phosphorous is evident. Fertilizer application levels in the Louisiana/Mississippi site should slightly exceed those of the Kansas/Oklahoma location because of more sandy soil, which incurs increased leeching.

Pesticide Application

Requirements for pesticides are largely unknown. Under experimental conditions, aphids proved to be the major pest. An aphicide, Meta-Systox R,® has been chosen as a general insecticide for all locations. Two treatments per acre are recommended.

Because weed control has been performed manually on all test plots, no knowledge exists as to requirements for, nor tolerance to, various herbicides by Euphorbia. This analysis will rely upon cultivation practices for weed control.

Irrigation

Irrigation may be accomplished either by sprinklers or furrows. Five types of irrigation systems that may be employed to cultivate Euphorbia in the fashion envisioned are:

- Center pivot
- Permanent solid set

- Hand move
- Wheel line
- Furrow.

The applicability of a system often is determined by variance in soil type or management practice. For example, the application rate of a center pivot system increases outward along the lateral to compensate for the increased area of coverage as the radius lengthens. It is the higher application rates at the outer ends that limit this type of system to coarser, high infiltration soils. Placed on soils with intake rates of less than one inch per hour, center pivot systems may lead to severe runoff problems.

The permanent solid set system has pipes permanently installed below ground and risers permanently in place. These systems are characterized by a high initial cost but lower overhead requirements. Hand-move lateral systems are supplied with quick-coupling joints and rotary head sprinklers. The lightweight aluminum pipe ranges from 20 to 40 feet in length. These may be used in paired laterals that apply irrigation to a strip and are then moved to the next strip. This facilitates a decline in capital costs, as a much smaller pump is required than if the entire field were sprinkled at once. However, labor costs are substituted for capital costs.

Furrow irrigation is a variation of flood irrigation where the water is confined to narrow furrows rather than border checks. Furrows may be either straight, zig-zag, or contour. Furrow irrigation is used for row crops, orchards, and vineyards.

Tables that compare the costs of employing the previously described irrigation systems are included in the Appendix. Investment in an irrigation system may range from $360 per acre for a hand-move system to $935 per acre for a permanent solid set system. Total operating costs average $200 per acre in the San Joaquin Valley and $150 per acre in the Imperial Valley/Yuma region. These estimates assume that fixed costs (depreciation, interest, and taxes) are constant in both irrigated sites, while operating costs vary primarily as a function of water costs and power requirements.

Water requirements for Euphorbia production in the San Joaquin Valley are estimated at 2 acre feet per year. Water costs in this region vary from $5 per acre foot in the older districts on the eastern side of the San Joaquin Valley to $80 per acre foot in some of the newer districts on the west side.[4] An average figure of $35 per acre foot has been selected for this analysis. Due to higher temperatures and increased rates of transportation, water requirements in the Imperial Valley/Yuma region are estimated at 4 acre feet per year. Water charges are considerably less in this area, averaging $4 per acre foot, because of the low-priced water available from the Colorado River Project. Power requirements, however, are double, due to the increased quantity of water applied.

Harvesting and Drying

This analysis assumes that Euphorbia harvesting costs would be closely aligned to corn silage harvesting costs in each of the locations specified. However, certain modifications must be made to accurately reflect the Euphorbia case. Typically, corn silage budgets include a charge for chopping, hauling, packaging, and sealing. Packing and sealing operations are included for on-farm storage of the silage and account for approximately 40% of the total harvest cost. As no on-farm storage is envisioned, packing and sealing charges must be removed from the harvesting cost estimates.

Two scenarios are envisioned for Euphorbia harvesting. The first scenario is a green-chop harvest, in which the plants are cut, chopped, and loaded in one serial process. The plant material is then transported to a conversion facility. The second scenario is a dry-chop operation. The dry-chop configuration is to mow and windrow to field dry, then chop, load, and transport the plant material to the conversion facility.

Several difficulties may be associated with the green-chop harvest. Harvesting the plant green (wet) suggests the necessity for drying sheds either at the production site or the conversion facility. If drying is to occur at the conversion facility, transportation and handling costs would be increased significantly because of increased weight and bulk. In addition, a green-chop harvest increases the probability of plant material fermentation.

Under laboratory conditions, the dry weight factor of Euphorbia has been estimated at 20%. Field dry conditions can be expected to generate a dry weight factor of approximately 30%. Assuming the extractable components of Euphorbia are not affected by dehydration, a dry-chop harvest would significantly reduce production costs. Requirements for dry sheds and equipment would be sharply reduced, as would problems associated with plant material fermentation. In addition, costs for transportation and handling would decline as plant weight and bulk are diminished. Because of these factors, estimated production budgets assume a dry-chop harvest.

Transportation

Transportation charges have been estimated on the assumption that Euphorbia would be grown on an energy farm encompassing an area of approximately 10 × 10 miles, with a maximum hauling distance of 15 miles. The rate assessed for transportation is 15¢/ton mile plus 50¢/ton for handling. This computes to $2.75/ton of transported plant material.

Land and Management Charges

Land charges have been prepared as an average land charge for the major row crops grown in the particular sites selected. Data for land charges were taken from crop production budgets prepared by the Firm Enterprise Data System.[5] For this report, management charges were assessed at 10% of all variable costs.

Yield

Field experiments with Euphorbia are currently being conducted at the University of California South Coast Field Station, Santa Ana, California. Experimental plots measuring 14 × 14 feet were planted with a 1 square foot grid. The plot was irrigated regularly and fertilized as required. Each month the average height of the plants was measured and sample plants were taken for determination of fresh weight, dry weight, and yield of the acetone and benzene extractable materials. Yield calculations were prepared by multiplying individual plant dry weights by 43,580 plants per acre. These experimental results have demonstrated that Euphorbia plants grew from 19 grams fresh weight in April to a maximum of 1,764 grams fresh weight in September. Applying a dry weight factor of 20% and assuming that 8% of the dry weight is extractable hydrocarbons, these experimental yields can be projected to 17 dry tons of plant material per acre, or an equivalent value of 10 barrels of oil.[6] In addition, these results suggest that a growing season of approximately 6 months affords sufficient time for maximum growth.

Duplication of experimental results, however, would be difficult under commercial conditions. Spacing would not be conducted on a 1 square foot grid, but rather in conventional row crop spacing of 2.5 square feet. This spacing pattern would permit both post-emergence cultivation and pesticide application that is not afforded by a 1 square foot grid. Because of the additional space, yields per plant can be expected to attain experimental levels.

A 6-month growing season, as evidenced in the experimental plots, ensures that all regions considered in this analysis could support Euphorbia production. The required changes in spacing to accommodate commercial production would yield approximately 6.8 dry tons per acre, or an equivalent of 3.7 barrels of oil.

III COMPARATIVE COST ANALYSIS

Estimated Euphorbia production costs were compared with corn and alfalfa production in each of the five regions considered. For comparability with corn and alfalfa estimates, costs incurred for transportation of Euphorbia to conversion facilities have been omitted from this analysis.

The evidence suggests that estimated Euphorbia production costs are quite similar to corn production costs. This relationship can be expected to continue, although the costs of several Euphorbia production inputs may be altered. Alfalfa production costs are less than those for Euphorbia in the Kansas/Oklahoma and Southern Illinois sites, but greater in the irrigated regions. Differences in productivity, seed costs, and irrigation requirements account for this differential. Table 3 summarizes the comparative cost analysis, and the following discussions highlight the key cost factors by region.

Southeast Kansas and Central Oklahoma

Corn production costs in the Kansas/Oklahoma region are quite similar to the production costs envisioned for Euphorbia in that region. These costs may be expected to remain comparable, although several components of the Euphorbia budget may be adjusted. For example, Euphorbia seed costs are currently six times that of corn. A reduction in seed costs, however, may be offset by an increased level of pesticide application, as knowledge of the agronomic characteristics of Euphorbia is advanced. In addition, a minimum tillage budget was prepared for Euphorbia. Corn production entails more extensive soil preparation. To the extent that experiments evidence cost-effective results from additional tillage practices, these may be expected to be adopted.

Table 3

COMPARATIVE PRODUCTION COST ESTIMATES
FOR EUPHORBIA, CORN, AND ALFALFA
(Fourth Quarter 1978 Dollars Per Acre)

Region	Euphorbia lathyris	Corn	Alfalfa
Kansas/Oklahoma	186.00	180.00[2]	150.00[3]
Louisiana/Mississippi	214.00	202.00[1]	[7]
Southern Illinois	245.75	210.00[4]	122.00[5]
San Joaquin Valley	483.80	506.16[6]	536.00[6]
Imperial Valley/Yuma	514.00	[7]	520.00[6]

Notes:

[1]Excludes transportation charges.

[2]"Cost of producing selected crops in the United States"--1975, 1972, and projections for 1977. USDA, Economic Research Service. Estimates for 1977 were increased by 8% for 1978. This is the amount the Producer Price Index rose between 1977 and 1978.

[3]Firm Enterprise Data Budget #965--increased 14% from 1976 to 1978 (see Ref. 5). This is the amount the Producer Price Index rose.

[4]Firm Enterprise Data Budget #275.

[5]Firm Enterprise Data Budget #342.

[6]Sample costs to produce crops; Division of Agricultural Sciences, University of California Leaflet #2360 (June 1976). Costs increased 14% as explained in Note 3.

[7]Data unavailable because of negligible production.

Alfalfa production costs are somewhat less than the estimated costs for Euphorbia. Seed costs for Euphorbia exceed those of alfalfa, as do land charges. Conversely, alfalfa harvest costs are greater than those estimated for Euphorbia because alfalfa is harvested more than once a year, while Euphorbia will be harvested once per year. Pesticide and fertilizer costs are roughly equivalent. As with corn the cost comparison, a reduction in Euphorbia seed costs may be offset by an increase in pesticide application and/or additional tillage practices.

Northeast Louisiana and Central Mississippi

Corn production costs in the Louisiana/Mississippi region are competitive with the costs estimated for Euphorbia. Euphorbia seed costs exceed those of corn, while fertilizer and insecticide application level for corn are greater than the amounts estimated for Euphorbia. Future developments may witness a counterbalancing effect between these two parameters, which will maintain comparable production costs.

Southern Illinois

In Southern Illinois, Euphorbia production costs slightly exceed those of corn production. Future alterations in this relationship will stem from the relative changes in seed costs, fertilizer, and pesticide application levels, and tillage practices.

Alfalfa costs are significantly less than those of Euphorbia. Larger costs for alfalfa harvest are countered by greater costs for Euphorbia seed, fertilizer, and land charges. This differential may be closed by a reduction in seed costs, although increased levels in pesticide and fertilizer application may serve to maintain it.

San Joaquin Valley

The San Joaquin Valley exhibits different results than the other regions examined. Corn production costs moderately exceed those estimated for Euphorbia. This cost differential may be accounted for in several ways. First, soil preparation for corn production requires more tillage practices than those envisioned for Euphorbia. Second, pesticide application levels for corn are greater. In addition to general insecticides, Kelthane® and Sevin® are often administered for mite and cutworm control respectively. Third, many corn producers are applying 3 acre feet of water rather than the 2 acre feet estimated as necessary for Euphorbia.

Alfalfa production costs also exceed estimated Euphorbia production costs. High productivity levels (8 tons per acre) require several cuttings, thereby generating a large harvesting cost. In addition, the 4.5 acre feet of water required for alfalfa production is more than twice the amount estimated as necessary for Euphorbia.

Imperial Valley, California, and Yuma, Arizona

In the Imperial Valley/Yuma region, almost no corn is produced. Cost of alfalfa production is quite similar to that of Euphorbia. The minor difference is explained in much the same manner as the San Joaquin Valley case. Water requirements for alfalfa (7 acre feet) exceed those projected for Euphorbia (4 acre feet), and alfalfa productivity requires several cuttings per year. This general parity may be expected to continue.

IV EFFECT OF INPUT VARIATION ON YIELDS AND COSTS

The impact on yields of variations in inputs is largely speculative. However, extensive conversations with technicians at the University of California South Coast Field Station suggest that variations in the amount of nitrogen applied do produce differences in yields. Plots receiving 200 pounds of nitrogen exhibit plant growth 12-18 inches taller than plots receiving 150 pounds of nitrogen. The cost effectiveness of additional nitrogen, however, has not been determined. Equally important to the amount of nitrogen is the timing associated with its application. Experiments have demonstrated that a 50-pound application per experimental plot per month from April through July produces maximum growth.

The effects on growth of alterations in other inputs are unknown. Experiments are currently being conducted to ascertain optimal planting and harvesting periods, although a 6-month growing season still appears sufficient to ensure maximum growth.

The impact on costs of changes in other inputs is more quantifiable than the growth effects. Seed costs are a prime example. Seed costs for Euphorbia are currently $40-50 more per acre than for corn and alfalfa in the five regions analyzed. A reduction in seed costs to levels that approach corn and alfalfa would serve to significantly reduce costs per acre. Conversely, pesticide costs can be expected to increase as a greater understanding of the agronomic characteristics of Euphorbia is advanced. Currently, pesticide costs for corn average $20-25 per acre in the five regions, while the estimates for Euphorbia assumed a $12 per acre charge for pesticides. In addition, no allocation was made for a post-emergence herbicide for Euphorbia, which may be expected to require an additional $5-10 per acre. Mention has been made of the tillage requirements for corn production and those envisioned for Euphorbia. To the extent that additional tillage proves cost-effective, it probably will be adopted.

In the case of alfalfa, the aforementioned changes in Euphorbia production inputs would serve to reduce the cost differential in the nonirrigated areas, and enhance the competitive position of Euphorbia in the irrigated regions.

In sum, alterations in the inputs required for Euphorbia production could reduce costs by $20-30 per acre. This would improve the cost competitiveness of Euphorbia vis-à-vis corn and alfalfa in all regions considered.

A 6-month growing season is seen as sufficient to ensure maximum growth. This suggests that a partial second crop could be cultivated in the irrigated areas. In the San Joaquin Valley, the growing season would permit approximately 50% maturation of a second crop, while the Imperial Valley/Yuma region could support 66% maturation. Production costs for a second crop would be reduced, as land and management charges, which account for 20-25% of all production costs, would not be incurred. As additional experiments are conducted, more precise cost estimates will be developed.

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Appendix

ESTIMATED PRODUCTION COSTS

Table A-1

COMPARATIVE COSTS OF IRRIGATION SYSTEMS,
SAN JOAQUIN VALLEY, CALIFORNIA
(Fourth Quarter 1978 Dollars)

	Center Pivot	Wheel Line	Hand Move	Permanent Solid Set	Furrow
Investment/acre	533.00	420.00	360.00	935.00	400.00
Overhead costs					
Depreciation	43.25	35.25	29.25	46.75	10.00
Interest[1]	20.25	16.80	14.40	37.40	24.00
Taxes[2]	10.10	8.40	7.20	18.70	8.00
Total	73.60	60.45	50.85	102.85	42.00
Operating costs					
Irrigation prep	--	--	--	--	54.00
Labor[3]	6.00	30.00	70.00	10.00	80.00
Power[4]	31.00	23.60	23.60	23.60	11.00
Water	70.00	70.00	70.00	70.00	70.00
Repair	9.00	7.20	8.40	14.40	2.75
Total	116.00	130.80	172.00	118.00	217.75
Total annual cost	189.60	191.25	222.85	220.85	259.75

Notes:

[1] Interest was valued at 8% on the average value.
[2] Taxes and other overhead was calculated at 2% of the original cost.
[3] Labor was charged at $5.15 per hour including fringe benefits.
[4] Power charges were $0.03/kilowatt hour.

Source: Fereras, Elias, "Irrigation Costs," Division Agricultural Science Leaflet 2875, University of California (1978).

Table A-2

COMPARATIVE COSTS OF IRRIGATION SYSTEMS, IMPERIAL VALLEY, CALIFORNIA AND YUMA, ARIZONA (Fourth Quarter 1978 Dollars)

	Center Pivot	Wheel Line	Hand Move	Permanent Solid Set	Furrow
Investment/acre	533.00	420.00	360.00	935.00	400.00
Overhead costs					
Depreciation	43.25	35.25	29.25	46.75	10.00
Interest[1]	20.25	16.80	14.40	37.40	24.00
Taxes[2]	10.10	8.40	7.20	18.70	8.00
Total	73.60	60.45	50.85	102.85	42.00
Operating costs					
Irrigation prep	--	--	--	--	54.00
Labor[3]	6.00	35.50	71.00	12.00	80.00
Power[4]	62.00	47.20	47.20	47.20	11.00
Water	16.00	16.00	16.00	16.00	16.00
Repair	9.00	7.20	8.40	14.40	2.75
Total	93.00	105.90	142.60	89.60	163.75
Total annual cost	166.60	166.35	193.45	192.45	205.75

Notes:

[1] Interest was valued at 8% on the average value.

[2] Taxes and other overhead was calculated at 2% of the original cost.

[3] Labor was charged at $5.15 per hour including fringe benefits.

[4] Power charges were $0.03/kilowatt hour.

Source: Fereras, Elias, "Irrigation Costs," Division Agricultural Science Leaflet 2875, University of California (1978).

Table A-3

ESTIMATED PRODUCTION COST FOR EUPHORBIA--NONIRRIGATED, MINIMUM TILLAGE
SOUTHEAST KANSAS AND CENTRAL OKLAHOMA

Operation	Custom Rate per Acre (dollars)	Materials			Total Cost per Acre (dollars)
		Kind	Amount	Cost per Acre (dollars)	
Variable costs					
Cultivation					
Discing, tandem	3.25	--	--	--	3.25
Harrowing	1.75	--	--	--	1.75
Planting	3.35	Euphorbia	2.0 lb	60.00	63.35
Fertilization					
Nitrogen	2.40	Anhydrous ammonia	50.0 lb	12.50	14.90
Phosphorous	1.45	Super phosphate	40.0 lb	8.00	9.45
Potash	1.45	Potash	40.0 lb	4.00	5.45
Lime	1.45	Agricultural limestone	0.3 ton	3.50	4.95
Pesticide application					
Insecticide 2×	3.20	Meta-Systox R®	0.5 gal	8.50	11.70
Herbicide (cultivation)	5.00	--	--	--	5.00
Harvesting and drying	20.00	--	--	--	20.00
Total variable costs					139.80
Fixed costs					
Land charge	35.00	--	--	--	35.00
Management	--	--	--	--	13.84
Transportation	2.75/ton	Euphorbia	6.8 ton	18.70	18.70
Total fixed costs					67.54
Total cost					207.34

Note: All costs expressed in fourth quarter 1978 dollars.

Table A-4

ESTIMATED PRODUCTION COST FOR EUPHORBIA--NONIRRIGATED, MINIMUM TILLAGE
NORTHEAST LOUISIANA AND CENTRAL MISSISSIPPI

Operation	Custom Rate per Acre (dollars)	Materials: Kind	Materials: Amount	Materials: Cost per Acre (dollars)	Total Cost per Acre (dollars)
Variable costs					
Cultivation					
Discing, tandem	3.90	--	--	--	3.90
Harrowing	2.40	--	--	--	2.40
Planting	4.10	Euphorbia	2.0 lb	60.00	64.10
Fertilization					
Nitrogen	2.80	Anhydrous ammonia	65.0 lb	16.25	19.05
Phosphorous	2.25	Super phosphate	50.0 lb	10.00	12.25
Potash	2.25	Potash	50.0 lb	5.00	7.25
Lime	2.25	Agricultural limestone	0.3 ton	3.15	5.40
Pesticide application					
Insecticide 2×	5.60	Meta-Systox R®	0.5 gal	8.50	14.10
Herbicide (cultivation)	5.00				5.00
Harvesting and drying	25.00				25.00
Total variable costs					158.45
Fixed costs					
Land charge	40.00	--	--	--	40.00
Management	--	--	--	--	15.85
Transportation	2.75/ton	Euphorbia	6.8 ton	18.70	18.70
Total fixed costs					74.55
Total cost					233.00

Note: All costs expressed in fourth quarter 1978 dollars.

Table A-5

ESTIMATED PRODUCTION COST FOR EUPHORBIA--NONIRRIGATED, MINIMUM TILLAGE
SOUTHERN ILLINOIS

Operation	Custom Rate per Acre (dollars)	Materials			Total Cost per Acre (dollars)
		Kind	Amount	Cost per Acre (dollars)	
Variable costs					
Cultivation					
Discing, tandem	3.35	--	--	--	3.35
Harrowing	1.70	--	--	--	1.70
Planting	3.50	Euphorbia	2.0 lb	60.00	63.50
Fertilization					
Nitrogen	2.75	Anhydrous ammonia	85.0 lb	21.25	24.00
Phosphorous	1.60	Super phosphate	40.0 lb	8.00	9.60
Potash	1.60	Potash	40.0 lb	4.00	5.60
Lime	1.60	Agricultural limestone	0.3 ton	2.30	3.90
Pesticide application					
Insecticide 2x	4.60	Meta-Systox R®	0.5 gal	8.50	13.10
Herbicide (cultivation)	5.00				5.00
Harvesting and drying	31.00				31.00
Total variable costs					160.75
Fixed costs					
Land charge	69.00	--	--	--	69.00
Management	--	--	--	--	16.00
Transportation	2.75/ton	Euphorbia	6.8 ton	18.70	18.70
Total fixed costs					103.70
Total cost					264.45

Note: All costs expressed in fourth quarter 1978 dollars.

Table A-6

ESTIMATED PRODUCTION COST OF EUPHORBIA--IRRIGATED
SAN JOAQUIN VALLEY, CALIFORNIA

Operation	Custom Rate per Acre (dollars)	Materials			Total Cost per Acre (dollars)
		Kind	Amount	Cost per Acre (dollars)	
Variable costs					
Cultivation					
Plowing	8.30	--	--	--	8.30
Discing, tandem	4.00	--	--	--	4.00
Harrowing	2.25	--	--	--	2.25
Irrigation	130.00	Water	2.0 acre ft	70.00	200.00
Planting	4.25	Euphorbia	2.0 lb	60.00	64.25
Fertilization					
Nitrogen	3.00	Anhydrous ammonia	150.0 lb	37.50	40.50
Pesticide application					
Insecticide 2×	7.00	Meta-Systox R	0.5 gal	8.50	15.50
Herbicide (cultivation)	6.00				6.00
Harvesting and drying	40.00				40.00
Total variable costs					380.80
Fixed costs					
Land charge	69.00	--	--	--	69.00
Management	--	--	--	--	38.00
Transportation	2.75/ton	Euphorbia	6.8 ton	18.70	18.70
Total fixed costs					125.70
Total cost					506.50

Note: All costs expressed in fourth quarter 1978 dollars.

Table A-7

ESTIMATED PRODUCTION COST OF EUPHORBIA--IRRIGATED
IMPERIAL VALLEY, CALIFORNIA AND YUMA, ARIZONA

Operation	Custom Rate per Acre (dollars)	Materials: Kind	Materials: Amount	Materials: Cost per Acre (dollars)	Total Cost per Acre (dollars)
Variable costs					
Cultivation					
Plowing	8.30	--	--	--	8.30
Discing, tandem	4.00	--	--	--	4.00
Harrowing	2.25	--	--	--	2.25
Irrigation 6×	164.00	Water	4.0 acre ft	16.00	180.00
Planting	4.25	Euphorbia	2.0 lb	60.00	64.25
Fertilization					
Nitrogen	3.00	Anhydrous ammonia	150.0 lb	37.50	40.50
Phosphate	2.50	Super phosphate	60.0 lb	12.00	14.50
Pesticide application					
Insecticide 2×	7.00	Meta-Systox R	0.5 gal	8.50	15.50
Herbicide (cultivation)	5.00				5.00
Harvesting and drying	42.00				42.00
Total variable costs					376.30
Fixed costs					
Land charges	100.00	--	--	--	100.00
Management	--	--	--	--	37.63
Transportation	2.75/ton	Euphorbia	6.8 ton	18.70	18.70
Total fixed costs					156.33
Total cost					532.63

Note: All costs expressed in fourth quarter 1978 dollars.