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THE ECONOMIC FEASIBILITY OF GROWING TARO IN ROTATION WITH FIELD CORN FOR DAIRY SILAGE ON THE ISLAND OF KAUAI

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CONTENTS

Tables

THE ECONOMIC FEASIBILITY OF GROWING TARO IN ROTATION WITH FIELD CORN FOR DAIRY SILAGE ON THE ISLAND OF KAUAI

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ABSTRACT

This study was conducted to determine the economic feasibility of growing taro in rotation with field corn for dairy silage during the wet months of the year on the island of Kauai, Hawaii. It was found that it would be more profitable to grow one crop of field corn for silage than to rotate field corn and taro.

The expected yields for taro and corn silage are 29 tons per acre and 19 tons per acre, respectively. Using a linear programming model, it was found that the taro yield would have to increase to above 46 tons per acre before a rotation of taro and field corn would be more profitable than growing only field corn.

Presently, the land cost per acre is $25.00. Using the expected yields for taro and field corn, it was found that the land cost would have to increase to $250.00 before a rotation of taro and field corn would be more profitable than growing only field corn.

This study did not include animal feeding trials.

Keywords: taro, corms, partial budget, dry matter basis.

INTRODUCTION

This study was conducted to determine the economic feasibility of growing taro in rotation with an existing field corn operation for dairy silage. Presently, some dairy operations on the island of Kauai, Hawaii, are growing field corn for silage from March to July, but find the remaining months of the year too wet to utilize the land for field corn. Recent agronomic experiments indicate that taro (*Colocasia esculenta*) could be a possible alternative silage crop grown during the wet months of the year (*4*).

Taro can be grown under both wetland and dryland conditions. Wetland taro is grown in flooded conditions, similarly to rice, while dryland taro depends on rainfall or irrigation to supply its heavy water requirements. The taro evaluated in this report would be grown under dryland conditions and would have a growing cycle of 30 weeks, or 7.5 months.

ASSUMPTIONS

The following assumptions were made so that the effects of a taro silage operation could be analyzed with partial budgets.

1. The existing field corn machinery is used for the taro operation with the addition of a taro planter and corm harvester.
2. The water requirement for taro, an average of 1½ to 2 inches per week, is satisfied by rainfall.
3. The herd size of the dairy operation is 480 cows. Of these, 340 are on-line producing milk and 140 are dry.
4. The silage consumption per cow is
   a. dry cows: 37.6 lb of corn silage per day
   b. high producing on-line cows: 21.7 lb of corn silage per day
   c. low producing on-line cows: 34.1 lb of corn silage per day.

Table 1: Cost of Production for Field Corn and Taro for Silage		
Costs Per Acre Per Year	Field Corn	Taro
Variable Costs	$364.00	$531.00
Fixed Costs	$257.00	$255.00
Total Costs	$621.00	$786.00

Source: Appendix A: Tables 9 and 10.

5. The total amount of corn silage required per year is 2694 tons.

6. There are one harvest of field corn and three harvests of taro silage per year. The first two harvests of taro are only the tops, while the final harvest is the whole plant (tops plus corms).

7. The silage yield[1] for each crop is
   a. corn: 19 tons per acre
   b. taro: 29 tons per acre.

8. There are no animal performance data on taro silage as a substitute feed for corn silage for ruminants. Usually, corn silage is harvested at between 25 and 35 percent dry matter (*5*), while taro top silage is harvested at approximately 12 percent dry matter and whole plant silage at 21 percent dry matter (*4*). Using *percentage of dry matter* as an *indication of feed quality,* it was determined that 1.76 tons of taro silage is equivalent to 1.0 ton of corn silage (Appendix C).

9. The wage rate for labor is that found in the present dairy industry:
   a. full-time labor: $7.50
   b. part-time labor: $6.00.

10. The silage is to be stored in trench silos. For the field corn, the loader with bucket, which fills and compacts the silage in the silo, is used for the same amount of time as the other field corn harvesting equipment. This storage rate is then applied to the taro silage operation.

11. The land is plowed only once a year.

BUDGET ANALYSIS

Partial budget analysis is a technique used to determine the profitability of alternative agricultural enterprises. A summary of the variable and fixed costs for each crop is given in Table 1. Four situations were analyzed to determine the profitability of rotating taro.

Situation 1: Present

Table 2 presents a situation in which only field corn is grown. With only one crop per year, 142 acres of land in production is required. The total production cost is $88,120.00 for 2698 tons of feed corn silage.

Situation 2: Field Corn and Taro Rotation

The feasibility of supplying half of the silage requirements with taro is shown in Table 3. With this proposed change, it would be necessary to have 71 acres in field corn production and 82 acres in taro production. The net change in profits is a negative $16,279.00. This would indicate that a rotation of field corn and taro for silage in this situation is not an economically feasible operation.

In order to find a situation in which taro would be economically feasible, the authors developed a linear programming model. The objective function was to determine the minimum combination of variable and land costs for both field corn and taro acreage, subject to the following constraints: (1) total silage yield required was 2694 tons, and (2) the total acreage, in rotation or single crop, would be less than or equal to 142 (Appendix B). Keeping the yield of corn at the assumed 19 tons per acre, the yield of taro was increased until a rotation of taro and corn was found, and then increased further until only taro would be produced (Table 4). The expected yield of taro, from experimental data, is 29 tons per acre, or a corn silage equivalent of 16.5 tons per acre. Using the above model, a rotation of taro and field corn would occur only when the taro yield increased to between 46 and 51 tons per acre, or a corn silage equivalent of 26 to 29 tons per acre; for taro yields of less than 46 tons per acre, only field corn would be grown. The taro silage

[1]The field corn silage yield estimate is from existing field corn operations. The taro silage yield estimate was determined from experimental data.

yield would have to increase to 53 tons per acre before field corn would not be grown.

Situation 3: Economically Feasible Rotation

If the taro silage yield increased to 48 tons per acre, or a field corn silage equivalent of 27 tons per acre, a rotation of corn and taro would be economically feasible (Table 5). In this situation 59 acres in rotation would be necessary to produce the required amount of silage. The net profitability over Situation 1 would be $513.00.

Situation 4: Economically Feasible with Taro Alone

To supply all of the silage requirements with only taro, the yield would have to increase to 53 tons per acre, or a corn silage equivalent of 30 tons per acre, before it would be economically feasible (Table 6). In this situation the net profitability over Situation 1 would be $3957.00.

The question of how an increase in land rent would affect the decision to produce taro silage was also investigated. Presently, the land rent is $25.00 per acre per year. Taking the original assumptions for field corn silage yield (19 tons per acre) and taro silage yield (29 tons per acre, or a field corn silage equivalent of 16.5 tons per acre), the annual rental price for land would have to increase to $250.00 per acre before a rotation of corn and taro would be economical (Table 7). This would indicate that the present rental price is not a significant factor in the decision to rotate taro and corn crops.

Finally, a comparison was made between the cost of producing field corn and taro silages and the cost of importing a silage feed substitute, alfalfa pellets. As was done previously, the percentage of dry matter was used as an indication of feed quality. Table 8 shows that field corn silage has the lowest cost per ton of the three feeds. However, both the field corn and taro silages have a lower cost than the imported substitute.

Table 2: Present Situation
(142 Acres of Field Corn)

Variable Cost		Present Benefit	
Land Preparation	16,367.00	Corn Silage (in Tons)	2,698.00
Planting	15,078.00	(19 Tons per Acre)	
Postplanting Fertilizer	8,612.00		
Harvesting	4,969.00		
Storage Cost	6,594.00		
Total Variable Cost	51,620.00		
Fixed Cost			
Machinery	32,950.00		
Land Rental	3,550.00		
Total Fixed Cost	36,500.00		
Total Cost	88,120.00	Corn Silage (in Tons)	2,698.00

Source: Appendix A, Table 10.

Table 3: Partial Budget 2

Proposed Change: Providing Half the Silage Requirements with Taro Silage
(71 Acres of Field Corn, 82 Acres of Taro)

Additional Costs		Additional Benefit	
Fixed Costs		Taro Silage (in Tons)	2,378.00
		Corn Silage Equivalents (in Tons)	1,353.00
Taro Planter and Corm Harvester			
Depreciation	507.00		
Interest	725.00		
Shelter and Insurance	95.00		
Variable Costs			
Land Preparation *	2,786.00		
Planting	20,346.00		
Postplanting Fertilizer	3,328.00		
Harvesting	6,184.00		
Corm Harvesting	3,788.00		
Storage Cost	5,829.00		
Reduced Benefit		Reduced Costs	
		Land Preparation	8,183.00
Corn Silage (in Tons)	1,347.00	Planting	7,539.00
		Postplanting Fertilizer	4,306.00
		Harvesting	2,484.00
		Storage Cost	3,297.00
		Land Rent	1,500.00
Total Annual Additional Cost	43,588.00	Total Annual Reduced Costs	27,309.00
Reduced Corn Silage (in Tons)	1,347.00	Taro Silage (in Tons)	2,378.00
		Net Change in Profits	(16,279.00)

Source: Appendix A, Tables 9 and 10.

Note: Assuming a taro silage yield of 16.5 tons per acre and a corn silage yield of 19 tons per acre

* Since it has been assumed that the land will be plowed once a year, the plowing cost has been removed from the taro operation.

Table 4: The Effects of Increased Taro Silage Yield on Rotation

Taro Yield (in Tons)	Corn Silage Equivalents	Acres of Corn	Acres of Taro	Acres in Rotation of Corn	Acres in Rotation of Taro
55	31	0	103	0	0
53	30	0	90	0	0
51	29	0	0	56	56
49	28	0	0	57	57
48	27	0	0	59	59
46	26	0	0	60	60
44	25	142	0	0	0

Table 5: Partial Budget 3

Proposed Change: Equivalent Amount Of Taro and Corn Acreage in Rotation
(Taro Yield of 48 Tons per Acre*, 59 Acres in Rotation)

Additional Costs		Additional Benefit	
Fixed Costs		Taro Silage (in Tons)	2,832.00
		Corn Silage Equivalents (in Tons)	1,609.00
Taro PLanter and Corm Harvester			
Depreciation	507.00		
Interest	725.00		
Shelter and Insurance	95.00		
Variable Costs			
Land Preparation**	2,004.00		
Planting	14,639.00		
Postplanting Fertilizer	2,395.00		
Harvesting	4,450.00		
Corm Harvesting	2,726.00		
Storage Cost	4,194.00		
Reduced Benefit		Reduced Costs	
		Land Preparation	9,567.00
Corn Silage (in Tons)	1,577.00	Planting	8,813.00
		Postplanting Fertilizer	5,034.00
		Harvesting	2,904.00
		Storage Cost	3,855.00
		Land Rent	2,075.00
Total Annual Additional Cost	31,735.00	Total Annual Reduced Costs	32,248.00
Reduced Corn Silage (in Tons)	1,577.00	Taro Silage (in Tons)	2,832.00
		Net Change in Profits	513.00

Source: Appendix A, Tables 9 and 10, and Appendix B.

* 58 tons of taro is equivalent to 33 tons of corn silage.

** Since it has been assumed that the land will be plowed once a year, the plowing cost has been removed from the taro operation.

Table 6: Partial Budget 4

Proposed Change: Providing all silage requirements with Taro silage
(Taro Yield of 53 Tons per Acre*, 90 Acres of Taro)

Additional Costs		Additional Benefit	
Fixed Costs		Taro Silage (in Tons)	4,770.00
		Corn Silage Equivalents (in Tons)	2,710.00
Taro Planter and Corm Harvester			
Depreciation	507.00		
Interest	725.00		
Shelter and Insurance	95.00		
Variable Costs			
Land Preparation	4,477.00		
Planting	22,331.00		
Postplanting Fertilizer	3,653.00		
Harvesting	6,788.00		
Corm Harvesting	4,159.00		
Storage Cost	6,397.00		
Reduced Benefit		Reduced Costs	
		Land Preparation	16,367.00
Corn Silage (in Tons)	2,698.00	Planting	15,078.00
		Postplanting Fertilizer	8,612.00
		Harvesting	4,969.00
		Storage Cost	6,594.00
		Land Rent	1,300.00
		Fixed Cost**	169.00
Total Annual Additional Cost	49,132.00	Total Annual Reduced Costs	53,089.00
Reduced Corn Silage (in Tons)	2,698.00	Taro Silage (in Tons)	4,770.00
		Net Change in Profits	3,957.00

Source: Appendix A, Tables 9 and 10, and Appendix B.

* 62 tons of taro silage is equivalent to 35 tons of corn silage.

** Fixed cost is from the fertilizer spreader which would be sold, since it would not be used in the taro silage operation.

Table 7: The Effects of Increased Land Rent on Rotation [1]

Land Rent	Acres of Corn	Acres of Taro	Acres in Rotation of Corn	Acres in Rotation of Taro
$25.00	142	0	0	0
.				
.				
.				
$175.00	142	0	0	0
$200.00	142	0	0	0
$225.00	142	0	0	0
$250.00	0	0	76	76
$275.00	0	0	76	76

[1] Assuming the yield to be 19 tons/acre for field corn and 16.5 tons/acre for taro.

Table 8: Feed Cost Per Ton

Feed	Tons Per Acre	Alfalfa Equivalents [1] (Tons)	Cost Per Ton
Alfalfa Pellets		1.0	$181.00
Corn Silage	19	6.2	$100.09
Taro Silage	29	5.4	$149.50

1 The alfalfa equivalents were determined on a dry matter basis. It was assumed that the alfalfa pellets were 92% dry matter, field corn silage was 30% dry matter, and taro silage was 17% dry matter.

DISCUSSION

Even though taro has been grown in Hawaii for centuries, and is generally important as a food crop throughout the wetter parts of the tropics, especially in the Pacific, there are very few references to it in the literature. This makes it worthwhile to investigate a few of the assumptions made.

First, the conversion ratio of taro silage to corn silage equivalents is unknown. This study uses a dry matter basis to determine this conversion. However, feeding trials are necessary to determine what the actual feed conversion is. Whether the actual conversion ratio is greater or less than that used in this study will affect the feasibility of feeding taro silage.

Second, the yield for taro used in this study was determined from experimental data. The actual yield that occurs in practice may be different from those obtained from experimental data.

Finally, it was assumed that the loader with bucket, which is used for storing the silage, would be required for the same amount of time as the other field corn harvesting equipment, and this storage rate was applied to the taro operation. Since taro silage has never been used in a large-scale operation, the required amount of time needed to cure the silage in a trench silo could vary. This could be important for the feasibility of the project because three harvests are required for the taro crop.

The study was conducted in a framework where silage was the only product from the taro crop. If a major market for the corms existed, such as for chips, poi, or baby food, and the taro tops could be made into silage, then the feasibility of such an operation could change. However, at present, no major market for the corms exists, and this does not seem likely to change in the near future.

This analysis was carried out for the Hawaiian situation. In other locations, where the yield of corn is lower, and the cost of production for each crop is different, such an operation could be feasible.

CONCLUSION

This study was conducted to determine the economic feasibility of using taro silage in rotation with field corn as a dairy feed. The partial budget analysis shows that with an expected yield for taro of 29 tons per acre, the taro operation is not economically feasible. A rotation of taro and field corn for silage would be economically feasible only if the yield of taro increased to 48 tons per acre. If such a yield were possible, the net change in profits from the present situation would be $513.00. For taro to completely replace corn silage, the yield from taro would have to increase to 53 tons per acre and would increase profits by $3957.00 from the present situation. Even if such levels of taro silage were possible, the palatability and nutritional quality of the feed are still unknown. This presents an additional risk to the taro silage operation.

An investigation into the effects of an increase in land rents on the feasibility of the taro operation was also done. It shows that land rents would have to increase substantially before a rotation with taro would be economical. Presently, land rents are $25.00 per year. They have to increase to $250.00 per year before a rotation of taro and field corn could be economically feasible.

Finally, a comparison of the cost of field corn and taro silages was made with an imported substitute, alfalfa pellets. On a dry matter basis, it was found that both field corn and taro silages are more economical than the alfalfa pellets.

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APPENDIX A: PRODUCTION COSTS FOR FIELD CORN AND TARO

Table 9: Corn Operation Budget

Corn Operation (Cost per Acre per Year)	Quantity	Unit	Rate Per Unit	Value or Cost	Subtotal
Variable Cost					
Land Preparation					
Full-time Labor	0.55	Hour	7.50	4.13	
Part-time Labor	0.35	Hour	6.00	2.10	
Tractor (140 HP)	0.55	Hour	22.44	12.34	
Tractor (55 HP)	0.35	Hour	9.83	3.44	
Plow	0.31	Hour	20.94	6.49	
Heavy Disc Harrow	0.15	Hour	67.61	10.14	
Fertilizer Spreader	0.07	Hour	13.58	0.95	
Light Disc Harrow	0.09	Hour	105.16	9.46	
Cultivator	0.28	Hour	9.81	2.75	
Fertilizer (Potash)	350.00	Lb	0.12	42.00	
Herbicide					
Lasso	3.00	Quarts	5.66	16.98	
Atrazine	2.50	Lbs.	1.79	4.48	
Subtotal					115.26
Planting					
Full-time Labor	0.00	Hour	7.50	0.00	
Part-time Labor	0.25	Hour	6.00	1.50	
Tractor (55 HP)	0.25	Hour	9.83	2.46	
Corn Planter	0.25	Hour	32.39	8.10	
Fertilizer (18:46:0)	325.00	Lb	0.19	61.75	
Insecticide (Furadan)	3.00	Lb	1.53	4.59	
Corn Seed	27.78	Lb	1.00	27.78	
Subtotal					106.18
Postplanting Fertilizing					
Full-time Labor	0.20	Hour	7.50	1.50	
Tractor (55 HP)	0.20	Hour	9.83	1.97	
Sidedresser	0.20	Hour	23.40	4.68	
Fertilizer (Urea)	350.00	Lb	0.15	52.50	
Subtotal					60.65

Harvesting				
Full-time Labor	0.49 Hour	7.50	3.68	
Part-time Labor	0.49 Hour	6.00	2.94	
Tractor (140 HP)	0.49 Hour	22.44	11.00	
Tractor (55 HP)	0.49 Hour	9.83	4.82	
Forage Chopper	0.49 Hour	12.22	5.99	
Forage Wagon 1	0.49 Hour	6.71	3.29	
Forage Wagon 2	0.49 Hour	6.71	3.29	
Subtotal				34.99
Storage Cost				
Full-time Labor	0.49 Hour	7.50	3.68	
Loader with Bucket	0.49 Hour	87.27	42.76	
Subtotal				46.44
Total Variable Cost				363.51
Fixed Cost:				
Ownership Cost				
Tractor (140 HP)	1.00 Acre	36.59	36.59	
Tractor (55 HP)	1.00 Acre	18.71	18.71	
PLow	1.00 Acre	8.83	8.83	
Heavy Disc Harrow	1.00 Acre	8.85	8.85	
Fertilizer Spreader	1.00 Acre	1.19	1.19	
Light Disc Harrow	1.00 Acre	12.88	12.88	
Cultivator	1.00 Acre	4.05	4.05	
Planter	1.00 Acre	11.94	11.94	
Sidedresser	1.00 Acre	6.32	6.32	
Forage Chopper	1.00 Acre	11.19	11.19	
Forage Wagon	1.00 Acre	6.49	6.49	
Forage Wagon	1.00 Acre	6.49	6.49	
Loader with Bucket	1.00 Acre	98.51	98.51	
Subtotal				232.04
Land Rental	1.00 Acre	25.00	25.00	
Subtotal				25.00
Total Fixed Cost				257.04
Total Cost				620.55

Source: See Appendix A Tables 11, 12, 16, 17, and 18.

Table 10: Taro Operation Budget

Taro Operation (Cost per Acre per Year)	Quantity	Unit	Rate Per Unit	Value or Cost	Subtotal
Variable Costs:					
Land Preparation					
Full-time Labor	0.55	Hour	7.50	4.13	
Part-time Labor	0.28	Hour	6.00	1.68	
Tractor (140 HP)	0.55	Hour	22.44	12.34	
Tractor (55 HP)	0.28	Hour	9.83	2.75	
Plow	0.31	Hour	20.94	6.49	
Heavy Disc Harrow	0.15	Hour	67.61	10.14	
Light Disc Harrow	0.09	Hour	105.16	9.46	
Cultivator	0.28	Hour	9.81	2.75	
Subtotal					49.74
Planting					
Seed Preparation (Part-time Labor)	16.00	Hours	6.00	96.00	
Full-time Labor	1.89	Hours	7.50	14.18	
Part-time Labor	3.78	Hours	6.00	22.68	
Tractor (55 HP)	1.89	Hours	9.83	18.58	
Planter	1.89	Hours	0.89	1.68	
Fertilizer (16:16:16)	500.00	Lb	0.19	95.00	
Subtotal					248.12
Postplanting Fertilizing					
Full-time Labor	0.20	Hour	7.50	1.50	
Tractor (55 HP)	0.20	Hour	9.83	1.97	
Sidedresser	0.20	Hour	23.40	4.68	
Fertilizer (Urea)	81.00	Lb	0.15	12.15	
Subtotal					20.30
Two Applications Per Cycle					40.59
First Two Harvests (Tops)					
Full-time Labor	1.12	Hours	7.50	8.40	
Part-time Labor	1.12	Hours	6.00	6.72	
Tractor (140 HP)	1.12	Hours	22.44	25.13	
Tractor (55 HP)	1.12	Hours	9.83	11.01	
Forage Chopper	1.12	Hours	12.22	13.69	
Forage Wagon 1 *	0.78	Hour	6.71	5.23	
Forage Wagon 2 *	0.78	Hour	6.71	5.23	
Subtotal					75.42
Corm Harvesting (Final Harvest)					
Full-time Labor	0.83	Hour	7.50	6.23	
Part-time Labor	0.83	Hour	6.00	4.98	
Tractor (55 HP)	0.83	Hour	9.83	8.16	
Corm Harvester	0.83	Hour	6.69	5.55	
Chopper	0.83	Hour	12.22	10.14	
Forage Wagon 1	0.83	Hour	6.71	5.57	
Forage Wagon 2	0.83	Hour	6.71	5.57	

Subtotal				46.20
Storage Costs				
(Three Harvests)				
Full-time Labor	0.75 Hour	7.50	5.63	
Loader with Bucket	0.75 Hour	87.27	65.45	
Subtotal				71.08
Total Variable Cost				531.14
Fixed Cost:				
Ownership Cost				
Tractor (140 HP)	1.00 Acre	36.59	36.59	
Tractor (55 HP)	1.00 Acre	18.71	18.71	
Plow	1.00 Acre	8.83	8.83	
Heavy Disc Harrow	1.00 Acre	8.85	8.85	
Light Disc Harrow	1.00 Acre	12.88	12.88	
Cultivator	1.00 Acre	4.05	4.05	
Planter	1.00 Acre	2.30	2.30	
Sidedresser	1.00 Acre	6.32	6.32	
Forage Chopper	1.00 Acre	11.19	11.19	
Forage Wagon 1	1.00 Acre	6.49	6.49	
Forage Wagon 2	1.00 Acre	6.49	6.49	
Loader with Bucket	1.00 Acre	98.51	98.51	
Corm Harvester	1.00 Acre	8.33	8.33	
Subtotal				229.54
Land Rental	1.00 Acre	25.00	25.00	
Subtotal				25.00
Total Fixed Cost				254.54
Total Cost				785.68

Source: Appendix A, Tables 11, 12, 16, 17, and 18.

* It was assumed that each wagon could hold 4 tons of taro silage at 12% dry matter.

Table 11: Equipment Prices and Uses

Implement	List Price ($)	Field Efficiency (Percent)	Speed (MPH)	Effective Field Capacity (Acres Per Hour)	Use (Hours Per Crop Acre)
Field Equipment					
Tractor 140 hp	52,000.00				1.04
Tractor 55 hp	25,000.00				1.29
Plow	7,680.00	80.00	4.15	3.22	0.31
Heavy Disc Harrow	12,000.00	77.00	4.0	6.84	0.15
Fertilizer Spreader	900.00	70.00	5.0	13.58	0.07
Light Disc Harrow with Herbicide Applicator	11,200.00	77.00	5.0	10.56	0.09
Cultivator	3,900.00	73.00	5.0	3.54	0.28
Corn Planter with Herbicide and Fertilizer Applicators	11,500.00	55.00	3.0	4.00	0.25
Sidedresser	5,500.00	80.00	3.5	5.09	0.20
Forage Chopper	8,500.00	60.00	3.75	2.05	0.49
Forage Wagon 1	7,000.00	60.00	3.75	2.05	0.49
Forage Wagon 2	7,000.00	60.00	3.75	2.05	0.49
Loader with Bucket	140,000.00				
Special Taro Equipment					
Taro Planter	2,000.00	55.00	2.0	0.53	1.89
Corm Harvester	10,000.00	60.00	2.75	1.20	0.83

Source: Machinery prices were from Honolulu farm machinery dealers as of November 1983. Field efficiencies, speed, field capacity, and use were determined from information and methods outlined in the Agricultural Engineers Yearbook, 1982; W. Bowers, Fundamentals of Machine Operation; and C. Culpin, Farm Machinery.

Table 12: Fixed and Variable Costs

Implement	Use (Hours Per Acre)	Total Hours (for 142 Acres)	Total Fixed Cost ($)	Fixed Cost Per Acre ($)	Variable Cost Per Hour ($)
plow	0.31	44.02	1,253.76	8.83	20.94
heavy disc	0.15	21.30	1,257.00	8.85	67.61
fert. spreader	0.07	9.94	168.30	1.19	13.58
light disc	0.09	12.78	1,828.40	12.88	105.16
cultivator	0.28	39.76	574.93	4.05	9.81
corn planter	0.25	35.50	1,695.29	11.94	32.39
sidedresser	0.20	28.40	897.88	6.32	23.40
chopper	0.49	69.58	1,589.50	11.19	12.22
forage wagon 1	0.49	69.58	921.08	6.49	6.71
forage wagon 2	0.49	69.58	921.08	6.49	6.71
tractor 140 hp	1.04	147.68	5,195.67	36.59	22.44
tractor 55 hp	1.29	183.18	2,656.25	18.71	9.83
loader	0.49	69.58	13,988.33	98.51	87.27
taro planter	1.89	268.38	326.50	2.30	0.89
corm harvester	0.83	117.86	999.17	7.04	6.04

Source: Time requirements for implement use were determined using methods outlined in W. Bowers, Fundamentals of Machine Operation, and C. Culpin, Farm Machinery. Costs were determined from the price of the implement from a Honolulu farm machinery dealer as of November 1983.

Table 13: Corn Production Operation

Corn Operation	Implement Size	Power Unit
Land Preparation		
Plowing	6 bottom, 16" spacing Moldboard Plow	140 hp tractor
Heavy Disc Harrow	17 Feet wide, 22-26" disk	140 hp tractor
Fertilizer Spreading	3 point hitch, 1,400 Lbs. capacity	55 hp tractor
Light Disc Harrow	21 feet wide with herbicide applicator	140 hp tractor
Cultivator	8 feet wide, sweeps	55 hp tractor
Planting		
Corn Planter	8 row planter, 30" spacing, with Fertilizer and insecticide applicators	55 hp tractor
Postplanting Fertilizing		
Sidedresser	6 row	55 hp tractor
Harvesting		
Forage Chopper	3 row, 30" spacing drawn chopper	140 hp tractor
Forage Wagons	672 cubic foot capacity	55 hp tractor
Storage		
Loader with Bucket	130 flywheel hp, 2 cubic yards bucket capacity	loader

Table 14: Taro Production Operation

Taro Operation	Implement Size	Power Unit
Land Preparation		
Plowing	6 bottom, 16" spacing Moldboard Plow	140 hp tractor
Heavy Disc Harrow	17 Feet wide, 22-26" disk	140 hp tractor
Light Disc Harrow	21 feet wide with herbicide applicator	140 hp tractor
Cultivator	8 feet wide, sweeps	55 hp tractor
Planting		
Taro Planter	2 row planter, 24" spacing, with fertilizer applicator	55 hp tractor
Postplanting		
Fertilizing		
Sidedresser	7 row, 24" spacing	55 hp tractor
Harvesting		
Forage Chopper	3 row, 24" spacing, drawn chopper	140 hp tractor
Forage Wagons	672 cubic foot capacity	55 hp tractor
Corm Harvester	3 row, 24" spacing	self-propelled
Storage		
Loader with Bucket	130 flywheel hp, 2 cubic yards bucket capacity	loader

Table 15: Equipment Used for Each Crop

Corn Operation	Taro Operation
1- 140 pto hp Tractor	1- 140 pto hp Tractor
1- 55 pto hp Tractor	1- 55 pto hp Tractor
1- plow	1- Plow
1- Heavy Disc Harrow	1- Heavy Disc Harrow
1- Fertilizer Spreader with Herbicide Applicator	1- Light Disc Harrow
1- Cultivator	1- Cultivator
1- Corn Planter with Herbicide and Fertilizer Applicator	1- Taro (transplanter) Planter with Fertilizer Applicator
1- Sidedresser	1- Sidedresser
1- Forage Chopper	1- Forage Chopper
2- Forage Wagons	2- Forage Wagons
1- Loader with Bucket	1- Corm Harvester
	1- Loader with Bucket

Table 16: Fertilizer Costs

Element	Fertilizer	Amount Lb Per Acre	Unit Price of Fertilizer($)	Fertilizer Cost Per Acre ($)	Price Per Lb ($)
N	Urea	350.00	292.00	51.10	0.15
K	Muriate of Potash	350.00	242.50	42.44	0.12
P	Di-Ammonium Phosphate 18:46:0	325.00	380.41	61.82	0.19

Source: Prices obtained from Honolulu fertilizer companies for shipments of 20-ton lots in November 1983.

Table 17: Herbicide Costs

Herbicide	Amount Lb Per Acre	Unit Price of Herbicide ($)	Herbicide Cost Per Acre ($)	Price Per Unit ($)
Lasso	3 Quarts	113.25 Per 5 Gallons	16.99	5.66 Per Quart
Atrazine	2.50	44.75 Per 25 Lb Bag	4.48	1.79 Per Lb
Total			21.47	

Source: Honolulu agricultural chemical companies in November 1983.

Table 18: Insecticide Costs

Insecticde	Amount Lb Per Acre	Unit Price of Insecticide ($)	Insecticide Cost Per Acre ($)
Furadan 10% Granules	3.00	76.50 Per 50 Lb Bag	4.59
Total			4.59

Source: Honolulu agricultural chemical companies in November 1983.

APPENDIX B: LINEAR PROGRAMMING MODEL TO DETERMINE FIELD CORN AND TARO ACREAGE

Variables

X_c = corn acreage (one harvest per year)
X_t = taro acreage (three harvests per year)
R_c = corn acreage (rotation)
R_t = taro acreage (rotation)
S = total amount of silage required, in tons
C_c = variable cost per acre of corn
C_t = variable cost per acre of taro
A_c = amount of silage per acre of corn, in tons
A_t = amount of silage per acre of taro, in tons
L = land charge per acre
TVC = total variable costs

Objective Function

Min. $TVC = (C_c + L)X_c + (C_t + L)X_t + (C_c + 1/2L)R_c + (C_t + 1/2L)R_t$

Subject to the following constraints:

$$A_c(X_c + R_c) + A_t(X_t + R_t) \geqslant S$$
$$R_c = R_t$$
$$1/2R_t + 1/2R_c + X_c + X_t \leqslant 142$$

APPENDIX C: CONVERSION OF TARO SILAGE TO CORN SILAGE EQUIVALENTS

Taro Harvest	Tons Per Acre (Tops)	Corms (Tons)	Total (Tons)	Each Harvest as a Percent of Total Yield	Dry Matter Level (%)	Percentage at Each Dry Matter Level
Tops	2.71		2.71	9.38	12.00	1.13
Tops	8.39		8.39	29.04	12.00	3.48
Corms + Tops	11.17	6.62	17.79	61.58	21.00	12.93
Total			28.89			17.54

Source: J. R. Carpenter and W. E. Steinke in Taro: A Review of Colocasia esculenta and Its Potentials, ed. Jaw-Kai Wang.

An overall dry matter percentage of 17 was used for taro silage to determine the corn silage equivalents. Using 30 percent as the dry matter for corn silage, it would require 1.76 tons of taro silage to be equivalent to 1.0 ton of corn silage.

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