EXTENSION PUBLICATIONS

College of Tropical Agriculture and Human Resources
University of Hawai'i at Manoa

Corn Silage Production in Hawaiʻi Using Sub-Surface Drip Irrigation and Precision Ag Tools

A Viable Model for Tropical and Subtropical Agriculturalists

At a Glance

We developed a model for a successful field corn silage production enterprise capable of providing a consistent supply of feedstuffs to support and sustain most local ranchers in Maui County so they can expand their current beef production operations and eliminate the need to depopulate animal numbers during times of limited rainfall (drought) and seasonal dormancy (winter months) when grass growth becomes dormant.

Background

Hawaiʻi's subtropical environment provides year-round grazing, but the lack of a true winter allows for many pasture pests, such as weeds, nematodes, and fungal pathogens to spread rapidly throughout the year. These, along with frequent drought patterns, creates a 'feast or famine' situation that makes it difficult for many in the state to (1) sustain livestock numbers without large input costs, and (2) maintain healthy grazing lands from year to year.

Over the past three decades, the cost of imported feed has skyrocketed and this, combined with the closure of sugar and pineapple plantations across the state, has limited the availability of bi-products available for use as feedstuffs to support the local livestock industries, leading to a decline in productivity and a trend toward shipping animals to the U.S. mainland for finishing.

As such, the objective of this project was to develop a model for a successful field corn silage production enterprise capable of providing a consistent supply of feedstuffs to support and sustain most local ranchers in Maui County so they can expand their current beef production operations and eliminate the need to depopulate animal numbers during times of limited rainfall (drought) and seasonal dormancy (winter months) when grass growth becomes dormant.

For a local feedstuffs enterprise to be viable in Hawaiʻi, its outputs must be significantly cheaper than feedstuffs sourced and shipped into the state from the U.S. mainland. The rising costs of inputs, such as fertilizer, chemicals, water, and seeds over the past decade necessitates the integration of technology to maximize production efficiency in order to lower the costs of production.

August 2023
Subject Category: Animal Sciences, AS-9

Kyle C. Caires
Department of Human Nutrition, Food, and Animal Sciences
Cooperative Extension Service, Maui County
kylecaires@yahoo.com, 541-760-6317

Shyloh Stafford-Jones
SJ Ag Operations

THIS INFORMATION HAS BEEN REVIEWED BY CTAHR FACULTY

Materials and Methods

The models presented herein utilize no-till planting technology (on 30-inch rows at an average population of 38,000 seeds per acre) and precision harvesting tools, in combination with subsurface drip irrigation (12- to 18-inch depth) to reduce water usage, improve control of fertilizer applications (N: 232.9, P:31.6, K: 73.2), and boost overall plant health. Taken together, the goal of these approaches is to reduce input costs and improve soil health and productivity to ensure sustainable crop yields for years to come.

The initial work for this project occurred in 2018, however, the devastating impacts of the pandemic on the increased pricing of inputs have since changed assumptions for production costs associated with planting and harvesting outcomes. Therefore, we will compare, contrast, and describe the original 2018 production and harvest data with the updated cost structure relative to 2022. Water rates implemented at the State of Hawai'i's agricultural parks were used. The results and models presented herein facilitate import replacement and are synergistic to both feedstuffs production and livestock enterprises, helping both industries increase overall profitability.

Proper selection of genetics is extremely important for the success of silage production, with pest resistance being a consideration due to Hawai'i's favorable environmental conditions for insects and fungal diseases. Hybrid selection for the current project (Croplan 5900VT2P) was based on prior research evaluating the viability of commercially available silage corn genetics from various seed companies; the 12 varieties evaluated produced yields ranging from 18.2 to 29.8 tons per acre (data not shown).

This project was completed utilizing planting and harvesting equipment designed for much larger farming operations (500 acres plus) that were provided by a third-party operation. The equipment consisted of a 16-row, no-till planter and a self-propelled forage harvester, as well as a 300-horsepower tractor. Since the cost of this equipment is extremely high for any operation under 500 acres, it is important to note that many different options are available for smaller operations. For seed establishment purposes, planting implements range in size from 4-, 6-, and 8-row setups; all being significantly cheaper than what we used in the present study. For harvesting purposes under 200-acres, a pull-type forage harvester is likely a more economical option because only a 200-hp tractor with a 1000-rpm PTO would be required. Pull-type harvesters are significantly more affordable than self-propelled forage harvesters. The machinery we use significantly reduces labor costs, however, increased fuel costs are a trade-off. Alternatively, smaller equipment for a smaller acreage will likely result in lower fuel costs but also higher labor costs, respectfully. Many other options are available for forage production operations under 50-acres. Contact your local Extension office or the authors for more detailed information.

Results

A summary of annual weather data, including temperature, wind speed, rainfall, and growing degree days at the site of the research trial is shown in Figure 1. Analysis of soil type at the project site, a semiarid and subhumid low mountain slope area, is described in Figure 2. Representative images of agronomic practices used from crop establishment to maturity are shown in Figure 3.

Corn silage production averaged 23.97 tons/acre across the 77.8 acres harvested, yielding 1864.1 tons of feedstuffs for the local livestock industry. Spatial data collected during harvesting was used to generate a yield map depicting wet tons of corn silage per acre, as shown in Figure 4. Of interest, red spots indicating poor yields occurred in areas that overlapped 100%, with crop losses and damage caused by feral axis deer populations observed during crop scouting (Figure 4). Overlapping images are shown to compare and contrast harvest yields with crop moisture levels, elevation at the site, and harvest speed (Figure 4).

Partial budget analyses were used to compare economic viability of corn silage production using inputs costs in 2018 versus 2022, with higher fertilizer, seed and fuel costs post-pandemic). At roughly 24.0 tons per acre yield and 2018 input costs for fertilizer (N: 232.9, P:31.6, K: 73.2) the breakeven cost of the corn silage is calculated

- continued on page 6

Forage Source	CP (%)	ADF (%)	NDF (%)	RFV (%)	TDN (%)
Alfalfa hay, early bloom	18-20	30-32	40.5-43.5	135-140	60-65
Alfalfa cubes, imported	15.5-16.0	33-34	45-47	120-125	60-65
Guinea grass, green chop (Maui)	4.5-5.5	46-48	70-75	65-70	55-57
Napier grass, green chop (Maui)	8-10	48-50	70-72	66-70	52-54
Corn silage, well-eared (Maui)	7.5-8.2	28-29	46-48	132-135	70-72

Table 1. Relative feed values for various forages (on a dry matter basis) available to livestock producers. CP=crude protein, ADF=acid detergent fiber, NDF=neutral detergent fiber, RFV=relative feed value, TDN=total digestible nutrients.

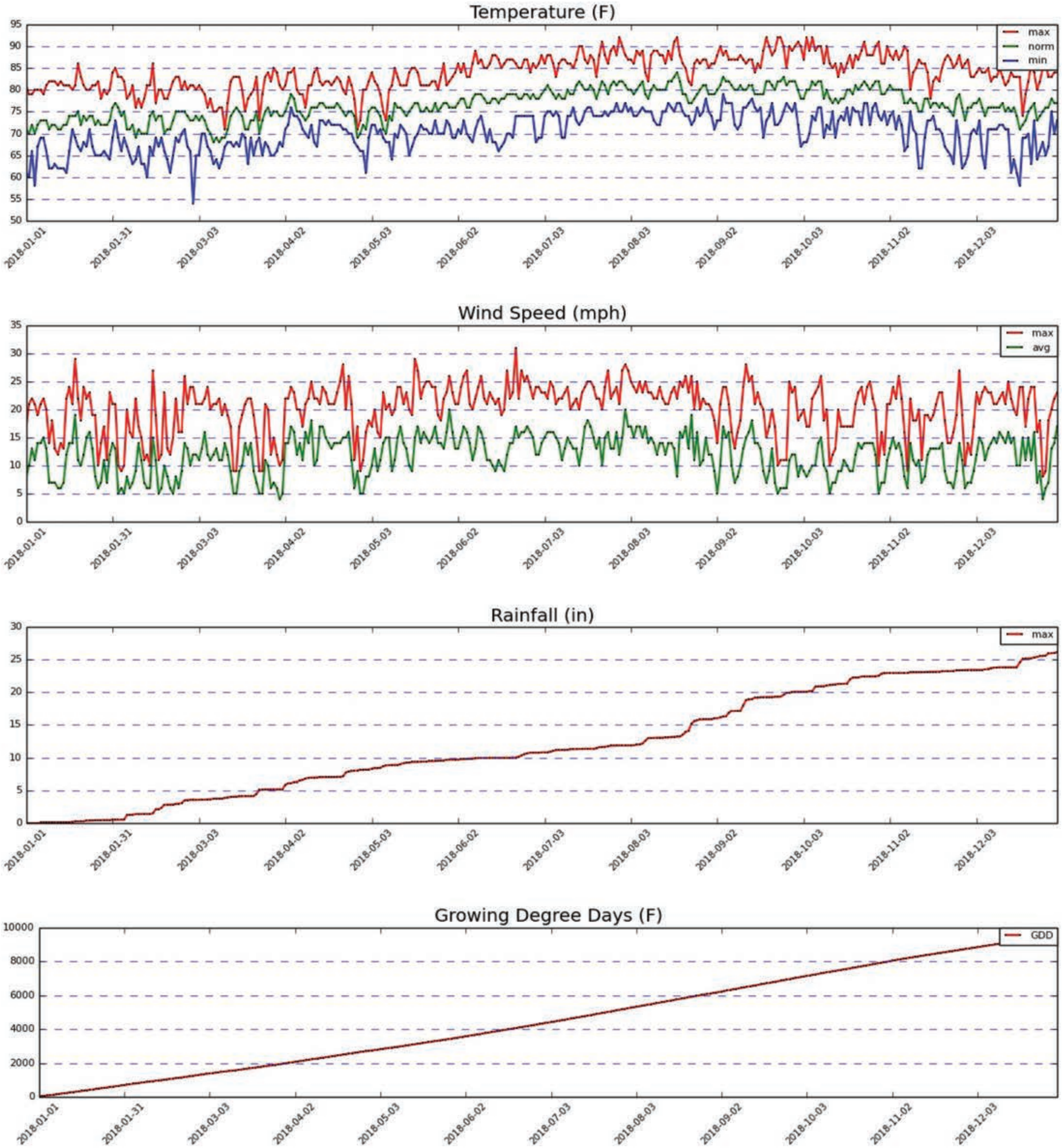
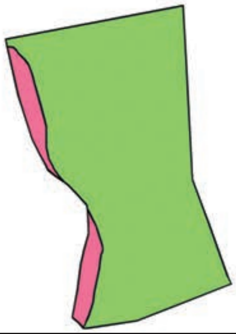


Figure 1. Summary of annual weather station data for ambient temperature, wind speed, rainfall and growing degree days observed at the site of the corn silage trial.



Code	Soil Description	Acres	% of Field	OM	NCCPI
EaA	Ewa silty clay loam (0-3% slope)	71.4	91.80%	3.00	0.36
MuB	Molokai silty clay loam (3-7% slope)	6.4	8.20%	2.50	0.31
		Weighted Average		**2.96**	**0.35**

Figure 2. Summary of soil description present at the site of the corn silage trial obtained from the USDA-NRCS SSURGO database. Organic matter (OM) was calculated using a depth-weighted average of the top 20 cm for all soil components. National Commodity Crop Productivity Index (NCCPI) is a common productivity model, ranging from 0.0 to 1.0, that ranks the inherent capacity of soils to produce commodity crops without irrigation.

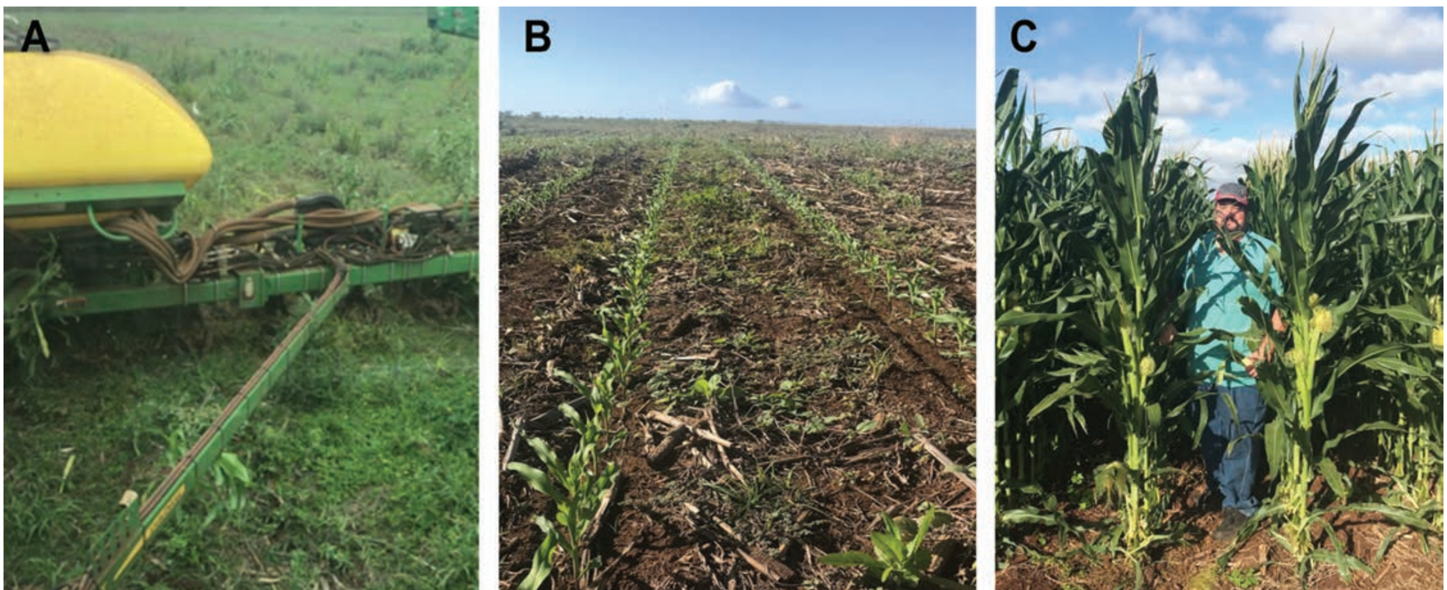


Figure 3. Representative images depicting (A) precision planting, (B) successful germination with one post-emergent herbicide application, followed by (C) crop maturity of the corn silage trial.

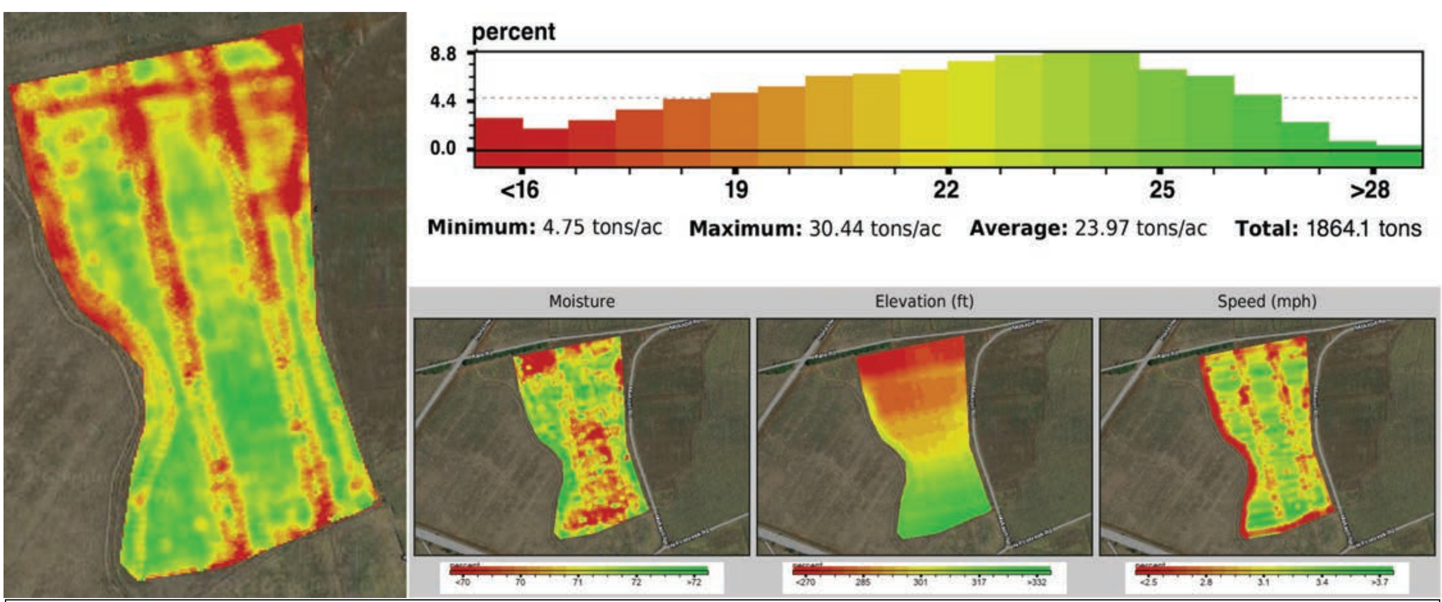


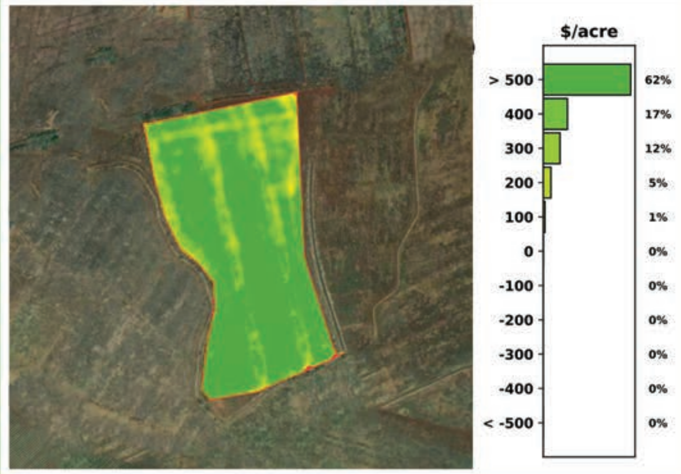
Figure 4. Silage corn trial yield map results (tons/acre) for the 77.8-acre harvest area. Moisture content (%), elevation (feet above sea-level) and harvest speed are also shown. Areas in red representing poor productivity overlap with sites of feral axis deer damage to the crop.

Summary (2018 inputs)

A

	Total	$/ton	$/acre	Farm avg $/acre
Crop Revenue	92,170.47	50.00	1,184.82	1,184.82
Other Revenue	0.00	0.00	0.00	0.00
Total Revenue	**92,170.47**	**50.00**	**1,184.82**	**1,184.82**
Seed	7,266.62	3.94	93.41	93.41
Fertilizer	16,461.72	8.93	211.61	211.61
Chemical	1,010.29	0.55	12.99	12.99
Land	7,779.27	4.22	100.00	100.00
Grain Drying/Handling/Hauling	1,555.85	0.84	20.00	20.00
Equipment	0.00	0.00	0.00	0.00
Custom Hire	0.00	0.00	0.00	0.00
Labor / Fuel	2,809.10	1.52	36.11	36.11
Insurance	0.00	0.00	0.00	0.00
Interest	0.00	0.00	0.00	0.00
Overhead/Home and Personal	6,270.09	3.40	80.60	80.60
Cost of Water	10,051.60	5.45	129.21	129.21
Total Expenses	**53,204.55**	**28.86**	**683.93**	**683.93**
Field Profit	**38,965.91**	**21.14**	**500.89**	**500.89**

2018 Profit by Yield Map



Field area	77.8 ac
Total Yield	1,843.4 ton
Average Yield	23.7 ton/ac

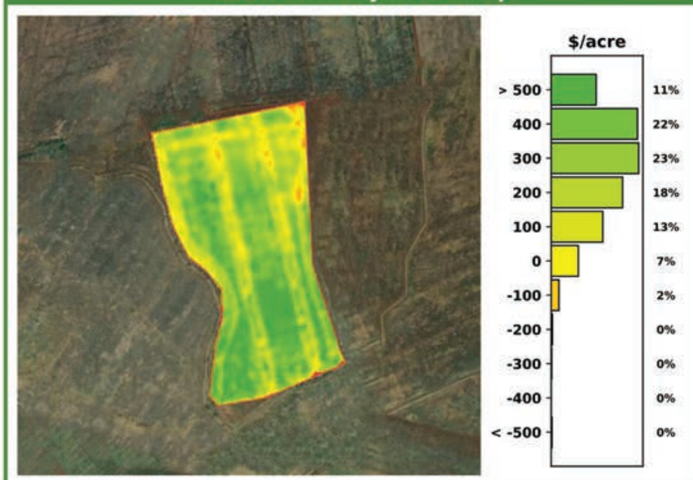
Nutrient Analysis: N: 232.9, P: 31.6, K: 73.2

Summary (2022 inputs)

B

	Total	$/ton	$/acre	Farm avg $/acre
Crop Revenue	92,170.47	50.00	1,184.82	1,184.82
Other Revenue	0.00	0.00	0.00	0.00
Total Revenue	**92,170.47**	**50.00**	**1,184.82**	**1,184.82**
Seed	9,086.19	4.93	116.80	116.80
Fertilizer	31,646.09	17.17	406.80	406.80
Chemical	1,727.00	0.94	22.20	22.20
Land	7,779.27	4.22	100.00	100.00
Grain Drying/Handling/Hauling	1,555.85	0.84	20.00	20.00
Equipment	0.00	0.00	0.00	0.00
Custom Hire	0.00	0.00	0.00	0.00
Labor / Fuel	2,809.10	1.52	36.11	36.11
Insurance	0.00	0.00	0.00	0.00
Interest	0.00	0.00	0.00	0.00
Overhead/Home and Personal	6,270.09	3.40	80.60	80.60
Cost of Water	10,051.60	5.45	129.21	129.21
Total Expenses	**70,925.19**	**38.48**	**911.72**	**911.72**
Field Profit	**21,245.27**	**11.52**	**273.10**	**273.10**

2022 Profit by Yield Map



Field area	77.8 ac
Total Yield	1,843.4 ton
Average Yield	23.7 ton/ac

Nutrient Analysis: N: 239.4, P: 31.2, K: 72.0

Figure 5. Partial budget analysis of corn silage production outcomes in Hawai'i using various input costs from (A) 2018 and (B) 2022.

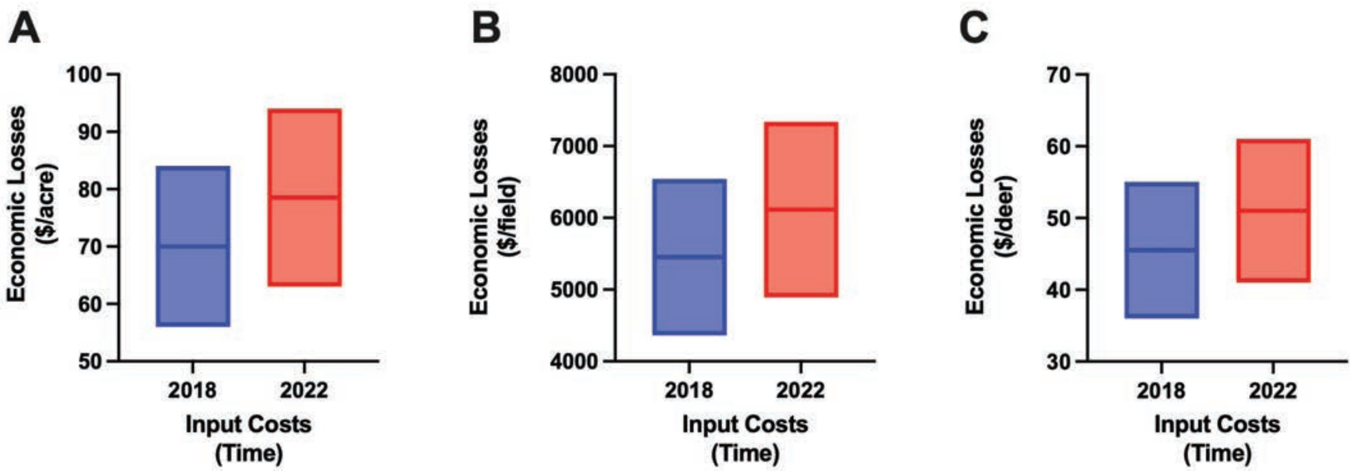


Figure 6. Economic losses of axis deer damage resulting from reduced yields on a (A) per acre, (B) total field, and (C) per deer basis, when corn silage is marketed at $50/ton (wet) using various input costs from 2018 and 2022.

at $28.86 per ton (Figure 5). Marketing corn silage at $50/ton yields to a profit per acre of approximately $500.89; a total profit of $38,965.91 for the 77.8 acre field (Figure 5). Post-pandemic rises in input costs necessitated a reevaluation of the yield data against 2022 prices for comparison. We observed a 133.3% rise in inputs, which led to a breakeven cost of $38.48/ton for production of corn silage in 2022 (Figure 5). Marketing corn silage at $50/ton still yields a profit per acre of approximately $273.10; a total profit of $21,245.27 for the 77.8 acre field.

Crop scouting throughout the project period identified feral axis deer as a major pest pressure affecting yields in the present trial. Yield losses due to axis deer damage, as presented in Figure 6 on a revenue lost per acre, revenue lost per field, and revenue lost on a per deer basis, using cost data from both 2018 and 2022, respectively.

Conclusion

Considering that two crops or corn silage can be planted and harvested each year on the same landmass, corn silage represents a lucrative venture for forage production enterprises to consider growing in order to provide feedstuffs for Hawai'i's livestock industries. For comparison, if corn silage produced is marketed at $80/ton, a rate cheaper than what is currently merchandised in California, profit levels (assuming 2018 and 2022 input costs) would increase to $1211.61/acre and $983.83/acre, respectively, for a single crop (not shown). Compared to many established green chop options currently in the state, corn silage offers roughly twice the yield of perennial forage on a per acre basis, in a much more nutrient dense form. Due to the current three-year drought, many livestock producers have destocked pastures and are currently feeding alfalfa cubes ranging in cost from $680 - $980/ton, landed, in Maui County. Local corn silage, even if marketed at higher $80/ton levels, still represents a more nutrient dense forage option at cost roughly less than $600-$919.60/ton as fed. Accordingly, local corn silage represents a major game changer for the livestock industry that will help individual ranches better drought-proof their pastures, and just as importantly, provide the feedstuffs availability needed in order to ramp up production of local beef and lamb protein industries. Contact your local Extension agent or animal nutritionist to achieve maximum benefit from the inclusion of corn silage in ruminant livestock rations. It is a high-energy feedstuff, balancing fiber measures against other energy measures like starch or sugar essential to ensure rumen health and animal performance measures.

We recommend that a forage production enterprise implement a crop rotation with soybeans or a legume-containing cover crop as a strategy to help with building soil health and mitigating novel pest pressures that can easily become a reality with corn-on-corn-on acres. Additional agronomic recommendations such as hybrid selections, planting populations, row spacings, planting dates, harvest methods and methods used for ensiling whole corn plants are highly variable and should be evaluated on a case-by-case basis relative to soil fertility data. Contact the authors or your local Extension agent for more information.