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Improved Leucaena (var. 'Wondergraze') for Sustainable Beef Production in Hawai'i:

Study 1, Evaluation of beef cattle performance and carcass characteristics

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Abstract

In Hawai'i, there is an increasing demand by consumers for locally grown agricultural food products. Within this food movement, demand for grass-fed beef is increasing, thus providing an opportunity for beef cattle producers to enter this niche market. However, the high fiber and low protein content of the forages in tropical pastoral systems causes slower gains and extended finishing time, often resulting in compromised carcass-quality characteristics, thus limiting the production of quality grass-fed beef. The objective of this study was to evaluate the incorporation of an improved variety of a high-protein tree legume, Leucaena (*Leucaena leucocephala* cv. 'Wondergraze'), on animal growth performance, days to market, and carcass and meat-quality traits in Hawai'i. Two treatment pastures, identical in size, paddock numbers, and grazing management, were developed: the control pasture (CP) was predominantly guinea grass (*Panicum maximum*), and the treatment Leucaena pasture (LP) was a mix of 60% guinea and 40% Leucaena. Each was 48.5 acres. Twenty-five crossbred weaned steers were randomly assigned to each pasture group, and animals in both groups were managed in the same way. Results show a significant improvement in average daily gain (1.64 vs 1.18 lb/day) and lower days to market (432 vs 609 d) for the LP compared to the CP. In comparison to CP, hot carcass weights were heavier (740.4 vs. 708.6 lb), USDA marbling scores (421.2 vs. 381.1) and backfat thickness (0.23 vs. 0.15 in) were greater, rib eye area was larger (13.6 vs. 12.6 in^2), and age at dentition lower (2.1 vs. 3.0 yr) for the LP. Results show that Leucaena-incorporated pasture produced 0.25 lb. more body weight gain per acre per day and improved carcass-quality traits.

Introduction

Consumer demand for locally grown agricultural food products is growing (Martinez et al. 2010). In Hawai'i, this trend provides an opportunity for beef cattle producers to increase beef production. However, highly productive pastoral lands for beef production are limited due to unfavorable rainfall and temperature parameters (Fukumoto et al. 2015). Improving the pastoral production capacity for sustained production of grass-fed beef is a high priority for producers targeting the local market.

Leucaena leucocephala is multi-purpose leguminous tree, widely naturalized throughout the tropics (Cook et al. 2005), producing highly nutritious forage for ruminant production. Its deep tap root system provides for drought tolerance. Through collaborative research efforts between CTAHR's Dr. James Brewbaker; Drs. Max Shelton and Scott Dalzell of the University of Queensland, Australia; and Mr. Peter Larsen of Leuc-Seeds Pty. Ltd, Australia (Dalzell et al. 2005), a unique forage-production model for integrating Leucaena into pastoral systems was developed for enhanced beef production. The Australian Leucaena model increased beef production up to four-fold (Shelton & Dalzell 2007).

The objective of the study was to evaluate beef cattle performance, carcass characteristics, meat tenderness, and forage quality of beef cattle grown and finished on improved Leucaena pastures for sustainable beef production in Hawai‘i.

Materials and Methods

The project site is in the Mahakuolo Ahupua‘a on the Hamakua Coast of the island of Hawai‘i; with an average rainfall of 73.3 in. (Giambelluca et al. 2013) and mean annual temperature of 71.1°F (Giambelluca et al. 2014), in the Pa‘auhau soil series (Hawaii Soil Atlas 2014). This low-elevation and wet zone is typically dominated by guinea grass (*Panicum maximum*).

Two treatment pastures, identical in size (48.5 acres), number of paddocks (10 equal-size paddocks), pasture rotation (70 days), and management, were developed (Figure 1). The *Leucaena leucocephala* pasture (LP) was planted with the cultivar ‘Wondergraze’ (Leucseeds Pty. Ltd. Queensland, Australia) (Figure 2). Seeds were directly sowed (April 2012) into 14 ft-wide prepared seedbeds, arranged in double rows spaced 24 in. apart (Figure 3). The double rows were established within existing stands of guinea grass. Four paddocks were reseeded (October 2012) due to poor establishment. The control pasture (CP) consisted of existing stands of guinea grass.

The cooperating rancher’s stocking rate was used in the study. Twenty-five weaned crossbred steer calves, approximately 8 to 10 months old, were randomly assigned to each treatment pasture and were provided water and mineral supplementation *ad libitum* and managed on a 70-day pasture rotation. Individual animal weights were recorded at the start of the evaluation period and after each pasture rotation. Animal health was monitored and appropriate treatments were provided during the study period as needed. For a period of 98 days, the cattle were removed from the study to allow establishment of the second planting of Leucaena in four paddocks. A visual assessment of market readiness or finish was made and a final weight was recorded within a week of slaughter.

Forage samples were collected prior to cattle rotation into a new paddock to measure the forage value at 70 days of re-growth. Forage samples were dried in a force

Figure 1. Google Earth image of treatment pastures, LP (on left) and CP. Treatment pastures are equal in size (48.5 acres), paddock number, rotation days (70 days), stocking rate, and management.

draft oven at 50°C, ground, and sent for nutrient analyses by NIR (Dairy One Lab, Ithaca, NY, USA).

Due to the limited processing capacity at the local abattoir, market steers were processed in five separate harvest periods (Figure 5). Carcass data collected include hot carcass weight, marbling score, backfat thickness, rib eye area, maturity score, age by dentition, and USDA grade equivalent. Following slaughter, 1-inch-thick boneless rib eye samples were collected from the 12th rib, individually vacuum-sealed, and shipped to the meat laboratory at the University of Hawai'i at Manoa. Upon arrival, the steak samples were repacked and aged in the refrigerator for 2 weeks from the slaughter date and then stored at -20° C for later shear force measurement. Once all rib eye steaks were collected, shear force measurements were carried out. Sealed samples were thawed overnight in a refrigerator. The thawed samples were cooked in a water bath at 70°C for one hour, cooled to room temperature for one hour, and chilled overnight in a refrigerator (Wheeler et al. 2005). The steaks were unwrapped and gently dried with paper towels, and six core samples (1/2 in. diameter) were taken parallel to the longitudinal orientation of the muscle fiber for each steak. The force required to cut the cores was measured by a Warner-Bratzler machine (G-R Manufacturing, Manhattan, KS, USA). The shear force value was the mean of the maximum force required to cut each set of core samples.

The effects of live weight gains, carcass characteristics, and shear force values between treatment groups were determined by ANOVA procedure using Prism6 program (Graphpad, San Diego, CA, USA).

Results and Discussion

Livestock performance results are summarized in Table 1. The terminal market weights for the CP and LP groups were similar, ranging from 1,386 to 1,390 lb., respectively. Average daily gains were significantly higher (1.64 vs 1.18 lb/day), and days to market (432 d vs 609 d) were significantly shorter for steers in the LP as compared to the CP group. ADG for steers in the LP group was 39.6% higher, with an advantage of 0.46 lb per day. LP group took 29% fewer days (177 days) to reach market size as compared to the CP group. The LP produced 0.25 lb more beef per acre per day than CP. Studies in Australia show that cattle produced on Leucaena/Buffel pastures showed increased growth performance ranging from 1.3 to 2.1 times, finishing 6 to 12 months ahead of cattle produced on Buffel or Green panic grass pastures (Dalzell et al. 2006).

Table 2 summarizes the carcass characteristics and shear force measurement. For the LP group, hot carcass weight was heavier (740.4 vs. 708.6 lb), marbling score (421.2 vs. 381.1) and backfat thickness (0.23 vs. 0.15 lb) were higher, rib eye area was larger (13.6 vs. 12.6 in^2), and age at slaughter was lower (2.1 vs. 3.0 yr) as compared to the CP group. The USDA-equivalent quality grade was higher for LP carcasses, averaging low Choice

Figure 2. Photograph of the LP pastures (foreground) and CP. The cattle-handling facility alley separates the treatment pastures.

Figure 3. Photograph shows a well-established pasture of alternating rows of Leucaena and guinea grass at the start of the study.

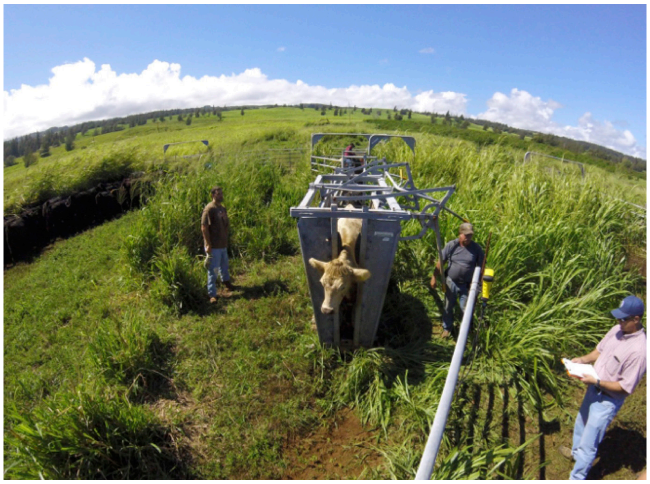

Figure 4. Cattle were weighed after a full rotation through the 10 paddocks over a 70-day period.

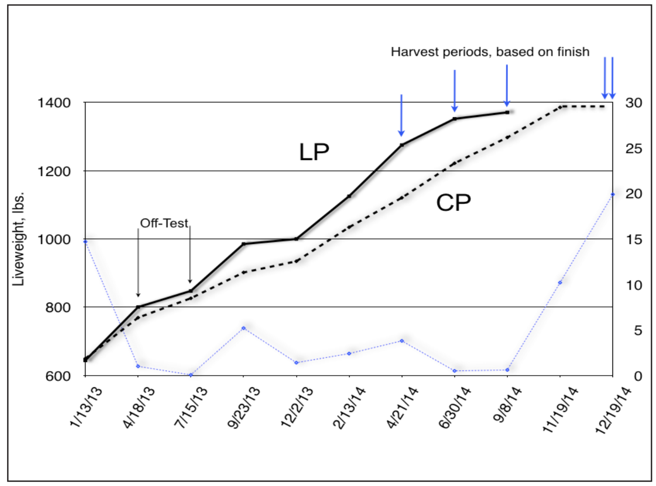

Figure 5. Growth performance of beef cattle on LP and CP pasture treatments and rainfall during study period.

Table 1. Comparison of the animal performance on guinea grass (CP) compared to guinea grass and Leucaena (LP) pastures, Hamakua, Hawai‘i Island.

	Guinea Grass Control (CP)	GG + Leucaena Treatment (LP)
Ave. Starting Weight, lb.	649.4 ± 10.0	644.0 ± 13.4
Ave. Ending Weight, lb.	1,385.8 ± 19.7	1,390.0 ± 18.8
On-Test Gain/ head, lb.	679.6 ± 12.9	698.7 ± 18.1
On-Test ADG, lb./day	1.18 ± 0.02	1.64 ± 0.04 **
On-Test Days to Harvest	608.9 ± 0.41	432.2 ± 12.4 **

Average + Standard Error
**means within a row are significantly different, $p < 0.01$

Table 2. Comparison of carcass weight, marbling score, rib eye area, back fat thickness, age at dentition, and shear force of steers on CP and LP pastures.

	Guinea Grass Control (CP)	GG + Leucaena Treatment (LP)
Carcass weight, lbs.	708.6 ± 11.7	740.4 ± 10.5 *
Marbling score	381.2 ± 12.8	421.2 ± 11.0 *
USDA grade equivalent	Select	Low Choice
Rib eye area, in^2	12.6 ± 0.22	13.6 ± 0.23 **
Back fat thickness, in	0.15 ± 0.01	0.23 ± 0.02 **
Age by dentition, yr	3.0 ± 0.06	2.1 ± 0.19 **
Shear force, kg	4.1 ± 0.17	5.0 ± 0.22 **

Average + Standard Error
Marbling Score: Slight=300, Small=400
* means within a row are significantly different, $p < 0.05$
** means within a row are significantly different, $p < 0.01$

compared to Select for CP. However, shear force values of rib eye steak samples were lower (more tender) for the CP compared to the LP group (4.1 vs 5.0 kg). This anomaly may have resulted from sampling errors in the steak samples received from each treatment, 10 for the LP and 25 for the CP. Shelton and Dalzell (2007) report that dryland grass/Leucaena pastures in Australia can produce beef of similar quality to grain-fed animals. In addition, beef animals grazed in grass/Leucaena pastures were marketed earlier, ranging from 1.3 to 2.8 dentition scores, compared to 4.0 for grass-based pastures.

Tables 3 and 4 summarize selected chemical and mineral content (analyses by Dairy One, Ithaca, NY) of the individual forages and provide an estimate of the quality of guinea grass and Leucaena proportioning of

Table 3. Nutritional content of selected quality components of guinea grass and Leucaena and the estimated content of the planted forage ratio of 60% guinea and 40% Leucaena.

	CP	ADF	NDF	NFC	TDN	RFV
	-------------- % Dry Matter Basis ---------------					
Guinea Grass (GG)	18.8	32.6	64.3	8.2	60	92
Leucaena (L)	29.4	23.3	32.2	32.3	71	205
60% GG:40% L	23.0	28.9	51.5	17.8	64.4	137

n=4, 67-day regrowth
CP=crude protein, ADF=Acid detergent fiber, NDF=neutral detergent fiber, NFC=non-fibrous carbohydrates,
TDN=total digestible nutrients, RFV=relative feed value

Table 4. Mineral content of guinea grass and Leucaena and the estimated content of the planted forage ratio of 60% guinea and 40% Leucaena

	Ash	Ca	P	K	Mg	S	Cl
	---------------------------------- % DMB ------------------------------------						
Guinea grass (GG)	11.4	0.38	0.33	2.76	0.31	0.25	1.22
Leucaena (L)	9.3	1.62	0.45	3.00	0.39	0.28	0.84
60% GG:40% L	10.6	0.87	0.37	2.86	0.34	0.26	1.07

n=4, 67-d regrowth
Ca=calcium, P=phosphorus, K=potassium, Mg=magnesium, S=sulfur, Cl=chloride

the nutrients at a 60:40 ratio (Shelton and Dalzell 2006). Leucaena forage contributes a higher crude protein, lower fiber levels (higher digestibility), higher non-fibrous carbohydrate, and higher relative feed value to ruminant diets than guinea grass. The minimum crude protein requirements for growing and finishing beef cattle are 16.4% and 12.3% respectively (NRC 1976).

Conclusion

Results of the study show that incorporation of an improved *Leucaena leucocephala*, cv. 'Wondergraze', into a tropical pastoral rotational grazing system significantly enhanced average daily gains, shortened days to harvest, and improved carcass traits as compared to guinea grass pastures. The improvement in animal growth and carcass traits is likely due to the enhanced nutritional quality of the grass–legume forage mixture.

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