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GROWING BARLEY FOR SHORT-TERM COVER CROPPING GREEN MANURE AND/OR FORAGE PRODUCTION IN LEEWARD OAHU

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SUMMARY

Since sugarcane is no longer grown in leeward Oahu, solutions for temporary ground covers, green manures, and forage are needed to keep the land productive and prevent soil erosion from intense winter rainfall. Barley (*Hordeum vulgare*) can be grown in the winter as a short-term forage crop in soils with a wide ranging pH in most years without supplemental irrigation. A 1.6 acre test field was established at the HARC Kunia Substation in November 1995, and harvested in the milk stage 107 days after planting. Rainfall during the experimental period was 12.5 inches. Yields ranged from 2.76 to 6.25 t/acre (fresh forage) when grown with supplemental nitrogen ranging from 0 to 184 lb N/acre, respectively. Crude protein (DM basis) ranged from 5.8 to 13.7%, net energy of lactation (NE_L) ranged from 0.58 to 0.62 MCal/lb, acid detergent fiber (ADF), a measure of the cellulose and lignin, ranged from 30.6 to 33.3%, percent total digestible nutrients (TDN) ranged from 66 to 68% and nitrates ranged from 0.01 to 0.35%. The average macronutrient concentration of barley was 0.15% P, 1.60% K, 0.14% Ca, 0.17% Mg, and 0.16% Na. All macronutrients with the exception of K were lower than required for top milk producing dairy cows. When fertilized with 46 lb N/acre between 3 to 6 weeks after planting the yield of fresh barley forage was approximately 5 t/acre, and if sold at approximately $37/t would represent a break-even point in production. This experiment demonstrates that milk-stage barley forage can be produced under nonirrigated, rain-fed conditions in leeward Oahu in years that receive at least 7 inches of rainfall.

INTRODUCTION

Climate and Soils requirements

Barley is more tolerant to drought, saline and alkaline soils and low quality irrigation water than other cereals. Its largest use is for animal feed, and it is the fourth most important cereal crop in the world. Barley has a broad ecological adaptation that sets it apart from other cereals (Rasmusson, 1985). Only wheat comes close to matching it in breadth of adaptation. Barley is cultivated in the tropics, either in the cool temperatures of high altitudes or it is fall-sown during the cool winter season. Spring barley is grown during short winter days in California and North Africa during times when temperatures are coolest and transpiration and evaporation losses lowest. Barley has the lowest transpiration rate among the small grains (Nuttonson, 1957).

Cultivation

Barley grows best on well-drained fertile loam or light clay soil. Sandy soils may hold insufficient moisture while heavy clays can waterlog, a condition unfavorable for barley (Leonard and Martin, 1963). However, high yields can be obtained on clay soils if good tillage and soil moisture prevail. Barley is more tolerant than other cereals to alkaline soils (Bower and Fireman, 1957), a soil pH of 6 to 8.5 is acceptable for plant growth. Barley can utilize either ammonium or nitrate nitrogen.

When spring barley is fall-sown as in the southwestern United States, best results are obtained with early November planting. Barley should be drilled or broadcast onto a dry rough seed bed (a single disking) and followed by irrigation. Barley should be sown 3/4 to 2.5 inches deep in firm contact with the soil. Work in Hawaii by Evensen (1992) showed that incorporation of the seed into the soil significantly increased ground cover, crop stand and reduced weed populations. Seeding rates range from 50 to 100 lb/acre.

Forage Value

Barley harvested as hay, green chop, or silage has an advantage over oats owing to its relative drought tolerance under semi-arid conditions (Hughes et al., 1962). The best quality hay or silage is obtained when barley is cut at the boot stage (Marx, 1974). Later harvests result in poorer quality feed and under dryland conditions increase the possibility of nitrate poisoning due to drought. Taking the first cut above the first node allows barley to regenerate so a second cut is feasible (Marx, 1974). Because of the high fiber content of barley hay there is a reduction in the amount of roughage needed in feedlot diets. Barley forage cut at heading is succulent, high in crude protein and fiber, and low in energy, especially non-structural carbohydrates (NSC). Digestibility of barley is maximum when at the mealy stage (soft dough, 20-25 days prior to harvest) (Foster and Prentice, 1987). Lang and Holmes (1969) emphasize the advantage of harvesting barley before fully ripened (milk to soft dough stage) with optimum protein content occurring 21 days before kernel maturity. Barley forage harvested at the milk stage was as satisfactory for lactating cows as silage prepared from barley harvested at the milk and soft dough stages and superior to barley silage made from barley in the hard dough stage (Fisher et al., 1972).

MATERIALS AND METHODS

Baronesse spring barley seed (McKay Seed Co., Almira, WA) was broadcast at a rate of 60 lb/acre using a tractor-mounted Vicon spreader onto land formally in sugarcane and recently plowed. Seed was immediately disked into the soil on 22 November 1995, on land minimally prepared. The field was a Molokai soil series with pH 6.7 and benefited from 3.2 inches of rain prior to planting providing sufficient subsurface moisture to assure germination. No fertilizer or herbicides were applied at planting and no irrigation was applied during the entire experiment. Experimental plots were 12 feet wide by 158 feet long (replicated three times per treatment) and were designed to facilitate cutting with a 6-foot wide tractor-mounted sickle bar mower. Nitrogen in the form of urea was broadcast onto the field for each treatment. Treatments were 0 lb N/acre, 46 lb N/acre 21 days after planting, 46 lb N/acre 42 days after planting, 92 lb N/acre 21 days after planting, and 184 lb N/acre 21 days after planting. Harvesting occurred 107 days (8 March 1996) after planting using a sickle-bar mower. Barley in the center 6 feet in the 12 foot wide plots was harvested the full length of the row (948 ft^2) leaving a 3-4 inch stubble and weighed fresh in the field. A subsample was taken from each plot to determine dry matter collected (70^0 C for 6 days). Samples were then ground to 2 mm and analyzed using wet chemistry for crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), non-structural carbohydrates (NSC) (composed of sugar and starch), net energy of lactation (NE_L), net energy of maintenance (NE_M), net energy gain (NE_G), total digestible nutrients (TDN), and nitrate ion concentration (DHI Laboratory, Ithaca, New York). Macronutrients were analyzed by the Agricultural Diagnostic Service Center, Honolulu, HI for P, K, Ca, Mg, and Na.

RESULTS AND DISCUSSIONS

Rainfall

Rainfall during the growing period was adequate to ensure germination and growth of the crop. Good rainfall prior to planting (3 inches from Nov. 1 to Nov. 21) assured sufficient soil moisture for germination. When compared to the average for Kunia, rainfall was normal with a total of 12.5 inches falling from planting to harvest (Table 1). The last 5 inches of rain that fell in early March (in a single downpour) did not contribute greatly to final yield based on preliminary yield results taken in late February.

Table 1. Rainfall from November 1995 to March 1996, average rainfall and the range in rainfall at Kunia Substation, West Oahu, Hawaii from 1963-1995.

Month	1996 Rainfall	Average Rainfall	Range
	--------------------------------------Inches--------------------------------------		
Nov. 1-21	3.17		
Nov. 22-30[1]	0.38	3.20	0.0-14.6
Dec.	2.27	3.65	0.0-15.4
Jan.	4.04	3.96	0.2-15.4
Feb.	0.79	3.18	0.1-09.9
Mar. 1-8	5.00	1.99	0.1-05.9
Mar. 9-31	0.00		
Total	15.65	15.98	

[1]Months in bold represent the period of barley growth from planting to harvest.

Yield and Dry Matter Content

Total fresh barley yields were taken only from replication number 3 owing to problems harvesting of the barley in the other replications in a single pass with the sickle-bar mower. Yields ranged from 2.75 tons to 6.25 fresh t/acre over the range of treatments (Table 2). Dry matter ranged from 25-34%, thus barley yields ranged from 0.94 to 1.58 tons DM/acre and represented a 60% increase in yield over the non-fertilized treatment. Yields of barley forage in this experiment are similar to other areas on the mainland. The increasing productivity of barley with increasing N was expected. The barley stand in the two highest N-fertilizer rates regenerated after cutting, and was still green 150 days after planting. While a second harvest from this regenerated stand would be low, it could be used for green manure or soil conservation. Weeds were not a problem in any of the treatments. Barley effectively competed against all weeds in this trial including guineagrass. The approach of disking barley seed into a stale seed bed helped to control early weed germination while the vigorous germination and growth of the barley prevented weed growth.

Table 2. Dry matter and biomass yields of milk-stage barley forage 107 days after planting (DAP).

Treatment		Fresh Barley t/acre	Dry Matter %	Dry Barley t/acre
0 lb urea/a		2.76	34.0	0.94
100 lb urea/a	21 DAP	4.50	30.5	1.38
100 lb urea/a	42 DAP	5.45	27.8	1.52
200 lb urea/a		6.13	24.5	1.50
400 lb urea/a		6.25	25.2	1.58
Average		5.02	28.4	1.38

Forage Quality

Barley forage quality increased with urea application. Crude protein concentrations increased from 5.8% in non-fertilized barley to 13.7% in the highest fertilizer rate. Nitrate also increased with increasing N-fertilizer rates and was especially high at the highest N-rate. Feeds with nitrate % less than 0.44% are safe to feed lactating cows. However the range of the highest treatment was 0.1-0.6 on a DM basis. Nitrate concentrations of 0.6 are safe to feed dry cows but pregnant dairy cows must be restricted to 50% of the feed. The ADF fraction is higher than the minimum required for a mature lactating cow while TDN was lower than required by lactating cows (Table 3). Fiber and energy were similar to early bloom alfalfa, timothy hay or orchardgrass, and better than early bloom ryegrass, napiergrass and bermudagrass (NRC, 1989).

Table 3. Nutritive value of milk-stage barley forage dry matter 107 days after planting (DAP), and the minimum requirement of a 1500 lb lactating dairy cow producing 77 lb milk/day.

Treatment	CP	ADF	NDF	NE_L	NE_M	NE_G	NSC	TDN	Nitrate
0 lb urea/a	5.8	33.3	55.9	0.58	0.59	0.35	25	66	0.01
100 lb urea/a 21 DAP	10.8	32.3	55.1	0.60	0.61	0.36	21	67	0.04
100 lb urea/a 42 DAP	9.0	31.1	55.6	0.62	0.62	0.37	22	68	0.02
200 lb urea/a	12.4	30.6	54.4	0.62	0.62	0.38	20	68	0.11
400 lb urea/a	13.7	31.2	52.8	0.62	0.62	0.38	20	68	0.35
Average	10.3	31.7	54.8	0.61	0.61	0.37	22	67	0.11
1500 lb Dairy Cow producing 77 lb milk/day	16.0	21.0	----	0.73	----	----	----	71	0.44

CP = crude protein %
ADF = acid detergent fiber (measures cellulose and lignin)
NE_L = Net energy for lactation
NE_M = Net energy for maintenance
NE_G = Net energy for gain
NSC = non-structural carbohydrates (sugar)
TDN = Total digestible nutrients
Nitrate ion = concentrations above 0.44 require restricted intake by lactating dairy cows.

Macronutrient concentrations were lower than required by mature dairy cows producing 77 lbs milk/day with the exception of K (Table 4). Levels of these macronutrients would have to be adjusted in the feed ration if barley were fed to dairy cattle. One area of concern is the imbalance between Ca:Mg ratio. This barley crop had a 1:1 ratio but requirements are based on a 3:1 Ca:Mg ratio. Liming the soil with calcium carbonate should correct this imbalance.

Table 4. Macronutrient concentration of milk-stage barley forage dry matter 107 days after planting for P, K, Ca, Mg, and Na.

		P	K	Ca	Mg	Na
		----------	----------	%	----------	----------
0 lb urea/lb		0.12	1.10	0.09	0.14	0.11
100 lb urea/a	21 DAP	0.15	1.57	0.13	0.18	0.15
100 lb urea/a	42 DAP	0.16	1.80	0.13	0.15	0.12
200 lb urea/a		0.17	1.60	0.15	0.18	0.17
400 lb urea/a		0.18	1.94	0.19	0.22	0.25
Average		0.15	1.60	0.14	0.17	0.16
1500 lb Dairy Cow producing 77 lb milk/day		0.40	0.80	0.60	0.20	0.18

Barley Economics

When green chop barley is fertilized at 46 to 100 lb N/acre and produces approximately 5 tons fresh green chop/acre, the break-even price ranges from $34.00-37.00/fresh ton. Table 4 gives the cost breakdown for barley green chop forage production, while Table 5 gives the break-even analysis for producing barley forage in Hawaii.

Table 5. Description and cost breakdown of planting 1 acre of barley in Hawaii.

	0	46[1]	46[2]	92	184
Fertilizer[3]	0.00	38.55	38.55	57.10	74.20
Plow[4]	44.00	44.00	44.00	44.00	44.00
Seed	14.40	14.40	14.40	14.40	14.40
Seeding[3]	20.00	20.00	20.00	20.00	20.00
Disk[4]	19.33	19.33	19.33	19.33	9.33
Harvest[4]	30.00	30.00	30.00	30.00	30.00
Transport[4]	20.00	20.00	20.00	20.00	20.00
Total	147.73	186.28	186.28	204.83	221.93

[1]46 lb N applied 21 DAP.

[2]46 lb N applied 42 DAP.

[3]Fertilizer and seeding were calculated using airplane spreading at $20/acre. Urea fertilizer sold for $371/ton.

[4]Labor was charged into the total and a rate of $23/hour was applied. Both harvesting and transport costs may increase slightly as yields increase. Tractor costs were calculated at $35/hr.

Table 6. Break-even cost analysis of fresh barley green chop delivered.

Tons/acre	0	46[1]	46[2]	92	184
3	$49.24	62.08	62.08	68.28	73.97
4		46.56	46.56	51.20	55.48
5		37.25	37.25	40.96	44.39
6				34.15	36.98

[1]46 lb N applied 21 DAP.
[2]46 lb N applied 42 DAP.

Interpretive Summary

Spring barley is easily established in arid locations without irrigation in Hawaii as long as sufficient soil moisture is available prior to planting. Expensive machinery is not required to establish barley since only ploughing and disking are required, although if barley is to be harvested for forage a level surface is desirable that may require additional land preparation. If barley is to be used for green chop forage or ensiled, the crop should be fertilized once with urea or a complete fertilizer. Urea rates of 100-200 lb/acre broadcast after germination will increase yield and quality of the feed. Barley green chop could be used as a partial replacement for imported feed. Higher rates of nitrogen (200 lb urea/acre) optimized fresh yield and increased persistence of the crop allowing the crop to regenerate. Barley competes vigorously with weeds and no major weed problems were encountered in the trial. In fact, few weeds were observed in the regenerated stands 150 days after planting. Barley allows producers the flexibility to cover their land cheaply during rainy winter months thus protecting their soil resources and may offer a marginal return on investment in good years. Barley left standing in the field with a full seed load can also be redisked into the soil to produce another stand.

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