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A DEMONSTRATION OF GRASS BIOMASS PRODUCTION ON MOLOKAI

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SUMMARY

Banagrass, a cultivar of *Pennisetum purpureum* Schum., was grown for two cropping cycles to estimate biomass production at the USDA Plant Materials Center, located at Hoolehua, Molokai. The project was designed as a scale-up based on earlier studies at the same site and was conducted to demonstrate the potential for large-scale biomass production using mechanical harvesting.

Banagrass was grown according to procedures developed in earlier trials beginning with the production of a vegetative seed crop on 0.7 acres. Seed was cut and planted in shallow furrows; irrigation, fertilization and weed control operations followed with crop canopy closure occurring about 4 months after planting. The plant crop was harvested at 7 months following planting, yielding 16.7 t/ac (26 t/ac on annualized basis). Small hand-harvested plots were cut from the demonstration to measure yield potential and the whole planting of 11.4 acres was mechanically harvested using a CLAAS sugarcane chopper harvester. The banagrass was ratooned (allowed to regrow) and harvested again at 8 months following the start of the ratoon. For the ratoon crop, only hand-cut plots were taken to estimate yield of biomass. The ratoon yield was 13% higher than the plant crop.

Mechanical harvesting resulted in a loss of 27% of the biomass measured in the field, representing an opportunity for improved recovery by changing the design of the harvester or investigating other harvesters. The study provides yield data which can be used to evaluate the economics of biomass production for conversions ranging from direct burning, conversion to liquid fuel, or conversion to structural fiber boards.

INTRODUCTION

Banagrass is a fast-growing, upright cultivar of elephantgrass (napiergrass) recognized for its potential as a biomass and windbreak crop. Banagrass was introduced to Hawaii from Australia in the mid-1970's through the sugarcane quarantine protocol for use as an indicator plant for ratoon stunting disease of sugarcane. Following completion of the quarantine requirements, banagrass was planted in Maunwilli, Oahu at the HARC breeding station. Its outstanding growth attracted attention and it was placed in observation and seed increase plots in Ewa, Oahu and at the HARC field station at Kunia, Oahu. Banagrass was distributed from Kunia to the island of Hawaii for use as a windbreak for fruit trees and it was also installed in five HARC yield trials for comparison with sugarcane (Wu and Tew, 1988, unpublished internal report). Plant crops of banagrass averaged 18.5 t/ac/yr dry matter, a yield not significantly different from those obtained in the adjacent sugarcane plots. First ratoon crops gave considerably higher yields, averaging 42 t/ac/yr which was about double the ratoon sugarcane yields. The lower yields in the plant crop reflected a poor stand owing to excessive depth of planting and damage to the young plants by the herbicide ametryn. The ratoon crops were extremely vigorous and required only minimum weed control.

Banagrass was also planted in the HARC "Biomass to Energy" trial on Molokai in 1986 (Osgood and Dudley, 1993). A plant crop and six ratoon crops were harvested from this trial from April 1987 to January 1991. Dry matter yields ranged from 11.55 t/ac/yr in the plant crop to 31.32 t/ac/yr in a summer-harvested fourth ratoon. Summer-grown crops of banagrass were about twice as productive as winter-grown crops. Vegetative seed from the Molokai planting was used to establish the Molokai Banagrass Demonstration trials reported below.

MATERIALS AND METHODS

Banagrass was planted on 11.4 acres at the USDA Plant Materials Center located at Hoolehua, Molokai. The soil at the site was an oxisol in the Molokai soil series. The planted crop and a single ratoon crop were harvested for determination of biomass yield.

The Plant Crop

Prior to planting, two distinct areas were observed in the field. One part of the field was covered with a dense stand of buffelgrass and the other was covered with leucaena and eucalyptus trees left from a previous experiment. The field was prepared by first removing the grass and trees and then ripping and plowing twice. Both areas of the field received a pre-plant application of glyphosate (Roundup) herbicide applied broadcast by tractor.

Banagrass vegetative seed was produced in a 0.7 acre block adjacent to the demonstration trial. The seed block was ratooned in September 1993 and did not flower, as expected, producing a high quality 7 month-old seed for planting in April 1994. The seed weight was 0.125 lb/ft and the weight of seed delivered per acre was estimated to be 0.73 tons. The seed was hand-planted with one-third seed overlap in the line and about 0.4 acres of seed was used to plant the 11.4 acres. An incomplete stand resulted owing to insufficient seed planted and erratic water movement to the seed; the remainder of the 0.7 acre seed block was used to supplement the original planting.

Following planting, drip irrigation tubing was placed on the soil surface along each row. The field was divided into four irrigation blocks which were set to receive water six hours per day. Irrigation was applied at the rate of estimated evaporation, or 0.35 in per day.

Preemergence applications of a mixture of atrazine and alachlor were applied by tractor at 2 plus 2 lb/ac (formulated material basis). Owing to the gaps in the stand additional weed control was required. This consisted of mowing between the rows and use of glyphosate as a spot treatment on the grass weeds.

Fertilizers N, P, and K were applied at about monthly intervals throughout the plant crop. The totals applied were N (203 lb/ac), P2O5 (90-133 lb/ac), and K2O (170-201 lb/ac). Fertilizers were applied through October 19, 1995.

Plots of 0.0046 acres (10 ft x 20 ft) were hand-harvested on November 30, 1994. Three randomly determined subsamples were taken in each block. Samples were also taken for moisture determination.

The entire demonstration area was harvested by a CLAAS chopper harvester, (Model CC1400 142, kW, 190 hp) operated each day between January 31 and February 3. The trash extractors were disabled to maximize the collection of biomass. The harvested banagrass was loaded directly into a Vanguard tipper-trailer (Model V1248-2,15 m^3, 20 yd^3) powered by a Case International two-wheel drive, rubber-tire tractor (model 595, 39 kW, 52 hp). The banagrass was removed from the field in a variety of tractor trailers with volumes ranging from 23 to 34 m^3. The residue left on the ground after harvest was determined by collection in small plots.

Ratoon Crop

After the plant crop harvest, the drip tubing was replaced and water was returned to the field. The crop start date was February 24, 1995. Nitrogen and potassium were each applied at 30 lb/mo for 6 months providing 180 lb/ac of N and K2O. No P was applied in the ratoon crop.

Owing to the rapid growth of the banagrass, only spot applications of Roundup were required to control the grass weeds.

Plots were hand-harvested for yield determination on October 17-18, 1995. Three randomly chosen subsamples were taken in each of the four blocks. Moisture samples were taken and the dry matter produced per acre was calculated.

Mechanical harvest was not arranged for the ratoon planting.

RESULTS

Plant and Ratoon Yields from Hand-Harvested Plots.

The annualized average yield of dry matter in the plant crop was 26 t/ac amounting to 2.16 t/ac/mo. Dry matter averaged 28.37%. This yield was higher than reported by Wu and Tew (1988) for an average of five plant crop sites. The ratoon crop yield averaged 30 t/ac/yr amounting to 2.51 t/ac/mo. Dry matter averaged 35.8%. This yield was lower than reported by Wu and Tew (1988). The average dry matter yield for the plant and ratoon crops combined was 28 t/ac (**Table 1**).

An unidentified leaf scorch was observed in the top two blocks in the ratoon crop. Biomass yield appeared to be affected by the scorch.

Mechanical Harvesting and Transport.

The harvester was able to cut two rows (5 ft spacing) for each pass across the field but, as a result, the average in-field speed was reduced to 1 mph. The removal of the detrashing mechanism increased the amount of biomass collected but reduced the bulk density of the biomass collected. A summary of the performance data for the harvesting and transport system is presented in **Table 2.**

A considerable amount of biomass was not collected by the harvester owing primarily to the inability of the base cutters to properly cut and deliver material to the chopper blades. This problem can be solved through design change or by changing the type of harvester used. The use of self propelled forage harvesters should also be considered. A slight increase in the elevation of the planted row would also improve recovery of biomass.

SUMMARY AND CONCLUSIONS

From an agricultural point of view, banagrass appears to be an ideal grass crop for biomass fiber production. Its rapid growth, upright habit and high fiber content give it an advantage over commercial Hawaiian sugarcane varieties which are slower growing, have a strong tendency to lodge, and have lower fiber content.

It was demonstrated that banagrass could be grown in large semi-commercial blocks to produce high biomass yield, and that mechanical harvest and transport were feasible.

The average annualized yield of a plant crop and the first ratoon was 28 t/ac. The planted crop of banagrass was lower yielding by 4 t/ac than the ratoon crop, confirming earlier yield information.

Based on an average of samples of crop residue taken from each block, there were 4.5 tons of biomass left in the field after mechanical harvesting; thus, percent field recovery of dry matter was 73%.

The cost of producing ratoon crops will be considerably lower than for planted crops owing not only to the obvious savings in planting cost but to a reduction in the maintenance cost, especially weed control. Canopy closure for the first ratoon occurred at about 2.5 months compared to 4 months for the planted crop. Since a large number of ratoon crops are expected, the production of biomass from the ratoon crops is of much greater importance than the plant crop.

Owing to its upright habit, banagrass is easily harvested by conventional sugarcane equipment such as the CLASS harvester and vanguard transporter used in this study. Other harvesters should be evaluated for harvesting for improvement in efficiency. In addition, forage harvesters should be evaluated and every attempt should be made to improve biomass recovery and the bulk density of the loads transported from the field.

Risks and Potential Problems

Banagrass is a potential weed, but not to a greater degree than the numerous other *Pennisetum purpureum* (elephantgrass, napiergrass) cultivars already in Hawaii and which have been widely planted in the past for forage. Banagrass has not been successful in naturalizing at the HARC Kunia Substation, where it has been grown for over 10 years; however, more success as a weed from spread of the true seed would be expected with increased rainfall.

Napiergrass is a serious weed pest in sugarcane especially when it becomes established in sugarcane seed fields. In this situation, vegetative cuttings (seed) of napiergrass will be planted along with sugarcane. Napiergrass is difficult to remove from commercial sugarcane fields once established. It is not recommended that plantings of napiergrass be made in close proximity to sugarcane, and especially sugarcane seed fields.

Little is known regarding the chemical makeup of banagrass or other napiergrass cultivars and therefore its value as a fuel for direct burning is still a question.

Land planted to banagrass should expect to be dedicated for a long period of time. Banagrass, as with other napiergrass cultivars, becomes firmly established in fields and is difficult to remove for establishment of alternative crops. Alternative uses of banagrass include forage, although other cultivars such as "Mott" are better suited for forage.

Table 1. Summary of banagrass yield for replicated (12) hand-harvested plots of 200 ft^2 in the plant and ratoon crop.

Yield	Plant Crop	Ratoon Crop
Fresh weight (t/a)	58.1	55.6
Fresh weight/yr (t/a/yr)	91	84
Dry matter %	28.4	35.8
Dry weight (t/a)	16.7	20
Dry weight/yr (t/a/yr)	26	30

Age at harvest was 7.7 months for the Plant Crop and 8 months for the Ratoon Crop.

Table 2. Mechanical harvesting results.

Adjusted harvester productivity (ac/hr)*****	0.65
Average particle length (inches)	11.3
Bulk density of biomass (lb/ft^3)	7 to 8
Recovery of biomass (%)	73
Biomass Harvest rate (t/hr)	27

***** Adjusted for time waiting for trucks.

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