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Productivity and Nutritive Value of *Pistia stratiotes* and *Eichhornia crassipes*[1]

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INTRODUCTION

Recent research (10, 11) has shown the potential of the waterhyacinth (*Eichhornia crassipes* [Mart.] Solms) as a biomass source for methane production through anaerobic decomposition. The characteristics of this aquatic plant which make it applicable to large scale methane production are a high yearly average net productivity in certain geographic areas (4) and an adequate nutritive value relative to the requirements of the bacterial flora responsible for the conversion of plant biomass to methane. Preliminary investigations indicated that the water lettuce (*Pistia stratiotes* [L.]) may also have potential as a biomass source for methane production. Although abundant information on the productivity and nutritive value of the waterhyacinth is available (1, 4, 5), there is a paucity of similar information for water lettuce. Boyd (1) and Boyd and Blackburn (2) presented information on the nutritive value of both waterhyacinth and water lettuce collected at various sites in central and south Florida. However, the recognition of considerable intraspecific variation of aquatic plants from different sites (3) makes comparisons difficult. Furthermore, information on the productivity of water lettuce is lacking.

The present study is an evaluation of the productivity and quality of water lettuce cultured under conditions of constant nutrient availability and biweekly harvesting to a predetermined density. For comparison, waterhyacinth was cultured under the same conditions.

METHODS AND MATERIALS

Research was conducted at the aquaculture facility at Harbor Branch Foundation, near Fort Pierce, Florida. Waterhyacinths and water lettuce were obtained from cultures existing at the facility. Plants were cultured outdoors in a small (10,000 l, 30 m^2) PVC-lined pond receiving an inflow of a nutrient solution at two volume-turnovers per day. The composition (mg/l) of the inflowing solution was: NO_3-N, 1.4; PO_4-P, 0.3; K, 1.56; CA, 1.0; Mg, 0.16; S, 0.21; Fe, 0.13; Mn, 0.05; Zn, 0.05; B, 0.001; Cu, 0.001; Mo, 0.001.

Waterhyacinths and water lettuce were stocked to a density of 10 and 5 kg wet wt./m^2, respectively, into duplicate 1-m^2 vexar cages. These densities have been found to be near the optimum for maximum net productivity for the two species. At two week intervals beginning on November 27, 1979 and ending June 30, 1980, the cages were lifted from the water, allowed to drain of excess water for five minutes, weighed, and plants were removed to return cultures to the original density. A sample of two or three plants were weighed, dried at 80 C for 48 hours and reweighed to provide a ratio of dry weight to wet weight. Once each month an additional three plants were retained for analysis. These plants were thoroughly washed in deionized water, and dried for 48 hours at 80 C. After drying, plants were ground in a food blender to a fine powder and stored.

Ash values were obtained by igniting the plant material for four hours at 550 C. Total nitrogen was determined with a Perkin-Elmer Model 240 elemental analyzer. Lignin plus cellulose was estimated as acid-detergent fiber according to Van Soest (6). Acid-detergent fiber values were corrected for ash content and artifact lignin produced upon drying of the plant material (7).

RESULTS AND DISCUSSION

The average daily net productivities for the two species are presented in Figure 1. On a dry weight and ash-free dry weight basis waterhyacinth was more productive than water lettuce with average dry matter productivities for the study period being 19.3 and 14.2 g dry wt./m^2 per day, respectively. The study period did not extend through the summer months, normally the period of greatest growth for both species in this geographic area. However, it is evident that both species are unusually productive.

Water lettuce was lower in acid-detergent fiber (ADF) than waterhyacinths (Figure 2) and the fiber content of both species varied seasonally. Minimum values occurred during the periods of minimum growth and increased as growth rates increased in the spring. The increase in ADF content as productivity increases is evidently related to the requirement for structural tissue. As growth rates increase, plant growth is restricted more to a vertical direction as the 1-m^2 quadrat frames restricted horizontal growth. Waterhyacinths were small with swollen petioles in the winter, but were larger and much taller with reduced swelling of petioles in the spring. Changes in the morphology of water lettuce were less noticeable although individual plants were

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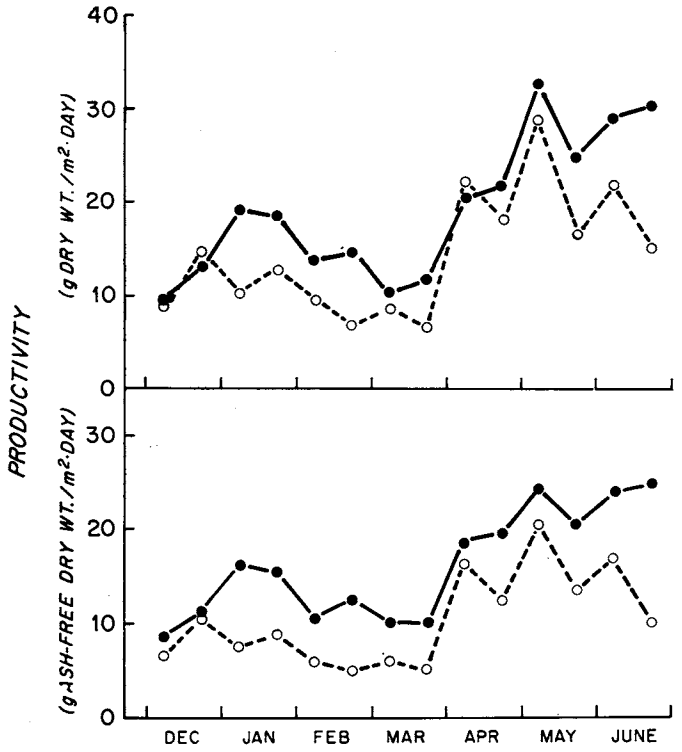

Figure 1. Dry matter and ash-free dry matter productivity of waterhyacinth (closed circles) and water lettuce (open circles). Each point is the average of the productivities in two 1-m² quadrants.

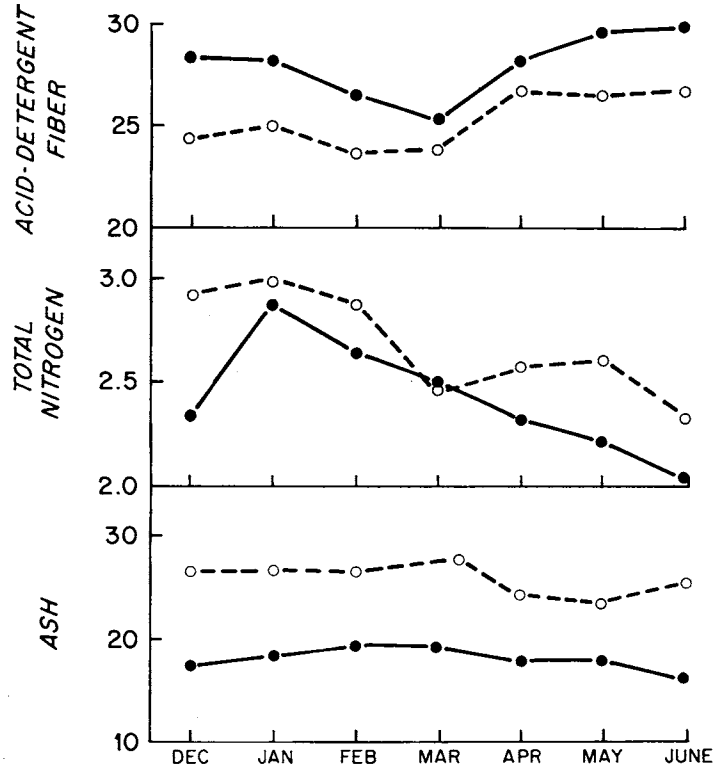

Figure 2. Acid-detergent fiber, total nitrogen and ash content of waterhyacinths (closed circles) and water lettuce (open circles). All values are expressed as percent of dry weight. Each point is the average of the analysis of two samples composited from three plants from each 1-m² quadrat.

somewhat larger in the spring compared to winter. Concommitant with these observations, the increase of ADF for waterhyacinths was greater (25.1% in March to 30.0% in June) when compared to water lettuce (23.8% in February to 26.5% in June).

Total nitrogen values (Figure 2) were generally higher for water lettuce than waterhyacinth. The greater nitrogen content of water lettuce is not related to differences in nutrient availability as plants were grown in the same pond under identical conditions. The greater growth rate of the waterhyacinth and the higher ADF content indicate that increased non-nitrogen containing dry matter production may tend to "dilute" nitrogen taken up by the plants. The average May productivity for waterhyacinth was 26.9 g dry wt./m², per day and the average nitrogen content was 2.22%, which meant that approximately 0.60 g N/m² per day was accrued by the plants. Water lettuce grew at an average of 23.4 g dry wt./m² per day with a nitrogen content of 2.60%, resulting in an accrual rate of 0.61 g N/m² per day. Thus, on an areal basis, assimilation of nitrogen was nearly equal and harvestable crude protein (% N x 6.25) was approximately the same per unit area.

Ash values were also higher for water lettuce, averaging 25.4% compared with 18.1% for waterhyacinth. No obvious seasonal trend in ash content was noticeable.

Boyd (1) collected samples of waterhyacinth and water lettuce from a number of sites in Florida and found waterhyacinth to have more protein and cellulose and less ash than water lettuce. Trends in fiber and ash content are the same as those in the present study. The higher crude protein content of waterhyacinth found by Boyd may be because plants were collected from different sites. Environmental nutrient levels can affect plant composition (3) and comparisons of plants from different sites may not indicate the actual potential of a particular species.

When grown under the same conditions, water lettuce appears to be of greater nutritive value than waterhyacinth. The lower ADF and higher nitrogen content indicate that water lettuce should decompose and produce methane at a faster rate than waterhyacinth. Preliminary studies at this facility indicate this to be the case, with water lettuce producing methane at a rate roughly 1.5 times faster than waterhyacinth on an equal volatile solids basis. However, waterhyacinth is a more productive plant on an ash-free dry matter basis and the ultimate volume of methane produced per unit area of plant stand over a given time period may be greater than with water lettuce.

LITERATURE CITED

1. Boyd, C. E. 1969. The nutritive value of three species of water weeds. Econ. Bot. 23:123-127.
2. Boyd, C. E. and R. D. Blackburn. 1970. Seasonal changes in the proximate composition of some common aquatic weeds. Hyacinth Contr. J. 8:42-44.
3. Boyd, C. E. and C. P. Goodyear. 1971. The nutritive quality of food in ecological systems. Arch. Hydrobiol. 69:256-270.
4. DeBusk, T. A., M. D. Hanisak, L. D. Williams, and J. H. Ryther. 1981. Effects of seasonality and plant density on the productivity of some freshwater macrophytes. Aquatic Bot. In press.
5. Knipling, E. G., S. H. West, and W. T. Haller. 1970. Growth characteristics, yield potential and nutritive content of waterhyacinths. Proc. Soil and Crop Sci. Soc. Florida. 30:51-63.

6. Van Soest, P. J. 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. Jour. Ass. ffic. Agr. Chem. 46:829-835.
7. Van Soest, P. J. 1965. Use of detergents in the analysis of fibrous feeds. III. Study of the effects of heating and drying on yield of fiber and lignin in forages. Jour. Ass. Offic. Agr. Chem. 48:785-790.
8. Van Soest, P. J. 1966. Nonnutritive residues: A system of analysis for the replacement of crude fiber. Jour. Ass. Offic. Agr. Chem. 49:546-551.
9. Van Soest, P. J. and R. H. Wine. 1967. Use of detergents in the analysis of fibrous feeds. IV. Determination of plant cell-wall constituents. Jour. Ass. Offic. Agr. Chem. 50:50-55.
10. Wolverton, B. C. and R. C. McDonald. 1975a. Application of vascular aquatic plants for pollution removal, energy and food production in biological systems. NASA Technical Mermorandum TM-X-72726.
11. Wolverton, B. C., R. C. McDonald and J. Gordon. 1975. Bioconversion of waterhyacinths into methane gas. NASA Technical Memorandum TM-X-72725.