Production of Waterhyacinths And Resulting Water Quality In Earthen Ponds[1]

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ABSTRACT

Waterhyacinths (*Eichhornia crassipes* (Mart.) Solms) were introduced into 0.04-ha earthen ponds to determine their response to various levels of inorganic fertilizer. The plants were confined within wooden rafts covering 11% of the surface area. Inorganic fertilizer was applied at rates of 0-0-0, 0-8-0, and 8-8-0 at N-P-K to the ponds to stimulate plant growth. Slight differences in pH, dissolved O_2, free CO_2, and water temperature were noted between open water and water directly under the mats within the roots when compared to ponds without waterhyacinths. Standing crops of waterhyacinth as wet weight upon draining were 174.5 metric tons per ha from the 0-0-0 treatment, 550.4 metric tons per ha from the 0-8-0 treatment, and 590.9 metric tons per ha from the 8-8-0 treatment.

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INTRODUCTION

Few studies have been carried out in which the production of waterhyacinth has been determined and measurements taken of the plant's effect on the water quality under natural or controlled conditions (King and Smith, 1947; Lynch *et al.* 1947; Penfound and Earle, 1948). Lynch *et al.* (1947) observed habitat conditions under a dense mat of waterhyacinth and in open water, and found that the former situation had a more uniform surface water temperature, lower pH, higher CO_2 tension, and a lower dissolved O_2 concentration. Penfound and Earle (1948) reported that pH of the water in bayous, canals, and ponds in the Mississippi River Delta was approximately 7.2 whereas the water in or near mats of hyacinths was usually acidic (pH 6.2-6.8). Lynch *et al.* (1947) observed the absence of oxygen directly under the roots of waterhyacinth and in open spaces between the mats, whereas low concentrations were recorded on the outer edge. This experiment was pursued to determine the effect of waterhyacinth on water quality and subsequent plant production in conjunction with fish culture (Wahlquist, 1970).

MATERIALS AND METHODS

This experiment was conducted at the Agricultural Experiment Station, Auburn University, Auburn, Alabama, from April 5 through November 20, 1967. Nine 0.04-ha ponds were stocked with waterhyacinths and nine ponds without plants served as controls. The waterhyacinths were confined within wooden rafts (46 m^2) covering 11.3% of the pond's total surface area (405 m^2). The waterhyacinth enclosures consisted of 2.54 by 15.24 cm pine boards nailed together to form a square (6.7 by 6.7 m). These enclosures were held stationary to the center of the pond by pine boards which were driven into the pond bottom and nailed to the raft. Each of nine rafts was filled on April 19-20, 1967 with approximately 1,400 waterhyacinths of uniform size collected from Lake Seminole, Georgia.

The effect of 0-0-0 and two fertilizer treatments of 0-8-0 and 8-8-0 was evaluated on plant growth and three ponds were assigned to each treatment. The ratios represent the weights of nitrogen (N), potassium (P), and phosphate (K), respectively, in the fertilizer. Nitrogen was provided is the form of ammonium nitrate (33.5%), and phosphate was provided in the form of triple super-phosphate (54%). Potassium was not added since adequate amounts were present in the water supply. The fertilizers were applied at the rate of 112 kg/ha (2.34 kg NH_4NO_3, 1.66 kg P_2O_5, and 0 kg K_2O). This procedure was followed at 2-week intervals from April 5 through May 19, 1967 for a total of 10 applications. When heavy plankton blooms occurred in several ponds during May, the interval between fertilizer applications was extended to four weeks.

Three samples of waterhyacinth per raft per month (0.55% surface area) were removed to sample for invertebrates. This removal was believed to have negligible effect on the final standing crop. On one occasion, when the plants grew over the sides of the wooden raft, they were cropped, weighed and discarded. These data were not added to the final weight upon draining. This procedure was discontinued, since by discarding cropped plants, nutrients were eliminated from the ponds. Thereafter, any plants overgrowing their frames were cropped, thrown back into the raft and allowed to decay.

To detect changes in water quality from the presence of water hyacinth, determinations for dissolved O_2, free CO_2, water temperature, and pH were made in each pond in June during the early phase of growth and again in September, after a season's growth. All determinations were made prior to sunrise during the critical period for dissolved O_2 and free CO_2 (Olson, 1932; Wiebe, 1934). Samples and readings were taken in the ponds at depths of 30.48 cm under the surface and 30.48 cm above the bottom under the middle of the raft. Samples were also taken at the same depths at a point 60.96 cm from the raft in open water, usually near the standing drain pipe where the water was deepest. Samples and readings were taken in ponds containing no waterhyacinth at the same depths but only near the standing drain pines. Water samples for total carbon analysis were taken in open water during August and September.

RESULTS AND DISCUSSION

Throughout the experiment, the waterhyacinths which were not fertilized remained small and the roots were stunted and clumped. Because of slow vegetative reproduction, these plants were dispersed within the raft and slight decay of floating parts and roots was observed. As the experiment progressed, waterhyacinths in ponds receiving 0-8-0 and 8-8-0 treatments grew. Upon sampling waterhyacinths in fertilized ponds, large amounts of decaying vegetative parts and roots were observed. Because of extensive vegetative reproduction, the plants were densely packed within the wooden frames and required periodic cropping. Chlorotic symptoms and variable growth in plants receiving 0-8-0 treatment could perhaps be attributed to the absence of nitrogen. A progressive increase in root length accompanied by reduced size of vegetative parts occurred from the edge to the center of the raft. This could represent a modification that resulted from competition for the limited 0-8-0 fertilizer or from nitrogen deficiency. From this experiment Lawrence and Mixon (1970) reported the following variable nitrogen levels as percent dry weight in the plants: 0-0-0 treatment (edge 1.09, middle 0.78), 0-8-0 treatment (edge 0.66, middle 0.88), and 8-8-0 treatment (edge 1.01, middle 0.70).

Although the abundance of plankton was not determined, observations on the color of the pond water showed that the ponds without waterhyacinth receiving fertilizer had rich plankton blooms (dark green) while the ponds with waterhyacinth receiving fertilizer had poor plankton blooms (light green to clear). The reduced production of plankton in hyacinth ponds was probably a result of competition for fertilizer between the waterhyacinths and phytoplankton.

June sampling showed that there was little difference in mean pH for ponds with waterhyacinths in either open water (6.0 to 6.8) or under the roots (5.4 to 6.8). The mean pH in ponds without waterhyacinths varied from 7.6 to 8.5. Free CO_2 was slightly higher at a depth of 30.48 cm under the waterhyacinth raft in the roots (7.6 to 9.8 ppm) than at the bottom under the raft (5.2 to 5.7 ppm), or in open water of waterhyacinth ponds receiving fertilizers (0.2 to 0.7 ppm). The higher free CO_2 readings in the water around the roots could be attributed to the plant respiration and lack of photosynthesis prior to sunrise. In ponds without waterhyacinth, free CO_2 concentration was less than 3 ppm. The mean dissolved O_2 concentration was similar in both ponds with or without water hyacinths (7.1 to 9.1 ppm). Water temperature varied slightly in all ponds (27.9 to 28.9 C). Overcast weather occurring during the sampling period and the cold rain of the previous evening might have caused enough water mixing to dissipate any temperature or O_2 stratification caused by the presence of waterhyacinths.

A cold front had passed through the Auburn area during the night previous to the September sampling period, and an air temperature of 8.0 C was recorded. The mean pH under the waterhyacinth roots varied from 5.6 to 7.2 while open water and bottom values varied from 6.0 to 7.2. Mean free CO_2 readings varied considerably under the roots of fertilized waterhyacinth (5.8 to 13.7 ppm) were very low (less than 2.0 ppm) in ponds with unfertilized water hyacinths. Mean dissolved O_2 concentrations under the water hyacinth roots (6.9 to 9.6 ppm) were similar to open water readings (8.9 to 9.7 ppm). King and Smith (1947) recorded much lower dissolved O_2 concentrations (non-measurable to 1.66 ppm) and much higher free CO_2 concentrations (greater than 14 ppm) in small ponds filled with waterhyacinth.

TABLE 1. ESTIMATED FINAL STANDING OF CROPS OF WATERHYACINTH

Fertilizer treatment	Wet weight (Kg)[a]	(Metric tons Wet weight per ha)
0-0-0	791.3	174.5
0-8-0	2,479.3	550.4
8-8-0	2,661.3	590.9

[a]Average of three ponds.

Carbon analyses indicated slight variation in total productivity between ponds with and without waterhyacinth. Mean readings for both months were slightly higher in ponds without waterhyacinth (9.7 to 12.5 ppm) than in ponds containing the plants (8.2 to 9.7 ppm).

The pH of the pond waters in the experiment was within the desirable range for the growth of waterhyacinths (Berg, 1960; Obied and Chadwick, 1964; and Chadwick and Obeid, 1966). Data presented in this study indicate that the plants did not create water quality parameters that were detrimental to the fish. Since waterhyacinth mats were managed within confined areas, wind and wave action resulted in mixing of pond water and produced satisfactory water quality for the maintenance of fish populations in shallow ponds.

Upon termination of the experiment, actual wet weights for control ponds and estimated wet weights for fertilized plants were obtained (Table 1).

Analysis of variance showed that the response of waterhyacinth standing crop to fertilization was statistically significant ($P < .055$). The standing crops were highest in 8-8-0 fertilized ponds followed by 0-8-0 and 0-0-0 treated plants. Duncan's multiple range test revealed that no significant difference existed between standing crops for 8-8-0 and 0-8-0 treated plants at the 5% level. However the standing crop of 0-0-0 treated plants differed significantly from both 8-8-0 and 0-8-0 plants at the 5% level.

Penfound and Earle (1948) reported a maximum estimated standing crop of 413.5 metric tons per ha during October 1945 for medium-sized plants near New Orleans, Louisiana. Their estimates were based on a sample of 0.15 m^2 compared to a sample of 3 m^2 in this experiment. Projecting the results of this experiment to wet weight in metric tons per ha would result in values 174.5 (0-0-0 treatment), 550.4 (0-8-0 treatment) and 590.9 (8-8-0 treatment). Comparing the extensive growth of waterhyacinth with their nutrient uptake (Denton, 1966; Lawrence, 1968), methods could be devised where quantities of waterhyacinth might be added to eutrophic waters and subsequently harvested to help alleviate the pollution problems.

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