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FISH PRODUCTION AS RELATED TO SOIL CHEMICAL CONSTITUENTS

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ABSTRACT

Catfish production varied 40 per cent among 12 ponds in a uniformity test. Survival, spawning, and trash fish made no significant contribution to this variation. Production was directly related to the amount of certain constituents found in the pond soils, namely, exchangable calcium, electrical conductivity, magnesium content of soil — water (1:2.5) extracts, and nitrate nitrogen.

INTRODUCTION

Variations in responses of fish to certain treatments are of universal occurrence. These variations are caused largely by the huge dependence of fishes on their constantly varying environment. Inherent productive capacities of ponds may account for other variations and, if so, may be related to one or more constituents found in the bottom soil.

The purpose of this study was to determine the magnitude of differences in production of ponds and to relate production to chemical constituents found in the bottom soil.

METHODS

Each of 12 one-tenth acre ponds were stocked on April 5, 1967, with 15 channel catfish (age group II) having a total weight of 10 pounds. The ponds, constructed on soil classified as Crowley slit loam, had remained dry during the preceding winter and were situated in 2 adjacent rows of 6 ponds each. Prior to flooding, soil samples were taken for analyses. Water for the ponds was screened with saran to prevent entry of trash fish. No feed or fertilizer was added to the ponds but a herbicide was used for control of filamentous algae. The fish were harvested after a 196-day growing season.

"Soil Test Values" were obtained for the soil samples by the University of Arkansas Soils Testing Laboratory, Fayetteville, Arkansas. These analyses consisted of pH, organic matter, electrical conductivity, and extractable or available nutrients.

Water soluble constituents were determined on samples at the Fish Farming Experimental Station by analyzing soil: deionized water extracts (1:2.5). Analyses were made on the extracts after being filtered through a Whatman No. 42 filter paper. Potentiometric methods were used for analyses of alkalinity and pH. Calcium and magnesium were determined complexometrically and phosphorus by the phosphomolybdate method.

Phosphorus and nitrogen determinations were made on the soil itself by methods in Black(1965), section 73 – 3.1 for phosphorus and section 84 – 3.5 for nitrogen. Ten ml of deionized water was substituted for 10 ml of 2N KCL in the nitrogen analyses.

Soil samples were air-dried, screened and pulverized before analysis.

RESULTS

Yield data indicate that ponds differ greatly in their production (Table 1). Total weight of stocked catfish that were recovered from each pond ranged from about 10 to nearly 23 pounds, with average weights from 0.72 to 1.63 pounds. This amounts to about a 40 per cent variation about the mean.

In this test, 100 per cent survival was not obtained. Trash fish were present even through incoming water was filtered, and spawning occurred in three of the twelve ponds; any one of these factors could influence production.

TABLE 1.
Yield data from a uniformity test of fish ponds.

	Stocked catfish recovered			*Other fish harvested*		
Pond	*Total Weight*	*Number*	*Avg. wt. (Variance)*	*Catfish Fingerlings*	*Trash Fish*	*Total Production*[1]
	Pounds		Pounds	Pounds	Pounds	Pounds
A1	21.35	15	1.42 (0.04)	0	0	21.35
A2	17.60	15	1.17 (0.06)	9.05	0	26.65
A3	12.70	14	0.91 (0.03)	2.70	2.40	17.80
A4	13.80	15	0.92 (0.02)	0	7.45	21.25
A5	13.90	15	0.93 (0.02)	0	5.90	19.80
A6	15.45	14	1.10 (0.03)	0	5.25	20.70
B1	9.35	13	0.72 (0.06)	3.10	0.40	12.85
B2	16.20	13	1.25 (0.06)	0	5.05	21.25
B3	17.50	15	1.17 (0.02)	0	22.50	40.00
B4	22.75	14	1.63 (0.07)	0	0	22.75
B5	13.15	13	1.01 (0.04)	0	19.55	32.70
B6	19.55	12	1.63 (0.04)	0	3.60	23.15

[1]Stocked catfish recovered + fingerlings + trash fish.

Each of the yield factors were correlated against the other and results are presented in Table 2. The only significant correlation was that between average weight and total pounds of catfish recovered. Evidently the other yield factors did not contribute significantly to the variation in production of catfish among the ponds.

Fish production was significantly related to certain soil test values as shown in Table 3. Correlation coefficients for exchangeable calcium and electrical conductivity were both significant when each was related to production. As the amount of either increased in soil, so did fish production. The conductivity relationship suggests water soluble components are involved. These can be examined by analysis of water extracts. Magnesium content was the only water soluble component of the extracts that was significant. Neither calcium or electrical conductivity was.

The method of analysis for soil nitrogen may be considered a measure of the water soluble nitrogen, mainly nitrate. As the water soluble nitrate nitrogen in soil increased so did production. This was the most significant correlation found among soil constituents.

TABLE 2.
Correlation coefficients of yield data

	Recovery	*Avg. wt., lb.*	*Fingerlings + trash*	*Total production*[1]
Stocked catfish, lb.	0.143	0.941*[2]	-0.177	0.298
Number recovered		-0.191	0.153	0.196
Avg. Wt. Catfish, lb.			-0.218	0.233
Fingerlings + trash				-0.263

[1]Stocked catfish + fingerlings + trash fish.

[2]Significant at the 1 per cent level of probability.

TABLE 3.
Average amount and range of certain soil constituents in twelve ponds and the correlation coefficients of each with the total poundage of stocked catfish recovered from the ponds

Constituent	*Amount*	*Range*	*r value*
Soil test values:			
Organic matter, %	1.2	0.9 - 1.4	0.293
pH	7.2	6.7 - 7.4	.364
Mn - lbs / acre	329	196 - 386	-.049
P - lbs / acre	13	8 - 20	.551
K - lbs / acre	330	255 - 440	.147
Ca - lbs / acre	5233	4200 - 7000	.676[1]
Na - lbs / acre	256	230 - 310	-.039
Mg - lbs / acre	710	545 - 920	.199
Fe - lbs / acre	355	220 - 411	.484
EC x 10^3	0.49	0.36 - 0.75	0.700[1]
Water extracts:			
Alkalinity, ppm as $CaCO_3$	67	16 - 89	0.069
PH	7.6	6.8 - 7.8	.024
EC x 10^3	0.37	0.27 - 0.64	.542
Ca, ppm	47	26 - 90	.501
Mg, ppm	13	6 - 23	.602[1]
P, ppm	none detected		
Ammonia - nitrogen mg/ 100 g	3.62	1.72 - 4.97	0.184
Nitrate - nitrogen mg/ 100 g	0.71	0.10 - 1.92	.765[2]
Inorganic phosphorus mg/ 100 g	66	40 - 89	.302
Organic phosphorus mg/ 100 g	14	5 - 28	-0.066

[1]Significant at the 5% level.

[2]Significant at the 1% level.

DISCUSSION

The results presented are from a uniformity test of fish ponds. The ponds were of the same size, shape, depth, age, constructed on the same soil type and in close proximity. Production differences were correlated with soil test values of extractable calcium and electrical conductivity, also, with water soluble magnesium and nitrate nitrogen content of the pond soils. The cause and effect of these associations were not studied.

Availability indexes for plant nutrients have been used for years in recommending fertilization programs for agricultural crops. It is foreseeable that indices could also be determined for fish crops. To a certain extent this is being done today. The addition of lime to ponds has been used for some time to increase production. This follows the correlation found here with calcium and magnesium, both of which may be components of lime. Production often increases in ponds which remained dry for a season. This observation may be explained in part by the soil component found here to be most significantly correlated with production – nitrate nitrogen. Flooding of a soil brings about an accumulation of ammonia nitrogen that is released from soil organic matter and organic accumulations on pond bottoms. When ponds are drained and the soil becomes dry and aerated, ammonia nitrogen is converted to nitrate. The drying process also renders certain types of organic matter more susceptible to decomposition with subsequent release of nitrogen. All these factors increase the nitrate available in the soil.

There is a tendency for agricultural field plots to yield in a similar relative order from year to year. Why should this not be true of fish ponds? In fact, fish culturists claim that they can depend on one certain pond to produce better than another. This tendency of differences in yield or production to be permanent is often overlooked in experimental work. It would be unwise to conclude that factor "A" outproduced factor "B" unless the differences found were greater than those which might be expected from differences in the inherent productive capacities of the ponds. The time required for determining the uniformity of fish ponds is often prohibitive but may be alieviated by resorting to a soil test procedure. Testing for nitrate nitrogen is suggested from the preceeding results.

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POLYETHYLENE TUBES FOR STUDIES OF FERTILIZATION AND PRODUCTIVITY

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ABSTRACT

The purposes of this study were (1) to determine the feasibility of using isolated columns of water as an efficient way to obtain a natural series of similar bodies of water that are subject to identical climatic and environmental conditions, and (2) to determine the effect of fertilization and the fertilization rate that will give optimum and/or maximum phytoplankton production.

Twelve open-ended transparent polyethylene tubes 4' in diameter and 9' in length, were used to isolate vertical "transects" of water in the study pond. Measurements of oxygen, pH, water temperature, and turbidity were made to determine any physical or chemical changes which may have been attributable to the tubes.

The affect of fertilization was studied by applying three rates of single analysis of commercial fertilizer to the test tubes. The three experimental rates chosen were equivalent to 50, 100, and 150 pounds of 20-20-5 analysis fertilizer per surface acre of water. The C^{14} method of Goldman and Wetzel (1963) was used to determine the rate of carbon uptake by the phytoplankton.

The data revealed that the physical and chemical characteristics of the water within the tubes did not vary appreciably among the tubes or between the tubes and the open lake water. These uniform conditions prevailed within the test tubes for sufficient time to allow comparison of fertilized tests.

Of the three seasonal fertilization tests made, the response to the added nutrients was greatest in the spring. The highest carbon assimilation rate (300.1 mg C/m^3 per hour) occurred one week after fertilization in water fertilized at the 100 pounds per