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CULTURING DAPHNIA FOR FISH FOOD

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This report has been prepared, under date of October 26, 1933, to answer general requests for information on this subject.

The use of fertilizers in the production of pond fishes is an old although not very extensive practice. Experiments have been carried out in Europe which indicate increases of 20 to 200% ~~increase~~ in carp production of fertilized ponds over unfertilized ponds. Within the last few years considerable investigations have been carried out by American workers and results have been very gratifying to fish culturists. The basic principle of pond fertilization for increase in fish production is the introduction of compounds of potassium, phosphorus and nitrogen into the water. The growth of plant and animal plankton, the main source of food for young fishes, depends upon the amount of these substances present.

Of the above three fertilizer constituents, phosphorus usually occurs in the smallest amounts in natural waters and being used up first is often the limiting factor in plankton production. Fertilizing ponds with phosphorus alone has given increase in production while fertilization with potassium or nitrogen alone fail in this respect. Superphosphate of lime is the most commonly used source

of phosphorus. However complete fertilization, using fertilizers containing all three of the above substances, gives the best results. Following are the results of some of the prominent investigators on the use of fertilizers in plankton production.

There are three general methods of procedure in Daphnia culture: (1) culturing the plankton in the bass rearing ponds; (2) culturing it in separate ponds which feed by gravity into the bass ponds; (3) culturing the Daphnia and other form in separate ponds, from which they are netted out and fed to the bass periodically.

RESULTS OF USING FERTILIZERS IN BASS REARING PONDS

Davis and Wiebe (1930) report on experiments at the Fairport, Iowa Station of the Bureau of Fisheries. They found the plankton production with various kinds of fertilizers to be as follows:

Fertilizer	Plankton per liter
Superphosphate and sheep manure (mixed 1 to 1)	484.11
Soybean meal	1812.21
Shrimp bran	621.4
Sheep manure	660.4
Control (no fertilizer)	265.72

Adding the fertilizers in small amounts at short intervals give better results than dumping the entire seasons fertilizer into the pond at one time, since loss through seepage may be greater if it all is added at once and also an excessive amount of decaying organic matter may deplete the oxygen or produce toxic chemical effects. The constituents of the fertilizers should be weighed and mixed in proper proportions. Small amounts of fertilizers should be scattered over the shallow margins of the pond, at intervals of about 10 days during the spring and early summer. Of a 3 to 1 mixture of sheep manure and superphosphate, 500 to 700 lbs. per acre has been found satisfactory; of soybean meal about 575 to 700 lbs. per acre. In ponds where the bottom soil is infertile up to a thousand lbs. per acre may be used.

Embody has found the use of 1½ tons of horse manure to the acre, added 3 weeks before the introduction of young fish, satisfactory, Relative to the coarse pond weeds, he recommends that they be entirely removed, if possible, from ponds where fertilizers are to be used.

Haempel, in using partial fertilization with superphosphate alone, found the use of 267 to 400 lbs. to the acre satisfactory; in using this he divided the amount in three lots adding the first lot early in the spring after the pond had been filled and the other two lots at following intervals of 4 weeks.

Juday in fertilizing natural lakes in Wisconsin with superphosphate anchored a perforated box full of the fertilizer in the middle of the lake, allowing the box to float just below the surface. In this way the material was constantly being dissolved and circulated through the pond, and a whole summer's dosage was put in at one time. This method would seem superior for bass ponds, in which the plankton is being produced.

RESULTS OF USING FERTILIZERS IN SMALL DAPHNIA REARING PONDS

Hayford (1927) reported on experiences at the Hackettstown, New Jersey, Station in culturing Daphnia magna in concrete ponds 5 ft. X 30 ft. X 2 ft. For fertilizer he used 20 quarts of solid green cow manure, mixed in an ash can of water adding four quarts of menhaden meal and four quarts of soybean meal. By seining out Daphnia with a fine cloth seine and feeding periodically to bass in rearing pond he obtained a production of 26000 two-inch small-

mouth bass in a pond 1/3 of an acre.

Langlois in Ohio used concrete ponds 30 ft. X 6 ft. X 2 ft., having a depth of water of 1 ft. To a volume of 100 cubic feet of water he used a mixture of 6 qts. of sheep manure and 1 qt. of superphosphate. A culture may last from 6 to 8 weeks by periodically adding more fertilizer; after that time it is best to drain out the tank and start a new culture. A few boards floated on the water to provide shade giving better results, since excessive ? from the sun will destroy Daphnia cultures.

Wiebe (1929 and 1930) at the Fairport, Iowa, Station used concrete ponds 50 ft. X 8 ft. with a volume of water of about 530 cubic feet, and depth of water 14" to 20". Following are the amounts of the various kinds of fertilizers which he used:

Pond	Kind of fertilizer	Amount used in pond	Calculated am't per acre
1	Superphosphate of lime	3 lbs.	345 lbs.
2	Mixture of: soybean meal	11 lbs.	1267 lbs.
	and superphosphate	5 oz.	36 lbs.
3	Shrimp bran	11 lbs.	1267 lbs.
4	Sheep manure	11 lbs.	1267 lbs.
5	No fertilizer (control)		

Chemical analysis of: soybean meal: phosphorus 1.2%, nitrogen (exclusive of nitrate nitrogen) 24%, and total organic matter 60.9%.

shrimp bran: total phosphorus 1.9%, total nitrogen exclusive of nitrate nitrogen) 7.1%, and total organic matter 52.6%.

The superphosphate is the 16% acid phosphate of commerce.

In all of his experiment, Wiebe found that fertilized ponds gave a plankton production greater than the unfertilized pond. He finds that soybean meal and shrimp bran, which in addition to containing phosphorus also contain large amounts of nitrogen, give better results than superphosphate which contains mostly phosphorus.

However other workers have obtained better results with superphosphate than with soybean meal or shrimp bran. The amount of natural organic material in the water and in the bottom of the pond and the kind of this material must vary greatly in different localities, thus the results of fertilizers would vary in different localities.

Following is a short section from a letter which I recently received from Dr. G. C. Embody, prominent fish-culturist at Cornell University, relative to pond fertilization:

"Daphnia magna seems to be the most promising form for culture in Central New York. Cultures may be produced at any time from May to October either in dirt or concrete lined ponds providing water temperatures do not exceed about 80 degrees F., and natural enemies are kept in check. From three to four weeks (at Ithaca) are required to bring a culture to its peak. It then seems more economical to use the culture immediately and start a new one, than to try to prolong the old culture. Fresh cow manure has produced the densest culture todate, followed closely by finely ground soy bean meal. In the case of dirt ponds supplied by neutral or slightly acid water the addition of lime stone increases the

density of the culture. One cubic foot of fresh cow manure for every 100 cu. feet of water in the propagating pond is about the maximum dose for a three weeks period. This applies to special Daphnia propagating ponds and not to bass rearing ponds. It is possible to obtain much denser cultures of Daphnia in these special propagating ponds than is the case in bass rearing ponds because in the former a much heavier dose of fertilizer may be used."

Paul R. Needham, in a report at the last American Fisheries Socieby meeting (1933), discussed the principles of Daphnia culture. The reasons for great production are ~~as~~: (1) short generations (4 to 7 days), (2) large number of young; (3) parthenogenetic production in the summer (all adults bearing young). As cultures grow stale, males and winter-egg bearing females are produced. (The winter eggs must be frozen before hatching). When this occurs, it is best to feed out the pond and start a new culture. The winter eggs may be recognized as blackish spheres in the body. The alkalinity of the water is important.

Krull in experiments in Michigan found the best production of Daphnia to take place in rather alkaline water (pH above 7.7, best about 8.0 or 8.2). The hydrogen ion concentration (pH) can be tested rather simply, but requires special chemicals and apparatus.

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