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Responsibility

Chemical fertilizers in pond aquaculture

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Producers must balance the benefits with risks of overuse

An expensive resource, fertilizers should be used conservatively.

Fertilizers frequently are used in pond aquaculture to stimulate phytoplankton productivity and enhance the availability of natural food organisms. Turbidity created by the phytoplankton also shades pond bottoms to discourage the growth of aquatic weeds.

Fertilizers are a valuable and expensive resource that should be used wisely and conservatively. Excess use of fertilizer is wasteful, encourages an overabundance of phytoplankton, and increases the concentrations of nutrients in aquaculture effluents.

Nutritive elements

Plants require nutritive elements that include oxygen, hydrogen, carbon, phosphorus, nitrogen, sulfur, calcium, magnesium, potassium, sodium, iron, manganese, zinc, and copper. Some species also may need boron, cobalt, molybdenum, and other trace elements.

In most soils, it is only necessary to apply nitrogen, phosphorus, and potassium to promote plant growth. These three nutrients are called primary nutrients in fertilizers. In aquaculture ponds, potassium fertilization usually is not necessary, so nitrogen and phosphorus are the most important nutrients.

Common fertilizers

The two most common fertilizers used worldwide in aquaculture are triple superphosphate (TSP) and urea. TSP is made by treating rock phosphate with phosphoric acid. Urea is made by reacting ammonia and carbon dioxide. Other common fertilizers used in agriculture and aquaculture are listed in Table 1.

Boyd, Approximate grades of common commercial fertilizers, Table 1

Fertilizer	Primary Nutrients (%) N	Primary Nutrients (%) P_2O_5	Primary Nutrients (%) K_2O
Urea	45	0	0
Calcium nitrate	15	0	0
Sodium nitrate	16	0	0
Ammonium nitrate	33-35	0	0
Phosphoric acid	20-21	0	0
Phosphoric acid	0	52-60	0
Ammonium polyphosphate	10-13	30-38	0
Superphosphate	0	18-20	0
Triple superphosphate	0	44-54	0
Monoammonium phosphate	11	48	0
Diammonium phosphate	18	48	0
Potassium phosphate	0	52	34
Calcium metaphosphate	0	62-64	0
Potassium nitrate	13	0	44
Potassium sulfate	0	0	50
Muriate of potash	0	0	60

Table 1. Approximate grades of common commercial fertilizers.

Muriate of potash and sodium nitrate are extracted from ores. The other materials are made from the raw materials of rock phosphate and ammonia. Rock phosphate is a phosphate-bearing mineral, but ammonia is made industrially by reacting atmospheric nitrogen with hydrogen. Most fertilizers are packed in bags and sold as dry granules or prills, but ammonium polyphosphate and phosphoric acid are liquids.

In fertilizers, nitrogen is present as urea, ammonium, or nitrate. Phosphorus occurs as orthophosphate or polyphosphate, while potassium appears in its ionic form. Fertilizers dissolve in water to release their nutrients. Urea begins to hydrolyze at once and is completely transformed to ammonia and carbon dioxide within hours or days. Polyphosphate also quickly hydrolyzes to orthophosphate.

Fertilizer grades

The grade of a fertilizer usually is reported as percentages of nitrogen (N), phosphorus oxide (P_2O_5), and potassium oxide (K_2O). Thus, triple superphosphate usually is a 0-46-0 fertilizer, diammonium phosphate is a 18-48-0 fertilizer, and urea is a 45-0-0 fertilizer. Table 1 shows the approximate grades of common commercial fertilizers. Notice that some primary fertilizer sources contain one primary nutrient, such as urea or triple superphosphate, while others contain two primary nutrients like diammonium phosphate and potassium phosphate.

Fertilizer nutrient content is sometimes reported in elemental form, i.e., nitrogen, phosphorus (P), and potassium (K). The factor for converting P_2O_5 to P is 0.437, while the factor for converting K_2O to K is 0.83. For example, triple superphosphate usually is about 46 percent P_2O_5. The P content is 46 percent P_2O_5 x 0.437 = 20.1 percent P. The P percentage can be converted to P_2O_5 by dividing the P content by 0.437.

Mixed fertilizers

A mixed fertilizer is made by blending two or more primary fertilizer sources to provide two or three primary nutrients. For example, a popular fish pond fertilizer used inthe United States has a grade of 20-20-5. It can be made byblending several combinations of fertilizer sources, one ofwhich is urea, triple superphosphate, and muriate of potash(MP). A 100-kg quantity would contain 20 kg each of Nand P_2O_5, and 5 kg K_2O, and could be made as follows:

20 kg N ÷ 0.45 kg N/kg urea = 44.4 kg urea
20 kg P_2O_5 ÷ 0.46 kg P_2O_5/kg TSP = 43.5 kg TSP
5 kg K_2O ÷ 0.6 kg K_2O/kg MP = 8.3 kg MP
Total nutrient sources = 96.2 kg

The nutrient sources do not add up to 100 kg, so a fillersuch as agricultural limestone must be added:

Nutrient sources	**96.2 kg**
Filler	**3.8 kg**
Mixed 20-20-5 fertilizer	**100.0 kg**

Mixed fertilizers representing a wide range of grades can be purchased in some nations.

Secondary nutrients

Sometimes fertilizers are supplemented with the secondary nutrients calcium, magnesium, and sulfur. The usual sources of these elements are calcium and magnesium sulfates. Supplements of trace elements, iron, manganese, zinc, copper, boron, and others may also be added to fertilizers.

Metallic trace elements should be chelated to enhance solubility and availability to phytoplankton. Trace elements combined with citric acid, ethylenediaminetetraacetic-acid (EDTA), or other chelating agents can be added, but inclusion of chelated trace metals increases fertilizer costs appreciably.

Liquid fertilizers

Fertilizer granules or prills are water-soluble but settle to the pond bottom before completely dissolving. Much of their phosphorus can be adsorbed by the bottom soil instead of dissolving in the water. This problem can be lessened by using liquid fertilizers.

Liquid fertilizers are denser than water and should be diluted 1:10 with pond water and splashed over pond surfaces or released into the propeller wash of an outboard motor while a boat is driven over the pond surface. If liquid fertilizers are not available or considered too expensive, granular or prilled fertilizers can be placed in 10-20 times their volume of pond water, predissolved by vigorous stirring, and splashed over the water surface.

Application rates

Application rates for N and P_2O_5 are usually 2-10 kilograms per hectare per application. Many farmers apply excessive nitrogen, however. I recommend applications of 2 kg N per hectare and 8 kg P_2O_5 per hectare for freshwater ponds, and 8 kilogram per hectare each for N and P_2O_5 in ponds filled with brackish water or seawater.

Fertilizer may need to be applied at intervals of two to four weeks to maintain phytoplankton blooms. However, more frequent applications may be necessary to initiate blooms. In ponds with feed applications, nutrients enter the water from feed wastes, and applications of fertilizers often are unnecessary or only necessary until feeding rates reach 15-20 kilograms per hectare per day.

Once blooms have been initiated, fertilizer can be applied according to need as judged by Secchi disk visibility. A Secchi disk visibility of 25-40 cm usually is considered adequate. As an example, the following scale can be used where normal application rates are 2 kg N per hectare and 8 kg P_2O_5 per hectare.

Boyd, Table 2

Secchi Disk Visibility (cm)	Application Rate (kg/ha) N	Application Rate (kg/ha) P_2O_5
25 or less	0	0
26-30	0.5	2
31-35	1.0	4
36-40	1.5	6
More than 40	2	8

Table 2

Most fish and shrimp farmers do not use mixed fertilizers, but purchase primary fertilizer sources. The application rates of urea (45 percent) and triple superphosphate (46 percent P_2O_5) necessary to provide 2 kilograms per hectare N and 8 kilograms per hectare P_2O_5 can be estimated as follows:

$$\textbf{2 kg N/ha} \div \textbf{0.45 kg N/kg urea = 4.44 kg urea/ha}$$
$$\textbf{8 kg } P_2O_5\textbf{/ha} \div \textbf{0.46 kg } P_2O_5\textbf{/kg TSP = 17.4 kg TSP/ha}$$

Of course, if a mixed fertilizer is used as an alternative to urea and triple superphosphate in the example above, it should have a ratio of 1 N:4 P_2O_5. This could be achieved with a 5-20-0 fertilizer or 8-32-0 fertilizer.

Diammonium phosphate and monoammonium phosphate are good fertilizers for freshwater, because they have N:P_2O_5 ratios of about 1:3 and 1:4, respectively. For brackish water or seawater, a fertilizer with a 1:1 N:P_2O_5 ratio is best, and a mixed fertilizer with a 20-20-0 grade is a good choice.

In brackish ponds used for shrimp culture, many farmers want to encourage diatom growth. This can be done by applying nitrogen fertilizers weekly at 2-3 kg N per hectare. Nitrate is especially efficient in promoting diatoms, and sodium nitrate can be used as a diatom-promoting fertilizer.

Fertilizers containing ammonium or urea are potentially acidic because nitrifying bacteria in water can oxidize ammonia to nitrate and yield hydrogen ions as shown in the following equation for ammonium sulfate:

$$(NH_4)_2SO_4 + 4O_2 \xrightarrow[\text{Nitrifying bacteria}]{} 2NO_3 + 4H^+ + 2H_2O + SO_4^{2-}$$

The hydrogen ions react in water to decrease total alkalinityand pH. The adverse influence of nitrification on alkalinityand pH can be counteracted by routine applicationsof agricultural limestone to ponds where alkalinity is naturallylow. In brackish water, seawater, and freshwater withalkalinity above 50 milligram per liter, acidity from nitrogen fertilizersusually is not a problem.

Storage

Fertilizers should be stored in a dry place to prevent caking. Since nitrate fertilizers are strong oxidants and explosive, they should not be stored near oil products or where sparks occur. Environment spills should be avoided to prevent toxicity to aquatic life and nutrient pollution.

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