EFFECTIVE AQUATIC WEED CONTROL ENTAILS MIXING MANAGEMENT TOOLS

By John Kerr, Assistant Editor

Even though the U.S. Department of Agriculture does not define the aquatic weed manager's work as integrated pest management (IPM), the term well describes the approach of the aquatic weed manager. Integrating diverse methods of control as opposed to a rifle approach with only one method has been the weed manager's tact long before the government coined it this way. He has gathered information about plants and their life cycles; identified natural predators and their characteristics; and discovered their vulnerability to various chemicals and breeding sites. Pursuing chemical, biological, mechanical, and cultural fronts against aquatic weeds has been not just the most effective way but the only way of control.

"When the notion of integrated control came out several years ago, there was talk of putting one method together with another to double control, smothering the weeds," says Louis Decell, manager of the aquatic plant control research program for the U.S. Army Corps of Engineers. "Now we are doing a better job of management. If you use an integrative program with different means, you get a synergistic approach to control."

Leon Bates, a biologist for the Tennessee Valley Authority, says, "The new trend, the necessary trend is integrating methods of control. These weeds are so efficient in reproducing, one means is not enough. Also, environmental compatibility is important and will require an integrated approach."

Chemicals still provide the most popular control for aquatic weeds. Herbicides are usually inexpensive, easy to use, and regularly successful. Although there is a constant influx of new materials on the market, most are variations of four major active ingredients or several minor ingredients. According to Dr. Alva Burkhalter, bureau chief of aquatic plant research and control for the Florida Dept. of Natural Resources, the four basic kinds of aquatic compounds include 2,4-D, copper compounds, endothall, and diquat. He lists minor ingredients as Amitrol, dalapon, dicholobenil, Fenac, simazine, Roundup, Diuron, Banvel, Ammate, and aeromatic oils.

Many variables exist for comparing the major ingredients. Labels should be closely read for uses and restrictions. Burkhalter cautions the applicator to look particularly at the active ingredients, because manufacturers of different formulations may attempt to sell a weak product at a cheap price. The charts (p. 17, 18) explain Burkhalter's compilation of major and minor herbicide ingredients, their uses, and limitations. However, use and restriction in one state may totally differ from that of another because of regulatory agencies.

Since 1963, biologists have been studying the white amur, a species of grass carp imported from China, and its ability to control weed spread. Only five states — Florida, Missouri, Arizona, Iowa, and Kansas — have laws that allow its use and those on a limited basis. States have made it illegal to import because of fear it will overpopulate waters of fish indigenous to the area.

Last year, study began on a hybrid carp, called the "triploid." This fish is a hybrid between the female grass carp from China and the male big head carp from Siberia. It contains 72 chromosomes compared to a normal 48 in the white amur. But more importantly, data from Hungary, where the fish was originally produced, shows that it is sterile. This could make it very attractive to states worrying about infestation of the white amur.

Jim Malone, owner of Jim M. Malone & Son Enterprises in Lonoke, Arkansas, developed the first triploid in the United States. He expects to sell the fish in Florida this year and has recently sent some to California for experiments. The triploid should be sterile 99 times out of 100 and be an excellent weed eater, Malone says. "If the triploid proves a success comparable to the white amur, it's predictable the Florida Game and Fish Commission will use it against native plants as well as exotics without a barrier restriction."

Tom Jackson of the Fish and Game Commission in Denver has also been studying the triploid and is enthusiastic about its potential in the west, where there are more than 20,000 square miles of water surface in 17 states. Much of this water lies in irrigation canals, which often have restrictions on herbicide use. "I'd like to substitute the carp for herbicides," Jackson says. His office has researched fluridone (Sonar), which shows promise for controlling hydrilla and other plants without harming fish. Yet it is his opinion that "The long term prospect for chemical control is that the cost is skyrocketing at a rate which will put it out of reach of small organizations. The same goes for mechanical controls with gas engines."

"I don't see the fish replacing chemicals and mechanical controls," Malone says. "I stress the point of fine tuning the water. We've always had two tunes available; we need three." He says that where potability is not a factor, one can use chemicals. And for immediate relief, mechanical controls do a good job. "The triploid is just another tool that needs to be incorporated into water management."

Other types of natural predators of aquatic weeds include insects, pathogens, and other animals. In the past 12-15 years, the Army Corps of Engineers has been researching two types of moths for the control of water hyacinth. The Sameodes moth has already proven successful. The Arzama moth, another good predator of the water hyacinth, does not yet reproduce itself for solid establishment in the environment. The Corps thinks it will happen in a year or two.

In other biological work, the Environmental Protection Agency has granted the Army Corps permission to go ahead with work on the Cercospora fungus, which also attacks the hyacinth. Crews

Major Ingredients of Aquatic Herbicides

Product	Uses	Restrictions
1. 2,4-D		Very selective, potential drift hazard. Limited in irrigation and swimming. Has potable drinking tolerance.
A. dimethyline salt	Broadleaves; floating and ditchbank plants	
B. butoxy ethanol	Submerged plants, mainly milfoil	
C. emulsamine	Broadleaves; floating and ditchbank plants	
Manufacturer: Many companies Comment: Only a few of the many formulations have aquatic registrations.		
2. Diquat	Submerged plants primarily, but fairly broad spectrum. Also for floating aquatics, such as duckweed and water hyacinth.	For irrigation, 2-3 weeks. Won't work in muddy water.
Manufacturer: Chevron and others Comment: Consumers beware! There are many trade names with varying rates and percentage of active ingredients. More active in warm climate and sunlight.		
3. Endothall	Most forms non-selective. Gives fairly broad control, but primarily for submerged weeds and algae trouble.	Toxic to fish at high rates.
Manufacturer: Pennwalt Comment: Some products are best used as partial treatments to prevent fish kill.		
4. Copper compounds	Primarily for algae control and in combination with endothall or diquat for submerged weed treatment.	Fish and plants are sensitive at low rates in soft water and high rates in hard water.
Manufacturer: Many companies Comment: Beware of the existence of many different types of coppers, especially copper sulfates. Most active in sunlight and higher water temperatures.		

have recently applied a commercial formula produced by Abbott Laboratories in a dry powder in a large-scale experimental test and are studying results.

Other micro-organisms which host upon aquatic weeds are being examined as potential control agents. Competitive plant species have been introduced in some areas to overtake existing noxious species. And although not done with any prescribed formulas, putting ducks and swans in an infested water body can help the situation.

Different types of mechanical equipment, which mainly cut and harvest aquatic weeds, are available to the weed manager. The boxed article delves into specific details of some of the equipment. Units range in size from sickle blades which attach to a rowboat up to large harvesters equipped with retrieval and unloading conveyors.

Harvesters often combine with chemical treatment for effective treatment along hard-to-reach shoreline areas. Another approach involves harvesting a week or so prior to chemical treatment. Drawbacks to harvesting include limited mobility around shorelines and uneven bottoms, short-term control requiring several cuttings, and the ability for regrowth to branch out and become denser.

Cultural controls, or ways of manipulating plant habitats, can also help stop the spread of weeds. A form of algae like the *Chlorela sp.* with a light green tinge keeps the sunlight from going below 2½ ft. of the surface. Applicators have also tried other means, such as black plastic sheeting, soluble dyes, and artificial structures.

Jim Carsner who runs Aquatic Control Co. in Tacoma, Washington, says that the State of Washington has purchased five acres of Aquascreen to control watermilfoil in parks and lakes. This fiberglass screen with a fine mesh sinks to the bottom and prevents light from getting to the plants. Because of its expense, the screen suits high-use areas.

Other plant managers have used drawdown or periodic lowering of water levels to expose bottom sediments for drying out underwater weeds. Freezing of the ground during drawdown will also kill the roots and underground stems of certain aquatic plants.

Using a combination of means seems to give the aquatic weed manager encouragement to experiment and share discoveries with his colleagues. Bill Rushing, president of the Aquatic Plant Management Society, thinks that environmental restraints and controls have also fostered this situation. Yet depending upon what part of the country and what type of water body you work, certain methods will be more successful. "All aquatic problems are site specific," Rushing says.

In the Tennessee Valley Authority area, which encompasses 625,000 acres of impounded water and 11,000 miles of shoreline, managers are spending more than a half million dollars a year to keep Eurasian waterfmilfoil at a level that allows use of the lakes. Research has shown that stranding or dewatering the weeds by water level drawdowns and then applying 2,4-D to colonies that remain in the water are effective and environmentally acceptable control methods. "The most effective and economical way to control waterfmilfoil is to lower the lake level to expose plants for several weeks to drying or freezing," says Leon Bates, but the Tennessee Valley Authority cannot lower all its lakes far enough without interfering with other uses.

"We know Eurasian watermilfoil can't be eliminated from the Tennessee Valley area," says Bates. "It's biologically so productive, it's not feasible to remove each fragment. All the plant needs is a single sprig to proliferate in a short period of time." He has investigated mechanical and biological means but they are not feasible at the present. Spinyleaf naiad, often mistaken for Eurasian watermilfoil, is another serious problem for

the Tennessee Valley Authority, which only recently got clearance to use diquat against it in some states.

Fears are arising that hydrilla, the bane of aquatic bodies in Florida, threatens to invade the Tennessee Valley. It is already an $8 million problem just trying to control its spread and keep some boat channels open in Florida. Researchers hope that the grass carp helps with both hydrilla and water hyacinth, Florida's two major infestations. Two weevils, the *Neochitina eichhorniae* and *Neochitina bruchi*, along with the Sameodes moth, also slow these rapidly growing weeds.

Mechanical harvesters work well for quick control in the artificial canals of Florida, but cannot sustain the check of weeds in natural systems. Weed managers use endothall and combinations of diquat and copper compounds on hydrilla and 2,4-D, and diquat on water hyacinth. Eurasian watermilfoil, alligatorweed, reeds, and other plants must be dealt with in artificial systems. Dr. Burkhalter says that the mixture of natural and artificial bodies of water as well as the various aquatic weeds in Florida lend good reason for integrative controls.

Donald Lee, coordinator of aquatic plant research and control in the Louisiana Dept. of Wildlife and Fisheries, says that Louisiana uses all of the four main ingredients on its aquatic weeds. He suggests 2,4-D for water hyacinth, alligatorweed, and Eurasian watermilfoil. Endothall, copper compounds, and diquat in varying rates help control submersed weeds.

Minor Ingredients of Aquatic Herbicides

Product	Uses	Restrictions
1. Amitrole (amino triazole)	Primarily ditchbank material. Fairly non-selective.	
Manufacturer: Union Carbide		
2. Dalapon (Dowpon)	Primarily for ditchbank and shallow water. Irrigation-type canals west of the Mississippi.	
Manufacturer: Dow		
3. Dichlobenil (Casoron)	Control in water levees. Works best in early part of growing season.	Irrigation, swimming, and fish.
Manufacturer: Thompson-Hayward		
4. Fenac	Primarily in drawdown areas.	
Manufacturer: Union Carbide		
5. Simazine (Aquazine)	Enclosed ponds or lakes. Broad spectrum.	For irrigation, 12 months.
Manufacturer: Ciba-Geigy		
6. Roundup	Primarily monocot ditchbank grasses and also broadleaves.	Limited in water.
Manufacturer: Monsanto		
7. Diuron (Karmex)	Primarily ditchbank and irrigation canals.	Apply after flushing.
Manufacturer: duPont		
8. Banvel (dicamba)	Primarily ditchbank.	Only has state registration for water use.
Manufacturer: Velsicol		
9. Ammate (ammonium sulfamate)	A chemical trimmer for ditchbanks and other areas.	
Manufacturer: duPont, Chipman		
10. Aeromatic oils (acrolein)	Irrigation canals in western states. Broad spectrum.	Highly toxic to fish and wildlife.

Although the white amur remains on the prohibited list in Louisiana, biological agents, such as the alligatorweed flea beetle, two species of hyacinth weevil, and two species of moths, are widely used. Very little mechanical control is involved, one reason being the deep ditches which prevent access.

The western part of the country is often overlooked in the subject of aquatic weeds. Of the 17 states, there are 240,000 miles of canal constructed by the Bureau of Reclamation. Dependence on this water for irrigation and holding reservoirs makes weed control very important from an economic standpoint.

In the Southwest, particularly southern Arizona, lakes and golf course ponds are loaded with spinyleaf naiad. Tom Camp, who runs the Aquatic Management Co. in Phoenix, employs chemical, biological, and cultural practices to counter the weed's spread. Aquathol K works well at low rates and won't hurt fish. The *Tilapia zillii* is a very aggressive, weed-eating fish, which reproduces between 1,000 and 5,000 within 28 days. Camp also will use *Chlorella* algae to his advantage. The phytoplankton give a light green tinge to the water and prevent sunlight from reaching beneath 2½ ft. of the surface.

In northern Arizona, Camp has a different problem — Eurasian watermilfoil in 90 percent of the lakes. He uses gypsum to bring the pH down in areas of extremely heavy growth and then a granular 2,4-D to clean up.

Scientists discovered a new infestation of hydrilla in 1977 in the Imperial Valley, whose water irrigates much of the cropland of Southern California. One quarter of the Imperial Valley's irrigation system, about 370 miles of canals and laterals, is filled with hydrilla. Experiments are presently testing the hybrid grass carp on a trial basis in an area from which the fish can't escape. Eurasian watermilfoil abounds in canals, reservoirs, lakes, and ponds; pondweeds of various types, spinyleaf naiad, cattails, and bullrushes also thrive.

One popular herbicide is the copper compound Komeen, says Leslie Sonder from the California Dept. of Food and Agriculture. It is especially effective in combination with Nalquatic, a thickening agent which holds the Komeen in close contact with a plant.

Dr. Richard Yeo of the botany department at the University of California-Davis suggests endothall and diquat for hydrilla, 2,4-D for watermilfoil, and acrolein for submersed water weeds. He is studying spikerushes, which grow only 1 to 2 inches tall, and can displace water weeds.

In the Northwest, serious action against aquatic weeds began in 1977 when the Army Corps began investigating Eurasian watermilfoil in the state of Washington. The Grand Coulee, which supplies water for thousands of acres of irrigation, had become a home for milfoil. The Seattle area is spotted with recreational lakes and residents noticed the encroachment of weeds. While the Seattle District Corps of Engineers was doing its study, Metro, Seattle's metropolitan area government, was also

conducting a two-year study.

The Corps presented a choice of methods to the local government, who manages the program. "We're letting them tell us what they want to use," says Bob Rawson from the Seattle District Corps. "We realize not one method is applicable to all situations. One method won't usually work." The program studied Aquascreen, harvesting, and herbicides.

Suzanne Schweitzer, program manager for the aquatic plant control program for Metro, says, "Aquatic plant control is a relatively new topic so we looked at what other parts of the country are doing." Metro has recommended that non-chemical control techniques should receive priority for 1980 with respect to the Corps of Engineers cost-sharing for the program. Metro is working this year with citizens and governmental agencies to halt use of the herbicides dichlobenil, diquat, and 2,4-D and by next year develop a uniform herbicide policy. It is encouraging harvesting on a much larger scale and use of Aquascreen on city beaches.

In the Midwest, managers of inland waters — ponds mainly for recreation, fishing, and watering livestock, golf course ponds used for ornamentals and irrigation, natural lakes, and drainage ditches — contend with filamentous algae, cattails, and underwater weeds like Eurasian watermilfoil. None of the states in this region have legalized biological controls. "People have worked with the grass carp but there is skepticism about its benefits," says Dr. Carole Lembi, from the department of botany and plant pathology at Purdue University.

Lembi says that the larger communities have invested money in mechanical harvesters, but chemicals are the main way of dealing with the problems. Copper compounds, especially copper sulfate and Cutrine-Plus, work on algae; Aquathol-diquat combinations against watermilfoil; and Dowpon against cattails. Lembi says that a combination tank mix of Cutrine-Plus, Aquathol, and diquat provides a broad spectrum control of algae, watermilfoil, coontail, and pond weeds.

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MECHANICAL OPTIONS FOR THE AQUATIC CONTROL MIX

Benefits of a successful aquatic weed control program clearly reveal themselves when one has seen the destruction and waste weeds can produce. When dead fish, foul odors, and excessive algae leave for clean, healthful, and enjoyable water, the transformation stuns the eye. That it happens does not startle the experienced applicator, but what can do the job may surprise him.

Chemicals, because of their popularity and long-time use for land applications, have been discussed more thoroughly than other means of aquatic management. Other industries have also begun to contribute to the relatively new field of aquatics. Manufacturers of harvesting equipment, aerators, and other products have devised their own solutions to weed problems. What follows captures a few of these now available.

Harvesters

In states where regulatory agencies have restricted certain substances in the water, use of mechanical haresting has become more widespread. Although documented reports are usually kept for chemical applications in an aquatic project, accounts of a mechanical harvesting operation rarely show specific cost and effectiveness information. A study done by Gerald Smith of Aquatic Control Technology, Inc., Wayland, MA, revealed that harvesting can be an effective control over aquatic weeds in terms of both cost and yield.

Aquamarine Corp., Waukesha, WI, makes a "CHUB"—Cutter Harvester Utility Boat—to control weeds. With two levers, an operator maneuvers the zero-turn radius transmission, which drives the two aluminum paddle wheels in six inches of water. Visibility is unrestricted and all controls operate easily.

High aluminum handrails and a non-skid deck make the CHUB safe. The cutter bars and conveyor stop automatically and instantly when the operator's foot leaves the clutch pedal. Simple V-belt and chain drives keep the harvester easy to maintain.

With the versatile CHUB trailer, the CHUB can be moved hundreds of miles with ease and any boat ramp allows you to start your next harvest within minutes. A CHUB shore conveyor is also available for direct loading of a truck. (Write **201** on reader service card).

Aerators

Through oxygenation and mixing, aerators can produce many beneficial effects on water quality. With an adequate supply of dissolved oxygen, fish will stay healthy and the natural processes that biodegrade organic wastes will have a chance to work. This reduces unpleasant odors and gives the water a cleaner, fresher appearance. Aerators can also create sparkling spray displays in ponds in parks, golf courses, and municipal bodies.

Barebo Inc., Emmaus, PA, makes an Otterbine line of industrial aerators, which it calls a "floating mechancial surface aeration/mixing system." They have two components — a high-density, foam-filled polyethylene plastic float and a sealed electric power unit that contains an electric motor which runs in a bath of oil. The motor operates at 1,750 rpm, a low speed that helps prolong motor and bearing life.

A corrosion-resistant impeller is mounted directly to a motor shaft. In operation, the impeller draws water in through an open, 360-degree water intake and pumps it through a flow chamber in the float. The flow chamber shapes the water into an attractive pattern of spray droplets. As the spray droplets travel through the air, they adsorb atmospheric oxygen, which is transferred to the water, where it dissolves. When the spray droplets strike the water, they help promote the natural transfer of

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Homeowners around Midwest lakes often form an association and then contract an applicator to do the work. A group of researchers recently started its own Midwest Aquatic Plant Management Society and is trying to get affiliation with the national organization. Its main objective, says Lembi, is to exchange technical information on aquatic plant management and involve the commercial applicator.

The Northeast, where aquatic weeds are fortunately not a severe problem, does not have a formal approach to the few weeds that find their way into lakes and rivers.

The North Atlantic division of the Army Corps has recently studied the water chestnut, Eurasian watermilfoil, and yellow floating heart in Lake Champlain and started a 10-year program with mechanical harvesters, says Dr. Robert Pierce of the division. New York has completely cut chemical control and is studying biological controls.

Managers, both researchers and applicators around the country, have begun to share expertise about the unique aquatic environment and the plants they want to control. Although problems vary throughout the states, this exchange crosses borders as freely as rivers. Florida's study on watermilfoil will help Washington, and Arkansas's experiments with the triploid should benefit California. Today's weed problems necessitate a broad-based diversified attack.

Aquatic plant management in many regions is just emerging from its embryonic form. For others who have been dealing with severe problems, the science, profession, and solutions are still in the early stages of development. Says Dr. Burkhalter, "Aquatic plant problems and control technology are rapidly changing. The future of aquatic plant management belongs to individuals who will do likewise." **WTT**

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additional oxygen to the water through splashmaking and wavemaking. The company makes various models for different applications. (Write **202** on reader service card).

Clean-Flo Laboratories, Inc., Hopkins, MN, manufactures an aeration system called the "Fish-Air." Based on the principle of multiple inversion, it floats the bottom water up to the surface to be oxygenated by the energy in the wind. Through this multiple inversion, Fish-Air rolls a pond or lake over and over so every drop of water repeatedly comes to the top.

The system consists of an oilless 1/3-horsepower, 115-volt, single-phase compressor, necessary fittings, a spare set of air filters, a location float, a microporous diffuser, and easy instructions. It can purify an acre of water 6 feet deep three to four times a week while using the electricity equivalent to a 250-watt light bulb. Fish-Air works in all types of water bodies. (Write **203** on reader service card).

Dredgers

Dredging can remove existing rooted plants and nutrient rich sediments and also increase water depths. If the bottom is properly contoured, underwater weed growth can be reduced or eliminated. Large hydraulic dredges may be used on large bodies of water.

The Water Vac Dredge, made by Aztec Development Co., Orlando, FL, removes both rooted weeds, such as hydrilla, by the roots and tubers, and floating weeds, such as water hyacinth. It can also deepen canals, remove shoals, and do work normally involved in dredging. Because of its nonturbidity and ability to ingest and mulch weeds, this machine can also take out deposited runoff, sediment, hazardous materials, and muck down to the original bottom and safely enclose these materials in pipes for transportation to remote areas.

The machine cuts an 8 foot wide by 18 inch deep row of weeds, and can operate to a depth of 10 feet, 6 inches. It is 30 feet, 2 inches long, 8 feet wide, and weighs 16,000 pounds. It can hold 360 gallons. (Write **204** on reader service card).

Dredgeast, Inc., New Canaan, CT, makes the Mud Cat dredger to remove mud, muck, silt, sand, chemical sludges, and industrial wastes from water bodies without severely disturbing the water. A well-muffled diesel engine, capable of pumping 2,000 gallons per minute of liquid with solid concentrations of up to 20 percent, powers it. The cutter head houses a spiral auger with twin horizontal screws which enables it to make a precise cut of up to 15 feet deep and 8 feet wide.

Mud Cat can remove 120 cubic yards of solids per hour. It maneuvers around stumps and other obstructions. It is 30 feet long by 8 feet wide and draws only 21 inches of water. (Write **205**).

Miscellaneous

Every piece of equipment used to control weeds is not mechanical yet the unique nature of this material defies classification into a large listing. One of these is Aquascreen, a closely woven, vinyl-coated screening material that is inert, very strong, and durable. Menardi-Southern Corp., Augusta, GA, manufactures it.

When pinned to the bottom of a pond, this material controls weeds by compression and by reducing 50 to 60 percent of the light necessary for growth. The weeds covered will decompose over a four to six week period, while life continues back and forth through the screen. It transfers to another site by just pulling the pins, moving it, and replacing it. (Write **206**).

Aquashade, Inc., Eldred, NY, also has a solution to the problem of aquatic weeds—Aquashade. This liquid concentrate turns water a beautiful blue to cut off the sunlight that weeds and algae need for growth. Water remains non-toxic to fish, wildlife, and people, making it immediately safe for swimming. It is a continuing control after application, stopping excessive algae and weed growth for a period as long as the color stays.

Aquashade is best applied at a rate of 1 gallon per acre of water four feet deep. Application remains in the water dependent on length of growing season, water flow rate, fertility, and clarity. (Write **207**).