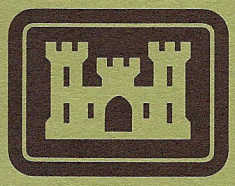
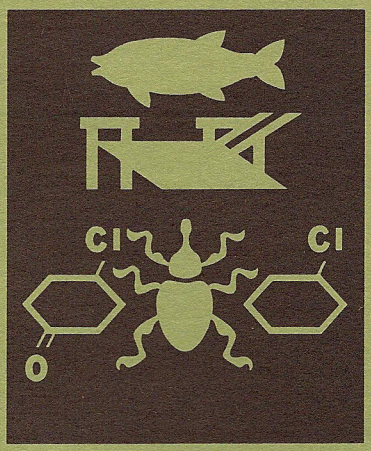
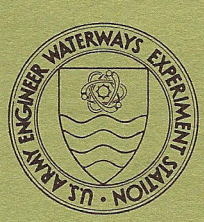
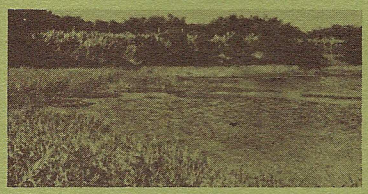
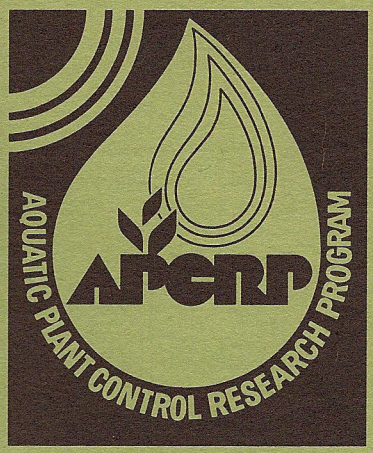


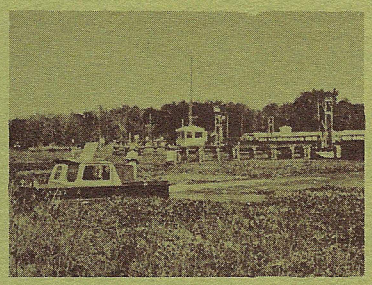
US Army Corps of Engineers











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AQUATIC PLANT CONTROL RESEARCH PROGRAM

Information Exchange Bulletin

HERBICIDE EVALUATION PROGRAM

BY R. E. HOEPPEL AND H. E. WESTERDAHL*

INTRODUCTION

Management of aquatic plants is accomplished primarily through the application of herbicides. However, the number of herbicides available for aquatic use has steadily declined over the past decade primarily as a result of the stringent requirements of the Federal Insecticide, Fungicide, and Rodenticide Act of 1972 and the Toxic Substances Control Act of 1976. Moreover, the limited economic market and rapidly increasing costs of developing, evaluating, and marketing new chemicals have also contributed to the reduction of registered aquatic herbicides.

All herbicides submitted for registration are reviewed by the U.S. Environmental Protection Agency (EPA). Before a Federal label for aquatic use of a herbicide can be obtained by the manufacturer or distributor, information must be submitted to EPA to establish safe tolerances in water, fish, and selected commodity crops and livestock and for human exposure and consumption. Even though a herbicide has been registered previously for agricultural purposes, additional research is necessary prior to registration for use in the aquatic environment.

Ideal herbicides for use in aquatic environments have a low toxicity to animals; those with high selectivity for certain aquatic plant species should provide less impact on natural biota and irrigated agricultural crops. The state-of-knowledge necessary for developing chemicals with high specificity is rapidly advancing. However, developing, evaluating, and marketing new chemicals solely for aquatic use has lagged because the costs presently exceed the market demands.

COOPERATIVE RESEARCH PROGRAM

The U.S. Department of Agriculture (USDA) has been actively involved for several years in evaluating chemicals that are important in improving agricultural production. The policy and rationale for this activity is set forth in the USDA Science and Education Administration, Agricultural

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Research (SEA, AR) Administrative Memorandum AM 120.4 dated 1 August 1975. The primary effort has been in the evaluation of herbicides for commodity crop applications; consequently, evaluation of herbicides for their potential as aquatic plant control agents has been given lower priority.

The U.S. Army Corps of Engineers, through the Aquatic Plant Control Research Program (APCRP), has increased the emphasis on herbicide evaluation for aquatic use by providing funding to support the aquatic herbicide evaluation program at the USDA Aquatic Plant Management Laboratory (APML) in Fort Lauderdale, Florida. The evaluation of herbicides is conducted in both controlled-environment laboratory aquaria and outdoor aquaria containing various growth stages of submergent, emergent, or floating nuisance aquatic plants.

In keeping with USDA policy and with APCRP concurrence, the APML evaluation program is available at no cost to private industry, government agencies, small producers, and individual researchers involved in developing new or improved herbicide formulations. The chemicals submitted to the APML may be experimental formulations, proprietary compounds, or commercial products. The research results are made available to the submitting party immediately following completion of the efficacy evaluation. Also, the results of the evaluation program are published in an annual report by the Waterways Experiment Station (WES); confidential information will not be disclosed if prior agreement has been arranged. Patent protection by the producer is deemed necessary for marketing; thus, every effort is made to protect products and unpatented confidential information.

A major function of the APCRP is to consider the results of the evaluation research program and recommend safe and effective herbicide formulations for aquatic use. New or improved products are generally given top priority in the evaluation program. However, research on herbicides developed for agricultural weed control is encouraged to determine their effectiveness in aquatic weed control. Herbicide formulations are screened in the order of their anticipated efficacy, selectivity, and safety.

APML Research Facilities

The APML evaluation research program is conducted by a highly qualified multidisciplinary team of scientists with many years experience in various phases of aquatic plant research, including laboratory and field experimentation. The analytical laboratory and controlled-environment space approximates 200 sq m. Laboratory test equipment includes radiochemical detectors, visible and ultraviolet spectrophotometers, pH and millivolt meters, multiparameter water quality analyzers, gas-liquid and high-pressure liquid chromatographs, and an atomic absorption spectrophotometer, and provides rapid monitoring of herbicides and environmental parameters. Furthermore, the semi-tropical environment of Fort Lauderdale allows year-round research and monitoring of phytotoxicity in the 250 outside aquaria.

Chemical Submission

Herbicide formulations can be submitted directly to the APML. These chemicals will be evaluated only upon receipt of a completed Form SEA 409, Cooperative Research Evaluation of Chemicals, which include the following:

- Information to show that evaluation is warranted.
- Name and structural formula of the chemical, if known.
- Available data on the toxicity of the chemical and byproducts to man, animals, and plants.

Proprietary formulations may be submitted for evaluation using confidential code names. Compounds of unknown biological activity that are of interest because of their chemical structure or other properties will be accepted for evaluation; chemicals submitted without compositional information may also be evaluated. However, the level of evaluation for a submitted herbicide depends on the nature and completeness of the available information.

The supplier also submits a confidentiality statement concerning the chemical identity, properties, and evaluation data of a submitted formulation. The period of confidence will be determined at the time of acceptance. If there is a need for an extension of the period of confidence, an ARS Form 410, Request for Extension of Period of Confidence, can be submitted.

When a herbicide is accepted for evaluation, the supplier is required to state in writing whether steps for patent applications have been taken or are contemplated; information on such herbicides will remain confidential. No product will be submitted to other agencies outside the APML and WES without the written permission of the supplier. The aforementioned USDA forms can be obtained from the USDA-APML, 3205 Southwest 70th Avenue, Fort Lauderdale, Florida 33314.

Chemical Evaluation

Herbicides accepted for evaluation are subjected sequentially to a series of efficacy evaluations (Figure 1). Initial evaluations consist of bench-top laboratory research. Promising chemicals are then evaluated further in large outdoor aquaria and eventually in small field plots.

Laboratory evaluation is conducted in a temperature- and

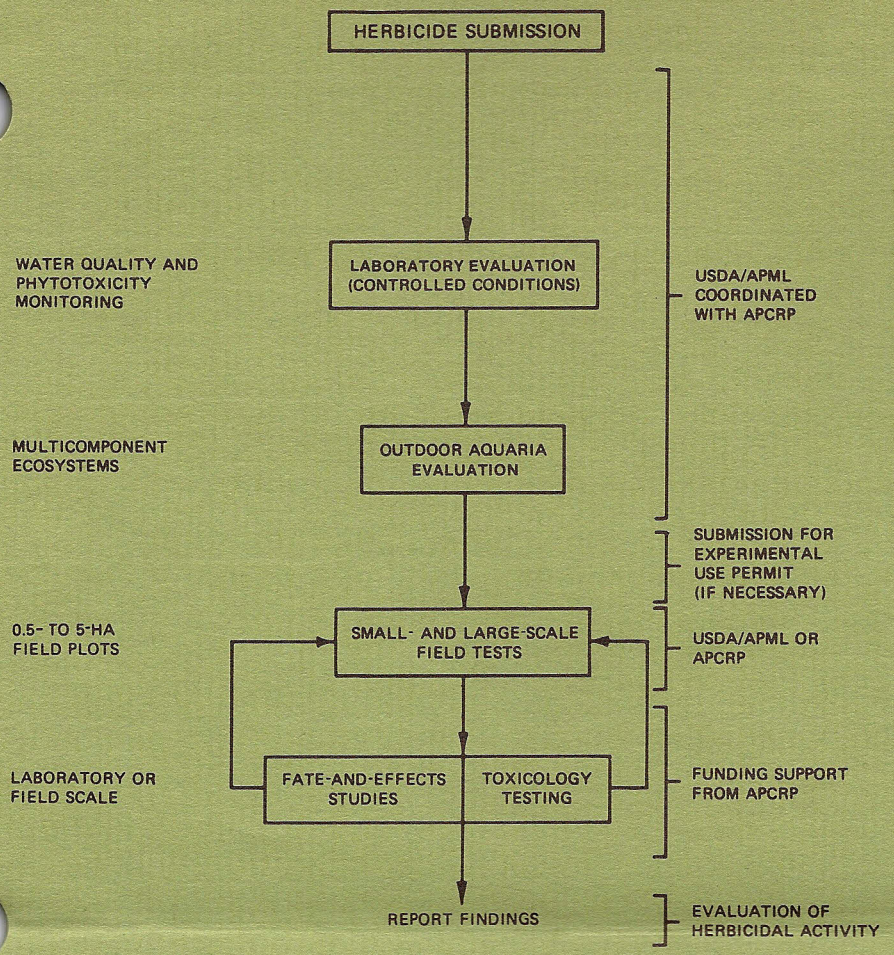

Figure 1. Herbicide evaluation program procedure

light-controlled environment. Target plants or propagules are acclimated in aquaria under optimal growth conditions for one week prior to evaluation. Each replicated treatment is compared with untreated controls.

The procedure for submersed aquatic plants (e.g., hydrilla, watermilfoil, pondweed, cabomba, and coontail) entails the planting of apical cuttings or vegetative propagules in a soil mix in small plastic cups, which are submersed in 3.8- or 19-ℓ glass jars (Figure 2). Static water conditions are maintained for evaluating most conventional herbicides (Figure 3). Controlled-release (CR) or selected conventional herbicide formulations are evaluated in aquaria equipped for continuous-flow conditions at precisely controlled rates using metering pumps (Figures 2 and 4).

Floating and emergent aquatic plants (e.g., waterhyacinth, water lettuce, alligatorweed, and torpedograss) are grown in 12-ℓ plastic containers (Figure 5) to which various herbicide doses are uniformly applied to the foliage.

Several concentrations of a specific chemical are evaluated at treatment rates suggested by the supplier or determined by the APML staff. If deemed necessary, suppliers are permitted to assist the APML staff in the evaluation research to ensure confidentiality or when product safety is uncertain. Occasionally, special investigations are made to determine the absorption and translocation of a given herbicide for specific aquatic plants. Herbicide combinations or herbicide-adjuvant mixtures are also evaluated for suspected synergistic responses.

Observations relative to plant growth and phytotoxicity are recorded at intervals of 0, 7, 14, 28, and 42 days posttreatment, with additional monitoring being conducted as required for the particular formulation. Phytotoxic response is qualitatively determined as percent injury, with reference to untreated controls. The qualitative factors noted in the evaluatory testing are given below:

Heavy Algal Cover
Leaves Heavily Calcified
Roots Evident
No Meristems on Main Stems

No Meristems on Branches
Leaves Turning Red on Main Stems
Leaves Turning Red on Branches
Stems Brittle

Plants Flaccid

Partial Leaf Loss
Total Leaf Loss on Branch
Internodes Decomposing

Nodes Decomposing

Branch Decomposing Near Tip
Main Stem Decomposing Near Tip
Branch Decomposing Throughout
Plants Decomposing (General Decomposition)
Only Root Material Left
Normal Growth
Very Slight Deterioration of Leaves or Stems
Advanced Decomposition (Only Few Stems Remain Intact)
General Regrowth In Evidence
Evidence of Solarizing
Complete Disintegration of Plant Material

Also, quantitative measurements of stem lengths, number of branches and nodes, wet- and/or dry-weight yield may be determined.

Herbicide formulations that offer the most potential for aquatic plant control are evaluated in 1000- to 4000-ℓ outside aquaria (Figure 6). The objectives are to evaluate efficacy and to determine

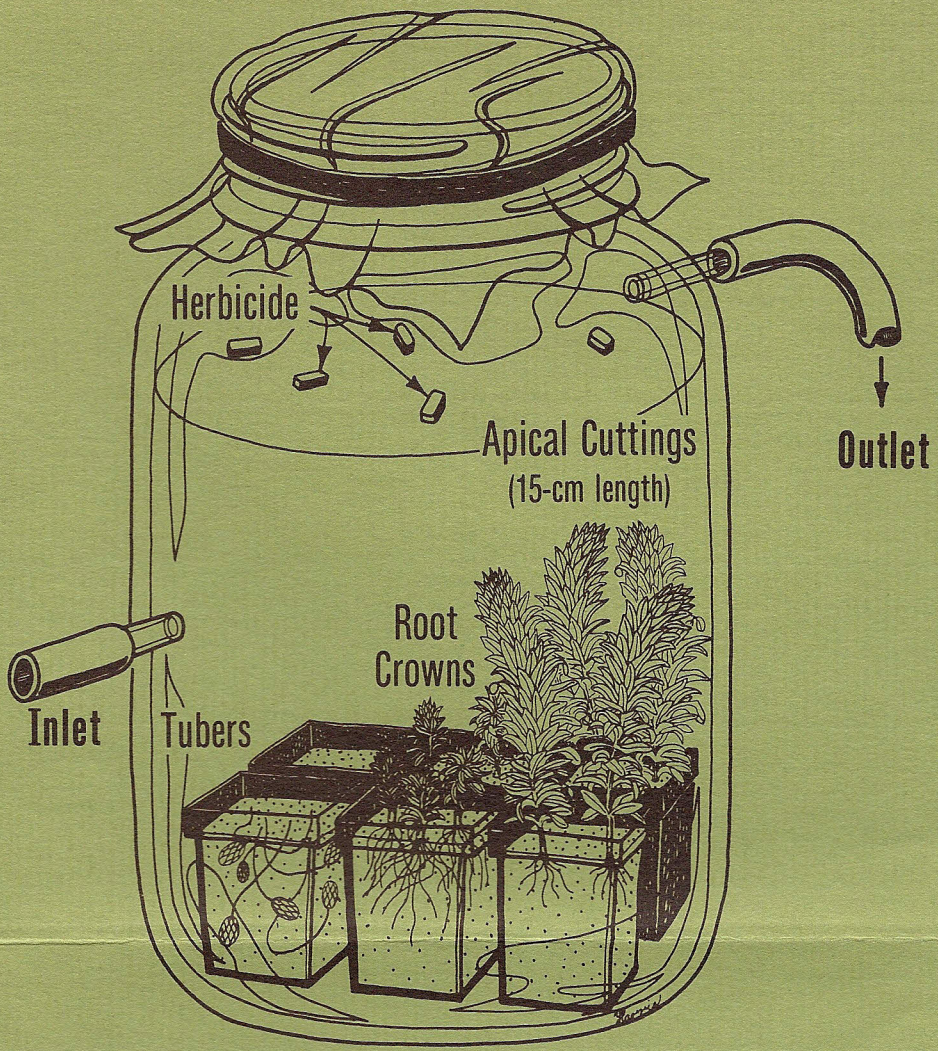

Figure 2. Schematic of continuous-flow jar setup for laboratory evaluation. When a controlled-release herbicide is being evaluated (as shown in the figure), the water flow rate coincides with the herbicide release rate

Figure 3. Static evaluation of submersed plants with conventional herbicides

realistic field application rates. These outside aquaria more closely approximate field conditions of plant density, light, temperature, and water circulation patterns than do the laboratory evaluations. They can be operated as static or continuous-flow systems. Chemicals that continue to show promise for commercial development are considered for fate-and-effects and toxicology studies performed under WES contracts and also for small-scale field evaluation. The WES and APML personnel will notify the supplier to recommend appropriate field evaluations and to assist in site selection. Suppliers of such herbicide formulations are encouraged to obtain an Experimental Use Permit.

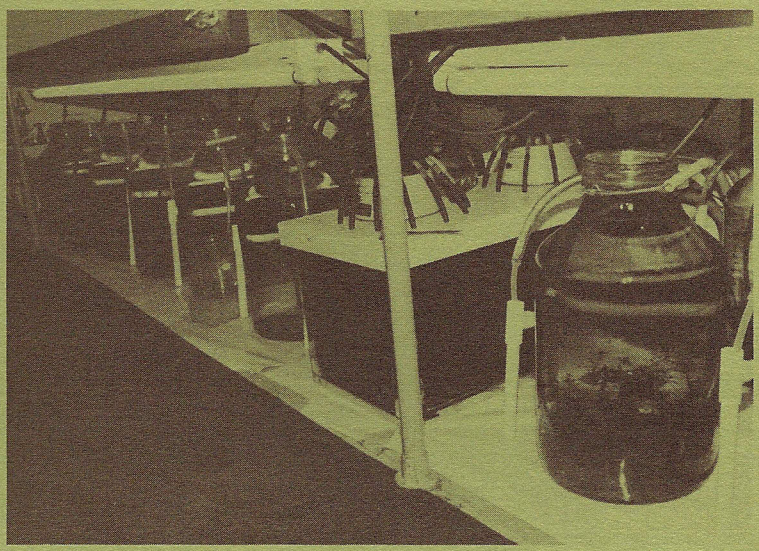

Figure 4. Continuous-flow setup to evaluate controlled-release herbicide effects on submersed plants

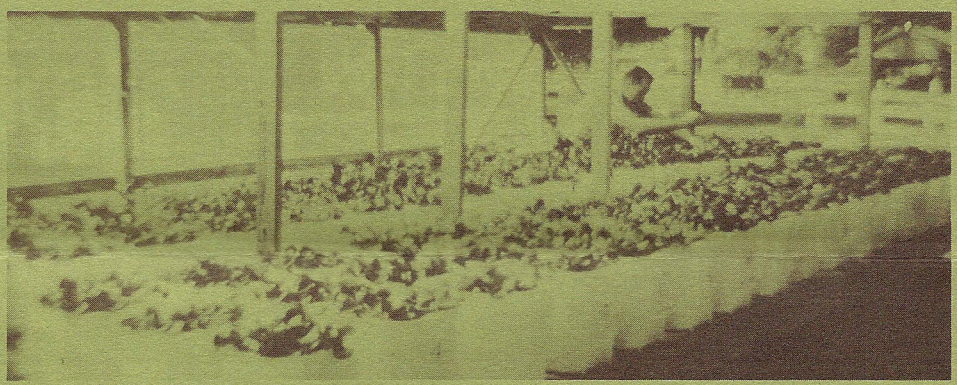

Figure 5. Laboratory setup to evaluate herbicide effects on floating and emergent aquatic plants

Figure 6. Outside aquaria

ACKNOWLEDGEMENT

The authors would like to acknowledge the assistance and comments provided during preparation of this article by Dr. Kerry Steward at the APML in Fort Lauderdale, Florida. The photos were provided by USDA.

APCRP PUBLICATIONS

Barko, John W., et al. 1980. "Growth and Metabolism of Three Introduced Submersed Plant Species in Relation to the Influences of Temperature and Light," WES Technical Report A-80-1, Environmental Laboratory.

Baer, R. G., and Quimby, P. C., Jr. 1980. "Field Studies and Laboratory Rearing of *Arzama densa* Wlk., a Biological Control Agent Against Waterhyacinth," WES Miscellaneous Paper A-80-6, prepared by the U. S. Department of Agriculture, Southern Weed Science Laboratory, for the Environmental Laboratory.

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This bulletin is published in accordance with Army Regulation 310-2. It has been prepared and distributed as one of the information dissemination functions of the Environmental Laboratory of the Waterways Experiment Station. It is principally intended to be a forum whereby information pertaining to and resulting from the Corps of Engineers' nationwide Aquatic Plant Control Research Program (APCRP) can be rapidly and widely disseminated to Corps District and Division offices as well as other Federal agencies, State agencies, universities, research institutes, corporations, and individuals. Contributions are solicited and will be considered for publication so long as they are relevant to the management of aquatic plants as set forth in the objectives of the APCRP, which are, in general, to provide tools and techniques for the control of problem aquatic plant infestations in the Nation's waterways. These management methods must be effective, economical, and environmentally compatible. This bulletin will be issued on an irregular basis as dictated by the quantity and importance of information to be disseminated. Communications are welcomed and should be addressed to the Environmental Laboratory, ATTN: J. L. Decell, U. S. Army Engineer Waterways Experiment Station, P. O. Box 631, Vicksburg, Miss. 39180, or call 601-634-3494.

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