AQUATIC PLANT CONTROL RESEARCH PROGRAM




TECHNICAL REPORT A-81-2

IMPROVING TECHNOLOGY FOR CHEMICAL CONTROL OF AQUATIC WEEDS

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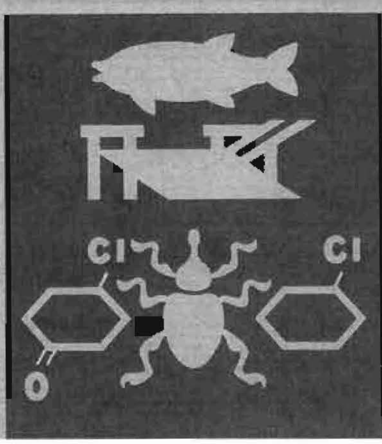

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There is worldwide consensus among those who manage or maintain water resources that nearly every conceivable water use can be prevented or at best curtailed by unmanaged aquatic weed growth. Management alternatives for chemically controlling aquatic weeds in the past have been limited primarily to herbicides; however, the number of these compounds that are available for use is decreasing.

With assistance of Government, industry, and university laboratories, the

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) search for new chemicals and new technology should be continued and expanded. The first step in a search for new chemical formulations is synthesis. The next step is efficacy screening using weed species for which control is desired. Once the efficacy of a chemical against a particular species has been determined, attempts to improve performance or safety may be initiated through innovative formulation techniques.

Several recently developed formulation techniques were identified as having considerable potential in maintaining control of aquatic weed regrowth. These new formulations provide controlled release (CR) of a herbicide over several months to a year.

The objectives during the past year included research, identification of new chemicals with efficacy for managing aquatic plants, and development of testing procedures for evaluating CR formulations.

Four areas of laboratory testing have been developed to meet the project objectives: (a) laboratory evaluation techniques for submersed aquatic plants, (b) laboratory evaluation of chemicals for growth inhibition of hydrilla propagules, (c) greenhouse evaluation techniques for emergent and floating aquatic plants, and (d) evaluation techniques in outside aquaria and small ponds.

This past year the following compounds were evaluated in the laboratory: 14 CR formulations, 2 coded-confidential compounds, 1 organic copper complex, and 1 adjuvant; 2 chemicals were field evaluated under Environmental Protection Agency Experimental Use Permits.

Investigation of relationships between herbicide efficacy and plant nutrition indicated that plants cultured in soils to which composted manure had been added were more resistant to diquat than were plants cultured with additions of liquid fertilizer.

Controlled-release formulations of diquat have been effective against hydrilla, southern naiad, and watermilfoil at rates as low as 0.25 mg/ℓ.

A coded compound from Kalo Laboratories, Inc., Kansas City, Missouri, was very effective against watermilfoil at 0.5 mg/ℓ.

Several CR formulations of diquat, 2,4-D, and endothall produced complete control of watermilfoil at rates from 0.25 to 4.0 mg/ℓ.

Ten experimental and standard formulations of fenac were found to be effective against watermilfoil at a treatment rate of 0.25 mg/ℓ.

Waterhyacinths were controlled under greenhouse conditions using R-24191 and several CR formulations of 2,4-D and diquat.

Of the six fenac formulations previously tested on waterhyacinths (at rates of 1.0 kg/ha and higher), retesting showed fenac plus (A 09563) to be effective at a rate of 0.1 kg/ha, and fenac liquid (A 70316) and fenac + dicamba (AL 3591) to be effective at a rate of 0.5 kg/ha.

Norflurazon was effective against waterlettuce at a rate of 4.0 kg/ha.

Evaluations in outside aquaria showed the coded Kalo compound and metribuzin to be effective against waterhyacinth.

The field trial of fenac in a Broward County, Florida, lake produced 100 percent control of hydrilla after 11 months. This level of control was maintained for 18 months.

Field testing in small ponds near Tampa, Florida, of hexazinone and various combinations of fenac + copper TEA produced complete control after 5 and 4 months, respectively. The dissolved oxygen was rapidly depleted by the treatments; however, it began to return after 3 weeks.

PREFACE

This report presents the results for FY 79 of an ongoing screening program to evaluate chemical formulations to determine their potential as aquatic plant control herbicides. The program is being conducted for the Aquatic Plant Control Research Program (APCRP) by the U. S. Department of Agriculture (USDA), Science and Education Administration, Aquatic Plant Management Laboratory, Fort Lauderdale, Florida. Funds for this effort are provided by the Office, Chief of Engineers, U. S. Army, under Appropriation No. 96X3122, Construction General, and CWIS No. 31548 through the APCRP at the U. S. Army Engineer Waterways Experiment Station (WES).

The principal investigator for the work was Dr. Kerry K. Steward, USDA, who prepared this report.

The work was monitored at WES by Dr. Howard E. Westerdahl of the Environmental Laboratory (EL) Chemical Control Technology Team, under the direct supervision of Dr. R. M. Engler, Chief, Ecological Effects and Regulatory Criteria Group, and Dr. R. L. Eley, Chief, Ecosystem Research and Simulation Division. The study was under the general supervision of Mr. J. L. Decell, Program Manager, APCRP, and Dr. John Harrison, Chief, EL.

Commanders and Directors of WES during the conduct of the study and the preparation and publication of this report were COL John L. Cannon, CE, and COL Nelson P. Conover, CE. Technical Director was Mr. F. R. Brown.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
inches	25.4	millimetres

IMPROVING TECHNOLOGY FOR CHEMICAL CONTROL OF AQUATIC WEEDS

PART I: INTRODUCTION

Background

1. The future availability of adequate fresh water for agriculture and other uses is a major concern in Florida, other areas of the United States, and abroad. Aquatic plants are serious deterrents to the efficient conservation and utilization of this vital resource. Aquatic plants cause severe problems to navigation in streams and inland waterways. Nuisance growths of aquatic plants interfere with flow and utilization of water for irrigated agriculture.

2. Aquatic plant infestations in farm ponds restrict their use for stock watering, fish production, fire protection, irrigation, waterfowl and wildlife use, and as a source of potable water. Recreational uses of water, such as fishing, swimming, and boating, are also prevented or severely curtailed by these aquatic growths.

3. Management of aquatic plants is primarily accomplished with herbicides; however, the number of these compounds available for use is decreasing. Only four herbicides are registered and widely used nationally for control of submersed aquatic plants, and only two herbicides are widely used for control of ditchbank plants. The use of 2,4-D for waterhyacinth control is restricted because of drift hazards to susceptible plants. The increasing cost of diquat is resulting in its decreasing use, with the consequence that aquatic plant problems are increasing in some areas.

4. Critical need exists to expand evaluation programs to discover and develop new environmentally safe herbicides and algacides for plant control in aquatic habitats.

Purpose

5. The purpose of this project is to expand evaluation research on the use of chemicals for aquatic plant management. New herbicides or chemical growth regulators need to be discovered that selectively

remove or regulate the growth of different aquatic plant species.

6. With the assistance of Federal regional laboratories, pioneer laboratories, and the chemical industry, attempts are being made to develop new and more effective chemicals that have high phytotoxicity to aquatic plants and minimal adverse effects on nontarget aquatic organisms.

7. Aquatic weeds treated in FY 1979 are listed below:

Alligatorweed	*Alternanthera philoxeroides* (Mart.) Griseb.
Cabomba	*Cabomba caroliniana* Gray
Chara	*Chara* spp.
Duckweed	*Lemna* spp.
Hydrilla	*Hydrilla verticillata* Royle
Paragrass	*Brachiaria mutica* (Forsk.) Stapf
Southern naiad	*Najas guadalupensis* (Spreng.)Mangus
Torpedograss	*Panicum repens* L.
Waterhyacinth	*Eichhornia crassipes* (Mart.) Solms
Waterlettuce	*Pistia stratiotes* L.
Watermilfoil	*Myriophyllum spicatum* L.

The names and sources of chemical compounds evaluated in 1979 are listed in Table 1.

PART II: MATERIALS AND METHODS

Laboratory Techniques

Submersed aquatic plants

8. Apical sections of submersed plants were planted in a sand-soil mix in small plastic pots and placed in 3.8- or 19-ℓ jars. Plants were then allowed to become established for approximately 1 week under controlled conditions of temperature (25°C) and light (25 to 40 μeinsteins $\cdot m^{-2} \cdot sec^{-1}$, from grow-lux fluorescent tubes for 14 hr). The plants were treated by injecting treatment solutions into the water with a hypodermic syringe. The treatments were then evaluated biweekly for phytotoxicity.

Growth inhibition of hydrilla propagules

9. Vegetative propagules (tubers) of hydrilla were planted in three pots (five tubers per 5-cm pot in a sand-soil mix). These pots were placed in a 3.8-ℓ jar filled with water. Chemical treatments were applied at the time of planting. Effects on germination were recorded along with phytotoxic response of sprouted plants. These tests were conducted in a growth lab under conditions of controlled light and tempature.

Greenhouse Techniques

10. Plants to be treated were grown in polyethylene-lined, 12-ℓ capacity plastic containers, and were allowed to become established in the greenhouse for a period of approximately 1 to 4 weeks prior to treatment. Each replicated treatment was applied by placing the containers in a 929-cm^2 enclosure with an open top and uniformly spraying the plants using a small atomizer. The total spray volume was equivalent to 935 ℓ/ha. Following application of the chemicals, the plants were moved to a greenhouse where treatments were periodically evaluated for phytotoxicity.

Outside Aquaria Techniques

11. Evaluations were conducted in aquaria of two sizes and types. One type consisted of circular, vinyl-lined containers manufactured for use as swimming or wading pools. The dimensions were 3.05 m in diameter (7.3×10^{-4}ha) with a maximum depth of 74 cm. The maximum volume was

5400 ℓ. The pools normally were filled to a 53 cm depth, which resulted in a volume of 3870 ℓ.

12. The second type of aquarium consisted of rectangular-shaped concrete boxes. Two coats of white epoxy paint covered the interior of each box. The dimensions were 77 cm wide x 219 cm long (1.7×10^{-4} ha) with the depth varying from 48 to 65 cm. The maximum capacity of these containers ranged from 815 to 1095 ℓ and the normal volume after adding soil was 500 to 825 ℓ.

13. When these aquaria were used for evaluating herbicide efficacy on submersed plants, apical cuttings of individual species were established by planting cuttings 15 cm in length into holes on 5.1-cm centers (428 stems/sq m). The holes were punched into a 15-cm layer of sand-organic soil mix on the bottom of each aquarium. Water levels were then slowly raised in the aquaria and the plants were subjected to an intermittent water flow until treatments were applied. For evaluation of herbicide efficacy on floating plant species, field-collected plants were established in the aquaria and allowed to completely cover the water surface before treating.

14. All chemical treatment rates were replicated a minimum of three times and were applied on an area (kilograms per hectare) or volume (milligrams per litre) basis. Phytotoxicity ratings, determined at various times after treatment, were made on a scale of 0 to 100 percent injury: 0 percent was no injury, and 100 percent was complete elimination of live plant tissue.

Field Evaluations

15. Three small ponds located on the Florida State Fairgrounds at Tampa, Florida, were used in this study. Pond No. 1 had a surface area of 0.57 ha, an average depth of 1.95 m, and a maximum depth of 3.05 m (at the time of treatment). This pond was treated with hexazinone at a rate of 1.0 mg/ℓ active ingredient (AI). Pond No. 2 had a surface area of 0.23 ha, an average depth of 1.05 m, and a maximum depth of 2.1 m. This pond was treated with fenac plus copper TEA at rates of 1.0 mg/ℓ AI fenac plus 1.0 mg/ℓ AI copper. Pond No. 3, the control pond, had a surface area of 1.50 ha, an average depth of 1.05 m, and a maximum depth of 1.35 m.

16. The three ponds were connected in series by culverts with Pond No. 1 receiving runoff from the roadway and Pond No. 3 serving as the outlet via a controlled spillway to a drainage ditch. The culverts between the ponds were blocked with plywood sheets to prevent intermixing between treatments.

17. The ponds were treated on 14 November 1978. The chemicals were applied below the water surface from an airboat equipped with a 200-ℓ capacity tank mixer permitting continuous liquid agitation and a bow-mounted boom with five 1.3-m trailing hoses fitted with weighted (1.7 kg) nozzles.

18. Samples were taken before treatment and after treatment on day 1; weeks 1, 2, 3, and 4; and months 2, 3, 4, 5, 6, and 7. Dissolved oxygen (DO) was also measured 6 hr after treatment in Ponds No. 2 and No. 3, and 1 day after treatment in all three ponds.

19. The DO, temperature, and Secchi disk transparency were measured from one station near the approximate center of each pond. The DO was determined with the azide modification of the Winkler Method (American Public Health Association, American Water Works Association, and Water Pollution Control Federation 1979). Water temperature was measured with a YSI Model 400 Tele Therometer. Water temperature and DO were measured at middepth, and 30.5 cm above the bottom. Changes in the water level were measured at a fixed reference point that was established at the time of treatment. Composite samples of water, hydrilla, and sediment were collected from five random locations. The water samples were taken at each of the five sites from the same depths used for monitoring DO. The samples were collected with a 1-ℓ polyethlene bottle fitted into a specially designed housing that allowed the cap to be removed and replaced at any desired depth. The pH was measured in each composite water sample with a Hellige color comparator. Hydrilla samples were collected by hand from the water surface and with a four-pronged hook from deeper areas. A liner-type core sampler fitted to a 3.4-m galvanized pipe handle was used to collect mud samples. Five mud samples

from each pond were composited to represent Ponds No. 1 and No. 3, respectively. Each core was 15 cm deep and 5 cm in diameter. Core samples 5 cm in diameter and at least 6 cm long were collected from Pond No. 2 prior to treatment and 6 months posttreatment. These cores were not composited. The water was allowed to drain through the core before dividing the sample into 1-cm-thick layers.

20. The water, plant, and sediment samples from Ponds No. 1 and No. 3 were shipped to E. I. duPont de Nemours and Company, Wilmington, Delaware, to be analyzed for hexazinone residues. The samples from Pond No. 2 were returned to the Aquatic Plant Management Laboratory, Fort Lauderdale, Florida, for copper residue analysis.

21. Efficacy evaluations were made on the same dates as sample collections.

22. Evaluations were made also on the effects of the herbicides on cattail. A marginal band of cattail (*Typha* sp.) was present around both Ponds No. 1 and No. 2. Although most of the cattails were growing in the water, a few were growing on the pond bank above the waterline.

PART III: RESULTS AND DISCUSSION

Laboratory Evaluations

Inhibition of hydrilla propagule germination

23. The following compounds (Table 2) were evaluated for inhibition of hydrilla tuber germination as well as for phytotoxicity toward any new sprouts: Krenite, Norflurazon, RO 3-7042, three controlled-release (CR) formulations of fenac (7310-172-1, 7310-172-2, and 7310-172-3) and liquid fenac.

24. Krenite and Norflurazon did not inhibit the sprouting of the tubers nor did they produce any phytotoxicity toward the newly sprouted plants.

25. The test with RO 3-7042 is still in progress, but after 8 weeks dose rates up to 20 mg/ℓ have not shown evidence of inhibiting tuber germination. However, the 5.0-mg/ℓ rate has effected 58 percent control of the new plants.

26. Evaluations of the various fenac formulations are also still in progress. During the first week, nearly all of the tubers sprouted (treatments and controls alike). Phytotoxicity values after the sixth week ranged from 58 percent at a 0.1-mg/ℓ dose to 99 percent at a 0.5-mg/ℓ dose for CR No. 7310-172-1, 8 percent at a 0.1-mg/ℓ dose to 98 percent at a 0.5-mg/ℓ dose for CR No. 7310-172-2, and 42 percent at a 0.1-mg/ℓ dose to 99 percent at a 0.5-mg/ℓ dose for CR No. 7310-172-3. These results for the CR formulations compare favorably with the reference liquid fenac, which produced phytotoxicity values of 42 percent at a 0.1-mg/ℓ dose and 99 percent at a 0.5-mg/ℓ dose.

Hydrilla

27. The additive SA-77, at a 12-mg/ℓ dose rate, produced 65 percent control of hydrilla after 2 weeks (Table 3). Regrowth reduced the control rating to 46 percent by the eighth week. This rate of treatment with SA-77 alone, appears to be near the threshold injury level.

28. Efficacy tests for two CR fiber formulations containing diquat are still in progress. Standard diquat is being tested for reference. After 10 weeks, formulation 9337-77-2-1 had produced 100 percent control

of hydrilla at a 0.25-mg/ℓ dose rate (Table 3). Only 4 weeks were required for 100 percent control at the 2.0-mg/ℓ rate. The lower rates of 9337-79-4-1 were not effective after 10 weeks; however, a 1.0-mg/ℓ rate produced 100 percent control in 10 weeks. Standard diquat produced 100 percent control in 8 weeks at a 0.25-mg/ℓ dose rate, after 6 weeks at 0.5-and 1.0-mg/ℓ dose rates, and after 4 weeks at the 2.0-mg/ℓ dose rate.

29. Krenite and Norflurazon were not effective at the 2.0-mg/ℓ rate after 8 and 22 weeks, respectively (Table 4).

30. Three copper formulations from Stoller Chemical Company were found to be ineffective against hydrilla at dose rates up to 2.0-mg/ℓ after 8 weeks. The reference copper, copper EDA, effected 100 percent control by the fourth week at the 2.0-mg/ℓ dose rate (Table 4).

31. Three CR formulations of the dipotassium salt of endothall (7310-142-1, 7310-142-2, and 7310-142-3), four blank formulations without herbicide (7310-135-1, 7310-135-2, 7310-135-3, and 7310-135-4), and a standard formulation of the dipotassium salt as a reference were evaluated against hydrilla.

32. Evaluation of 7310-142-1 has been completed. After 8 weeks the 2.0-mg/ℓ treatment was not effective. In contrast, the reference material produced 100 percent control at the same rate after 6 weeks (Table 3). Evaluations of the remaining experimental formulations are still in progress; after 6 weeks, none have been effective at the 2.0-mg/ℓ dose rate. However, the commercial formulation of endothall elicited 82 percent control at the above rate (Table 5).

33. Hydrilla was cultured in the usual manner with the addition of 0.2 mg/ℓ of commercial 12-6-6 liquid fertilizer plus 0.08 mg/ℓ of chelated iron. Cultures were also set up with the plants potted in a mixture of soil plus 10 percent dried cow manure. No additional nutrients were added to this second series.

34. Both cultures were treated with low rates of diquat to determine whether the method of culture would affect herbicidal efficacy. The highest concentration (0.04 mg/ℓ) did not produce injury to either

culture (Table 6).

35. Dry weights, obtained from the control plants after 14 weeks of growth, showed a nonsignificant 16 percent increase for hydrilla grown in the manure culture over the liquid fertilizer culture (Table 7).

Southern naiad

36. The additive SA-77, at a 12-mg/ℓ dose rate, was not effective. Only 49 percent control was reached after 8 weeks and regrowth was evident after 4 weeks (Table 3).

37. Both CR formulations of diquat were effective against naiad (Table 3). Only 2 weeks were required for 100 percent control with a 0.25-mg/ℓ dose rate of 9337-77-2-1, while 8 weeks were required for the same rate of 9337-79-4-1. The 0.5-mg/ℓ dose rate of this latter formulation required 4 weeks for complete control. The reference diquat also required 4 weeks for complete control at a rate of 0.25 mg/ℓ.

38. Krenite, Norflurazon, and the CR formulations of endothall were not effective against naiad at a 2.0-mg/ℓ rate (Tables 3 - 5). The standard dipotassium salt of endothall produced only 56 percent control after 6 weeks at a rate of 2.0 mg/ℓ.

39. Of the three copper formulations from Stoller Chemical Company, two were effective against naiad. A 0.5-mg/ℓ rate of 1579 and 2.0-mg/ℓ rate of 1979 both produced 97 percent control after 8 weeks. The non-coded formulation was not effective. The reference standard of copper EDA produced 99 percent control after 4 weeks at 1.0 mg/ℓ, while 100 percent control was reached after 4 weeks at a 2.0-mg/ℓ rate (Table 4).

40. In the comparative test with diquat against naiad cultured with soil plus liquid fertilizer and soil plus cow manure, it appears that the plants grown in the latter medium are more resistant to the herbicide. After 9 weeks, as little as 0.01 mg/ℓ of diquat produced 90 percent control of the naiad cultured with soil plus liquid fertilizer while the 0.02-and 0.03-mg/ℓ rates effected 98 and 100 percent control, respectively. In contrast, the two lower rates were not effective against plants cultured with the soil/manure mixture, and 0.03-mg/ℓ treatments produced only 77 percent control after 11 weeks (Table 3).

There was a nonsignificant increase in dry weight of the control plants cultured with manure over the control plants cultured with the liquid fertilizer (Table 7).

<u>Watermilfoil</u>

41. The threshold injury level for SA-77 against watermilfoil appears to be a concentration between 10 and 12 mg/ℓ, which produced 88 and 100 percent control, respectively, after 8 weeks (Table 3).

42. There was no difference in efficacy between the two CR formulations of diquat and the standard formulation. All three materials produced 100 percent control of milfoil at a rate of 0.25 mg/ℓ after 4 weeks (Table 3).

43. The 7310-142-1 SRRC formulations of endothall produced 63 to 87 percent control after 8 weeks at a rate of 0.5 mg/ℓ. The same rate of the reference endothall gave complete control in 8 weeks. Only 2 weeks were required for 1.0 mg/ℓ of the reference endothall to produce 100 percent control (Table 3). In a second test, which is still in progress, the formulation 7310-142-2 produced 100 percent control at a 0.5-mg/ℓ rate after 6 weeks and at a 1.0-mg/ℓ rate after 4 weeks. Formulation 7310-142-3 was faster acting and comparable to the reference material; both produced complete control at a rate of 0.5 mg/ℓ in 2 weeks (Table 5).

44. Nonherbicide blank formulations are also being evaluated in this second test. Concentrations of metallic ions in the blanks are equal to the ion concentrations produced by the herbicide-loaded formulations containing a 2.0-mg/ℓ dose rate of the endothall acid. There was apparent toxicity toward milfoil from the various blanks since 18 to 23 percent control resulted from the blank treatments (Table 5).

45. Milfoil plants cultured in soil plus liquid fertilizer were complete controlled by 0.01 mg/ℓ of diquat after 8 weeks and by 0.03 mg/ℓ after 3 weeks. Plants cultured in the soil plus manure mixture were more resistant to diquat since the 0.03-mg/ℓ dose rate only produced 88 percent control in 11 weeks and a 0.04-mg/ℓ does rate only produced 90 percent control by 7 weeks. Growth of the control plants was much

more luxurious in the soil/manure mixture. The dry weight increase for these plants was 133 percent as compared to the plants grown with the addition of liquid fertilizer (Table 7).

46. A confidential compound from Kalo Laboratories was very effective against milfoil. While a 0.25-mg/ℓ dose rate produced 99 percent control in 4 weeks, regrowth was rapid. However, the 0.5-mg/ℓ rate provided 100 percent control in the same time period (Table 8).

47. Ten experimental and standard formulations of fenac were evaluated against milfoil. All were 100 percent effective at rates of 0.25 mg/ℓ after 4 to 6 weeks. The fenac ferric salt (NB 1094-60) produced 100 percent control within 2 weeks at the 0.5-mg/ℓ rate (Table 8).

48. A CR polymer formulation of 2,4-D produced 97 percent control of milfoil after 10 weeks at a rate of 4.0 mg/ℓ (Table 9). Another CR formulation incorporating lignin (polycyclic aromatic compounds in wood) and 2,4-D produced 100 percent control after only 4 weeks at a dose rate of 1.0 mg/ℓ and after 8 weeks at a 0.5-mg/ℓ rate (Table 8).

49. Two floating CR formulations of 2,4-D (7310-119-1 and 7310-119-2) both produced complete control of milfoil after 6 weeks at a 1.0-mg/ℓ dose rate. Since these formulations were packed in water, a repeat test was initiated 8 months later to determine if there had been any loss of active material into the packing medium. Both formulations and the reference formulation were equally effective at the 0.5-mg/ℓ rate, producing 100 percent control in 4 weeks (Table 9). The experimental materials had not lost their potency but had lost their CR capabilities.

50. Two sinking formulations of 2,4-D were also evaluated, 7310-113-1 and 7310-113-2. Both of these compounds produced complete control of milfoil after 6 weeks at a 2.0-mg/ℓ rate and after 8 weeks at a 1.0-mg/ℓ rate (Table 9).

Cabomba

51. Krenite, at 2.0 mg/ℓ, was completely ineffective against cabomba after 8 weeks (Table 4).

52. Norflurazon produced little damage to the test plants at a dose rate of 2.0 mg/ℓ after 22 weeks (Table 4). However, from the beginning of the test through termination there was a sustained loss of chlorophyll in the meristematic area. No other injury was evident.

53. None of the Stoller copper formulations nor the copper EDA used for reference were effective against cabomba at dose rates up to 2.0-mg/ℓ (Table 4).

54. The 7310-142-2 and 7310-142-3 CR formulations of endothall have not produced any evidence of phytotoxicity toward cabomba after 6 weeks at dose rates of 2.0 mg/ℓ (Table 5). This test, however, is still in progress.

55. Diquat, at dose rates up to 0.04 mg/ℓ, had no phytotoxic effect on cabomba that was cultured in soil plus liquid fertilizer or soil plus manure (Table 6). However, far better growth of the plants cultured with the manure medium was observed. Dry weight comparisons of the control plants showed a significant 200 percent increase in plant material from the soil/manure cultures over the soil/liquid fertilizer cultures (Table 7).

56. Rates as high as 4.0 mg/ℓ of the confidential compound from Kalo Laboratories were not effective against cabomba (Table 8).

57. None of the 10 fenac formulations were totally effective against cabomba. The highest level of control, 82 percent, was achieved with 2.0 mg/ℓ of the fenac potassium salt (AL 3589) after 8 weeks (Table 8).

58. The CR formulation of 2,4-D with lignin produced only 38 percent control at a 4.0-mg/ℓ dose rate after 10 weeks (Table 8).

Chara

59. The additive SA-77 at a 12-mg/ℓ dose rate produced 72 percent control after 2 weeks (Table 3). Regrowth began 3 weeks after treatment.

60. Only one of the Stoller copper compounds (Copper DET 1579) had an effect on chara, producing 75 percent control at a 2.0-mg/ℓ dose rate after 8 weeks. Treatment with the reference copper (Copper EDA) at a 1.0-mg/ℓ rate resulted in 100 percent control in the same time period (Table 4).

61. Evaluation of the following compounds at dose rates to 2.0 mg/ℓ against chara either have been completed or are currently in progress: Krenite, Norflurazon (Table 4), three CR formulations, a standard formulation of endothall for reference (Tables 3 and 5), and two CR fiber formulations of diquat and liquid diquat for reference (Table 3). None were effective during the first 6 weeks.

Waterhyacinth

62. The CR formulation of 2,4-D based on lignin produced 97 percent control after 6 weeks at a 4.0-kg/ha rate. However, regrowth was evident after 10 weeks. Stauffer's R-24191 effected 100 percent control after 6 weeks at a 4.0-kg/ha dose rate.

63. Both Krenite and Norflurazon at a 4.0-kg/ha dose rate (Table 10) were totally ineffective against waterhyacinth. The two floating CR formulations of 2,4-D (7310-119-1 and 7310-119-2) were not effective after 12 weeks at dose rates up to 4.0 kg/ha.

64. Six experimental formulations of fenac were previously found to be effective against hyacinth at rates as low as 1.0 kg/ha. These compounds were rerun at lower rates. Fenac liquid (A 70316) produced 99 percent control after 4 weeks at the 0.5-kg/ha dose rate while fenac plus (A 08563) effected 98 percent control after 4 weeks at a dose rate of 0.1 kg/ha. Control with fenac + dicamba (AL 3591) reached 100 percent after 8 weeks at a dose rate of 0.5 kg/ha. The fenac potassium salt (AL 3589) produced 98 percent control after 6 weeks at a 1.0-kg/ha dose rate. Regrowth with the latter treatment began after 10 weeks. The fenac potassium/sodium salt (77-A-599) and the fenac sodium salt produced ratings of 91 and 85 percent, respectively, after 4 weeks at a dose rate of 1.0 kg/ha. Regrowth was present in both treatments by the sixth week.

65. The CR fiber formulations of diquat (9337-77-2-1 and 9337-79-1B-1) were applied to the water column below the plant roots. Similar applications were made with the standard formulation of diquat for reference. Foliar applications of the standard diquat formulation were also made for comparison. Rates of 1.0, 2.0, and 5.0 kg/ha were

used for the water column treatments and 0.5, 1.0, and 2.0 kg/ha for the foliar treatments.

66. Water column application of fiber formulation 9337-77-2-1 and the reference material were equally effective when applied at a 1.0-kg/ha dose rate. Both resulted in complete control by the tenth week. The 2.0-kg/ha treatment rate of the fiber formulation produced a slower response than the corresponding reference treatment; the fiber formulation required 10 weeks for total control compared to 4 weeks for the standard formulation. However, the high treatment rate of 5.0 kg/ha produced 100 percent control in 4 weeks for both the experimental and reference treatments. Fiber 9337-79-1B-1 was not as effective as its counterpart since 8 weeks was required for 100 percent control at a 5.0-kg/ha rate. The lower rates of 1.0 and 2.0 kg/ha produced 73 and 99 percent control, respectively, after 10 weeks.

67. In contrast to the above water column treatment, which required considerable time and higher application rates for complete control, the foliar applications produced the desired result in 4 weeks at a 0.25-kg/ha rate and 2 weeks at a 2.0-kg/ha rate.

Waterlettuce

68. Both the Kalo material and Krenite were not effective on waterlettuce at treatment rates of 4.0 and 6.0 kg/ha, respectively (Table 11). Norflurazon, at 4.0 kg/ha, produced 100 percent control by 8 weeks. After 10 weeks, 98 percent control was reached for the 2.0-kg/ha treatment rate.

Duckweed

69. Duckweed showed no evidence of phytotoxicity from treatment with either the Kalo compound or Krenite at applications of 4.0 kg/ha (Table 12). Norflurazon, at a 4.0-kg/ha dose rate, produced 92 percent control by the eighth week.

Torpedograss

70. The Kalo product at 4.0 kg/ha and Krenite at 6.0 kg/ha were not effective against torpedograss (Table 13). Norflurazon at a rate of 6.0 kg/ha produced only 28 percent injury to the plants after 10 weeks.

Beyond 10 weeks, regrowth occurred rapidly.

Paragrass

71. Phytotoxic response was not shown by paragrass to treatment rates of 6.0 kg/ha for Krenite and 4.0 kg/ha for the compound from Kalo Laboratories (Table 14). Norflurazon was moderately toxic to paragrass at a 6.0-kg/ha rate. The herbicidal action was slow. Approximately 16 weeks was required for 88 percent control.

Alligatorweed

72. After 6 weeks, the Kalo product produced 95 and 97 percent control of alligatorweed at 2.0- and 4.0-kg/ha rates, respectively (Table 15). Plant damage was very rapid between the first and second weeks; thereafter, herbicidal activity was much slower.

Outside Aquaria Evaluations

73. Applications of 2.0- and 4.0-kg/ha rates of the Kalo compound to waterhyacinth in outside aquaria produced 98 and 100 percent control, respectively, after 10 weeks (Table 16). By the fourteenth week, regrowth was evident in the 2.0-kg/ha treatments.

74. Metribuzin, at 2.0 kg/ha, effected 99 percent control after 6 weeks. After 10 weeks, the 1.0-kg/ha rate was nearly as effective, producing 98 percent control.

Field Evaluations

Lake evaluation of fenac for hydrilla control

75. A 4.1-ha surface area of Tigertail Lake (Broward County, Florida) was treated in November 1977 with 2 mg/ℓ granular fenac. The control level of hydrilla reached 100 percent by the eleventh month. Complete control continued until the termination of the test at 18 months. At that time, a thorough check of the lake using SCUBA revealed no regrowth (Table 17).

Small pond evaluations of hexazinone and fenac plus copper TEA for hydrilla control

76. Hexazinone and fenac plus copper triethanolamine (copper TEA) treatments were evaluated for the control of hydrilla in three small ponds near Tampa, Florida, in November 1978. The purpose of this

investigation was to determine phytotoxic effects of the treatments and the fate of the herbicides in the water, plants, and aquatic sediments. Temperature, pH, dissolved oxygen (DO), Secchi disk transparency, and herbicide efficacy were monitored during the study. Tables 18 - 21 include field evaluation information concerning the treatments with hexazinone and fenac plus copper TEA. Data for the control pond can be found in Table 22.

77. Temperature. There was little difference in water temperature among the three ponds (Figure 1) because of their close proximity. The average water temperature distributions representing top, middepth, and bottom levels for all ponds were similar and varied seasonally. The ponds were thermally stratified from the day of treatment until the fourth week posttreatment (mid-December), after which time winter mixing was complete and uniform water temperatures existed throughout each pond. By mid-February (3 months posttreatment), stratification was again evident.

78. pH. The pH values over the 7-month period followed the same general trend for both treated ponds and control pond (Figure 2). The relatively low pH values for Ponds No. 1 and No. 2 during the first 2 weeks, as compared to the control pond, may be due to the effect of the treatments. Any interference in plant metabolism would reduce the uptake of CO_2 by the plants and result in a low pH. The rapid drop in pH of Pond No. 2 could be attributed to the addition of copper that may have formed insoluble basic copper carbonates, thus lowering the pH (Hutchinson 1957).

79. Dissolved oxygen. The DO was depressed almost immediately after the herbicide treatments (Tables 18, 20, and 22). In Pond No. 2 (Table 20), which was treated with fenac plus copper TEA, the DO dropped approximately1.5 mg/ℓ for each sampling depth within the first 6 hr and to 2 to 3 mg/ℓ after the first day. The DO was reduced to zero at all depths after 1 week. In Pond No. 1 (treated with hexazinone) (Table 18) the DO levels dropped by nearly 13 mg/ℓ at the surface and 1 mg/ℓ at middepth during the first day. There was no measurable DO near the

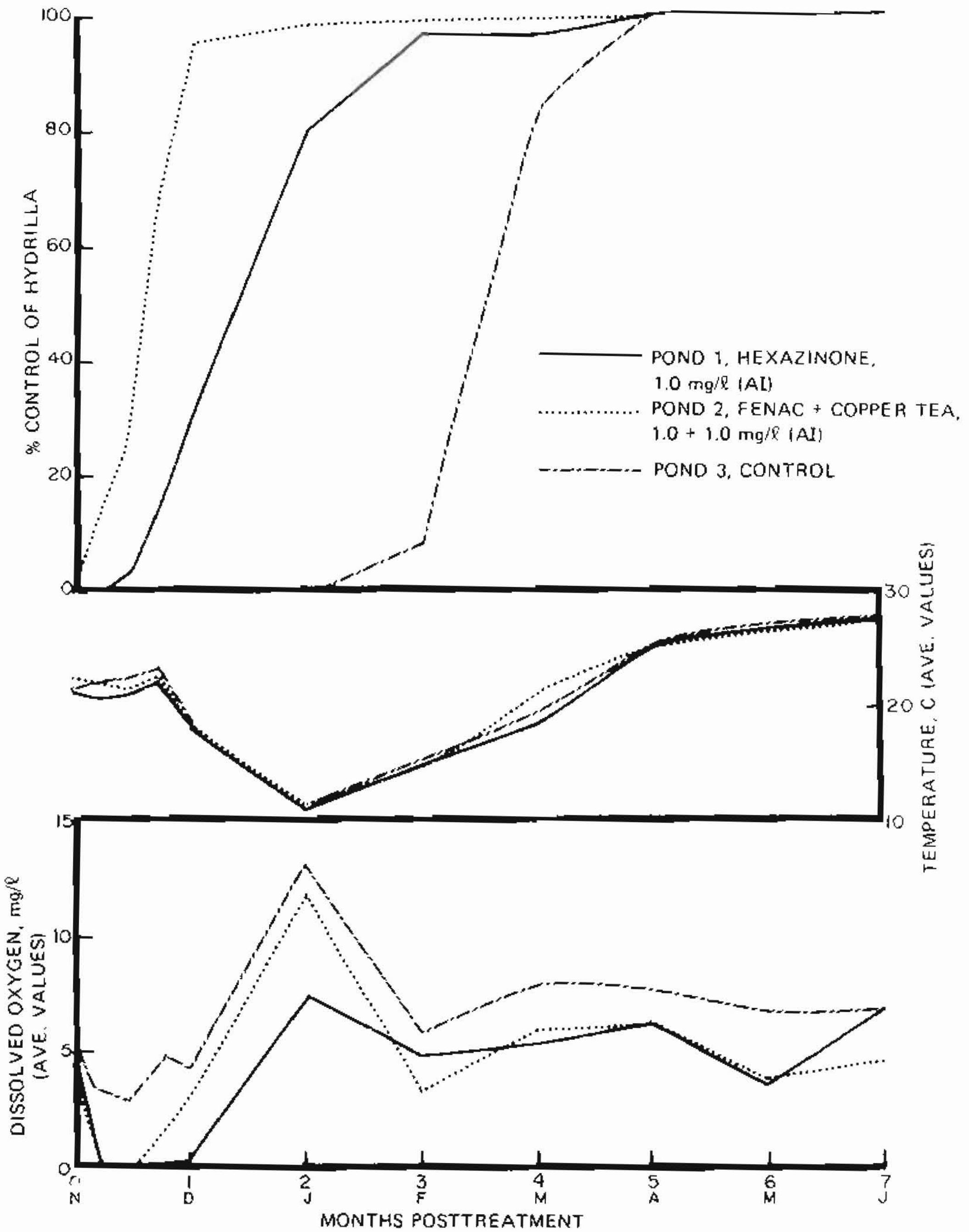

Figure 1. Dissolved oxygen, temperature, and percent control of hydrilla for three ponds in Florida

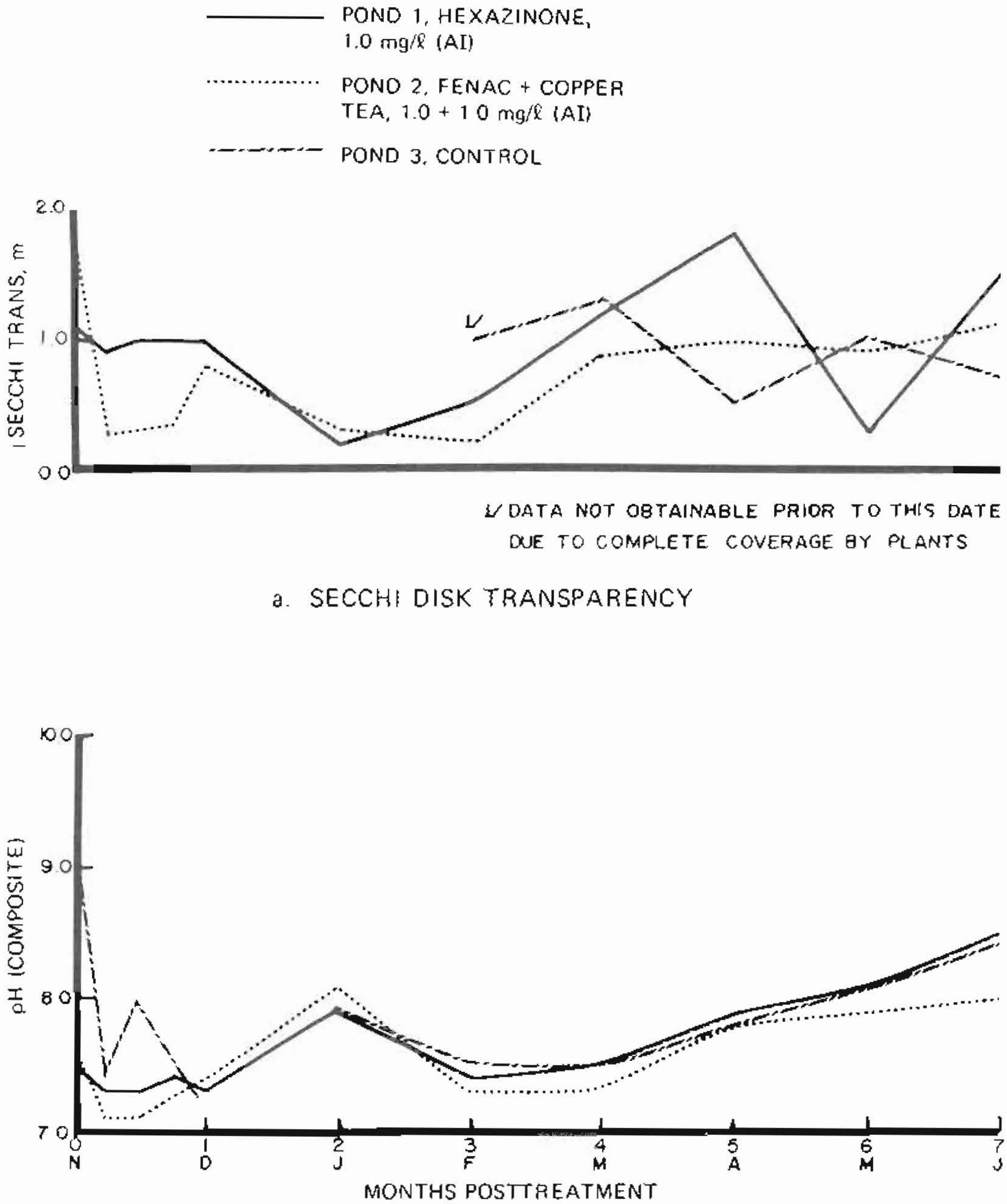

Figure 2. Secchi disk transparency and pH for three ponds in Florida

bottom prior to treatment. By the first week, DO levels were also zero in this pond to all depths. The DO levels in the control pond (Table 22) also dropped radically in the mid and bottom depths during the first and second weeks. During the first week, the DO levels for the surface was 8.0 mg/ℓ while the mid and bottom DO levels were 1.1 and 0.9 mg/ℓ, respectively.

80. The cloud cover had begun to clear around 1200 hr and by 1350 (when the DO samples were collected) the sky was clear. The observed variability could be attributed to the amount of light available for photosynthesis at the different water levels. Thus, the surface of the control pond would have received enough light to be above the compensation point and to have produced a higher level of DO. However, under the reduced light conditions at the lower depths, oxygen consumption from organic respiration and decomposition would be greater than photosynthetic production and thus would account for the low DO levels. During the second and third weeks, the mornings were clear with resultant higher levels of DO at the lower depth. Cloud cover during the early morning of the fourth week of sampling supressed DO levels slightly. Van, Haller, and Bowes (1976) have stated that: (a) the light penetration through a hydrilla mat is small; (b) the bulk of photosynthesis activity occurs between sunrise and noon; and (c) net photosynthesis in the afternoon is very low. Haller and Sutton (1975) reported a 95 percent reduction in light at a depth of only 0.33 m in a hydrilla mat.

81. The DO began to return in Pond No. 1 (Table 18) by the third week and had reached staisfactory levels (>7 mg/ℓ) by the end of the second month. In Pond No. 2 (Table 20), acceptable DO levels were present by the fourth week. The ponds had completely mixed during the fall destratification (4 weeks after treatment), providing a relatively uniform DO content throughout the ponds. The DO supersaturation levels measured in Ponds No. 2 and No. 3 (which were considerably more shallow than Pond No. 1) were aided by the falling ambient temperatures that increased the oxygen solubility in the water. It should also be noted that the highest DO concentrations occurred during the second month

when the water temperatures were the lowest (Figure 1).

82. Continued removal of hydrilla in the treated ponds had no further effect on the DO, which remained at levels comparable to those in the control pond after the second month.

83. The DO levels were higher in Pond No. 1 two months after the initial treatment than they had been prior to treatment. Presumably, the removal of vegetation from the deeper areas reduced respiratory loss of DO and increased photosynthetic DO production by allowing greater light penetration to the remaining plants.

84. The loss of DO during the first week produced partial fish kills in Ponds No. 1 and No. 2. At the time observations were made, only seven 10-to 18-cm dead fish were seen (one bass, *Micropterus salmoides* (Lacepded), and six bluegill, *Leponix macrochirus* (Rafinesque). However, these had been dead several days and were partially eaten by numerous gulls that had moved into the area. In Pond No. 2, approximately 30 dead fish (bass, bluegill, and catfish, *Ictalurus* sp.) were noted. There were also several small blugill in obvious distress. Many of these fish were also being consumed by the gulls. In the control pond, over 40 dead shad were seen floating on the surface. More were probably entangled in the dense vegetation. No other species were observed. Although DO levels were sufficiently low to kill these fish at the time of observation, the fish had been dead several days. There could have been much lower DO levels during the preceding week since DO levels had been decreasing during the previous 2 weeks (Table 22).

85. Secchi disk transparency. Secchi disk transparency for Pond No. 1 remained relatively stable at 1.0 m for the first 4 weeks (Table 19). Thereafter, through the second month, as decomposition of hydrilla increased, the Secchi transparency decreased (Figure 2). By the third month most of the hydrilla (97 percent) was gone. Water clarity began to improve to the point where it surpassed the pretreatment conditions. The low Secchi transparency (0.3 m) at 6 months resulted from roadway runoff 2 weeks after a 43-cm rainfall. Barricades blocking the connection of Pond No 2 caused Pond No. 1 to overflow its banks.

86. In Pond No. 2, plant decomposition (15 percent by the first week) occurred much sooner than in Pond No. 1, with a resultant lowering of water clarity (Table 21, Figures 1 and 2). The transparency remained low until the fourth month when Secchi disk transparency values reached 1.0 m, which was similar to the control pond (Table 23). Since the interpond connections were blocked, Ponds No. 2 and No. 3 rose only slightly and received no direct contamination from the roadways. Also, the small watersheds for these ponds were heavily grassed. Thus, there was little external silt added to the ponds, and no reduction in water clarity was observed following heavy rainfall.

87. Due to the solid mat of vegetation in the control pond, no Secchi disk transparency readings were obtained for the first 2 months. By the third month, the plants had dropped so that readings were obtainable. The water clarity of this pond tended to fluctuate inconsistently near the 1-m depth (Figure 2).

88. Herbicidal efficacy on hydrilla. At 1 week posttreatment, herbicidal effects of hexazinone were evident in Pond No. 1. The top few centimetres of hydrilla were flaccid and an oily film had appeared on the water surface. By the end of the second week, turbidity had decreased significantly. After 3 weeks, the plants had begun to sink and control was estimated at 15 percent (Table 18). By the end of the second month, there was very little hydrilla left on the surface and 80 percent control was achieved. At 3 months posttreatment (97 percent control), only small amounts of nearly colorless hydrilla were found on the bottom. However, new growth was evident on some of the dying material. At 5 months posttreatment, 100 percent control of hydrilla was achieved. After 7 months, propagule regrowth was evident in the shallow area near the south shore.

89. Herbicidal effects were more rapid in Pond No. 2 (fenac plus copper TEA treatments); control was estimated at 15 percent (Table 20) by the end of the first week. At that time, the hydrilla had dropped to the bottom, and an oily film was present on the water surface. Approximately 70 percent control was achieved by week 3, 95 percent by

week 4, and 100 percent by month 4. No evidence of regrowth was found during the 7-month sampling period.

90. During the first 2 months both hydrilla and chara were healthy in the control pond. However, by the third month the hydrilla had dropped 30 to 90 cm. While the chara still appeared healthy, the hydrilla plants were losing chlorophyll and leaves. Plant damage jumped from 8 percent at 3 months to 85 percent at 4 months (Table 22). At that time, the remaining hydrilla were flaccid, yellowish in color, and losing leaves, while the remaining chara were white and nearly decomposed. Neither hydrilla nor chara were present at 5 and 7 months posttreatment. No explanation is available for this sudden decline of hydrilla and chara.

91. Herbicidal efficacy on cattail. Damage to cattail did not appear in Pond No. 1 until the second week. Thereafter, there was a relatively rapid increase in control (Table 18) through the second month (85 percent) when nearly 100 percent control of the cattails originally exposed to the treated water was achieved. However, those plants near the shoreline, which had been on dry ground until the previous month, were showing very little evidence of injury. Between the second and third months, the newly flooded cattails were producing new growth, and the control rating was correspondingly reduced to 80 percent. Plant rhizomes originally exposed to the herbicide were beginning to slough off and float to the surface. After 4 months the previous month's regrowth was showing evidence of phytotoxicity; by the seventh month, 100 percent control of the emergent plants was achieved. The few plants above the water level remained unaffected.

92. The response of cattail to fenac plus copper TEA was much slower. Three months was required for visible effects to appear (Table 20). Very little change was noted between the third and fourth months (10 and 12 percent, respectively); however, by the fifth month, the treatment response increased dramatically to 94 percent. Complete control (100 percent) of the cattails originally exposed to the treated water was achieved by the seventh month.

93. Summary of herbicidal efficacy. Herbicidal applications resulted in a decrease of DO from pretreatment levels to zero within the first week following treatment. This was a result of increased oxygen utilization during plant decomposition. Suppression of the DO continued until the third and fourth weeks following treatment. After recovery, the DO levels in the treated ponds were similar to the control pond.

94. Only small variations in pH among the three ponds were noted except during the first month after treatment. Reduced pH values during the first month may have resulted from the treatments.

95. Secchi disk transparency decreased as decomposition of the hydrilla increased. Water clarity improved by the third month, surpassing pretreatment levels.

96. Herbicidal efficacy of the hexazinone treatment was slower than the fenac + copper treatment since by the third week plant damage values were 15 and 70 percent, respectively. By the third month, there was little difference between the treatments; complete control was reached by both after 5 months.

97. Both compounds produced 100 percent control of emergent cattails growing in the ponds. Plant response was much faster in the pond treated with hexazinone. Nearly 100 percent control was achieved by the second month. The pond treated with fenac + copper required 3 months before effects were visible and 7 months before complete control was achieved.

PART IV: STATISTICAL COMPARISONS OF CR FORMULATIONS

98. The CR herbicide formulations have great potential for maintaining phytotoxic levels of herbicide in dynamic environments by slowly releasing a herbicide at prescribed rates for an extended time period.

99. As previously described, several experimental CR formulations containing 2,4-D were evaluated for efficacy toward watermilfoil. During these tests, it became apparent that conventional evaluation techniques were not adequate.

100. Herbicide efficacy is a function of: (a) the inherent susceptibility of the particular plant species; (b) the growth stage of the plant, e.g. immature stages are usually most susceptible; and (c) the environment in which the plant is growing. In the laboratory the susceptibility function may be investigated independently by exercising control over functions (b) and (c).

101. Selectivity and ultimately the efficacy of some chemicals is strongly related to dosage levels. A plant that is resistant at a low treatment level may be injured or killed at a higher level. For any one plant, under given controlled conditions, there is a certain concentration below which the response does not occur and above which it does occur. This value has often been called a threshold but the term tolerance is also widely accepted.

102. Because of inherent and environmental variability, this tolerance value will vary from one plant to another within a population. In other words, there will be a range of response among individuals at any given concentration.

103. In order to compare various formulations of the same herbicide or to make comparisons between herbicides, a reliable technique is needed for comparing plant response to herbicide concentration. Finney (1971) discussed techniques for statistical analysis of experimental dose-response data. Response data from the authors' evaluations of various CR formulations containing 2,4-D were subjected to modified probit analysis and regression analysis to determine the utility of this technique.

Procedure

104. For the statistical analyses, precent injury (response) data were transformed to probits, and exposure times were converted to logarithms. These data were then subjected to linear regression analysis. The regression equation ($y = a + bx$) was used to estimate the time required to produce 50 percent injury (LT_{50}) for each of the dose rates since this range has been determined to provide the most accurate estimate.

Discussion

105. The LT_{50}'s along with the slope b of the regression lines are useful statistics for comparing the various formulations. The slope measures variability of plant sensitivity to a given herbicide and dose. Where most plants are similarly affected, the slope is steep. Conversely, a gentle slope indicates a wide range of sensitivity to the particular herbicide dose. Moreover, the slope is a measure of response rate since it is a function of the change in ordinate units (response) produced by a change in abscissa units (time).

106. Plots of plant response with time at two treatment levels of a CR formulation are illustrated in Figure 3. The parallel regression lines of the two treatment levels in Figure 3 indicate that the response rates were essentially equal. The difference in magnitude of response between the two treatment levels is readily apparent.

107. Analyses of the response data from the bioassays of the various CR formulations are shown in Table 24. Response data from bioassays of two conventional 2,4-D formulations were included for comparison.

108. The minimum length of time to produce 50 percent injury appears to be in the range of 1 to 2 weeks. The maximum length of time required to produce this injury was estimated as 24 weeks for the reference 2,4-D acid at the 0.25-mg/ℓ treatment level. In general, the slopes of the regression lines at the lower dose rates were less steep than at the higher rates, indicating a greater degree of variability in individual plant response to the lower concentrations.

109. The LT_{50}'s and the slopes of the regression lines were

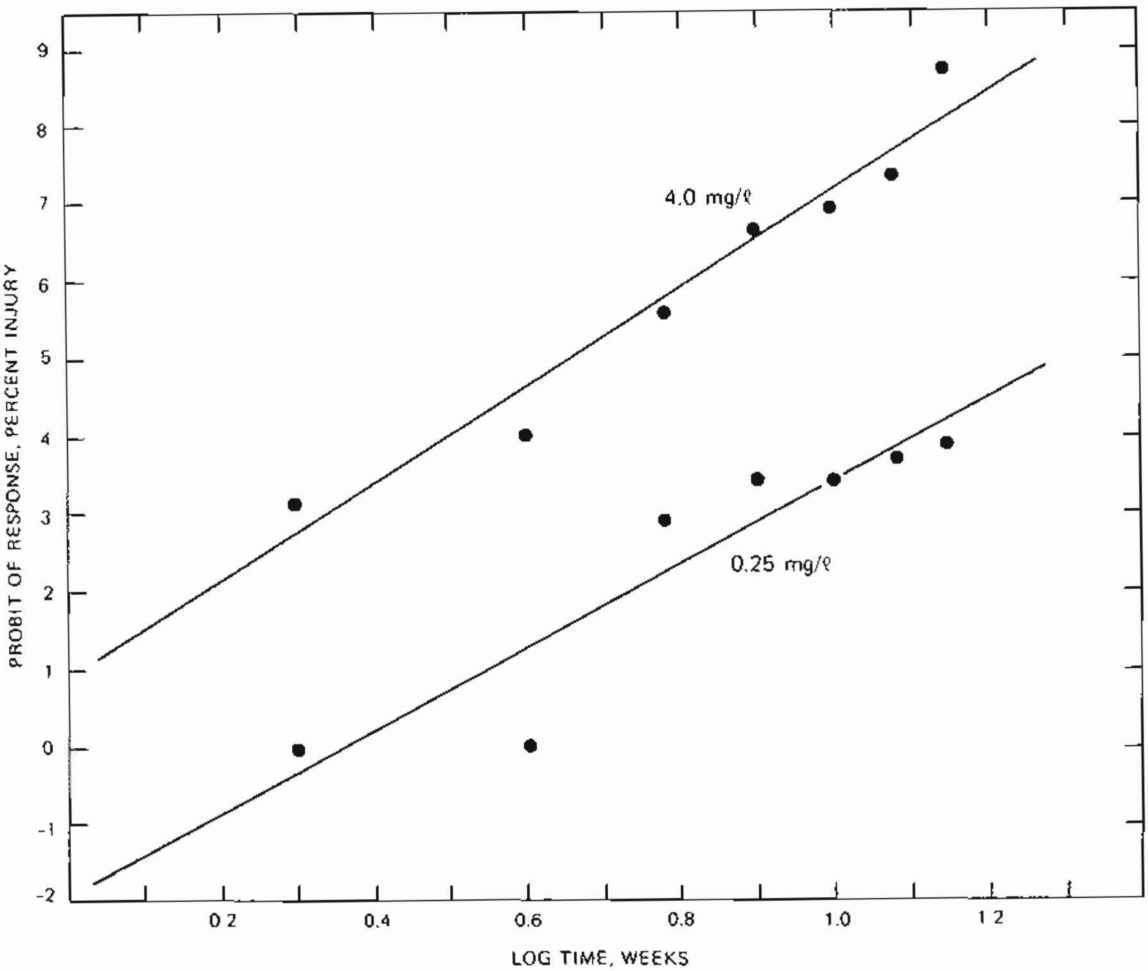

Figure 3. Watermilfoil response with time at two treatment levels of 2,4-D PolyAce polymer

arbitrarily retabulated in order to compare the various formulations. These data are presented in Tables 25 and 26.

110. The most rapid plant response was produced by the reference butoxyethanolester (BEE) formulation, and the slowest response was produced by the PolyAce CR formulation (Table 25).

111. These response data indicate that the threshold level of the BEE formulation of 2,4-D was near 0.25 mg/ℓ, and for the 2,4-D acid formulation the threshold level was greater than 1.0 mg/ℓ. None of the CR formulations released quantities of active 2,4-D sufficient to reach the threshold level when applied at dose rates of 0.25 mg/ℓ. Most CR formulations did release sufficient quantities of herbicide to exceed threshold levels when applied at dose rates of 1.0 mg/ℓ. The PolyAce polymer formulation released active 2,4-D very slowly since the estimated LT_{50}'s were considerably greater than for the other CR formulations and the reference 2,4-D acid formulation. In contrast, the lignin-based CR formulation released active herbicide quite rapidly since LT_{50}'s were comparable to the 2,4-D BEE reference formulation. The CR formulations from USDA's Southern Regional Research Center were intermediate in terms of response produced. These latter formulations were synthesized from a commercial preparation of the dimethylamine salt of 2,4-D. The PolyAce polymer was formulated from 2,4-D acid. The source of the 2,4-D for the lignin base formulation was not identified.

112. It is obvious that the phytotoxic response produced by CR formulations is affected by the chemical form of the active ingredient as well as by the rate of release of that ingredient from the formulation. In future tests, all CR formulations will be compared with the chemical formulation from which it was synthesized.

113. Inspection of data in Table 16 reveals that considerable variability in slope existed between formulations at individual dose levels as well as between dose levels within formulations. As mentioned earlier, slopes were steepest at higher dose levels, indicating a more uniform response to these higher rates.

114. Because of variability, comparison of regression data was difficult. Statistical techniques do exist, however, for comparing

the relative potency of various formulations through tests of parallelism of the regression lines. Unfortunately, the present data were inadequate for these tests.

Conclusions

115. Modified forms of probit and regression analyses should provide useful methodology for evaluating the efficacy of CR formulations for aquatic weed control. However, probit analyses are best utilized in what Finney terms "quantal" response, i.e. "all-or-nothing" response. Since plant response to herbicides is most often a gradual response, a third dimension (time) is introduced to the dimensions of response and dose rate. In order to best utilize these techniques, changes will need to be made in the evaluation techniques currently being used. The type and extent of these changes will include a broader range of concentrations, an increase in the number of individual plants used (larger sample size) to increase the accuracy of estimates, and possibly the reduction of periodic injury ratings to a single rating at a specific time.

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TABLE 1

Names and Sources Of Chemicals Evaluated In Fiscal Year 1979

Common Name	Chemical Name	Source
Copper DEA	Copper-Diethylene Triamine Complex	Stoller Chemical Company, Inc. AQUA-COP 8582 Katy Freeway Houston, Texas 77024
Copper EDA	Copper-Ethylenediamine Complex	Sandoz, Inc. (Komeen)
Copper TEA	Copper-Triethanolamine Complex	Sandoz, Inc., Crop Protection K-lox 480 Camino Del Rio South San Diego,California 92108
Diquat	6,7-dihydrodipyrido(1,2-a:2',1'-c) pyrazinediium dibromide	Chevron Chemical Company, Ortho Div. 940 Hensley Street Richmond, California 94804
Diquat 9337-79-1B-1 Diquat 9337-77-2-1 Diquat 9337-79-4-1	Controlled release formulation	Southern Research Insitute (SRI) 2000 Ninth Avenue South Birmingham, Alabama 35205
Endothall	Dipotassium salt of 7-oxabicyclo (2.2.1)heptane-2,3-dicarboxylic acid	Pennwalt Corporation Agricultural Chemical Division 1630 East Shaw Avenue Fresno, California 93710
Endothall 7310-142-1 Endothall 7310-142-2 Endothall 7310-142-3		USDA, SEA, SRRC* 1100 Robert E. Lee Boulevard P. O. Box 19687 New Orleans, Louisiana 70179

(continued)

* U. S. Department of Agriculture, Science and Education Administration, Southern Regional Research Center.

(Sheet 1 of 3)

TABLE 1 (continued)

Common Name	Chemical Name	Source
Fenac	Salts of 2,3 6-trichlorophenylacetic acid	Amchem Products, Inc. Agricultural Chemicals Div. Ambler, Pennsylvania 19002
Fenac 7310-172-1 Fenac 7310-172-2 Fenac 7310-172-3		USDA, SEA, SRRC
Hexazinone	3-cyclolhexyl-6(dimethylamino)-1-methyl-1,3,5-trizaine-2,4(1H, 3H)-dione	E. I. duPont de Nemours & Co. Biochemicals Department Wilmington, Delaware 19898
KL-218-0378	Confidential	Kalo Laboratories, Inc. 9233 Ward Parkway, Suite 150 Kansas City, Missouri 64114
Krenite	Ammonium Ethyl Carbamoylphos phonate	E. I. duPont de Nemours & Co.
Metribuzin	4-Amino-6-1(1,1-dimenthylethyl)-3-(methlythio)-1,2,4-triazin-5(4H)-one	E. I. duPont de Nemours & Co.
Norflurazon	4-Chloro-5-(Methylamino)-2-α, α, α-Trifluoro-m-Tolyl)-3 (2H)-Pyridazinone	Sandoz, Inc.
R-24191	Confidential	Stauffer Chemical Company Western Research Center Richmond, California 94804

(continued)

TABLE 1 (concluded)

Common Name	Chemical Name	Source
RO 3-7042	a-Amino-6-Methyl BEnzoic Acid	MAAG Agrochemicals Research and Development HLR Sciences, Inc. Kings Highway, P.O. Box X Vero Beach, Florida 32960
SA-77	d-limonene and an unspecified mix of emulsifiers	JBL International Chemicals, Inc. P. O. Box 457 Hialeah, Florida 33010
2,4-D	Dimethylamine salt of 2,4-dichlorophenoxy acetic acid	Thompson Hayward Chemical Co. P.O. Box 2383 Kansas City, Kansas 66110
2,4-D		University of Washington Seattle, Washington 98195
2,4-D PolyAce		Wright State University Dayton, Ohio
2,4-D 7310-113-1 2,4-D 7310-113-2 2,4-D 7310-119-1 2,4-D 7310-119-2		USDA, SEA, SRRC

(Sheet 3 of 3)

TABLE 2

Laboratory Evaluations of Various Herbicides for Phytotoxicity Toward Hydrilla Tubers, 1979

Date of Evaluations	Chemical Designation*	Company or Source*	Rate mg/l	Posttreatment Control, Percent** 2 days G	E	5 days G	E	1 wk G	E	2 wks G	E	3 wks G	E	4 wks G	E	5 wks G	E
10/4/78	Krenite	duPont	0.10	0	0	11	0	13	0	13	0	13	0	13	0	0	0
			0.20	0	0	0	0	13	0	13	0	13	0	13	0	0	0
			0.40	0	0	10	0	13	0	14	0	14	0	14	0	0	0
	Control			0	0	10	0	12	0	12	0	12	0	12	0	0	0
10/5/78	Norflurazon	Sandoz	0.10	0	0	9	0	12	1	13	1	13	2	13	5	13	7
			0.20	0	0	10	0	12	1	13	1	13	2	13	5	13	7
			0.40	0	0	10	0	13	2	14	2	14	3	14	7	14	10
			1.00	0	0	0	0	11	1	13	1	13	5	13	10	13	12
	Control			0	0	10	0	12	0	12	0	12	0	12	0	12	0

Chemical	Rate mg/l	Posttreatment Control, Percent 6 weeks G	E	7 weeks G	E	8 weeks G	E	9 weeks G	E	10 weeks G	E	11 weeks G	E	12 weeks G	E
Norflurazon	0.10	13	9	13	9	13	9	13	11	13	14	13	14	13	14
		3	9	13	10	13	10	13	11	13	13	13	13	13	13
		14	12	14	15	14	14	14	16	18	14	18	14	14	18
		13	14	13	20	13	21	13	24	13	24	13	24	9	24
Control		12	0	12	0	12	2	12	2	12	2	12	3	12	4

(continued)

* See Table 1 for complete information.

** G = Number germinated out of 15 total; E = Evaluation (percent injury).

TABLE 2 (concluded)

Date of Evaluations	Chemical Designation	Company or Source	Rate mg/l	Posttreatment Control, Percent																			
				2 days		5 days		1 wk		2 wks		3 wks		4 wks		5 wks		6 wks		7 wks		8 wks	
				G	E	G	E	G	E	G	E	G	E	G	E	G	E	G	E	G	E	G	E
7/17/79	RO 3-7042	MAAG	0.50	0	0	2	0	2	0	2	0	2	1	2	0	2	2	2	2	2	2	2	2
			1.00	0	0	4	0	4	0	5	0	5	1	5	1	5	2	5	2	5	2	5	4
			5.00	0	0	3	0	3	0	3	3	3	3	3	5	3	6	3	32	3	38	3	98
			10.00	0	0	3	0	4	0	4	3	3	3	3	25	4	28	4	38	4	45	4	97
			20.00	0	0	1	0	1	0	1	35	1	12	1	58	1	58	1	58	1	58	1	68
	Control			0	0	3	0	3	0	3	0	3	0	3	0	3	0	3	1	3	4	3	4
8/03/79†	7310-172-1	SRCC	0.10	16	0	18	0	18	2	18	40	18	42	18	43	18	50	18	58				
			0.25	19	0	19	0	19	10	19	67	19	67	19	74	19	95	19	97				
			0.50	17	0	18	2	18	15	18	88	18	88	18	95	18	98	18	99				
	7310-172-2	SRCC	0.10	19	0	20	1	20	2	20	2	20	3	20	4	20	7	20	8				
			0.25	18	0	18	2	18	5	18	42	18	44	18	52	18	68	18	82				
			0.50	17	0	17	2	17	7	17	62	17	62	17	70	17	95	17	98				
	7310-172-3	SRCC	0.10	19	0	19	1	19	1	19	2	19	9	19	13	19	32	19	42				
			0.25	18	0	19	2	19	2	19	38	19	40	19	57	19	94	19	96				
			0.50	19	0	19	2	19	7	19	70	19	71	19	92	19	99	19	99				
	Fenac Liquid		0.10	18	0	19	1	19	1	19	3	19	3	19	12	19	26	19	42				
			0.25	18	0	18	2	18	10	18	53	18	43	18	82	18	93	18	97				
			0.50	19	0	19	3	19	20	19	87	19	88	19	91	19	98	19	99				
	Control			19	0	20	0	20	0	20	0	20	0	20	0	20	0	20	0				

† 20 tubers total.

TABLE 3

Laboratory Evaluations of Various Herbicides for Phytotoxicity Toward Combined Hydrilla (H), Naiad (N), Chara (CR), and Milfoil (M), 1979

Date of Evaluation	Chemical Designation*	Company or Source*	Rate mg/l	Posttreatment Control, Percent: 2 weeks H	2 weeks N	2 weeks CR	2 weeks M	4 weeks H	4 weeks N	4 weeks CR	4 weeks M	6 weeks H	6 weeks N	6 weeks CR	6 weeks M	8 weeks H	8 weeks N	8 weeks CR	8 weeks M
8/18/78	SA-77	JBL	0.25	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	12
			0.50	0	0	0	0	0	0	0	1	0	0	0	3	0	0	0	15
			1.00	0	0	0	0	0	0	0	1	0	0	0	10	0	0	0	20
			2.00	0	0	0	0	0	0	0	2	0	0	0	12	0	0	0	12
			4.00	0	0	0	0	0	0	0	4	0	0	0	17	0	0	0	32
			6.00	0	1	0	0	1	0	0	5	0	0	0	18	0	0	1	25
			8.00	5	3	4	3	6	4	5	7	8	8	11	20	7	9	12	25
			10.00	7	7	7	7	12	13	14	41	11	14	52	93	8	12	62	88
			12.00	65	25	72	14	53	48	73	58	55	47	65	82	46	49	61	100
	Control			0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1
3/09/79	7310-142-1 (Endothall)	SRRC	0.50	0	1	0	2	1	1	1	10	0	1	1	50	1	2	1	63
			1.00	0	1	0	35	1	1	0	53	1	9	1	73	1	28	1	80
			2.00	0	1	2	45	0	1	2	65	1	1	1	85	1	1	1	87
	Endothall (Potassium)	SRRC	0.50	0	0	1	77	3	1	1	88	6	1	1	99	18	1	1	100
			1.00	6	0	1	100	43	1	0	100	80	2	1	100	93	4	1	100
			2.00	58	1	0	100	85	2	0	100	100	2	2	99	100	5	0	100
	Control			0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	6

(continued)

* See Table 1 for complete information.

TABLE 3 (concluded)

Date of Evaluation	Chemical Designation	Company or Source	Rate mg/l	Posttreatment Control, Percent: 2 weeks H	N	CR	M	4 weeks H	N	CR	M	6 weeks H	N	CR	M	8 weeks H	N	CR	M
6/18/79	9337-77-2-1 (Diquat)	SRI	0.25	3	100	0	48	64	100	0	100	87	100	0	100	99	100	0	100
			0.50	6	99	0	55	63	100	0	100	95	100	0	100	100	100	0	100
			1.00	28	100	0	47	83	100	0	100	99	100	0	100	100	100	0	100
			2.00	12	99	0	48	100	100	2	100	100	100	5	100	100	100	10	100
	9337-79-4-1 (Diquat)		0.25	0	67	0	32	0	72	1	100	0	93	0	100	0	100	1	100
			0.50	0	95	0	45	2	100	0	100	15	100	0	100	33	100	0	100
			1.00	0	85	0	40	50	100	0	100	96	100	0	100	100	100	0	100
			2.00	1	99	0	48	57	100	33	100	92	100	35	100	100	100	35	100
	Diquat		0.25	1	99	0	57	45	100	0	100	78	100	0	100	100	100	100	100
			0.50	4	100	0	53	87	100	33	100	100	100	33	100	100	100	100	34
			1.00	35	99	0	62	98	100	0	100	100	100	0	100	100	100	100	0
			2.00	32	99	0	55	100	100	3	100	100	100	5	100	100	100	100	5
	Control			0	0	0	2	0	0	5	0	0	0	0	5	0	0	0	0

Chemical Designation	Company or Source	Rate mg/l	10 weeks H	N	CR	M
9337-77-2-1 (Diquat)	SRI	0.25	32	100	0	100
		0.50	100	100	0	100
		1.00	100	100	0	100
		2.00	100	100	5	100
9337-79-4-1 (Diquat)		0.25	0	100	1	100
		0.50	11	100	0	100
		1.00	100	100	0	100
		2.00	100	100	35	100
Diquat		0.25	100	100	0	100
		0.50	100	100	34	100
		1.00	100	100	0	100
		2.00	100	100	2	100
Control			0	0	0	45

TABLE 4

Laboratory Evaluations of Various Herbicides for Phytotoxicity
Toward Combined Hydrilla (H), Naiad (N), Cabomba (C), and Chara (CR), 1979

Date of Evaluation	Chemical Designation*	Company or Source*	Rate mg/l	Posttreatment Control, Percent: 2 weeks H	N	C	CR	4 weeks H	N	C	CR	6 weeks H	N	C	CR	8 weeks H	N	C	CR	10 weeks H	N	C	CR
1/18/79	Krenite	duPont	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
			0.50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
			1.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
			2.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
	Control			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
	Norflurazon	Sandoz	0.25	1	1	3	0	5	1	5	0	6	2	5	0	6	2	5	0	6	2	5	0
			0.50	5	1	5	0	6	1	6	0	7	1	6	0	7	1	6	0	9	1	6	0
			1.00	6	1	2	0	7	1	3	0	7	1	3	0	7	1	4	0	8	1	6	0
			2.00	6	1	4	0	8	1	5	0	8	1	7	0	8	0	3	7	9	3	10	0
	Control			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date of Evaluation	Chemical Designation*	Company or Source*	Rate mg/l	12 weeks H	N	C	CR	14 weeks H	N	C	CR	16 weeks H	N	C	CR	18 weeks H	N	C	CR	20 weeks H	N	C	CR
	Norflurazon	Sandoz	0.25	6	3	12	0	6	3	13	0	5	2	21	0	6	2	27	0	6	4	33	1
			0.50	11	2	6	0	11	2	6	0	10	2	4	0	10	3	7	0	10	5	33	1
			1.00	8	2	12	0	8	2	13	2	6	3	12	0	7	2	16	0	7	3	22	0
			2.00	9	2	10	0	9	3	16	1	6	4	22	2	8	4	25	2	6	12	35	2
	Control			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date of Evaluation	Chemical Designation*	Company or Source*	Rate mg/l	22 weeks H	N	C	CR
	Norflurazon	Sandoz	0.25	13	4	65	1
			0.50	10	5	35	1
			1.00	7	4	30	0
			2.00	6	22	56	2
	Control			1	1	67	0

(continued)

* See Table 1 for complete information.

TABLE 4 (concluded)

Date of Evaluation	Chemical Designation	Company or Source	Rate mg/l	Posttreatment Control, Percent															
				2 weeks				4 weeks				6 weeks				8 weeks			
				H	N	C	CR	H	N	C	CR	H	N	C	CR	H	N	C	CR
4/24/79	Copper DET** 1579	Stoller	0.25	0	1	0	0	0	6	1	0	0	8	3	0	0	10	7	1
			0.50	38	3	0	0	30	95	1	0	20	95	2	2	15	97	2	5
			1.00	47	94	0	0	42	98	0	3	20	100	2	3	13	100	8	8
			2.00	62	86	0	2	68	99	3	10	57	100	14	63	50	100	9	75
	Copper DET 1979	Stoller	0.25	0	1	0	0	0	6	1	0	0	12	1	0	0	42	6	3
			0.50	4	4	0	0	4	15	1	1	2	23	12	2	4	52	12	5
			1.00	6	4	0	1	7	20	1	1	7	17	3	2	5	68	4	8
			2.00	32	14	0	2	43	30	0	2	37	97	3	3	52	97	6	15
	Copper DET	Stoller	0.25	0	1	0	1	0	5	2	1	0	7	12	2	1	40	12	3
			0.50	2	2	0	2	3	6	0	2	4	35	26	4	4	38	26	5
			1.00	4	3	0	1	9	32	1	3	7	45	7	3	7	73	6	8
			2.00	17	3	0	2	53	30	1	2	43	80	7	5	38	90	11	15
	Copper EDA†	Sandoz	0.25	3	3	0	1	3	27	0	1	1	42	2	2	5	37	11	22
			0.50	68	5	0	12	90	25	1	34	83	40	3	62	69	37	4	68
			1.00	87	97	0	20	93	99	1	70	90	97	4	82	85	92	4	100
			2.00	98	98	1	27	100	100	1	91	100	100	8	98	100	100	16	100
	Control			0	0	0	0	0	0	0	0	0	1	6	1	0	1	32	1

** Copper diethylene triamine.
† Copper ethylenediamine as Komeen.

TABLE 5

Laboratory Evaluations of Various Herbicides for Phytotoxicity
Toward Combined Hydrilla (H), Naiad (N), Milfoil (M), Cabomba (C), and Chara (CR), 1979

Date of Evaluation	Chemical Designation*	Company or Source*	Rate mg/l	Posttreatment Control, Percent														
				2 weeks					4 weeks					6 weeks				
				H	N	M	C	CR	H	N	M	C	CR	H	N	M	C	CR
7/26/79	7310-142-2 (Endothall)	SRCC	0.50	0	0	77	0	0	0	0	98	0	0	0	0	100	0	0
			1.00	0	0	99	0	0	0	0	100	0	0	0	0	100	0	0
			2.00	0	0	99	0	0	0	0	100	0	0	0	0	100	0	0
	7310-142-3 (Endothall)	SRCC	0.50	0	0	100	0	0	0	0	100	0	0	0	0	100	0	0
			1.00	0	0	100	0	0	1	0	100	0	0	10	3	100	0	0
			2.00	2	2	100	0	0	4	4	100	0	0	23	42	100	0	0
	Endothall (Potassium)		0.50	2	0	100	0	0	3	0	100	0	0	4	0	100	0	0
			1.00	0	0	67	0	0	2	0	100	0	0	10	0	100	0	0
			2.00	65	33	100	0	0	73	52	100	0	0	82	56	100	0	0
	7310-135-1 (Blank)		0.00	0	0	9	0	0	0	0	13	0	0	0	0	22	0	0
	7310-135-2 (Blank)		0.00	0	0	6	0	0	0	0	12	0	0	0	0	22	0	0
	7310-135-3 (Blank)		0.00	0	0	9	0	0	0	23	11	0	0	0	28	23	0	0
	7310-135-4 (Blank)		0.00	0	0	7	0	0	0	0	10	0	0	0	0	18	0	0
	Control			0	0	2	0	0	0	0	2	0	0	0	0	7	0	0

* See Table 1 for complete information.

TABLE 6

Comparison of Diquat Efficacy Against Hydrilla (H), Southern Naiad (N), Cabomba (C), and Watermilfoil (M) Cultured in Two Different Media

Date of Evaluation	Chemical Designation*	Company or Source*	Rate mg/l	1 week H	M	C	N	2 weeks H	M	C	N	3 weeks H	M	C	N	4 weeks H	M	C	N	5 weeks H	M	C	N
3/29/79	Diquat (Soil + Liquid Fertilizer)**	Chevron	0.01	0	3	0	2	0	22	0	32	0	31	0	32	0	93	0	37	0	97	0	45
			0.02	0	10	0	13	1	57	0	80	1	83	0	85	1	93	0	85	1	93	0	90
			0.04	0	38	0	67	1	99	0	88	1	100	0	96	1	100	0	96	0	100	0	96
	Control			0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	3	0	1	0	4
	Diquat (Soil + Manure)†	Chevron	0.01	0	2	0	0	0	3	0	0	0	5	0	0	0	5	0	1	0	5	0	1
			0.02	0	4	0	1	0	8	0	0	0	11	0	2	0	35	0	12	0	27	0	21
			0.03	0	5	0	1	0	8	0	3	0	15	0	7	0	47	0	30	0	52	0	33
			0.04	0	3	0	1	0	25	0	2	0	47	0	2	0	80	0	4	0	80	0	4
	Control			0	0	0	0	0	0	0	2	0	1	0	0	0	1	0	0	0	3	0	0

Date of Evaluation	Chemical Designation*	Company or Source*	Rate mg/l	6 weeks H	M	C	N	7 weeks H	M	C	N	8 weeks H	M	C	N	9 weeks H	M	C	N	10 weeks H	M	C	N
	Diquat (Soil + Liquid Fertilizer)**	Chevron	0.01	0	98	0	57	0	99	0	67	0	100	0	73	0	100	9	87	0	100	50	90
			0.02	1	97	0	95	1	97	0	95	0	97	0	95	1	100	0	98	1	100	1	98
			0.03	1	100	0	96	2	100	0	98	2	100	0	99	1	100	1	100	2	100	2	100
			0.04	1	100	0	96	2	100	0	96	2	100	0	97	2	100	3	98	2	100	5	99
	Control			0	1	0	4	0	2	0	2	0	5	0	4	0	17	3	17	0	42	3	25
	Diquat (Soil + Manure)†	Chevron	0.01	0	6	0	1	0	7	0	2	0	6	0	2	0	5	0	3	0	5	0	3
			0.02	0	53	0	21	0	53	0	20	0	53	0	19	0	38	0	20	0	42	0	20
			0.03	0	57	0	34	0	57	0	39	0	57	0	41	0	72	0	44	0	82	0	72
			0.04	0	88	0	6	0	90	0	7	0	90	0	8	0	90	4	10	0	90	4	14
	Control			0	3	0	3	0	3	0	3	0	5	0	4	0	3	0	3	0	5	0	9

(continued)

* See Table 1 for complete information

** Liquid fertilizer mixture (0.2 ml/l of commercial 12-6-6 liquid fertilizer plus 0.08 mg/l chelated iron).

† 10 percent dried cow manure mixed with soil prior to potting of plants.

TABLE 6 (concluded)

Date of Evaluation	Chemical Designation	Company or Source	Rate mg/l	Posttreatment Control, Percent																			
				11 Weeks				12 weeks				13 weeks				14 weeks				15 weeks			
				H	M	C	N	H	M	C	N	H	M	C	N	H	M	C	N	H	M	C	N
3/29/79 (cont'd)	Diquat (Soil + Liquid Fertilizer)**	Chevron	0.01	0	100	9	90																
			0.02	1	100	0	98																
			0.03	3	100	1	100																
			0.04	2	100	3	99																
	Control			0	50	5	25																
	Diquat (Soil + Manure)†	Chevron	0.01	0	100	0	90																
			0.02	1	100	1	98																
			0.03	3	100	2	100																
			0.04	2	100	5	99																
	Control			0	5	0	9																

TABLE 7

Comparisons of Dry Weights of Four Species of Plants Cultured In Two Different Media After 12 Weeks of Growth

Species		Dry Weight, g: Soil + Liquid Fertilizer	Dry Weight, g: Soil + Cow Manure	Percent Increase*
Hydrilla		0.47	0.67	
		0.39	0.61	
		0.67	0.49	
	Σ	1.53	1.77	
	$\bar{X}$	0.51	0.59	15.7
Watermilfoil		0.04	0.17	
		0.04	0.01	
		0.01	0.02	
	Σ	0.09	0.20	
	$\bar{X}$	0.03	0.07	133.3
Southern naiad		0.01	0.02	
		0.01	0.01	
		0.02	0.01	
	Σ	0.04	0.04	
	$\bar{X}$	0.01	0.01	0.0
Cabomba		0.32	0.52	
		0.24	0.59	
		0.22	1.24	
	Σ	0.78	2.35	
	$\bar{X}$	0.26	0.78	200.0

* Values represent percent increase of mean dry weights of plants grown in soil + manure cultures above mean dry weights of plants grown in soil + addition of liquid fertilizer. Only Cabomba dry weight was increased by the addition of manure; the difference was significant at P = 10 percent.

TABLE 8

Laboratory Evaluations of Various Herbicides for Phytotoxicity Toward Combined Milfoil (M) and Cabomba (C), 1979

Date of Evaluation	Chemical Designation*	Company or Source*	Rate mg/l	Posttreatment Control, Percent 2 weeks M	C	4 weeks M	C	6 weeks M	C	8 weeks M	C	10 weeks M	C	12 weeks M	C	14 weeks M	C
8/23/78	Confidential	Kalo	0.25	95	0	99	0	88	0	78	0						
			0.50	98	0	100	0	100	0	100	0						
			1.00	99	0	100	0	100	0	100	0						
			2.00	99	0	100	0	100	0	100	0						
			4.00	100	0	100	0	100	0	100	0						
	Control		0.00	0	0	1	0	2	0	2	0						
9/26/78	Fenac Plus (Sugarcane) (A 08563)	Amchem	0.25	48	0	100	0	100	0								
			0.50	45	0	100	2	100	3								
			1.00	45	0	100	2	100	2								
			2.00	41	0	100	5	100	7								
	Control		0.00	2	0	1	0	1	0								
9/28/78	Fenac Plus (Sugarcane) (A 70316)	Amchem	0.25	35	0	97	0	100	0	100	1						
			0.50	52	0	100	0	100	0	100	1						
			1.00	87	0	100	0	100	0	100	3						
			2.00	88	0	100	0	100	0	100	5						
	Control		0.00	3	0	1	0	1	0	1	0						
10/4/78	Fenac Granule (77-A 591)	Amchem	0.25	75	0	100	0	100	0	100	1	100	2	100	5	100	47
			0.50	88	0	100	0	100	6	100	29	100	33	100	36	100	80
			1.00	98	0	100	0	100	8	100	34	100	36	100	53	100	72
			2.00	98	0	100	1	100	46	100	54	100	60	100	72	100	82
	Fenac Granule (77-A 610)	Amchem	0.25	92	0	100	0	100	0	100	0	100	0	100	1	100	8
			0.50	95	0	100	0	100	0	100	1	100	4	100	17	100	44
			1.00	99	0	100	0	100	17	100	27	100	72	100	76	100	95
			2.00	100	0	100	4	100	48	100	58	100	68	100	80	100	92

(continued)

* See Table 1 for complete information.

TABLE 8 (continued)

Date of Evaluation	Chemical Designation	Company or Source	Rate mg/l	Posttreatment Control, Percent													
				2 weeks		4 weeks		6 weeks		8 weeks		10 weeks		12 weeks		14 weeks	
				M	C	M	C	M	C	M	C	M	C	M	C	M	C
10/4/78 (cont'd)	Fenac Ferric	Amchem	0.25	97	0	100	0	100	0	100	0	100	0	100	2	100	5
	Salt Granule		0.50	100	0	100	0	100	3	100	27	100	29	100	31	100	62
	(77-A 610)		1.00	100	0	100	0	100	10	100	40	100	58	100	67	100	93
	(NB 1094-60)		2.00	99	0	100	1	100	35	100	60	100	67	100	72	100	83
	Fenac Copper	Amchem	0.25	33	0	70	0	100	0	100	0	100	1	100	2	100	8
	Salt Granule		0.50	15	0	38	0	100	0	100	0	100	1	100	1	100	3
	(77-A 590)		1.00	5	0	100	0	100	1	100	4	100	11	100	22	100	63
	NB 1081-99)		2.00	98	0	100	0	100	7	100	42	100	73	100	78	100	91
	Control			3	0	3	0	2	0	2	3	0	0	0	9	2	33
10/11/78	Fenac Dry	Amchem	0.25	67	0	100	0	100	0	100	1						
	Solium Salt		0.50	95	0	100	0	100	0	100	1						
			1.00	97	0	100	0	100	0	100	4						
			2.00	100	0	100	0	100	3	100	17						
	Fenac	Amchem	0.25	65	0	100	0	100	1	100	1						
	Potassium/		0.50	73	0	100	0	100	1	100	5						
	Sodium		1.00	95	0	100	0	100	3	100	35						
	(77-A 599)		2.00	97	0	100	0	100	22	100	80						
	AL 3588)																
	Fenac Liquid	Amchem	0.25	98	0	100	0	100	2	100	4						
	Potassium		0.50	97	0	100	0	100	1	100	2						
	salt		1.00	97	0	100	0	100	4	100	3						
	(AL 3589)		2.00	97	0	100	0	100	7	100	82						
	Fenac + Di-	Amchem	0.25	95	0	100	0	100	1	100	3						
	camba (AL		0.50	99	0	100	0	100	2	100	2						
	3591) (Am-		1.00	96	0	100	0	100	3	100	4						
	chem 66-67)		2.00	99	0	100	2	100	12	100	73						
	Control		0.00	1	0	1	0	2	0	2	0						

(continued)

TABLE 8 (concluded)

Date of Evaluation	Chemical Designation	Company or Source	Rate mg/l	2 weeks M	2 weeks C	4 weeks M	4 weeks C	6 weeks M	6 weeks C	8 weeks M	8 weeks C	10 weeks M	10 weeks C	12 weeks M	12 weeks C	14 weeks M	14 weeks C
10/12/78	2,4-D (Lignin)	Univ. of Washington	0.25	0	0	23	0	31	0	36	0	55	0				
			0.50	33	0	70	0	78	0	100	0	100	0				
			1.00	73	0	100	0	100	0	100	0	100	0				
			2.00	78	0	100	0	100	0	100	0	100	1				
			4.00	92	0	100	3	100	29	100	0	100	38				
	Control			0	0	1	0	1	0	5	0	18	0				

Posttreatment Control, Percent

(Sheet 3 of 3)

TABLE 9

Laboratory Evaluations of Various Herbicides for Phytotoxicity Toward Watermilfoil, 1979

Date of Evaluation	Chemical Designation*	Company or Source*	Rate mg/l	Posttreatment Control, Percent 2 wks	4 wks	6 wks	8 wks	10 wks	12 wks	14 wks	16 wks
10/17/78	Polymer PolyAce 40:60 (2,4-D)	Wright St. University	0.25	0	0	2	5	5	9	13	15
			0.50	0	1	3	5	5	10	12	17
			1.00	0	0	5	7	12	78	88	89
			2.00	0	3	7	33	68	87	94	98
			4.00	0	17	72	95	97	99	100	100
	Acetone		1 ml	0	0	2	3	5	7	32	28
	Control			0	0	1	2	2	7	11	12
11/08/78	7310-113-1 (2,4-D)	SRRC	0.25	1	0	33	57	70	78		
			0.50	6	47	73	82	90	97		
			1.00	20	94	98	100	100	100		
			2.00	22	97	100	100	100	100		
	7310-113-2 (2,4-D)	SRRC	0.25	10	38	40	62	72	73		
			0.50	22	27	85	93	97	100		
			1.00	23	92	99	100	100	100		
			2.00	33	98	100	100	100	100		
	Control			0	0	0	1	4	30		
11/18/78	7310-119-1 (2,4-D)	SRRC	0.25	1	1	17	15	34	62		
			0.50	3	21	37	56	72	78		
			1.00	32	98	100	100	100	100		
			2.00	33	96	100	100	100	100		
	7310-119-2 (2,4-D)	SRRC	0.25	1	16	40	55	74	87		
			0.50	12	89	98	100	100	100		
			1.00	35	100	100	100	100	100		
			2.00	35	100	100	100	100	100		
	Control			0	0	0	1	3	19		

(continued)

* See Table 1 for complete information.

TABLE 9 (concluded)

Date of Evaluation	Chemical Designation	Company or Source	Rate mg/l	Posttreatment Control, Percent							
				2 wks	4 wks	6 wks	8 wks	10 wks	12 wks	14 wks	16 wks
07/05/79	7310-119-1 (2,4-D)	SRRC	0.50	84	100						
	7310-119-2 (2,4-D)	SRRC	0.50	82	100						
	2,4-D (Ref.)	Thompson Hayward	0.50	83	100						
	Control			3	2						

TABLE 10

Greenhouse Evaluations of Various Herbicides for Phytotoxicity Toward Waterhyacinth, 1979

Date of Evaluation	Chemical Designation*	Company or Source*	Rate kg/ha	Posttreatment Control, Percent 1 wk	2 wks	4 wks	6 wks	8 wks	10 wks	12 wks	14 wks	16 wks
10/18/78	2,4-D (Lignin)	Univ. of Washington	0.50	1	1	23	73	80	75			
			1.00	1	2	28	63	67	58			
			2.00	2	8	68	83	80	67			
			4.00	3	20	88	97	97	25			
	Control			0	0	0	0	0	1			
10/19/78	R-24191	Stauffer	0.50	2	3	10	34	57	57			
			1.00	6	14	52	75	80	91			
			2.00	5	80	99	100	100	100			
			4.00	11	96	100	100	100	100			
	Krenite	duPont	0.50	0	0	0	0	0	4			
			1.00	0	0	0	0	0	3			
			2.00	0	0	0	0	0	2			
			4.00	0	0	0	0	0	2			
	Control			0	0	0	0	0	2			
11/20/78	Norflurazon	Sandoz	0.50	0	0	0	1	2	3	3	5	7
			1.00	1	1	1	1	2	3	4	5	7
			2.00	2	2	2	2	2	3	4	5	7
			4.00	3	3	4	4	5	7	10	9	11
	Control			0	0	0	0	1	2	3	3	5
1/18/79	7310-119-1 (2,4-D)	SRRC	0.50	1	1	1	2	2	3	4		
			1.00	1	1	2	2	2	5	6		
			2.00	0	0	1	1	1	5	6		
			4.00	1	2	5	7	11	11	13		
	7310-119-2 (2,4-D)	SRRC	0.50	0	0	0	1	1	3	4		
			1.00	0	0	1	1	1	3	4		
			2.00	0	0	1	1	1	5	5		
			4.00	1	1	6	8	9	17	20		
	Control			0	0	0	0	1	2	3		

(continued)

* See Table 1 for complete information.

TABLE 10 (continued)

Date of Evaluation	Chemical Designation	Company or Source	Rate kg/ha	Posttreatment Control, Percent								
				1 wk	2 wks	4 wks	6 wks	8 wks	10 wks	12 wks	14 wks	16 wks
2/23/79	Fenac Liquid (Sugarcane) (A 70316)	Amchem	0.10	25	65	62	58					
			0.25	28	83	91	89					
			0.50	40	90	99	99					
			1.00	38	93	98	100					
	Fenac Plus (Sugarcane) (A 08563)	Amchem	0.10	45	85	98	98					
			0.25	40	85	97	97					
			0.50	45	88	98	98					
			1.00	50	95	100	100					
	Control			0	0	1	2					
5/04/79	Fenac Liquid Potassium Salt (A1 3589)	Amchem	0.10	3	3	2	2	2	3			
			0.25	5	12	14	13	2	3			
			0.50	6	15	43	20	13	14			
			1.00	9	23	92	98	98	98			
	Fenac + Dicamba (A1 3591) Amchem 66-67	Amchem	0.10	4	3	4	3	2	2			
			0.25	6	8	5	4	2	2			
			0.50	11	23	96	99	100	100			
			1.00	13	28	96	95	93	92			
	Fenac 77-A-599	Amchem	0.10	3	2	2	2	2	2			
			0.25	5	5	6	2	2	2			
			0.50	10	15	72	9	4	4			
			1.00	11	23	91	76	75	73			
	Fenac Dry Sodium Salt	Amchem	0.10	2	2	1	1	2	3			
			0.25	5	7	11	4	2	2			
			0.50	10	17	37	14	12	9			
			1.00	10	25	85	43	37	35			
	Control			0	0	0	2	4	4			

(continued)

TABLE 10 (concluded)

Date of Evaluation	Chemical Designation	Company or Source	Rate kg/ha	Posttreatment Control, Percent								
				1 wk	2 wks	4 wks	6 wks	8 wks	10 wks	12 wks	14 wks	16 wks
5/11/79	Diquat ** 9337-77-2-1	SRI	1.00	1	5	79	90	98	100			
			2.00	2	9	88	93	97	100			
			5.00	5	37	100	100	100	100			
	Diquat ** 9337-79-1B-1	SRI	1.00	2	3	31	38	64	73			
			2.00	2	4	92	92	98	99			
			5.00	3	8	99	99	100	100			
	Diquat ** (Liquid)	Chevron	1.00	4	8	88	88	98	100			
			2.00	7	33	100	100	100	100			
			5.00	10	85	100	100	100	100			
	Diquat† (Liquid)	Chevron	0.50	12	93	100	100	100	100			
			1.00	15	99	100	100	100	100			
			2.00	15	100	100	100	100	100			
	Control			0	0	2	2	3	5			

** Chemical applied to water column.
† Chemical applied as a foliar spray.

TABLE 11

Greenhouse Evaluations of Various Herbicides for Phytotoxicity Toward Waterlettuce, 1979

Date of Evaluation	Chemical Designation*	Company or Source*	Rate kg/ha	Posttreatment Control, Percent							
				1 wk	2 wks	4 wks	6 wks	8 wks	10 wks	12 wks	14 wks
9/15/78	Confidential	Kalo	0.50	1	1	2					
			1.00	1	1	5					
			2.00	2	5	10					
			4.00	7	14	19					
	Control			0	0	0					
4/19/79	Krenite	duPont	1.00	0	0	1	2	2	4	7	7
			2.00	0	0	1	1	1	2	5	6
			4.00	0	0	1	1	1	2	6	6
			6.00	0	0	1	2	1	1	6	7
	Norflurazon	Sandoz	1.00	0	2	11	30	40	40	95	80
			2.00	0	5	68	78	97	98	98	98
			4.00	0	15	85	97	100	100	100	100
			6.00	0	17	87	97	100	100	100	100
	Control			0	0	1	1	1	1	2	5

* See Table 1 for complete information.

TABLE 12

Greenhouse Evaluations of Various Herbicides for Phytotoxicity Toward Duckweed, 1979

Date of Evaluation	Chemical Designation*	Company or Source*	Rate kg/ha	Posttreatment Control, Percent				
				1 week	2 weeks	4 weeks	6 weeks	8 weeks
9/6/78	Confidential	Kalo	0.50	0	2	2	2	-
			1.00	0	2	2	2	-
			2.00	0	2	2	2	-
			4.00	0	2	2	2	-
	Control			0	1	1	1	-
2/15/79	Norflurazon	Sandoz	0.50	0	1	5	17	20
			1.00	0	1	7	23	47
			2.00	0	1	7	20	33
			4.00	0	1	10	60	92
	Krenite	duPont	0.50	0	0	2	3	5
			1.00	0	0	2	3	5
			2.00	0	0	2	3	6
			4.00	0	0	2	3	7
	Control			0	0	0	3	9

* See Table 1 for complete information.

TABLE 13

Greenhouse Evaluations of Various Herbicides for Phytotoxicity Toward Torpedograss, 1979

Date of Evaluation	Chemical Designation*	Company or Source*	Rate kg/ha	Posttreatment Control, Percent 1 wk	2 wks	4 wks	6 wks	8 wks	10 wks	12 wks	14 wks	16 wks	18 wks
9/07/78	Confidential	Kalo	0.50	0	0	0							
			1.00	0	0	0							
			2.00	1	1	1							
			4.00	1	1	2							
	Control			0	0	0							
	Krenite	duPont	1.00	0	0	1	1	1	6				
			2.00	0	0	1	1	3	6				
			4.00	0	0	1	1	4	8				
			6.00	1	2	4	7	15	28	25	24	23	23
	Control			0	0	0	0	5	5	5	5	5	5

* See Table 1 for complete information.

TABLE 14

Greenhouse Evaluations of Various Herbicides for Phytotoxicity Toward Paragrass, 1979

Date of Evaluation	Chemical Designation*	Company or Source*	Rate kg/ha	Posttreatment Control, Percent									
				1 wk	2 wks	4 wks	6 wks	8 wks	10 wks	12 wks	14 wks	16 wks	18 wks
9/07/78	Confidential	Kalo	0.50	0	0	0	0						
			1.00	0	0	0	0						
			2.00	0	0	0	0						
			4.00	0	0	0	0						
	Control			0	0	0	0						
3/27/79	Krenite	duPont	1.00	0	0	0	1	1	2				
			2.00	0	0	0	1	1	2				
			4.00	0	0	0	1	1	2				
			6.00	0	2	2	2	2	2				
	Norflurazon	Sandoz	1.00	0	0	3	5	7	7	7	7	7	7
			2.00	1	2	3	11	15	17	21	25	35	38
			4.00	1	3	5	15	20	30	37	42	60	60
			6.00	2	15	18	23	35	40	62	81	88	88
	Control			0	0	0	3	4	7	8	10	10	10

* See Table 1 for complete information.

TABLE 15

Greenhouse Evaluations of Various Herbicides for Phytotoxicity Toward Alligatorweed, 1979

Date of Evaluation	Chemical Designation*	Company or Source*	Rate kg/ha	Posttreatment Control, Percent			
				1 week	2 weeks	4 weeks	6 weeks
9/05/78	Confidential	Kalo	0.50	1	1	11	52
			1.00	4	67	75	80
			2.00	6	82	91	95
			4.00	8	92	96	97
	Control			0	0	1	2

* See Table 1 for complete information.

TABLE 16

Circular Pool Evaluations of Various Herbicides for Phytotoxicity Toward Waterhyacinth, 1979

Date of Evaluation	Chemical Designation*	Company or Source*	Rate kg/ha	Posttreatment Control, Percent							
				1 wk	2 wks	4 wks	6 wks	8 wks	10 wks	12 wks	14 wks
8/29/78	Confidential	Kalo	0.50	3	5	7	18	20	37	38	41
			1.00	5	7	11	32	52	86	88	88
			2.00	7	10	18	63	89	98	98	98
			4.00	11	15	45	93	99	100	100	100
	Control			0	0	0	2	2	5	5	5
9/18/78	Metribuzin	duPont	0.50	5	6	14	17	78	80	80	
			1.00	6	10	38	72	97	98	98	
			2.00	7	21	90	99	99	99	99	
	Control			0	0	2	2	2	2	2	

* See Table 1 for more complete information.

TABLE 17

Field Evaluations of Various Herbicides for Phytotoxicity Toward Hydrilla

Date of Evaluation	Chemical Designation*	Company or Source*	Rate mg/l	Posttreatment Control, Percent						
				2 wks	4 wks	6 wks	2 mos	3 mos	4 mos	5 mos
11/2/77	Fenac	Amchem	2.0**	0	7	30	50	62	75	85
				6 mos	7 mos	8 mos	9 mos	10 mos	11 mos	12 mos
				95	98	99	99	99	100	100
				13 mos	14 mos	15 mos	16 mos	18 mos		
				100	100	100	100	100		

* See Table 1 for complete information.

** A rate of 2.0 mg/l was applied to a 10.8-acre lake. Total lake volume concentration equaled 0.87 mg/l.

TABLE 18

Percent Control, DO, and Temperature of a Hydrilla- and Cattail-Infested 0.8-ha Pond Treated with 1.0 mg AI/l of Hexazinone

Evaluation Period	Observation Date	Percent Control		Time	Dissolved Oxygen, mg/l			Temperature, °C		
		Hydrilla	Cattail		Top	Middle	Bottom	Top	Middle	Bottom
-1 day	11/13/78	0	3	1405	14.1	1.6	0.0	24.0	19.9	19.5
+1 day	11/15/78	0	3	1540	1.3	0.7	0.0	--	--	--
1 week	11/21/78	0	3	1130	0.0	0.0	0.0	21.4	21.0	20.0
2 weeks	11/28/78	3	6	1200	0.4	0.0	0.0	22.5	20.2	19.9
3 weeks	12/05/78	15	15	1155	0.5	0.4	0.0	23.0	22.7	20.2
4 weeks	12/12/78	30	60	1136	0.5	0.3	0.3	18.0	18.0	18.0
2 months	01/15/79	80	85	1330	7.8	7.4	7.1	11.0	11.0	11.0
3 months	02/14/79	97	80	1025	6.0	5.2	3.0	15.3	14.9	14.5
4 months	03/14/79	97	85	1020	6.0	6.1	4.0	20.0	18.0	17.4
5 months	04/17/79	100	95	1050	6.1	6.3	6.4	25.9	25.2	25.0
6 months	05/14/79	100	99	1005	6.7	3.9	0.0	29.5	28.4	23.0
7 months	06/13/79	100(T)*	100	1020	6.3	6.8	6.8	28.0	27.9	27.9

* T = trace of regrowth.

TABLE 19

pH, Secchi Disk, and Water Level of a Hydrilla- and Cattail-Infested 0.8-ha Pond Treated with 1.0 mg AI/l of Hexazinone

Evaluation Period	pH Composite	Secchi Disk m	Water Level cm	Remarks
-1 day	7.5	1.1	0.0	Sixty percent pond coverage as 12- to 16-in.* mat. Open areas have a 6- to 10-in. layer of hydrilla on bottom.
1 week	7.3	0.9	0.0	Oily film on water. Top 1-1/2 in. flaccid, rest turgid. Fish kill - one bass and six bluegill. Scores of top minnows alive.
2 weeks	7.3	1.0	-2.1	Oily film still present. Plants flaccid to middepth, turgid near bottom.
3 weeks	7.4	1.0	+9.2	Plants sinking. About 20% have dropped or shifted to north shore. Flaccid to middepth. Plants on bottom turning black.
4 weeks	7.3	1.0	+6.1	Plants still sinking. Plants near bottom turgid. Some defoliation. Cattail damage for plants in water only.**
2 months	7.9	0.2	+47.2	Very little hydrilla on surface, some on bottom as a mat. Plants flaccid, have leaves and are yellow-green in color. Cattail nearly 100% in deeper water. About 3% close to shore - a previously dry area now flooded.
3 months	7.4	0.5	+45.8	No hydrilla on surface, few small patches with and without leaves on bottom. Color mostly gone. A small amount of new growth evident on the dying material. Cattail has about 20% new growth. Original material 100% dead with some rhizomes starting to float up. Regrowth near shore.

(continued)

* A table of factors for converting U. S. customary units of measurement to metric (SI) is presented on page 3.
** Fish kill observed by security guard sometime during week of 18 December 1978. About 12 bass were seen.

TABLE 19 (concluded)

Evaluation Period	pH Composite	Secchi Disk m	Water Level cm	Remarks
4 months	7.5	1.2	+45.4	Very little hydrilla remains. Most of recovered material has leaves and is generally turgid. About 1 to 2% is healthy new growth while the general condition of the remainder varies from moderate color loss to advanced decomposition. Cattail has about 15% regrowth showing signs of wilting and drying of leaf tips. About 5 to 7% of old plant material remains undamaged and growing above water on the bank.
5 months	7.9	1.8	+37.1	No evidence of hydrilla. Cattails have about 5% of plants remaining. These are growing above water on the bank.
6 months	8.1	0.3	+41.2	No hydrilla. Control of cattails originally in the water is 99% with a trace of regrowth. Of the plants originally on the bank, 20% are still above water and healthy; 80% have been in the water since January and are showing damage. Approximately 1 week earlier, this area received 17 in. of rain. This pond had filled to the road level with some overflow. The culvert barricades are still intact.
7 months	8.5	1.5	+42.0	Hydrilla regrowth evident. Three sprouted tubers recovered from shallow area near south shore. Complete control of cattail originally in the water. Damage to those cattails that had been on the bank or only recently in the water was 4%. Filamentous algae on water surface and bottom of pond.

TABLE 20

Percent Control, DO, and Temperature of a Hydrilla- and Cattail-Infested 0.4-ha Pond
Treated with 1 mg AI/l of Fenac + 1 mg AI/l of Copper TEA

Evaluation Period	Observation Date	Percent Control		Time	Dissolved Oxygen, mg/l			Temperature, °C		
		Hydrilla	Cattail		Top	Middle	Bottom	Top	Middle	Bottom
-1 day	11/13/78	0	3	1440	5.0	4.1	4.6	26.0	20.5	20.0
+6 hours	11/14/78	0	3	1645	3.5	2.9	2.9	--	--	--
+1 day	11/21/78	0	3	1545	3.0	1.3	1.2	--	--	--
1 week	11/21/78	15	3	1301	0.0	0.0	0.0	23.9	21.2	20.8
2 weeks	11/28/78	25	3	1305	0.0	0.0	0.0	23.2	20.7	20.5
3 weeks	12/05/78	70	3	1325	2.3	1.8	0.0	24.0	22.9	21.2
4 weeks	12/12/78	95	3	1235	3.2	3.2	2.6	18.0	18.0	18.0
2 months	01/15/79	98	3	1440	13.8	11.6	10.5	11.2	11.2	11.2
3 months	02/14/79	99	10	1118	3.8	3.4	3.1	15.1	14.7	14.5
4 months	03/14/79	100	12	1120	6.0	6.0	5.9	21.5	21.1	20.8
5 months	04/17/79	100	94	1155	6.4	5.9	5.7	26.0	25.9	24.8
6 months	05/14/79	100	99	1114	4.6	4.0	3.0	29.5	27.0	23.8
7 months	06/13/79	100	100	1120	5.0	4.2	4.7	27.5	27.5	27.5

TABLE 21

pH, Secchi Disk, and Water Level of a Hydrilla- and Cattail-Infested 0.8-ha Pond Treated with 1.0 mg AI/l of Fenac + 1 mg AI/l of Copper TEA

Evaluation Period	pH Composite	Secchi Disk m	Water Level cm	Remarks
-1 day	7.7	1.9	0.0	Surface fringe around pond. Central area has hydrilla 2 to 3 ft high.
1 week	7.1	0.28	0.0	Hydrilla dropped to bottom. Plants blackish-green. Flaccid, nodes solid not brittle. Oily film. Thirty-one dead fish (three species).
2 weeks	7.1	0.3	-2.1	Hydrilla near shore starting to decompose. Plants in central area flaccid but strong. Leaves attached.
3 weeks	7.3	0.35	+9.2	Hydrilla disappearing. Plants brittle at nodes and leaves separate easily.
4 weeks	7.4	0.8	+6.1	Very little hydrilla found (N-NE part of pond).
2 months	8.1	0.3	+47.2	Very little hydrilla remains as defoliated but healthy, turgid stems.
3 months	7.3	0.2	+45.8	Only five stem fragments found. One with solidly attached leaves and brittle, 2.6 cm long. Four without leaves, portions brittle and portions flaccid. Green in color. Cattails - frost damage only.
4 months	7.3	0.9	+45.4	No evidence of hydrilla. A few cattail plants starting to fall over, remainder beginning to brown.
5 months	7.8	1.0	+37.1	No evidence of hydrilla. Cattail 94 percent controlled. The remaining cattails are healthy and are found only on the bank on the east side.
6 months	7.9	0.9	+41.2	No hydrilla. Control of cattails originally in the water 99 percent with a trace of regrowth. No damage to plants on the bank. During previous heavy rain, this pond had risen only slightly.
7 months	8.0	1.1	+42.0	No hydrilla. Control of cattails originally in the water 100 percent. Five percent regrowth from shore plants moving into the water. Filamentous algae on water surface and bottom of pond.

TABLE 22

Percent Control, DO, and Temperature of a Hydrilla- and Chara-Infested 4-ha Control Pond

Evaluation Period	Observation Date	Percent Control		Time	Dissolved Oxygen			Temperature, °C		
		Hydrilla	Chara		Top	Middle	Bottom	Top	Middle	Bottom
-1 day	11/13/78	0	0	1625	12.1	12.7	6.6	25.1	19.9	19.9
+6 hours	11/14/78	0	0	1655	11.8	11.8	6.2	--	--	--
+1 day	11/15/78	0	0	1600	11.9	11.8	5.8	--	--	--
1 week	11/21/78	0	0	1345	8.0	1.1	0.9	25.2	21.0	20.9
2 weeks	11/28/78	0	0	1340	5.8	2.5	0.5	26.0	21.0	20.3
3 weeks	12/5/78	0	0	1405	6.2	5.8	2.4	23.8	3.1	23.0
4 weeks	12/12/78	0	0	1305	4.9	4.5	3.4	18.0	18.0	18.0
2 months	1/15/79	0	0	1510	13.6	12.9	12.7	11.2	11.2	11.2
3 months	2/14/79	8	0	12.0	6.0	5.2	6.0	17.1	15.0	14.0
4 months	3/14/79	85	97	1220	7.8	8.3	8.2	20.9	20.0	18.1
5 months	4/17/79	100	100	1325	7.7	7.7	7.7	27.1	25.2	24.6
6 months	5/14/79	100	100	1300	7.2	6.6	6.0	28.2	27.5	26.8
7 months	6/13/79	100	100	1145	7.4	6.6	6.0	27.8	27.8	27.7

TABLE 23

pH, Secchi Disk, and Water Level of a Hydrilla- and Cattail-Infested 4-ha Control Pond

Evaluation Period	pH Composite	Secchi Disk m	Water Level cm	Remarks
-1 day	9.3	No open water	0.0	Solid pond coverage: 75% hydrilla, 25% chara.
1 week	7.4		0.0	No change in plant material. Two dead bluegill found.
2 weeks	8.0		-2.1	
3 weeks	7.5		+9.2	Forty-three dead shad on water surface. Dead less than 2 to 3 days.
4 weeks	7.3		+6.1	Few dead shad on surface; most decomposed or eaten by birds, etc.
2 months			+47.2	
3 months	7.5	1.0	+45.8	Plant material has dropped 1 to 3 ft. Hydrilla losing chlorophyll and leaves in small areas. Overall, slight leaf loss. Generally flaccid, some still turgid.
4 months	7.5	1.3	+45.4	Remaining hydrilla flaccid, losing leaves, and dark yellowish-green in color. Remaining chara white and nearly decomposed.
5 months	7.8	0.5	+37.1	No evidence of hydrilla or chara.
6 months	8.1	1.0	+41.2	No evidence of hydrilla or chara. During previous heavy rains, pond rose only sightly. Main spillway remained open.
7 months	8.4	0.7	+42.0	No evidence of hydrilla or chara. Slight plankton bloom present.

TABLE 24

Modified Probit and Regression Analyses of Response Data from Eurasian Watermilfoil Bioassays of Various Controlled Release Formulations of 2,4-D

Statistic†	Dose Rate, mg/l				
	0.25	0.5	1.0	2.0	4.0
			Lignin Base (University of Washington)		
a	-1.24	2.39	2.5	2.82	4.1
b	6.9	5.8	10.3	9.8	7.7
r	0.91*	0.84 NS	1.0 NS	1.0 NS	1.0 NS
LT_{50}, weeks	8.0	2.8	1.7	1.7	1.3
			PolyAce Polymer (Wright State University)		
a	-1.92	0.557	-3.22	0.57	0.88
b	5.28	4.13	7.78	4.81	6.24
r	0.92**	0.93**	0.94**	0.94**	0.97**
LT_{50}, weeks	21.9	22.4	11.2	8.3	4.6
			7310-113-1 (SRRC)		
a	2.67	3.45	4.16	4.23	
b	4.13	4.11	7.07	9.3	
r	0.996***	0.993***	0.980*	0.999**	
LT_{50}, weeks	7.7	4.5	2.6	2.4	
			7310-113-2 (SRRC)		
a	3.04	2.51	2.07	1.93	
b	2.45	4.87	7.13	8.65	
r	0.98***	0.93**	0.99**	0.99**	
LT_{50}, weeks	6.3	3.2	2.6	2.3	
			7310-119-1 (SRRC)		
a	1.27	2.09	1.90	1.90	
b	3.35	3.42	8.7	8.5	
r	0.92**	0.998***	0.996*	0.994 NS	
LT_{50}, weeks	13.0	7.1	2.3	2.3	

(continued)

† Regression equation $y = a + bx$
a = y intercept
b = slope
r = coefficient of correlation, NS = not significant
* = 5% probability; ** = 1% probability; and *** = 0.1% probability
LT_{50} = time required to produce 50% injury.

TABLE 24 (concluded)

Statistic	Dose Rate, mg/l 0.25	0.5	1.0	2.0	4.0
			7310-119-2 (SRRC)		
a	1.38	1.49	1.99	0.5	
b	4.3	7.7	8.5	13.7	
r	0.99***	0.988*	0.997*	1.0 NS	
LT_{50}, weeks	7.0	2.9	2.3	2.1	
			2,4-D Acid (Ref.)		
a	2.40	1.74	-0.09		
b	1.88	4.49	11.05		
r	0.88*	0.96**	0.994 NS		
LT_{50}, weeks	24	5.3	2.9		
			2,4-D BEE (Ref.)		
a	2.73	3.13	3.56		
b	6.20	6.22	6.27		
r	0.975*	0.82 NS	0.97 NS		
LT_{50}, weeks	2.3	2.0	1.7		

TABLE 25

Comparison of LT_{50}'s of Various Controlled Release Formulations of 2,4-D

Formulation	LT_{50} (weeks) at Indicated Dose Level, mg/l				
	0.25	0.5	1.0	2.0	4.0
7310-113-2	6.3	3.2	2.6	2.3	---
7310-119-2	7.0	2.9	2.3	2.1	---
7310-113-1	7.7	4.5	2.6	2.4	---
7310-119-1	13.0	7.1	2.3	2.3	---
BEE (Ref.)	2.3	2.0	1.7	---	---
Lignin	8.0	2.8	1.7	1.7	1.3
PolyAce	21.9	22.4	11.2	8.3	4.6
Acid (Ref.)	24	5.3	2.9	---	---

TABLE 26

Comparison of the Slopes of Regression Lines for Response Time of Watermilfoil to Various Dose Levels of Controlled Release Formulations of 2,4-D

Formulation	Slope b at Indicated Dose Level, mg/l				
	0.25	0.5	1.0	2.0	4.0
7310-119-2	4.3	7.7	8.5	13.7	---
7310-113-1	4.1	4.1	7.1	9.3	---
7310-119-1	3.4	3.4	8.7	8.5	---
7310-113-2	2.5	4.9	7.1	8.7	---
BEE (Ref.)	6.2	6.2	6.3	---	---
Lignin	6.9	5.8	10.3	9.8	7.6
PolyAce	6.2	6.2	6.3	---	---
Acid (Ref.)	1.9	4.5	11.0	---	---

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Steward, Kerry K
  Improving technology for chemical control of aquatic weeds / By Kerry K. Steward, Aquatic Plant Management Laboratory, U. S. Department of Agriculture, Science and Education Administration, Fort Lauderdale, Fla. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1981.
  32, [38] p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; A-81-2)
  Annual report for FY 1979.
  Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under USDA/SEA 12-14-7001-992.
  References: p. 32.

1. Aquatic plant control. 2. Aquatic weeds. 3. Chemcontrol. 4. Herbicides. 5. Laboratory tests. I. United States. Army. Corps of Engineers. II. United States. Dept. of Agriculture. Aquatic Plant Management Laboratory, Fort Lauderdale, Fla. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; A-81-2.
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