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DEVELOPMENT AND EVALUATION OF CONTROLLED RELEASE HERBICIDES

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The objective of this program was to establish the necessary dosages of controlled release diquat, 2,4-D acid, and silvex for application to susceptible aquatic weed species. It was known from previous work that these agents are incorporable in several elastomeric matrices and will release at a biologically effective rate upon exposure to water. Formulations of the above agents were prepared at 100 percent, 90 percent, 50 percent, and 25 percent maximum loadings in hot polymerized styrene-butadiene copolymer, cold polymerized

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styrene-butadiene copolymer, natural rubber, synthetic natural rubber, cis polybutadiene, and an ethylene-propylene-diene terpolymer. In addition, the first processible compounds of fenac acid, fenuron, and endothall were prepared in the same matrices at maximum loading. Loss rate analysis work was initiated by determination of a standard photometric calibration curve for 2,4-D acid, silvex acid, and diquat.

Several plant species were procured and conditioned. Bioassays were performed with controlled release 2,4-D acid at dosages commensurate with predetermined loss rates against *Cabomba caroliniana*, *Vallisneria*, and *Elodea*. Also, bioassays of controlled release fenac acid, fenuron, and endothall at 10 ppm were completed against *Cabomba*, *Vallisneria*, milfoil, and *Elodea*. Blanks were likewise evaluated, from which it was deduced that the observed phytotoxicity resulted from the slow release of the herbicide and not from the rubber matrix or the various compounding ingredients.

EC-8 and EC-10 copper-bearing materials, at practical dosage levels, were effective against *Cabomba*. Endothall/CB-220 and Endothall/A-4616 were effective against watermilfoil and *Cabomba*. Controlled release fenac acid in the 4616, 1001, and SN-600 bases showed good results against watermilfoil and *Cabomba*. Also, of the six 2,4-D acid controlled release elastomers that were tested, four showed 90 percent or greater control against *Cabomba*.

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PREFACE

The study reported herein was conducted under Contract No. DACW39-76-C-0029. The work was administered under the direction of the Mobility and Environmental Systems Laboratory (MESL) of the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi. Mr. George Janes, Miss Suzanne Bille, and Professor Nate Cardarelli of the Creative Biology Laboratory, Barberton, Ohio, performed various segments of the effort described herein and prepared this report. On 22-24 October 1975, Mr. Janes attended the Aquatic Plant Control Research Program (APCRP) meeting held in Charleston, South Carolina, where he presented an outline of this program. The following reports concerning this effort were presented at that and other meetings.

Janes, G. A., "Controlled Release Herbicides - Rubber Formulations," 1975 Meeting, APCRP, Charleston, South Carolina, 22-24 October 1975.

Bille, S. M., "Chronicity Phenomenon and Controlled Release Copper," WSSA 16th Annual Meeting, Denver, Colorado, 2-5 February 1976.

Janes, G. A., "Control of Aquatic Weeds by Chronic Intoxicity," 171st Meeting of ACS, New York, New York, 7-9 April 1976.

Janes, G. A., "Aquatic Weed Abatement With Controlled Release Herbicides," 172nd Meeting of ACS, San Francisco, California, 29 August-3 September 1976.

Janes, G. A., "Evaluation of New Controlled Release Aquatic Herbicides," 3rd Annual ICRPS, University of Akron, Akron, Ohio, 12-15 September 1976.

Janes, G. A., "Development and Evaluation of Controlled Release Herbicides," 1976 Meeting APCRP, Jacksonville, Florida, 20-22 October 1976.

All phases of this work and preparation of the report were conducted under the general supervision of Messrs. W. G. Shockley, Chief, MESL, Mr. B. O. Benn, Chief, Environmental Systems Division, and J. L. Decell, Chief, Aquatic Plant Research Branch.

Director of the WES during the preparation and publication of this report was COL John L. Cannon, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

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
acres	4046.856	square metres
gallons (U. S. liquid)	0.003785412	cubic metres
pounds (mass)	0.4535924	kilograms
pounds (force) per square inch	6.894	kilopascals
Fahrenheit degrees	0.555	Celsius degrees of Kelvins*

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: C = 0.555 (F - 32). To obtain Kelvin (K) readings, use: K - 0.555 (F + 459.67).

DEVELOPMENT AND EVALUATION OF CONTROLLED RELEASE HERBICIDES

PART I: INTRODUCTION

1. Previous studies demonstrated that the butoxyethanol ester of 2,4-dichlorophenoxyacetic acid could be incorporated in various elastomeric matrices and slowly released therefrom upon immersion in water.[1] Release continues at a near uniform rate for several years. Effective action against various aquatic weeds was indicated in small pool tests. Effective usage against Eurasian watermilfoil was confirmed at another laboratory.[2] In small-scale field tests, it has been demonstrated that one formulation, 14 ACE-B, is effective against watermilfoil, *Myriophyllum spicatum*, and water hyacinth, *Eichornia crassipes*.[3]

2. In order to allow selective treatment of the pertinent phytozone controlled release (CR) materials were designed as floaters, suspenders, and sinkers.

3. During the course of these early investigations, it was noted that very small dosages would destroy the subject weed if the exposure period was of sufficient length. The concentration-time relation obviously did not hold. It was hypothesized that a *chronic* intoxication mechanism (chronicity phenomena) was present as opposed to the acute syndrome observed with conventional treatment dosages. Chronicity phenomena were subsequently investigated by the Creative Biology Laboratory (CBL).[4]

4. During the chronicity phenomena work, 14 herbicidal materials were used on 8 major water weeds and the chronicity phenomenon was found in most, though not all, instances.

5. Aquatic herbicides showing ability to destroy aquatic weeds at 0.01 ppm/day to 0.001 ppm/day continuous concentration (namely silvex, diquat, and 2,4-D acid) were incorporated in several elastomers and placed in bioassay. Results were favorable.[5,6]

6. Controlled release technology, as demonstrated by the aquatic

herbicide chronicity phenomena studies as well as other pesticide work, has shown that it is practical to attempt variation in the approaches to pest weed control that offer significant economic and environmental advantages.[7]

7. Objectives of the work performed in the study described herein were several-fold: to optimize diquat, silvex, and 2,4-D acid formulations; to determine toxicant release rates and establish tentative field dosages; to supply 14 ACE-B, controlled release 2,4-D BEE, controlled release copper sulfate, and other compounds to outside laboratory and field test sites; and to extend studies to preliminary formulation and evaluation of controlled release fenac acid, endothall acid, and fenuron.

PART II: FORMULATIONS

Herbicides and Master Formulations

8. The formulation study described on the following pages involved the development of 144 controlled release compounds using the six study herbicides. Six controlled release master formulations, including two of those previously found effective, were selected. Recipes are provided in Table 1. Chemical names and sources of each master formulation ingredient and study herbicide are given in Table 2.

9. Portions of the master batch were turned on the rubber mill and the given herbicide slowly added to the point where no more was acceptable by the formulation. This became the maximum loading possible on the small scale equipment used. Larger mixing equipment would probably permit a 3 percent to 5 percent maximum. In repeat millings, each master/herbicide combination was prepared at 90 percent maximum, 50 percent maximum, and 25 percent maximum agent concentrations of 2,4-D acid, silvex, and diquat, respectively. Endothall, fenuron, and fenac were prepared only at maximum loading. The maximum mill loadings found are shown in Table 3. All materials were vulcanized at 290°F for 30 minutes at 8000 psi* pressure.

10. Processibility varied for each formulation. 2,4-D acid presented no problems in mill mixing, vulcanization, or sample preparation. At maximum loading silvex formulations presented some difficulty due to tackiness during milling (especially using SN-600, the synthetic natural rubber base). Elasticity of the cured material was poor. Diquat processed easily in all aspects from the mechanical standpoint. Since the supplier would not provide a technical grade diquat, it was necessary to remove the solvent system and perform repeated washes to purify. Fenuron melted out all materials during the curing process and a 10 percent to 20 percent agent loss is probable. Fenac was compatible with

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 4.

all materials except EPCAR 5465. Considerable melt out during press cure was observed in this mixture.

11. Considering the toxicity of the materials used both positive ventilation at the mill and press as well as face and eye protection for all personnel involved in the mixing operation are essential for safety and highly recommended.

12. Dow Chemical Company would not supply technical grade 2,4-D acid or silvex, so that purchases of chemically pure material from other sources was necessary. The Pennwalt Corporation charged a rather exorbitant $100 for 1 kg of technical endothall. Problems of this type can be expected to continue in future research and evaluation work.

Loss Rate Analysis

13. Spectrophotometric standard curves were determined using the Coleman Hitachi 101 instrument set at 2350 Å (transmission) for 2,4-D acid, 3100 Å for diquat, and 2250 Å for silvex. Figures 1 through 3 depict these curves, respectively.

14. Pellets of 2,4-D acid materials, cut to 1-cm^2 in size and of known weight, were placed in three 4-oz bottles containing 100 ml of deionized water. Bottles were capped to prevent water loss. Weekly spectrophotometric readings were made and recorded. Water was changed after each reading. Blank formulations, i.e. nontoxic materials of the same base matrix, were run in all cases, and the blank values were subtracted from the raw data. All 2,4-D acid-based materials were run at 70°F and 80°F. The large number of samples involved and the length of the study period (4 months) precluded the use of water baths and small lab incubators. A large incubator capable of holding the desired temperatures was fashioned out of laboratory equipment. Tables 4 and 5 depict loss rate data for 2,4-D acid-based materials at 70°F and 80°F, respectively. Table 6 and Table 7 depict loss at 70° and 80°F per unit time as ppm/cm^2-day.

15. Using a standard curve at 3100 Å for purified diquat (Figure 2) loss rate readings were made on Ameripol SN-600, Ameripol CB-220, and

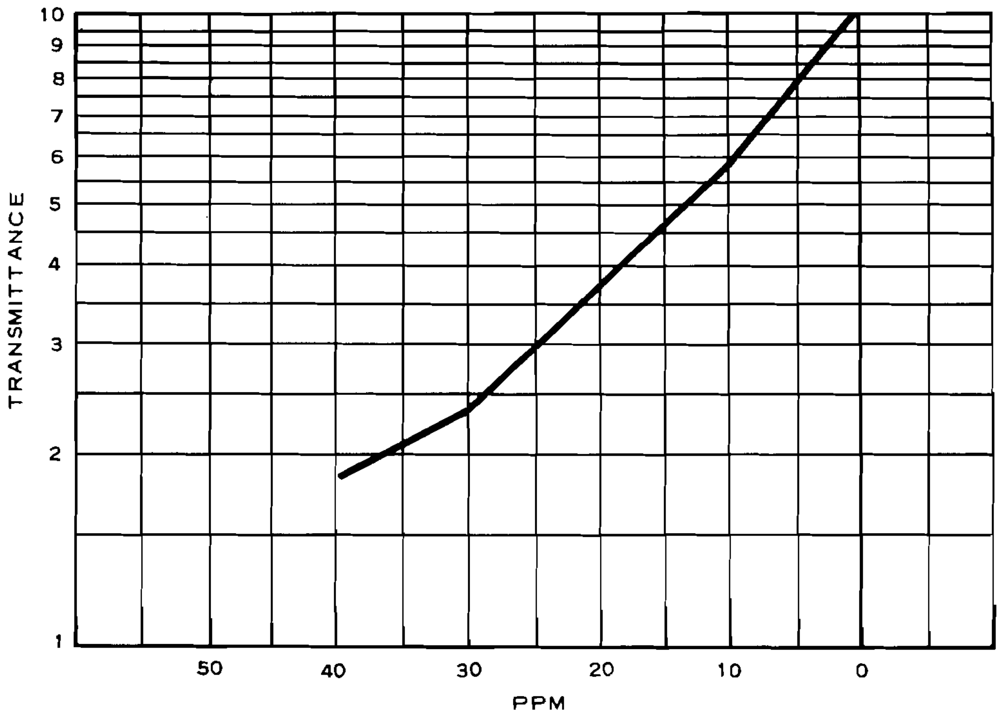

Figure 1. 2,4-D acid spectrophotometric calibration curve (2350 Å)

Ameripol SBR-4616 based materials. The procedure was the same as that described in the 2,4-D acid analysis. Since neither the original nor the modified degree of purity is precisely known, it is impossible to accurately interpret the data at this time. However, the values reported for the spectrophotometric comparison of diquat release at 70°F (Table 8) all err in the same direction and thus are valid for comparison purposes. The values shown are the direct readings from the spectrophotometer and vary inversely with the release rate. Thus as a preliminary conclusion, the medium loadings (50 percent of maximum) appear to be releasing at a rate commensurate with long life and effective results.

16. Loss rate studies were performed at different temperatures to see how temperature effects loss, if at all. A listing of 2,4-D acid losses at 70°F and 80°F is given in Table 9.

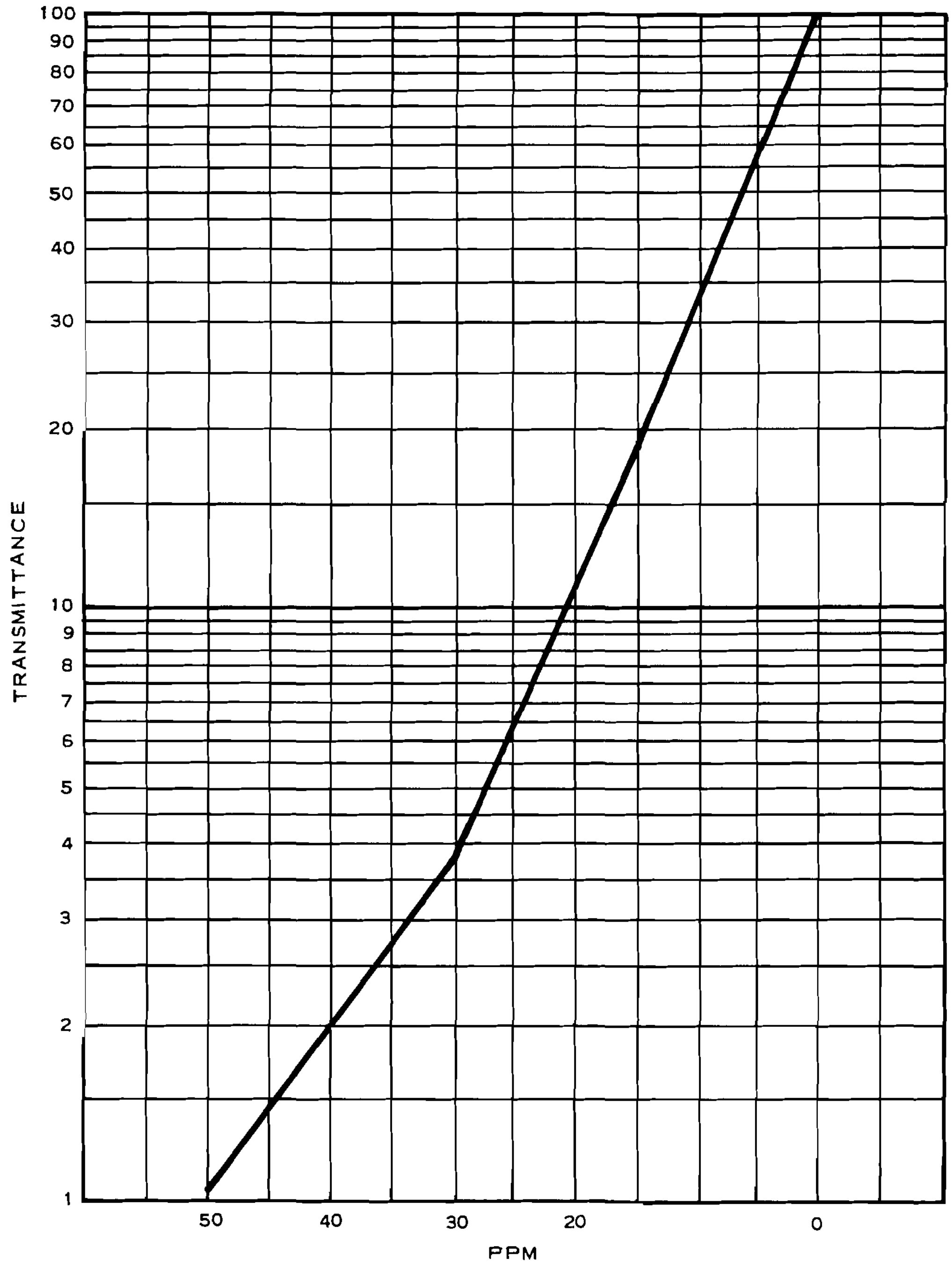

Figure 2. Diquat spectrophotometric calibration curve (3100 Å)

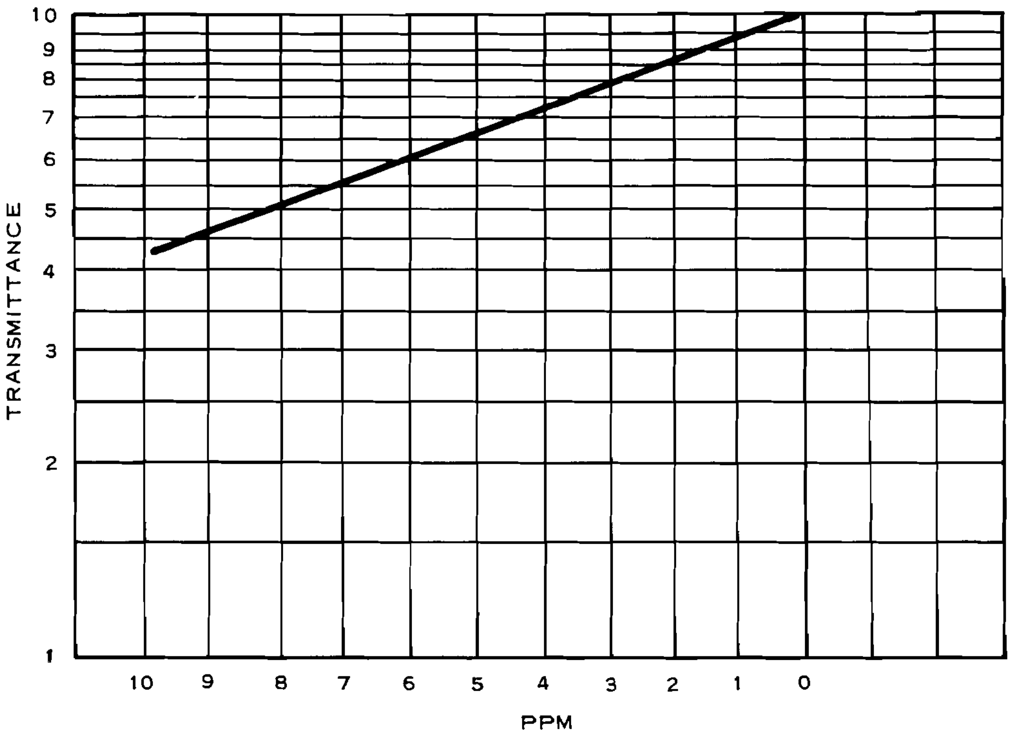

Figure 3. Silvex spectrophotometric calibration curve (2250 Å)

PART III: BIOASSAYS

17. In the bioassay studies three plants were potted in a plastic cup containing approximately 100 g soil, and the cup and plants were submerged in a one-gallon wide-mouth jar containing 3 l of tap water. Three of these units comprised each bioassay. Gro-lux lights were set for a 14-hour day/10-hour night cycle, and plants were conditioned to this cycle for a minimum of 2 weeks. During this period jars were covered with Saran wrap to help control water loss. At the end of the conditioning period, the toxic materials were introduced into the jars. Water temperature throughout the tests was approximately 44°C.

18. Initially, Eurasian watermilfoil, Cabomba, Vallisneria, and Elodea were exposed to fenuron, fenac acid, and endothall at a rate of 10 ppm active ingredient. EC-14 and EC-15 (30 percent fenac acid) in a blend of polyethylene homopolymer with polyethylene-polypropylene copolymer, plus EC-8 and EC-10, copper sulfate systems, as furnished by the Environmental Chemicals Co., Inc., of Chicago, were also tested. These materials are relatively inexpensive to produce. Thus if they provide relatively long-term controlled release, they would be of considerable practical value. Since loss rate studies were not performed on these materials, the dosages selected were randomized.

19. A number of bioassays were also performed using 2,4-D acid and silvex. Dosage levels for these toxicants were determined by combining data from previous studies (5) with loss rates presented in this report, assuming a desired 30-day mortality. Table 10 depicts the findings of the past chronicity investigation.

20. Bioassays were made at the end of a 30-day period. Readings were recorded on a 0 to 10 subjective rating system (with 0 = complete mortality and 10 = healthy, normal growth) and based upon visual estimates of browning and thinning.

21. Plant species manifest individual characteristics when dying. The following is a general description of individual characteristics exhibited by various plant species when dying. However each plant reacts a little differently depending on the herbicide used, and the

mortality made is not identical for each agent. Milfoil, for instance, shows a little thinning and a gradual darkening of the foliage to the point where a gentle touch or disturbance of the water can cause disintegration. Elodea gradually loses foliage until only a stem is left, and once this stem breaks off from the root network, regeneration appears to be impossible. Vallisneria turns yellow and the leaves gradually lose substance, becoming mere threads. Cabomba blackens and putrifies.

22. Bioassay results for milfoil are shown in Tables 11 through 13. Tables 14 through 19 illustrate Cabomba bioassay results. Tables 20 through 24 depict Vallisneria results and Tables 25 through 30 list Elodea results. Tables 31 and 32 present data on blank masters, i.e. the cured rubber without the presence of toxicant.

23. By combining the data from the prior chronicity investigation (Table 10) with the release rate data on 1-cm^2 pellets, it was possible to project the number of acres of a specific plant that could be controlled with a given amount (100 lb) of the various 2,4-D acid study compounds (Table 33). For the purpose of this comparison, the 60-day chronic dose was selected, and the period of control or effective life was projected on this basis.

24. Several of the compounds show promise. It is apparent that these can be made even more effective by adjusting pellet size and shape, which in turn alters release rates. Also, the chart does not take into consideration the toxic requirements to maintain clear water, which would be expected to be lower than the chronic level.

25. The information in Table 33 should be used as a tool or guide rather than the ultimate answer. There are many variables which could cause the dosages required to vary under actual field conditions, most important of which may be the pellet size.

26. Release rates were determined using pellets 1-cm^2 in size to provide a basis for comparison with other compounds and with various laboratory and production studies of the same compound. The rate of toxicant delivery is proportional to pellet size and exposed surface area. By increasing the thickness of the pellet one can achieve a

predictable reduction in the percent average release rate per day, and thereby extend the service life.

27. Release rates are shown based on mature plant mortality. Sublethal control and dosages necessary to prevent reinfestation are considered the most desirable.

PART IV: ADDITIONAL RESEARCH ITEMS

28. As part of the contract effort, CBL collaborated with WES and the University of Southwestern Louisiana, Lafayette, in the planning and initiation of pool tests of CR materials.

29. Several meetings were held to discuss materials, application rates, and experiment design. Ultimately, two CR materials were furnished to the University of Southwestern Louisiana for inclusion in their program; 14 ACE-B, a 18.7 percent 2,4-D BEE compound with a two-year release and E-51, a 50 percent $CuSO_4$ with a 6-month life.

30. On 26-28 September 1976, we traveled to WES, Vicksburg, Mississippi, to participate in the development of a management plan for chemical control of aquatic plants.

31. One result of this meeting was a current list of noxious aquatic weeds in the order of their importance in the Corps of Engineers control program. Since *Hydrilla* is now perhaps the number one problem among the submerged weeds, steps were taken to include this plant in our research program.

32. On 29-30 September 1976, a trip was made to Lafayette, Louisiana, with a WES representative to examine the tests in process, evaluate results, and make plans for further testing.

33. The plant *Hydrilla* was brought into the laboratory and planted in typical test aquaria. It grew quite well under laboratory conditions, quickly rooting and spreading. An initial evaluation of this plant against E-51, the CR copper compound used in the Lafayette pool tests, is now underway. Dosage levels of 10 and 20 lb per acre (rubber weight) are being used.

PART V: CONCLUSIONS

34. EC-14 and EC-15, controlled release fenac in a plastic matrix, were not able to kill within the 30-day test period but did demonstrate considerable biocidal activity.

35. EC-8 and EC-10 copper-bearing materials appeared to be effective against *Cabomba* while showing poor results with Eurasian watermilfoil, *Vallisneria*, and *Elodea* at practical dosage levels.

36. Endothall/CB-220 and Endothall/A-4616 were effective against watermilfoil and *Cabomba*.

37. Controlled release fenac acid in the 4616, 1001, and SN-600 bases showed good results against Eurasian watermilfoil and *Cabomba* but not *Elodea*.

38. Controlled release fenuron was ineffective against all test aquatic weeds at practical concentration levels.

39. Loss rate data has been completed for 2,4-D acid substances, and the diquat evaluations are underway.

40. Evaluations of several 2,4-D acid controlled release elastomers against *Cabomba* at dosages computed from the earlier chronicity study and present loss rate analysis were completed. The results did not reach 100 percent, but several materials showed good control at 30 days exposure. The most prominent 2,4-D acid materials appear to be the higher loadings in the CB and NRX bases with EPCAR close behind. The SN looks good from loss rate data, but the bioassays did not produce the expected results.

41. 2,4-D acid appears to release rapidly from CB-220, A-1001, A-4616, while the slower release EPCAR material provides superior results.

42. The loss rate comparison study of 2,4-D acid at 70° and 80°F showed that loss increased at higher temperatures.

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Table 1

Master Formulation Recipes

Ingredients	Master Formulations					
	A-1001	A-4616	CB-220	SN-600	NRX	EPCAR 5465
Ameripol SBR-1001	100	--	--	--	--	--
Ameripol SBR-4616	--	100	--	--	--	--
Ameripol CB-220	--	--	100	--	--	--
Ameripol SN-600	--	--	--	100	--	--
Natural rubber	--	--	--	--	100	--
EPCAR 5465	--	--	--	--	--	100
ISAF black	15.0	15.0	--	--	--	--
HAF black	--	--	15.0	15.0	15.0	--
SRF black	--	--	--	--	--	10.0
Zinc oxide	3.0	3.0	3.0	3.0	1.0	--
Sulfur	2.0	2.0	1.4	2.0	--	1.25
Altax	1.75	2.5	--	--	--	--
Stearic acid	--	1.5	2.0	0.5	0.5	0.5
NOBS #1	--	--	1.2	--	--	--
CBTS	--	--	--	2.0	2.0	--
TMTDS	--	--	--	--	1.0	1.0
Captax	--	--	--	--	--	0.75
Sulfads	--	--	--	--	--	0.75

Table 2

Materials and Source of Supply

Trade Name	Chemical Name	Source
Ameripol SBR-1001	Styrene-butadiene copolymer (hot polymerized)	B. F. Goodrich Chem. Co., Cleveland, Ohio
Ameripol SBR-4616	Styrene-butadiene copolymer (cold polymerized)	B. F. Goodrich Chem. Co., Cleveland, Ohio
Ameripol CB-220	Cis polybutadiene	B. F. Goodrich Chem. Co., Cleveland, Ohio
Ameripol SN-600	Synthetic natural rubber	B. F. Goodrich Chem. Co., Cleveland, Ohio
Natural rubber	Polyisoprene	Natural Rubber Bureau, Hudson, Ohio
EPCAR 5465	Ethylene-propylene-diene terpolymer	B. F. Goodrich Chem. Co., Cleveland, Ohio
ISAF black (Vulcan 6 - N231)	Carbon black, particle size average 30 mμ	Cabot Corp. Akron, Ohio
HAF black (Vulcan 3)	Carbon black, particle size average 45 mμ	Cabot Corp. Akron, Ohio
SRF black (Sterling S N-770)	Carbon black, particle size average 160 mμ	Cabot Corp. Akron, Ohio
Zinc oxide		Matheson, Coleman and Bell, E. Rutherford, N. J.
Sulfur		Matheson, Coleman and Bell, E. Rutherford, N. J.
Altax	Benzothiazyl disulfide	R. T. Vanderbilt Co., N. Y.
Stearic acid		Mallinckrodt Chem. Works, #St. Louis, Mo.

(Continued)

Table 2 (Concluded)

Trade Name	Chemical Name	Source
NOBS #1	N-oxydiethylene benzothiazole-2-sulfenamide	American Cyanamid Co., Bound Brook, N. J.
CBTS	N-cyclohexyl-2-benzothiazolesulfenamide	Monsanto Chem. Co., Akron, Ohio
TMTDS	Tetramethylthiuram disulfide	E. I. Dupont Wilmington, Del.
Captax	Mercaptobenzothiazole	R. T. Vanderbilt Norwalk, Conn.
Sulfads	Dipentamethylene-thiuram tetrasulfide	R. T. Vanderbilt Norwalk, Conn.
Silvex	2-(2,4,5-Trichloro phenoxy) propionic acid	Dow Chem. Co. Midland, Mich.
Diquat	6,7-dihydrodipyrido (1,2-a:2',1'-c) pyrazinediium dibromide	Chevron Chem. Co. San Francisco, Calif.
2,4-D acid	2,4-dichlorophenoxyacetic acid	Dow Chem. Co. Midland, Mich.
Fenac acid	Sodium salt of 2,3,6-trichlorophenylacetic acid	Amchem, Ambler Pa.
Fenuron	3-phenyl-1, 1-dimethylurea	Scientific Prod. Co., Evanston, Ill.
Endothall	7-Oxabicyclo(2.2.1) heptane-2,3-dicarboxylic acid	Pennwalt Corp. Tacoma, Wash.

Table 3

Maximum Mill Loadings of Selected Agents

Agent	Master Formulations, Percent					
	A-1001	A-4616	CB-220	SN-600	NRX	EPCAR 5465
2,4-D acid	37.0	80.0	82.1	57.2	61.2	53.2
Diquat	54.3	68.6	64.0	55.5	65.8	73.0
Silvex	80.2	75.2	66.0	47.4	48.4	49.6
Fenac acid	33.0	66.8	52.2	57.6	44.4	68.0
Endothall	49.1	47.0	54.7	73.0	45.8	50.0
Fenuron	53.9	57.6	51.2	50.0	57.2	68.5

Table 4

2,4-D Acid Loss at 70° F: Percent Accumulative

2,4-D Acid Loading Percent	Accumulative Percent 2,4-D Acid Loss										
	Day			Week							
	1	2	3	1	2	3	4	8	12	16	17
A-1001*											
9.3	9.5	11.7	12.1	13.7	17.5	19.3	21.1	27.0	30.3	32.4	32.8
18.5	3.8	5.2	6.2	8.4	11.3	13.0	14.5	19.6	23.3	26.6	27.6
33.3	6.2	8.5	9.9	14.0	18.9	21.5	24.0	31.6	36.2	40.3	41.53
A-4616*											
20.0	3.4	5.0	6.0	9.3	13.6	15.7	17.7	24.1	27.8	31.5	32.4
40.0	6.0	9.0	11.4	16.5	23.1	26.8	30.0	39.4	45.7	52.7	54.7
72.0	3.7	6.5	7.9	10.6	14.2	16.9	19.5	28.5	35.2	42.5	44.4
SN-600*											
14.3	1.2	1.9	2.5	3.6	4.6	5.5	5.9	6.8	7.9	8.3	8.3
28.6	3.2	4.5	5.6	8.6	11.5	14.0	15.6	20.7	24.7	27.1	27.9
51.5	4.3	6.3	8.4	13.0	17.7	21.4	25.0	31.9	38.4	43.0	43.7
CB-220*											
20.5	8.9	14.4	17.7	24.1	32.0	36.7	39.1	41.5	42.2	43.1	43.1
41.1	6.1	11.5	14.1	18.9	25.1	30.3	34.7	46.5	54.2	60.7	61.5
73.9	3.2	7.2	10.0	16.6	25.6	33.3	41.8	66.8	83.4	91.0	91.0
NRX*											
15.3	5.4	8.0	10.4	16.8	23.6	30.8	35.2	45.1	52.6	55.7	56.3
30.6	4.3	8.2	10.4	17.3	24.3	32.0	36.4	45.6	59.1	65.8	67.4
55.1	3.3	5.8	8.4	14.7	21.3	29.0	35.4	52.4	64.9	74.3	76.5
EPCAR*											
13.3	2.3	2.6	3.4	4.7	7.1	9.9	12.0	18.3	23.6	27.7	28.7
26.6	2.5	3.7	4.5	6.9	10.3	14.0	16.5	24.0	29.9	34.2	35.1
47.9	4.2	6.3	8.9	12.3	17.1	21.4	24.3	32.4	41.8	47.5	48.1

* Base matrix.

Table 5

2,4-D Acid Loss at 80° F: Percent Accumulative

2,4-D Acid Loading Percent	Accumulative Percent 2,4-D Acid Loss										
	Day		Week								
	1	2	1	2	5	6	12	13	14	16	17
A-1001*											
9.3	16.5	20.7	25.7	27.9	34.4	34.5	35.4	35.4	35.5	35.8	36.0
18.5	8.8	10.2	14.8	17.7	26.4	27.3	32.8	33.3	33.9	35.1	35.7
33.3	5.2	7.6	14.8	18.9	31.4	27.8	39.9	40.8	41.8	43.8	44.7
A-4616*											
20.0	11.3	14.4	19.8	25.4	34.2	37.1	42.9	43.9	44.4	45.4	45.8
40.0	5.1	10.5	19.2	26.2	36.3	39.7	48.6	50.1	51.6	55.0	56.2
72.0	3.8	7.4	12.3	17.3	27.7	31.2	40.4	41.9	43.7	47.3	49.0
SN-600*											
14.3	1.7	2.2	3.3	4.1	5.1	5.4	5.9	6.0	6.0	6.0	6.1
28.6	3.4	4.5	7.9	11.5	18.2	20.4	25.2	26.0	26.6	27.8	28.3
51.5	5.4	8.9	16.5	22.4	29.7	32.1	37.6	38.5	39.2	41.2	42.0
CB-220*											
20.5	19.9	26.0	37.1	42.7	46.7	48.1	49.7	50.0	50.7	51.2	51.5
41.1	8.0	13.3	23.2	32.6	47.3	52.2	62.8	64.6	66.0	67.5	67.8
73.9	4.2	7.9	19.1	32.7	52.2	58.7	79.7	82.7	87.2	92.7	93.5
NRX*											
15.3	10.1	13.3	27.7	32.5	46.8	48.6	59.7	61.0	62.0	64.1	65.0
30.6	4.5	8.1	20.1	28.3	52.8	55.4	71.0	72.8	75.1	80.1	81.9
55.5	5.3	8.5	22.8	30.9	55.1	58.5	78.9	81.8	85.4	93.9	96.1
EPCAR*											
13.3	5.2	6.0	10.5	14.1	24.8	26.2	34.7	36.3		40.7	42.1
26.6	5.0	7.0	14.1	18.7	32.6	34.3	44.7	46.0		52.5	54.1
47.9	6.1	9.6	17.4	22.3	37.3	39.1	49.9	51.7		58.4	60.4

* Base matrix.

Table 6

2,4-D Acid Loss at 70° F Per Unit Time (ppm/cm^2-day)

2,4-D Acid Loading Percent	Numbers = ppm/cm^2-day, days										
	1	2	3	4-7	8-14	15-21	22-28	29-77	78-85	86-91	92-120
A-1001*											
9.3	17.7	4.0	0.8	0.8	1.0	0.2	0.5	0.3	0.2	0.2	0.1
18.5	14.5	5.3	3.8	2.1	1.4	0.9	0.8	0.6	0.5	0.5	0.5
33.3	33.6	12.4	7.8	5.6	3.5	2.0	2.0	1.2	0.8	0.8	0.9
A-4616*											
20.0	12.1	5.8	3.7	2.9	2.2	1.1	1.0	0.6	0.5	0.3	0.5
40.0	41.4	21.2	17.2	8.8	6.4	3.7	3.2	2.0	1.5	2.0	1.8
72.0	51.8	38.4	20.1	9.3	7.1	5.3	5.2	3.9	3.4	3.4	3.7
SN-600*											
14.3	3.7	2.1	1.7	0.8	0.4	0.4	0.2	0.1	0.1	0.1	0
28.6	16.7	7.1	6.0	3.9	2.2	1.9	1.2	0.9	0.6	0.6	0.5
51.5	44.7	21.9	21.8	12.2	7.1	5.5	5.4	2.5	2.0	2.3	1.5
CB-220*											
20.5	32.6	20.7	12.1	5.7	4.2	2.5	1.3	0.2	0.1	0.1	0.1
41.1	46.9	40.6	20.5	9.0	7.4	5.0	4.9	2.7	2.0	2.1	1.5
73.9	50.8	64.8	45.4	26.5	20.7	17.6	19.7	12.3	8.8	7.4	2.5
NRX*											
15.3	14.5	6.8	6.6	4.2	1.0	2.8	1.7	0.9	0.5	0.3	0.3
30.6	21.1	19.4	10.9	8.4	5.0	5.4	3.0	2.0	1.6	1.3	1.1
55.1	31.4	24.2	25.2	15.1	9.1	10.5	8.8	5.0	4.8	4.0	2.8
EPCAR*											
13.3	5.1	0.8	1.7	0.7	0.8	0.9	0.7	0.5	0.4	0.4	0.3
26.6	10.8	5.3	3.5	2.6	2.1	2.3	1.6	1.0	0.8	0.7	0.6
47.9	37.3	19.7	22.6	7.8	6.1	5.6	3.7	2.9	2.2	1.9	1.5

* Base matrix.

Table 7

2,4-D Acid Loss at 80° F Per Unit Time (ppm/cm^2-day)

2,4-D Acid Loading Percent	Numbers = ppm/cm^2-day, days: 1	2	3-5	6-7	8-14	15-42	43-91	92-98	99-112	113-119
A-1001*										
9.3	30.3	7.7	2.0	1.6	0.5	0.4	< 0.1	< 0.1	< 0.1	< 0.1
18.5	32.1	4.9	3.4	3.3	1.4	1.2	0.5	0.3	0.3	0.3
33.3	30.3	14.5	9.4	7.0	3.3	2.9	1.0	0.9	0.9	0.8
A-4616*										
20.0	43.9	12.0	5.1	2.9	3.1	1.6	0.5	0.3	0.3	0.3
40.0	41.9	44.5	17.1	10.0	8.3	4.0	1.7	1.8	2.0	1.4
72.0	59.1	56.5	17.3	12.5	11.1	7.8	3.4	4.0	4.0	3.8
SN-600*										
14.3	5.2	1.7	0.8	0.5	0.3	0.1	< 0.1	0	0	< 0.1
28.6	18.6	6.2	4.6	2.6	2.8	1.7	0.6	0.5	0.4	0.5
51.5	54.5	35.0	19.3	9.3	8.3	3.5	1.3	1.1	1.4	1.1
CB-220*										
20.5	81.2	25.1	11.9	4.8	3.3	0.8	0.2	0.3	0.2	0.1
41.1	63.2	41.8	18.7	11.4	10.7	5.5	2.0	1.5	0.9	0.4
73.9	69.3	60.7	32.8	43.4	31.9	15.3	8.1	10.5	6.5	1.9
NRX*										
15.3	26.5	8.4	8.5	6.1	1.7	1.5	0.7	0.4	0.4	0.3
30.6	23.1	18.1	12.3	12.2	5.6	4.9	1.9	1.8	1.7	1.3
55.1	58.0	34.0	34.1	27.1	11.7	10.6	5.8	6.9	6.0	3.4
EPCAR*										
13.3	12.6	2.0	2.4	1.7	1.2	1.0	0.5	0.5	0.5	0.5
26.6	23.4	9.7	7.1	6.0	2.9	2.6	2.3	1.5	1.5	1.1
47.9	56.1	31.6	16.1	11.9	6.1	5.4	2.4	2.7	3.0	2.6

* Base matrix.

Table 8

Spectrophotometric Comparison of Diquat Release at 70° F

	Numbers = Direct Reading (Transmittance)											
	Percent Diquat in SN-600				Percent Diquat in CB-220				Percent Diquat in SBR-4616			
Days	Blank*	13.9%	27.8%	50.0%	Blank	16.0%	32.0%	57.6%	Blank	17.2%	34.3%	63.7%
1	91.5	4.1	1.3	1.1	38.4	16.7	2.2	0.5	91.2	29.7	3.6	0.3
2-4	91.1	32.9	6.3	0.1	93.5	34.5	4.7	0.1	81.4	29.7	3.6	0.3
5-7	93.1	48.6	7.5	0.7	97.6	52.9	3.6	0.5	83.6	46.1	10.4	0.6
8-14	89.7	40.9	3.4	0.5	96.2	37.0	1.6	0.6	73.5	35.5	3.6	0.5
15-21	93.2	55.7	8.4	2.7	96.9	45.3	1.7	5.8	80.4	56.4	11.3	9.6
22-28	94.8	61.9	5.6	2.7	97.2	51.9	3.3	16.4	78.3	60.4	12.1	45.0
29-35	95.0	68.9	8.1	20.9	98.2	60.7	6.2	45.0	83.3	69.5	21.1	72.6
36-42	95.9	67.7	9.4	45.0	97.4	57.9	10.9	72.0	83.5	68.3	20.9	80.1
43-49	96.1	71.3	12.6	55.8	98.2	62.6	10.3	83.1	85.9	67.1	17.1	83.4
50-56	94.7	70.6	15.1	60.8	97.4	65.5	12.8	87.4	86.6	71.8	24.7	87.5
57-63	95.0	71.3	13.0	56.7	96.8	63.7	17.8	90.2	83.3	72.7	26.4	89.8
64-70	93.0	70.7	15.4	70.6	95.9	65.9	14.7	90.8	84.6	73.3	27.3	89.5
71-77	93.2	63.3	19.0	60.3	95.1	63.8	16.1	92.3	86.3	76.3	34.6	91.2
78-105	90.0	32.7	6.7	61.4	96.4	34.4	8.4	91.8				
106-112	95.5	70.5	27.5	89.9	97.7	72.3	29.5	96.4				
78-112									62.2	41.4	8.1	84.6

* Blank materials contain no diquat.

Table 9

Comparison of 2,4-D Acid Loss at Two Temperatures

Material	Loading Percent	Temperature Degrees F	Percent Loss (Accumulative) Day 1	Day 2	Week 1	Week 2	Week 6	Week 13	Week 17
SBR-4616	20.0	70	3.4	5.0	9.3	13.6	21.4	28.7	32.4
		80	11.3	14.4	19.8	25.4	37.1	43.8	45.8
	40.0	70	6.0	9.0	16.5	23.1	35.2	47.7	54.7
		80	5.1	10.5	19.2	26.2	39.7	50.1	56.2
	72.0	70	3.7	6.5	10.6	14.2	24.2	36.9	44.4
		80	3.8	7.4	12.3	17.3	31.2	41.9	49.0
SN-600	14.3	70	1.2	1.9	3.6	4.6	6.3	8.0	8.3
		80	1.7	2.2	3.3	4.1	5.4	6.0	6.1
	28.6	70	3.2	4.5	8.6	11.5	18.0	25.4	28.0
		80	3.4	4.5	7.9	11.5	20.4	26.0	28.3
	51.5	70	4.3	6.3	13.0	17.7	28.5	39.6	43.7
		80	5.4	8.9	16.5	22.4	32.1	38.5	42.0
EPCAR	13.3	70	2.3	2.6	4.7	7.1	15.2	24.8	28.6
		80	5.2	6.0	10.5	14.1	26.2	36.3	42.1
	26.6	70	2.5	3.7	6.9	10.3	20.3	31.0	35.1
		80	5.0	7.0	14.1	18.7	34.3	46.0	54.1
	47.9	70	4.2	6.3	12.3	17.1	28.3	43.3	48.1
		80	6.1	9.6	17.4	22.3	39.1	51.7	60.4
SBR-1001	9.3	70	9.5	11.7	13.7	17.5	24.1	30.8	32.8
		80	16.5	20.7	25.7	27.9	34.5	35.4	36.0
	18.5	70	3.8	5.2	8.4	11.3	16.9	24.1	27.6
		80	8.8	10.2	14.8	17.7	27.3	33.3	35.7
	33.3	70	6.2	8.5	14.0	18.9	27.8	37.2	41.5
		80	5.2	7.6	14.8	18.9	32.6	40.8	44.7
CB-220	20.5	70	8.9	14.4	24.1	32.0	40.3	42.4	43.1
		80	19.9	26.0	37.1	42.7	48.1	50.0	51.5
	41.1	70	6.1	11.5	18.9	25.1	40.5	55.8	61.5
		80	8.0	13.3	23.2	32.6	52.2	64.6	67.8
	73.9	70	3.2	7.2	16.6	25.6	54.2	85.3	91.0
		80	4.2	7.9	19.1	32.7	58.7	82.7	93.5
NRX	15.3	70	5.4	8.0	16.8	23.6	40.2	53.4	56.3
		80	10.1	13.3	27.7	32.5	48.6	61.0	65.0
	30.6	70	4.3	8.2	17.3	24.3	41.0	60.9	67.4
		80	4.5	8.1	20.1	28.3	55.4	72.8	81.9
	55.1	70	3.3	5.8	14.7	21.3	43.8	67.8	76.5
		80	5.3	8.5	22.8	30.9	58.5	81.8	96.1

Table 10

Chronic Dosages For 30- and 60-Day Mortality

Herbicide	Days	Cabomba ppm/day	Vallisneria ppm/day	Milfoil ppm/day	Elodea ppm/day
2,4-D acid	30	0.1	0.2	0.008	0.03
	60	0.1	0.2	0.001	0.001
Silvex	30	0.2	1.1	0.08	0.07
	60	0.2	0.1	0.005	0.01
Diquat	30	1.3	0.01	0.005	0.06
	60	1.3	0.001	0.005	0.01

Table 11

Fenac Versus Eurasian Watermilfoil
Dosage: 10 ppm (Active)

Code or Base	Percent Toxicant Loading	Percent Accumulative Mortality, days							
		2	6	10	14	18	22	26	30
EC-15	30.0	0	0	7	10	23	57	63	63
EC-14	30.0	0	7	10	20	53	87	87	93
A-1001	33.0	3	10	13	37	73	77	73	77
A-4616	66.8	3	10	13	30	60	100		
SN-600	57.6	0	7	17	37	53	87	100	
CB-220	52.2	0	7	13	23	73	100		
NRX	44.4	0	0	20	37	90	100		
EPCAR 5465	68.0	0	7	17	37	53	87	100	
Control	--	0	0	3	10	10	10	3	3

Note: Bioassays are an average of 3 runs of 3 plants each.

Table 12

Endothal Versus Eurasian Watermilfoil
Dosage: 10 ppm (Active)

Base	Percent Toxicant Loading	Percent Accumulative Mortality, days							
		2	6	10	14	18	22	26	30
A-1001	49.1	0	3	7	17	23	27	27	33
A-4616	53.0	0	0	13	23	40	60	53	67
SN-600	73.0	0	0	13	27	40	47	60	67
CB-220	45.4	3	13	33	47	67	83	100	
NRX	45.8	0	10	17	20	20	23	33	30
EPCAR 5465	50.0	3	7	7	23	27	40	63	73
Control	--	0	0	0	2	5	7	3	3

Table 13

$CuSO_4$ Versus Eurasian Watermilfoil
Dosage: 10 ppm (Active)

Code	Percent Toxicant Loading	Percent Accumulative Mortality, days 2	6	10	14	18	22	26	30
EC-8	50.0	3	3	7	10	13	23	33	47
EC-10	50.0	0	13	13	17	13	17	17	33
Control	--	0	0	0	0	0	0	0	0

Table 14

Fenac Versus Cabomba, Dosage: 10 ppm (Active)

Code or Base	Percent Toxicant Loading	Percent Accumulative Mortality, days 2	6	10	14	18	22	26	30
EC-15	30.0	3	20	33	37	40	43	43	43
EC-14	30.0	0	17	20	37	47	50	47	50
A-1001	33.3	0	43	70	73	73	77	93	100
A-4616	66.8	0	10	47	93	100			
SN-600	57.6	0	17	57	67	77	77	90	100
CB-220	52.2	3	10	60	80	83	87	90	90
NRX	44.4	0	20	63	87	93	100		
EPCAR 5465	68.0	0	13	27	43	57	60	60	63
Control	--	0	3	5	3	3	3	5	3

Table 15

Endothal Versus Cabomba, Dosage: 10 ppm (Active)

Base	Percent Toxicant Loading	Percent Accumulative Mortality, days 2	6	10	14	18	22	26	30
A-1001	49.1	7	13	23	27	47	73	70	73
A-4616	53.0	3	13	23	57	77	87	100	
SN-600	73.0	7	23	30	43	60	53	70	73
CB-220	45.4	10	43	63	90	100			
NRX	45.8	3	13	30	40	73	73	73	70
EPCAR 5465	50.0	10	33	40	50	50	43	30	47
Control	--	0	3	3	7	5	3	2	2

Table 16

Fenuron Versus Cabomba, Dosage: 10 ppm (Active)

Base	Percent Toxicant Loading	Percent Accumulative Mortality, days 2	6	10	14	18	22	26	30
A-1001	53.9	0	0	7	17	27	47	63	77
A-4616	57.6	3	13	27	33	53	60	53	50
SN-600	50.0	0	17	33	43	57	67	70	70
CB-220	51.2	7	33	60	70	77	87	93	100
NRX	57.2	7	33	53	60	63	63	60	63
EPCAR 5465	68.5	3	30	43	43	53	63	63	67
Control	--	0	0	0	3	5	5	8	8

Table 17

$CuSO_4$ Versus Cabomba, Dosage: 10 ppm (Active)

Code	Percent Toxicant Loading	Percent Accumulative Mortality, days 2	6	10	14	18	22	26	30
EC-8	50.0	17	50	67	77	77	77	80	93
EC-10	50.0	17	57	73	80	80	77	80	93
Control	--	0	3	3	7	5	3	2	2

Table 18

2,4-D Acid Versus Cabomba

Base	Percent Toxicant Loading	Dosage Per 31 grams	Percent Accumulative Mortality, days 2	6	10	14	18	22	26	30
A-1001	9.3	0.045	7	17	33	53	53	67	70	70
	18.5	0.060	7	40	73	87	80	83	87	93
	33.3	0.038	7	20	47	83	90	90	93	97
A-4616	20.0	0.051	3	23	40	57	57	73	73	83
	40.0	0.030	3	27	50	67	80	90	93	90
	72.0	0.040	3	20	30	40	60	67	80	90
SN-600	14.3	0.250	10	20	37	73	87	93	97	93
	28.6	0.095	10	13	20	30	33	40	43	47
	51.5	0.062	0	7	7	13	20	23	23	20
CB-220	20.5	0.050	0	10	13	20	17	23	17	20
	41.1	0.044	13	53	67	77	80	83	83	80
	73.9	0.040	3	10	20	37	63	73	83	87
NRX	15.3	0.040	7	20	23	33	30	37	47	50
	30.6	0.040	0	7	20	37	53	67	73	73
	55.1	0.040	3	13	23	33	40	50	53	67
EPCAR 5465	13.3	0.200	3	10	23	27	27	27	27	20
	26.6	0.073	13	43	67	83	90	87	93	93
	47.9	0.028	10	23	43	67	73	83	100	
Control	--		0	0	0	5	9	9	11	9

Table 19

Silvex Versus Cabomba

Base	Percent Toxicant Loading	Dosage Active ppm	Percent Accumulative Mortality, days 1	3	11	18	25	32
CB-220	59.4	36	0	0	0	20	33	47
	33.0	36	0	0	7	13	13	13
	16.5	36	0	0	40	87	90	93
	33.0	12	0	0	3	27	10	67
SN-600	38.7	36	0	0	0	3	17	27
	23.7	36	0	0	17	30	43	43
	11.9	36	0	3	0	27	30	47
NRX	12.1	36	0	0	23	83	87	87
	24.2	36	0	13	40	57	57	63
Control	--	--	0	1	16	20	20	71

Note: Timer malfunction, which exposed plants to 24 hr a day Gro-lux light, was discovered on day 27 and corrected. Lights were working correctly on day 18.
Results are not valid due to above, but do indicate a strong trend by 18th day.
Figures suggest that a small amount of silvex may be beneficial to plants exposed to excessive light.

Table 20

Fenac Versus Vallisneria, Dosage: 10 ppm (Active)

Base	Percent Toxicant Loading	Percent Accumulative Mortality, Days 2	6	10	14	18	22	26	30
A-1001	33.3	3	20	27	47	67	77	80	83
A-4616	66.8	7	20	43	47	67	80	90	90
SN-600	57.6	7	27	47	60	77	80	73	77
CB-220	52.2	7	20	37	63	67	70	70	80
NRX	44.4	13	37	50	73	90	100		
EPCAR 5465	68.0	7	20	37	50	70	70	73	77
Control	--	0	0	3	4	10	9	7	8

Note: EC-14 and EC-15 were deferred from testing against Vallisneria based on results demonstrated against Cabomba.

Table 21

Endothall Versus Vallisneria, Dosage: 10 ppm (Active)

Base	Percent Toxicant Loading	Percent Accumulative Mortality, days							
		2	6	10	14	18	22	26	30
A-4616	53.0	3	27	50	87	100			
CB-220	45.4	0	17	50	100				
Control	--	0	3	3	3	7			

Note: Endothall compounds of the other four elastomers were deferred from testing against Vallisneria because of the results against Cabomba.

Table 22

2,4-D Acid Versus Vallisneria

Base	Percent Toxicant Loading	Dosage Per 31 gram	Percent Accumulative Mortality, days							
			2	6	10	14	18	22	26	30
NRX	15.3	0.05	0	3	3	3	7	3	7	10
	30.6	0.05	0	0	3	7	7	7	3	3
	55.1	0.05	0	23	57	47	60	70	63	67
Control	--	--	0	0	0	0	0	0	0	3

Table 23

Fenuron Versus Vallisneria, Dosage: 10 ppm (Active)

Base	Percent Toxicant Loading	Percent Accumulative Mortality, days							
		2	6	10	14	18	22	26	30
A-1001	53.9	10	17	17	13	13	10	13	13
A-4616	57.6	0	3	7	7	13	23	23	40
SN-600	50.0	3	3	7	7	7	10	10	13
CB-220	51.2	3	7	7	10	13	17	20	20
NRX	57.2	0	0	10	10	10	20	17	30
EPCAR 5465	68.5	3	7	7	3	3	13	13	20
Control	--	0	0	0	0	0	3	8	5

Table 24

$CuSO_4$ Versus Vallisneria, Dosage: 10ppm (Active)

Base	Percent Toxicant Loading	Percent Accumulative Mortality, days 2	6	10	14	18	22	26	30
EC-8	50.0	7	13	30	37	47	57	60	67
EC-10	50.0	13	37	43	63	63	67	63	70
Control	--	0	0	3	4	10	9	7	8

Table 25

Fenac Versus Elodea, Dosage: 10 ppm (Active)

Base	Percent Toxicant Loading	Percent Accumulative Mortality, days 2	6	10	14	18	22	26	30
A-1001	33.0	0	7	13	23	47	47	53	50
A-4616	66.8	0	7	17	43	53	57	63	70
SN-600	57.6	0	3	7	17	13	17	13	10
CB-220	52.2	0	7	17	20	27	30	43	40
NRX	44.4	0	3	7	17	23	33	40	53
EPCAR 5465	68.0	0	0	7	7	7	7	17	17
Control	--	0	1	1	3	4	4	4	4

Table 26

Endothall Versus Elodea, Dosage: 10 ppm (Active)

Base	Percent Toxicant Loading	Percent Accumulative Mortality, days 2	6	10	14	18	22	26	30
A-4616	53.0	10	20	27	40	50	47	50	70
CB-220	45.4	13	43	60	67	67	67	77	77
Control	--	0	0	0	5	5	5	5	10

Table 27

$CuSO_4$ Versus Elodea, Dosage: 10 ppm (Active)

Base	Percent Toxicant Loading	Percent Accumulative Mortality, days 2	6	10	14	18	22	26	30
EC-8	50.0	10	27	27	30	37	57	67	67
EC-10	50.0	3	13	17	10	3	3	3	0
Control	--	0	1	1	3	4	4	4	4

Table 28

2,4-D Acid Versus Elodea - Run 1

Base	Percent Toxicant Loading	Dosage Per 3l (Rubber)	Percent Accumulative Mortality, days 2	6	10	14	18	22	26	30
NRX	15.6	0.05 g	3	10	20	27	37	30	33	40
	30.6	0.05 g	0	0	10	10	17	17	13	20
	55.1	0.05 g	3	17	33	47	53	63	63	60
Control	--	--	3	3	3	5	8	8	8	10

Table 29

2,4-D Acid Versus Elodea - Run 2

Base	Percent Toxicant Loading	Dosage Per 3l (Rubber)	Percent Accumulative Mortality, days 3	8	11	19	26	33	40
NRX	15.6	0.04 g	0	3	0	17	57	63	77
	30.6	0.04 g	0	0	0	3	20	20	20
	55.1	0.05 g	7	33	40	50	97	97	97
CB-220	20.5	0.05 g	3	7	3	20	20	17	17
	41.0	0.04 g	0	10	10	40	53	67	73
	82.1	0.04 g	0	3	0	17	37	40	47
Control	--	--	3	7	7	15	27	27	30

Note: As with Table 19, a timer malfunction resulted in the plants being exposed to a 24-hr-day cycle. This malfunction was discovered on day 26 and corrected. Lights were working correctly on day 17; results through day 11 are assumed to be correct.

Table 30

Fenuron Versus Elodea, Dosage: 10 ppm (Active)

Base	Percent Toxicant Loading	Gram Dosage Per 31 (Rubber)	Percent Accumulative Mortality, days						
			3	8	11	19	26	33	40
A-1001	53.9	0.0599	3	10	3	27	33	40	40
A-4616	57.6	0.0522	0	3	0	10	10	10	17
SN-600	50.0	0.0600	10	17	23	43	53	53	70
CB-220	51.2	0.0590	0	7	0	7	7	7	7
NRX	57.2	0.0530	0	0	0	0	0	0	0
EPCAR 5465	68.5	0.0530	10	20	17	17	30	37	63
Control	--	--	4	10	10	26	46	56	66

Note: A timer malfunction resulted in the plants being exposed to a 24-hour-day cycle. This malfunction was discovered on day 26 and corrected. Lights were working correctly on day 17.

Table 31

Nontoxic Base Versus Cabomba, Dosage: 0.02 g/l

Base	Percent Accumulative Mortality, days							
	2	6	10	14	18	22	26	30
A-1001	0	0	0	3	3	3	3	3
A-4616	0	0	0	0	3	7	13	13
SN-600	0	3	7	3	3	7	17	17
CB-220	3	3	13	10	10	10	17	13
NRX	0	0	0	0	0	0	13	17
EPCAR 5465	0	3	7	10	13	17	23	20

Table 32

Nontoxic Base Versus Vallisneria, Dosage: 0.02 g/l

Base	Percent Accumulative Mortality, days							
	2	6	10	14	18	22	26	30
A-1001	0	3	3	7	7	13	23	17
A-4616	3	3	3	3	7	7	10	7
SN-600	0	0	0	3	10	13	13	13
CB-220	0	0	0	0	7	10	13	10
NRX	0	10	10	10	13	13	13	10
EPCAR 5465	0	3	10	13	13	13	20	20

Table 33

Treatment Dosage and Projected Life of 2,4-D Acid Compounds

Base	Percent Toxic	Average Release/Day 70° F	Acres/100-lb Treatment C[1]	M[2]	E[3]	Life Month
A-4616	20.0	0.63	0.5	46.0	46.0	11.2
	40.0	1.15	1.7	170.0	170.0	8.9
	72.0	0.70	1.9	185.0	185.0	10.8
A-1001	9.3	0.75	0.3	25.0	25.0	10.4
	18.5	0.52	0.4	35.0	35.0	12.0
	33.3	0.86	1.1	105.0	105.0	9.8
CB-220	20.5	1.39	1.0	104.0	104.0	8.4
	41.1	1.23	1.9	185.0	185.0	8.7
	73.9	1.49	4.1	405.0	405.0	8.2
SN-600	14.3	0.21	0.1	11.0	11.0	21.9
	28.6	0.56	0.6	58.8	58.8	11.3
	51.5	0.89	1.7	169.0	169.0	9.4
NRX	15.3	1.25	0.7	70.0	70.0	8.7
	30.6	1.31	1.5	147.0	147.0	8.5
	55.1	1.22	2.5	247.0	247.0	8.7
EPCAR 5465	13.3	0.55	0.3	26.0	26.0	12.0
	26.6	0.74	0.7	72.0	72.0	10.5
	47.9	1.22	2.1	214.8	214.8	8.7

Note: C[1] = *Cabomba*; M[2] = Milfoil; E[3] = *Elodea*.

$$\text{Acres/100-lb treatment} = \frac{A \times B}{C}$$

$$\text{Life} = \left[\left(\frac{A}{A \times B}\right) \div 30 \text{ days}\right] + 6 \text{ months}$$

where:

A = Active pounds in 100 lb material.

B = Percent average release/day.

C = __ lb/acre foot of water (see Table 10 for the chronic dosage necessary for a 60-day mortality).

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Janes, G A

Development and evaluation of controlled release herbicides / by G. A. Janes, S. M. Bille, N. F. Cardarelli, Creative Biology Laboratory, Incorporated, Barberton, Ohio. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1978.

17, [18] p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; A-78-1)

Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C., under Contract No. DACW39-76-C-0029.

References: p. 17.

1. Aquatic plant control. 2. Bioassay. 3. Herbicides. I. Bille, S. M., joint author. II. Cardarelli, N. F., joint author. III. Creative Biology Laboratory, Inc. IV. United States. Army. Corps of Engineers. V. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Technical report ; A-78-1.

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