TECHNICAL FISHERIES SESSION

A PRELIMINARY REPORT ON THE COMPARATIVE TESTING OF SOME OF THE NEWER HERBICIDES

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ABSTRACT

A simple method for the comparative testing of herbicides for emergent weeds was developed and used over a three-year period to compare the effect of recently introduced herbicides with that obtained from the use of a 2, 4-D ester in a fuel oil carrier.

The herbicides tested included amitrol (3-amino-1, 2, 4-triazol), dalapon (sodium salt of 2, 2 dichloropropionic acid), erbon (2-(2, 4, 5 tricholorophenoxy) ethyl 2, 2 dichloropropionate), Kuron (propylene glycol butyl ether ester of 2-(2, 4, 5 trichlorophenoxy) propionic acid), Kuramine (amine formulation of 2-(2, 4, 5 trichlorophenoxy) propionic acid), CMU (3-(p-chlorophenyl)-1, 1-dimethylurea) and the propylene glycol butyl ether ester of 2, 4-D. These compounds were tested singly and in various combinations of two herbicides. TCA (sodium salt of trichloroacetate) was combined with several of the forms also.

Several species of marginal and emergent weeds were included in the tests such as cattail, sedge, grass, rush and other plants often occurring in shallow waters and pond margins.

On the species of weeds treated, dalapon, amitrol, the propylene glycol butyl ether ester of 2, 4-D and CMU were most effective when used alone. Combinations of TCA-kuron, dalapon-kuron, amitrol-kuron, amitrol-erbon, TCA-erbon, amitrol-dalapon and dalapon-2, 4-D were as effective in killing the vegetation treated as was the standard 2, 4-D ester in oil treatment. Generally a combination of two herbicides gave better results than either of the agents used alone. CMU was the only herbicide tested which had strong residual effects although several of the treatments exhibited residual effects extending into the season following the one in which they were applied.

INTRODUCTION

More than ten years have passed since the use of 2, 4-D for aquatic weed control was first advocated (Hall and Hess, 1946; Bauman, 1947; Surber *et al.*, 1947). During the years which followed its introduction, 2, 4-D has been widely employed as both a selective and a non-selective weed killer.

For the control of marginal and emergent aquatic weeds in and around small ponds the recommendations of Snow (1949) have been tested in field use under varied conditions throughout the southeast. For general use on mixed growths of marginal or emergent pond weeds infesting farm or hatchery pond areas a mixture of 0.3-0.5 percent 2, 4-D in the ester form and diesel fuel or kerosene applied as a drenching spray has been effective in giving seasonal control of most weeds. Usually some respraying is needed to eliminate new growth and weeds missed by the initial application. On most areas, from 100 to 200 gallons of the mixture are needed to give adequate coverage. Thus an application rate of from 3.0 to 8.0 pounds of 2, 4-D is needed per acre using this treatment. These rates when properly applied have given successful results on all forms of emergent weeds occurring at the U. S. Fish Cultural Station, Marion, Alabama.

A number of other herbicides have been developed and introduced for various uses in recent years. While most of these compounds are designed for specific agricultural uses, a few have shown promise of being applicable to aquatic weeds also. In order to evaluate these introductions, it appears that a procedure for screening the new herbicides would be useful in determining whether or not they would be an improvement over the 2, 4-D-diesel oil mixture presently being used.

PROCEDURE DEVELOPED AND MATERIALS TESTED

In 1954, work was begun on a screening method for testing the herbicides showing promise in emergent aquatic weed control. Answers to several questions were needed on each new introduction. Would the product kill weeds as well as the 2, 4-D-diesel fuel mixture? If so, was it economically feasible to use the effective treatment? Also, were any hazards associated with its use?

In order to obtain answers to these and other questions, a tentative method was adopted for testing new weed killers. Plots measuring 20 by 20 feet were selected in areas supporting weeds such as cattail, marsh grasses, sedges and related forms. In most instances the weeds were treated before they were mature, but three trials were conducted in the late summer or early fall. Treatments of the chemicals being tested were applied to the plots using a knapsack sprayer. One gallon of spray solution was used per plot, a rate of approximately 110 gallons per acre. A small amount of household detergent was included in water carrier sprays as a wetting agent. Initial treatments were applied in duplicate in most cases, but in a few instances, lack of suitable vegetated area restricted duplication. If the results appeared promising further replication was then carried out. Rates of application generally comparable in cost to those used for 2, 4-D were selected as starting points.

Prior to or shortly after treatment, the major species of vegetation growing on the plots were identified and notes made on the total amount of growth present. Following treatment, the plots were inspected at least three times during the remainder of the growing season to determine the results. Evaluation of the treatments was done by visually estimating the degree of damage to plant growth on the plot. Damage was expressed as a percentage value ranging from zero to a one hundred percent kill of treated plants. A complete kill of all top growth with no regrowth was taken as 100 percent. Less kill than 100 percent was given a percentage value corresponding to the estimated amount of top growth killed. This is a variation of a technique which has been used by other investigators who were working on similar problems (Grigsby *et al.*, 1955). No effort was made to adjust the percent of kill to compensate for uneven coverage of the plot caused by poor spraying technique. Close attention to uniform application of the spray reduced this factor greatly as the work progressed however.

For determination of residual effects of the treatments, plots were inspected in the spring, summer, and where necessary, the fall of the following year. In some instances further checks were made where residual effects continued into the second year.

In 1955 the method of testing was modified as follows: A plot size of 10 by 10 feet was used. A buffer strip three feet wide was left between plots. A 10-foot square frame made of two by two inch lumber bolted at the corners was used to establish the plots. By placing a marker stake at each corner of the frame, a plot could be marked with a minimum of time and effort. Using the outline frame a series of test plots could be readily established even where the experimental area was irregular in shape. An application rate of 218 gallons per acre (½ gallon per 100 square feet) was used as the 110 gallon rate used previously was too low for adequate coverage where the weed growth was heavy. The spray was applied with a small two-gallon size compression cylinder type pressure sprayer similar to the Hudson Bugwiser No. 220 Model B. A fan type spray nozzle giving a fine drop spray was used. As a control treatment, one or more plots were treated with 4-8 pounds 2, 4-D per acre (ester form) in an oil carrier for comparison purposes.

The test method as outlined and modified has worked well for two seasons and enables the investigator to test several herbicides and concentrations in a comparatively small area. The marking frame and small plot size greatly reduces the time required to conduct a given experiment. Uniform coverage of the plot can be readily obtained and the small plot size facilitates evaluation of results.

A number of species of emergent and marginal species of plants are available on the Marion Station for use in weed control studies. Species classified as hard-to-kill plants include reed grass, *Phragmites sp.*, knotgrass, *Paspalum distichum,* cut-grass, *Leersia oryzoides,* cord grass, *Spartina spartinae,* wool grass, *Scirpus eriophorum,* and the sedges *Cyperus acuminatus* and *C. ery-*

throrhizos. Species present which are moderately hard to kill include soft rush, *Juncus effusus,* spike rush, *Eleocharis obtusa,* needle rush, *Eleocharis acicularis,* cattail, *Typha latifolia,* smartweed, *Polygonum sp.,* water lily, *Nympheae odorata,* water shield, *Brasenia schreberi* and lizard's tail, *Saururus cernuus.* Identification of the species present was made using the keys of Fassett (1940) and Eyles and Robertson (1944).

In a few instances, a pure stand of one species of plant was available for use, but generally several species would be present on a given plot with the species composition being about the same with the amount of a given species varying from plot to plot.

During 1954, five herbicides were included in the tests. These were TCA (trichloroacetate, sodium salt), CMU (3-(p-chlorophenyl)-1-1 dimethylurea), dalapon (2,2 dichloropropionic acid), Kuron (propylene glycol butyl ether ester of 2-(2,4,5 trichlorophenoxy) propionic acid), and Kuramine (amine formulation of 2-(2,4,5 trichlorophenoxy) propionic acid). In 1955, amitrol (3-amino-1,2,4-triazol), erbon (2-(2,4,5 trichlorophenoxy) ethyl 2,2 dichloropropionate) and the propylene glycol butyl ether ester of 2,4-D were added. A few combinations were also tested during the year. During 1956 the rate of application of the most promising of the introductions was refined and more combinations were tested. For obvious reasons the short or common name for the above formulations will be used in the remainder of the paper.

DISCUSSION OF RESULTS

The procedure outlined previously was used to test eight herbicides and 18 combinations of two herbicides. Under appropriate headings, results of the comparative tests will be discussed in some detail. All rates of application are given in terms of pounds of the acid equivalent or active ingredient per acre. A detailed listing of treatment data and results for the 236 test plots included in the study is omitted for the sake of brevity.

Amitrol (3-amino-1,2,4-triazol): This formulation was applied in water solution at rates ranging from 3.4 to 40.8 pounds per acre to broad-leaved annuals, blackberry, cattail, cord grass, cut-grass, lizard's tail, spike rush, soft rush, smartweed, reed grass, water shield, water lily and wool grass. Results obtained were uniformly good on members of the grass family treated, but amitrol was generally ineffective in killing the species of sedges and scome of the rushes treated. A rate of 20.4 pounds per acre failed to kill wool grass in one instance. A rate of 13.6 pounds was ineffective in killing soft rush, although a kill of 90 and 95 percent was noted on two plots of spike rush receiving 6.8 pounds per acre. Regrowth following treatment was not noticeably different from that obtained from other herbicides in the test with the exception of CMU.

Of the weeds on which amitrol was tested, the grasses except for reed grass and cord grass appeared to be susceptible. Also susceptible were cattail, smartweed, spike rush and several broad-leaved annuals. Resistant species appeared to be soft rush, wool grass, water shield, water lily, reed grass and cord grass. As a general recommendation, a rate of 10 pounds per acre of amitrol (active ingredient) should be used for susceptible plants while 20 pounds per acre or more may be needed on the resistant species.

CMU (3-(p-chlorophenyl)-1-1-dimethylurea): CMU has been available as a herbicide for several years and it could hardly be classed as a new introduction. Because of the high cost of using this material,* little effort was devoted to its testing. Three plots were treated at a rate of 65 pounds per acre in water solution. Growth on one plot was mainly grass while the other two had several species of plants including smartweed, wool grass, soft rush, reed grass, and broad-leaved annuals. The initial effect of the treatment was very slow compared to the other herbicides. By the end of the growing season the treated plots were devoid of all vegetation, however, and remained so for the growing season following treatment. Twenty-one months after treatment, evidence of residual effects could still be observed although several species of weeds were establishing themselves in the treated area.

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* About $3.00 per pound of the commercial formulation containing 80 percent active ingredient.

Where the high initial cost can be justified by the need for prolonged residual action, the use of this herbicide should be considered. It appears valuable as a soil sterilant for special uses however rather than a general control agent.

Dalapon (2,2 dichloropropionic acid, sodium salt): dalapon was tested more extensively than any other agent included in this report as it appeared to have considerable promise as a herbicide. A total of 45 test plots was included with rates of from five to 100 pounds per acre being tried. Species of vegetation on the test plots included cattail, cut-grass, cord grass, knotgrass, needle rush, smartweed, soft rush, spike rush, reed grass, water shield, water lily, wool grass and broad-leaved annuals.

Dalapon has been recommended by its manufacturers as a grass killer. Results of our experiments indicated that grass was killed at rates as low as five pounds of the acid equivalent material per acre. The 10-pound per acre rate was consistently effective on cattails and the grasses in the tests except for reed grass and cord grass. Dalapon was not as effective on members of the sedge family treated as it was on grasses. An exception was on needle rush which appeared to be only moderately resistant to dalapon.

Species of weeds susceptible to dalapon included cut-grass, cord grass, knotgrass, cattail and smartweed. Reed grass, water shield, water lily, soft rush, wool grass, spike rush and needle rush appeared to be moderately to strongly resistant. On susceptible vegetation, 10 pounds of active dalapon per acre was as effective as 8 pounds of 2, 4-D applied in a diesel oil carrier. This compound did not kill as wide a range of plant species as did 2, 4-D, however.

Results from several test plots indicated that there was little to be gained in increasing the rate of application above 40 pounds per acre. The increased kill from the added amount of herbicide did not appear to justify the cost of the additional material. Some residual effects were noted up to eight months after application at rates above 20 pounds per acre. At rates of 40-100 pounds, residual effects on the species of plants treated persisted throughout the growing season following treatment. On plots of cattails treated with rates of 20, 30 and 40 pounds of dalapon per acre, reduction of regrowth in May following treatment the previous August was 95, 99 and 99 percent, respectively. Other forms of plants replaced the cattail on the plots, however, and the completeness of the initial kill may have been responsible for the lack of recovery of treated vegetation rather than a sterilizing effect exerted by the chemical.

Poor results were noted from applications of dalapon to susceptible weeds where as much as 1/3 of the plant was submerged. Needle rush growing in a seepage area of a pond bottom was not killed although growth in surrounding areas on moist ground was effectively killed. A rate of 40 pounds per acre killed only 25 percent of the water shield and water lily growing on another plot. In still another instance a rate of 40 pounds per acre failed to materially damage knotgrass growing partly submerged in a pond margin. Apparently the solubility of the dalapon resulted in the spray solution being diluted to an ineffective level before enough of the herbicide penetrated the treated plants.

Dalapon is recommended for grass and cattail control at rates of from 10 to 20 pounds of the acid equivalent material per acre. Residual value of the higher rate seems to be better than the 2, 4-D-oil mix and might justify use of the higher rate of application.

Erbon: Five plots of vegetation carrying the following species of weeds were treated with active erbon at rates of 10.4, 20.8, 41.6 and 83.2 pounds per acre: Cut-grass, cord grass, cattail, spike rush, soft rush, smartweed, wool grass, and broad-leaved annuals. Only 85 percent of the growth on a plot treated with 83.2 pounds per acre was killed. Use of erbon in a diesel oil carrier at a rate of 10.4 pounds active erbon per acre gave a 90 percent kill. This compares with a 90-95 percent kill obtained from five pounds 2, 4-D per acre in a diesel oil carrier. Erbon did not appear promising as an emergent herbicide for marginal aquatic weeds based on these limited tests.

Kuron: Kuron was tested on 12 plots at rates of 2.6, 5.2, 10.4, 20.8, 41.6, and 83.2 pounds of acid equivalent material per acre. A kill of 100 percent was obtained on two plots of spike rush treated with 20.8 pounds per acre. The 2,4-D controls averaged a 93 percent kill at a rate of five pounds per acre in this same trial. Other species of plants sprayed did not respond to Kuron as well as spike rush, however. A plot treated at a rate of 83.2 pounds per acre showed an 80 percent kill of broad-leaved annuals, cord grass, wool grass, cut-grass, lizard's tail and spike rush. A rate of 10.4 pounds in diesel oil gave a kill of 88 percent where that obtained from a 5-pound 2, 4-D control treatment was 95 percent using the same carrier.

Based on the above results, the general use of Kuron for marginal and emergent pond weed control was not indicated.

Kuramine: Ten plots were used to compare the effectiveness of Kuramine to the standard 2, 4-D treatment. Rates ranging from 2.6 to 83.2 pounds per acre were used. The highest kill obtained was 80 percent of the weeds on a plot of mixed grasses and broad-leaved weeds treated at a rate of 10.4 pounds per acre in a diesel fuel carrier. This result along with others ranging from 10 to 75 percent kills discouraged ideas that Kuramine would displace 2, 4-D as the standard emergent pond vegetation control agent.

2, 4-D (Isopropyl ester form) : † When used in a water carrier, 2, 4-D is generally ineffective on the grasses and several members of the sedge family usually found in pond margins. However, the combination of the ester form of 2, 4-D and an oil carrier is extremely effective in controlling all species of marginal weeds tested when properly applied. A rate of five pounds 2, 4-D acid equivalent per acre is normally sufficient to kill 90-100 percent of the weeds in a treated area. Since this treatment can be depended upon to kill vegetation at this rate, this performance has been adopted as a criterion for other competitive herbicides.

2, 4-D (propylene glycol butyl ether ester) : ‡ Based on a limited number of tests (10 plots), the propylene glycol ether ester of 2, 4-D appears to be about as effective on the species of plants treated as was the isopropyl ester of 2, 4-D. Rates of 5.2, 10.4 and 20.8 pounds per acre were used. Where water was a carrier, generally little kill resulted when the weeds were moderately to strongly resistant to 2, 4-D. In one test though, a rate of 5.2 pounds 2, 4-D per acre killed 95 and 96 percent of the spike rush growing on two plots. When oil was used as a carrier results were about the same as those obtained where a similar amount of isopropyl ester was applied the same way.

Reputedly the propylene glycol butyl ether ester is less volatile than is the isopropyl ester. Where damage to adjacent desirable plants is a possibility, consideration could be given to using the first formulation. From the standpoint of both cost and effectiveness, however, the use of the isopropyl ester is indicated at present.

TCA (sodium trichloroacetate): Although not a new introduction, TCA was included in the tests to provide more information on the performance of this herbicide. Ten plots were treated with TCA at rates of 21.6, 43.2, 64.8 and 86.4 pounds per acre. As was expected, TCA gave better results as a grass killer than it did as a control agent for sedges, cattails or broad-leaved weeds. A rate of 43.2 pounds per acre eliminated 99.5 percent of the cut-grass growing on one plot. Effects generally were much poorer, as a rate of 21.6 pounds failed to kill spike rush and rates of 43.5-64.8 pounds per acre showed much less damage than did the 2, 4-D control treatments. Based on results of this series of experiments, dalapon appeared to be much more effective as a marsh grass killer than TCA.

Combinations of Two Herbicides: On mixed growths of weeds it has become common practice to combine several herbicides in order to broaden the effectiveness of a treatment. A combination may even improve results obtained in treating a single species of vegetation. Grigsby *et al.* (1955) found that the addition of small amounts of silvex or 2, 4, 5-T to three rates of dalapon increased the rate of kill of cattails as compared to treatments of dalapon alone. Included in those experiments were several combinations of the herbicides being evaluated.

Amitrol and dalapon were tested at rates ranging from 0.9-5.0 pounds of each per acre respectively up to 13.6-60 pounds. On plots carrying mixed growths of broad-leaved annuals, cut-grass and wool grass, slightly better results were obtained from this combination at five pounds of each per acre than was gotten by use of either singly at 10 pounds per acre. Amitrol alone

† Esteron 44 manufactured by Dow Chemical Co

‡ Esteron 1010 manufactured by Dow Chemical Co.

showed a kill of 95 percent, dalapon 94 percent and the combination gave an average kill on two plots of 97 percent. Lower rates of the two herbicides did not give consistent enough results to make their use promising although effective kills were obtained in some instances at the 3.4-5.0, 1.7-5.0 and 0.9-5.0 pounds per acre rate. The combination was not promising as a control for those members of the sedge family included in the tests.

Amitrol combined with the 2, 4-D ester did not appear to be more effective than either of the agents used singly. Kuron and amitrol gave an average kill of 97 percent on two plots where they were combined at a rate of 20.8 pounds Kuron, 5.0 pounds amitrol per acre. Kuramine and amitrol at 20.8-3.4 pounds per acre respectively showed a kill of 95 percent on two plots while only 90 percent of the plants on two other plots were killed at a rate of 20.8-6.8 pounds Kuramine-amitrol per acre. Presence of more wool grass was the reason for the reduced effect of the heavier rate as neither of these agents killed this species effectively.

The combination amitrol-TCA appears to warrant further study, as a rate of 3.4-21.6 pounds of each respectively per acre gave a 98 percent kill of cut-grass, smartweed and reed grass. Amitrol-erbon was about as effective at a rate of 3.4 pounds amitrol, 20.8 pounds erbon per acre. On two plots supporting broad-leaved annuals, cord grass, cut-grass and cattail, a 96 percent average kill was obtained on two plots.

Dalapon in combination with 2, 4-D (isopropyl ester) was tested on ten plots. A rate giving results comparable to those obtained from the standard 2, 4-D-oil treatment was 10 pounds dalapon and 10 pounds 2, 4-D per acre. A lower rate was not tested. A rate of five pounds dalapon, 10.4 pounds Kuron appeared to be as effective as the standard treatment. An average kill of 91 percent was obtained on four plots. This would have been much higher except for the failure of the combination to effectively eliminate the members of the sedge family which were treated.

Dalapon plus Kuramine was tested on ten plots. An effective rate was 10 pounds dalapon and 5.2 pounds Kuramine per acre. This combination did not show good results on members of the sedge family which were treated however. Two plots were treated with dalapon-TCA. A rate of 10 pounds dalapon and 21.6 pounds TCA per acre gave as good a kill as did the standard 2, 4-D treatment. It was no better than 10 pounds of dalapon alone, however.

A combination of five pounds dalapon and 20.8 pounds erbon killed 90 percent of the growth present on two plots of mixed species of weeds. In view of the amount of erbon used, this was not a favorable comparison with the more successful treatments. This combination was not effective against the species of sedge treated when used at a rate of 5.0 pounds dalapon and 10.4 pounds erbon per acre.

One of the most effective combinations tested on the sedges was a mixture of TCA and Kuron at a rate of 21.6 pounds TCA and 10.4 pounds of Kuron per acre. An average kill of more than 97 percent was noted on four plots treated at this rate. This combination killed other weeds well also, with a rate of 10 pounds TCA and 20.8 pounds Kuron killing 98.5 percent of a mixture of weeds on two plots. It showed up well on the broad-leaved annuals, cattail, cut-grass, cord grass, soft rush, spike rush and wool grass. Consistently better results were obtained on the plots treated with this combination than with any other tried. A TCA-erbon mixture was tested but did not appear too promising on the basis of the six plots observed. Use of a rate of 21.6 pounds of TCA and 20.8 pounds erbon per acre gave an average kill of 97 percent on two plots of mixed weeds but this is believed to be too high a rate of application to be economically feasible.

SUMMARY

Based on the results of experimental treatments applied to 15 species of emergent or marginal aquatic weeds, recommendations for their control are given in Table I. The amount of herbicide to use is estimated on the basis of an average density of standing vegetation. For extremely heavy growths the amounts shown may need to be increased 50 percent or more. Where the stand of vegetation is less, the required amount may be reduced by as much as 50 percent.

In a majority of cases the treatment of choice is the 2, 4-D ester in an oil carrier. Although several of the formulations singly or in combination were slightly more effective than was this treatment, 2, 4-D is preferred because of its economy and broad application to all types of vegetation. For pure stands of weeds it may be desirable to use one of the treatments which is specific for a certain group of plants. Usually an area to be treated is supporting several types of weeds necessitating treatment with a non-selective agent such as 2, 4-D in oil.

Dalapon compared favorably with 2, 4-D on grasses and cattail. It did not kill the sedges well however. Amitrol gave similar results and appears to augment the effects of dalapon or TCA when combined with these herbicides. Dalapon and Amizol combined gave slightly higher rates of kill than did either of the fomulations when used in comparable amounts alone. A combination of TCA and Kuron was extremely effective on all sedges treated. This mixture also killed grasses and broad-leaved plants well.

The propylene glycol butyl ether ester of 2, 4-D gave about the same results as the isopropyl ester in limited comparative tests.

Effective growth inhibition of all plants present for almost two years was obtained from a CMU application of 65 pounds active material per acre. High cost of this material limits its use considerably. None of the other herbicides gave evidence of such marked inhibition of regrowth, although dalapon exerted noticeable cattail growth inhibition from August of one year until September of the following year.

TABLE I

RECOMMENDED TREATMENTS FOR WEEDS STUDIED IN THE SCREENING EXPERIMENT

Species of Weed *Common and Scientific Name*	*Agent*	*Treatment of Concentration*†	*Choice* * *Carrier*	*Rate in Lbs. Per Acre*‡
Cattail—*Typha latifolia*	2, 4-D Ester	0.5	Diesel Fuel	4.0
	Dalapon	1.0	Water	16.0
	TCA-Kuron	1.2–0.6	Water	20.0–10.0
Cord Grass—*Spartina spartinae*	Dalapon	1.8	Water	30.0
Cut-Grass—*Leersia oryzoides*	2, 4-D Ester	0.5	Diesel Fuel	4.0
	Dalapon-Amitrol	0.3–0.3	Water	5.0–5.0
Knotgrass—*Paspalum distichum*	2, 4-D Ester	0.5	Diesel Fuel	4.0
Needle Rush—*Eleocharis acicularis*	2, 4-D Ester	0.3	Diesel Fuel	2.5
Lizard's Tail—*Saururus cernuus*	2, 4-D Ester	0.3	Diesel Fuel	2.5
Reed Grass—*Phragmites* sp.	2, 4-D Ester	0.75	Diesel Fuel	6.0
	Dalapon	1.8	Water	30.0
Sedge—*Cyperus acuminatus*	2, 4-D Ester	0.5	Diesel Fuel	4.0
	TCA-Kuron	1.2–0.6	Water	20.0–10.0
Sedge—*Cyperus erythrorhizos*	Same as *C. acuminatus*			
Soft Rush—*Juncus effusus*	Same as *C. acuminatus*			
Smartweed—*Polygonum* sp.	2, 4-D Ester	0.3	Diesel Fuel	2.5
Spike Rush—*Eleocharis obtusa*	2, 4-D Ester	0.3	Diesel Fuel	2.5
Water Shield—*Brasenia schreberi*	2, 4-D Ester	0.3	Diesel Fuel	2.5
Water Lily—*Nymphaea ororata*	2, 4-D Ester	0.3	Diesel Fuel	2.5
Wool Grass—*Scirpus eriophorum*	Same as *C. acuminatus*			

* Where more than one agent is listed for a weed the first herbicide is preferred, with others listed in order of preference.

† Percentage of active material in the spray solution.

‡ Active ingredient or acid equivalent using 200 gallons of spray solution per acre. Where oil is used as a carrier, 100 gallons of spray solution per acre gives adequate coverage of average stands of emergent aquatic vegetation.

In conclusion, it appears that in view of general effectiveness and economy of application, the ester form of 2, 4-D in an oil carrier is the best emergent herbicide recommendation at present. When dealing with special problems, consideration should be given to the use of several effective chemicals which may do a better job either alone or in combination with other agents. As the newer chemicals become more widely used their cost will be lowered in many instances. When this happens their use can be justified where now it is economically infeasible.

Additional study of the most promising herbicides included in these experiments is needed to further refine rates of application. New introductions and combinations of accepted herbicides also need to be tested. The use of the screening technique outlined in this paper is suggested as an aid in carrying out this work.

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PROPAGATION OF CHANNEL CATFISH (Ictalurus lacustris) AT STATE FISH HATCHERY

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INTRODUCTION

Requests for channel catfish for stocking purposes have greatly increased during the past few years. The supply of fingerlings from state and private hatcheries has not met the demand for stocking these fish in public and private waters of the state. Channel catfish are an important game and commercial fish (minimum length as a commercial fish is sixteen inches) in Arkansas. Many farmers are requesting channel catfish stocked in their ponds in combination with game fish. In Arkansas, during the past five years, commercial fish farming in the rice belt has grown so that now several thousand acres are under water. The production of fingerling channel catfish by private hatcheries for stocking these areas appears to be a lucrative enterprise.

The demand for edible size channel catfish for the commercial market and home consumption has increased steadily. Retail prices range from forty to sixty cents per pound. The value derived from stocking farm ponds with channel catfish has not been definitely determined, since limited numbers of farm ponds have been stocked with fingerlings from this hatchery and the harvest has not been completely evaluated. However, catch reports from pond owners would indicate that 40 to 60 percent of the fish stocked were caught. These fish ranged in weight from one to three pounds after being in the pond for only one growing season.

During the fall of 1956. in cooperation with the U. S. Soil Conservation Service, 12 choice farm ponds were stocked for experimental purposes. The stocking rate was 50 fingerling catfish per acre. The results of this experimental stocking will not be known until the fall of 1957 and thereafter. It is hoped that continued observation and experimental culture of this type with the channel catfish will (1) furnish farmers with additional meat for their tables and (2) better utilize the resources of their ponds.

Methods used for propagating this species vary from hatchery to hatchery and from state to state. The following pages are devoted to a description of