RESULTS OF FIELD TESTING NEWER AQUATIC HERBICIDES WITH EMPHASIS ON SPOT TREATMENT APPLICATIONS[1]

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ABSTRACT

Included are data for 73 weed control experiments using nine herbicides and their combinations.

Fifty pre-emergent soil applied field experiments conducted during winter drawdown indicated that Fenac (2, 3, 6 trichloro phenylacetic acid) and Casoron (2, 6-dichlorobenzonitrile) were the most effective herbicides tested when applied at the rate of 20 lbs. acid equivalent per acre.

The effectiveness of these herbicides appeared to be greatly influenced by the condition of the pond bottom at the time the application was made. Fenac treatments gave excellent control of ten common aquatic plant species with only the grasses and lilies showing extreme tolerance. Casoron provided satisfactory control of eleven species of aquatic plants including lilies.

The addition of 2, 4-D to Fenac did not appear to be beneficial in controlling lilies when applied during winter drawdown.

Five other herbicides tested as pre-emergents during winter drawdown were not significantly effective.

Diquat (1:1-ethylene-2:2′-dipyridylium dibromide) proved to be a suitable herbicide for spot treatment applications. Excellent control of five common vascular aquatic species was observed at concentrations ranging from one to five gallons Diquat per surface acre of infestation. Final results indicated that most species tested could be controlled with 1.5 gallons Diquat per surface acre of infestation. Regrowth varied from 0% to 20% within 60 days after treatment in ponds adequately fertilized. However, higher rates of reinfestation occurred in ponds not receiving post treatment management.

Marginal vegetation was greatly reduced after being sprayed with Diquat at the rate of one pint Diquat to ten gallons water plus ½ pint surfactant and then burned once the plants had died.

Karmex (Diuron(3-(3, 4 dichlorophenyl)-1, 1 dimethylurea) proved to be effective in controlling *Lemna minor* at rates of .25, .33 and .50 ppm. A light to moderate fish kill was experienced at all concentrations and was attributed to low oxygen. No plankton bloom developed in these ponds within six weeks after treatment, even though normal fertilization was initiated.

Lorox (Linuron(3-(3, 4-dichlorophenyl)-1-methoxy-methylurea) did not satisfactorily control *Eleocharis acicularis* at rates as high as 1.0 ppm over a period of thirty days.

INTRODUCTION

Even though more and more compounds are being found to be effective acquatic herbicides, numerous situations arise which make it impractical to treat many small impoundments to their entirety. Earlier studies by the writer indicated that winter drawdowns often improved a fishery by allowing carnivorous species to reduce the forage fish through increased predation and at the same time forcing the many mobile aquatic invertebrates from their weedy sanctuaries making them more readily available for food. In some instances such drawdowns reduce the aquatic vegetation problem the following year, but generally the winters are too mild in Georgia to be very effective (Pierce, Frey and Yawn, 1963).

In order to reap the benefits from the two former effects of a winter drawdown, it is important that fishing areas are clear of aquatic vegetation during the following fishing season. The following discussions give the results of testing seven different herbicides and their combinations applied during winter drawdowns for such control.

Fenac 10G and Fenac 2, 4-D Combination: (2, 3, 5 trichloro phenol acetic acid plus 2, 4-D).

Earlier investigations proved Fenac to be effective in controlling certain species of aquatic vegetation when applied as a pre-emergent during a winter drawdown. (Pierce, Frey and Yawn, 1964).

The above study indicated that many of the common species of aquatic vegetation were satisfactorily controlled if the herbicide became "fixed" into the soil prior to flooding.

Since the weed-control capabilities of this herbicide were found to be primarily limited to the ability of the herbicide to become fixed into the soil, it was considered necessary to determine under what conditions fixation took place, and if the addition of a phenoxy herbicide (2, 4-D) would control lilies since earlier studies indicated this group of plants was virtually unaffected by Fenac alone. With the exception of the aquatic grass *Hydrochloa carolinensis* and lilies, each of the test species was satisfactorily controlled with Fenac at the rate of 20 lbs. acid equivalent per acre when the test plot was well drained and moist (but not soaked) during and soon after the herbicide was applied. If the test plots were poorly drained allowing water to stand or constantly seep from the area, poor results were noted. Unfortunately, it was found that most shallow weedy ponds had only a limited number of areas that drained sufficiently to allow herbicides to become properly fixed into the soil.

Since leaching is the primary problem in the poorly drained wet areas, a less soluble acid formulation of Fenac and 2, 4-D was tested. Even though these herbicides were attached to clay granules, the herbicides apparently still leached from the areas since the degree of control was unsatisfactory. However, the writer feels that in most instances, better control was noted when using this less soluble formulation than when using the standard product under similar conditions. As mentioned before, the 2, 4-D was added with the Fenac in an attempt to control lilies that were present. Some reduction was noted, however by mid-summer, the lilies became as well established as they were prior to the drawdown and treatment. Therefore, the writer does not recommend the Fenac or Fenac 2, 4-D combination to be used in ponds where lilies are the primary problem. Of the plant species tested, *Eleocharis acicularis, Myriophyllum heterophyllum, Juncus repens, Potamogeton diversifolius, Hydrotrida carolinensis* and *Utricularia spp.* were found to be susceptible to the Fenac treatment, while lilies and grasses were not.

Casoron G4 and Casoron 2, 4-D Combination: (2, 6-dichlorobenzonitrile plus 2, 4-D)

With the exception of the grasses, this herbicide showed promise as a control of most species of aquatic vegetation tested. Unlike Fenac, Casoron also controlled lilies and appeared to be somewhat more adapted to drawdown applications since the material did not appear to readily leach from the test area when applied on poorly drained pond bottoms.

Plant species controlled with Casoron after winter drawdown application were *Eleocharis acicularis, Myriophyllum heterophyllum* and *Utricularia sp. Carex sp.* and *Sparganium sp.* were present but were not well enough established to determine whether or not they were greatly affected. However, these two species did not spread within the treated areas during the current growing season indicating that the treatment had at least restricted their normal growth. Unless complete control is experienced, it is very difficult to determine the full effects of a herbicide on a multiple species population since the reduction of one plant species often encourages the less susceptible species to thrive. This is particularly true when shade producing emergent species are growing in the same test area as submergents.

In two post emergent tests, Casoron satisfactorily controlled *Nymphaea odorata* at ten and twenty lbs. acid equivalent per surface acre but failed to significantly reduce *Hydrochloa carolinensis* in the same plot. In fact, it appeared that the reduction of the white water lily *(Nymphaea odorata)* allowed the southern watergrass *(Hydrochloa carolinensis)* to become better established, probably bcause of the reason mentioned in the preceding paragraph.

In one experiment, the combination of Casoron and 2, 4-D at the rate of 20 lbs. acid equivalent each per acre completely controlled *Eleocharis acicularis, Hydrotrida caroliniana, Juncus repens* and *Nuphar advena.* It is not known whether or not the 2, 4-D added to the control since no regrowth was present in the entire plot when one half of the area was treated with Casoron alone while the other equal portion was treated with the same amount of Casoron plus 2, 4-D at the rate of 20 lbs. active per acre.

TOK 3G: (2, 4-dichlorophenyl 4-nitrophenylethe—3%)

This promising experimental turf herbicide did not satisfactorily control aquatic mono or dicotyledons when tested at rates of ten and twenty lbs. acid equivalent per surface acre.

Hydrothol 191 and Hydrothol 191 plus 2, 4-D: (Cocoamine of Endothol plus 2, 4-D)

This mono-cocoamine of Endothol by itself did not prove to be an effective herbicide for the control of aquatic vegetation when applied at rates of five, ten and twenty lbs. acid equivalent per surface acre during winter drawdown. Of the eight experiments conducted, only one area provided any measurable degree of control. However, in three instances, no regrowth was found in the treated area but nor was there any in the control areas, thereby making it impossible to attach any significance to the treatments.

A high degree of control was noted when treating *Myriophyllum heterophyllum, Hydrotrida caroliniana, Eleocharis acicularis, Utricularia sp.* and *Nymphaea odorata* with a combination of ten lbs. Hydrothol 191 plus 20 lbs. 2, 4-D acid equivalent per surface acre, but since Hydrothol 191 proved to be virtually ineffective in the other tests, the writer feels compelled to assign most of the control to the 2, 4-D.

Aquathol Plus Granules: (3.6% Endothol acid plus 5.0% Silvex acid)

Unsatisfactory control resulted when testing this combination of Endothol and Silvex for the control of aquatic vegetation when applied at a rate of 20 lbs. acid equivalent per surface acre during winter drawdowns. However, the author noted when applying the granules that a white snow-like material was present in the bags. It was later learned that this was the potassium salt of Silvex that had crystallized and separated from the granules. Therefore, an undetermined amount of the Silvex was actually applied to the test areas.

Aqua Kleen 2, 4-D Granules: (2, 4-dichlorophenoxyaretic acid, Butoxy Ethanol Ester)

Many field tests have been conducted using this commonly used herbicide. It was the intent of the investigator to use this broad leaf killer as a comparison rather than to determine its suitability as a non-selective herbicide for the control of aquatic vegetation when applied during winter drawdown. As was expected, only limited measurable control was observed.

POST EMERGENT SPOT TREATMENT APPLICATIONS USING DIQUAT

(1:1-ethylene-4, 4′-dipyridylium dichloride)

As mentioned earlier in this report, fisheries workers are often compelled to develop specific techniques for controlling aquatic vegetation in an impoundment where total treatment is not feasible. This is particularly true for situations where the cost of a treatment determines whether or not an application can be made.

Herbicides designed for effective post-emergent spot treatment applications should not require special applicators, be relatively non-selective, non-toxic to fish and livestock and require a short exposure period. Diquat has these characteristics; however, it is costly (the primary reason for trying to find ways it can economically be used), becomes detoxified when coming into contact with clay colloid and is not an effective control for lilies. Realizing Diquat's attributes and limitations, the writer conducted thirteen spot treatment applications at rates ranging from one to five gallons per surface acre of infestation. The degree of infestation ranged from 20% to 70% of the total pond.

Excellent control (80%-100%) was experienced at all rates tested for periods up to sixty days. The lowest degree of control (80%) was noted in a pond infested with needlerush *(Eleocharis acicularis)* and treated at the low rate of one gallon per surface acre of infestation. Since only 30% of the pond was infested, the dilution was much greater than in impoundments where treatments included 65% and 70% of the pond's surface.

In each experiment, Diquat was mixed with enough water to obtain complete coverage. No differences were noted between spray and broadcast applications when good coverage was experienced.

Where water movement is minimal, the investigator considers concentrations not exceeding 1.5 gallons per surface acre infestation adequate for controlling *Eleocharis acicularis, Myriophyllum heterophyllum, Juncus repens* and *Juncus effusus.* There are surely many more aquatic species that can be controlled at this low rate but were not available for treatment during the test period. Unless fertilization is effective soon after the application, regrowth can be expected in shallow water within thirty days.

Southern watergrass *(Hydrochloa carolinensis)* is very common in central and south Georgia and is considered one of the most difficult species to control. This is primarily because this grass can be both aquatic and semi-aquatic, often requiring a herbicide to be applied far upon the pond's margin. The plant becomes aquatic when the semi-aquatic form extends into the pond via rhizomes. If the water is shallow, the plant will become rooted in the pond bottom, and the extent to which it moves out into the pond is dependent on the water's depth and light penetration. Since the degree of infestation is greatly influenced by the physical condition of the pond, it is apparent that one would have to denude the entire edge of the pond before reinfestation could not reoccur. This is generally impossible and undesirable; therefore, either reconstruction or periodic chemical control are the only alternatives. Even though deepening the edges of a pond to prevent marginal vegetation from spreading is desired, it is often impractical. Since chemical control is generally the most feasible, different concentrations of Diquat were tested for reducing marginal vegetation problems. Marginal mats of southern watergrass were controlled when sprayed with Diquat at one to forty and one to eighty concentrations. One pint of a surfactant was added to each 25 gallons of spray solution. Within ten days, the grass in the water was dead but not decayed. No life was seen in the stems; therefore, it is believed that regrowth will be slow. Comparable results were noted between the foliage sprayed and ppm spot treatments. However, the spray applications were one-tenth as expensive since much less material was required.

The writer is positive that regrowth will occur but believes the problem should be considerably less after each application.

Floating Diquat pellets gave excellent control of *Lemna minor* when treated at the rate of 20 lbs. (1 lb. Diquat cation) pellets per surface acre. The application consisted of scattering the pellets over the duckweed mats from the shoreline. Eighty per cent control was experienced and lasted for thirty days. The writer feels that complete control could have been accomplished if better coverage could have been possible.

In one experiment, cutgrass *(Leersia oryxoides)* and a light infestation of parrot's feather *(Myriophyllum brasiliense)* was sprayed with Diquat at the rate of one pint Diquat to ten gallons water plus a surfactant. Within five days, all of the cutgrass above the ground appeared dead. Since marginal vegetation does not readily decay, it often presents a problem even after it has been killed. To alleviate this problem, the test area was burned two weeks after treatment, but because of persistent rains and some new growth, the treated area would not burn freely without the addition of small quantities of kerosene. However, the writer is certain that the treated area would have burned to the ground within seven days after treatment if post application rains had not interfered. To test this, a one-eighth acre plot was marked off in a weedy field and sprayed with Diquat. Five days after treatment the area was easily burned. The fire stopped soon after it reached the green untreated vegetation.

The combination of Diquat and fire for marginal vegetation control can be highly desirable in areas where tall vegetation is not accessible to mowing equipment. Some regrowth should be expected; therefore, additional treatments would be necessary.

In cooperation with the California Chemical Company, the Georgia Game and Fish Commission treated a pond heavily infested with *Anacharis densa* and non-branched filamentous algae at the rate of 1.0 ppm Diquat cation. This experiment included pre and post water and fish tissue analysis. These results are pending. Complete control was obtained within ten days after treatment. No sign of regrowth was present during the entire summer even though a heavy plankton bloom never developed.

RESULTS OF FIELD TESTING TWO SUBSTITUTE UREA COMPOUNDS FOR THE CONTROL OF VASCULAR AQUATICS

Karmex: (Diuron(3-(3,4-dichlorophenyl)-1,1 dimethylurea)

In recent years, this herbicide has proven to be an effective algacide and is presently being used at several state and federal fish culture facilities.

It has been reported that Karmex effectively controlled filamentous algae at concentrations as low as ½ lb. per surface acre of water, and in four instances *Najas sp.* was eliminated at concentrations of .75 to 1 lb. per surface acre (Sills, 1964). The economical aspects of this herbicide (less than $4.00 per acre) encouraged the author to test Karmex as a control of vascular plants, particularly those that have proven to be relatively difficult and expensive to reduce.

During the summer of 1965, three small ponds containing duckweed *(Lemna minor)* were treated with Karmex at rates of .25, .33 and .5 ppm. Since this material is relatively insoluble in water, a surfactant was added.

Excellent control was noted; however, in each instance a light to moderate fish kill was experienced. Two of the three experiments were conducted on the same date. One pond was moderately infested with duckweed, while the other was virtually covered. A few bream and bass were reported to have died in each pond three or four days after treatment. Considerably more fish were killed in the pond heavily infested with duckweed and treated with .25 ppm Karmex than in the pond moderately infested but treated at .5 ppm. Since the heavier fish kill occurred in the pond treated with less Karmex, the author was of the opinion that the fish died of oxygen depletion rather than direct toxicity from the Karmex. To verify this, another pond heavily infested with duckweed was treated with Karmex at the rate of .33 pp. Immediately prior to the treatment, an oxygen test was conducted on the pond. At a three-foot depth, only 1.75 ppm oxygen was present. Such conditions often exist in ponds covered with vegetation since sub-surface photosynthetic action is suppressed. Four days after treatment, approximately fifty lbs. of bream died per acre. In investigating the fish kill, another oxygen test was conducted. Oxygen on the surface was only 1. ppm and on the bottom (four-foot depth), it was 0.0 ppm. No additional fish were seen dead; however, many fish of all sizes were seen swimming slowly near the surface, particularly in shaded areas and near a small spring seeping out of a steep clay bank. Additional oxygen tests one week later produced 1.75 ppm oxygen at the surface and .2 ppm on the bottom. No sign of a developing plankton bloom was noted for five weeks after treatment, even though the pond was well fertilized. From the above data, the author considers it hazardous to use this or any other herbicide having strong algacidal properties for controlling vascular aquatic plants, since apparently the B.O.D. cannot be met during the period when the vegetation is decaying and normal phytoplankton photosynthetic action does not occur. However, in hatcheries where fresh oxygenated water can be substituted for normal phytoplankton photosynthesis, these herbicides may be desirable.

Lorox: (Linuron (3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea)

This compound is more soluble than Karmex but appeared to be less phytotoxic. Needlerush *(Eleocharis acicularis)* was virtually unaffected at 0.1 ppm and only moderately controlled at 1.0 ppm.

The 35% control obtained using 1.0 ppm over a thirty-day period suggests that this herbicide is not a desirable vascular aquatic herbicide at economically feasible levels.

SUMMARY

In analyzing the above data, the following conclusions are made:

1. Fenac 10G is an effective control of many aquatic species when applied at the rate of 20 lbs. acid equivalent per surface acre during a winter drawdown in ponds whose bottoms are well drained, allowing the herbicide to become "fixed" into the soil.
2. The addition of 2, 4-D did not significantly add to the winter drawdown treatments.
3. The less soluble acid formulation of Fenac appeared to be as effective as the standard Fenac compound.
4. Only well drained pond bottoms are adapted for soil sterilant treatments during winter drawdown.
5. Casoron G4 controlled eleven common aquatic species when applied on exposed mud flats during winter drawdowns in areas well drained.
6. Diquat was effective in reducing aquatic weed problems when used as a spot treatment at the rates of one to five gallons Diquat per surface of infestation. For most species, and conditions, 1.5 gallons per surface acre of infestation is adequate.
7. Marginal vegetation was satisfactorily controlled after being sprayed with a one to eighty concentration of Diquat plus a surfactant and burned once the plants turned brown.
8. Karmex was effective in controlling duckweed *(Lemna minor)* at concentrations ranging from .25 to .5 ppm. However, light to moderate fish kills were encountered each time. Low oxygen was determined to be the cause of death. Normal plankton blooms were not present for five weeks after treatment.
9. Lorox was found to be an ineffective herbicide for the control of needlerush *(Eleocharis acicularis)* at rates ranging from 0.1 to 1.0 ppm.

HERBICIDES TESTED[1]

(1) Fenac 10G (10% 2, 3, 5 trichlorophenyl acetic acid)
(2) Fenac plus 2, 4-D
(3) Casoron G4 (2, 6-dichlorobenzonitrile)
(4) Casoron plus 2, 4-D
(5) TOK 3G (2, 4-dichlorophenyl 4-nitrophenylethe—3%)
(6) Hydrothol 191 (Cocoamine of Endothol)
(7) Hydrothol 191 plus 2, 4-D.

[1] Herbicides provided through the courtesy of Amchem Products, Inc., Thompson-Hayward Chemical Company, Rohm & Haas Company, Pennsalt Chemicals Corporation, Chevron Chemical Company and E. I. du Pont De Nemours & Company, Incorporated.

(8) Aquathol Plus Granules (3.6% Endothol acid plus 5.0% Silvex acid)
(9) Aqua Kleen 2, 4-D Granules (2, 4-dichlorophenoxyaretic acid, Butoxy Ethanol Ester)
(10) Diquat (1:1-ethylene-2:2′-dipyridylium dibromide)
(11) Karmex (Diuron (3-(3,4-dichlorophenyl)-1, 1 dimethylurea)
(12) Lorox (Linuron (3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea)

LITERATURE CITED

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DIURON AS AN AQUATIC HERBICIDE

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INTRODUCTION

Pondowners and fish culturists are continually searching for a herbicide that will kill aquatic weeds at a reasonable price. Field trials using diuron were conducted on farms of cooperators with Soil and Water Conservation Districts in Arkansas. Results indicate that powdered 3-(3,4-dichlorophenoxy)-1, 1-dimethyl urea (diuron)[1] is an effective aquatic herbicide. Results are reported in this paper.

The wettable powder form of the commercial product contains 80 per cent diuron. It has been marketed in huge amounts in Arkansas as a premerge for selective control of weeds in cotton fields. The U. S. Department of Agriculture has registered diuron for use in cotton. The Department has not, however, registered diuron for use as an aquatic herbicide.

Siles (1964) reported on results obtained from applications of diuron to control filamentous algae. His data showed that diuron was effective against several forms of filamentous algae at rates above one-half pound per surface acre.

METHODS

Rate of Application. Diuron was used at the rate of one pound per surface acre, and one-half pound per surface acre. One application was made at the rate of one pound of diuron for 35 surface acres.

Method of Application. The chemical was applied as a dry powder and as a spray. The powder was allowed to drift over the water surface with the wind spreading it. Spray material was also applied. Applications were made by walking along the edge of the water or broadcasting from a boat. Broadcasting of the dry powder was the most practical when the plants were in the water. Spraying was more practical when the plants were on moist or dry land.

[1] Marketed by E. I. du Pont Co. under the trademark "Karmex."