EXPERIMENTAL CONTROL OF *JUNCUS ROEMARIANUS* WITH HERBICIDES

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One of the most important weed plants in the brackish coastal marshes of North Carolina is needlerush, *Juncus roemerianus.* Many thousands of acres of potentially valuable waterfowl and furbearer habitat are dominated by this plant species.

The most extensive acreages of needlerush in North Carolina are those bordering Pamlico Sound and its tributaries, where approximately 75 per cent of the marsh areas are dominated by this pest. In the less brackish marshes of Currituck Sound, needlerush does not generally occur in the vast unbroken stands typical of the Pamlico area, but is still an important pest, rendering many thousands of acres useless to waterfowl and furbearers.

In 1949 a series of experiments to determine an economical means of eradicating needlerush were begun under the Waterfowl Segment of the North Carolina Marsh Resources Investigation, Federal Aid in Wildlife Restoration Project 6-R. Initially a series of herbicide plots were established at Leechville in Hyde County, NC, by Mr. T. Stuart Critcher, then leader of the Waterfowl Segment of Project 6-R. Since 1950 the experiments have been conducted by Yates M. Barber. These experiments have been confined to brackish marsh areas. Other experiments have been conducted on needlerush in nearly fresh water marsh areas by Mr. Kenneth A. Wilson under the Fur Segment of the Marsh Resources Investigations. It is the purpose of this paper to report only on those experiments performed under the Waterfowl Segment.

HERBICIDE TESTS

The study area on the Pungo River at Leechville in Hyde County is typical of much of the needlerush marsh in North Carolna. It is mildly brackish, has a deep peat soil, and is not subject to any regular rise and fall of the tide. Strong southerly winds cause some inundation of the marsh areas, while strong northerly winds result in low tides.

A total of 153 herbicide plots were established in needlerush on this area. All plots are thirteen feet square, and are permanently marked. A Dobbins Model 44-G pressure type sprayer was used for spraying all plots. Plots in unburned needlerush were sprayed with one gallon of spray solution per plot, using a cone-type nozzle. All plots in burned needlerush were sprayed with one quart of carrier per plot, using a Tee-jet fan-type nozzle. In all cases the vegetation was given a thorough wetting.

Dupont Spreader-Sticker was used as a wetting agent in most of the water borne sprays.

Efforts have been directed towards control of needlerush in a single application and only one herbicidal treatment was given each plot. Single treatment control is desirable both because of economic factors and because second and third

applications of herbicide may damage desired plants occurring as a result of the first treatment.

A total of eleven herbicides or combinations of herbicides were tested on needlerush. These were as follows:

1. P.E.C. — An experimental chemical of the B. F. Goodrich Co. Applied at rates of 26 to 64 gallons of 20 per cent active P.E.C. per acre. Carrier — diesel oil. Results: Produced complete chemical mowing effect, quickly killing all stems back to ground level. Regeneration from rootstocks was rapid and complete.
2. A.M.C.C. — An experimental chemical of the B. F. Goodrich Co. Applied in diesel oil at rates from 25 to 13 gallons of 100 per cent active A.M.C.C. per acre. Results: Some of stems killed to ground level. Regeneration rapid and complete.
3. Fenester — An experimental chemical of the B. G. Goodrich Co. Applied in diesel oil at rate of 32 gallons of 20 per cent active fenester per acre. Results: Some of stems killed to ground level. Regeneration from roots, rapid and complete.
4. X-3900 — An experimental chemical of the B. F. Goodrich Co., containing 10 per cent active Diisopropyl Dixanthogen. Applied in diesel oil at rates from 51 to 69 gallons of 10 per cent active ingredient per acre. Results: Slight stem kill. Rapid and complete recovery.
5. XP 40-Z — An experimental chemical of the Sherwin Willians Co. Applied at rates of 1 to 4 gallons of active chemical per acre, in both water and diesel oil. Results: Some stem kill, regeneration rapid and complete.
6. WE 2014 — An experimental chemical of the Sherwin Williams Co. Applied at rates of 1 to 4 gallons per acre in water, and 1 and 2 gallons in diesel oil. Results: No visible effect.
7. Ammate. (Ammonium Sulfamate) — Applied in water at rates of 128 to 768 lb. of 80 per cent Ammonium Sulfamate per acre. Results: Some stems killed to ground level, but regeneration rapid and complete.
8. Sodium TCA (Sodium Trichloroacetate) — Applied in water at rates of 10 to 200 lbs. of 70 per cent active Sodium TCA. per acre. Results: Some stem kill, but regeneration rapid and complete.
9. Esteron 245 — Contains 43 per cent Isopropyl ester of 245 Trichlorophenozyacetic acid. Applied in water at rates from 1 to 27 lbs. acid equivalent per acre. Results: Some stem kill, but roots unaffected. Also applied in diesel oil at rates from 1 to 27 lb. acid equivalent per acre. Results: Approximately 30 per cent kill of stems and roots at highest concentration.
10. Esteron Brush Killer — Contains 22 per cent Isopropyl ester of 2,4-Dichlorophenoxyacetic acid, and 21.5 per cent Isopropyl ester of 2,4,5, Trichloraphenoyacetic acid. Applied in water at rates of 1.5 to 18 lbs. acid equivalent per acre. Results: Apparently effective only to the extent of 2, 4-D present in application. Also applied in oil at rates of 2 to 18 lbs. acid equivalent per acre. Results: Only slightly better than those obtained with Brush Killer in water.
11. 2,4-D. 46 per cent Isopropyl ester of 2, 4-Dichlorophenoxyacetic acid — Applied at rates of 1 to 27 lb. acid equivalent per acre. This was the only herbicide tested which provided an effective kill of needlerush.

CONTROL OF NEEDLERUSH WITH 2, 4-D

A total of 55 test plots were established in needlerush using the Isopropyl ester of 2, 4-D. Nineteen plots in both burned and unburned stands of needlerush sprayed during 1950, showed that 80 to 95 per cent kill could be obtained with 9 to 18 pounds acid equivalent per acre. There appeared to be little difference between plots sprayed in burned and unburned areas. Since coverage of the vegetation in the burned area could be obtained with more certainty, and a smaller amount of carrier was necessary, all 1951 plots were established in needlerush which had been burned during the preceeding winter.

Thirty-six plots were sprayed with various concentrations of 2, 4-D during 1951. Beginning on May 18, at which time the needlerush was just coming into flower, six concentrations of 2, 4-D in water were applied at rates from 1.6 to 27 lbs. acid equivalent per acre. Five similar series of plots were sprayed at various intervals during the summer, terminating on September 12, at which time seasonal growth appeared to be ended.

These plots have shown that needlerush can be killed by spraying with the Isopropyl ester of 2, 4-D when applied at a rate of 27 lb. acid equivalent per acre. Total and complete eradication of the needlerush was achieved with this concentration only in the plot treated at the time that the plant was in flower. Subsequent applications at this strength, applied at intervals throughout the summer, showed gradually more ineffective results.

A plot sprayed with 27 lb. acid equivalent six weeks after the plant flowered, showed a 99 per cent kill of needlerush, but in the mid-September plot, when the plant was approaching dormancy, the kill was only about 95 per cent.

A similar pattern of greatest effectiveness when the plant was in flower was shown by applications of 13 and 20 lbs. acid equivalent per acre applied at the same time that the 27 lb. applications were made. During the flowering period, the kill was at least 98 per cent for a 20 lb. application, but in the fall sprayed plots the kill was not better than 90 to 95 per cent. Applications of 13 lbs. per acre at time of flowering gave 90 to 95 per cent kill, while fall sprayings gave only 75 to 90 per cent kill.

Sprayings with 2,4-D were made under various conditions of surface water, ranging from six inches below to two inches above ground level. There has been no apparent difference in results which could be attributed to this variation in water level.

In the initial sprayings of needlerush with 2, 4-D six cc of Triethanolamine was added to the spray solution, in hopes of obtaining a hormone effect on the plant. As no effect could be determined, this was discontinued.

Six drops of Dupont Spreader Sticker were added to all later sprayings with 2, 4-D to reduce surface tension and insure thorough wetting of the vegetation.

COST OF TREATMENT

No large scale sprayings of needlerush with herbicides have been made in these experiments. Therefore cost figures are not available from actual practice. The following figures have been calculated from other sources. According to price quotations obtained this summer, the Isopropyl ester form of 2, 4-D, containing 3.34 lb. acid equivalent per gallon, in drum lots, now costs $3.50 per gallon. Costs

of chemicals for a 27 lb. acid equivalent per acre treatment would therefore be $28.00 per acre.

It is estimated that the cost of applying herbicides by plane, using some of the more modern equipment, should not exceed one dollar per acre, excluding the pilots salary. This estimate is somewhat higher than figures obtained from commercial operators engaged in aerial insecticide work. Assuming this estimate to be reasonable, this would place the per acre cost of treating needlerush with 27 lb. acid equivalent per acre at $29.00 for a single application. Applications of this high concentration of 2,4-D by plane would probably be possible only in areas far removed from the cultivation of 2,4-D susceptible crops.

Information was not immediately available on the cost of herbicide spraying with tractor drawn equipment, but it is estimated that the cost of application would be between $2.00 and $4.00 per acre, using a small crawler tractor, and 100 gallon low pressure sprayer with a fourteen foot spray boom. This would give a per acre treatment cost, with 27 lb. acid equivalent per acre, of $30.00 and $32.00. One apparent disadvantage of this method is that the 2,4-D may not be as effective against that needlerush which is mashed into the soggy soil by the tractor and spray equipment.

The above application costs are only estimates, but they are probably not too high. A per acre cost for eradication of needlerush, of $29.00 to $32.00, would probably be difficult to justify where large stands were being treated.

In attempting to eradicate needlerush for the improvement of waterfowl habitat, it seems worthwhile to consider one of two facts of importance. Most of the needlerush marsh in North Carolina is relatively high marsh. Most of these areas are flooded by high tides at some time, but with no consistent pattern. Many such areas are rarely flooded during the winter when waterfowl are present. Therefore it is questionable that much of this marsh area would be utilized to any great extent by waterfowl even if the needlerush were replaced by more desirable vegetation, unless the area was impounded.

In an impoundment with controlled water level, it is probable the large stands of needlerush can be controlled by burning, flooding or other means which would prove more economical than 2,4-D. The spot application of 2,4-D with back sprayers would be justifiable against remnant stands which had escaped destruction because of marsh elevation or other cause. Also its use is feasible against small spot invasions of areas.

In considering the eradication of needlerush in muskrat habitat, which may or may not be impounded, it was suggested that cost of the use of 2,4-D might be justifiable in areas where large populations of muskrats were present, but food supplies were inadequate. Treatment in such cases might be less than that necessary for total eradication of the needlerush, since *Scirpus Olneyi* in mixed stands with needlerush, rapidly increases when the needlerush is thinned or destroyed.

PLANT SUCCESSION FOLLOWING DESTRUCTION OF NEEDLERUSH

In every plot of needlerush sprayed, *Fimbristylis castanea,* has been present. Its density has ranged from one or two plants per plot to as high as 10 per cent of the stand. Other plants which have been present in various plots have been saw grass, salt grass, *Scirpus Olneyi, Kostelezkya Virginica, Panicum virgatum,* and a species

of spikerush. The spikerush may be *Eleocharis rostellata,* but identification is uncertain since it has not been possible to obtain a seed spike.

The presence of these various species of plants in any particular section of marsh seems to be closely associated with the elevation of the marsh in relation to water level. As little as one inch difference in elevation seems to exclude certain species from an area. Several plots containing *Scirpus Olneyi* are approximately one inch lower than nearby plots containing saltgrass. Neither plant appears in association with the other on this area.

Fimbristylis castanea has readily shown itself able to survive any concentration of 2,4-D applied during the early summer, and immediately puts forth vigorous growth and seeds heavily as the needlerush dies back. New plants from seed appear on vacant ground the following year. In plots sprayed in late summer, however, at which time *Fimbristylis* is fruiting, there is apparently some kill of the species, although the plant has never been eliminated from any plot.

Scirpus Olneyi has been present in a number of plots sprayed with from 7 to 18 lbs. acid equivalent per acre of 2,4-D at various times during the growing season. Density of the three-square has ranged from 8 stems to 5 per cent of the stand in the plot. The 2,4-D caused a kill back to ground level in all cases, but regrowth was rapid, and spread by rhizomes had begun by the end of the season. During the following growing season the plant has been vigorous, seeded heavily, and spread by rhizomes has frequently been as much as 15 to 18 inches into the vacant territory from which the needlerush was eradicated. In every instance the three-square has survived and increased. It now covers up to 30 per cent of some plots where an eighty per cent kill of needlerush was obtained in 1950, and some of the plot is still bare.

Sawgrass occurred in several plots that were sprayed with heavy concentrations of 2,4-D. Only slight yellowing effect was ever noted on the plant. In a plot in which 90 per cent kill of needlerush was obtained in late June of 1951, 15 plants of sawgrass had spread by September 1952 until *Cladium* dominated more than 90 per cent of the plot. In all plots where *Cladium* occured it has spread rapidly after a kill of needlerush.

Saltgrass, when present in plots, has spread rapidly, providing complete ground cover around scattered living stems of needlerush. A few stems of salt grass have appeared in plots where it was not formerly present.

Kosteletzkya virginica was present in many of the plots at time of spraying. When sprayed with even the weaker concentrations of 2,4-D, this plant wilted in a few hours. Some plants were killed, others still exist at the end of the second growing season, but in a dwarf, deformed state. Some plants apparently recovered, and many new plants have appeared in vacant areas left after the destruction of needlerush.

The species of spikerush which now occurs in many of the plots, was recorded in only a few plots at the time of spraying. It was probably present in many instances, but was overlooked in the dense stand of needlerush. By the end of the second growing season after that in which the plot was sprayed, this plant had occupied much of the available territory, in some cases providing a fairly dense ground cover. The plant apparently seeded well in 1952, but no surviving seed spike could be found when the plots were inspected in late September after an absence of more than two months.

Panicum virgatum has not appeared in any plot, although it was scattered in one or two of the plots at the time of spraying.

Several species of Composits have appeared in the vacant areas left in several plots. Marsh goldenrod and an undetermined species of aster have been most common, occurring usually as scattered plants. Loosestrife and *Sabatia* sp. have also occured as occasional plants. The only new plant having potential food value to waterfowl seems to be a species of *Amaranthus* which appeared during the summer of 1952 in most of the effective plots of 1950 and 1951. In some plots this plant dominated most of the plot, in others it occurred only as an occasional plant.

One of the most important considerations in examining plant succession on newly created vacant areas in marshes, is that of waterlevel. Small amounts of surface water may preclude successful germination of many seeds which would flourish and grow on exposed soil.

On the areas in which these experiments were conducted, surface water of one to two inches is the general rule during the months of June, July, and August, due to prevailing southerly winds. This may provide some measure of explanation for the absence of many marsh plants which are present in the vicinity, but have not appeared in the plots, although it may also be a question of seed supply.

Observation of these plots and a wild fire which swept over the area in 1951 indicate that burning of herbicide treated areas during the first winter after spraying is beneficial. This removes all dead material, allowing better light conditions for growth of new plants.

None of the test plots were seeded artificially, but experiments along this line are desirable for several reasons. The quickest possible competition should be placed upon any remnants of needlerush which have survived through incomplete spray coverage. Uneffected plants of needlerush have consistently shown themselves capable of reinvading unoccupied areas. A spread of fifteen inches of rhizomes in a single season is not uncommon. The establishment of stands of desired vegetation would be more quickly obtained through seeding of herbicide treated areas.

CONCLUSIONS

1. Of eleven herbicides and combinations of herbicides tested against needlerush, only the isopropyl ester of 2,4-D produced an effective kill.
2. In one series of experiments, needlerush was eradicated by application of the isopropyl ester of 2,4-D at a rate of 27 lb. acid equivalent per acre.
3. 2,4-D was most effective against needlerush in the spring when the plant was in flower.
4. The estimated cost of $29.00 to $32.00 per acre for large scale applications of 2,4-D at a rate of 27 lb. acid equivalent per acre, may be difficult to justify, but spot spraying of small areas of needlerush in impoundments is practical.
5. Perennial plants such as saltgrass, sawgrass, *Scirpus Olneyi, Fimbristylis castanea,* and *Elocharis* sp. when present in plots, have survived sprayings with 2,4-D and have increased tremendously under reduced competition in the plots.

6. Several annual weeds, and a species of *Amaranthus* have appeared in the plots during subsequent seasons after needlerush was thinned or destroyed.
7. Burning of plots during the winter following applications of herbicide improves conditions for the growth of new plants through removal of dead material.
8. Artificial seeding of plots was not tested, but is desirable in order to produce desired vegetation more quickly, and to provide competition to remnant stands of needlerush, which otherwise soon begin reinvasion of vacant areas.