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History of Aquatic Weed Control in the United States

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Aquatic weed control in general followed the developments in terrestrial weed control, with initial federal aquatic research being conducted in the 1920's by the Division of Agristology. In the meantime, the Corps was operational in waterhyacinth control in southern states by mechanical and chemical means. The Department of Interior also became involved, particularly in the eastern U.S. where "weeds" or less desirable waterfowl plants were encroaching into wetlands and displacing desired waterfowl plants. Aquatic weed research greatly increased following the development of organic herbicides in the 1940's, and reached a peak in the late 1960's and early 1970's. Timmons, Steenis, Lawrence, Ennis, Seaman, Weldon, Blackburn, and many others were all heavily involved in the development of aquatic plant management programs. In fact, the emphasis of the WSSA on research and not operations lead to the formation of the APMS.

Maintaining Navigation: One Facet of The U.S. Army Corps of Engineers Role in Aquatic Plant Management

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Management of aquatic plants for purposes of navigation has always figured prominently in Corps authorities for aquatic plant management. The Rivers and Harbors Act of 1899 (Removal of Aquatic Growth Project), as amended; the Pilot Project in 1958; and the Expanded Comprehensive Project of 1965 all cite navigation interests. Historical and contemporary efforts are described; as are the various programs underlying these missions.

Aquatic Plants and Public Health Insects

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Immature stages of biting flies, particularly mosquitoes, rely on aquatic vegetation for protection from predation and, in some cases, as a source of oxygen. Emergent macrophytes, floating, and submerged plants can be either deleterious or beneficial. This presentation will address the plant components of aquatic communities that make for good and poor mosquito habitats. These principals will then be applied to the challenge of designing and managing wetlands for wildlife and waste water treatment, or retention and detention ponds, without creating mosquito problems. Is it really possible?

The Use of Herbicides to Control Nuisance Aquatic Species in the Maintenance of Mitigation Areas

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The following three techniques have been successfully used to control nuisance aquatic species in maintenance of planted mitigation areas:

1. Selectivity due to individual characteristics of herbicides and labeled recommendations for plant control.

2. Selective control by manual application of herbicide on specific target plants, using dyes, drift-control agents, and accurate application.

3. The combined process of cutting all vegetation and timely application of herbicide during regrowth.

Herbicide Concentration and Exposure Time Relationships for the Control of Hydrilla and Eurasian Watermilfoil

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Herbicide concentration and exposure time relationships have been developed under laboratory conditions to assess herbicide efficacy. Emphasis has been placed on short exposure times that occur in flowing water systems and other areas of high water exchange. Endothall, 2,4-D and triclopyr have been evaluated against Eurasian watermilfoil (Myriophyllum spicatum), and fluridone and endothall have been evaluated against hydrilla (Hydrilla verticillata). Plant injury increased with increasing concentrations and/or exposure times, to a threshold level above which control was achieved. Results from these experiments provided a new tool for selecting the appropriate herbicide and optimal application rate for controlling hydrilla and Eurasian watermilfoil.

Eradication of Hydrilla from Eastman Lake and the Chowchilla River

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On June 20, 1989 hydrilla was found in Eastman Lake, a U.S. Army Corps of Engineers reservoir located approximately 50 miles northeast of Fresno, CA. As a result of this discovery, a delimiting survey was conducted in the surrounding area. In addition to the Eastman Lake infestation, 25 miles of the Chowchilla River was found to be infested. After an extensive treatment program, complete topgrowth removal was attained by August 30, 1989.

Sonar Update - Flowing Water Experimental Use Permit

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Sonar was applied to flowing canals in Melbourne, FL during March 1989 and March 1990 in order to evaluate efficacy of fluridone and time/dose relationships. Preliminary data suggest exposures over 30 - 40 days of 10 - 30 ppb fluridone capable of controlling Hydrilla in flowing water. A second series of trials has begun.

Greenhouse Studies for Torpedograss Control with Fluridone

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Fluridone provided 90% + control of torpedograss growing in the greenhouse at rates as low as 0.28 kg/ha, depending on application method and surfactant. Best control was obtained with fluridone plus 0.5% surfactant applied in 860 l/ha to the foliage and soil surface. Applications to the soil surface alone were slightly less effective and application to the foliage only provided no control of torpedograss.

Optimizing Diquat Treatment of Benthic Mats of Lyngbya wollei: A Field Study

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Experiments evaluated the influence of season and application-mode on the effectiveness of Diquat applications (0,2,4,10 gallons/acre-foot). Diquat was applied to isolated benthic mats held in field enclosures during: 1) autumn, after most surface mats were benthic; 2) winter, when surface biomass was minimal: and 3) spring, as surface mats formed. Subsequent midsummer harvests were assayed for: biomass change: filament viability; photosynthetic potential; and in situ distribution.

Analysis has produced recommendations on the effective timing of Diquat application and introduced insights into the preferred characteristics of amending agents.

Polyploidy in Hydrilla verticillata (L.f.) Royle

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Karyotypes of root tips from 20 hydrilla populations from North and Central America, Asia and Australia have been compared. No significant differences in chromosome morphology have been observed. However, various combinations of diploid, triploid and tetraploid cells (x=8) were observed together in root tips of all populations except those from a Panang Island population, where only diploid cells were observed. These observations explain previous discrepancies in the ploidy of different hydrilla collections from the same populations.

Influence of Spikerush Herbage on Growth of Hydrilla

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Dry herbage of the spikerush plants, Eleocharis cellulosa torr. and Eleocharis interstincta (Vahl.) R. & S., collected from Lake Okeechobee, exhibited growth-retarding effects on hydrilla [Hydrilla verticillata (L.f.) Royle] cultured outdoors. Information will be presented on the influence of the spikerush herbage on hydrilla dry weight, number of tubers, tuber weight, and hydrilla tissue nutrients.

The Long Term Effect of 2,4-D on Non-Target Spatterdock

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Spatterdock (Nuphar luteum) is often exposed to 2,4-D as a non-target plant during waterhyacinth treatments. Damage to spatterdock can usually be seen soon after treatment, but the long term effects of 2,4-D have not been fully documented. In order to determine these effects, five spatterdock plots were treated with various rates of 2,4-D in Orange Lake, Florida and monitored for eight months.

Ecological Aspects of Redroot (Lacnanthes tintoria Ell.) and Its Control

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Redroot (Lacnanthes tintoria Ell.) belongs to the family Haemadoraceae. It is found growing in low wet areas along the coast from Massachusetts to Florida and Louisiana. Redroot reproduces from both rhizomes and seed. In cranberry bogs it persists, proliferates, and becomes an economic problem. There are indications that redroot has allelopathic properties; this may be an important ecological aspect in terms of competition. Various studies are underway to explore its reproductive capacity and allelopathic aspects.

Uptake and Accumulation of Selenium by the Rooted Aquatic Macrophyte Ruppia maritima

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Food chain accumulation of selenium has been implicated in dramatic acute and teratogenic toxicity to waterfowl in and around the agricultural drainage evaporation ponds of the Central Valley of California. Ruppia maritima is the dominant macrophyte in these communities, and is also known to be a food source for various waterfowl and shorebirds. This study compares the rate of uptake and accumulation of three Se species from the water column: selenite (+4), selenite (+6), and seleno-methionine.

Effects of Fluridone Treated Irrigation Water on St. Augustine Grass

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Newly developed application techniques and residue analysis of fluridone in lake waters suggests that optimum control of hydrilla occurs when the weed is exposed to low concentrations of fluridone for relatively long time periods. Multiple fluridone applications create concern for aquatic plant managers when posting treated water with recommended irrigation restrictions. St. Augustine grass was irrigated twice each week with water containing 0.0, 2.5, 5.0, 10, 20, 40, 80, 120, and 240 ppb (μg/l) fluridone. Results clearly show that the amount of organic matter of the soils in which St. Augustine grass is grown determine the no-effect level of treated irrigation water on this species.

Comparative Effects of Antagonistic Ions on Glyphosate Efficacy on Torpedograss

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Studies were conducted to determine the effects of ions present in diluent on the activity of glyphosate (N-phosphonmethyl glycine). In addition, changes in the UV absorbance characteristics of iron as influenced by glyphosate were determined as an indication of chemical complexing. Solutions comprised of glyphosate (1.68 kg ha^{-1}), the surfactant MON-0818 (0.5% v/v), and various concentrations of calcium and ferric and ferrous iron (0, 0.2, 2, 5, and 10 μM) were applied to the foliage of torpedograss. Iron antagonized the activity of glyphosate to a much greater extent than calcium. Statistically, both forms or iron caused the same amount of antagonism. The UV absorbance of iron was altered both synergistically and antagonistically indicating chemical interaction between glyphosate and iron.

The Role of Iron in the Growth of Lyngbya majescula

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Lyngbya majescula, a filamentous, freshwater, blue-green alga, grows excessively in nutrient rich waters. The role of iron in the growth of L. majescula, with a view to determining nutrient function as well as possible inhibition characteristics has been studied. Results to date will be discussed.

Critical P Concentration and Seasonal Variation in Biomass Allocation and Productivity of Myriophyllum aquaticum

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The tissue phosphorus concentration that limits growth of Parrotfeather (Myriophyllum aquaticum) was estimated in a greenhouse study using classical yield response methodology. Critical (growth limiting) P concentration ranged from 0.04% P to 0.12% P depending upon tissue used as an index. The significance of nutrient limitation of parrotfeather growth in a shallow, central California lake will be discussed along with aspects of productivity and biomass allocation.

Microbial Degradation of Fluridone

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Studies were conducted to determine whether populations of lake microbes degrade fluridone. Inocula consisting of hydrosoil + water was collected from seven lakes and transferred to a mineral media/fluridone solution. Fluridone degradation occurred in two of the inoculated solutions. The half-life of fluridone in mineral media inoculated with samples from Lakes McLeod and Pierce were 185 and 310 days, respectively. Microbial enrichment (ie., a half-life decrease to 67-91 days) occurred when isolates from Lake McLeod were reinoculated in fluridone/mineral media. Organisms capable of growth on silica/fluridone plates were identified as a species of fungus (Aspergillus proliferans) and a gram-negative bacteria (Pseudomonas sp.).

Novel Effects of the Herbicide Mariner On the Reproductive Biology of Aquatic Weeds: Implications For Long-term Management Strategies

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Mariner (Bensulfuron), in addition to acting as an excellent preemergent soil applied herbicide and early post emergent water-applied herbicide, also produces two salutory effects in hydrilla and American pondweed when they are exposed mid-to late season--blockage of propagule formation and precocious sprouting. These effects require 3-5 day exposures at 50 ppbw, but longer days generally caused more inhibition of propagule formation. Exposures up to 14 days at 10 ppbw were not effective. Those winter buds which were formed in the presence of 50 ppbw Mariner were smaller than ones produced on untreated plants.

The Effect of Slow-release Fertilizer Application on Wildrice Production

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Wild rice (Zizania aquatica L.) production problems were observed in Oval Lake in northwestern Ontario. This lake, characterized by organic sediment, had been intensively managed for commercial wild rice production for several years. An experimental plot was established in 1986 to determine if the application of slow-release fertilizer could increase wild rice production. Samples if wild rice plants and sediment were collected for analysis in 1986 and 1987.

Grass Carp - All or Nothing for Submersed Weed Control in Southern Waters

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Aquatic plant managers have never had the capability to economically remove all submersed plants from large ecosystems. In the past 16 years, grass carp stocking in Florida has shown that with a few unusual exceptions, submersed weeds have been either totally removed or not affected by numerous stocking rates of fish. There appears to be no long term "in-betweens". This appears contradictory to results obtained with grass carp in northern latitudes where partial weed control is possible with the grass carp. Now that total long term submersed weed control (eradication) is possible, biologists are faced with the dilemma of determining if submersed vegetation is necessary in aquatic ecosystems.

Sediment Characteristics That May Influence Aquatic Plant Distributions in the United States

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Sediment characteristics such as organic carbon may influence the distribution and density of rooted aquatic vegetation. We investigated the range of sediment characteristics in 24 physiographic provinces of the continental United States. Organic carbon, cation exchange capacity, particle size distribution and estimated particle surface area varied two or more orders of magnitude. These data may be valuable for examining the role of sediments in regulating distributions of steno-tolerant rooted aquatic plant species and for investigation of the influence of these plants on sediment digenesis.

Exotic Aquatic Plant Index

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The exotic aquatic plant index was one of the indices developed as part of the Strategic Assessment of Florida's Environment (SAFE) Project funded by the Department of Environmental Regulation. The Exotic Aquatic Plant Index is a per mile value of ratio of area covered by the plants to total area of waterbodies. The 1986 Plant Index value was 50.6 based on a scale of 0-100.

The Peroxidase Response of Hydrilla verticillata (L.f.) Royle to Sublethal Concentrations of Heavy Metals and Sulfometuron Methyl

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The aquatic plant, Hydrilla verticillata (L.f.) Royle, was cultured in 10% Hoagland's solution augmented with $NaHCO_3$. They were exposed to sublethal amounts of Cu, Se, Cr, Mn and the herbicide, sulfometuron methyl. After 7 days, peroxidase was extracted and assayed. There was a significant change in activity after exposure to 0.1 ppm Cu, 1 ppm Se, 10 ppm Cr, 10 ppm Mn and 0.01 ppm sulfometuron. There was also a change in optimum pH for the enzyme. Peroxidase may be useful as an indicator of sublethal stress in hydrilla.

Factors Influencing the Distribution and Growth of Lyngbya

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Lyngbya infestations in the U.S. are concentrated in the southeastern states, though mats can be collected from as far north as Minnesota. The geographic distribution and biomass of infestations are influenced by water temperature and the length of the"Lyngbya" growing season. Ion content of the water also influences growth and distribution: Lyngbya displays limited salinity tolerance; and known infestations are restricted to limestone-enriched regions. The ability of Lyngbya mats to survive during extended periods of complete darkness enhances cumulative accrual of biomass over many years, to values exceeding 6 kg FW/m^2.

Effects of Sediment Fertility and Initial Plant Density on the Growth of Hydrilla and Potamogeton

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Hydrilla verticillata (L.f.) Royle and Potamogeton nodosus Poiret were grown at high and low levels of plant density and sediment fertility. In corresponding treatments, Potamogeton produced greater total biomass and root-to-shoot ratios than Hydrilla. Growth of both species was generally more affected by sediment fertility than plant density. The two species demonstrated different survival strategies on nutrient-poor sediment. Hydrilla maximized shoot production as a means of lateral expansion; Potamogeton allocated proportionately greater biomass below-ground to enhance nutrition.

Regenerative Capacity of Myriophyllum aquaticum Cultured in Vitro

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Effects of tissue type (nodal segments vs internodes), cytokinin type (isopentenyladenine, benzyladenine, zeatin), liquid vs agar-solidified media on shoot regeneration of Myriophyllum aquaticum was examined. Maximum shoot regeneration of M. aquaticum (19 fold increase) occurred in liquid medium supplemented with 10 μM isopentenyladenine following 14 days culture. Benzyladenine was inhibitory to shoot multiplication at the higher levels used. Internode segments exhibited a high capacity for adventitious shoot formation when cultured on agar-solidified media supplemented with isopentenyladenine.

Interactions Between Two Pondweeds Across A Light Gradient

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Previous work suggested that light may be a limiting resource when two pondweeds, Potamogeton pectinatus and P. gramineus, are grown in competition experiments. Addition series experiments were set up at 4 light levels ranging from 16 to 100% full sun. Competitive abilities were estimated using the reciprocal yield model. The coefficient of determination indicated that competition was important at all but the lowest light level. P. gramineus was a stronger competitor. In general more dry matter was allocated to propagule production at higher light levels. At the highest light level P. pectinatus allocated about 10%. Results support Grime's triangular model.

Competition Among Different Species of Aquatic Macrophytes: A New Zealand Example

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From in situ lake experiments, Lagarosiphon major (exotic), Myriophyllum triphyllum and Potamogeton ochreatus (natives) all showed a lag phase in shoot growth. This was due to development of a root system, and to water nutrient availability. In laboratory experiments L. major rooted and grew faster, both in length and biomass, than the native species. These results suggest that L. major has a competitive advantage.

Growth and Photosynthesis of Hydrilla as a Function of Temperature

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Hydrilla was grown under 30/25 or 15/10°C day/night temperature regimes. Plants at the higher temperature had higher growth rates. Photosynthetic rates of Hydrilla from both temperatures increased with increasing temperatures from 5 to 35°C. The plants acclimated to the lower growth temperature, as shown by their photosynthetic response. The dissolved inorganic carbon availability also influenced the response to temperature.

The Ecology and Management of Eurasian Watermilfoil in Lake George, New York

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Lake George is large, oligotrophic lake in the Adirondack Mountains of New York with a diverse flora (approximately 50 submersed species). Eurasian watermilfoil (Myriophyllum spicatum L.) was first observed in Lake George in 1985, and has since spread. Eurasian Watermilfoil has impacted on native plants in some areas, but has not spread as rapidly as expected. A few initial attempts have been made at managing the plant, with a long-term plan under development.

Revegetation of Northern Lacustrine Littoral Zones Dominated by Myriophyllum spicatum

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University of Wisconsin

We examine the possibility of restoring communities of native plant species in Eurasian watermilfoil dominated lakes that exhibit improved water quality. Interspecific competition experiments with milfoil and Potamogeton amplifolius were supplemented with growth experiments along sediment and water quality nutrient gradients to assess this hypothesis. These data suggest that local lake conditions may determine the success of management programs directed at littoral zone restoration.

Ecology of Eurasian Watermilfoil Invasions and Declines

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Typically, Eurasian watermilfoil (Myriophyllum spicatum) invades new locations, dominates them for 10 to 15 years, and then declines. The replacement of native species, the extent of domination, and the likelihood of an eventual decline vary considerably among locations. Literature accounts provide many clues as to the factors responsible for this variation. Recognition of these controlling factors can lead to more effective management of nuisance watermilfoil populations.

Role of the Littoral Zone in Lacustrine Nutrient Dynamics

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Through uptake from the sediment, submersed aquatic macrophytes potentially transport nutrients to the overlying water column. Elevated pH, associated with macrophyte photosynthesis, further enhances phosphorus flux directly from littoral sediments. Convective hydraulic circulation, among other processes, facilitates littoral-pelagic nutrient exchanges. These properties of the littoral zone can have important effects on overall lacustrine nutrient dynamics. Potential influences of the littoral zone on phytoplankton production and species composition need to be considered in macrophyte management.

Response of Alligatorweed to Triclopyr Amine

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Alligatorweed was treated with triclopyr amine in June and September 1989 at rates varying from 0.75 to 4.5 lb/acre or with a 1.25 percent solution sprayed to wet. Glyphosate (1.25% sprayed to wet) was used as a positive control. All rates of triclopyr amine or glyphosate resulted in essentially complete defoliation by 14 days after treatment. Regrowth occurred by the end of the season. Studies are continuing in 1990 to refine timing, rates of application, and frequency of treatment.

Mechanical Control of Aquatic Plants via Rotovation

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Rotovation is a relatively new technique that has been developed and expanded on in recent years in the western U.S. and Canada. The rotovation process involves removal of the plant's root system and has been proven effective at up to a 98% removal rate. Demonstration projects have shown that the process provides relatively long term control (2 years plus) of submersed and emergent aquatic plants compared to conventional mechanical control methods. The technology and operational projects will be reviewed.

Management of Water Hyacinths for Water Quality Improvement

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Waterhyacinths (Eichhornia crassipes (Mart.)Solms) were stocked in Round Lake, a small eutrophic lake in central Florida for the purpose of determining the effects a managed waterhyacinth crop covering approximately 30% of the lake surface would have on water quality. Parameters measured include clarity (Secchi Disk depth),nitrogen, phosphorus, carbon, temperature, dissolved oxygen, pH, conductivity, and algae biomass (chlorophyll a). Data taken during the first year of a two year study show large improvements in clarity (>600% increase) and chlorophyll a concentrations (>90% reduction) in both the waterhyacinth covered and open sections of the lake. Nutrient concentrations (soluble reactive phosphorus, total phosphorus, ammonium-N, total Kjeldahl nitrogen, and total organic carbon) in the water column declined during the study period. Surface (0.5 m) water temperature underneath the waterhyacinth crop was lower than in the open section. At other depths, the temperature differences between open and covered areas were negligible . Likewise, dissolved oxygen levels were lower underneath the waterhyacinth crop at the surface, while at lower sampling depths the D.O. concentrations were similar. Values of pH were generally found to be slightly lower underneath the crop. Conductivity was similar between the two sections. The data suggest that waterhyacinths are capable of successfully replacing algae. Growth and expansion of the water- hyacinth crop transfer nutrients from the water into plant biomass. Harvesting of the waterhyacinths exports nutrients from the water body, thus removing the potential for their recycling. The harvested waterhyacinths are then used to produce vermicompost, a reusable byproduct. At the end of the project term, the entire waterhyacinth crop will be completely harvested.

Diquat Residues following Repetitive Treatments

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Two studies were conducted to determine the extent of Diquat residue dissipation, mobility in water and sediment, and accumulation in edible fish tissues under actual field conditions. For both studies ORTHO DIQUAT Herbicide - H/A was applied at a rate equivalent to two gallons of formulation per surface acre (4 lb cation/acre) in four application treatment programs with approximate spray intervals of 30 days. At both test sites, diquat cation residues were rapidly eliminated from the water column following each application with half lives values ranging from 0.72 days to 2.3 days. Accumulation of Diquat residue in the sediment ranged from <0.01 to 1.20 ppm in the top 5 cm and did not exceed 0.38 ppm in the bottom 5 cm. There was no accumulation of Diquat in edible tissue of catfish and a maximum residue of 0.3 ppm in the edible tissue of Tilapia sampled on the day following application of diquat. There was no trend of increasing residues in fish with increasing number of application.

Effective Use of SONAR-SRP in Marginal Treatments for Control of Myriophyllum spicatum

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Based on controlled semi-field experiments, SONAR-SRP was effective for control of Myriophyllum spicatum at label recommended application rates (60 lb/acre) under static conditions (no water exchange). At label recommended application rates, SONAR-SRP will probably not provide effective control of M. spicatum when water exchange rates exceed once every three days. Formulations with slower release rates may yield better control in flowing aquatic systems.

Herbicide Gravity Feeder

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This paper presents two new techniques for applying the herbicides by using a simple feeder developed by the authors called KG Herbicide Gravity Feeder. The feeder can be used for injecting the acrolein (Magnacide H) in channels under gravity to control submerged weeds. The system is connected directly to the acrolein drum where the effluent discharge is controlled by a calibrated changeable orifice. These orifices are calculated and calibrated under different heads 1 to 6 meters to apply the acrolein quantity in the drum (165 litre) in time periods from 1 to 8 hours.

Effects of Application Rate and Exposure Time of Bensulfuron-methyl on Hydrilla verticillata

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Four experiments were conducted to evaluate the potential of bensulfuron methyl 60 DF (BSM) for hydrilla (Hydrilla verticillata) control in Florida. The data from these experiments suggest that long exposure to low concentrations of BSM regulate the growth of hydrilla. However, a greater application rate than 100 ppb BSM, or long exposure will be needed for hydrilla control when used for applications where the herbicide will be diluted in the environment. Support for this research was supplied by the USDA/ARS under Cooperative Agreement No. 58-43YK-9-001 and E. I. Du Pont De Nemours and Co.

Establishing Grass Carp Stocking Rates in Southeastern Ponds

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Stocking grass carp for aquatic weed control is becoming more popular for several reasons. Because many factors influence the ability of grass carp to effectively control aquatic weeds, it is difficult to establish stocking rates that will satisfy pond owners. Observations based on post-stocking evaluations from ponds in Georgia will be presented. Some suggestions for establishing grass stocking rates will be given.

Recent Advancements in Mechanical Means of Aquatic Plant Management

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A brief overview of the severe limitations of the conventional methods of mechanical harvesting, and the introduction of the revolutionary means as developed by AquaDoc Inc. Presentation will include a visual display of this new and patented process.