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Research Article

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Survival Increasing of Sturgeon Fries by Controlling Submerged Weeds

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Abstract Sturgeons are the most valuable aquatic animals in the Caspian Sea. Sturgeon fries at 100 mg weight easily trapped in heavy dense stands of submerged aquatic vegetation. Due to the often detrimental impacts of submerged weeds on growth and mortality of young fish, removal of nuisance vegetation with minimal harm to sturgeon fries is a desirable goal. Paraquat (1,1´-dimethyl-4, 4´-bipyridinium ion) was evaluated at rates of 0, 0.5, 1, 2, 5, and 10 mg L^{-1} in the fish ponds for control of *Potamogeton crispus*, *Ceratophyllum demersum*, *Myriophyllum spicatum* and *Hydrilla verticillata* in the International Institute of Caspian Sea, Shahid Ansari and Shahid Beheshti Fish Research Stations, Rasht, Iran during 2011-2012. Paraquat treatments were conducted on May 25, 2011 and June 10, 2012. The 5 mg L^{-1} treatments and above reduced biomass of all aquatic weeds by > 75%. Treatment of 10 mg L^{-1} reduced the biomass of aquatic weeds by > 90%; however this application rate also significantly reduced growth several desirable and non-target species such as *Chara* by > 90%. Biomass of submerged weeds following the 0.5, 1, 2 mg L^{-1} application of paraquat were reduced 8, 12 and 26% respectively. Results showed the removal of competitive, canopy forming weeds such as *Potamogeton crispus*, *Ceratophyllum demersum* and *Myriophyllum spicatum* open new areas and increased the survivability rate of sturgeon fries by 45%.

Keywords Sturgeons fries, Fish ponds, Submerged weeds, Paraquat

Introduction

In aquatic habitats plant density is an important factor, which can make plants wanted or unwanted. Aquatic plants are usually useful plants which become weeds when their growth becomes excessive, and some type of control or management become necessary to ensure continued use of water body [1-2]. Weed problems in aquatic habitats are generally caused by the growth of dense vegetation, which hampers the use of water bodies. When massive growths of submerged weeds occur, they can have an influence on water quality because oxygen is depleted by plant respiration, interfere with fish movement, which often causing fish kills [3-5].

Control methods are usually based on physical removal or herbicides [6-7]. Various methods have been used in the last 30 years to control of unwanted aquatic plants. Although herbicides and plant growth regulators can control many weed species, there is limitation on using them in water bodies. The success of a chemical treatment against submerged weeds depends on the concentration of the herbicide that comes into contact with target plant, the length of time a target plant is exposed to the herbicide, and timing of application. The response is also related to the properties of individual herbicides and the sensivity of the target species to each herbicide [8].

Information on herbicide uptake and lethal concentration in plant tissues is extremely limited for aquatic macrophytes, especially submerged species [9]. Rapid dilution and dispersal of herbicide residues from the treatment area following herbicide application (due to diffusion and water movement) can reduce both concentration and exposure time to a level less is required for complete control. Previous studies have focused on the use of contact herbicide like diquat for control of submerged weeds, to provide a temporary weed-free period in the target area for up to one year [9-11].

The *Potamogeton crispus*, *Ceratophyllum demersum*, *Myriophyllum spicatum* and *Hydrilla verticillata* and *Potamogeton pectinatus* are problematic submersed weeds of rivers, irrigation networks and drainage channels and fish ponds throughout temperate and subtropical regions of the world [11-15]. Sturgeon fries easily trapped in heavy dense stands of submerged aquatic vegetation. Due to the often detrimental impacts of submerged weeds on growth and mortality of young fish, removal of nuisance vegetation with minimal harm to sturgeon fries is a desirable goal.

Paraquat (1,1´-dimethyl-4, 4´-bipyridinium ion) is widely used to control these submerged weeds, and is typically applied at 1 mg L^{-1} active ingredient, with a minimum exposure period of 24 hours [16], to provide control for up to 1 year [9-11]. Increasing concern about use of herbicides in aquatic ecosystems has produced pressure to reduce the loadings of herbicides used for aquatic weed management. One possible approach is to combine reduced concentrations of herbicide treatments with other control techniques in integrated management programs. Van Vierssen and Hootsmans (1990) suggested manipulation of underwater light regime, i.e., using turbidity promoting benthic feeding fish coupled with a low dose of herbicide to cause chronic stress to the target weeds, and followed, where necessary, by mechanical removal [17]. This approach was used in channel systems in Argentina [18-19], with good results. In this study we evaluated the effectiveness of low doses of diquat to control of submerged weeds in the fish ponds at the north of Iran.

Materials and Methods

In order to evaluate the potential of paraquat for controlling the growth and spread of submerged weeds such as *Potamogeton crispus*, *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Hydrilla verticillata* and *P. pectinatus* an experiment was conducted between 2011-2012, in the experimental fish pond facility, located at the International Institute of Caspian Sea, Shahid Ansari and Shahid Beheshti Fish Research Stations, Rasht, Iran. Six small fish ponds (12m length, 10m width, 1.5m water depth) which covered by natural vegetation such as *Hydrilla verticillata*, *Potamogeton pectinatus*, *P. crispus*, *Ceratophyllum demersum*, and *Myriphyllum spicatum* were selected. Stock rate in each fish pond was 125 Sturgeon fries. A pond, without paraquat application acted as control. Mean chemical characteristics of ponds water were calcium 4.6 mg L^{-1}, pH 8.26, nitrate 0.63 mg L^{-1}; reactive phosphate 0.53 mg L^{-1} and chlorine 0.31 mg L^{-1}.

When plants height reached an average of 40 cm, paraquat treatments were applied on May 25, 1999 and June 10, 2000. Paraquat concentrations were 0, 0.5, 1, 2, 5, and 10 mg L^{-1}. Each treatment was replicated 2 times in a complete randomized block design. Treatments were made by injecting the herbicide solution into the water with hypodermic syringes. This experiment took place in 90 days. Samples were taken by using 50 cm^2 quadrat frame with all plants within that removed to evaluate a percentage of visual damage, plant dry weight (g), shoot length (cm) and compared with controls. Also, sturgeon survival (%) at each pond at the end of experiment was measured.

In this experiment data were analyzed for treatment effects by standard ANOVA procedures with subsequent use of Tukey's Least Significant Difference test to separate means [20].

Results

Injury to submerged weeds occurred at most concentrations. Dry weight (g) of submerged weeds following the 0.5, 1, 2 mg L^{-1} application of paraquat were reduced 8, 12 and 26% respectively. The 5 mg L^{-1} treatments and above reduced biomass of all aquatic weeds by > 75%. Treatment of 10 mg L^{-1} reduced the biomass of aquatic weeds by > 90%; however this application rate also significantly reduced growth several desirable and non-target species such as *Chara* by > 90% (Figure 1a). Paraquat at 0.5 and 1 mg L^{-1} were ineffective to decrease significantly submerged weeds dry weight and shoot length. Results showed the removal of competitive, canopy forming weeds such as *Potamogeton crispus*, *Ceratophyllum demersum* and *Myriophyllum spicatum* open new areas and increased the survivability rate of sturgeon fries by 45% (Figure 1d).

Most shoots in the 1, 2, 5 and 10 mg L^{-1} paraquat concentrations were brown, necrotic and appeared dead. Shoot lengths were significantly reduced by increasing the paraquat concentrations. Despite a 22 and 27% reduction in shoot length compared with untreated plants, there were no significant differences between 0.5 and 1 mg L^{-1} paraquat with controls. Greater reductions of plant length were observed at high doses of paraquat (Figure 1b).

The inhibition of tuber and rhizome production persisted long after the plants had recovered from initial herbicidal effects. The duration of belowground organs suppression increased with increasing dose. The 0.5, 1, 2, 5 and 10 mg L^{-1} paraquat reduced tuber and rhizome production 33, 48, 58, 72 and 96% respectively. The tubers produced in the treated ponds were also much smaller than those of untreated plants (Figure 1c).

Discussion

Increasing effects on plants were observed, as expected, with increasing paraquat concentrations. However, rapid regrowth occurred at low concentrations treatments (0.5 and 1 mg L^{-1} paraquat) were inefficient in significantly reducing submerged weeds dry weight. New growth of submerged weeds at the treated ponds remained bleached and necrotic while in contact with paraquat. Regrowth of treated weeds depended on the paraquat concentrations and exposure times. When paraquat was removed and deactivated, submerged weeds began to regrow from rhizome and tubers. Regrowth from tuber and rhizomes suggests a lack of herbicide transport to tubers [21], in keeping with the well-known poor ability of paraquat for translocation within the plant [22]. The results suggest that low doses of paraquat can control submerged weeds, but must be in contact for >24 hours. Long exposure periods are difficult to achieve for paraquat in ambient conditions, even using formulations with slow-release properties [5,7]. Residue loss in flowing water, herbicide adsorption to organic and clay particles in water and sediment, and antagonistic action from Ca^{++} ions in water are all known problems affecting paraquat [7, 22]. Our results showed that submerged weeds response to paraquat were unable to survive by concentration of 2 mg L^{-1} and above.

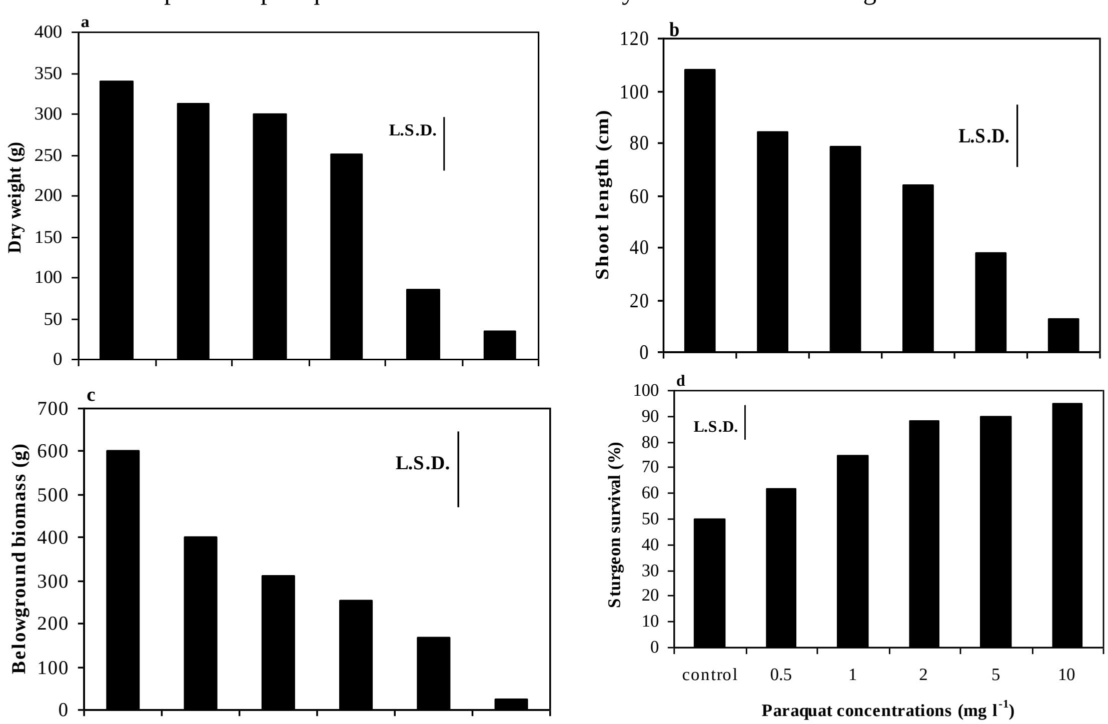

Figure 1: Effects of paraquat concentrations on plant dry weight (g), shoot length (cm), belowground biomass (g) and (d) sturgeon survival in experimental fish ponds. Separate bars represent least significant difference: L.S.D. (p<0.05).

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