Some Aspects of the Economics of Aquatic Weed Control in Fish Culture

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ABSTRACT

The economics of aquatic weed control in fish culture ponds by manual, mechanical, and chemical methods is compared. Chemical control by the use of different herbicides has been shown to be more economical and beneficial than manual or mechanical operations. The reasons adduced include effectiveness of chemicals in reducing recurring cost, variability in work output in physical removal efforts, and unsuitability of mechanical equipment in deep waters. Although initial chemical control costs may be higher in some cases compared to other methods, it is considered more beneficial in fish ponds because the weeds release nutrients back into production and long range costs are generally less.

INTRODUCTION

In intensive fish culture it is essential that the entire productive potential of the ecosystem is fully utilized for fish production, and that weeds do not remove and keep out of production essential nutrients in the soil or those added through fertilization. The cost of control of aquatic weeds for large scale operations was determined several years ago (23) at US $20 per ha for submersed weeds, and US $30 per ha for surface vegetation by herbicide application. Mechanical methods cost $53 per ha and US $88 per ha respectively, whereas in fish culture operations the costs tend to be different because of the smaller size of the ponds and different methods employed. The conversion of aquatic weeds into useful nutrient inputs released by the killed weeds add to the fertility of the pond and make the herbicide method more remunerative to be favorably compared to some of the best fertilizer treatments (21). In this context, the economics of aquatic weed control in fish culture by various methods available to the fish farmer viz., manual, mechanical, biological and chemical have not been properly evaluated as has the economics of such operations in irrigation systems, recreational lakes and major impoundments (3, 7, 8, 9, 10, 22). Such studies are scarcely available in fish culture (1, 4, 5, 15, 18). In underdeveloped countries, the need to educate the public who are reluctant to adopt cheaper and more useful scientific methods rather than the costlier labor-intensive traditional unproductive efforts in vogue, is great.

MATERIALS AND METHODS

The trials were carried out under actual field conditions in marked out plots of 50 to 1300 m^2 areas in ponds varying in size from 0.03 to 6.6 ha as indicated in Tables 1 to 5. The density of weeds was estimated with the help of a light bamboo 1 x 1 m frame, by sampling 5 to 10 different points in the infestation and average the samples in terms of fresh weight (Kg/m^2) after absorbing the excess water from the plants with a dry cloth.

The manual effort in the removal of weeds was to pull the weeds physically out of water with attached roots and rhizomes by hand, which often resulted in breaking of plants. Sometimes the weeds, as in the case of floating plants, were pushed to the margins of the pond by long bamboo poles or dragged by a rope thrown into the water after fastening a stone, or by using a strong wide mesh coir rope net. In the case of submersed weeds, a pole provided with a small cross piece at one end was also used to twist the weeds before pulling them out. Rooted emergent weeds like water lilies, lotus, sedges and water grasses were very hard to pull out and a hand sickle or scythe was used to cut them at soil level. The people engaged for manual control method were daily paid workers or regular farm hands. The work output was calculated in terms of area and weight of weeds removed. The rate of Rs.4 (1 US $ = Rs.8) per man-day, working on an average for 6 hours a day was used (1976).

The costs and doses of herbicides applied were based on active ingredient as for e.g., 2,4-dichlorophenoxy acetic acid (2,4-D) @ Rs.15 per kg since the percentage of active ingredient varied in the formulations used. Wetting agents used were mostly domestic detergents available in India.

Foliar spraying was carried out by foot-pump sprayers with 50 m hoses which could be kept on shore. The sprayer nozzles delivered fine or coarse spray by suitable adjustment and the spray volume varied from 500 to 1000 l/ha. A modified, locally made sprinkler attachment was used with higher spray volumes of even 5000 l/ha in the case of morning glory[1] to facilitate shower like spray reaching tall plants and the falling droplets hitting lower leaves. The same type of nozzle was also used for spraying aqueous solutions of ammonia on water lettuce and water moss to ensure larger droplets falling on the leaves and better coverage.

RESULTS AND DISCUSSION

The work output by manual methods (Table 1) was highest for water hyacinth, water lettuce and water moss and hence, the cost of control was higher than for other weeds. However, between the individual weeds, the work output varied due to density, depth, area of infestation and other factors like efficiency, endurance and experience of the workers. Repeated cutting of the leaves and other above ground parts increased the costs of rooted emergent weed control. The rooted submersed weeds required at least six to seven manual removal operations per year, resulting in the cumulative cost of control highest among the three types of infestations studied.

Previous estimates (12, 13) on the cost of control by manual means for waterhyacinth, water lettuce and duck weeds in fish culture operations was lowest, between Rs.52.50 to Rs.150 per ha, as the wages were also lower at

[1]See Table 6 for list of common and scientific names.

TABLE 1. COST OF MANUAL METHOD OF CLEARANCE OF AQUATIC WEEDS IN VARIOUS PONDS IN INDIA.

Pond location	Area (ha)	Weed	Biomass (kg/m^2)	Labor[1] (hr/ha)	Labor cost[2] (Rs/ha)	Work output[3] (kg/hr)
Sec V Killa Cuttack	0.01	*Eichhornia*	29.0	900	600	327
Fish Farm Pipli	6.60	*Eichhornia*	29.0	803	535	355
Sec IV Killa Cuttack	0.51	*Eichhornia*	15.0	600	400	255
Sheik Bazar Cuttack	0.25	*Eichhornia*	19.0	360	240	528
Stewart school Cuttack	0.03	*Pistia*	2.8	134	89	210
Stewart school Cuttack	0.08	*Pistia*	1.5	226	151	68
Sec IV Killa Cuttack	0.03	*Pistia*	1.4	480	320	29
Sec IV Killa Cuttack	0.45	*Pistia*	4.5	822	548	55
Sheik Bazar Cuttack	0.25	*Pistia*	4.0	353	234	227
Fish Farm Barang	2.50	*Salvinia*	16.0	965	644	165
Fish Farm Barang	0.11	*Salvinia*	16.7	303	202	552
Fish Farm Barang	0.05	*Salvinia*	12.5	800	533	136
Stewart school Cuttack	0.32	*Spirodela*	1.2	204	136	58
Stewart school Cuttack	0.07	*Spirodela*	1.0	70	47	147
Fish Farm Barang	0.02	*Panicum*	0.4	307	205	11[4]
Kanika Pond Cuttack	0.03	*Hydrilla*	3.8	767	511	42[5]
Sec. IV Killa Cuttack	0.50	*Hydrilla*	—	415	277	—
Sec. V. Killa Cuttack	0.55	*Hydrilla*	—	342	228	—
Fish Farm Kausal yagang	0.13	*Nymphaea*	—	362	241	—[6]
Fish Farm Chowduar	0.06	*Cyperus*	3.5	600	400	58

[1]Number of man hours taken to clear 1 ha.
[2]Cost of labor to clear 1 ha in Rs (1 U.S. $=Rs 8 approx.).
[3]Quantity of weeds in Kg removed per man hours.
[4]At least three cuttings at/above ground level in 1 yr.
[5]For one clearance only; average of six to seven clearances taken.
[6]Three cuttings of emergent leaves in 1 yr.

that time (Rs.1.50 man-day). However, the work output calculated showed that 210 to 600 man-hours were required to clear 1 ha. The cost of control of waterhyacinth of a maximum density of 115 Kg/m² was Rs.875/ha @ Rs.3/man-day which calculated to be 1752 man-hours/ha (17). The clearance of submersed weeds likewise differed in cost and effort according to estimates of different workers (13, 19), from 624 man-hours/ha for initial clearance to 3360 man-hours for three to four clearances in a year.

Compared to manual methods just referred to, mechanical methods were more effective and economical. A mechanical weed cutter effectively cut rooted emergent and submersed weeds consisting of water lilies, hydrilla and bushy pondweed with a combined infestation of 20 to 30 kg/m². The work output of the machine in terms of time taken to clear an area was 7.5 hrs/ha with a petrol consumption of 7.5 liters and 1 liter of engine oil. The total cost including interest on capital outlay, depreciation, maintenance and operational charges was Rs.125 per ha for a single clearance only.

In another trial, two winches were used for 3 hours to pull out rooted submersed weeds in an area of 0.04 ha (75 man-hr and Rs.63/ha). The mechanical methods and equipment used above were not suitable in depths greater than 1 m, and the partial control achieved necessitated recurring expenditure for control and increased cumulative costs. It was also difficult to transport the heavy equipment to different ponds and such equipment was suitable only in large areas for keeping the weeds under a manageable level.

Chemical control methods were compared by use of ammonia for control of submersed aquatic weeds; floating weeds (waterhyacinth) by 2,4-D formulations; water lettuce by aqueous ammonia; water moss by paraquat; rooted emergent weeds (lotus, morning glory and sedges) by 2,4-D formulations; and water grass by 2, 2-dichloropropionic acid (dalapon). Excellent waterhyacinth control was achieved (Table 2) as reported earlier (20), and the cost of follow-up maintenance operations were less than for other weeds. The total cost of control by herbicide treatment was also more economical than for manual removal. Control of water lettuce and water moss by paraquat or ammonia was cheaper than the manual method (11), though the latter method can be more economical in thin infestations (Tables 2 and 3). Hydrilla and coontail were effectively controlled by applying anhydrous ammonia (15, 16, 18 and 19). Follow-up maintenance operations tend to be high initially, but gradually become less as the infestation was reduced from 29 kg to about 3 kg/m² (Table 4). The maintenance operations on coontail were not sufficient for total plant removal, hence the weed reappeared again within 2 to 3 months. The cost of control of submersed weeds by ammonia application, though apparently higher than manual means, is economical because of the fertilizer value of ammonia and non-recurring expenditure of the method.

The control of rooted emergent weeds (Table 5) by treatment with herbicides also indicated that the herbicide method was more economical because repeated cuttings required in manual methods increased the costs of the same.

Thus, in the case of water lilies, cost of control by spraying 2,4-D herbicides was found to be cheaper than by manual cutting of leaves which had to be repeated at least three times in a year. Similarly, water grasses and sedges were more economically controlled by herbicidal spraying than by manual cutting operations.

It was evident from the study that weed control expenses are not recurrent yearly as the expenses of the initial control

TABLE 2. COST OF CLEARANCE OF FLOATING INFESTATIONS OF *Eichhornia* BY CHEMICAL (2,4-D) TREATMENTS.

Pond location	Area (ha)	Biomass (kg/m²)	Dose (kg/ha)	Chemical (Rs/ha)	Labor (hr/ha)	Labor Cost (Rs/ha)	Control (%)	Maintenance Labor[1] (hr/ha)	Maintenance Cost (Rs/ha)	Total Cost[2] (Rs/ha)
Stewart School Cuttack	0.33	21	5	95	260	173	94	46	30	298
Kengeri Tank Mysore	1.45	54	5	94	136	90	90	0	0	184
Pipli Fish Farm	0.58	29	8	287	144	96	96	0	0	383
Sec V Killa Cuttack	0.43	20	6	113	125	83	99	70	47	255
Keonjhar House Cuttack	0.06	18	5	100	98	65	94	160	107	272
CRRI Cuttack	3.00	18	5	98	123	98	100	186	124	320

[1]Maintenance by picking up or spraying leftover plants. Labor required in hours per hectare.
[2]Total cost calculated by adding chemical cost and cost of spraying + maintenance.

TABLE 3. COST OF CLEARANCE OF *Pistia* AND *Salvinia* BY CHEMICAL TREATMENT.

Pond[1] location	Area (ha)	Biomass (kg/m²)	Dose (kg/ha)	Chemical[2] Cost (Rs/ha)	Labor (hr/ha)	Labor Cost (Rs/ha)	Control %	Maintenance cost (hr/ha)	Maintenance cost (Rs/ha)	Total cost (Rs/ha)
Sheik Bazar Cuttack	0.25	9	50	182	200	133	77	24	16	331
Killa Moat Cuttack	0.46	5	0.2	45	72	48	98	6	4	97
Barang Fish Farm	0.06	11	1.0	206	108	72	92	18	12	310

[1]Sheik Bazar = *Pistia* treated with ammonia. Killa Moat = *Pistia* treated with Paraquat. Barang Fish Farm = *Salvinia* treated with Paraquat.
[2]Chemical cost including wetting agent.

TABLE 4. ECONOMICS OF CLEARANCE OF SUBMERSED WEEDS WITH AMMONIA.

Pond location	Area (ha)	Depth (m)	Biomass (kg/m²)	Dose (ppm N)	Chemical cost (Rs/ha)	Labor[1] (hr/ha)	Labor[2] cost (Rs/ha)	Control (%)	Maintenance cost (Rs/ha)	Total[3] cost
Kanika Pond Cuttack	0.03	1.2	*Hydrilla* (29)	16.2	591	233	155	93	510	1256
Kanika Pond Cuttack	0.04	1.2	*Hydrilla* (3.4)	19.0	690	100	67	83	183	940
Palace Pond Cuttack	0.23	0.6	*Cerato-phyllum* (4.5)	11.5	258	156	104	77	24	386

[1]Number of man hours required to treat 1 ha.
[2]Cost of labor used in treating 1 ha in Rs (1 US $ = Rs 8 approx.).
[3]Total cost calculated by adding chemical cost, cost of spraying and maintenance costs.

TABLE 5. COST OF CLEARANCE OF EMERGENT WEEDS BY CHEMICAL TREATMENT. PLANTS WERE ALL TREATED WITH 80% SODIUM SALT OR 40% AMINE FORMULATIONS OF 2,4-D, EXCEPT *Panicum*, WHICH WAS TREATED WITH 2,2- DICHLOROPROPIONIC ACID.

Location	Area (ha)	Weed species	Dose (kg ai/ha)	Chemical cost (Rs/ha)	Labor[1] (hr/ha)	Labor[2] cost (Rs/ha)	Control (%)	Mainten-ance[3] labor (hr/ha)	Maintenance cost (Rs/ha)	Total[4] cost (Rs/ha)
Kanori Tank Cuttack	0.75	*Nymphaea*	9	175	27	18	100	0	0	203
Kanori Tank Cuttack	1.3	*Nelumbo*	6	117	140	93	100	0	0	210
Patnaik Tank Cuttack	0.8	*Nelumbo* and *Ipomoea*	5	153	40	27	100	0	0	180
Patnaik Tank Cuttack	0.5	*Panicum*	9	292	260	173	70	0	0	465
Chauduar Fish Farm	0.005	*Cyperus* sp. (old plants)	12	225	100	67	93	70	47	339
Chauduar Fish Farm	0.01	*Cyperus* sp. (young plants)	6	120	100	67	100	0	0	287

[1]Number of laborer hours required to spray 1 ha.
[2]Cost of labor for spraying 1 ha.
[3]Maintenance by picking up leftover plants.
[4]Total cost calculated by adding chemical cost, spraying and maintenance operations.

TABLE 6. LIST OF COMMON AND SCIENTIFIC NAMES OF AQUATIC PLANTS.

Common name	Scientific name
Waterhyacinth	*Eichhornia crassipes* (Mart.) Solms.
Water lettuce	*Pistia stratiotes* L.
Watermoss	*Salvinia cucullata* Roxb.
Water lilies	*Nymphaea nouchali* Burm.
"	*N. stellata* Willd.
"	*Nymphoides cristatum* (Roxb.) O. Kuntze.
"	*N. indicum* (L.) O. Kuntze.
Lotus	*Nelumbo nucifera* Gaertn.
Hydrilla	*Hydrilla verticillata* (L.f.) Royle
Bushy pondweed	*Najas graminea* Del.
None	*N. indica* (Willd.) Cham.
Coontail	*Ceratophyllum demersum* L.
Watermilfoil	*Myriophyllum spicatum* L.
Morning Glory	*Ipomoea carnea* Jacq.
Sedges	*Cyperus* spp.
Water grasses	*Panicum* spp.
Water spinach	*Ipomoea aquatica* Forsk.

operations are highest when the infestations are densest. Experience showed that after the first treatments, the maintenance costs are much less in subsequent years. In the case of watermilfoil it was reported (2) that there was a progressive reduction in the regrowth from 50 to 75 percent and near elimination after the third clearance. A single herbicide treatment may reduce aquatic weed growth to a point when a new species also can establish itself and develop into a weed problem unless continuous control is exerted. Single application costs, without follow-up and maintenance operations, were found to increase cost two-fold, because large quantities of chemicals were needed to obtain control, and more money was also spent on labor within a short time. This phenomenon has been reported in other countries also (3).

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