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# Biological based chemical integration for early control of water hyacinth

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## ABSTRACT

Water hyacinth (*Eichhornia crassipes*) is the most gregariously growing aquatic weed of India. An attempt was made to control water hyacinth from a village pond of about one hectare through integration of herbicides and bio-agents. One thousand bioagent weevils of *Neochetina* spp. were released as initial inoculation in the pond over an area of 3000 $m^2$ for further population build up. Three herbicides namely 2,4-D (1.5 and 2.0 kg/ha), glyphosate (2.0 and 2.5 kg/ha) and paraquat (0.7 and 1.0 kg/ha) were applied in adjoining area after 15 days of bioagent inoculation in an area of 10 x30 $m^2$ in three replicates for each dose. Population samples of water hyacinth and bioagent were taken after spray and release, respectively. On appearing new growth of water hyacinth in treated area, 15% of the total pond was again sprayed with the herbicides after 6 months. 2,4-D (2.0 kg/ha) proved the best herbicide to control water hyacinth (98.20 %) followed by glyphosate 2.5 kg/ha (95.85 %) and paraquat 1.0 kg/ha (93.48 %). After initial control, highest regrowth was recorded in paraquat treated replications followed by 2,4-D and glyphosate. Population sampling of bioagants revealed spread and increase in number of the weevil in the entire pond. Bioagents also invaded re-growth rapidly resulted after herbicide spray. *Neochetina* spp. adult population was found increased in the adjoining area treated with herbicides. After 9 months of biological and chemical integration, the first cycle of complete control was achieved. This early collapse of weed within a period of 9 month could be possible due to integration of herbicide and bioagents which would otherwise have taken minimum 24-36 month by the bioagents alone. After some time, again water hyacienth population increased due to new germination from buried seeds or from the left stolons of water hyacinth. This second wave of water hyacinth was again collapsed in 21 months due to integration of one spray of herbicides after one month of regrowth.

**Key words :** Water hyacienth, Aquatic weed, Integrated management, Biological control, Chemical control.

Water hyacinth (*Eichhornia crassipes*), originated in South America is the most gregariously growing aquatic weed in five tropical and sub-tropical nations of the world including India. It was introduced in India first time in West Bengal in 1889 as an ornamental plant and by now it has been recorded from all types of water bodies like ponds, canals and drainage in most of the cities and villages including major river systems - Brahmaputra, Cauvery, Ganges *etc.* in India. The rapid spread is due to its capacity to reproduce fast by vegetative and sexual methods. The seeds of water hyacinth are reported to remain viable for as long as 20 years. Under ideal conditions water hyacinth plants can double their number in 10 days (Gopal and Sharma 1981). Water hyacinth is well documented for its ability to evaporate water rapidly through transpiration besides causing tremendous loss to fish production and hydral electricity. Study in Egypt showed the actual loss of water through evapotrans-piration from water hyacinth was 1.22 $Cm^3/Cm^2$/day. Hence, control of this weed has received prime attention by the planners and government.

Manual or mechanical methods of its control are not cost effective. Use of herbicides is effective and economical but may have potential risks on non-target organisms and water quality. The insect bioagents *Neochetina bruchi* and *N. eichhoornae* commonly called *Neochetina* spp. are known biological control agents which have cleared water hyacinth from many aquatic bodies in India (Jayanth 1988, Sushilkumar and Varshney 2007, Varshney *et al.* 2007, Ramchandraprasad *et al.* 2010). Biological control is cost effective, self-sustaining and eco-friendly but take long time (20-36 month after the inoculation of bioagent) to control one cycle of water hyacinth (Sushilkumar 2004). Integration of the fungal pathogen *Cercospora rodmanii* with natural populations of arthropods (mainly *N. eichhorniae* and *N. bruchi*) appeared to provide complete control of *E. crassipes*, while combinations of *C. rodmanii* with low rates of 2,4-D and diquat showed a degree of compatibility which merited further study (Charudattan 1986). Haag *et al*., (1988) also studied the effects of two different patterns of applying 6.7 kg glyphosate/ha on *E. crassipes* regrowth and on water hyacinth weevil (*N. eichhorniae and N. bruchi*) population dynamics. Haag (1986) also found integration of bioagents and herbicide effective to control water hyacinth in a pond in Florida. The pond in the village in the present study was a source of water for day-to-day need of villagers and used to dry rapidly in the summer season due to the presence of water hyacinth. Therefore, an attempt was made to control water hyacinth in the village pond of about one hectare size through the integration of herbicides and bio-agents to reduce the time taken by the bioagents and chemical load in the aquatic environment if used alone. It will add to have knowledge for the time taken by the bioagents alone to control water hyacinth, justifying need of biological based integrated management of water hyacinth.

## MATERIALS AND METHODS

About 1000 weevils of *Neochetina* spp. were released over an area of 3000 $m^2$ in an one-hectare pond of a village of Jabalpur (Madhya Pradesh), severely infested with water hyacinth for more than 20 years. The whole pond was so densely covered by the mat of water hyacinth that water was not visible form outside. The inoculated area was marked by thermocoal pads inserted in the nylon rope. To evaluate the effective herbicide, two doses of each herbicides *viz.*, 2,4-D (1.5 and 2.0 kg/ha), glyphosate (2.0 and 2.5 kg/ha) and paraquat (0.7 and 1.0 kg/ha) were applied in other left area in three replication. In control, only water was sprayed. In each replication, 10x30 $m^2$ area was sprayed leaving a minimum buffer of about 2.5 meter width from each other. Subsequently, only higher doses of above herbicides were applied on re-growth and new growth as un-replicated way in 5x100 $m^2$ area at six-month interval, covering about 15% area of the pond, respectively.

Population samples of water hyacinth were taken with the help of 1$m^2$ quadrate after herbicide spray at 7, 14 and 21 days interval for all the doses and after one month interval for subsequently sprayed higher doses and per cent control was calculated. The population of weevil was counted quarterly by sampling 25 water hyacinth plants selected at randomly covering entire pond along with the observations on the status of water hyacinth damage caused by the bioagents. To see the impact in long terms, population samples of water hyacinth were also taken at randomly at quarterly interval from five places with the help of 1$m^2$ quadrate, covering entire pond along with observations on number of floweres/$m^2$, average plant height, leaf length and width and dry weight/plant (n=25). The villagers were advised not to use water of the pond at least for one week after herbicide spray.

## RESULTS AND DISUCSSION

2,4-D 2.0 kg/ha proved the best herbicide to control water hyacinth at 21 days after treatment (DAT) while glyphosate and paraquat were at par with each other (Table 1). The pond was again fully infested after three months of herbicides spray due to re-growth, which was highest in paraquat treated area, followed by 2,4-D and glyphosate.

Meanwhile, signs of establishment of bioagents were found and sampling revealed spread and increase in the population of bioagents in the entire pond. Bioagents also invaded re-growth resulted after herbicide spray. Water hyacinth started to show die back symptoms by six months of bioagents inoculation, which was an indication of the good biotic pressure on water hyacinth by the weevils. After 6 month of release, the adult and grubs of *Neochetina* spp. were recorded about 9 and 5 per plant, respectively. *Neochetina* adult population was also found increased in the adjoining area treated with herbicides in December. This increase in number of weevil/plant exerted more damage on water hyacinth adjoining to the chemical treated area. First and second cycle of collapse of water hyacinth was observed within a period of 9 and 21 month, respectively (Table 2). There was drastic decrease in flower production in second (flush) of growth, which reduced to about two flower/$m^2$ from initial 15/$m^2$. Like wise, there was decrease in height of plant, dry weight and length and width of leaves.

The achieving of two cycles of control of water hyacinth within a period of 21 months after initial release of weevils could be possible due to integration of herbicide with the bioagents, which would otherwise have taken minimum 20-36 month by the bioagents alone to control one cycle of water hyacinth. This integrated approach drastically reduced the herbicide load in the aquatic environment as well as helped tremendously to conserve the water in the pond.

The integration of weevils and growth retardant paclobutrazol have also resulted complete control of water hyacinths regardless of plant densities. The combined effects were synergistic, with accelerated leaf mortality rates exceeding production rates leading to early plant death (Van and Center 1994). Haag and Haback (1991) have demonstrated the potential for increasing effectiveness of water hyacinth weevils using integrated approach in Florida where 80% of Calf Pond, a 6-ha lake in Florida, was sprayed every 3-4 weeks with 2.2 kg/ha

**Table 1. Effect of different treatment of herbicides on control (%) of water hyacinth**

| Herbicides | Dose (Kg/ha) | Water hyacinth population/m$^2$ at different DAT | | | Control (%) at different DAT | | |
|---|---|---|---|---|---|---|---|
| | | 7 | 14 | 21 | 7 | 14 | 21 |
| 2,4-D | 1.5 | 5.9 (34.7) | 4.7 (22.66) | 2.4 (6.6) | 49.9 (58.4) | 70.0 (87.9) | 80.6 (97.0) |
| | 2.0 | 5.3 (28.0) | 3.5 (12.0) | 1.7 (4.0) | 54.7 (66.4) | 75.4 (93.6) | 82.8 (98.2) |
| Glyphosate | 2.0 | 6.9 (48.0) | 4.1 (17.3) | 3.8 (14.7) | 40.6 (42.4) | 72.6 (90.7) | 75.44 (93.5) |
| | 2.5 | 6.5 (41.3) | 2.9 (8.0) | 3.1 (9.3) | 45.22 (50.4) | 78.3 (95.7) | 78.3 (95.9) |
| Paraquat | 0.75 | 7.2 (52.0) | 6.8 (45.3) | 3.9 (16.0) | 37.8 (37.6) | 60.5 (75.7) | 75.0 (92.9) |
| | 1.0 | 6.3 (40.0) | 6.0 (36.0) | 3.8 (14.7) | 46.2 (52.0) | 64.0 (80.7) | 75.6 (93.5) |
| Control | - | 9.1 (83.3) | 13.6 (186.7) | 15.00 (225.3) | - | - | - |
| LSD (P=0.05) | | 1.0 | 1.4 | 1.6 | 7.8 | 4.9 | 6.0 |

Figures in parentheses represents original value; DAT - Date after treatment

**Table 2. Average *Neochtina* spp. population/plant at quarterly interval with the status of water hyacinth after initial release in the pond**

| Month after release | Population of *Neochetina* spp. | | Status of water hyacinth in the pond |
|---|---|---|---|
| | Adult/ plant | Larvae/ plant | |
| 3 | 1.7 | 4.3 | No visual impact |
| 6 | 8.7 | 5.1 | Heavy biting scars on leaves started indicating impact of bioagent |
| 9 | 1.4 | 4.1 | Complete drying of leaves and petioles, only small portions of plant, severely damaged by the bioagents below the water surface; re-growth and fresh germination started amidst the dried plant. **Collapse of first cycle** |
| 12 | 6.5 | 7.4 | 3 month old re -growth and new growth of second wave, only scars on the leaves but no die back symptoms. |
| 15 | 7.4 | 3.7 | 6 months old second wave growth, no die back symptoms but heavy biting scars of weevils on leaves |
| 18 | | | Drying of upper portion started indicating severe damage by bioagents |
| 21 | 6.0 | 5.6 | Collapse of second cycle |

of 2,4-D to reduce surface cover of water hyacinth and therefore to enhance the water hyacinth weevil population increasing the biocontrol potential of these insects. Untreated plants were surrounded by a floating barrier along one shore and left to serve as a reservoir for the weevils; present at an initial mean density of 3.2 adult weevils/m$^2$. Weevil production in Oct. 1986 raised the weevil density to 3 times that observed in Oct. 1985 and the number of feeding scars was twice that observed in Dec. 1985. The resultant heavy feeding damage reduced plant density and biomass severely and by Apr. 1987, no live water hyacinth plants remained in the lake. In the present study also, there was increase in population of *Neochetina* spp. after herbicide spray which resulted early control of water hyacinth. Wright and Bourne (1990) reported that application of 2,4-D at 0.5-2.0 kg/ha against water hyacinth resulted in changes in plant quality including decreased leaf hardness and increased N content. These changes in quality of leaf increased the weed's biological control agents, the pyralid *Sameodes albiguttalis* and the curculionids *N. eichhorniae* and *N. bruchi*.

Haag *et al.* (1988) found that in the 1$^{st}$ treatment, after half the weed mat had been sprayed, heavy insect feeding damage caused a total decline of the weed population. In the 2$^{nd}$ treatment, after half the weed mat was sprayed, the infestation was left with a long boundary area along with daughter plants. In these ponds, the plant population rapidly expanded to fill available open water. Plant growth rate surpassed the weevil population rate of increase, and insect feeding damage was not sufficient to control the weed mats.

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