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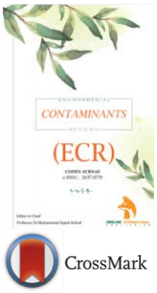

REVIEW ARTICLE

BIOLOGICAL CONTROL OF WATER HYACINTH

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ABSTRACT

Water hyacinth (*Eichhornia crassipes*) is a floating aquatic weed and native of Amazon River. Water hyacinth is one of the fastest growing plants they primarily reproduce from runners or stolons. Each plant of *E. crassipes* can produce thousands of seeds each year and these seeds can remain viable for more than 28 years. Water hyacinth caused water loss through evapotranspiration which is more significant than indigenous weeds. Water hyacinth caused many problems in canals, ponds, lakes, rivers likes they are blocking of canals and causing floods, reduction of water quality, oxygen depletion, increased evapotranspiration rate, fish production problems, the beauty of ponds and effects on human health. Controlling methods of water hyacinth includes physical, chemical and biological but the biological method is effective and environment friendly. *Neochetina bruchi*, *N. eichhorniae*, and water hyacinth borer (*Sameodes albiguttalis)* are found effective biological control on water hyacinth. These weevils are feed on water hyacinth and reducing the size of water hyacinth, its vegetative propagation, and seed production. Semi-aquatic grasshopper *Cornops aquaticum* is also found effective control on water hyacinth.

KEYWORDS

Water hyacinth, Characteristics, Physical, Chemical and Biological control.

1. INTRODUCTION

Water hyacinth (*Eichhornia crassipes* (Mart.) Solms.) is a floating aquatic weed which is the most invasive species in the world. Water hyacinth is a native of Amazon River where it's become an extremely serious weed. Water hyacinth has a rapid propagation and morphological characteristics that makes well adaptation of this weed in rapid distance dispersal and successful colonization in a short time (Obeid, 1984). Water hyacinth is also known as one of the fastest growing plants they primarily reproduces from way of runners or stolons, which eventually form daughter plants. Each plant can produce thousands of seeds each year, and these seeds can remain viable for more than 28 years (Sullivan, 2012). Some species of water hyacinth are found to grow between 2 to 5 meters (7 and 16 feet) in a day in some sites of Southeast Asia (Gopal, 1987). A scientist reported that the nature of common water hyacinth (*Eichhornia crassipes*) are vigorous growers and they double their mat size within one to two weeks (Dickinson, 2014). *E. crassipes* caused water loss through evapotranspiration which is higher than indigenous weeds. In Sudan total annual loss caused by *E. crassipes* was calculated to be 7 milliards m^3, taking the total area infested by *E. crassipes* in the country to be 3000 km^2 (Desougi and Obeid, 1978).

Water hyacinth decreased the productivity of the river by blocking the light from penetrating the river water, which changes in the flora and fauna underneath, decrease fish production and caused eutrophication under growing mats therefore water quality is also affected. It also helps increasing health hazards that is incidence of malaria and schistosomiasis (Navarro and George Phiri 2000). Water hyacinth creates many problems in canals, ponds, lakes, rivers likes they are blocking of canals and causing floods, creates problems for water transport, reduction of biodiversity, reduction of water quality, oxygen depletion, creates breeding grounds for insects and vectors, increased evapotranspiration rate, fish production problems and effects on human health.

2. CHARACTERISTICS AND GEOGRAPHICAL DISTRIBUTION OF WATER HYACINTH

According to (Gopal, 1987) water hyacinth has the following systematic, developmental, morphological, ecological and biological characteristics (Gopal, 1987). A) The average size of water hyacinth is 40 cm but it can reach up to 1 m in height and it has a high rate of multiplication and vegetative reproduction. B) The seeds remain viable for long periods up to 15 years and no known natural enemies for seeds. C) The stems and leaves of water hyacinth contain air-filled which gives to the plant. D) It grows in mats up to 2 m thick and double its plants population in 15-18 days by asexual vegetative reproduction. E) Each mother plants of water hyacinth produces 4 daughter plants that are capable for reproduction after 2 weeks. F) When the plant of water hyacinth is matured it consists of pendants roots, stolons, rhizomes, inflorescences and fruit clusters. Water hyacinth is found all parts of the tropical and subtropical regions of the world. It is initially originated from the Amazon Basin in tropical South America. Due to human and animals' activities it's enter in Africa, Asia, India, Australia, Central America North America (California and southern states) and New Zealand (Dagno, 2012).

In 1879, water hyacinth was first recorded in Egypt and later found in Incomati River in Mozambique in 1946 then Zambezi River and some rivers in Ethiopia in 1956. Introduction and spread of water hyacinth have been affected in many parts of Africa. In Zimbabwe the weed was first observed in 1937 in water bodies around Harare (Chenje, 1998; Mujingni, 2012). Climate change is a significant problem for distribution of water hyacinth. The pH requires for plant growth is neutral but it can tolerate in

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4 to 10 pH values. It requires 28-30^0 C water temperature and 21-30^0 C air temperature for growth. The water temperature between 27-33^0 C can doubles the plant population in two weeks (Center, 2002). The limiting factor for undisturbed growth of water hyacinth is low air humidity from 15% to 40%. Water hyacinth is tolerates drought because it can survive in moist sediments up to several months (Center, 2002). In coastal areas, salinity is the main obstacle for growth of water hyacinth (Evans, 1963; De Groote, 2003).

2.1 Control methods

The control method of water hyacinth includes various options but in this paper physical, chemical and biological control methods are described.

2.2 Physical method

Manual extraction is more effective than chemical and biological methods for removal of water hyacinth but manual removal of water hyacinth is suitable only for small area. Manual removal is difficult in large area because it's required more labor for the removal of water hyacinth and in some area presence of aquatic animals such as snake, crocodiles are serious risks for the labor. Labors are also requiring water-based vehicles (eg- boat, stimmer) for removal of water hyacinth and also require land-based vehicles for transport the vast quantities of water hyacinth which is removed from that area. The advantages of manual removal of water hyacinth are environmentally friendly, useful only for small areas, complete removal of water hyacinth and disadvantages are required high cost, more labor, problematic to dispose the weed.

2.3 Chemical control

Spraying of chemical herbicides such as Bispyribac, Diquat, Glyphosate, Imazamox, Imazapyr, Penoxsulam, Triclopyr, 2,4-D and Florpyrauxifen-benzyl are found more effective in reduction of water hyacinth. Bispyribac, Glyphosate, Imazamox, Imazapyr, Penoxsulam, Triclopyr, 2,4-D and Florpyrauxifen-benzyl are systemic herbicide and they are absorbed by green parts of the plant and move within the plant to site of action. Diquat is contact herbicide and its act quickly as compare to systemic herbicide. (Villamagna and Murphy, 2010) reported that Paraquat, Diquat, Glyphosate, Amitrole, 2, 4-D acid are more effective in reducing the water hyacinth plant. Chemical control is found more harmful for the micro-organisms and other non-target plants that provide habitat for other organisms. It's also effects to the fish production.

2.4 Biological control

The biological control method is environmentally safe solution, cost-effective, beneficial for the aquatic animals and plants. In 1970, three species of weevil were released by USDA (United States Department of Agriculture) researcher in United States. These species are *Neochetina bruchi*, *N. eichhorniae*, and water hyacinth borer *Sameodes albiguttalis* and they feed on water hyacinth. These weevil species were introduced into the Gulf Coast states, such as Louisiana, Texas, and Florida, where thousands of acres area was infested by water hyacinth. In 1980, it was found that 33% of water hyacinth mats are decreased. The main limitation on the use of biological predation on water hyacinth is life cycle of the weevils. The life cycle of weevils is ninety days (Sanders, 2014). These weevils are regulating water hyacinth by limiting size of water hyacinth, its vegetative propagation, and seed production and they are also carrying microorganisms that can be pathological to the water hyacinth. These weevils feed on stem tissue of the water hyacinth, which results in a loss of buoyancy for the plant, which will eventually sink (Jiménez, 2014).

The adults of these weevil's attack on water hyacinth and feed on the leaf pseudolamina and petioles by removing tissues and the larvae tunnel inside the petioles and the crown. The optimum temperature required for feeding and development of both species is 25° C. The progeny of *N. bruchi* and *N. eichhorniae* are reared separately for a period of 61 days (one generation period) on 41 hyacinth plants then results found that they reduced their population growth by 25.4% and 12.7% respectively. According to a report of Sudan 1979, found that the growth of the plants reduced by 22.5% when progeny of *N. bruchi* and *N. eichhorniae* are mixed cultured and control the population of the plants is increased by 136.6%. Stocking of hyacinth plants with adults and larvae of both species separately found that *N. bruchi* is more efficient from *N. eichhorniae* in checking the growth of the plant (Bashir, 1984).

Semi-aquatic grasshopper *Cornops aquaticum* is also considered as a biological control agent. Grasshopper has been introduced into South Africa in controlled trials and this insect is specific to the water hyacinth and its family. This insect feed on the water hyacinth and it introduces a secondary pathogenic infestation (Amédégnato, 2008). A researcher considered biological agents into 3 groups in his research work according the priority of these agents (Cordo, 2016). He considered first priority for screening agents, second priority for recently release or under testing agents and third priority for poorly known agents. He considered *N. eichhorniae, N. bruchi, N. albiguttalis* and *O. terebrantis* in first priority, *E. catarinensis, X. infusella, C. aquaticum, B. densa, P. tenuis* and *Thrypticus* spp. in second priority and *Brachinus* sp*, A. subornata, M. acuminata, T. inexacta, M. electrae, E. setigena, C. falvipilus, Hydrellia* sp. and *F. eichhorniae* are in third priority. Studies were also made in the Sudan to test microorganisms pathogenic to water hyacinth for biological control purposes. In field studies *Alternaria eichhorniae* was reported to cause 100% kill in combination with *N. bruchi* and *N. eichhorniae* (El Tayeb, 1992).

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