# Water hyacinth (*Eichhornia crassipes* (Mart.) Solms) seed longevity and the implications for management

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**Summary** Water hyacinth, *Eichhornia crassipes* (Mart.) Solms, is a highly invasive weed that has degraded aquatic ecosystems in many tropical, subtropical and warm temperate regions of the world causing environmental and cultural problems. It grows rapidly and one plant can produce thousands of long-lived seeds. New infestations are established by movement of seed and daughter plants that are produced at the apices of stolons.

Previous case studies found water hyacinth seeds can remain viable for up to 20 years. This paper provides anecdotal evidence from a case study that the longevity of water hyacinth seeds in the field can exceed 28 years. We discuss the implications this has on long term management and control of water hyacinth and how dormancy may be broken to facilitate control.

**Keywords** Water hyacinth, *Eichhornia crassipes,* seed viability, seed longevity, seed dormancy.

## INTRODUCTION

Water hyacinth, *Eichhornia crassipes* (Mart.) Solms is a free floating perennial aquatic plant, native to Amazonia, Brazil (Wright and Purcell 1995). It has spread throughout the tropical, subtropical and warm temperate regions of the world and caused environmental and cultural problems (Wright and Purcell 1995, Centre *et al*. 2002). Water hyacinth forms dense impenetrable mats across water surfaces that greatly decrease biodiversity. It degrades water quality and limits access by humans, machinery, animals and birds (Centre *et al*. 2002). Water hyacinth also has a large evapo-transpiration rate losing water into the atmosphere at up to six times that lost by open water (Pieterse 1978).

Water hyacinth reproduces by both stolons and seed. Its productivity is one of the highest for photosynthetic organisms (Pieterse 1978). It has rapid growth rates with plant doubling times varying from 5 days (Perkins 1973) to 11–15 days (Penfound and Earle 1948). Vegetative propagation is the most common mode for spread but seeds can also be a source of new infestations or re-infestation (Pieterse 1978). Up to 3000 seeds can be produced per inflorescence with each rosette being capable of producing several inflorescences per year (Barrett 1980). Seeds remained viable for 20 years in New Zealand (Matthews *et al.* 1977).

Biological control is often the preferred control method although successful biological control is slow commonly taking two to six years in tropical and subtropical countries where water hyacinth cover was commonly reduced by 55 to 95% (Julien *et al.* 1999, Julien 2012).

Chemical and mechanical control measures have been used for water hyacinth control since the early 1900s, but they are expensive and often ineffective on all but small infestations (Julien *et al*. 1999). However chemical and mechanical controls are still used on some larger infestations such as in the Gwydir wetlands in inland northern NSW where both methods were integrated. Here zero tolerance has been set to try and prevent movement of water hyacinth further down the Murray Darling basin, which remains uninfested downstream of the Gwydir wetlands (Sullivan and Blackmore 2009).

Eradication of water hyacinth is difficult because of its rapid growth rate and its ability to reinfest from long-lived seeds.

## BACKGROUND

Conditions required for germination of water hyacinth seeds have been studied for over 100 years (Obeid and Tag el Seed 1976). Various, and sometimes conflicting requirements have been promoted with some reports suggesting drying of seeds and subsequent rupturing of the seed coat as being necessary (Obeid and Tag el Seed 1976). Parija (1934) said that the seed coat acts as a physical barrier to germination. He used various treatments to rupture or soften the seed coat and had 100% germination when the micropylar end of the seed was removed. Robertson and Thein (1932) reported that germination was governed by alternate wetting and drying, while Haigh (1936) reported that high temperatures and/or intense light induced germination. Hitchcock *et al.* (1949) agreed with Haigh and found that shallow water temperatures of 28–36°C gave 100% germination. Hitchcock *et al.* (1949) also found better germination of seeds stored wet rather than dry. Obeid and Tag el Seed (1976) showed that shallow water depth, clay soils, high organic matter and light all enhanced germination as did wetting, drying and rewetting the seeds. They also found that after 12 months, 98% of wet-stored seeds germinated compared with 35% of dry stored seeds. Manson and Manson (1958) found that seeds could germinate on damp soil or on rafts of partly decomposed water hyacinth. Das (1969) found that submerged seeds did not germinate unless they were aerated.

## HISTORY OF WATER HYACINTH IN DOWSE LAGOON

Dowse Lagoon (Figure 1) is a small 15 ha lagoon in Sandgate, a northern suburb of metropolitan Brisbane, Australia.

A flowering water hyacinth infestation was discovered in Dowse Lagoon in November 1976. All water hyacinth plants were sprayed and killed in December 1976 with a mixture of 2,4-D (500 g $L^{-1}$ low odour formulation at 2.0 L $ha^{-1}$), diquat (at 1.25 L $ha^{-1}$) and a wetting agent (at 1.75 L $ha^{-1}$). A small number of water hyacinth plants germinated in October 1977 in the same area of the lagoon. These plants were sprayed with the same herbicide mixture and all died before flowering.

Brisbane City Council Officers have regularly monitored Dowse Lagoon for water hyacinth germination since 1976. The lagoon continued to hold water from 1976 until it completely dried out during the drought of 2004. No water hyacinth plants were detected in the lagoon between October 1977 and the 2004 drought.

High rainfall during the summer of 2004/2005 resulted in the lagoon filling to a depth of about 300 mm. During March 2005 thousands of water hyacinth seeds germinated in Dowse Lagoon in the same area as the initial infestation. These new plants were destroyed through mechanical removal (Truxor® amphibious harvester) and follow up spraying (glyphosate 360 g $L^{-1}$ at 9.0 L $ha^{-1}$ with an air-entrainment nozzle) before they could flower and set seed.

After 2005 the lagoon began to slowly dry out and in 2007 it was once again completely dry. The lagoon refilled in 2009 and has remained full until the present time (May 2012). There have been no water hyacinth germinations in Dowse Lagoon since 2005. Due to the above circumstances it is likely that water hyacinth seeds were last produced in Dowse Lagoon in December 1976.


**Figure 1.** Dowse Lagoon, Brisbane, Queensland on 16/6/2009. (Image © 2012 Sinclair, Knight, Merz & Fugro).

## DISCUSSION

The question that needs to be asked is whether it is possible that seeds leading to the 2005 germination could have come from any source other than from the 1976 seed set.

Dowse Lagoon lies within a highly urbanised and tiny catchment with no other known water hyacinth infestations and the lagoon is only recharged from local storm water. Dowse Lagoon has no connectivity to watercourses in adjoining catchments as nearby water bodies are separated by significant topographic barriers that are never breached even in times of flood. Therefore water hyacinth seeds that germinated in 2005 are unlikely to have washed down from within the catchment nor come from adjoining catchments.

In 2005 many thousands of seeds germinated and this would have required a large seed bank. Also the 2005 germinations occurred in the same area of the lagoon as the 1976 infestation.

These facts imply that seeds for the 2005 germinations came from the seed bank deposited by the 1976 infestation and that the seeds remained dormant under conditions that prevailed in Dowse Lagoon from 1977 until dormancy was broken in 2005.

Dormancy of the seeds may have been broken when the lagoon and mud surrounding the seeds dried out followed by a refilling of the lagoon. This agrees with the findings of Matthews (1967) who found that seeds that fall to the bottom of a pond will not germinate until the water recedes allowing the seeds to dry. During the summer of 2004–2005, the seeds would also have been exposed to higher temperatures and increased light radiation. These conditions also agree with many of the different factors found to contribute to water hyacinth germination. The seeds would have experienced desiccation (Obeid and Tag el Seed 1976), alternate wetting and drying (Robertson and Thein 1932), exposure to high temperatures and light (Haigh 1936, Hitchcock *et al*. 1949) and availability of oxygen (Das 1969), and they germinated in shallow water (Obeid and Tag el Seed 1976). The events that led to germination in Dowse Lagoon were similar to what Matthews (1971) found in New Zealand. He suggested that germination usually occurred between January and March when water levels recede exposing the seeds to desiccation. Temperatures and light intensity would also have been greater between January and March than at other times in New Zealand and germination occurred after rainfall inferring shallow water at some point in time.

Hitchcock *et al*. (1949) found better germination of seeds that were kept wet after collection while Obeid and Tag el Seed (1976) found much higher germination of seeds that were stored in wet conditions (98.3%) when compared to those that were stored in dry conditions (35%). One possible reason for higher germination is that wet stored seeds have a much slower death rate and this case study supports this suggestion. If the 2005 germination in Dowse Lagoon was from seeds set in 1976 then these 'wet stored' seeds were kept under water for 27 years, remained viable and germinated after 28 years.

## MANAGEMENT IMPLICATIONS

It is not clear which combinations of seed desiccation, alternate wetting and drying, shallow water, oxidation, higher temperatures and/or increased light radiation were responsible for breaking of seed dormancy and subsequent germination when Dowse Lagoon dried out.

Such hydrological factors can be utilised for water hyacinth management providing water at a site can be drained or drawn down to expose the seed bed and allow it to dry out. This will break seed dormancy, promote germination and reduce the seed bank. This method could easily be used for the management of water hyacinth in small farm dams and for management of larger sites like the Gwydir Wetlands where water inflows can be controlled. The Gwydir Wetlands receive 'environmental flows' from Copeton Dam and water could be held back and used judiciously for germination and treatment of water hyacinth.

If this method is employed, surveillance will need to be carried out regularly with quick treatment of any reinfestation. Timing of activities is critical to prevent seed set.

An additional benefit of drying infestations is that seeds continue to lose viability the longer that they remain dry. Obeid and Tag el Seed (1976) showed that after 12 months, only 35% of dry stored seeds germinated and Barton and Hotchkiss (1951) showed that water hyacinth seeds stored dry for three years failed to germinate.

Longevity of submerged water hyacinth seeds in the field has management implications that require long term surveillance, in this case for at least 28 years. Brisbane City Council has a policy of indefinite routine inspection of all known infestations. It is not known how long seeds remain viable when kept under water but because of the mass germination in Dowse Lagoon 28 years after seeds were set, it is suggested that longevity of water hyacinth seeds could greatly exceed 28 years when seeds remain submersed.

There was no germination of water hyacinth when the lagoon began to refill in 2009. Is it possible that all viable water hyacinth seeds germinated in 2005 and that there are no longer any viable water hyacinth seeds in Dowse Lagoon?

This case study shows that seeds of water hyacinth can remain viable for up to 28 years when kept under water in conditions similar to those that prevailed in Dowse Lagoon between 1976 and 2005. Some seeds germinated after one year but many seeds remained dormant until the lagoon dried out in 2004 and refilled in 2005. Dormancy of the seeds was broken when the lagoon dried out and this information can be utilised to help manage water hyacinth infestations.

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