INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 13, No. 1, p. 1-9, 2018
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

# Effect of sowing dates on germination of common water hyacinth (*Eichhornia crassipes* mart) solms in central Iraq

**Adnan Hussein Alwakgga[1], Agha Mushtaque Ahmed*[2]**

[1]*University of Diyala, College of Agriculture, Diyala, Iraq*

[2]*Department of Entomology, Faculty of Crop Protection, Sindh Agriculture University, Tando Jam, Sindh, Pakistan*

Article published on July 24, 2018

**Key words:** Sowing dates, Water Hyacinth, Seed germination

**Abstract**

Keeping in view, the importance of water Hyacinth *(Eichhornia crassipes* Mart.)Solms in reducing the biological diversity, this research was aimed to determine the seed germination percentage in suitable environmental condition in order to stop its further extension to improve the long-term management particularly in Diyala province. This study included the identification of the seed ability to germinate and the environmental circumstances affecting the propagation of the water Hyacinth plant by seed. Three sowing dates of different months for seed were selected (March, April and May). The experiment was designed with three replicates using the Randomized Complete Block Design. The results of the experiment indicated the seed germination average was 84% in general and germination occurred only at the temperature range of 28-35° C that went through three stages (Germination, floating and growth of the plant).The plant produced six to seven daughter plants within nine to eleven days after floating. The seed sown on the 20$^{th}$ of March (the first date) needed 43 days to germinate. The percentage of time saving of the floating time laps in the third sowing reached 44.54%. The seed sown on the 20$^{th}$ of March provided advanced plant height 13.2cm.The third seed sowing date of the 20$^{th}$ of May showed higher root length 25.45cm. Leaf area indicated 1.743 m$^2$ in the third seed sowing. Green plant weight as the first seed sowing date reached 4775.2gm/m$^2$. The present information will be usefull to manage this invasive plant throughout the world.

***Corresponding Author:** Agha Mushtaque Ahmed ✉ adnan_alwakaa2003@yahoo.com

## Introduction

The water Hyacinth *(Eichhornia crassipes* Mart.) Solmsbelongs to family Pontederiaceae, order commelinalesis, one of the perennial aquatic plants originated from the Amazon water basin in Brazil (Center *et al.,* 2005). It has extent in over 50 countries of the world which are mainly located between latitudes of 39° North and 39° South (Martinetz and Gomez, 2007).

Its spread carried out through sexual and vegetative progression. A single inflorescence with 20 flowers can produce up to 3000 seeds and then variable number of seeds per square meter of vegetation range from 400 to 3400 sqm depending on the sampling site and time of year further spread (Pieterse and Murphy, 1993). Furthermore, these plants have an ability to keep their viability for more than 20 years in moist environment and up to six months in dry conditions (Barrett, 1989).

The seeds of the water Hyacinth need a dormancy period even at the presence of favorable germination *conditions* which can be broken by wetting, drying and re-wetting (Baskin et al., 2003). Most seeds may fail to germinate due to the lack of suitable germination conditions or due to the failure of pollination that relies mainly upon the activity of the bees.

The lack of moisture may cause the loss of germinating seedlings and the absence of suitable temperature causes the failure of seed germination varied from 10% to 100% (Oki and Ueki, 1979; Orapa and Julien, 1999). Apart from temperature, the most important factors which influence the germination of water Hyacinth seed are depth of water and the availability of oxygen (Toy, 2005).

The seedling has the potential of occupying an area of 20 times larger than the area occupied at the initial stage within four weeks (GIC, 2006). The seed may be considered as a new source of infestation or re-infestation of areas previously treated. Due to the adherence of the water Hyacinth seed to the mud and other sediments as well as to the feet and feathers of birds, it could be further relocated to other remote areas (Wilson *et al.,* 2005; GIC, 2006).

The flowering of the water Hyacinth extends to less than 15 days and at this stage, the flowering spike bends downwards, enters the water and releases the seed into the water (Oki and Ueki, 1979; Gopal, 1987). Each flowering spike may produce more than 14 capsules and each capsule may further yield 3 to 250 seeds (canter *et al.,* 2002). The lifetime of the flowers extends to one to two days and the production of seed requires one to two months to ripen and deliver the seed from the fruits (GIC, 2006). Wright and Purcell (1995) and Center *et al.* (2002) also mentioned that the seed of the water Hyacinth germinate as the green carpet decomposed at the availability of suitable moisture in the shallow and warm water.

In keeping the importance of water Hyacinth, this research was aimed to determine the seed germination percentage in suitable environmental condition and the spread of this dangerous weed in order to improve the long-term management particularly in Diyala province.

## Materials and methods

*Collection of seed*

A number of capsules (fruits) containing 150 to 420 seeds of common water Hyacinth were collected from the Jisr-Diyala site near Baghdad. Each spike contained three to eight fruits, meanwhile some of these fruits were not ripe but those already ripe were large in size.

*Sowing and germination of seeds*

The large and ripe fruits were selected (Fig. 1) for the experiment purpose during the month of October 2014. The fruits were wrapped with a piece of cloth and placed in water at the depth of 10 cm to 20 cm in order to pass through the dormancy period (Orapa and Julien, 1999). In the next consecutive year (2015) when the water temperature reached 19 °C to 22 °C, the seeds were spread in a plastic container (25 cm deep and 60 cm in diameter) which contained soil at the depth of 10 cm and sowing was performed for three different consective dates (20$^{th}$ of March, 20$^{th}$ of April and 20$^{th}$ of May) in order observe their effect on plant physical characters.

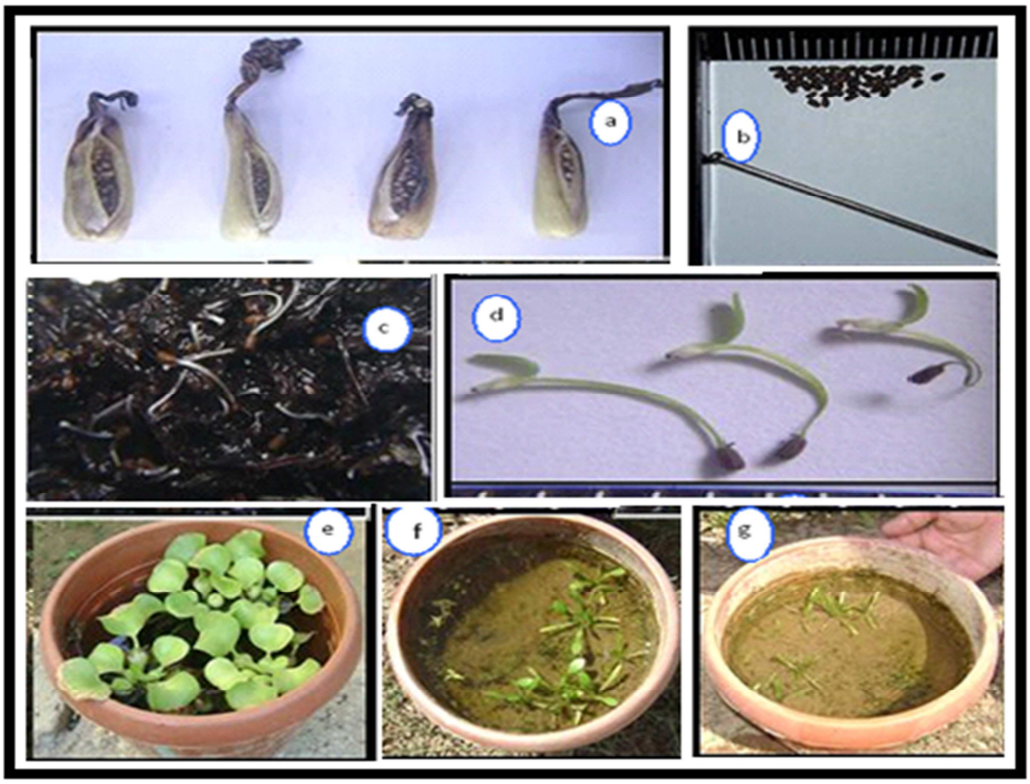


**Fig. 1.** Germination of water Hyacinth lant. a. The seed capsules b. The water Hyacinth seed c. Seed germination of the previous year d. The appearance of the primary cotyledon leaves e. Under-water seed germination f. The initial leaves and their quantities after germination g. The floating of the seedlings and the appearance of the air-bags at the base of leaves.

*Observation of plant characteristics*

After one month of seed germination, nine strong floating seedlings were selected and placed at a similar container as mentioned above and kept to grow for one month in order to allow them to develop and adopt the local environment. On the first of July 2015, every three plants were placed in their respective container. Each container represented an experimental unit.


**Fig. 2.** The embryonic development of water Hyacinth seed. a. The first stage of the seedling life and the clear appearance of the embryonic root b. The separation of the embryonic roots and the appearance of a brown to black colored layer showing the appearance of the permanent roots c. The floating sage of the seedling and the appearance of the thick, Permanent roots.

The plants were left in their respective containers until the time when they occupied the entire surface of their container. Subsequently, they were taken out of their containers and the measurements were taken such as Plant height (cm), the number of stalks in a square meter, the number of leaves in a square meter, the root length (cm), the leaf width/diameter (cm), the leaf area in a square meter, the wet weight in kilograms per square meter, the dry weight in kilograms per square meter, the time elapsed until occupying one-quarter square meter after seeding, the time period elapsed between seeding to germination and the time elapsed until noticing the first floating of the seedlings from the time of seeding.

The diameter average of ten leaves was taken and calculated by using the circle area equation ($A= \pi r^2$, where a=area and r= radius) then multiply the result by the number of leaves found in one square meter.

*Statistical analysis*

The experiment was applied according to Complete Randomized Block Design (RCBD) with three replicates. Five randomly selected plants were used from each replication and their averages were taken to make the above-mentioned measurements. All the collected data were statistical analysis using one way ANNOVA test through Statistical Analysis Software (SAS ver. 9.2) and the means were separated through Duncan Multi-Range Test for comparison at a probability level of 0.05.

**Results and discussion**

*Seed germination under water*

The embryonic rootlet appeared first followed by the little stem and the two cotyledon leaves as shown in (Fig. 2). The length of the germination process depended upon the surrounding conditions as indicated by the sowing Timings of this study. Germination did not occur at all without the availability of light and water or the needed moisture in addition to the suitable temperature of 24°C to 45°C. The seed, which was shaded by the thick green carpet of the mother plant, did not germinate. The water Hyacinth resumed its growth and eventual spreaded in the same location after a short period of time.

*Floating of seedlings*

This stage commenced as swellings appeared at the base of the primary leaves (two to five little leaves). Such swellings contained air, which helped the floating of the plant towards the water surface and moved to other locations as the water flows. At the same stage, the plants lose their embryonic rootlets, which hold the plant to the bottom of the water body. The length of these rootlets was between 12cm to 22cm and white in color (Fig. 2).

They disappeared six to eleven days after germination. A brown to black colored layer formed at the contact point between the embryonic rootlets and the seedling. The rootlet separated from the seedling as it floats towards the surface. This study showed that the water Hyacinth plant possesses a great ability to utilize all growth factors and adaptation with the surrounding environment. It was able to use all life supporting factors. It indicated in Fig.1 that the percentage of germination increased by the availability of the residues of plants from previous years. The water Hyacinth produced a thick green masses floating on the water, which led to the formation of thick organic matter on the water body floor because of the eventual aging, dying, sinking and decomposition of the plant.

**Table 1.** The influence of the seed sowing dates upon the different characteristics of plant.

| Seeding date | Plant height / cm | Root length / cm | Number of daughter plants/ $m^{-1}$ | Number of leaves/ $m^{-1}$ |
|---|---|---|---|---|
| 20/03/2015 | 13.2 a | 14.11 b | 184.44 a | 1305.9 b |
| 20/04/2015 | 10.7 b | 18.45 b | 194.44 ab | 1367.3 ab |
| 20/05/2015 | 11.4 b | 25.45 a | 160.77 b | 1496.9 a |

The values with similar letters do not differ significantly by the studied characteristics, given 5% probability.

This condition forms an ideal environment for seed germination. The cleared water surface after the sinking of the dying plants would allow the light to pierce through the water to the bottom of the water body, which provided good germination opportunity of the seed, which is located under the decomposed green matter. This result is in agreement with Gao *et al.* (1990) about the importance of the light as a seed-germination factor.

*Plant volume/growth of the plant*

As a result, the plant produced six to seven daughter plants within nine to eleven days after floating. This daughter plant may reach the height of more than 90cm. It is called here the second stage of the life of the plant as the stage of floating. It is the stage of the transformation of water Hyacinth seedlings onto mature plant characterized by the appearance of the fibrous roots and real leaves in addition to development of daughter plants and extensions. Germination rates also give an indication of how quickly habitats respond when optimum conditions occur (Riddin and Adams, 2009).

**Table 2.** The influence of the seed sowing dates upon different characteristics of the leaf.

| Seed sowing dates | Width of the leaf diameter/ cm | The leaf area of / $cm^2$ | Green weight $gm/m^2$ | Dry weight $gm/m^2$ |
|---|---|---|---|---|
| 20/03/2015 | 4.1 a | 0.758 b | 4775.42 a | 325.75 a |
| 20/04/2015 | 3.8 a | 1.468 a b | 4123.95 b | 216.41 a |
| 20/05/2015 | 4.16 a | 1.743 a | 4585.55 a b | 289.41 a |

The values with similar letters do not differ significantly by the studied characteristics, given 5% probability.

The above-mentioned stages of the water Hyacinth plant development from germination to the formation of the mature plant vary according to the date of germination or their environmental conditions.

*Length of germination times*

The results in regarding the length of the germination times (Fig. 1) indicated variation according to the date of seedlings. The seed sown on the 20th of March 2015 (the first date), needed 43 days to germinate; this represented nearly double the period took to germinate the seed sown on the third seeding date of the 20th of May 2015 which was 23 days. However, the seed sown on the 20th of April 2015 (the second group) needed 31 days to germinate. This indicated that the speed of seed germination increased as the water temperature aroused. The findings of the present study are in accordance with Zhang *et al.* (2010).

*The time laps of the floating of the seedlings*

The time laps of the floating of the seedlings were clearly influenced by the seed sowing dates ($p<0.05$). The third date showed the least number of 32 days for the seedlings to float in comparison with the first and second dates. The first seed sowing date required 61 days for the seedlings to float; while it took 53 days for the second seeding date.

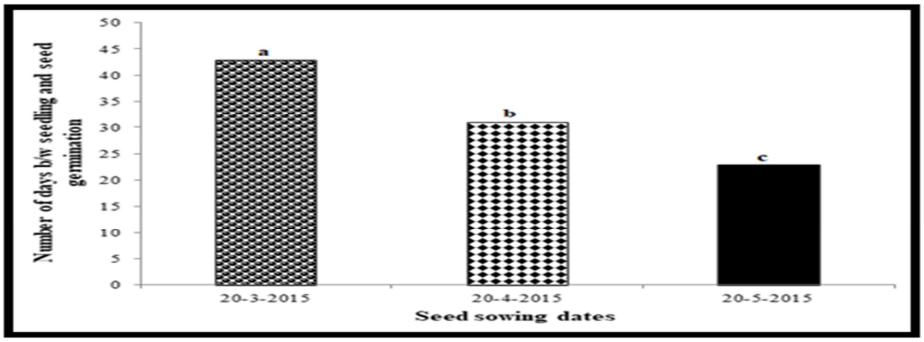


**Fig. 1.** The influence of the seed sowing dates of the water Hyacinth and the germination time in the year of 2015. The different letters on bar-diagrams shows significant variation among seedlings ($p<0.05$).

The percentage of time saving of the floating time laps in the third sowing reached 44.54% in comparison with the first seed sowing date. This period is considered to be long as the water Hyacinth plant could utilize it to multiply into huge numbers; many The percentage of time saving of the floating time laps in the third sowing reached 44.54% in comparison with the first seed sowing date. This period is considered to be long as the water Hyacinth plant could utilize it to multiply into huge numbers; many research articles indicated the ability of the plant to multiply by 12 folds within only two weeks (Zhang and Barrett, 2010). Many studies indicated that the Water Hyacinth seed keep their viability to over 20 years in moist environment (Albano*et al.,* 2011).Therefore, it is assumed that the control of the water Hyacinth must be repeated or the plants shall be removed in the fifth month of the growing season instead of the earlier months. In addition, the time laps between the dates of the control would be reduced when the extermination was carried out around the 20th of May 2015. This ensured higher control success rate.

The seed which germinated on the 20th of March must be treated 61 days after germination; the seed germinates on the 20th of April must be treated 53 days after germination and the seed which germinated on the 20th of May must be treated 23 days after germination. This will provide a clear picture about the period required to prepare the water Hyacinth eradication machinery and equipment.

research articles indicated the ability of the plant to multiply by 12 folds within only two weeks (Zhang and Barrett, 2010). Many studies indicated that the Water Hyacinth seed keep their viability to over 20 years in moist environment (Albano*et al.,* 2011). This is in an addition to gain the knowledge about the behavior of this invasive weed which provided us with the ability to stop its spread. In general and in view of the field tests, the floating stage is the most important one for the propagation and spreading of the Water Hyacinth through the seed. Some seed may germinate then die and would not float due to the thickness of the green cover of the Water Hyacinth, or because of the existence of water algae or due to the lack of light or the reduction of the germinating seed.

Therefore, seed germination without floating of the seedlings is not an indicator of the propagation strength. The percentage of germination reached to more than 87%; however, only 20% of the seed reached the floating stage.

The rest of the seed and seedlings perished due to the effects of the algae, which kept the seed trapped in the bottom of the water body or due to the effect of other aquatic plants. The Water Hyacinth seedlings fail to produce mature plants or underwater daughter plant and die after a short time due to the physiological nature of the Water Hyacinth as it transforms from a plant capable of breathing like a submerged one onto a semi-submerged plant, or due to the failure to perform the photosynthesis process caused by the lack of light.

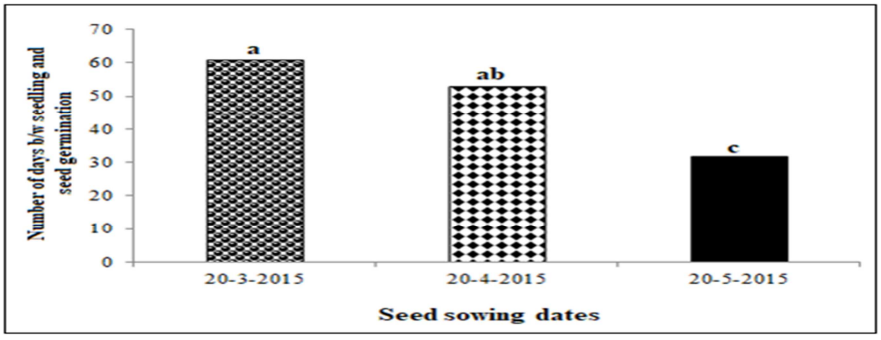


**Fig. 2.** The influence of the seed sowing dates of Water Hyacinth upon the time laps till the first appearance of floating, for the year 2015 in Diyala Province. The different letters on bar-diagrams shows significant variation among seedlings ($p<0.05$).

*Plant height*

The results in Table 1 showed a significant difference ($p<0.05$) among the dates in relation to the plant height. According to the seed sowing dates, the seed sown on the 20th of March, 2015 provided advanced plant height reaching 13.2 cm in comparison with the

second and third seed sowing dates which showed that the plant heights of 10.7 cm and 11.4 cm, respectively. This behavior indicated the strength and ability of the plant to utilize the ideal circumstances to grow by increasing the number of daughter plants, to preserve the species, to survive and to dominate the other surrounding plants. Therefore, the water Hyacinth is considered as one of the invasive plants and it is one of hundred most dangerous and invasive plants in the world as it occupied the fifth position (Gao-Lei, 2004).

*Root length characteristics*

A significant difference also displayed ($p<0.05$) in root length characteristics among the three seed sowing dates. The third seed sowing date of the 20th of May 2015 showed higher root length of 25.45cm in comparison with the first date of the 20th of March 2017 and the second date of the 20th of April 2015. They indicated the root lengths of 14.11cm and 18.45cm, respectively. This is in accordance with the findings of Heard and Winterton (2000) and GIC (2006). It was noticeable that the period needed for the daughter plants originating from a single seed sown at the first date to occupy ¼ m² was 126 days (Fig. 3); on the other hand, the same needed 81 days for the third seed sowing date. These results were nearly in agreement with the finding of Gunnarsson and Petersen (2007) who described that one single water Hyacinth plant found in a Spanish river, multiplied to 100 plants within four weeks occupied an area 20 times bigger in area it occupied at the beginning.

*Leaf area*

The results regarding leaf area indicated 1.743 m² in the third seed sowing date which was significantly higher than the first date of the 20th of March 2015 as it reached 0.758 m². The leaf area has an important role as it represents the surface area of the water body occupied by the plant. The increased leave's surface area lead to the rise of the plant's ability to benefit from the growth essentials and lead to the preservation of the dry matter in the form of carbohydrates stored in the crown of the plant. This would give the plant the ability to resume the growing process in the following season.

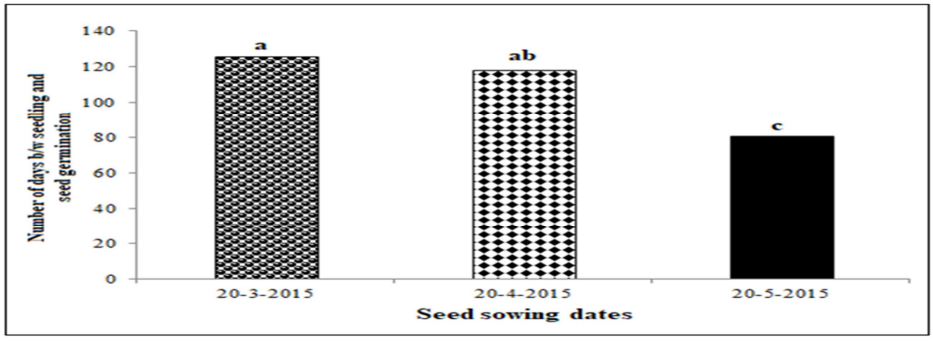


**Fig. 3.** The influence of the seed sowing dates of the Water Hyacinth upon the time laps needed to occupy ¼ m2 of the water surface, for the year 2015 in Diyala Province. The different letters on bar-diagrams shows significant variation among seedlings ($p<0.05$).

*Green plant weight*

The results in Table 2 showed a significant differences ($p<0.05$) in the characteristic of green plant weight as the first seed sowing date reached 4775.2 gm/m² in comparison with the second seed sowing date which indicated the weight of 4123.95 gm/m². The reason may be attributed to the increase realized by the height of the plant and its connection with the length or volume of the root mass. The root masses represent 50% of the total plant volume. This is in addition to the increase of the number of daughter plants. No significant differences were found in relation to the leaf diameter and the dry weight. This may be due to the variation of the number of days from the seeding to the reading times for each seed sowing date. Such differences in the number of days may cause the plants to become equal and no significant difference is visible.

**Conclusion**

The influence of the germination dates of the Water Hyacinth seed upon the time required to spread and

occupy one-quarter square meter on the water surface. It is notable that a single seed sown on the 20th of March 2015 required 126 days to be able cover ¼ m²; the second seed sowing date of the 20th of April 2015 and the third seeding date of the 20th of May 2015, needed 118 days and 81 days, respectively. Therefore, we assume that the ability of the water Hyacinth to accelerate its growth in the fifth month as the water temperature increased is due to the atmospheric increase of the temperature. This is in addition to the lengthening of the daylight period. The growth acceleration increases as the summer season approaches. Furthermore, all the the plant characterishters were observed different in varies sowing dates as as compared to each other that displayed the effect of sowing dates on plant characters.

## Acknowledgments

We highly acknowledge the University of Diyala, College of Agriculture, Diyala, Iraq for providing all the facilities for field and laboratory work.

**References**

**AlbanoP, Coetzee JA, Ruiz Téllez T, Hill MP.** 2011. A first report of water hyacinth (Eichhornia crassipes) soil seed banks in South Africa. South African Journal of Botany **3,** 795-800. https://doi.org/10.1016/j.sajb.2011.03.009

**Barrett SCH.** 1989. Sexual reproduction in Eichhorniacrassipes (water Hyacinth) II.Seed production in natural populations. Journal of Applied Ecology **17,** 113-124.

**Baskin CC, Baskin JM, Chester EW.** 2003. Ecological aspects of seed dormancy-break and germination in *Heteranthera limosa* (Pontederiaceae) a summer annual weed of rice fields. Weed Research **43,** 3–107. https://doi.org/10.1046/j.13653180.2003.00321.x

**Center TD, Van TK, Dray FA, Franks SJ, Rebelo MT, Pratt PD, Rayamajhi MB.** 2005. Herbivory alters competitive interactions between two invasive aquatic plants. Biological Control. **33,** 173-185. https://doi.org/10.1016/j.biocontrol.2005.02.005

**Center TD, Hill MP, Cordo H, Julien MH.** 2002. Water Hyacinth in biological control of invasive plants in the Eastern United States, USDA Forest Service Publication FHTET-**4,** 41-64 p.

**Gao T, Thomas GL, Pauley GB.** 1990. Effects of canopy formation by floating and submergent aquatic water hyacinth on the water quality of two shallow Pacific Northwest Lakes. Aquatic Botany **38,** 231-248. https://doi.org/10.1016/0304-3770(90)90008-9

**Gao-Lei, Bo L.** 2004. The study of a specious invasive plant, water Hyacinth (Eichhorniacrassipes): Achievements and challenges. Acta-Phytoecologica-Sinica **28, 735**–752.

**GIC Grupo.** 2006. de Investigación en Biología de la Conservación de la Universidad de Extremadura. Informesobredistribución y biologíareproductora del jacinto de Agua en el Guadiana, 12 vols., Diciembre de 2006, Confederación Hidrográfica del Guadiana, Ministerio de MedioAmbiente, Badajoz, España, **2,** 247 p.

**Gopal B.** 1987.Aquatic plant studies1.Water Hyacinth. Elsevier, Amsterdam.

**Gunnarsson C, Petersen CM.** 2007. Water Hyacinths as a resource in agriculture and energy production: a literature review. Waste Management **27**, 117–129.

**Heard TA, Winterton SL.** 2000.Interactions between nutrient status and weevil herbivory in the biological control of water Hyacinth. Journal of Applied Ecology **37,** 117-127. http://dx.doi.org/10.1046/j.13652664.2000.00480.x

**Julien MH, Orapa W.** 1999. Structure and management of a successful biological control project for water hyacinth. In:M.P.Hill, M.H.Julien and T.D.Center (Eds) proceeding of the first IOBC Global Working Group Meeting for the Biological and Integrated Contrlo of water Hyacinth.16-19 November, Harare, Zimbabwe 123-134 p.

**Martinez JM, Gomez BMA.** 2007. Integrated control of Eichhornia crassipes by using insects and plant pathogens in Mexico. Crop Protection **26,** 1234-1238. https://doi.org/10.1016/j.cropro.2006.10.028

**Pieterse AH, Murphy KJ.** 1993. Aquatic weeds: the ecology and managementof nuisance aquatic vegetation. Oxford University Press.593 p.

**Riddin T, Adams JB.** 2009. The seed banks of two temporarily open/closed estuaries in South Africa. Aquatic Botany **90,** 328–332. https://doi.org/10.1016/j.aquabot.2008.12.003

**Toy NA.** 2005. Water Hyacinth adaptation to higher saline levels. Oxford University Press, New York.

**Ueki K, Ito M, Oki Y.** 1979. Seed production and germination of Eichhornia crassipes in Japan .Proceedings of the Seventh Asian Pacific Weed Science Society Conference, 257-260.

**Wilson JR, Holst N, Rees M.** 2005. Determinants and patterns of population growth in water Hyacinth. Aquatic Botany **81**, 51–67.

**Wright AD, Purcell MF.** 1995. Eichhorniacrassipes (Mart.) Solms-Laubach .In :RH. Groves, R.C.H. Shepherd and R.G. Richardson.(Eds). The Biology of Australian Weeds. 111-121.

**Zhang Y, Zhang D, Barrett S.** 2010. Genetic uniformity characterizes the invasive spread of water Hyacinth (*Eichhornia crassipes*), a clonal aquatic plant. Moleculer Ecology **19,** 1774-1786. https://10.1111/j.1365-294X.2010.04609.x