GreenariA
Go Green, Learn Green
An Agricultural Monthly e-Magazine

Volume 03, Issue 03, 2025
ISSN: 2584-153X
Article ID: G-25-0303

EXPLORING INNOVATIVE SOLUTIONS: USING EICHHORNIA CRASSIPES FOR SUSTAINABLE PRODUCTS

Rupal Dupare[1], Parmeet Kaur[2], Jay Mute[3] and Shilpakar Narwade[3]

[1]Dr. Rajendra Prasad Central Agricultural University, Bihar
[2]Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana
[3]Maharashtra Animal and Fisheries Sciences University, Nagpur
**Corresponding Author Mail ID: rupalocean@gmail.com*

Abstract

Eichhornia crassipes, or water hyacinth, is an invasive aquatic plant native to the Amazon Basin. It disrupts freshwater ecosystems by depleting oxygen, blocking water flow, and reducing biodiversity. However, it also offers potential for sustainable use in wastewater treatment, bioenergy, and handicrafts. Projects like Assam's "Weed to Wealth" and the Harike Wetland initiative in Punjab show how it can be repurposed for economic and environmental benefits. By combining management strategies and utilizing its positive aspects, water hyacinth can be transformed from a harmful species into a valuable resource for sustainable development.

Introduction

Eichhornia crassipes, commonly known as water hyacinth, is an aquatic plant native to the Amazon Basin in South America (Parolin et al., 2010). It is renowned for its rapid growth and reproductive capabilities, which have led to its spread worldwide. However, this has made it one of the most problematic invasive species in freshwater ecosystems. The rapid proliferation of water hyacinth has resulted in severe ecological, economic, and public health consequences, including reduced biodiversity, water quality degradation, and problems to agricultural and industrial activities (Degaga, 2018). The International Union for Conservation of Nature has listed it among the 100 most aggressive invasive species and recognized it as one of the 10 most destructive weed species globally (Ben et al., 2022). Despite its reputation as a harmful weed, water hyacinth also holds significant potential for various sustainable uses. It is rich in cellulose and hemicelluloses, making it an excellent source for bioenergy production, composting, and eco-friendly products (Carreño-Sayago & Rodríguez-Parra, 2019). Several innovative initiatives have emerged in response to the challenges posed by water hyacinth, highlighting its potential as a valuable resource.

Scientific Classification

Domain	**:**	Eukaryota
Kingdom	**:**	Plantae
Clade	**:**	Angiosperms
Clade	**:**	Monocots
Order	**:**	Commelinales
Family	**:**	Pontederiaceae
Genus	**:**	*Eichhornia*
Species	**:**	*crassipes*

Figure 1. *Eicchornia crassipes*

Morphology and Biology

Eichhornia crassipes exhibits distinctive physical characteristics that contribute to its rapid growth and spread. Individual plants typically range from 10 to 50 cm in height, though dense mats of water hyacinth can cover large areas, sometimes extending over hectares of water. Its leaves are circular to ovate, measuring 10 to 20 cm in width, with a waxy, waterproof, and glossy surface that aids in buoyancy. These leaves are supported by swollen petioles filled with spongy, air-filled tissue, allowing the plant to float on the water surface (Hasan and Chakrabarti, 2009). The flowers of water hyacinth are striking, with beautiful lavender to light blue petals due to which it is referred to as “noxious beauty” (Namitha et al., 2024) and a prominent yellow spot on the uppermost petal that attracts pollinators. The flowers grow in spikes, with each spike bearing 8 to15 flowers. Beneath the surface, the roots are feathery, fibrous, and purplish-black, providing both anchorage and nutrient uptake, particularly in nutrient-poor waters (Ben et al., 2022). It reproduces through both vegetative and sexual means. Vegetatively, the plant produces stolons, or horizontal stems, which connect individual plants, forming an expanding network. Even a single fragment of the plant can regenerate into a new plant when conditions are favourable. Water hyacinth also reproduces sexually, producing small, light seeds that can remain viable for up to 20 years (Sullivan & Wood, 2012). These seeds germinate readily in shallow, nutrient-rich waters. Its growth rate is incredibly rapid; under optimal conditions, the biomass can double in just 5 days (Gaikwad and Gavande, 2017) and can form mats that reach up to 2 meters in thickness, further contributing to its invasive nature.

Figure 2. Fibrous Roots of *Eicchornia crassipes*

Figure 3. Glossy swollen petioles

Habitat and Distribution

Eichhornia crassipes naturally thrives in tropical and subtropical freshwater systems. However, its spread has been extensive, and it is now found in over 80 countries (Bhattacharya *et al*., 2015) across multiple continents, including Africa, Asia, North America, and Australia. This global distribution has been largely facilitated by human activities, such as its introduction for ornamental purposes. The plant flourishes in slow-moving or stagnant freshwater bodies, including lakes, ponds, reservoirs, canals, floodplains, and wetlands (Ndinwa *et al*., 2012). It thrives in environments that are rich in sunlight and nutrients, particularly those high in nitrogen and phosphorus, often resulting from agricultural runoff or untreated sewage. In terms of environmental tolerance, water hyacinth grows best in temperatures ranging from 28-30°C (Damtie *et al*., 2022) but can survive in a broader range of 12-35°C. While it primarily prefers freshwater, it can tolerate slight salinity. Furthermore, the plant is well-adapted to low-oxygen environments, aided by its ability to float on the water surface (Qaisar *et al*., 2005).

Ecological Impacts

Eichhornia crassipes, while offering some ecological benefits, also poses significant negative impacts on freshwater ecosystems.

Positive Impacts

- **Water Purification:** It absorbs pollutants like heavy metals (cadmium, mercury) and excessive nutrients (nitrates and

phosphates) (Akter *et al*., 2023). Useful in bioremediation of contaminated water bodies.

- **Biodiversity:** Provides temporary shelter for small aquatic organisms, such as fish and invertebrates (Wang and Yan, 2017).

Negative Impacts

- **Ecosystem Disruption:** Blocks sunlight, preventing photosynthesis in submerged aquatic plants. Reduces dissolved oxygen levels, leading to the death of fish and other aquatic life (Namitha *et al*., 2024).
- **Economic Costs:** Clogs irrigation channels, obstructing agricultural water supply, disrupts hydroelectric power generation by blocking turbines and hampers navigation and fishing activities (Harun *et al*., 2021).
- **Public Health:** Serves as a breeding ground for mosquitoes and pests that transmit diseases like malaria and dengue (Isalkar *et al*., 2018).
- **Biodiversity Loss:** Outcompetes native aquatic plants, leading to monocultures and reduced ecosystem diversity (Shanab *et al*., 2010).

Control and Management

Effective control of *Eichhornia crassipes* requires a combination of methods such as mechanical, biological and chemical control methods.

- **Mechanical Control**: It involves physical removal using dredges, harvesters, or manual labour, which is effective for small infestations but can be expensive and labour-intensive for large areas (Elenwo and Akankali, 2019).
- **Biological Control**: It includes the use of insects like *Neochetina eichhorniae* and *Neochetina bruchi*, which feed on the leaves and petioles, reducing its growth (Karouach *et al*., 2022). Additionally, fungi such as *Alternaria alternata* are being explored for their potential to damage the plant.
- **Chemical Control**: It often involves spraying herbicides like glyphosate and 2,4-D to kill the plants, although this approach carries risks, such as water contamination and harm to non-target organisms (Chu *et al*., 2006).

To prevent further spread, it is crucial to educate communities about the ecological impacts of water hyacinth and regulate its use as an ornamental plant, including imposing bans where necessary. Integrated management strategies, combining mechanical, biological, and chemical methods, are essential for sustainable control. Additionally, regular monitoring of water bodies helps prevent the re-establishment of the invasive plant.

Human Uses and Benefits

Eichhornia crassipes has numerous practical applications that can be harnessed for human benefit, despite its invasive nature. It has numerous practical applications that can be harnessed for human benefit, despite its invasive nature. One of its key uses is in wastewater treatment, where it acts as a natural biofilter, removing pollutants such as heavy metals, pesticides, and organic matter.

Additionally, It is being used in the production of bioenergy, including biogas and bioethanol, offering a renewable energy source (Nahar and Sunny, 2024). In the realm of handicrafts, the dried plant is woven into products like mats, ropes, and furniture (Rakotoarisoa *et al*., 2016).

Water hyacinth can also serve as livestock feed after proper treatment to reduce its high-water content and nutrient imbalance (Indulekha *et al*., 2019). Furthermore, research is ongoing into its potential applications in carbon sequestration and phytoremediation.

Utilization of *Eichhornia crassipes* for Environmental and Economic Sustainability:

While *Eichhornia crassipes* is primarily known for its environmental challenges, various initiatives have explored innovative ways to transform this invasive species into a valuable resource. The following examples highlight how different regions have turned the nuisance of water hyacinth into a sustainable solution.

"Weed to Wealth" Initiative in Assam, India

In Assam, India, the Assam State Rural Livelihood Mission (ASRLM) launched the "Weed to Wealth" initiative, a program aimed at utilizing water hyacinth for economic and environmental benefits. The initiative trains local communities, particularly women, to craft products from the plant, such as purses, table mats, laundry baskets, laptop bags, and even tiffin carriers. This initiative not only provides a sustainable way to control water hyacinth but also generates income and employment opportunities. Various self-help groups (SHGs) from districts like Darrang, Kokrajhar, Nagaon, Tinsukia, Majuli and Dhemaji are actively involved in this initiative, and their products have received recognition at fairs across India (Sarma and Sanowal, 2024).

Harike Wetland, Punjab: Transforming Water Hyacinth into Compost and Handicraft

The Harike Wetland in Punjab has also adopted a creative approach in 2011 to managing the proliferation of water hyacinth. The wetland, initially managed by the Harike Forest Department as part of their habitat improvement efforts, started using water hyacinth for producing compost and crafting handicrafts.

The invasive plants removed from the water bodies are repurposed as organic compost, reducing the environmental impact of disposal. Furthermore, fiber extracted from the water hyacinth is used to create eco-friendly handicrafts, which support the local economy by offering a sustainable source of income for artisans.

Ajay Bahuudeshiya Sanstha in Chandrapur district, Maharashtra

The study on the availability of water hyacinth and its potential for handicraft production. The research revealed that dried stems of the plant could be used to make items such as bags, baskets, and mats. The project has contributed to maintaining biodiversity by regularly removing water hyacinth, reducing its negative impact on water bodies. However, one challenge we face is establishing a market presence, as there is limited awareness of handicrafts in our district. We are working to expand our reach by participating in exhibitions and promoting our products to outside markets (Qureshi & Dhotkar 2024)

These initiatives show cases how water hyacinth can be effectively used, contributing to both environmental conservation and economic growth through sustainable product development.

Conclusion

Eichhornia crassipes is an ecological nuisance in many parts of the world due to its invasiveness, but also a resource for water purification, bioenergy, and other applications. Effective management strategies, coupled with innovative uses, can help mitigate its negative impacts while maximizing its benefits. By turning the challenges of water hyacinth into opportunities for ecological and economic growth, this invasive species can be made a valuable resource for sustainable development.

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