Association of Makhana (Euryale Ferox Salisb) with Macrophyte Weeds in Katihar District of Bihar, India

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Abstract

Euryale ferox Salisb. (makhana/gorgon nut) is an important annual wetland floating leaf angiospermic macrophyte which grows naturally in wild forms in aquatic bodies. It is also cultivated in ponds, low land stagnant water, fields etc. This plant is especially cultivated in northern Bihar, West Bengal, Manipur and MP for its seeds. Roasted/popped seeds of makhana (puffs) are tasty, light, crispy, fatless, aphrodisiac, spermatogenic and with high carbohydrate, protein and mineral contents. Therefore, makhana puffs have especially become a delicacy in the diet of riches and are in high demand in western and gulf countries. Bihar is the largest producer (90%) of makhana in India and the world too. In north Bihar, Katihar district is known for its fine network of Himalayas’ emanating rivers as well as a large number of other natural and man-made aquifers. Euryale ferox (makhana) is the most common aquatic macrophyte grown as cash crop in the non-calcareous belts of Koshi and Mahananda rivers of Katihar. In the initial stage of growth of makhana crop its water bodies are heavily infested with aquaphyte weeds. Hence, a periodic manual, herbal or chemical weeding of aquatic bodies in early stages is essential for the establishment of makhana seedlings. In the present study, altogether 35 macrophyte species belonging to 33 genera of angiosperms and pteridophytes were recorded from makhana crop fields. The important macrophytic weeds were Eichhornia crassipes, Monochoria hastata, Ceratophyllum demersum, Nelumbo nucifera, Nymphaea nauchali etc. were recorded in the present investigation. These aquatic macrophytes pose a great threat to the growth of makhana and considerably reduce the crop yield. These aquaphytic weeds also show detrimental allelopathic effects on the cultivation of makhana. However, makhana has the great potentiality as a solution for poverty alleviation and livelihood security especially for economically poor rural people who thrive in wetland areas.

Key words: Makhana, weedy macrophytes, association, yield reduction, livelihood security.

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INTRODUCTION

Euryale ferox Salisb. (makhana/gorgon nut/prickly water lily) is an important wetland macrophyte which grows naturally in wild form or cultivated in pond, low land stagnant water, fields etc. It is one of the important underutilized aquatic food crop next to deep-water rice and water chestnut [1]. It belongs to water lily family Nymphaeaceae, although it is occasionally regarded under a distinct family Euryalaceae also. It is a monotypic genus [2] growing in the shallow littoral parts of flood plain wetland which are of perennial nature. The plant is widely prevalent in tropical and sub-tropical regions accomplished with humid to sub-humid environment and mainly cultivated as a source of starch protein [3, 4]. It provides livelihood to the fisherman and other related communities [5, 6]. On account being fatless aphrodisiac, spermatogenic and high carbohydrate and protein content makhana is in high demand in western and gulf countries [7]. Makhana is a forced annual plant and aquatic bio-resource of India. Bihar is the leading producer of makhana and it produces about 90% of makhana in India [8]. North Bihar of India ranks first (80%) not only in Bihar but also in the world in the production of makhana. Production of makhana pop in state is estimated to be around 20,000 MT with major producing district being Darbhanga, Madhubani, Purnea and Katihar. Wetlands in the region of North Bihar has 2,69,418 ha comprising an average of 4.96% of its total geographical area. In Bihar district Madhubani occupies the highest share of total production of makhana pop, which contributes about 20% of total production in the state i.e. 3000 MT followed by Katihar 18%, Darbhanga, Purnea and others [9]. Maximum wetland area in Katihar district is 21,011 ha i.e. about 10.30% of the geographical area of the district.
Makhana cultivation in clusters of Katihar is done in two systems pond systems and field systems [11].

Euryale ferox Salisb. is ecologically classified as floating leaf emergent macrophyte or as a rooted floating macrophyte (aerohydrophyte). Since makhana is an aquatic crop therefore, several other aquaphytes/aquatic macrophytes are also used to grow in association with makhana. They are usually harmful to makhana plants by competing for nutrients, sunlight and space. But on the other hand when they decay during grand growth period of makhana then they become helpful by supporting nutrients of organic origin to makhana plants. Some macrophytes associated with makhana grow up to maturity of makhana plant and are really competitors. They may add nutrients for subsequent crops but need to be removed to get good growth of makhana. It has been recorded that due to gregarious invasion of Eichhorniacrassipes, Pistia stratiotes, Lemna perpusilla, Monochoria hastate, Salvinia molesta, Cyprus exaltatus, Alternanthera philoxeroid and Typha angustata, Euryale ferox have been disappeared from previously inhabited water in West Bengal [12]. Makhana prefers tropical and subtropical climate, temperature between 20 °C – 35 °C, humidity between 50%-90% and rainfall between 100 cm-250 cm [13] and favoured by neutral pH [14]. Physicoclimatic conditions, soil characterisation, rainfall, temperature and terrain favour makhana cultivation in North Bihar. Euryale ferox Salisb. (Makhana) is the foremost aquatic macrophyte grown as cash crop in the non-calcareous Koshi-Mahananda belt of Katihar. In the surveys of makhana cultivated areas of Katihar district during 2016 - 2019, almost all makhana growing water bodies were found to be moderately or heavily infested by the aquatic macrophytes. So both from ecological and agricultural point of views it was thought necessary to know the status and impact of aquatic macrophyte weeds on makhana production as makhana crop is rapidly infested by weeds too in the initial stage of establishment of the seeding.

MATERIALS AND METHODS

A detailed survey was conducted during 2016-2019 in makhana cultivated fields/ponds situated in wetland areas of 9 ponds of three blocks of Katihar district of Bihar (Table – 1, Plate - 1). The survey involved methods of observations, interactions, interviews along with individual group discussion to identify major cluster producing makhana and existing cultivation system and processing operation including collection of aquatic macrophytes. Macrophyte collection is done seasonally and identified with the help of standard books [15-19] and consulting different herbaria of NBRI, Lucknow and PG Dept of Botany TMBU, Bhagalpur.

Macrophytes associated with makhana were directly collected from different sites of makhana cultivated fields/ponds while those from deeper water with the help of long handled hook. Collected specimens were thoroughly washed at the spots, excess water soaked with filter paper, kept in the polythene bags lined with filter paper and brought to the laboratory. On the same day, the specimens were shade dried, kept in the sun for few minutes and then put in herbarium pressure for making herbarium of them. These herbaria were used further for identification.

| TABLE 1: Study Area of Katihar District |
|---|---|---|
| SITES | BLOCKS | VILLAGES | PONDS |
| | | | |
| I | BARARI | 1. Bisharia | 1. Bisharia Pokhar/Pond |
| | | 2. Ronia | 2. Ronia Railway Dhala Pond |
| | | 3. Laxmipur | 3. Laxmipur Road Pond |
| II | KORHA | 4. Gorgamma | 4. Gorgamm Dhar / Pond |
| | | 5. Najra Chowki | 5. Najra Chowki Pond |
| | | 6.Pulwaria Chowk | 6. Pulbaria Chowk Pond |
| III | KATIHAR | 7. Mania | 7. Mania Pond |
| | | 8. Kolasi | 8. Kolasi Pond |
| | | 9. Naya Tola | 9. Naya Tola Pond |
RESULTS AND DISCUSSION

In Katihar district out of 16 blocks makhana cultivation is done mainly in 13 blocks. Based on thorough investigations of three blocks, makhana associated macrophytic weeds in Katihar district were classified as emergent, floating, submerged and subaerial. Association of different macrophytes with makhana in ponds of Katihar district are depicted in Table - 2. Seasonal fluctuations in abundance of other macrophytes associated with Makhana are depicted in Table - 3.
Table-2: Macrophyte Weeds Found in Association with E. ferox Salisb. In Katihar District

| Common Name       | Botanical Name | Family         | Class      | Division       |
|--------------------|----------------|----------------|------------|----------------|
| Sub aerial         |                |                |            |                |
| 1. Alligator weed  | Alternanthera philoxeroides (Mart.) Griseb. | Amaranthaceae | Eudicots   | Angiosperms    |
| 2. Water spinach   | Ipomoea aquatica Forsk. | Convolvulaceae | Eudicots   | Angiosperms    |
| 3. Water starworts | Limnophila heterophylla (Roxb.) Benth. | Scrophulariaceae/P lantaginaceae | Eudicots | Angiosperms |
| 4. Frog fruit      | Lippia nodiflora (L.) Greene | Verbenaceae | Eudicots | Angiosperms |
| 5. Prime rose      | Ludwigia sp.L. | Onagraceae | Eudicots | Angiosperms |
| 6. Water clove     | Marsilea quadrifolia L. | Marsileaceae | Polyplodiopsis | Peridophyta |
| 7. Leaf pond weed  | Monochoria hastate (L.) Solms | Pontederiaceae | Monocots | Angiosperms |
| 8. Knot grass      | Polygonum hydropiper L. | Polygonaceae | Eudicots | Angiosperms |
| 9. Khubahramdana   | Scirpus articulatus L. | Cyperaceae | Monocots | Angiosperms |
|                    |                |                |            |                |
| Submerged          |                |                |            |                |
| 10. Shola pith plant | Aeschynomone aspera L. | Fabaceae | Eudicots | Angiosperms |
| 11. Horn wort      | Ceratophyllum demersum. L. | Ceratophyllaceae | Eudicots | Angiosperms |
| 12. Water weed     | Hydrilla verticillata (L.F.) Royle | Hydrocharitaceae | Monocots | Angiosperms |
| 13. Watermilfoil   | Myriophyllum sp. L. | Haloragaceae | Eudicots | Angiosperms |
| 14. Water nymphs   | Najas sp. L. | Hydrocharitaceae | Monocots | Angiosperms |
| 15. Pond weed      | Potamogeton crispus L. | Potamogetonaceae | Monocots | Angiosperms |
| 16. Bladder worts  | Utricularia sp. L. | Lentibulariaceae | Eudicots | Angiosperms |
| 17. Tape grass      | Vallisneria spiralis L. | Hydrocharitaceae | Monocots | Angiosperms |
|                    |                |                |            |                |
| Emergent           |                |                |            |                |
| 18. Indian water fern | Ceratopteris thalictroides Brongniat | Pteridaceae | Polyplodiopsis | Peridophyta |
| 19. Goose foot     | Chenopodium sp. L. | Amaranthaceae | Eudicots | Angiosperms |
| 20. Nut grass      | Cyperus exaltatus Retz. | Cyperaceae | Monocots | Angiosperms |
| 21. Rice flat edge | Cyperus sp. L. | Cyperaceae | Monocots | Angiosperms |
| 22. Grass weed     | Cyperus rotundus L. | Cyperaceae | Monocots | Angiosperms |
| 23. Rusty grass    | Fimbristylis sp. Vahl | Cyperaceae | Monocots | Angiosperms |
| 24. Ancient water grass | Hygropyza aristata (Retz.) Nees ex Wight & Arn. | Poaceae | Monocots | Angiosperms |
| 25. Goose berry    | Physalis sp. L. | Solanaceae | Eudicots | Angiosperms |
| 26. Chichor         | Polygona vulgaris L. | Polygonaceae | Eudicots | Angiosperms |
|                    |                |                |            |                |
| Floating           |                |                |            |                |
| 27. Mosquito fern   | Azollapinnata R. Br. | Salvinia | Polyplodiopsis | Pteridophyta |
| 28. Water hyacinth | Eichhorniaceae sp. (Mart.) Solms | Pontederiaceae | Monocots | Angiosperms |
| 29. Small duck weed | Lemnasp. L. | Araceae | Monocots | Angiosperms |
| 30. Kamal gatta    | Nelumbonucifera Gaertn. | Nelumbonaceae | Eudicots | Angiosperms |
| 31. Water lily     | Nymphaea mononahali Burm. f. | Nymphaeaceae | Eudicots | Angiosperms |
| 32. Water          | Pistia stratiotes L. | Araceae | Monocots | Angiosperms |
| 33. Floating fern  | Salvinianatis (L.) All. | Salvinia | Polyplodiopsis | Pteridophyta |
| 34. Duckweed       | Spirodela polyrhiza (L.) Schleid. | Araceae | Monocots | Angiosperms |
| 35. Water meal     | Wolfia aurhizal (L.) Horkel ex Wimm. | Araceae | Monocots | Angiosperms |

Table-3: Seasonal Fluctuations in Abundance of Macrophyte Weeds Associated with Makhana at Different Sites of Katihar District

| Name of Macrophytes | Site-I | Site-II | Site-III |
|---------------------|--------|--------|---------|
|                     | W     | S     | R     | W     | S     | R     | W     | S     | R     |
| 1. Aeschynomone aspera L. | ++    | +++   | +++   | ++    | ++    | +++   | ++    | ++    | +++   |
| 2. Alternanthera philoxeroides (Mart.) Griseb. | ++    | +     | +++   | ++    | +     | +++   | ++    | +     | +++   |
| 3. Azollapinnata R. Br. | +++   | +     | ++    | +++   | ++    | +     | +++   | ++    | +     |
| 4. Ceratophyllum demersum L. | +++   | +++   | +++   | +++   | +++   | +++   | +++   | +++   | +++   |
| 5. Ceratopteris thalictroides (L.) Brongniart | -     | +     | +++   | +++   | ++    | +++   | ++    | +     | +++   |
| 6. Chenopodium sp. L. | +     | ++    | +++   | ++    | +     | ++    | +     | ++    | +++   |
| 7. Cyperus exaltatus Retz. | *     | +++   | ++    | +++   | ++    | +++   | ++    | +     | +++   |
| 8. Cyperus iria L. | +++    | ++    | +++   | +++    | ++    | +     | +++    | ++    | +     |
| 9. Cyperus rotundus L. | ++    | +++   | +     | +++    | +     | ++    | +++    | +     | ++    |
| 10. Eichhornia crassipes (Mart.) Solms | ++++++ | ++++ | ++++ | ++++ | ++++ | ++++ | ++++ | ++++ | ++++ |
| 11. Fimbristylis sp. Vahl | ++    | +++   | +     | +++    | +     | ++    | +++    | +     | ++    |
| 12. Hydrilla verticillata (L.F.) Royle | ++    | +++   | +++   | +++    | +++   | ++    | +++    | ++    | ++    |
| 13. Hygropyza aristata (Retz.) Nees ex Wight & Arn. | ++    | +++   | +     | +++    | +     | -     | -     | -     | -     |

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Altogether 33 genera and 35 species of macrophytes were identified during the present study from different makhana cultivated ponds of Katihar districts (Table - 1). Out of these macrophytes, angiosperms were represented by 29 genera and 31 species and pteridophytes by 4 genera and 4 species. Among angiosperms dicots were represented by 14 genera and 15 species and monocots by 14 genera and 16 species (Fig. - 1) Site - I exhibited the maximum number of genera (29) and species (32) followed by Site - II (26 genera and 26 species) and Site – III (25 genera and 25 species) respectively (Fig. -2). However, it was reported 11 species of aquatic macrophytes from the different ponds of Darbhanga [20].

| No. | Species Name                                      | ++ | +++ | ++ | +++ | +++ | ++ | +++ | ++ |
|-----|--------------------------------------------------|----|-----|----|-----|-----|----|-----|----|
| 14  | Ipomoea aquatiaca Forssk.                        | +++| +++ | ++ | +++ | +++ | ++ | +++ | ++ |
| 15  | Lenna sp. L.                                      | +++| +   | ++ | +   | +   | +++| +   | ++ |
| 16  | Lippia nodiflora (L.) Greene                     | -  | -   | +  | ++  | +   | -  | -   | -  |
| 17  | Limnophila heterophylla (Roxb.) Benth.           | -  | -   | -  | -   | +   | +  | +   | +  |
| 18  | Ludwigia sp L.                                    | ++ | +   | +++| ++  | ++  | +  | +++ | +  |
| 19  | Marsilea quadrifolia L.                           | +++| +++ | +++| +++ | +++ | +++| +++ | +++|
| 20  | Monocharia hastata (L.) Solms                    | ++ | +++ | +++| +++ | +++ | ++ | +++ | +++|
| 21  | Myriophyllum sps. L.                              | ++ | +++ | +++| -   | -   | -  | -   | -  |
| 22  | Najas sp.L.                                       | ++ | +++ | +++| +   | +   | ++ | +++ | +++|
| 23  | Nelumbo nucifera Gaertn.                          | ++ | ++  |    |     |     |    |     |    |
| 24  | Nymphaea nouchali Burm.f.                         | ++ | +   | +++| ++  | ++  | ++ | +++ | +++|
| 25  | Pistia stratiotes L.                              | ++ | +++ | ++ | ++  | +   | -  | -   | -  |
| 26  | Potamogeton crispus L.                            | ++ | +++ | ++ | +   | +   | ++ | +++ | +++|
| 27  | Polygonum sylvestris L.                           | +  | +   | +  | -   | -   | -  | -   | -  |
| 28  | Polygonum hydropiper L.                           | +++| +++ | +++| +++ | +++ | +++| +++ | +++|
| 29  | Physalis sp. L.                                   | -  | +   | ++ | +   | +   | ++ | -   | -  |
| 30  | Salvinia natans (L.) All.                         | +++| +   | ++ | +   | +   | ++ | +++ | +  |
| 31  | Scirpus articulatus L.                            | +  | +++ | ++ | +   | ++  | +  | +   | +  |
| 32  | Spirodela polyrhiza (L.) Schleid.                 | +  | +++ | ++ | +++ | ++  | -  | -   | -  |
| 33  | Utricularia sp. L.                                | +  | ++  | +  | -   | -   | -  | -   | -  |
| 34  | Vallisneria spiralis L.                            | ++ | +++ | ++ | +++ | +++ | ++ | +++ | ++ |
| 35  | Wolffia arrhiza (L.) Horkel ex Wimm.              | +++| ++  | ++ | +++ | +   | +++| ++  | ++ |

Fig-1: Total No.of Genera and Species of Macrophyte Weeds Found in Makhana Cultivated Ponds of Katihar District
Fig-2: Total No. Of Genera and Species of Different Types of Macrophytes Found in Makhana Cultivated Ponds of Different Sites of Katihar District
Among different aquatic macrophytes 9 were emergent, 9 subaerial, 9 floating and 8 were submerged. Seasons had profound effects on the abundance of other macrophytes growing in association with makhana. Seasonal fluctuations showed maximum abundance of macrophytes during summer i.e. grand growth period of makhana closely followed by winter due to wide and favorable range of temperature, pH, nutrients etc. However, the lowest abundance was recorded during rainy season i.e. during harvesting and post-harvesting period of makhana.

Ceratophyllum demersum, Hydrilla verticillata, Eichhornia carassipes, Monochoria hastata and Vallisneria spiralis were present throughout the year. Percentage frequency of C. demersum, H. verticillata, E. carassipes and Monochoria hastata showed maximum positive correlation with makhana (Table - 3). The dominant macrophytes recorded were Cyperus rotundus, C. exaltatus, Eichhornia carassipes, Lemna sp., Azolla pinnata, Spirodela polyrhiza, Nymphaea nauchalhi, Nelumbo nucifera, Ceratophyllum demersum, Potamogeton crispus, Ludwigia sp., Polygonum hydropiper, P. sylvestris, Marsilea quadrifolia, Alternanthera philoxeroides, Ipomoea aquatica and Monochoria hastata. These macrophytes compete with makhana (E. ferox Salisb.) for nutrients, sunlight, space etc. and reduce the growth, increase the cost of labours and reduce the growth and yield of makhana plants. They cause damage in both the fields of agriculture and pisciculture. In our investigation some macrophytes like Nelumbonucifera, Nymphaea nauchalhi, Eichhornia carassipes, Aeschynomene aspera and Monochoria hastata were also observed as the most troublesome weeds. Cyperus deformis, C. rotundus, Hydrilla verticillata, Aeschynomene aspera and Sagittaria guayaneshave been reported as the common weeds in Darbhanga which pose problems in makhana cultivation [8]. It is also reported that the main cause of the decline of makhana (E. ferox Salisb.) cultivation in West Bengal was the gregarious invasion of these macrophytes [21]. Some macrophytes associated with makhana grow up to maturity of makhana plants and are really competitors. But on the other hand several other macrophytes growing in association with makhana decay during the grand growth period and helpful in supplying nutrients of organic origin to the subsequent crops [22]. However, to obtain good growth of E. ferox Salisb. these macrophytes need to be removed from makhana cultivated ponds. Aquatic macrophytes also foster malaria, encephalitis and other mosquito borne diseases.

On the other hand, from ecological point of view these macrophytes provide shelter and refuges to periphytes [23], zooplankton [24], other invertebrates like fishes and amphibians. They are also important for human beings as a source of food, biomass and building materials [26] as well therapeutic agents [27,28] and they also play a key role in biochemical cycles in aquatic system [22]. However, to obtain good growth of E. ferox Salisb. these macrophytes need to be removed from makhana cultivated ponds.
cultivated ponds. Aquatic macrophytes also foster malaria, encephalitis and other mosquito borne diseases.

CONCLUSIONS

Macrophyte weeds pose problems in the cultivation of agricultural crops. Aquatic macrophytes like Nelumbo nucifera, Nymphaea nauchali, Eichhornia crassipes, Monochoria hastata, Aeschynomene aspera and some others act as weeds and pose a great threat to the cultivation of makhana in aquatic bodies. They compete for light, nutrients and space with makhana and reduce their growth and yield. Hence weeding of these macrophytes from makhana cultivated ponds or other aquatic systems are essential in earlier stages of development and establishment of makhana. This increases the cost of makhana production to the farmers. But on the other hand these macrophytes also provide nutrients to makhana plants after decaying during grand growth period of makhana i.e. in summer. Thus they play a vital role in biogeochemical cycling. Weed management is a serious problem for the cultivation of makhana crops. It has been found that cultivators usually destroy all aquatic weeds during cultivation of makhana crops. There is an increasing trends of use of chemical weedicides by the makhana cultivators which not only destroy obnoxious weeds but also some periphytes and smaller aquatic animals too. Therefore, mechanical weeding of only larger aquatic obnoxious macrophytes which grow up to the maturity of makhana crops like Nelumbo nucifera, Nymphaea nauchali, Eichhornia crassipes, Aeschynomene aspera, Monochoria hastata, Potamogeton crispus etc. in makhana ponds will be more beneficial from both agricultural and ecological point of views. Organic cakes of neem and castor may also be helpful. Some weeds germinate but their growth is suppressed by the rapid growth of makhana crop which covers the entire field within the month. Smaller macrophytes do not create many problems as they require little nutrients, little spaces and light and finally occupy intermediate spaces between makhana leaves.

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