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

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Abstract **Original Research Article**

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 imortant macrophytic weeds were *Eichhornia crassipes, Monocharia hastata, Ceratophyllum demursum, 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.

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 widly 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 of its 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

[10]. 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 (aerohydatophyte). 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, Lemmna perpusilla, Monochoria hastate, Salvinia molesta, Cyprus exaltatus, Alternanthara philoxeroid and Typha angustata,Euryale ferox have been disappeared from previously inhabited water in West Bengal [12]. Makhana prefers tropical and sub-tropical 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 seedling.

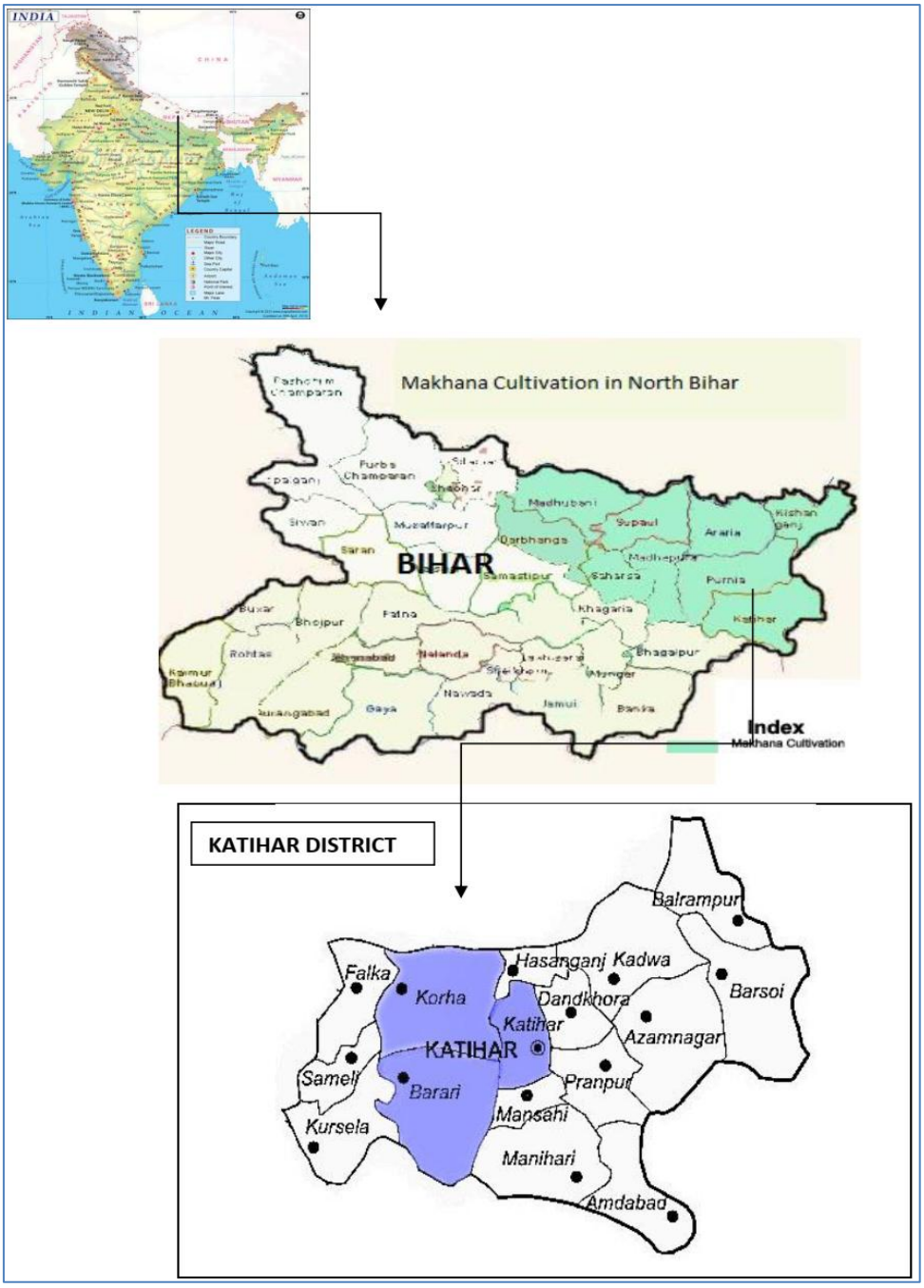
MATERIALS AND METHODS

A detailed survey was conducted during 2016-2019 in makhana cultivated fields/ponds situated in wetland areas of 9 pounds 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 2. Ronia 3. Laxmipur	1. Bisharia Pokhar/Pond 2. Ronia Railway Dhala Pond 3. Laxmipur Road Pond
II	KORHA	4. Gorgamma 5. Najra Chowki 6.Pulwaria Chowk	4. Gorgamm Dhar / Pond 5. Najra Chowki Pond 6. Pulbaria Chowk Pond
III	KATIHAR	7. Mania 8. Kolasi 9. Naya Tola	7. Mania Pond 8. Kolasi Pond 9. Naya Tola Pond



MAP - 1: LOCATION MAP OF KATIHAR DISTRICT IN BIHAR

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	AIternanthera philoxeroide(Mart.) Griseb.	Amaranthaceae	Eudicots	Angiosperms
2. Water spinach	Ipomoea aquaticaForssk.	Convolvulaceae	Eudicots	Angiosperms
3. Water starworts	Limnophila heterophylla (Roxb.)Benth.	Scrophulariaceae/Plantaginacaea	Eudicots	Angiosperms
4. Frog fruit	Lippia nodiflora (L.) Greene	Verbenaceae	Eudicots	Angiosperms
5. Prime rose	Ludwigia sp.L.	Onagraceae	Eudicots	Angiosperms
5. Water clove	Marsilea quadrifolia L.	Marsileaceae	Polypodiopsida	Peridophyta
7. Leaf pond weed	Monocharia hastate (L.) Solms	Pontederiaceae	Monocots	Angiosperms
8. Knot grass	Polygonum hydropiperL.	Polygonaceae	Eudicots	Angiosperms
9. Khubahiramdana	Scirpus articultatus L.	Cyperaceae	Monocots	Angiosperms
Submerged				
10. Shola pith plant	Aeschynomene 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	Myriophyllumsp.L.	Haloragaceae	Eudicots	Angiosperms
14. Water nymphs	Najas sp.L.	Hydrocharitaceae	Monocots	Angiosperms
15. Pond weed	Potamogeton crispusL.	Potamogetonaceae	Monocots	Angiosperms
16. Bladder worts	Utricularia sp. L.	Lentibulariaceae	Eudicots	Angiosperms
17. Tape grass	Vallisneria spiralisL.	Hydrocharitaceae	Monocots	Angiosperms
Emergent				
18. Indian water fern	Ceratopteris thalictroides Brongniat	Pteridaceae	Polypodiopsida	Pteridophyta
19. Goose foot	Chenopodium sp.L.	Amaranthaceae	Eudicots	Angiosperms
20. Nut grass	Cyperus exaltatusRetz.	Cyperaceae	Monocots	Angiosperms
21. Rice flat sedge	CyperusiriaL.	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	Hygroryzaaristata(Retz.) Nees ex Wight &Arn.	Poaceae	Monocots	Angiosperms
25. Goose berry	Physalissp.L.	Solanaceae	Eudicots	Angiosperms
26. Chichor	PolygonamsylvestrisL.	Polygonaceae	Eudicots	Angiosperms
Floating				
27.Mosquito fern	Azollapinnata R. Br.	Salviniaceae	Polypodiopsida	Pteridophyta
28.Water hyacinth	Eichhorniacrassipes(Mart.) Solms	Pontederiaceae	Monocots	Angiosperms
29. Small duck weed	Lemnasp.L.	Araceae	Monocots	Angiosperms
30. Kamal gatta	NelumbonuciferaGaertn.	Nelumbonaceae	Eudicots	Angiosperms
31. Water lily	Nymphaea nouchaliBurm.f.	Nymphaeaceae	Eudicots	Angiosperms
32. Water	Pistia stratiotes L.	Araceae	Monocots	Angiosperms
33. Floating fern	Salvinianatans (L.) All.	Salviniaceae	Polypodiopsida	Pteridophyta
34. Duckweed	Spirodelapolyrhiza (L.) Schleid.	Araceae	Monocots	Angiosperms
35. Water meal	Wolffiaarrhizal (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. Aeschynomene aspera L.	++	+++	+++	-	-	+	++	++	+++
2. AIternanthera philoxeroide (Mart.) Griseb	++	+	+++	++	+	+++	++	+	+++
3. Azolla pinnata R.Br.	+++	+	++	++	+++	+	+++	+	+
4. Ceratophyllum demersum L.	+++	+++	+++	+++	+++	+++	+++	+++	+++
5. Ceratopteris thalitroides (L.) Brongniart	-	-	-	+	+	++	+	+	++
6. Chenopodium sp. L.	+	+	+++	-	-	-	+	++	+++
7. Cyperus exaltatus Retz.	+	+++	++	++	+++	++	+	+++	++
8. Cyperus iria L.	++	+++	++	++	+++	++	+	++	+
9. Cyprus rotundus L.	++	+++	++	+	+++	++	++	+++	++
10. Eichhornia crassipes (Mart.) Solms	+++	+++++	++++	+++	+++	+++	+++	+++	+++
11.Fimbristyllis sp. Vahl	++	+++	+	-	-	-	+	+++	+
12. Hydrilla verticillata (L.F) Royle	++	+++	++	+++	+++	+++	++	+++	++
13. Hygroryza aristata (Retz.) Nees ex Wight & Arn.	++	+++	+	++	+++	+	-	-	-

14. Ipomoea aquatiaca Forssk.	+++	+++	++	+++	+++	++	+++	+++	++
15. Lemna 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. Polygonam sylvestris L.	+	+	+	-	-	-	-	-	-
28. Polygonum hydropiper L.	+++	+++	+++	+++	+++	+++	+++	+++	+++
29. Physalis sp. L.	-	+	++	+	+	++	-	-	-
30. Salvinia natans (L.) All.	+++	+	++	+	++	+	+++	+	++
31. Scirpus articultatus L.	+	+++	+++	+	++	++	+	+	+
32.Spirodela polyrhiza (L.) Schleid.	+	+++	++	++	+++	++	-	-	-
33. Utricularia sp. L.	+	++	+	-	-	-	-	-	-
34. Vallisneria spirailis L.	++	+++	++	+++	+++	+++	++	+++	++
35..Wolffiaarrhiza (L.) Horkel ex Wimm.	+++	++	++	++	+++	+	+++	++	++

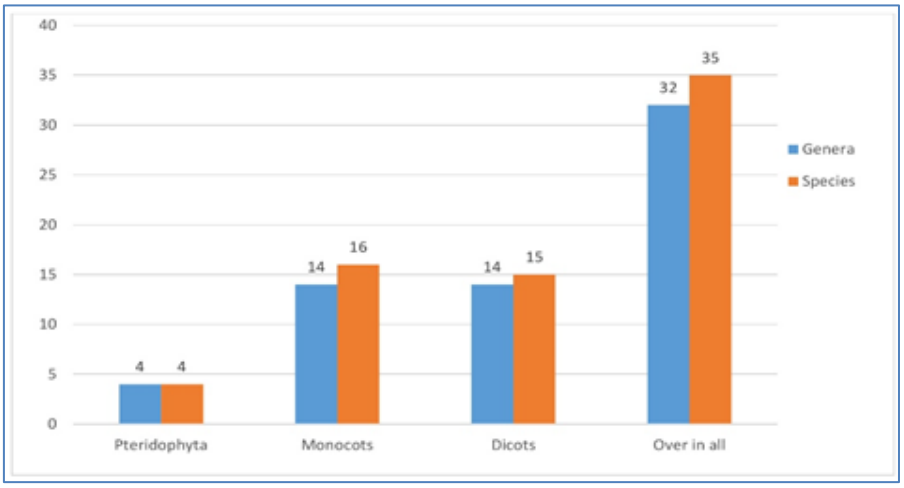


Fig-1: Total No.of Genera and Species of Macrophyte Weeds Found in Makhana Cultivated Ponds of Katihar District

Altogether 33 genera and 35 species of macrophytes were identified during the present study from different makhana cultivated ponds of Katihar disricts (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].

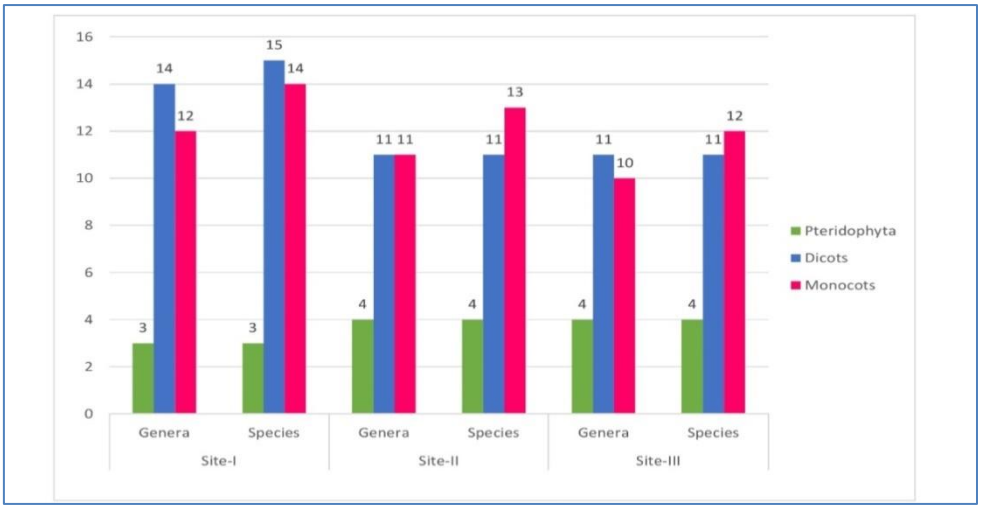


Fig-2: Total No. Of Genera and Species of Different Types of Macrophytes Found in Makhana Cultivated Ponds of Different Sites of Katihar District

Hygroryza aristata

Nelumbo nucifera

Spirodela polyrhiza

Azolla pinnata

Marsilea quadrifolia

Polygonum sp.

Physalis sp. Scirpus Scirpus articulatus

Farmers doing weeding

Nymphaea nouchali

Plate-1: Macrophyte Weeds Associated with Makhana in 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 carssipes, Monocharia hastata and Vallisneria spiralis were present throughout the year. Percentage frequency of C. demersum, H. verticillata, E. crassipes and Monocharia hastata showed maximum positive correlation with makhana (Table - 3). The dominant macrophytes recorded wereCyperus rotundus, C. exaltatus, Eichhorniacrassipes, Lemna sp., Azolla pinnata, Spirodela polyrhiza, Nymphaea nauchali, Nelumbo nucifera, Ceratophyllum demersum, Potamogeton crispus, Ludwigia sp., Polygonum hydropiper, P. sylvestris, Marsilea quadrifolia, Alternanthera philoxeroide, Ipomoea aquatica and Monocharia 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, Nymphaeanauchali, Eichhorniacrassipes, Aeschynomene aspera and Monocharia hastata were also observed as the most troublesome weeds.Cyperus defformis, C. rotundus, Hydrilla verticillata, Aeschynomene aspera and Sagittaria guayanesishave beenreported 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 invertabrates [25] and some other vertebrates 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. 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, Monocharia 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, Monocharia 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 suppreesed 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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