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Assessment of Macro and Microelement Accumulation Capability of Aquatic Weeds Growing with Gorgon Nut

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Abstract: Gorgon nut (*Euryale ferox* Salisb.) is an aquatic plant, and generally grows in ponds or lakes with aquatic weeds and thus faces strong competition for the uptake of nutrients from the growing medium. However, weeds can be used as roughages for animals and for organic compost as weeds remove nutrients from water bodies. Furthermore, their nutrient absorption capacity has not been studied in detail especially when they are growing in association with gorgon nut. In this study, an attempt has been made to assess the food value of *Marsilea quadrifolia*, *Eichhornia cressipes, Ceratophyllum demersum, Ipomoea aquatica and Azolla pinnata,* growing in association with gorgon nut. The results showed that *Ipomoea aquatic* had the highest protein content while N concentration was highest in *Azolla pinnata* (3.60 %). The maximum P and K content were found in *Ceratophillum demersum* and *Ipomoea aquatica*, respectively. The highest accumulation of heavy metals was observed in the tissues of *Marsilea quadrifolia* and lowest in *Ipomoea aquatica*.

Key words: *Aquatic weeds, macronutrient, micronutrient, soil sediments, water*

Introduction

Weeds grow under varied edaphic conditions of climate throughout the year in the agricultural field as well as in the uncultivated land. They compete with the main crop in the uptake of nutrients. Singh and Singh (1939) reported that many weeds are highly selective in the absorption of certain ions and are rich in major and trace elements. Likewise, aquatic plants also selectively absorb macro and micronutrients from water and soil sediments (Singh 2017).

The aquatic environments are normally rich in inorganic nutrients as they receive them from water flowing from the nutrient rich agricultural fields and households of densely populated localities. Therefore, it helps the higher plants to grow profusely in the aquatic environments and thus increase the gross productivity through photosynthesis. Decomposition of aquatic plants also add several inorganic nutrients to aquatic environment, through the activities of microbes (Kumar *et al*. 2018)

Aquatic plants are considered as an important component of the aquatic ecosystem not only as food

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source for aquatic invertebrates, but also act as an efficient accumulator of heavy metals (Janauer 2001). Bio-availability and bio-accumulation of essential and non-essential metals in aquatic ecosystems is gaining significance globally. Several of the submerged, emergent and free floating aquatic plants are known to accumulate and bio-concentrate heavy metals producing an internal concentration several folds greater than their surroundings (Chen *et al*. 2008). Various aquatic macrophytic species show different behaviour regarding their ability to accumulate elements in roots, stems and / or leaves (Jackson 1998). The property of accumulation of elements was found useful in bio-monitoring and amelioration of water bodies (Vajpayee *et al*. 1995; Whitton and Kelley 1995).

Gorgon nut (*Euryale ferox* Salisb.) is an aquatic plant with large spiny floating leaves, also known as fox nut or *makhana* mostly cultivated in ponds (water depth: 0.75 m to 1.20 m) and low lying shallow wetlands having water depth of 0.45 m to 0.60 m (Singh 2017). The cultivation of gorgon nut is mainly concentrated in north Bihar and in some part of Assam. Bihar contributes 85 % of the total gorgon nut production from India. The productivity potential of the gorgon nut crop is 2.8 to 3.0 t ha^{-1} (Kumar *et al.* 2014). The yield potential can be increased up to 4.0 t ha^{-1} but due to heavy infestation of aquatic weeds its potential gets impaired. However, weeds also contribute organic matter and nutrients to the soils on their decomposition and some of them are used as for roughage to animals. The present study highlights the chemical composition of commonly growing weeds associated with Gorgon nut suited to organic compost and fodder.

Materials and Methods

The weeds *E. crassipes*, *M. quadrifolia, C. demersum*, *I. aquatica* and *A. pinnata* available in the makhana fields were collected prior to the flowering stage from the farm of the ICAR-RCER, Research Centre for Makhana, Darbhanga. The biomass was calculated on dry weight basis. The weed plants were uprooted from the water column, air-dried and ground through Willey crushing machine to pass through a 2 mm sieve. The sieved material was stored for chemical analysis.

The numbers of weed plants were counted on per square meter area basis. The organic carbon, total nitrogen (N), phosphorus (P), potassium (K), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) plant constituents were estimated according to the procedures outlined by Jackson (1973)**.** The nutrient concentrations in plant samples were expressed on a dry weight basis. Mean nutrient concentrations in the plant material were calculated. Crude protein was estimated, multiplying total nitrogen by a factor of 6.25.

Results and Discussion

Population density, biomass yield and protein content of aquatic weeds growing in association with makhana crop

The highest number (132 plants m^{-2}) of plants was recorded for *M. quadrifolia* while the lowest was with *E. crassipes* (Table 1). The number of plants recorded with *C. demersum* and *I. aquatica* were 5 and 10, respectively. The highest protein content was recorded in the biomass of *I. aquatica* (25 %) followed by *A. pinnata* (22.5 %). The other three weed species had almost similar protein content in their vegetative organs. On account of having a large vegetative organ, *E. crassipes* had maximum biomass. The *I. aquatica* was the second largest contributor of organic matter (1.30 q ha^{-1}) to the soil whereas the lowest biomass (0.07 q ha^{-1}) was added by *C. demersum*. *I. aquatica* also contained the highest organic carbon content (45 %) followed by *E. crassipes* (42 %).

Table 1. Population density, biomass yield and crude protein content of certain aquatic weeds growing in association with makhana crop

Aquatic weed species	No. of plants / m^2	Organic carbon (%)	Crude protein (% d.w.)	Standing weed biomass dry Weight (kg ha^{-1})
Marsilea quadrifolia	132	36	14.06	62.00
Eichhornia crassipes	2	42	15.35	200.00
Ceratophyllum demersum	5	30	18.20	7.00
Ipomoea aquatica	10	45	25.00	130.00
Azolla pinnata	-	29	22.50	120.00

-Difficult to count

Macronutrient content in aquatic weeds

The submerged species (*C. demersum)* had higher content of N (2.78 %) compared to floating leaved vascular weed species. *A. pinnata* was superior than vascular plants for nitrogen content (3.60 %), due to its association with *Anabaena azollae* further application of *Azolla* as green manure to wheat (Prasad and Ram 1981) and increased N concentration in wheat crop (Ram and Prasad 1982). On an average, *C. demersum* contained nearly twice the mineral P (0.30 %) than the emergent species whereas the lowest content of P was recorded with *A. pinnata* (0.08 %). This might be attributed to the fact that *A. pinnata* being a rootless flora do not have any direct support system to absorb nutrients from soil sediments. The similar trend of P concentration in vegetative tissues of *Euryale ferox* was reported by Kumar *et al.* (2018). All the weeds absorb K in higher quantity from the soil solution and it was highest in *E. crassipes* (2.85 %). The C:N ratios varied from 10.80 to 17.70. A critical C:N ratio of 20 for the added organic materials has been suggested by Jensen (1929). According to him, plant residues having a C:N ratio above this will cause an initial immobilization of soil nitrogen when added to the soil, whereas below this, net release of inorganic nitrogen will take place. All emergent plants and *A. pinnata* had C:P ratio more than 225:1. A critical C:P ratio around 200 (Kaila 1949) for the mineralization of soil organic phosphorus has also been described. Thus it can be inferred that these weeds may likely to result in the sustained microbial release of nitrogen, phosphorus and other plant nutrients.

Table 2. Chemical analysis of inorganic elements of aquatic weed species (on oven dry-basis)

Aquatic weed species	Organic carbon (%)	N (%)	P (%)	K (%)	C:N	C:P
Marsilea quadrifolia	36	2.25	0.16	1.56	16:1	225:1
Eichhorni acrassipes	42	2.40	0.13	2.85	17.5:1	323:1
Ceratophyllum demersum	30	2.78	0.30	2.52	10.8:1	100:1
Ipomoea aquatica	45	2.54	0.20	2.65	17.7:1	225:1
Azolla pinnata	29	3.60	0.08	0.67	8.05:1	362.5:1

Micronutrient content in aquatic weed

In general, uptake of elements by wetland plants varies among species, and is related to rooting depth and plant life form (Guilizzoni 1991). It was observed that *M. quadrifolia* (2400 mg kg^{-1}) and *C. demersum* (2405 mg kg^{-1}) were equally capable in absorbing Fe from the soil sediment. Singh (2017) reported similar concentration of Fe in tissues of gorgon nut and water chestnut. Mays and Edwards (2001) opined that submerged and floating-leaved species, which can absorb soluble elements directly from the water into shoots, often have greater accumulation of metals than emergent species. The Mn concentration was found in the order of *M. quadrifolia* (800 mg kg^{-1}), *E. crassipes* (1245 mg kg^{-1}), *C. demersum* (492 mg kg^{-1}), *I. aquatica* (700 mg kg^{-1}) and *A. pinnata* (360 mg kg^{-1}). Emergent plant species, in general, appeared to contain more concentration of Mn than the submerged plant (*C. demersum)*. This was in agreement with the findings of Shah and Reddy (2014). *A. pinnata* had the lowest concentration of Zn (40 mg kg^{-1}) among the aquatic weeds while the highest concentration of Zn was recorded in plant tissues of *M. quadrifolia* (195 mg kg^{-1}). Singh (2017) also reported similar findings in *Euryale ferox*. Maximum accumulation of Cu was found in shoot system of *M. quadrifolia* (38 mg kg^{-1}) followed by *I. aquatica* (35 mg kg^{-1}) which indicated that this species could be used as phyto-remediant for Cu contaminated water bodies. Rai and Sinha (2001) and Rai *et al.* (1996) also reported high accumulation of Cu in tissues of *I. aquatica*, *Marsilea minuta* and *Nelumbo nucifera*. Similar inferences were also drawn by Sawidis *et al*. (1995).

Table 3. Micro-nutrient content in aquatic weed species

Aquatic weed species	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})
Marsilea quadrifolia	2400	840	195	38
Eichhornia crassipes	2225	1245	170	33
Ceratophyllum demersum	2405	492	182	28
Ipomoea aquatica	2300	700	90	35
Azolla pinnata	550	360	40	32

Conclusion

Based on chemical composition, the weed species can be used as fodder crop as they were rich in protein content. *C. demersum* was identified as a good source of essential N, P and K. The addition of these weeds is likely to result in the microbial release of nitrogen, phosphorus and other plant nutrients. It could be concluded that *M. quadrifolia and C. demersum* have higher capacity to absorb heavy metals from the soil solutions and may be used as phytoremediants.

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