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Bioaccumulation of Plant Nutrients by *Euryale ferox* Salisb. Growing in Field Condition in Northern Bihar of North India

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ABSTRACT

E. ferox an aquatic plant requires a rich soil, preferably growing in still water. It prefers tropical and sub-tropical climate. In general, aquatic plants take up large quantities of nutrients and metals from environment, releasing them when they decay. They also differ both in their capacity to take up nutrient elements in root tissues and in the proportion of nutrient transferred to above ground parts. With this view, nutrient elements concentrations in different parts of the *E. ferox* and their contribution to the soil system were studied. The study showed that *E. ferox* tended to have highest tissue concentrations of N and P in the leaf parts while the less soluble Fe, Mn and intermediately soluble Zn exhibited greater concentrations in roots than in shoots. Thus, *E. ferox* can also be proved to be a better option as an alternative crop to include it in cropping system mode under field condition to replenish the exhausted nutrients such as N, P and Zn by the cultivation of other cereal crops.

Introduction

The northeastern part of India has chains of rivers, intersected with many tributaries and canals. This has made possible a saucer-shaped wetland ecosystem bounded by land. Categorically, wetlands are lands transitional between terrestrial and wet areas, where the soil is frequently waterlogged during rainy months the water table is usually at or near the surface or the land is inundated by varying depths of water. Wetlands form the transitional zone between land and water. Saturation with water is the dominant factor, determining the nature of soil developed and the type of the plant and animals communities living on it.

Wetlands within the state of Bihar are attributed mainly to the complex fluvial geomorphology of the Gangetic tributaries which have over a period of time created a number of natural depressions and cut-off meanders known variously as *mauns, chaurs* and *taals*. These wetlands are a characteristic feature of the inter fluvial regimes of Gangetic plains which are completely inundated during monsoon and remain shallow with a maximum depth of 1.5m, and mostly dry by March-June. Kabartaal (Begusarai), Kusheshwarsthan (Darbhanga), Baraila (Vaishali), and Motijheel (East Champaran) are some of the major wetlands of the state. Wild rice, *Makhana* (*Euryale ferox*), and water chestnut (*Trapa bispinosa*), and some of the aquatic weeds such as *Cyperus* spp., *Eleocharis* sp., *Phragmites* sp., *Hydrilla verticillata*, *Vallisneria spiralis, Eichhornia crasssipes* and *Azolla pinnata* are some of the main wetland flora that form an integral part of local culture.

The total area of wetlands in India has been estimated to be 15.26 m ha approximately covering 5% of national geographic area (Kumar, 2012). The survival of human civilization is inextricably linked with wetlands, which sustain the economic stability of hundreds of millions of people. And this swampy environment of the carboniferous period produced and preserved many of the fossil fuels on which we greatly depend now. Thus James (1995) has rightly termed these areas as Nature's Kidney."

E. ferox is one of the most popular and economically important food crop of north Bihar wetlands. It is an annual floating-leaved herb (with C3 type of photosynthesis) growing in diverse areas from the tropics to the frigid zones, with a great importance to a wide sector of rural people. It is native to Southeast Asia, and prevalent in tropical and subtropical regions with humid to sub-humid environments, like China, Japan, Malaysia, Thailand, the Philippines, Java, Sumatra, Nepal, Bangladesh, Sri Lanka, and India. In India, it is distributed in West Bengal, Bihar, Manipur, Tripura, Assam, eastern Odisha, Kashmir lakes and Uttar Pradesh. However, its commercial cultivation is limited to north Bihar. In the state of Bihar, major *E. ferox* producing districts include Darbhanga, Madhubani, Saharsa, Supaul, Araria, Kishanganj, Purnia and Katihar. Approximately, 80% of total production of processed *E. ferox*comes from Darbhanga, Madhubani, Purnia and Katihar districts alone. Area under *E. ferox* cultivation in Bihar is about 13,000 ha.

From nutritional point of view, *E. ferox* is considered a superior dry fruit, as it is endowed with several rich nutritional ingredients. The popped *E. ferox* contain 12.8% moisture (w/w), 9.7% protein, 0.4% fat, crude fiber (% by wt) 0.2, calorific value (k.cals/100 g) 358, amylose 18.2%, phosphorus 53.2 mg/100 g, and iron 1.4 mg/100 g (Kumar *et al.*, 2011). It has high essential amino acid index (Jha *et al.*, 1991a, b).

Besides the production of food, wetlands are continuously enriched by the addition of large quantities of biomass, and the soil is enriched in consequence. *E. ferox* is also known to incorporate huge amount of organic matter (6-10 tonnes/ha) to the soil on account of having large leaf size and extensive root system. Soil organic matter serves as an important store house of nutrients, drives nutrient cycle, improves soil productivity, promotes water retention, and reduces erosion (Bulluck *et al.*, 2002). Under crop cultivation, changes in soil organic matter status would determine the dynamics of alluvial soil quality of wet lands. In addition to makhana, the other component crops also add an appreciable amount of organic matter to soil. Jha and Dutta (2003) had reported the chemical changes in soil under *E. ferox* plants growing in naturally existing ponds.

The biomass yield of makhana, growing in ponds in India, was positively correlated with N, K, and organic C, with the electrical conductivity of the soil, and with the contents of N, K, P, Na, Cl, HCO^{-1}, Ca + Mg, and SO_4^{-2}(Dutta and Jha, 1984; Dutta *et al.*, 1986). A typical grayish black-to black coloured soil dominated by clay (mucky type) is the main characteristic feature in low-lying areas of this zone. Indeed, organic matter is comparatively high, but, due to anaerobic condition prevailing for many months during wet season, it is partially decomposed. The soil status may further be improved if same period is allowed for quick decaying of such waste materials during post-wet months under aerobic conditions. In this region, one of the most conventional practices by farmers is to utilize this resource-rich humus soil for the succeeding arable crops (rice, potato and wheat) (Mahto and Jha, 1998). The aquatic plants growing in the study area exhibit different macro and micro element concentrations depending on the plant organ and both the sampling time and the sampling sites. Roots of aquatic plants absorb nutrient elements from the sediments and accumulate high concentrations (Baldantoni *et al.*, 2004). It is a novel study and on this aspect, no reference is available particularly on contribution of nutrients by *E. ferox* crop to the soil.

In the light of above mentioned facts the present study is an evaluation of chemical composition of different organs of *E. ferox* plants growing in shallow wetland condition in Darbhanga region of northern Bihar.

Materials and Methods

A field trial was conducted during 01.03.2012 to 30.03.2015 at the research farm of the ICAR-RCER, Regional Research Centre for Makhana, Darbhanga, north Bihar, India, located in the Bagmati flood plain (lat. 26° 10' N, long. 85° 87' E, elev. 49 m a.s.l. and mean annual rainfall 1150 mm). *E. ferox* plants were uprooted from the soil, air-dried and ground through Willey crushing machine to pass through a 2-mm sieve. The sieved material was stored for chemical analysis. Plant samples were taken at physiological maturity of *E. ferox* plants for the determination of nitrogen(N), phosphorus (P), potassium (K), iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn)in edible and non-edible parts of the plant. Crop uptake of macronutrients such as N, P and K and micronutrients such as Fe, Mn, Cu and Zn were estimated by multiplying the dry matter yields (after drying at 70°C to constant weight) of the crop with their corresponding nutrient contents. Nutrient contents in plant parts were measured using standard procedures (Jackson, 1973). All nutrient concentrations in plant samples were expressed on a dry weight basis. Mean nutrient concentrations in the plant material of each crop were calculated.

Results and Discussion

Nutrient absorption by *E. ferox*

The data on absorption of macro and micro nutrient elements by the different organs of the *E. ferox* have been depicted in figures 1–7. The concentration of N, P and K in different vegetative organs of *E. ferox* showed that leaf tissues recorded maximum N (0.31%) followed by root parts (0.28%). The lowest N content (0.24%) was recorded in fruit sheath and petiole (Fig. 1) while in case of P concentration the fruit sheath (0.50%) was found to be the highest accumulator organ of the plant (Fig. 2). In particular, for nitrogen and phosphorus, Jha and Dutta (2003) found N and P concentrations ranging, respectively, from 0.16 to 0.19% and 0.16 to 0.57% in vegetative parts of *E. ferox*. N and P concentrations reported by them are comparable to those measured in *E. ferox* leaves collected from old traditional ponds. By contrast, the concentration of K was higher in roots (0.55%) than in leaves (040%). The fruit sheath (0.28%) was observed as the lowest accumulator of K (Fig. 3). The low contents of K in tissues of *E. ferox* might be attributed to prolonged flooding that resulted in decreased concentration in flooded plants, which is supported by lower transport of K to shoots under flooding.

Root oxygen deficiency decreases the selectivity of K^+/Na^+ uptake by roots in favour of Na^+ and retards the transport of K^+ to shoots (Thompson *et al.,* 1989). This change in selectivity of ion uptake may be one of the causes of Na accumulation in flooded plants (data not shown). Similar results have been reported by Jha and Dutta (2003).

Roots of *E. ferox* showed a high absorption of plant nutrients from the sediments and accumulation of high concentrations of micronutrients like Fe, Mn, Cu and Zn. This may be attributed to the fact that in flooded soils, soluble Fe^{2+} and Mn^{2+} can lead to excessive uptake during prolonged inundation.

Even if shoots and / or leaves of *E. ferox* were found to accumulate an appreciable quantity of trace elements but lesser (Fe and Mn) than roots. Similar observations were also made by Qian *et al.,* (1999) who found that most trace elements showed a greater concentration in roots than shoots. Fe and Mn concentrations continued to be greater in roots of *E. ferox*.

The maximum concentration of iron (Fe) (2405 mg/kg) (Fig. 4) and manganese (Mn) (1050 mg/kg) (Fig. 5) were recorded in root parts of the plant while the lowest concentration of Fe (1790 mg/kg) and Mn (935 mg/kg) were determined in fruit sheath. The shallow roots and exposed leaves of *E. ferox* may have facilitated higher uptake of these less soluble metals which became concentrated in the aerobic water saturated *E. ferox* tend to be absorbed primarily from upper sediment layers via roots (Spence, 1964). Root oxidation could also have contributed to formation of Fe plaques which can absorb metals and are associated with divalent cations that can interfere with uptake of elements such as Na (Mitsch and Gosselink, 2000).Ye *et al.,* (2001) too had reported higher concentration of Fe in roots compared to shoots of cattail (*Typha latifolia*) in wetland used to treat coal combustion by-product leachate. Indeed, high contents of metals (particularly of Fe and Mn) in roots and low concentration in leaves indicate that only a fraction is transferred from roots to the above ground part of the plant.

The leaf tissue of *E. ferox* was observed to be the highest accumulator of zinc (105 mg/kg) followed by petiole tissues (80 mg/kg) (Fig. 7). In contrast to Fe and Mn absorption the absorption of Zn metal was found to be higher in shoot than root. This might be attributed to the higher mobility of Zn in the plant body in comparison to Fe and Mn. Pertaining to the copper concentration in plant tissues, almost similar/equivalent amount was noticed in different vegetative organs of *E. ferox* plant (Fig. 6).

This type of uptake pattern confirms the direct adsorption from the water into the shoots or confirms the contribution of water pertaining to translocation of nutrients to the shoot parts of the plant. It is difficult to establish whether, and in what proportion an element is taken up from sediments by the roots of floating plant or from water directly by the shoots; it certainly depends on the chemical behavior of elements and also on sediment geochemistry (Jackson, 1998).

Fig.1 N concentrations in different vegetative and seed parts of *E. ferox*

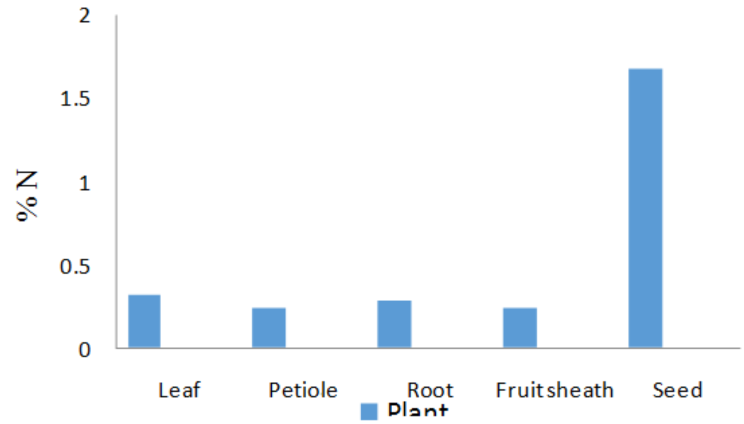

Fig.2 P concentrations in different vegetative and seed parts of *E. ferox*

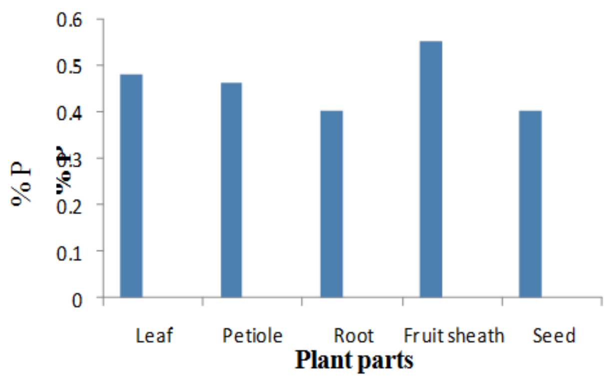

Fig.3 K concentrations in different vegetative and seed parts of *E. ferox*

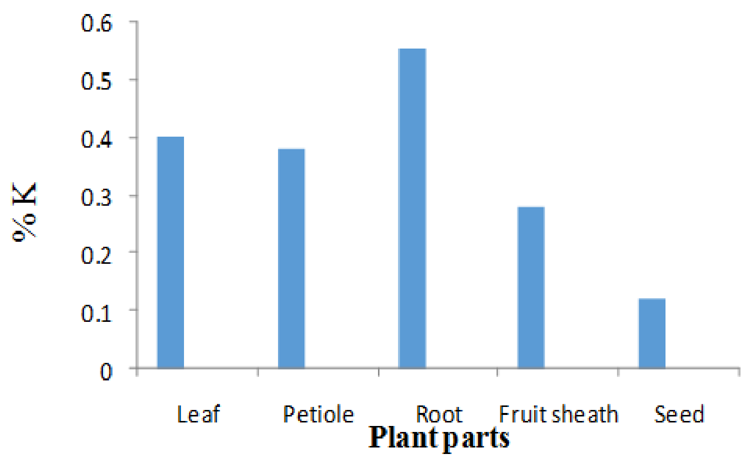

Fig.4 Fe concentrations in different vegetative and seed parts of *E. ferox*

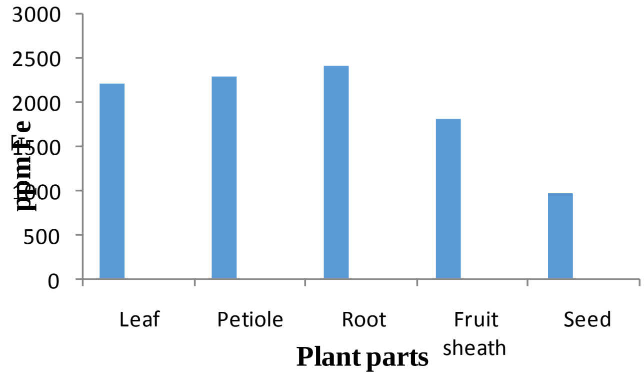

Fig.5 Mn concentrations in different vegetative and seed parts of *E. ferox*

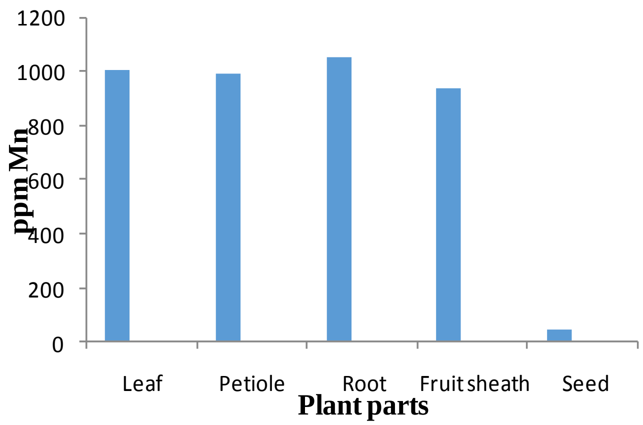

Fig.6 Cu concentrations in different vegetative and seed parts of *E. ferox*

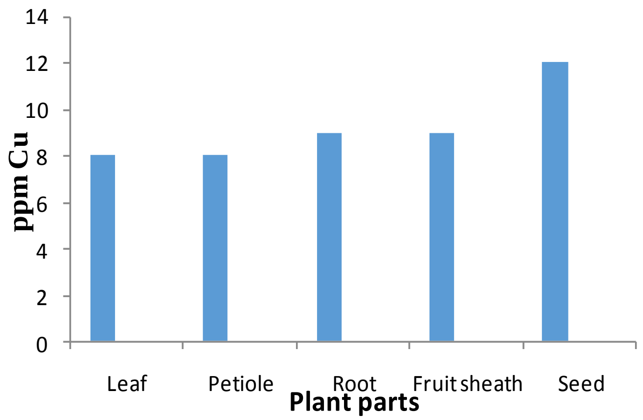

Fig.7 Zn concentrations in different vegetative and seed parts of *E. ferox*

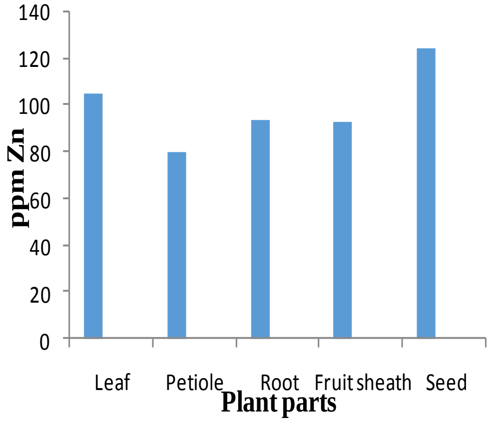

Table.1 Nutrient contribution through *E. ferox* to the soil (mean values of three years data)

Plant parts	N kg/ha	P kg/ha	K kg/ha	Fe kg/ha	Mn kg/ha	Cu kg/ha	Zn kg/ha
Leaf	14.72	22.80	19.00	10.45	4.75	0.038	0.50
Petiole	4.05	7.77	6.42	3.85	1.67	0.01	0.13
Root	11.87	16.96	23.32	10.19	4.45	0.04	0.039
Fruit sheath	3.71	8.51	4.33	2.77	1.44	0.01	0.14
Seed	35.07	8.40	2.52	2.016	0.08	0.02	0.26
CD (*P*=0.05)	1.065	1.135	0.638	0.661	0.502	0.011	0.033

Moreover, it is difficult to establish the amount of an element that is transferred from the roots to the shoots.

Trace metal concentration in aquatic plants vary considerably according to the part of the plant as well as to the chemical characteristics of the plants (Baldantoni *et al.*, 2004).

The starch and hard coat of seed have also been proved to be the excellent contributor of macro-elements such as N and P as the seeds have been found to accumulate significant amount of Fe and Zn.

Nutrient contribution through *E. ferox* to the soil

The importance of *E. ferox* in relation to improvement of soil fertility has shown that biomass on decomposition adds approximately 34.35, 56.04, 53.07and 27.26, 12.31 kg/ha N, P, K, Fe and Mn, respectively to the soil (Table 1). The maximum contribution of nutrients has been made by leaf and root organs of E. *ferox*. These results are in conformity with the findings of Singh *et al.*, (2014) who reported that makhana based cropping system found to be the best cropping system pertaining to the improvement in fertility status of soil. They also reiterated that enrichment of nutrients to the soil system under the Makhana cropping system involving is due to its contribution through addition of an appreciable amount of organic matter (10 t/ha) into the soil on decomposition of the biomass (Kumar *et al.*, 2013). Earlier, Jha and Dutta (2003) also noticed Makhana cropping in natural pond significantly contributed an appreciable quantity of P and K to the soil. Singh *et al.*, (2014) found similar results regarding the quantity of micronutrients added into the soil due to decomposition of biomass of makhana crop. The removal of N, P, K, Fe, Mn, Cu and Zn by the seeds from the pond soil has been recorded as 35.07, 8.40, 2.52, 2.016, 0.08, 0.02 and 0.26 kg/ha, respectively. However, the total uptake of these nutrients made by *E. ferox* was recorded to be 69.42 kg/ha N, 64.44 kg/ha P, 55.59 kg/ha K, 29.27 kg/ha Fe and 12.39 kg/ha Mn. The uptake and removal amount of other nutrients from the soil is very less as it does not take part in effectively affecting the fertility status of soil.

In conclusion, *E. ferox* grown in shallow wetlands/field condition accumulated substantial amount of P, Fe, Mn and Zn elements in biomass, which could certainly contribute to removal of these elements from metal contaminated waters and soils. The leaf and root of the plant have been found to be the major contributor of nutrients to the soil. *E. ferox* tended to have highest tissue concentrations of the less soluble Fe and Mn, with greater concentrations in roots than in shoots. Thus, *E. ferox* proved a better option as an alternative crop to be included in cropping system mode to replenish the exhausted nutrients such as N, P and Zn by the cultivation of other cereals (rice and wheat). Thus, it greatly helps in sustainable management of natural resources. *E. ferox* has been identified as one of the most important aquatic crop whose cultivation is highly beneficial for soil-water-plant continuum as it contributes a lot of organic matter to the soil. It also provides most of the nutritionally important essential elements such as P, Fe and Zn in higher quantities as compared with other cereal and leguminous crops.

References

Baldantoni, D., Alfani, A., Di Tommasi, P., Bartoli, G., De santo, A. (2004) Assessment of macro and microelement accumulation capability of two aquatic plants. *Environ. Pollut.*130: 149-156.

Bulluck, L.R., Brosius, M., Evanylo, G.K. and Ristaino, J.B. (2002) Organic and synthetic fertility amendments on organic conventional farms. *Appl. Soil Ecol.*,19: 147-160.

Dutta, R.N. Jha, U.N. and S.N. Jha, (1984) Water quality and soil properties of ponds as influenced by *E. ferox* cultivation. *Plant and Soil*,80: 441-445.

Dutta, R.N., Jha, U.N. and Jha, S.N. (1986) Relationship of biomass yield of *E. ferox* with soil properties and water quality, *Plant and Soil*, 95: 345-350.

Jackson, M L. (1973) *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd., New Delhi, 498 pp.

James, E.J. (1995) Managing the wetlands and their watersheds. *Yojana*, 39 (182): 43-50.

Jha, S.N. and Dutta, R.N. (2003) Soil-Water Chemistry of *E. ferox* Cultivation. In. Mishra, R.K, Jha, V. and Dehadrai, P.V. (eds). DIPA, ICAR, New Delhi. Pp. 73-84.

Jha, V., Kargupta A. N., Dutta R.N., Jha U.N., Mishra R.K. and Saraswati, K. C. (1991). Utilization and conservation of *Euryale ferox* Salisb in Mithila (North Bihar), India. Aquatic Bot., 39:295-314.

Jha, V., Barat, G.K.,and Jha, U.N. (1991) A Nutritional evaluation of *Euryale ferox* Salisb (Makhana). Journal of food science and Technology. 8 (5):326-328.

Mahto, A., and Jha, V., (1998) Masimizing productivity in the low lying field of Darbhanga (north Bihar, India): A case study of crop rotation between Makhana (*Euryale ferox* Salisb.) and Wheat (*Triticum aestivum*) J. fres water Bio. 10(1-2):25-31.

Kumar, L., Gupta, V.K., Jha, B.K., Singh, I.S., Bhatt, B.P. and Singh, A.K. (2011) Status of (*Euryale ferox* Salisb.)

Cultivation in India. *Tech. Bull. No. R-32/PAT-21*. ICAR RCER, Patna P. 31.

Kumar, L., Singh, I.S., Gupta, V.K., Bhatt, B.P., Jha, B.K. and Sikka, A.K. (2013) Makhanaki Kheti ki UnnatTakneek. *Technical Bulletin* Pp. 1-31. Published by ICAR Research Complex for Eatern Region, Patna.

Kumar, R. (2012) Conserving Wetlands in India Prospects and Challenges. *News Letter* (Sarovar), 1: 6-10, Published by Wetlands International-South Asia, New Delhi

Mitsch, W.J. and Gosselink, J.G. (2000) Wetlands, Third edn., John Willey and Sons, Inc., New York.

Qian, J., Zayed, A., Zhu, Y., Yu, M. and Terry, N. (1999) Phytoaccumulation of trace elements by wetland plants: III. Uptake and accumulation of ten trace elements by twelve plant species. *J.Environ. Qual.*,28: 1448–1455.

Singh, I.S. (2014). Nutrient contribution by makhana crop to the soil and removal of nutrients by seed parts. *Annual Report* (2013-14), ICAR RCER, Patnap. 49.

Singh, I.S., Kumar, L., Singh, A.K., Bhatt, B.P. and Singh, S.P. (2014) Impact of makhana, (*Euryale ferox* Salisb.) based cropping systems on nutrient dynamics of inceptisols of north Bihar. *Int. J. Agric. Stat. Sci.*, 10: 125-129.

Spence, D.H.N. (1964) Themacrophyte vegetation of fresh water lochs, swamps and associated fens. (In): Burnett, J.H. (ed.), The Vegetation of Scotland. Oliver & Boyd, Edinburgh.

Thomson, C.J., Atwell, B.J., Greenway, H. (1989) Response of wheat seedlings to low O_2 concentrations in nutrient solution: II K^+/Na^+ selectivity of tissues of different age. *J. Exp. Bot.*,40: 993-999.

Ye, Z., Whiting, S.N., Lin, Z.Q., Lytle, C.M., Qian, J.H. and Terry, N. (2001) Removal and distribution of iron, manganese, cobalt and nickel within a Pennsylvania constructed wetland treating coal combustion by product leachate. *J. Environ. Qual.*, 30: 1464-1473.

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