



Potentiality of water chestnut (*Trapa natans*) in aquaculture of Bangladesh

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ABSTRACT

The study was conducted to know the contribution of water chestnut (*Trapa natans*) in the aquaculture of Bangladesh. The study were also performed to know the general biology of the plant, propagation process, growth performance, culture system, problems, harvesting system, per decimal (dec) production etc. Data were collected from four upazilas under four districts for eight months from April to November 2017. Traditional culture system was included in this research work that was practiced by the farmers in our country. During the study some food items were made with water chestnut flour, such as cake, halua, morobba and raw water chestnut was used to make different types of curry. Chemical analysis showed that the moisture content were 96.67%, 90.35%; lipid were 1.20%, 1.65%; protein were 0.30%, 0.94%; carbohydrate were 0.50%, 5.38%; ash were 0.18%, 0.64% and fiber were 1.15%, 1.05%, respectively for green and red water chestnut. The marketing channels from farmers to consumers were passed through a number of intermediaries such as local water chestnut traders (paikers), wholesalers and retailers. The cost-benefit ratio was varied from one farmer to another because of their culture systems, economic capability, labor cost, disease, ownership of land etc. The production cost was BDT 80/dec and benefit was BDT 220/dec in one case, however for other farmer the production cost was BDT 100/dec and benefit was BDT 506.25 for second cases. Improved traditional culture system was used for second cases so farmers got high profit. If these culture systems are expanded throughout the country especially in flood plain region, farmers will get extra benefit from their land. In Bangladesh, agricultural crops frequently damaged due to flood. If water chestnut in these flood affected land is cultured, farmers will recover their investment and get extra benefit.

INTRODUCTION

Aquaculture in Bangladesh is growing so rapidly which meets the food security and economic solvency of huge number of people. Aquaculture contributes 55% among the total fish production (42.77 lakh MT). Aquaculture covers the farming of both animals (including crustaceans, finfish and molluscs) and plants (including seaweeds and freshwater macrophytes). Now a day's aquatic plants are included in aquaculture due to its food value as well as medicinal values in our country. Among the aquatic plants (total 150 species in Bangladesh), water chestnut is one of the most important aquatic plant which provide us nutritious food as well as medicine. It is also known as water caltrop, panifol or singhara. This fruit belongs to the kingdom *Plantae* and

Lythraceae family. It has three species of the genus *Trapa*: *Trapa natans*, *T. bicornis* and the endangered *Trapa rossica*. Though, it is a seasonal vegetable, mostly available after rainy season till the start of winter but processed water chestnut is available throughout the year in many countries. Besides their crunchy texture and sweet mild flavor, water chestnut possesses remarkable nutritional composition, making them an excellent food source (Adkar et al., 2014; Daily Sun, 2017). It is one of the most popular vegetables used in Asia, due to its special feature and medicinal values. They are used to make flour and cake. It is rich in carbohydrate, fiber, vitamins and minerals. In Thailand, it is the important component of famous Thai desert 'tabtimkrob'. In the developed countries, it is used along with bacon strips as a hors d'oeuvre and mixed with drinks in Indonesia.

In India, water chestnut flour uses to make puri, halua, ruti, barfi, batter etc. and other forms are also used such as juice, cake, sliced, eaten raw and steamed. The juice of water chestnut is used to control diarrhea and dysentery and the fruits are used in treating sore throat, anemia, fractures, and bronchitis and in leprosy (Rahman et al., 2000). It helps in treating hypertension during pregnancy and improves fetal growth. The dried seeds stop bleeding and treat miscarriage issues in women. It also promotes mammary gland secretion of milk. The juice extracted from water chestnuts eliminates the humor of bile and phlegm and cures plethora. It also increases virility. Water chestnuts eliminate inflammations and blood impurities. Jaiswal (2015) reported that it prevents goiter and thyroid problems, cures tonsils, relief from cracked heels and lips, keep good pregnant ladies. It has adequate amount of K and low amount of Na thus good for blood pressure and heart. Rani et al. (2016) stated that water chestnut is almost fatless and therefore a healthy food option; an excellent source of potassium (350-360mg), a very important mineral for human and an ideal fruit for diabetic patients. 100 g water chestnut contains (97 calories), fat (0.1g), K (584mg), Na (14mg), carbohydrates (24g), protein (1.4g), and fiber (2g); Ca (1%), vitamin C (6%), vitamin B-6 (15%), and Mg (5%).

Although water chestnut is considered as aquatic weeds in many countries and control practices are done but in Asian region it is used as vegetables or fruit for its medicinal and nutritional value. As part of cultivation, water chestnut culture is becoming popular in Bangladesh. There are some fellow lands that are not used for agricultural purposes and remain under water during rainy season, water chestnut can be easily cultivated in this non agriculture waddy land. In addition, the production cost of water chestnut is minimum in Bangladesh and the environment is favorable for its production. For these reason water chestnut culture is becoming popular in this country. Many districts such as Bogura, Naogaon, Sherpur, Jamalpur, Satkhira are cultivating water chestnut for commercial purposes. In Satkhira, many people are engaged in water chestnut production. They have already converted their fish and rice production pond or low land to water chestnut culture land because it is more profitable in cost

and benefit ratio. In Dawangonj upazila of Jamalpur district, almost all agricultural farmers are converted to water chestnut farmers with little investment since this area is affected by flood.

Generally, farmers follow very simple culture technique for agricultural production. Some farmers use few fertilizers and herbicides for more production and some are not using anything in the production unit. Nominal care is taken by the farmer and after several months they get their crops. Now a day, farmers consider water chestnut as a cash crop. In the 2014-2015 fiscal year, water chestnut had been planted in 100 ha of land at Dawangonj upazila and now this limit has been crossed to 150 ha for the last fiscal year. Water chestnut cultivation brings huge change for farmers in Jamalpur district. Their livelihood is being improved and economic solvency has been increased. During harvesting season, the water chestnut markets become very busy. Temporary employment opportunity also created in this period. A good number of people are engaged for harvesting and marketing of water chestnut. Market held beside the railway station for easy transport and huge amount of water chestnut come to the market from different places. Buyers from different districts including Mymensingh, Gazipur, Dhaka and Sherpur come to the market to procure water chestnut. About 10 tons' water chestnut is transported daily from Dawangonj to the other parts of the country. Boiled water chestnuts also sell in the local market for easy consumption.

Water chestnut can be cultured with negligible cost because in traditional culture system there is no need of huge amount of fertilizer, labor, intensive care, pesticide for production of chestnut. The water chestnut culture is low cost aquaculture; however, the benefit is high. For these reason the marginal farmers can easily culture water chestnut with minimum cost and increase their earning to maintain their households. Considering the prospect and potentialities of water chestnut the present study was conducted to know the contribution of water chestnut in the aquaculture of Bangladesh. The study were also aimed to know the general biology of the plant, propagation process, growth performance, culture system, problems, harvesting system, per decimal (dec) production in Bangladesh.

MATERIALS AND METHODS

Study period and area

The study was conducted for a period of eight months from April to November, 2017. Data were collected through investigation of *hoar*, *beel*, pond and personal interview from different areas, such as Islampur upazila, Jamalpur; Bhaluka upazila, Mymensingh; Tala upazila, Satkhira; Hail *Hoar*, Sreemangal upazila, Moulvibazar and Field Laboratory Complex, Bangladesh Agricultural University (BAU), Mymensingh.

Target group

In the study area, a group of fishermen, fish farmer, shopkeeper, water chestnut harvester, public representative, day labor etc. were reported the traditional culture technique of water chestnut. Experienced persons were selected for interviewing. They were selected by general people of the study areas.

Preparation of interview schedule

In order to get a complete picture to fulfill the objectives of the study, a draft interview schedule was prepared. Then the interview schedule was pretested in the study area. Attention was paid to incorporate any new information, which was not designed to be asked and filled in the draft interview schedule. The interview schedule was then modified, changed and rearranged according to the experience gathered from the pre-test. The final schedule was developed in logical sequence so that the water chestnut harvester could answer chronologically. The schedule included various questions related to water chestnut culture technique, transplanting system, harvesting system, fertilizing system, per dec production, per plant production, problems of water chestnut culture, marketing system and the impacts on other aquatic weeds and fish.

Collection of data

During collection of data, both primary and secondary sources were considered. Primary data were collected from respondents by the researcher himself. Several visits were made to the study area

to collect accurate information related to objectives of the study through interview schedule. For the study, a combination of individual interview, such as focus group discussions (FGD) and key informant interviews were used for collecting the data from the respondents.

Sample collection

Water chestnut plants were collected from the study areas to transplant in pond of Field Laboratory Complex for close observation.

Transplantation

For the observation, some water chestnut plants were transplanted in the Field Laboratory Complex, BAU to know the growth performance, spreading pattern, leaves pattern, problems of water chestnut culture, suitability of soil, per dec production, per plants production and other relevant data.

Nutrient value analysis

Nutrient value was analyzed in nutrition laboratory to know the percentage of moisture, protein, fat and carbohydrate for two different varieties which was collected from different study areas.

RESULTS AND DISCUSSION

Habitat and reproductive mechanisms

During the study it was found that plant grew in slow-moving water up to 152.4-182.88 cm deep and needed nutrient-rich fresh water. Sunlight was very essential to propagate the plant. Their growth hampered due to insufficient sunlight. Soft substrate was very suitable for healthy growth. During the survey period it has been found that water chestnut plant shed seeds during winter. The seeds germinated in the mud during the warmer months, and produced stems that reached the water surface and produced rosettes. A single seed gave rise to 10 to 15 rosettes. Each rosette could produce up to 15 to 20 seeds (Table 1). The submerged stem produces new shoots and thus it propagates and spreads over the whole water surface. During the direct field observation, fragmentation process was used to disperse the

plant on the whole pond. During the study period it was observed that more than two-third of the plant remains submerged in water whereas the upper leaves float on the surface of water, giving a mat-like appearance to the water surface. It has glossy green floating leaves with triangular shape, inconspicuous white flowers. Stem reached only

152.4-182.88 cm. Each rosette produced at least 15 fruits and average no. was 21 fruits. And average fruit weight was 15g. However, Mehrhoff (2010) reported that annual aquatic plant with a submerged stem can reach 12-15 feet. Each rosette produces 8-10 fruits; it remains viable up to 12 years.

Table 1: An overview of different parts of water chestnut plant

Body parts	Number /rosette	Range	Average
Stem		15-20 cm (length)	17.5 cm
Leaves	65-70	10-15 cm (length)	12.5 cm
Flower	15-20	0.8-1.0 cm/petal	0.9 cm/petal
Fruit	15-20	12-18 g/water chestnut	15 g/water chestnut

Ecological threat

The study revealed that this aquatic plant formed dense floating mats that limited the penetration of light and oxygen to the other submerged species such as fish. Water chestnut competed with the native aquatic weeds such as duck weeds, kalmi, helanca, malancho, chad mala and other organisms for nutrients and space and offered little nutritional value for others. For these reason, it is a great challenge to culture water chestnut with fish and other aquaculture species. During the study it has been found that plant grows in slow-moving water up to 5-6 feet deep and needs nutrient-rich fresh water. Sunlight is very essential to propagate the plant. Their growth become hampers due to insufficient sunlight. Soft substrate is very favorable for healthy growth. Hummel and Kiviati (2004) found the similar trend of water chestnut

growth in aquatic environment. The species is found most abundantly in water around 2 m deep and in soft substrate.

Uses of water chestnut

According to the respondents water chestnut is one of the most popular vegetables in the country due to its special feature and medicinal values. People eat water chestnut as raw or boiled, someone uses to make salad. They cook various curries with the water chestnut. Some poor people eat water chestnut as their main food during winter season because of food scarcity in Dawangonj Upazila. During the study period some food item were made with water chestnut flour such as water chestnut cake, halua, morobba and raw water chestnut was used to make different type of curry (Figures 1 & 2).



Figure 1: Water chestnut flour, cake and halua



Figure 2: Water chestnut morobba, curry with dry fish and curry with egg

Proximate composition

During the study period proximate composition were analyzed in the Nutrition laboratory, Faculty of Fisheries, BAU, Mymensingh (Table 2). From the analysis it was found that carbohydrate content was remarkably higher in red water chestnut than green water chestnut. Chemical analysis showed that the moisture content for green and red water chestnut were 96.67% & 90.35 %; lipid were 1.20% & 1.65%; protein 0.30% & 0.94%; carbohydrate 0.50% & 5.38%; Ash 0.18% & 0.64% and fiber 1.15% & 1.05%, respectively. Shalabh et al. (2012) showed that the moisture content of water chestnut was 81.12% (wet basis). Fresh nuts having considerable water content are taken at breakfast (Puste, 2004). Negligible amount of fat content (0.36%) was noticed in the fruit which substantiates its importance as dietary food. Lee and Hwang (1998) also reported low crude lipid content (0.06%) in Chinese water chestnut. Crude fiber content of the water chestnut was found to be 0.72%, slightly higher than reported in Chinese water chestnut by Lee and Hwang (1998) as 0.60%. Total ash content obtained in fruit was 1.33% confirming good

amount of minerals in the fruit. Total protein content calculated in the fruit was 1.87%. Low protein content was reported earlier in water chestnuts (Puste, 2004). Total carbohydrate content was 11.26%. Lee and Hwang (1998) reported the contents of moisture, crude protein, crude lipid, crude ash, crude fiber and carbohydrate in the Chinese water chestnuts to be 79.40%, 1.74%, 0.065, 1.10%, 0.60% and 17.71%, respectively.

The result of the present study reported that the nutrient content of water chestnut was quiet comparable with those reported by Shalabh et al. (2012). During the study period, it has been found that the moisture content under mature stage were 96.67% & 90.35% (wet basis), however, Shalabh et al. (2012) reported that moisture content reduced at mature stage (81.12%) and over matured content less moisture. Total ash content was 0.18% & 0.65%, however ash content was increased due to maturity and was found 1.33%. Similarly, carbohydrate, lipid, fiber, protein was increased with increased in maturity. Other reason might be due to difference in variety, geophysical area, season and experimental error.

Table 2: Proximate composition (%) of water chestnut (Wet Basis)

Water chestnut	Moisture (%)	Protein (%)	Lipid(%)	Carbohydrate(%)	Ash (%)	Fiber (%)
Green	96.67	0.30	1.20	0.50	0.18	1.15
Red	90.35	0.94	1.65	5.38	0.64	1.05

Natural production of water chestnut (Local)

When the fruit ripen in November, it goes downward and took several months to germinate (March) the stem. After few days later the tree branches were spread-out (from March to August)

in the whole water body. Flower appeared from July to August (Figure 3). After 30-40 days later each flower turned into fruit and became eligible for human consumption. Each plant provided at least ten branches and each branch held eight to ten fruit (Figure 4). Fruit harvesting was running

until late winter. Main harvester group was young people. Fruit harvesting was quite difficult because each fruit carried rigid spine in the body but the fruit was not big and the nut in the fruit was so hard, for these reason there was less demand for village people and the local market. So locally these fruit is called Jungli Singra.



Figure 3: Water chestnut plant with flower



Figure 4: Spiny water chestnut (Local)

Traditional culture of water chestnut (Hybrid)

Ripen fruit goes downward under water and germinates in the soil. Growth appeared in February and plant branches spread over water. When the branches were large, then the cutting process was done. Three branches of plant with rosette were taken and the roots were bundled together and put into the mud. The transplanted plant was adapted to the soil within three days. The bundle of plant branches was planted together at 10 feet interval. After 10 days later, 250g urea fertilizer for cluster of 8 plant branches was given, the plant continued to grow rapidly. After 10 days, another dose was given. The plant branches spread over 8.25 dec area within a few days. Cutting of plant branches for spreading were done till the month of June, and it should not be done after the month of June. In the month of September, the flower appeared in the rosettes and it took one

month to produce fruits, and fruits were collected in October, November, and December. Production was 160-200kg/dec.

Improved culture of water chestnut

Two kg seeds were given in the pond at the month of July and then the seed germinated. Then the plant branches cut and spread out into 264 dec water area. Then the fertilizer was given to the pond at 3kg per 33 dec. Fertilizer was applied by mixing with water. Fertilizer used only once. In the month of October flower appeared. It took 30 days to get fruit from flowers. There were 8 to 10 fruits in a rosette. Pesticide (Paithen-7) used for three times. Before flowering, pesticide was applied, pesticide was also applied after first harvest of fruit and another applied before final harvest.

Water chestnut culture in pond of field laboratory complex of BAU

In April, some water chestnut rosettes (15-18) brought from Jamalpur district to observe the culture system of water chestnut. Three rosettes tied together and transplanted in the Field Laboratory Complex pond at 304.4 cm regular interval (Figure 5). Twenty to Twenty-five days later, the rosettes began to spread over the pond. Two times the pond weeds were cleaned. Within three months, the water chestnut plant spread throughout the pond and. It was so aggressive plant that other aquatic weed could not reproduce here. A few rosettes planted, but they covered at 22 dec areas. Sunlight could not reach the bottom of the water. Flowers appeared in September. It took three to four days to turn fruit. The fruit took 30 to 40 days to mature. The fruit collected during October and November and the production was high due to good water quality of the pond and the water level was enough. For these reason we achieved good production.

Problems

During the study period it was observed that some insect (Beetle, Chironomid midge) infestation on the green leaves of water chestnut (Figures 6 & 7). When the plant produced fruit, crab and snail also attacked the fruit (Figures 8 & 9).



Figure 5: Water chestnut plant spread-out the whole pond in Field Laboratory Complex.



Figure 6: Beetle and Chironomid midge



Figure 8: Snail attack on water chestnut



Figure 7: Rotten leaf due to pest attack



Figure 9: Water chestnut eaten by snail

Marketing system

A marketing system includes all activities involve in the flow of goods from the points of initial production to the ultimate consumer (Figure 10). It includes the exchange activities associated with transferring property rights to commodities, physically purchasing and allocating resources, handling, products, disseminating information to participants and institutional arrangements for facilitating these activities. Specific place is necessary for marketing system. The market should be situated in such a place that it can easy for sellers to bring product in the market and buyers also can easily transport the goods to their respective places. If the location is favorable, it will give much speed to the marketing system. Cheap transport system is prerequisite for good marketing system. In our country railway communication is cheap so buyers use this kind of transport system. Other communication system is also necessary for complete marketing system.



Figure 10: Marketing activities of water chestnut

Marketing channel

Water chestnut marketing channel was not well established yet (Figure 11). The marketing channel from farmers to consumers passed through a number of intermediaries such as: local water chestnut traders (paikers), wholesalers and retailers.

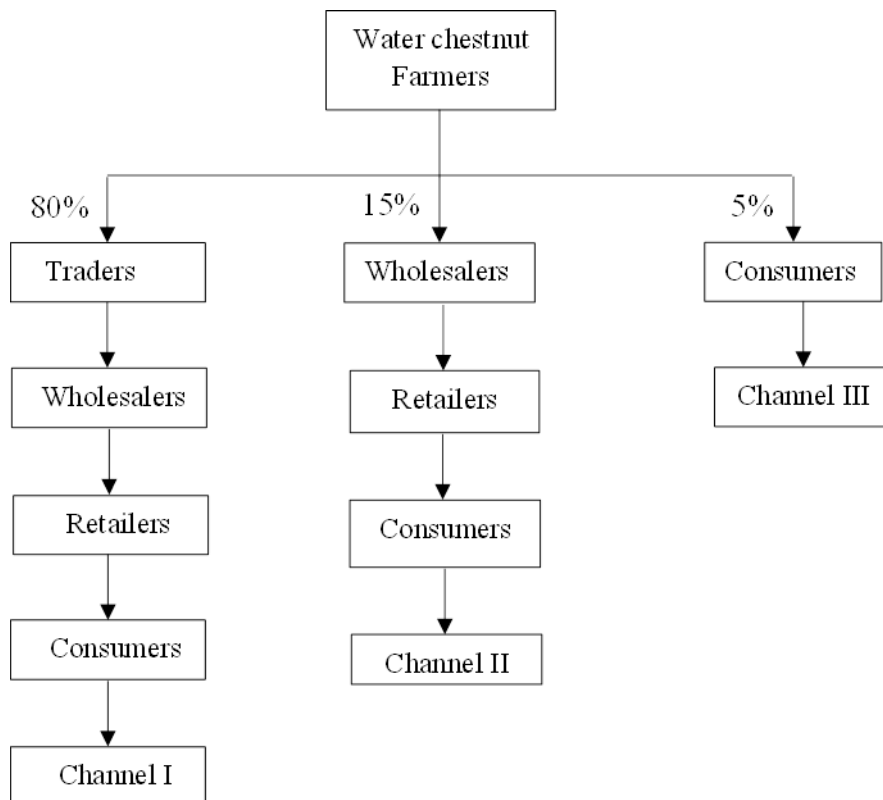


Figure 11: Water Chestnut marketing channel from farmers to consumers based on survey

With a few exceptions, water chestnut farmers never directly communicate with consumers. Market communication was usually being made through middlemen. The paikers carried the water chestnut (about 80%) to the markets by their own or hired transport and sell them to wholesalers who in turn sold that water chestnut to the retailers. Farmers partially sold their water chestnut directly to the wholesalers (about 15%); the wholesalers sold it to the retailers.

During survey, it was observed that the price of water chestnut depended on market structure, species maturity and size of water chestnut. Farmers also noted that price varied according to size, freshness, supply and demand. Seasonal variations occur in case of prices and the price remains highest in September and lowest in pre-winter (November to December) during the water chestnut harvesting season. Farmers also

mentioned that production cost of water chestnut was minimum compared to other crops and marginal farmers cultured water chestnut with low investment.

Cost-benefit analysis

The cost-benefit ratio was different for different farmers because of their culture system, economic capability, labor cost, disease, ownership of land etc. During the study period it has been found that the price of water chestnut was not always same during the whole harvesting season. At the beginning of harvesting season, the price was higher. After a few days the price was fallen down. Two cost-benefit analyses were given below for better understanding the cost variation between two farmers. Both cost-benefit ratios were for one dec pond area that was given in table 4 and 5.

Table 3: Price variation during harvesting season

Variety	Harvesting Period	Tk/40kg
Green water Chestnut	At the beginning of harvesting season	2000
	In the middle of harvesting season	800-1000
	At the end of harvesting season	380-400
Red Water Chestnut	At the beginning of harvesting season	3000
	In the middle of harvesting season	1000-1500
	At the end of harvesting season	550-600

Table 4: Cost-benefit analysis of farming in the study area (First farmer)

Serial No.	Working components	Quantity (Per dec)	Total price (Tk)
1	Element		
	Seed	150g	8
	Pesticide		12
	Labor		30
	Cost of land (Own land)		
	Cost of fertilizer	3kg	30
	Total cost		80
2	Production	30kg	300
3	Net profit= Production-Total cost		220

Table 5: Cost-benefit analysis of farming in the study area (Second farmer)

Serial No.	Working components	Quantity	Price per dec (Tk)	Total price (Tk)
	Element			
1	Cost of lease	1 dec	60	60
	Cost of pesticide		10	10
	Cost of labor		24	24
	Cost of fertilizer	0.6 kg	6	6
	Total cost			100
	Production			
	Harvest			
2	1 st Harvest	7 kg	50	350
	2 nd Harvest	5 kg	25	125
	3 rd Harvest	5 kg	10	50
	4 th Harvest	5 kg	10	50
	5 th Harvest	2.5 kg	12.5	31.25
	Total revenue			606.25
3	Net Profit= Total revenue- Production cost			506.25

Present study revealed that cost of seeds was not so high in water chestnut farming while other costs were noticeable and the production failure was limited, so farmer got lot of benefit without huge investment. It was observed that the production cost was 80Tk/dec and benefit was BDT 220/dec in one case, however for other farmer the production cost was BDT 100/dec and benefit was BDT 506.25 for second cases. The per dec cost variation occurred due to financial capability, land cost, fertilizer cost, insecticide cost etc., however both farmer got enough profit from their cash crop. The Universe Nature (2017) reported that the production cost was BDT 168-252/dec and benefit was BDT 840-880. So water chestnut farming is a profitable business. Singh et al. (2017) showed that Integrated Farming System Model by integration of fish and water chestnut with makhana was developed in 50 ha of land in Darbhanga district. The net benefit from the system was recorded at BDT 88,354 (159,378 – 73,019) as compared to traditional system i.e. makhana production alone.

CONCLUSIONS

Water chestnut is a floating plant with submerged roots anchored with soil which grows in shallow water fields, ponds, lake, *beels* and flood plain. It is a good source of nutrition and the whole plant has various positive pharmacological effects. It is delicious and contains carbohydrates, proteins and essential minerals and is reported to be used in many Ayurveda preparations as diuretic, aphrodisiac, nutrient, appetizer, astringent, coolant, antidiarrheal and tonic. They are also useful in lumbago, sore throat, bilious affections, bronchitis, fatigues & inflammation. Though these fruit has great benefits as food and medicine, it is used as vegetable in many countries and flour also used to make delicious food like cake, halua, ruti, puri etc. Many people do not know about it in our country. So they do not know about the multipurpose uses of water chestnut. If the culture system is expanded throughout the country especially in flood plain region, farmers will get extra benefit from their land. In our country, flood

visits frequently and damages a lot of agricultural crops. If we can culture water chestnut in these flood affected land, farmers will recover their investment and they can get extra benefit.

Recommendations

On the basis of the major findings of the study, the following recommendations were made to improve the water chestnut culture system:

1. Scientific culture system should be introduced to increase the production;
2. Marketing and management facilities should be improved with addition of more market places along with local market;
3. Disease problem should be identified by the researcher to solve the problems;
4. Good Water quality and depth should be maintained for good production;
5. Training and lending facilities should be introduced among farmers;
6. Mass awareness should be raised about the benefit and multipurpose uses of water chestnut; and
7. Further research is needed to gather scientific knowledge about water chestnut.

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