

## Integrated Aquaculture with Fox Nut- A Case Study from North Bihar, India

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### ABSTRACT

#### Keywords

Fox nut, Integrated farming system, Water chestnut, Fishes, Pond and agricultural fields.

#### Article Info

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Integrated Farming System Model by integration of fish and water chestnut with fox nut was developed in 50 ha of land in Darbhanga district. The net benefit from the system was recorded at Rs. 68,545 (1,26,505 – 57,960) as compared to traditional system i.e. fox nut production alone. Field based system of Makhana cultivation was standardized with other crops like fish, rice and water chestnut in cropping system mode. The gross return from Fox nut-fish, Fox nut-rice and Fox nut-water chestnut was obtained as Rs. 2,82,810, 2,73,840 and 3,54,340 per ha, respectively while a gross return of Rs. 1,32,552 was obtained from Fox nut cultivation alone. The highest benefit cost ratio was recorded with Fox nut-water chestnut combination (1.79) followed by Fox nut-fish combination in field system of Fox nut cultivation under integrated farming system model.

### Introduction

Fox nut (*Euryale ferox*), an aquatic crop of the Family *Nymphaeaceae* commonly known as MAKHANA, is unique, highly nutritious, fully organic non-cereal food, blessings for the rural poor, especially of flood prone zone of north Bihar, lower Assam, and part of Bengal and who have perfected art of cultivating fox nut. It is grown in stagnant perennial water bodies like ponds, land depressions, oxbow lakes, swamps and ditches. Fox nut seeds are also called as Black Diamond. The seeds of Fox nut are popped and eaten as roasted as well as used in

preparation of various kind of sweets and recipes. Fox nut is considered a superior dry fruit, as it is endowed with several rich nutritional ingredients.

The popped fox nut contain 12.8% moisture (w/w), 9.7% protein, 0.4% fat, crude fiber (% by wt) 0.2, calorific value (K. cal/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 some medicinal properties too and there is a great export potential of this crop.

## **Production of fox-nut in Bihar**

Bihar State accounts for over 80% of the Fox nut production of the country. Darbhanga, Madhubani, Saharsa, Katihar, Purnea, Supaul, Kishanganj Araria and Sitamari districts are major producer of Fox nut. These districts comprise an area of 15000 ha under fox nut cultivation. The State Government has set a target to extend the cultivation of fox nut in 20,000 ha by 2020, by adopting the field based fox nut cultivation technology. Use of huge labours is the most important component of fox nut cultivation and its post-harvest processing. Five lakh families is directly involved in fox nut cultivation, harvesting, popping, and produce selling. According to an estimate of state government that Fox nut is grown in an area of about 15000 hectare.

The total yield recorded to be about 22500 tons of fox nut seed (gurri) and 7500 to 10,000 tons of popped fox nut which fetches 187 to 250 crores of rupees approximately. Moreover it is privilege that fox nut cultivation and popping is done only in India while other countries are only cultivating it. It is grown there as a wild aquatic weed of ornamental/medicinal purpose.

## **Climate and morphology**

Fox nut (*Euryale ferox* Salisb) is a plant of tropical and subtropical climate. For its proper growth and development the conducive range of air temperature is 20<sup>0</sup> C--35<sup>0</sup> C, relative humidity 50%-90% and annual rainfall 100 cm-250 cm, organically reach water bodies with less than 50% water transparency (Mandal *et al.*, 2010). An important aquatic herb, prickly water plant with gigantic floating nature leaves of a size of 1-2 m and these leaves are born on 0.90 to 1.5 m feet long petioles predominantly nerved and reticulated-veined beneath, green in upper and purple in lower side, thorny in both side of

leave even in entire plant (Kumar *et al.*, 2014). It grows well in stagnant water of 0.2-2 m depth, with thick rhizomatous stem, deeply rooted in cluster form in sediment.

The crop growth period of Fox nut in pond system generally varies between nine to ten months; thus, farmers are unable to get more than one crop in a year. Furthermore, the yield potential of fox nut grown in this (pond system) condition has been recorded only 1.1 to 1.6 t/ha (Mishra *et al.*, 2003). In field condition the productivity of improved strain of fox nut varied between 2.6 and 3.0 t/ha (Kumar *et al.*, 2012). They further reported that in field condition the crop growth period was of only four months. To make the Fox nut cultivation in deep water ponds more profitable, the utilization of ponds should be diversified by integrating the other aquatic crop such as water chestnut, water lily and some fishes in a scientific manner.

Water chestnut (*Trapa bispinosa*) is popularly known as singhara or *paani phal*. In India, It is mainly grown in Madhaya Pradesh, Uttar Pradesh, Bihar and Odisha. It is an annual floating-leaved aquatic plant of temperate and tropical fresh-water wetlands, rivers, lakes, ponds, and estuaries.

It is a native crop of Eurasia and Africa, where it is cultivated for its large nutritious seed. Like Fox nut it also requires 0.30-0.60 m depth of water throughout its growth period. It is cultivated during the months of July to November every year. It adds the phytomass in the range of 1 t/ha to 15 t/ha. Its vegetative part is rich in Fe and Zn contents. The yield potential varies from 1 to 6.0 t/ha. The nutritional value of raw seed of water chestnut is 4.7% protein, 0.3% fat, 0.6% fiber, 23.3% starch (carbohydrate), 1.1% minerals and 70.0% water. Water chestnut kernels are used to treat rabies, poisonous animal bites, diarrhea and other diseases.

## **Materials and Methods**

### **Crop cultivation**

Fox nut is cultivated either in water bodies/ponds having water depth of 1.20-1.80 m or in 0.30-0.60 m deep shallow agricultural fields.

### **Pond system**

It is the traditional method of fox nut cultivation. In water bodies, seed sowing is not required, since leftover seed of previous crop serves as planting materials of subsequent crops. However, Fox nut cultivation in new water bodies (ponds) requires seed sowing. The seeds should be broadcasted @ 80 kg/ha in the month of December. In general, pond cultivation is linked with low productivity as collection of seed from bottom is a very tedious process and possesses drudgery to health to Jalkar farmers. Under pond condition, it takes a duration of complete one year. Thus no other crop can be grown.

### **Field system**

The methodology of fox nut cultivation in agriculture fields consisting 0.30-0.60 m depth of water, has been standardized by ICAR Research Complex for Eastern Region. This system is very easy to operate and provides opportunities to cultivate cereals and fodder crops in the same piece of land in same year. It raises the crop intensity by 200-300%. The prerequisite for this system is to raise a nursery. In cropping system mode of fox nut cultivation, water chestnut, fish, particularly catfishes, sweet flag could be cultivated successfully. Hence diversification in aquatic food system is possible in cropping system mode of Fox nut cultivation.

The field is well prepared by two to three deep ploughing, however, before ploughing,

for the proper nourishment of seedlings, fertilizers @ 100:60:40 / ha, respectively, of N, P and K is applied. The field is filled with water up to the 0.45 m height of bund and the seeds are sown in the month of December. An amount of 20 kg healthy seed is broadcasted uniformly in the entire nursery plot. For transplanting in one hectare area, an area of 500 m<sup>2</sup> is enough for raising the nursery. A water level of 0.30 m. height is maintained throughout the growing period of seedlings, i.e., from December to March. The seedlings are transferred from the nursery plot to the main field in the first week of April and transplanted at a distance of 1.20 x 1.25 m.

### **Integration of fishes and water chestnut with fox nut**

Pond of 1.0 acre size is selected and cleaned and followed by removal of carnivorous fishes by applying mahua oil cake @ 2.5 t/ha. Transplanting and gap filling work was also conducted for optimization of crop geometry @ 7,000 plants/ha. The 10% area in the middle of pond was kept vacant as refuge area for proper oxygenation and better growth of fishes.

The fish species (*Rohu*, *Katla*, *Common carp* and *Mrigal*) were integrated @ 6,000 numbers/ha as fingerlings in the ratio of 40:20:20:20, respectively in March-April and again in the month of September after harvest of Fox nut. The harvesting of fishes gets completed in the month of December-January before the emergence of Fox nut crop. Water chestnut is harvested in the month of October-November. Since it is sown in the month of 2<sup>nd</sup> week of August and gets ready for first harvesting in the last week of October.

The area under pond and agricultural lands is given in the tables 1 and 2, respectively.

A multi-disciplinary research team representing the disciplines of soil science,

plant breeding, horticulture, engineering and forestry was involved in the in-depth analysis of respective components. The ultimate goal is to work out the economics of different components thereafter draw a concrete conclusion pertaining to most economically remunerative system after making the comparison of the efficacy of different components.

### Case studies

To improve the livelihood of Fox nut growers the NAIP project “Sustainable livelihood

improvement through need based integrated farming system models in disadvantaged districts of Bihar” was initiated in April, 2009 in 50 ha ponds of fox nut growers of Sadar block of Darbhanga district. During the year 2013-2014, the coverage area of this project was extended from one district to three districts (Darbhanga, Madhubani and Muzaffarpur) and the mode of Fox nut cultivation widened from traditional ponds to shallow agricultural fields. Out of this 50 ha area, 36.4 ha was allotted under traditional pond system while rest 13.6 ha was covered under field mode of Fox nut cultivation.



Fox nut leaf



Fox nut flower



Matured fruit of fox nut



Exposed view of seed setting in Fox nut fruit



Fishes collected from pond



Fox nut plants growing in field condition



Matured seed of fox nut

Raw makhana puff



Matured plant of water chestnut



Fresh fruit of water chestnut



Field view of makhana

**Fig.1** A view of fox nut+fish system in pond



**Fig.2** A view of water chest nut crop in fox Nut pond



**Fig.3** A view of fox nut crop at farmer's Field under NAIP



**Fig.4** A view of fish harvesting from fox nut field



**Table.1** Economic analysis of different combinations in pond system of Fox nut cultivation

Component combinations	Total area (ha)	Total production (t)			Average productivity (t/ha)			Gross return (Rs) /ha	Net return (Rs) /ha	Ranking of Net returns
		Fox nutseed	Fish	Water chestnut	Fox nut seed	Fish	Water chestnut			
Fox nut + Fish	22.60	33.67	14.01	--	1.48	6.75	---	2,05,270	1,02,635	III
Fox nut-Water Chestnut	6.40	10.36	---	88.32	1.62	---	14.56	2,15,320	1,07,660	II
Fox nut + Fish-Water Chestnut	4.65	6.73	1.70	64.17	14.48	3.67	13.80	2,53,010	1,26,505	I
Fox nut	2.75	4.55	----	----	16.56	----	----	1,15,920	57,960	IV

**Table.2** Economic analysis of different combinations in field mode of Fox nut cultivation

Component combinations	Total area (ha)	Total production (t.)				Average productivity (t/ha)				Gross return (Rs) /ha	Net return (Rs) /ha	Ranking
		Fox nut	Fish	Water chestnut	Rice	Fox nut	Fish	Water chestnut	Rice			
Fox nut + Fish	8.40	24.02	3.78	-	-	2.84	0.56	-	-	2,82,810	1,21,520	II
Fox nut - Rice	3.00	9.07	-	-	12.36	3.02	-	-	41.20	2,73,480	1,16,322	III
Fox nut - Water Chestnut	1.20	3.55	-	25.2	-	2.96	-	21.00	-	3,54,340	1,56,436	I
Fox nut	1.00	3.15	-	-	-	3.15	-	-	-	2,20,920	88,368	IV

## Results and Discussion

Five years results of this multicenter prize agriculture system are presented and discussed as under:

In both systems, integrated concept of farming systems were adopted to augment the per unit area net income of fox nut growers. The results of this project have been presented in tables 1 and 2. These results indicate that the net returns in both integrated farming systems are near about two folds of the solo fox nut production system. Among all combinations of two systems, fox nut- water chestnut (in field condition) was recorded to give the highest net return (Rs. 1,56,436/-) to fox nut growers followed by fox nut + fish - water chestnut in ponds (Rs. 1,26,505/-) and Fox nut + Fish (Rs. 1,21,520/-) in field system. On the other hand, Fox nut + Fish combination gave net return of Rs 1.02.635/- only which was at par with the net returns i.e., Rs 1,07,660/- only obtained from Fox nut-water chestnut combinations. The findings of this project suggest that integrated farming may be very helpful to improve the economic status of fox nut growers by providing sustainable livelihood to them.

Thus, it is felt that fox nut cultivation in cropping system modes offers unique opportunity to cultivate it at shallow water depth with optimum yield. This particular technology could extend fox nut cultivation in 1 million ha, subject to availability of life

saving irrigation and seed extraction machine. Govt. of Bihar will have to extend the facilities for increasing area under Fox nut since it is commercially cultivated in Bihar only.

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