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Improved agro-technique for makhana cultivation

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Makhana is mainly cultivated in North Bihar, mainly Seemanchal area. It has good health benefits, many medicinal values and most common dry fruit which has low or negligible fat content, but rich in protein, carbohydrates and minerals. It is used for milk-based food preparations like kheer, pudding etc. To enhance its economic significance, standard agro-techniques such as improved varieties (viz. Sabour Makhana 1, Swarna Vaidehi), climate and cultivating system, integrated nutrient management (INM), harvesting techniques, and post-harvest packages are necessary to the farmers in order to realize potential yield and achieve better returns. The yield of improved varieties ranges from 28-30 q/ha and pop recovery from 50-55%.

Keywords: Makhana, Bihar, Foxnut

MAKHANA or Gorgan nut or fox nut (*Euryale ferox*) is a most popular, ceremonial and unique product of Eastern India particularly Bihar. It grows well in stagnant water (4-6 months duration) with water depth of 0.5 to 1.2 m and even in the shallow ponds. It is native of South-East Asia continents particularly India and China. At present, the crop is commercially cultivated in several countries of the world. In India, it is cultivated mainly in North Bihar, West Bengal and some parts of Assam. Bihar is the leading state of makhana producing state contributing 85% of the total India's production. It is considered as cash crop and is marketed in the form of popped makhana, commonly known as Makhana pop (lawa). In Bihar, its cultivation is concentrated in seemanchal (Koshi) region encompassing 10 districts of Bihar (Table 1). This district has vast area under water stagnation for 6-7 months in a year with varying depth of water table. It is the fifth agricultural produce from Bihar which received the GI tag due to its specific climatic condition. It helps farmers to get the maximum price of their produce.

Makhana is an exclusively self-pollinated plant in which fertilization takes place at an early stage of their development. Its flower is epigynous, produces bright purple flowers having more than 40 corolla, ovary (7-16) chambered with 6 - 8 seeds/locule. It has industrial demands as a source of high-quality starch for textile industries especially for coating *Banarasi sarees* and silk cloths which contain quality fabrics and starch has appreciable amount of amino acid. The expanded and popped kernels are used in almost all the Vedic oblation and other religious rituals. Despite the unique properties of makhana, the consumers have lack of information about the product and its various uses. Transportation plays a vital role in the supply chain of makhana, a commercially produced product primarily

Table 1. The district wise area, production and productivity of makhana

District	Area (ha)	Production (Mt)	Productivity (t/ha)
Darbhanga	3534	7421.40	2.10
Madhubani	3467	7280.70	2.10
Sitamarhi	146	277.40	1.90
Purnea	5549	11652.90	2.10
Katihar	6143	12900.30	2.10
Saharsa	2549	5352.90	2.10
Supaul	2468	5182.80	2.10
Madhepura	1461	2907.29	1.99
Araria	1427	2639.95	1.85
Kishanganj	1143	2000.25	1.75
	27887	57,615.99	20.09

in north Bihar. The demand for makhana across the country creates opportunities for local wholesalers and other agents to benefit by transporting it to distant markets. The makhana's price in these remote markets is generally 60-70% higher than the local market, making transportation a significant value-addition to the product. Due to its bulkiness, makhana requires more space compared to grains, even for smaller quantities. In the local market, makhana is normally sold at rates ranging from 350-500 per kg depending upon grading size, but once it reaches metropolitan markets, its price significantly jumps to 700 per kg or more, reflecting the increased demand and the importance of transportation in connecting supply with demand across regions.

Health and nutritional value

Makhana pop has enormous health benefits and most common dry fruits which has low or negligible fat content, but rich in protein, carbohydrates and minerals. It is used for milk-based food preparations like kheer, puddings and pulses-based curry, snacks. *Euryale ferox* has been reported for various pharmacological activities comprising anti-diabetic, anti-melanogenic, anti-hyperlipidemic, hepatoprotective, immune-modulatory and anti-cytotoxicity action. Due to presence of dietary fibre, it is also good for constipation and is considered to be an effective food for controlling blood pressure, blood sugar, heart diseases, and anaemia. Traditionally, it is used for the treatment of diabetic nephropathy, enuresis, chronic diarrhea, and dysfunction of the liver. The kernel powder is used in different kinds of ayurvedic medicines to strengthen the spleen and kidneys. It is a gluten-free food, rich in folate that helps in the development of a baby during the first trimester of pregnancy and has also been found to be effective for women at the post-natal stage. The calorific value of raw seeds and puffed seeds is 328 kcal/100g and 362 kcal/100g respectively. Nutritional studies indicates that edible portion of the seed contains 12.8% moisture, 9.7% protein, 0.1% fat, 76.9% carbohydrate, 0.5% mineral contents and 1.45% iron in addition to a good fraction of sugar, phenol and ascorbic acid. Amino acid index is higher than that of staple foods, which indicates its unique food quality. Foxnut possess a superior nutritional profile relative to other dry fruits such as walnut, almond, cashew nut or coconut in contents of sugar, proteins, phenol and ascorbic acid.

Improved agro-techniques

The Kosi region of Bihar is naturally waterlogged, not only in ponds but also in low-lying cultivable areas, making it suitable for cultivation in field conditions. To enhance its economic significance, standard agro-techniques such as improved varieties, climate and cultivating system, integrated nutrient management (INM), harvesting techniques, and post-harvest packages are necessary to the farmers in order to realize potential yield and achieve better returns.

Varieties

Sabour Makhana-1: This variety is selection from the local by BAU, Sabour and released by the State Varietal Release Committee of Bihar during 2016. It exhibits distinctive features such as large spherical leaves, dark purple flowers, medium-sized fruits, and small oval seeds with an incredibly thin seed coat (0.29 mm) having potential yield of 32-35 q/ha with high-quality makhana pop recovery (55-60%).

Swarna Vaidehi: This variety has been developed by ICAR-RCER, Patna, and released by State Varietal Release Committee during 2013 for Bihar, Assam, Chhattisgarh and Odisha. It thrives in stagnant perennial water bodies, including ponds, land depressions, oxbow lakes, swamps, and ditches. It exhibits a remarkable production potential of 28-30 q/ha having 42-48% makhana pop recovery rate. It is commercially cultivated in North Bihar, Manipur, parts of West Bengal, and Madhya Pradesh.

At present, these varieties are under cultivation in large areas by progressive farmers and cooperative groups located in Darbhanga, Purnea, Madhubani, Katihar, and Sitamarhi) of Bihar and gaining valuable experience in its cultivation.

Table 2. Comparison of Sabour Makhana1, Swarn Vaidehi and Local Variety

Particular	Sabour Makhana-1	Swarn Vaidehi	Local Variety
Seed rate(kg/ha)			
i. Transplanting	22-25	25-30	45-50
ii. Direct sowing	40-45	42-47	80-90
Sowing time	December-January	December-January	December-January
Germination %	90-95	90-92	70-75
Plant growth	Vigorous	Vigorous	Less vigorous
Disease/Pest incidence	Moderate	Moderate	Susceptible
Water depth (m)			
i) In field condition	0.3 to 0.5	0.3 to 0.5	0.3 to 0.5
ii) In pond condition	1.2-1.5 or more	1.2-1.5 or more	1.2-1.5 or more
Yield (q/ha)	32-35	28-30	16-18
Pop recovery %	55-60	40-41	35-40
Cost of cultivation (₹/ha)	1,19,017	1,20,017	98,490
Gross return (₹/ha)	3,73,800	3,70,800	2,00,100

Climate and morphology

Makhana is an important aquatic herb with gigantic leaves of 1-2 m size, thorny and floating in water. The upper surface of leaves is green and lower side is purple with 0.90 to 1.5 m long petiole. It is normally grown in tropical and subtropical climates in stagnant water of 0.2-2 m depth. It requires temperature in the range of 20 to 35°C; relative humidity of 50- 90% and annual rainfall of 100-250 cm for proper growth and development with water transparency of 50%.

Whole makhana fruit (left); Cross section of makhana fruit showing seeds (right)

Crop cultivation

- **Pond system:** It is very old method of cultivation maintaining water depth of 1.5-2 m. There is no need of seed sowing in old pond but in new pond, seeds are sown by broadcasting method @ 80 kg/ha during December-January. This system gives low yield and it is very tedious and cumbersome to harvest kernel from the bottom of the pond. It takes one year to complete the crop cycle.
- **Field/farming system:** It is a modern method of makhana farming requiring less time and water maintaining 30-60 cm water depth. Intercropping is possible with fodder in same year. It requires nursery for raising 2-3 months seedlings having 4-5 leaves, light green in colour which are suitable for transplanting in main field at the spacing of 1.25 m × 1.25 m during 4th week of March- 1st week of April. Crop diversification can be made by growing different water crops like water chestnut, fish, particularly catfishes, sweet flag along with makhana cultivation.

Integrated nutrient management

Cultivating Makhana in the region requires slightly higher doses of micronutrients (copper and zinc) as Zn plays a crucial role in flowering, fruit growth and seed formation. The application of NPK and FYM, in combination, enhances the yield of Makhana. Makhana exhibits a favourable response to FYM application as compared to NPK fertilizers, hence right quantity (dose) of farmyard manure (FYM) is considered crucial as it also provides traces of micro-nutrients elements. For obtaining higher yield of Makhana under field conditions, 20 t/ha FYM and NPK @100:60:40 kg/ha as a basal application in the pond between February and March was found most effective. Full dose of phosphorus, potassium and FYM and half dose of nitrogen, along with 30 kg of lime should be applied at the time of final land preparation about 5 days before transplanting while remaining half nitrogen is applied in 2-3 equal parts, starting at 20-25 days of transplanting.

Insect-pest management

The most prevalent insect is mollusca, aphid (*Rhopalosiphum nymphaeae* L.), caseworms (*Elophila depunctalis* W. & *E. crisonalis* W.) and rib borer (*Chironomous spp*.) that causes 17.04% to 23.67% loss in seed yield. To control this insect-pest, root deep treatment for 30 min with Imidacloprid and Thiamethoxam @ 5 g/l before sowing followed by spraying of 5% neem oil 40 days after planting and repeat at 25 days of interval effectively manages the crop.

Weed management

The aquatic weeds need to be kept under controlled condition especially during early stages of plant growth after transplanting, as these compete with the main crop for nutrients, water, light and space growth of makhana leaves. Depending on weed infestation intensity, at least 2-3 hand weeding are necessary at 15-20 days interval starting from early stage (25-30 days after transplanting) to till the water surface covered by large spherical makhana leaves. Once, water surface completely covered by large spherical makhana leaves, the growth of weeds is suppressed. *Euryale ferox* has been reported for various pharmacological activities comprising antidiabetic, anti-melanogenic, antihyperlipidemic etc.

Harvesting and yield

In pond system, harvesting required experienced farmer for picking matured makhana kernels from bottom of the pond which is very labour intensive. This is done with the help of a horn shaped bamboo pole, locally known as the 'Kaara'. Later on, the mud is sieved through a locally made bamboo screen or sieve known as the 'Ganiya'. The yield of makhana seed range from 22 to 30 quintals per hectare depending upon the variety. In field system, makhana harvesting is less labour intensive and less risky with higher seed yield collection in comparison to pond system.

Seed processing

The seeds (gudi) cannot be consumed directly and need to undergo manual processing to become 'pop' or popped makhana. The processing involves several steps, including cleaning, grading, sun drying, preheating, roasting, popping, and polishing. The value of makhana significantly increases after this processing steps that

Harvesting of makhana seed

transforms a raw seed to a popped makhana. Initially, farmers sell the raw makhana seeds to processors at a price of approximately ₹ 90-120/kg. The conversion ratio of one kilogram of seed to popped makhana is about 30-40%, which means that from one kilogram of raw seed, nearly 350-400g of popped makhana are obtained. The popped makhana is sold at a higher price, usually around ₹ 250-400 per kilogram. Consequently, the value of the makhana is nearly doubled after it undergoes the transformation from seed to pop.

Processing of pop

Makhana pops are consumed in their raw form, but several companies in India are enhancing their appeal by adding value through the incorporation of various flavours such as onion, chili, pudina, cream, and other spices. These flavoured makhana pops undergo roasting and are then packaged in small packets similar to other snakes/chips, making them convenient for marketing and sale. Thus value addition allows the makhana pops to be marketed as a delightful and ready-to-eat snack option, making them increasingly popular among consumers.

Grading and sorting

Local wholesalers receive makhana from processors hailing from various regions, and this makhana is a mix of different pop sizes. The sorting process is carried out either manually or by using a makhana grader at the warehouses of the local wholesalers. The size grading is crucial as the market value of the makhana varies directly with the size of the pop. Larger-sized pops had higher prices in the market due to their increased demand and appeal to consumers.

Challenges

Foxnut farmers are experiencing a lack of skilled workforce on the ground. Workers need to spend hours in water to cultivate and harvest foxnut. But it is difficult to find skilled workers in the area. Weed management and proper harvesting are two crucial steps in foxnut farming. Every step is labour intensive and we need to spend a lot of time and energy on these steps.

Sabour makana-1 variety holds significant potential, especially in waterlogged areas that have been historically overlooked and underutilized. By cultivating Sabour Makhana-1, farmers can reliaze from higher net returns without depleting natural resources.

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Contribution of KVKs in State Policy

Kerala

- KVK Pattanamthitta has been declared as the State Resource Centre for Jackfruit value-addition based on the pilot programme on jackfruit based entrepreneurship promotion by the KVK
- KVK Alapuzzha is the State Resource Centre for agro-processing and value-addition

Lakshadweep

- After Sikkim, Lakshadweep islands has been declared organic and the large area organic certification is done by the KVK

Maharashtra

- Farm pond has become a State Level Programme

Bihar

- 38 districts are now being covered with Climate Resilient Agriculture (CRA) policy
- NARI has been integrated with the Nutri-garden along with Anganwadi programme (18000 centres)

Jharkhand

- Bora bandi technology for soil and water conservation has been undertaken by the Jharkhand Government to diversify rice-vegetable cropping system in ~500 villages

West Bengal

- Land shaping technology in Sunderbans increased cropping intensity to 270% and income upto Rs. 4 Lakhs/ha from Rs. 30 thousand. Technology was multiplied in 2000 hectares and attracted investment (Rs. 30 crores) from State Government