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Performance of Makhana (*Euryale ferox* Salisb.) as a highly profitable venture in waterlogged areas prone to flooding

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Abstract
Diversifying crops is key to boosting land productivity. Lowlands are being used to achieve this and improve yields. Demonstrations are an effective way to transfer technology. A study was undertaken to find out the profitability of Makhana cultivation under a periodical waterlogged situation due to seasonal flood in NICRA adopted village Khanabadi of Kishanganj district of Bihar. The newly released variety of makhana, Sabour Makhana-1, was demonstrated at unproductive land (water logging of 1m depth) of Khanabadi village. The results showed that the performance of newly released varieties was better on the demonstrated field of NICRA-adopted village in comparison to local variety. Sabour Makhana-1 has demonstrated in 6 farmers' fields in 8 ha area resulting in 24.30 q/ha with net income of Rs.1,58,150.00/ha with technological support by Krishi Vigyan Kendra, Kishanganj under NICRA project.

Keywords: Makhana, NICRA, waterlogged, unproductive land

Introduction
India is the highest makhana-producing countries and it is also cultivated in Korea, Japan, and Russia to some extent. It is also known as gorgon nuts. It originates from lotus seeds. Foxnut (Makhana) can be consumed alone as roasted, dessert items and can be combined with vegetables and prepared as a delicious porridge after popping it like corn. Makhana farming has the potential to be highly profitable, and its seeds are referred as a "black diamond." It has been demonstrated that the net profit from this aquatic cash crop. The fox nut, also called the gorgon nut, is a highly valued cash crop cultivated in the Mithila region of Bihar. It stands out from other cash crops due to its notably larger size by (Kumar *et al.*, 2020b) [4]. However, the total area dedicated to Makhana cultivation only ranges from 13000 to 15000 ha according to (Mandal *et al.* 2010) [7] and (Singh *et al.* 2017) [10]. It has been established that makhana is a highly nutritious cuisine that is also beneficial for daily health. Its pops pose many vitamins, essential minerals, digestible fiber, and fat-free organic produce consisting of many nutrients. Its successful cultivation requires a temperature range of 20 to 35 ^{0}C for proper growth and development, as well as a relative humidity of 50-90 percent and annual rainfall of 1000-2500 mm. Bihar alone produces more than 85% of all makhana produced in India and making it the nation's top producer. Makhana is a crop that can thrive in low-lying areas where rice is not viable due to frequent flooding. This plant can grow and produce fruit in stagnant water. It is particularly successful in northern Bihar. The local population is fortunate to have access to many wetlands and waterlogged areas known as chaur. These areas serve as vital landscape components and support the growth of valuable aquatic crops such as Makhana and water chestnut. The abundant natural crops in the area provide significant financial benefits to the people. It's worth noting that makhana can survive in water as shallow as 1.0 ft, and even withstand depths of up to 12 ft. or more. However, growers should avoid lotic ecosystems with running water as makhana cannot be grown there.

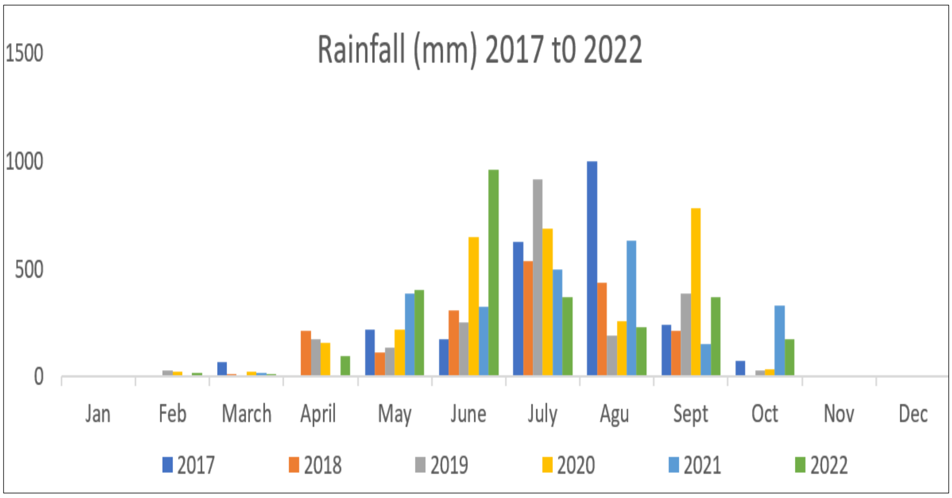
In intense flooding, the strong currents can wreak havoc on the crop, washing away floating seeds, or uprooting plants. It's crucial to remember that this can lead to severe financial losses for farmers. Kishanganj is renowned for being one of the leading districts in Makhana production. Makhana is grown in either perennial water bodies with depths between 4-5 feet or in the field system. Research institutions have recently standardized the field system method for Makhana cultivation. It involves growing Makhana in agricultural fields at a water depth of one foot (Kumar *et al.*, 2011) [5]. The Makhana seedlings are initially grown in a nursery before being transplanted at the right time into the main field. The transplanting might occur anywhere from the first week of February to the third week of April, depending on the availability of the field and nursery. This approach shortens the length of the Makhana crop by up to four months. Helping farmers replace traditional cultivation systems with new methods, as well as providing commensurate subsidies, will result in a complete overhaul of the cultivation system, increasing per hectare yield and thus increasing the incomes of millions. Recently Makhana of Bihar received a GI tag.

Materials and Methods

Under the TDC-NICRA project, one village adopted under flood vulnerability by KVK, Kishanganj in March 2021 and carried out different activities under technology demonstration components through various modules benefiting of farmers community. Technology Demonstration Component (TDC) of NICRA which is implemented based on climatically vulnerable villages of the district focuses on enhancing the adaptive capacity of farmers in these districts to climatic change and to ensure the security of livelihood in times of climatic aberrations.

Climate and Rainfall

The district has a moist and humid climate, with a winter season from November to February. January is the coldest month, with an average daily temperature of 5-10 ºC and a maximum daily temperature of 32-41 ºC. The summer season begins in March and ends in June, followed by the monsoon season which lasts until September. This district is dubbed the "*Cherapunji of Bihar*" due to the highest rainfall compared to any other district in Bihar. The average annual rainfall in the district is 2355 mm. The district receives about 85% of the total rainfall from the southwest monsoon. The southwest monsoon extends from the middle of June to the end of September. The six-year (2017 to 2022) rainfall statistics are given in Graph-1.



Graph 1: Rainfall (mm) 2017 to 2022, Source: IMD, Pune, 2022

Krishi Vigyan Kendra in Kishanganj conducted a study to demonstrate farming techniques to six selected farmers in a village affected by floods and unproductive land covering eight hectares. This was done under the NICRA project during 2021-22 and 2022-23. Because a transplanted makhana crop yield more than a direct sown crop, the farmer was trained in the art of nursery raising. By the Krishi Vigyan Kendra, the blocked drain was cleaned by a group of farmers of the village to drain the water accumulated in the flood in that selected area, so that this work was done keeping in view the possibility of Makhana cultivation when the water level was reduced about 2 feet. Training program organized on makhana production of field and pond system during 05 December 2021 at KVK, Kishanganj Table 1. KVK successfully convinced farmers in waterlogged areas that Makhana production was achievable through their efforts. By implementing a nursery system, they could decrease seed requirements by a third and increase crop yield during transplantation. In January 2021, a nursery was established using 30 kg of seed per 500 m², which proved successful when the seedlings were later transplanted in a one-hectare area. The transplantation process was conducted with the utmost care to avoid root damage, and the plants were spaced 1.0 m apart in rows and between plants. The planting process was accomplished between the 3rd week of February and the 1st week of March, ensuring optimal conditions for growth. Demonstrations were conducted to study the gap between the potential yield of Sabour Makhana-1 (33.5 q/ha, demonstration yield, technology gap, and technology index in technology dissemination in the adopted village under the objective of flood vulnerability of NICRA programme. During the crop season, KVK scientists provided guidance to farmers on the best practices to follow. They recorded the data on the output of the improved variety. The study used the technology index to measure the technical feasibility achieved through demonstrations, as defined by Ghintala *et al.* (2018) [2]. The extension gap, technology gap, and technology index were then calculated using formulas suggested by Samui *et al.* (2000) [9] and Yadav *et al.* (2004) [12]. Performance data was recorded, compiled, and compared for interpretation and inference.

Technology gap (kg/ha) = Potential yield - Demonstration yield

Technology Index (%) = Potential yield - Demonstration yield / Potential yield X 100

Table 1: Comparison of packages and practices on field and pond system of makhana production technology

Parameter	Field System	Pond Eco-System
Water Requirement	Just 1 feet	At least 4-6 feet
Seed Requirement	20 kg/ha	80-90 kg/ha
Source of water	Irrigation water or any other perennial source of water	Natural water as perennial water bodies
Fertilizers and manure	It can be applied very easily before and after the transplantation	Not possible due to the high depth of standing water
Weed management	Very easy	Very tedious
Crop duration	Short (4-5 months)	Long to very long (8-10 months)
Seed yield	2.6-3.0 t/ha	1.8-2.0 t/ha
Scope for grain and fodder production	Water Chestnut, Rice, Wheat, Barseem and other field crops can be grown in rotation.	Not possible
Possibility of maximum no. of crops in a year	Three	Two
Intensification of cropping system	Makhana - Water Chestnut Makhana - Barseem, and Makhana - Rice -	Makhana with Water Chestnut

Source: MSME, Scheme report, 2012

Results and Discussion

During the 2021-22 season, a demonstration was conducted which resulted in an average nut yield of 27.24 q/ha. The technological gap, which was observed to be 9.2 q/ha during the same period, was attributed to the variability in soil fertility and climatic conditions. Nevertheless, the farmer's cooperation in carrying out the demonstration reflects the more frequent adoption of recent production technologies with high-yielding varieties. This, in turn, would change with time-to-time brainstorming of stakeholders. The feasibility of the evolved technology in the selected field of the village was shown through the technology index. The feasibility of the technology was indicated by the lowest values (27.46%) of the technology index. It has been reported that there are workers in a pond where approximately 10,000 plants per hectare can be found. According to Kumar *et al.* (2011a, 2011b) and Khadatkar *et al*. (2015) [3], the seed yield in the traditional system was around 1.8-2.0 tons per hectare. The demonstration yielded an average net return/ha of Rs. 1,58,150/-, and the total return from the demonstrated land of the adopted village under the NICRA programme was Rs. 12,65,200/- (Table 2). Performance of yield (q/ha), technology gap (q/ha), technology index (%) and economic impact of makhana production under waterlogged conditions.

Table 2: Performance of average yield, technology gap, technology index and economics of makhana in the flood-prone field

Average yield (q/ha)	Technology gap (q/ha)	Technology index (%)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs. /ha)
24.30	9.20	27.46	97000	255150	158150

Conclusion

The result finds out that yield of the makhana crop could be increased with the intervention of the newly released variety Sabour Makhana-1 under a waterlogged area due to the effect of flood hence, adopting the integrated approach in the cultivation of makhana will increase the income as well as the livelihood of the farmers.

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