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Determination of the production costs per hectare and the constraints faced in production of fox-nut in Darbhanga district (Bihar)

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Abstract
The fox-nut (*Euryale ferox*) is an aquacultural crop in the Nymphaeaceae family. Fox-nut grows in perennially stagnant aquatic bodies such as land depressions, swamps, ponds, and ditches. Fox-nut is grown as a crop in India, mainly in the states of Bihar and parts of North Eastern region Bihar accounts for roughly 85 percent of India's fox-nut production. Average of the total cost of cultivation of fox-nut in Darbhanga district of Bihar was approx. Rs. 109395.70/hec., the average yield is 2037.5 kg/hec., average gross return is Rs. 380335.70/hec. and average net return was Rs.298104.30/hec. Average cost of cultivation of fox-nut seed is Rs 53.69/Kg. Major cost item in cultivation of fox-nut is human labour cost which is 35.75 percent of total cost of cultivation. The total operational cost was estimated to be 84.32 percent while average fixed cost is 15.67 percent to the total cost.

Keywords: Production, cost, constraints

Introduction
Fox-nut, also known as Gorgon nut or Makhana (*Euryale ferox* Salisb.), is a Nymphaeaceae family aquatic crop. *Euryale ferox* (Fox-nut) is only found in Southeast Asian countries such as India, China, Nepal, Bangladesh, Japan, Russia, Korea, and others in the tropical and subtropical regions. Fox-nut seeds, which are tiny and spherical with a black to brownish outer covering, are the plant's edible portion.

The Fox-nut is thought to be a native of Southeast Asia and China, but it can be found almost anywhere in the world. It has been discovered in Japan, Korea, Russia, North America, Nepal, Bangladesh, and a few locations in India, but it is extremely restricted to tropical and subtropical Southeast Asia (Agricultural statistics at a glance, 2019). The Fox-nut market is expected to grow at a CAGR of nearly 7% between 2019 and 2022. The global Fox-nut market will grow by USD 72.5 million between 2019 and 2022.

The fox-nut seed is mainly composed of 57% carbohydrates, 34.77% fat, 7.2% protein, and 0.4% other ash. The edible portion of a fox-nut contains 79.8% carbohydrates, 10.40% moisture, 8.7% protein, 0.5% fat, and 0.5% ash content. According to calorific analysis, raw fox-nut contains 259 kcal/100 gm and popped fox-nut contains 358 kcal/100 gm. Thus, the calorific value of Fox-nut compares favourably to staple foods like wheat and rice. After recognising the commercial importance of the Fox-nut, the ICAR Research Complex for Eastern Region in Patna (Bihar) developed Swarna Vaidehi, the first affordably priced Fox-nut variety.

Materials and Methods
A multistage stratified random sampling procedure has been adopted for the present investigation to select the ultimate unit of the sample. There are 38 districts in Bihar out of these 90% of the fox-nut is grown in the four district i.e. Darbhanga, Purnia, Katihar & Madhubani. The district Darbhanga of Bihar has been selected purposively for the present study based on the fact that it is one of the districts having maximum area under fox-nut cultivation.

The district Darbhanga is divided in 18 blocks. Two blocks which is approximately 5% were chosen purposively for this study from a total of 18 blocks in the district namely Darbhanga Sadar block and Manigachhi block. The rationale behind choosing these two blocks as they are famous location for fox-nut farming in the district.

Measures of Cost Concepts

Total costs: The total costs were divided into variable costs and fixed costs.

Variable costs: Variable costs included the cost of human labor, seed, irrigation charges, fertilizers, plant protection chemicals, interest on working capital and land revenue, etc.

Fixed costs: Fixed costs included rental value of owned pond, rent for leased in the pond, depreciation on tools and implements, and interest on fixed capital.

Interest on fixed capital: The rate of interest was 8.5 percent per annum on fixed assets as the fixed deposits in commercial banks fetch 8.5 percent interest on the amount deposited. Since the rental value of owned land was considered, land value was excluded from fixed capital. The interest was apportioned on a crop acreage basis.

$$\text{Interest on working capital} = \frac{\text{rate of interest x no. of crop month x operational cost}}{100 \text{ x } 2 \text{ x } 24}$$

Measures of cost of cultivation

Cost A1 = This gives the total cash expenses incurred by the grower. It includes the following items.

1. Cost of hired labour
2. Cost of seed
3. Cost of manures and fertilizers
4. Plant protection chemicals
5. Irrigation charges
6. Interest on working capital
7. Depreciation of fixed resources
8. Land revenue paid to the government
9. Miscellaneous expenses

Cost A2 = Cost A1 + Rent paid for leased-in land
Cost B1 = Cost A2 + interest on fixed capital assets (excluding land)
Cost B2= Cost B1+ Rental value of own land (not land revenue) and rent paid for leased land.
Cost C1= Cost B1+ imputed value of family labour.
Cost C2= Cost B2 + imputed value of family labour.
Cost C3=Cost C2+ cost of management (10% of cost C2).

Analysis of the constraints faced by farmers in the production and marketing of fox-nut

Constraints faced by farmers have been analyzed through surveys based on demographic profiles of the farmers like age groups, pond holding size, and educational level. The Garret ranking technique (Henry Garrett) has been used to analyze the constraints faced by the farmers. Garrett's ranking was applied to the respondents' rankings of various attributes. Garret's scorecard was used to assign scores to percentage values. For each attribute, the mean of the Garret scores was calculated. Farmers regard the attribute with the highest mean score as a significant constraint. Garrett percentages were calculated by using the following formula-

$$\text{Percent position} = \frac{(Rij - 0.5)}{Nj} \times 100$$

Where,
Rij = The jth individual's rank for the ith item.
Nj = The number of items ranked by the jth person.

Results and Discussion

Cost of cultivation of fox-nut

In the cultivation of Fox-nut, several operations are involved which are highly intensive and high-cost wearing. It was an old-age traditional experience being followed by the fishing community of the cultivating area. When a new pond is taken under fox-nut cultivation the pond is prepared according to the need of the crop, and seeds of fox-nut are broadcasted or can be transplanted also. In old ponds where fox-nut has been cultivated in the previous season seeds has to be left in the pond in process of harvesting which allows the seed to germinate, this practice was seen as common in the study area. There was less use of chemical fertilizer or no chemical fertilizers is used in the pond system cultivation of fox-nut. The organic content of the ponds soil becomes rich because of the cultivation of fox-nut year after year in the same pond system. After the maturity of the fox-nut most parts of the plants falls into the pond and decay which increases the organic content of the pond. Depending on the weed infestation, fox-nut may require more than one weeding. It can be done either manually or with a straw rope. To weed, the cultivator holds one end of the straw rope and slides it across the surface of the pond, creating a heap of weeds that is eventually removed from the pond. Harvesting is accomplished by diving into the pond and collecting the fox-nut seeds. Heaps of the seed are made and washed in the pond with a cylindrical basket made of bamboo sticks having space in between two sticks which act as a sieve. Papery membranes of seeds are removed by crushing. The seeds are black and similar to peas in size seed.

Human labour: The fox-nut cultivation is highly labour intensive which requires skilled as well as unskilled level. At different stages of fox-nut cultivation different type of skilled labours are needed. So it has become important while hiring the labour that they should expertise in that work. There are two types of human labour used in cultivation of fox-nut one is hired labour and another is family labour. While calculating the cost incurred on the family labour it was taken minimum and time a family members spend the farm. In the table 1 the average cost of family labour per hectare is Rs 8073 which is approx. 9.35% of the total cost of production and the average cost of hired labour is Rs. 22795 which is 26.40% of the total cost of production. On adding family labour and hired labour the total average cost of human labour is Rs.30868 which is 35.75% of the total cost of production.

Seed cost: The cultivation of fox-nut is highly dependent on quality of the seeds used in the cultivation. Traditionally it was found that the seeds was taken from the previous year of the crops but in the study area it was found that some vigilant farmers use quality seed which result in the high production of fox-nut. The average cost of seed per hectare is Rs. 7425 which is 8.60% of the total cost of cultivation.

Manure & fertilizer: Manures and fertilizers essential component for the highest production for the crops, so in case of fox-nut cultivation. Fertilizers and manures are required at regular interval of time for highest production. On an average Manuring cost for fox-nut is Rs. 3272.33 and the cost incurred on fertilizer is Rs. 6268.18.

Plant Protection: Plant protection also needed for the fox-nut cultivation because different type of disease, and pest attacks happens and it needed to be controlled so the plant protection measures were taken**.** In plant protection generally insecticides are used 2 to 3 times to control the different insects such as flies, aphids, etc. The average cost incurred by the fox-nut cultivators on the plant protection was Rs. 9146.91 which is 10.59% of the total cost.

Irrigation: As fox-nut is grown in the pond so water is a necessary component, whenever the water level in a pond goes down, make it necessary to do the irrigation. The average cost of irrigation per hectare is Rs. 11212.50 which is 12.98% of the total cost.

Miscellaneous: Some miscellaneous costs incurred during the cultivation of fox-nut which are not discussed in separate subheadings are discussed in this subheading. Combining all that the cost incurred is Rs. 2489.28 which is 2.88% of the total cost.

Interest on working capital: The interest incurred on working capital is Rs. 2120 per hectare which is approx. 2.45% of the total cost.

Total Operational cost: Total operational cost incurred per hectare of fox-nut cultivation is Rs. 72802.68 which is 84.32% of the total cost.

Rental value own land/ leased land: The average rental value for fox-nut cultivation was Rs. 12500 which was 14.47% of the total cost.

Depreciation: The depreciation is calculated on the fixed assets was Rs. 327.40.

Interest fixed working capital @9.5%: Interest fixed working capital is fixed at 9.5% of the value of the fixed assets which in this study was incurred Rs. 613.7 which was an average of 0.71 percent

Land revenue tax: Tax levied by the state on the agricultural land which was negligible as compared to the production cost.

The total fixed cost: The total fixed cost incurred was Rs.13534

Gross return: The gross return of fox-nut cultivation in the study area was Rs.380335.57

Net return: The net return was approx. Rs.298104. With a view to have a deeper insight of the various components of cost in growing fox-nut a detailed analysis of related data was carried out and discussed above and the findings have been placed in Table 1.

Table 1: Cost of production per hectare

S. No.	Constraint	Marginal Farmers (141)	Small Farmers (36)	Semi-medium Farmers (15)	Medium Farmers (8)	Sample average
1	Human labour charges	29876 (34.33)	31040 (35.74)	31040 (36.18)	31516 (36.79)	30868 (35.75)
2	Hired labour charges	17460 (20.06)	21340 (24.57)	25220 (29.39)	27160 (31.70)	22795 (26.40)
3	Family Labour charges	12416 (14.27)	9700 (11.16)	5820 (6.78)	4356 (5.08)	8073 (9.35)
4	Seed cost	8100 (9.4)	7560 (8.70)	7200 (8.39)	6840 (7.98)	7425 (8.60)
5	Manure costing	3475.65 (3.99)	3367.77 (3.87)	3219.97 (3.75)	3025.95 (3.53)	3272.33 (3.79)
6	Fertilizer cost	6239.07 (7.17)	6254.55 (7.20)	6275.06 (7.31)	6304.05 (7.35)	6268.18 (7.26)
7	Cost incurred on plant protection	9103.84 (10.46)	9116.69 (10.49)	9112.59 (10.62)	9254.55 (10.80)	9146.91 (10.59)
8	Irrigation charges	11550 (13.26)	11250 (12.95)	11050 (12.88)	11000 (12.84)	11212.5 (12.98)
9	Miscellaneous expenditure	3056.55 (3.51)	2589.47 (2.98)	2245.36 (2.61)	2065.76 (2.41)	2489.285 (2.88)
10	Interest incurred on working capital calculated @ 12%	2142.03 (2.46)	2135.35 (2.45)	2104.28 (2.45)	2100.18 (2.45)	2120.46 (2.45)
11	Total operational cost	73543.14 (84.49)	73313.83 (84.42)	72247.26 (84.21)	72106.49 (84.17)	72802.68 (84.32)
12	Rental value of own land or lease land	12500 (14.36)	12500 (14.39)	12500 (14.57)	12500 (14.59)	12500 (14.47)
13	Depreciation cost	299.05 (0.34)	325.25 (0.37)	335.25 (0.39)	350.05 (0.40)	327.4 (0.37)
14	Interest incurred on fixed working capital @ 9.5%	612.37 (0.70)	613.62 (0.70)	614.01 (0.71)	614.8 (0.71)	613.7 (0.71)
15	Land revenue tax	93.15 (0.10)	93.15 (0.10)	93.15 (0.10)	93.15 (0.10)	93.15 (0.10)
16	Total fixed cost	13504.57 (15.51)	13532.02 (15.58)	13542.41 (15.78)	13558 (15.83)	13534.25 (15.67)
17	Total cost	87047.71 (100)	86845.85 (100)	85789.67 (100)	85664.49 (100)	86336.93 (100)

(Figures in parentheses represent a percentage of the total cost)

In the Table 1 the cost incurred on human labour for the marginal section of farmers was Rs. 29876 which was 34.33 percent of the total cost. When it was split in family labour and hired labour, the more cost is incurred on the hired labour as compared to family labour. The percent of total cost incurred on seed in this section of the farmers was 9.4 percent of the total cost and about 3.99 percent cost on the manures. The percent cost for the fertilizer and plant protection was 7.17 and 10.46 percent respectively. The percent cost incurred on the irrigation was 13.26 percent. The total operational cost percent was 84.49 percent of the total cost in this section of farmers and the total fixed cost percent incurred was about 15.51 percent. So the total cost comes out to be Rs. 87047.71.

The total cost incurred on the small section of the farmer was Rs. 86845.85 having percent of operational cost was 84.42 and percent of total fixed cost was 15.58 percent. The percent cost incurred on human labour was 35.74 percent of the total cost. The percent of total cost incurred on seed in this section of the farmers was 8.70 percent of the total cost and about 3.87 percent cost on the manures. The percent cost for the fertilizer and plant protection was 7.20 and 10.49 percent respectively. The percent cost incurred on the irrigation was 12.95 percent.

The maximum percent of the total cost incurred in cultivation of the fox-nut in semi-medium category of the farmers was under labour with 36.8 percent. The percent of costing of seeds, manures, fertilizers, plant protection and irrigation was 8.39, 3.75, 7.31, 10.62, 12.88 respectively. The percent of total cost incurred on operational cost was 84.21 percent and the percent of the total fixed cost was 15.78 percent. The total cost incurred was 85789.49.

The medium section of the farmers the cost of percent incurred on the labour was 36.79 which was maximum. The cost of percent incurred on the seeds, manures, fertilizer, plant protection, irrigation was 7.98, 3.53, 7.35, 10.80, and 12.84 percent respectively. Percent of the total cost incurred on the operational cost was 84.17 percent and the remaining on the fixed cost. The total cost in this category was Rs. 85664.49.

The average cost incurred on the cultivation of the fox-nut on 1 hectare of the pond was Rs. 86336.93. The average percent of the operational cost was Rs. 72802.68 and the total fixed cost average percent was 15.67. The average cost incurred on the human labour was 35.75 percent. The average percent of the total average cost incurred on the seeds, manures, fertilizer, plant protection and irrigation was 8.60, 3.79, 7.26, 10.59, and 12.98 respectively.

Cost of fox-nut cultivation according to cost concept

The cost of fox-nut cultivation on marginal, small, semi-medium, and medium farms was estimated using various cost concepts as shown in table 2. The table shows that, on average, the total cost required to produce one hectare of fox-nut in the study area was estimated at Rs.109395.7, with cost A1 (the sum of all variable costs excluding the imputed value of family labour) estimated at Rs. 78263.93 per hectare. After adding interest on fixed capital to cost A1 i.e. Cost B1 the cost went up to Rs. 78877.63 per hectare. Cost B2 amounted to Rs. 91377.63. Cost C1 which is the addition of cost B1 and the value of family labour was calculated at Rs. 86950.63. Cost C2 comprises cost B2 and the imputed value of family labour which amounted to Rs. 99450.63. The overall cost C3 consists of cost C2 and 10 percent of cost C2 as a managerial cost, was came to be estimated at Rs. 109395.70 per hectare.

Table 2: Cost of foxnut cultivation in terms of cost concept (Rs/hectare)

S.No.	Cost	Marginal Farmers	Small Farmers	Semi-medium farmers	Medium Farmers	Sample Average
1.	Cost A1	74631.71	77145.85	79969.67	81308.49	78263.93
2.	Cost A2	87131.71	89645.85	92469.67	93808.49	90763.93
3.	Cost B1	75244.08	77759.47	80583.68	81923.29	78877.63
4.	Cost B2	87744.08	90259.47	93083.68	94423.29	91377.63
5.	Cost C1	87660.08	87459.47	86403.68	86279.29	86950.63
6.	Cost C2	100160.1	99959.47	98903.68	98779.29	99450.63
7.	10% of c2* (for managerial work)	10016.01	9995.947	9890.368	9877.929	9945.063
8.	Cost C3	110176.1	109955.4	108794	108657.2	109395.7

Size-wise analysis of the cost concept of the sample fox-nut cultivators revealed a similar trend. It is clear from the table that total cost of cultivation per hectare (cost C_3) was comparatively high to the marginal size group, followed by small, semi-medium, and medium size fox-nut cultivators that indicated decreasing trend of cost C_3 with increasing farm sizes. It was Rs 110176.10, Rs 109955.40, Rs 108794, and Rs. 108657.20 for marginal, small, semi-medium, and medium size fox-nut cultivators, respectively.

The possible reasons for decreasing cost as the farm size increases were mainly due to manual labour, and low production rate due to small farm size because the cultivation is less scalable by marginal farmers as compared to large farmers.

Cost and return of fox-nut cultivation

As in business or farming profit maximization is the main motivating factor for the investment of resources. In the profit maximization, resources are used wisely so that the investors of the resources get the maximum profit from their investment and their interest in the present business should not loose. It also happens in the cultivation of fox-nut. Hence, in this section, efforts have been made to discuss the cost of cultivation, production, gross return, net return and output-input ratio of fox-nut and the result has been shown in table 3.

Table 3: Cost and Return

S.No.	Particulars	Marginal	Small	Semi-medium	Medium	Sample Average
1	Cost of cultivation (Rs/ha)	110176.1	109955.4	108794	108657.2	109395.7
2	Production(Q/ha)	21.8	20.4	19.8	19.5	20.37
3	Price (Rs/Q)	20000	20000	20000	20000	20000
4	Gross return (Rs/Ha)(price*production/yield)	436000	408000	396000	390000	380335.7
5	Net return (Rs/.ha)(coc-gr)	325823.9	298044.6	287206	281342.8	298104.3
6	Output - input ratio(coc/nr)	3.95	3.71	3.63	3.58	3.72
7	Cost of production (Rs./Q)	5053.95	5389.97	5494.64	5572.16	5369.11

Table 4: Income measures in terms of cost concept on fox-nut farm

S. No.	Particulars	Marginal	Small	Semi-medium	Medium	Sample Average
1	Gross return (Rs/ha.)	436000.00	408000.00	396000.00	390000.00	407500.00
2	Net Return (Rs.ha)	325823.90	298044.60	287206.00	281342.80	298104.30
3	Net Return Over (Rs.ha)					
	Cost A1	361368.30	330854.20	316030.30	308691.50	329236.10
	Cost A2	348868.30	318354.20	303530.30	296191.50	316736.10
	Cost B1	360755.90	330240.50	315416.30	295576.70	325497.40
	Cost B2	348255.90	317740.50	302916.30	295576.70	316122.40
	Cost C1	348339.90	320540.50	309596.30	303720.70	320549.40
	Cost C2	335839.90	308040.50	297096.30	291220.70	308049.40
	Cost C3	325823.90	298044.60	287206.00	281342.80	298104.30
4	Benefit cost ratio					
	Cost C1	3.16	2.91	2.84	2.79	2.92
	Cost C2	3.04	2.80	2.73	2.68	2.81
	Cost C3	2.95	2.71	2.63	2.58	2.72

Parameters like cost of cultivation, gross return and net return of fox-nut were found to be decreasing with increasing farm size of households. Cost of cultivation was highest for the marginal farmers i.e. Rs. 110176.1 and lowest for medium size farmers i.e. Rs. 108657.2. The sample average of the cost of cultivation was Rs. 109395.7. Gross return for the marginal farmer in the fox-nut cultivation was Rs. 436000, for the small farmers it was Rs. 40800, for semi-medium it was Rs. 396000 and gross return for the medium farmer was Rs. 390000. The sample average of the gross return for the fox-nut cultivation was Rs. 380335.7. However, net return on fox-nut production was found to be Rs.325823.90, Rs.298044.60, Rs. 287206 and Rs. 281342.80 in case of marginal, small, semi-medium and medium fox-nut cultivators, respectively and the sample average for the net return was Rs. 298104.3.

This indicated that medium farmer used their available resource more efficiently followed by small, semi-medium and then medium fox-nut cultivators. On an average, per hectare yield of fox-nut came to be 20.37 quintals. It is revealed from the table that, on an average, fox-nut cultivators received Rs. 298104.30 per hectare as net income from cultivation. Further, this table shows that, on an average, output- input ratio was 3.72 which indicates that, from one rupee investment cultivator gets a profit Rs. 2.72.

Measure of income in term of cost concept

Income measures of fox-nut cultivator on marginal, small, semi-medium and medium farms in terms of various cost concepts and the income measures have been presented in Table 4.

Table 4: Income measures in terms of cost concept on fox-nut farm

S. No.	Particulars	Marginal	Small	Semi-medium	Medium	Sample Average
1	Gross return (Rs/ha.)	436000.00	408000.00	396000.00	390000.00	407500.00
2	Net Return (Rs.ha)	325823.90	298044.60	287206.00	281342.80	298104.30
3	Net Return Over (Rs.ha)					
	Cost A1	361368.30	330854.20	316030.30	308691.50	329236.10
	Cost A2	348868.30	318354.20	303530.30	296191.50	316736.10
	Cost B1	360755.90	330240.50	315416.30	295576.70	325497.40
	Cost B2	348255.90	317740.50	302916.30	295576.70	316122.40
	Cost C1	348339.90	320540.50	309596.30	303720.70	320549.40
	Cost C2	335839.90	308040.50	297096.30	291220.70	308049.40
	Cost C3	325823.90	298044.60	287206.00	281342.80	298104.30
4	Benefit cost ratio					
	Cost C1	3.16	2.91	2.84	2.79	2.92
	Cost C2	3.04	2.80	2.73	2.68	2.81
	Cost C3	2.95	2.71	2.63	2.58	2.72

It may be observed from the table that gross return from the marginal, small, semi-medium and medium farm size group of farmers came to be Rs. 436000, Rs. 408000, Rs. 396000 and Rs. 390000 respectively. The net return form the different farm size was Rs. 325823.9, Rs. 298044.60, Rs. 287206 and Rs. 281342.80 for marginal, small, semi-medium and medium respectively.

For marginal farm size Cost A1 was Rs. 361368.30, Cost A2 was Rs. 348868.3, Cost B1 was Rs. 360755.90, Cost B2 was Rs. 348255.90, Cost C1 was Rs. 348339.9, Cost C2 was Rs. 335839.9 and Cost C3 was Rs. 325823.90. And for small farm size Cost A1 was Rs. 330854.2, Cost A2 was Rs. 318354.20, Cost B1 was Rs. 330240.50, Cost B2 was Rs. 317740.50, Cost C1 was Rs. 320540.50, Cost C2 was Rs. 308040.50 and Cost C3 was Rs. 298044.60. For semi-medium farm size Cost A1 was Rs. 316030.30, Cost A2 was Rs.315416.30, Cost B1 was Rs. 303530.30, Cost B2 was Rs. 302916.30, Cost C1 was Rs. 309596.30, Cost C2 was Rs. 297096.30 and was Cost C3 Rs. 287206. For medium size farm group the Cost A1 was Rs. 308691.5, Cost A2 was Rs. 296191.50, Cost B1 was Rs. 295576.70, Cost B2 was Rs. 295576.70, Cost C1 was Rs. 303720.70, Cost C2 was Rs. 291220.70 and Cost C3 was Rs. 281242.80.

The sample average for Cost A1 was Rs. 329236.10, Cost A2 was Rs. 316736.10, Cost B1 was Rs. 325497.40, Cost B2 was Rs. 316122.40, Cost C1 was Rs. 320549.40, Cost C2 was Rs. 308049.40 and Cost C3 was Rs. 298104.30.

Benefit cost ratio for marginal size farm group for Cost C1 was 3.16, for Cost C2 it was 3.04 and for Cost C3 it was 2.95. For small size farm group cost benefit ratio on Cost C1 was 2.91, Cost C2 was 2.80, and Cost C3 was 2.71. The benefit cost ratio for the semi-medium farm size group for Cost C1 was 2.84, Cost C2 was 2.73 and Cost C3 was 2.63. For medium size farm group the benefit cost ratio for Cost C1 was 2.79, for Cost C2 it was 2.68 and for Cost C3 it was 2.58.

The sample average for benefit cost ratio for Cost C1, Cost C2 and Cost C3 was 2.92, 2.81 and 2.72 respectively.

Constraints faced by fox-nut growers in production

The survey was conducted to elicit the opinions of farmers regarding the constraints faced by the farmers in fox-nut production and the results are presented in the Table 5 Garretts was applied for ranking these constraints. As opinioned by most of the farmers, labour scarcity during peak time was the major problem with mean score of 54.84 problem faced by fox-nut farmers so this problem given second rank. The fourth rank was given to high labour cost (52.18) followed by Lack of improved cultivars (47.7). Lack of credit facility (52.66), awareness of new technologies in fox-nut cultivation (45.85), Lower productivity of fox-nut pop (44.31), high cost of fertilizer (40.54), Input supply centre is far away (42.41), and no ownership of pond (68.51) is ranked first and is the most pain point for the fox-nut growers.

The findings indicates that labour scarcity during peak time was most severe constraint reported by the farmers with second rank (79.83). This might be due to the fact that availability of labour was major issue as fox-nut cultivation requires of labour from planting to harvesting.

Table 5: Constraints faced by fox-nut growers in production.

S. No.	Particulars	Percent position	Garrett score	Garrett Mean score	Rank
1	Labour scarcity during peak time	5.27	81	54.84	II
2	High labour cost	30.38	68	52.18	IV
3	Non availability of pond ownership	4.46	62	68.51	I
4	Unavailability of improved cultivars	7.29	56	47.7	V
5	Unavailability credit facility	9.32	50	52.66	III
6	unawareness of new technologies in fox-nut cultivation	6.89	44	45.85	VI
7	High cost of fertilizers	5.67	38	40.54	IX
8	Lower productivity of fox-nut pop	4.86	31	44.31	VII
9	Input supply centre is far away	6.89	19	42.41	VIII

Net income was the highest over Cost A1 and lowest over Cost C3, thereby indicating direct relationship between net return and farm size. But marginal cultivator gets more net return than small, semi-medium and medium cultivator. One probable reason for this observation may be due to marginal farm size respondents owned a meager amount of land, and they wanted to take maximum possible returns from their small size of land by giving their maximum effort. It was revealed from the table that on an average a fox-nut cultivator received Rs. 298104.30 per hectare as net income. The overall B-C ratio over Cost C1 was found to be 2.92, while the same over Cost C2 and Cost C3 were estimated to be 2.81 and 2.72 respectively.

Constraints in production of fox-nut have been studied. Lack of ownership of the pond with highest Garret score of 68.51 is the major constraint faced by the farmers. The large percentage of fox-nut cultivators cultivate the nuts on leased land or in ponds owned by the government or privately. Other challenges faced by farmers in the production of fox-nuts include highly skilled operation, limited scientific knowledge of cultivation, limited access to improved seed varieties, absence of credit facilities, short lease periods, and labor-intensive cultivation.

Author's contribution

Conceptualization and designing of the research work (P. Kumari, A.S. Noel); Execution of Field/Lab experiments and data collection (P. Kumari); Analysis of data and interpretation (A. Rai, P. Kumari); Preparation of manuscript (A. Rai)

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