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Opportunity of pearl millet (Bajra) production: A case study in Bihar

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Abstract
The present study aimed to identify the costs and returns, resource use efficiency, sustainability and the constraints faced by sample farmers in Bajra production. A multistage sampling technique was adopted for selection of 120 sample farmers from four villages of Bhojpur district of Bihar. Cost concept A, Cobb- Douglas production function, modified multi criteria approach and Garrett's ranking technique was used for analysis. Sample farmers responded that Bajra is more remunerative but less sustainable than rice. They also reported that the independent variables like area, labour and rent paid for leased in land significantly explained the variations in gross returns by 83 per cent and the major constraints faced by them was lack of labour during peak season coupled with high wage rate.

Keywords: bajra production, costs and returns, resource use efficiency, sustainability, constraints

Introduction
Pearl millet (*Pennisetum glaucum* L.) commonly known as "*Bajra*" or "*Bajri*" is the most popular and nutritive cereal grown in tropical and semi-arid region of India. The crop is traditionally grown for both food and fodder purpose on marginal lands with low fertility under drought condition (Meena and Kumar, 2017: Chaudhari *et al.*, 2015, Nagaraj *et al.*, 2012) [1, 3, 8]. The country produced 9.13 million tonnes of bajra from an area of 7.38 million hectares with an average productivity of 1237 kg/ha (GoI, 2019) [6]. Rajasthan, Gujarat, Madhya Pradesh, Haryana and Maharashtra are the major bajra producing states in India (Deshmukh *et al.*, 2010) [5]. Though bajra is very nutrient rich but due to low productivity and improvement in yield of other cereal crops especially rice and wheat, the trend in area, production and productivity was stagnant; the CAGR was worked out to be -0.01, 0.01 and 0.02, respectively for the period 1997-98 to 2017-18 (GoI, 2019) [6].
The scenario of growth in area, production and productivity (CAGR 0.05, 0.02 and 0.03, respectively for the period 199-00 to 2017-18) of bajra in Bihar was slightly better than the country's situation. During 2017-18, Bihar produced 4.97 thousand tonnes of Bajra from an area of 4.38 thousand hectares with productivity of 1135.80 kg/ hectare (https://aps.dac.gov.in/APY/Public_Report1.aspx). In Bhojpur district, bajra was cultivated in 0.98 thousand hectares of land with production of 1.11 thousand tonnes during the same period. The Compound Annual Growth Rate (CAGR) from 1997-98 to 2017-18 of area, production and productivity of bajra in the district almost remain constant from which were 0.01, 0.04 and 0.03, respectively.
Overflow of rice- wheat production, health consciousness and growing demand for nutri-cereal based products gave rise the scope of obtaining remunerative prices to Bajra farmers. This study was the part of examining the economics of cereal production system in Bhojpur district. The study entails the cost of cultivation, resource use efficiency, sustainability and constraints of bajra production in the study area.

Materials and Methods
Multistage sampling technique was adopted for selecting the sample respondents. The primary data was collected from the selected farmers for the agricultural year 2017-18. Bhojpur district of Bihar was selected purposively as one the major cereal producing district, falls in Zone III-B. At second stage, two blocks of Bhojpur district namely, Garahani and Koilwar were selected by Simple Random Sampling without Replacement (SRSWOR) technique. In the next stage, two villages from each block and 30 cereal growers from each village i.e. totalling four villages and 120 cereal growers were selected randomly.

Estimation of Costs and Returns

The total costs were divided into two broad classes i.e. Variable or operational costs and fixed costs. Variable costs include costs incurred on seed, manure and fertilizer, plant protection chemical, expense on irrigation, labour charge, interest on working capital, rent paid for leased in land and miscellaneous charges etc. and fixed costs include land revenue, interest on fixed capital, depreciation on farm implements & machinery etc. All the cost was taken at actual price paid by the sample farmers or valued at the prevailing market prices in the area.

Estimation of Resource use efficiency

Cobb- Douglas production function was fitted to know the resource use efficiency and functional relationship between the dependent variable and independent variables was estimated by using this method. For each explanatory variable the Marginal Value Product (MVP) and Marginal Factor Cost (MFC) were calculated and compared to know the resource use efficiency of identified cereal crop production. The Cobb-Douglas type of production function is as follows:

$$Y = a\, x_1^{b1}\, x_2^{b2}\, x_3^{b3}\, x_4^{b4}\, x_5^{b5}\, x_6^{b6}\, u$$

Where,

Y = Gross returns (Rs); a = intercept; x_1 = Area (acres); x_2 = Seeds (Rs.); x_3 = Fertilizer and manure, x_4 = Plant protection chemicals (Rs.); x_5 = irrigation (Rs.); x_6= Labour (Rs.); u =error term

The function was converted into linear form by making logarithmic transformation of all the variables (Rahaman *et al.*, 2015).

$$\text{Ln } Y = \ln a + b_1 \ln x_1 + b_2 \ln x_2 + b_3 \ln x_3 + b_4 \ln x_4 + b_5 \ln x_5 + b_6 \ln x_6 + \ln u$$

Measurement of sustainability

A composite sustainability index for identified cereals in the study area was calculated by using modified Multi Criteria Approach developed by Boggia and Abbozzo (1998) [2], for deriving the sustainability through combining six components which are gross income per acre, ratio of output value to input cost, fertilizer productivity, pesticide productivity, percentage cost of eco-friendly inputs to total cost of cultivation and ratio of cost of owned inputs to the total cost of cultivation. The six indicators have been measured and expressed in different units. Hence the values were converted into unit values (U_{ij}) by using simple range and variability as formula given below:

$$U_{ij} = \frac{Y_{ij} - \text{Min } Y_j}{\text{Max } Y_j - \text{Min } Y_j}$$

Where,

Y_{ij} is the value assigned by i^{th} respondent on j^{th} component

Min Y_j is minimum score on j^{th} component

Max Y_j is maximum score on j^{th} component

U_{ij} is unit value of i^{th} respondent on j^{th} component

Each indicator is ranked by experts in the descending order according to their relative importance for sustainable use and Garrett's ranking technique was involved to reveal their importance. Average score was derived from the obtained scores that is known as scale value (S_j) of each component in different cereals. The unit values (U_{ij}) for each indicator were multiplied by respective component scale value (SI_i), summed up and divided by total scale value to get Sustainability Index (SI_i) of each of the combinations in different cereals. The value of SI_i is in percentage. Higher the SI_i, higher will be the sustainability of the cereal among the identified cereals (Bharti *et al.*, 2017; Rahaman and Haldar, 2014) [1, 10].

$$SI_i = \frac{\sum_{i=1}^{n} U_{ij} * S_j}{\sum_{i=1}^{n} S_j}$$

Estimation of constraints by Garrett's ranking technique

In this method, respondents were asked to rank the specific constraints faced by them according to their own perception in descending order. The assigned rank was converted into respective percentage position which was subsequently transferred into Garrett score using Garrett's table. For each constraint, scores of individual respondents were added together and their mean was calculated. Thus, mean score for each constraint was arranged in descending order and ranked (Rahaman and Haldar, 2014, De and Rahaman, 2014; Rahaman *et al.*2015; Rahaman *et al.* 2013) [10, 4, 11].

$$\text{Percentage position} = \frac{100(R_{ij} - 0.50)}{N_j}$$

Where,

R_{ij} = Rank given for the i^{th} item by the j^{th} individual and

N_j = Number of items ranked by the j^{th} individual.

Results and Discussions

Classification of farmers according to the size of operational holding

The classification given by Reddy *et al.* (2004) [12] was followed to categorize the sample farmers of the study area based on their size of operational holding irrespective of ownership holding. The respondents were post stratified into marginal and small (Group I) having operational holding size less than equal to 2.50 acres, semi-medium farmers (Group II) with holding size ranging from 2.5 to 5.0 acres and medium and large famers (Group III) farmers (more than equal to 5.0 acres) and presented in the table 1. The table indicate that total 45 farmers belonged to Group I category (37.50%) and predominated the study area followed by 39 farmers in Group III (32.50%) and 36 farmers in Group II (30.00%). It was found that majority of the sample farmers (32 farmers) of Garahani block belonged to Group III (53.34%) followed by the 20 farmers in Group II (33.33%) and 8 farmers in Group I (13.33%). Whereas majority of the sample farmers (37 farmers) of Koilwar block belonged to the category of Group I (61.67%) category followed by 16 farmers in Group II (26.67%) and 7 farmers in Group III (11.66%). A typical distinction in distribution of farmers has been observed between Garahani and Koilwar blocks. The average operational holding of the farmers belonged to Koilwar block of Bhojpur was comparatively smaller than Garahani block farmers. It may be inferred that the proximity of Koilwar block to the relatively urban centre Ara gave an edge to the farm family to diverse their livelihood activity to non-farm

sector than its counterpart Garahani block farmers where the farmers were mostly dependent on agriculture for their livelihood activities.

Table 1: Classification of the sample farmers based on the size of operational holding

Category	Size of operational land holding	Number of farmers		
		Garahani block	Koilwar block	Overall block
Group I	≤ 2.5 acres	8(13.33)	37(61.67)	45(37.50)
Group II	2.5 to 5 acres	20(33.33)	16(26.67)	36(30.00)
Group III	≥ 5 acres	32(53.34)	7(11.66)	39(32.50)
Total		60(100.00)	60(100.00)	120(100.00)

Note: Figures in parenthesis indicates percentage to total

Costs and returns of bajra production on the sample farms

Due to lack of availability off timely supply of irrigation water in sufficient quantity some of the Koilwar block farmers shifted *kharif* rice with bajra production for market though it was not the staple food of the people of the region. The costs and returns per acre of bajra production in last year are presented in Table 2. The farmers generated net returns of Rs. 13057.30 per acre on an average with returns to costs ratio of 2.50, which indicate that by employing one rupee in bajra production one can get gross return of 2.50 rupees. The higher market price coupled with low input cost made the returns to cost ration of bajra production high. Total variable cost and total fixed cost was Rs. 8509 and Rs. 217, respectively. The cost of hired labour, machine labour, fertilizer and rent paid for leased in land were the major costs contributing 50.31, 13.20, 9.62 and 7.63 per cent to the total cost, respectively. Among the three categories of farmers, the marginal and small farmers (Group I) have earned highest net income of Rs. 13829.14 per acre with returns to costs ratio of 2.67. The major costs, they incurred were cost of hired labour, machine labour, fertilizer and seed contributing 50.80, 13.15, 10.22 and 7.45 per cent to total cost, respectively. The semi medium (Group) II farmers fetched Rs. 12200.75 per acre with returns to cost ratio of 2.17. The cost of hired labour, machine labour, rent paid for leased in land and fertilizer were the major cost items contributing 46.07, 13.82, 13.44 and 8.55 per cent to total cost, respectively. The medium and large farmers (Group III) farmers earned Rs. 10935.39 per acre with returns to cost ratio of 2.52. The major costs, they incurred were cost of hired labour, machine labour, fertilizer and plant protection chemicals contributing 61.34, 11.42, 9.51 and 6.12 per cent to total cost, respectively.

Table 2: Costs and returns of Bajra production on the sample farms (in Rupees per acre)

Particulars	Overall			
	Group I	Group II	Group III	AF
A. Cost of cultivation (Major explicit cost items)				
i. Seed	617.06(7.45)	596.92(5.73)	365.71(5.07)	582.37(6.67)
ii. Fertilizer	846.31(10.22)	890.77(8.55)	685.71(9.51)	839.43(9.62)
iii. Plant protection chemical	561.70(6.78)	684.73(6.57)	440.81(6.12)	580.40(6.65)
iv. Hired labour	4208.43(50.80)	4800.00(46.07)	4421.86(61.34)	4391.08(50.31)
v. Machine labour	1089.73(13.15)	1440.00(13.82)	822.86(11.42)	1152.00(13.20)
vi. Rent paid for leased in land	473.80(5.72)	1400.00(13.44)	0.00(0.00)	665.51(7.63)
vii. Miscellaneous cost	151.35(1.83)	200.00(1.92)	114.29(1.59)	160.00(1.83)
viii. Interest on working capital	125.65(1.52)	191.45(1.84)	86.99(1.21)	138.69(1.59)
B. Total variable cost	8074.03(97.47)	10203.87(97.95)	6938.23(96.25)	8509.48(97.50)
ix. Land revenue	40.00(0.48)	52.00(0.50)	30.00(0.42)	42.03(0.48)
x. Depreciation	169.75(2.05)	162.00(1.56)	240.06(3.33)	175.89(2.02)
C. Total fixed cost	209.75(92.53)	214.00(2.05)	270.06(3.75)	217.92(2.50)
Total Cost (B+C)	8283.78(100.00)	10417.87(100.00)	7208.29(100.00)	8727.40(100.00)
D. Gross Income				
i. Grain	18815.11	19203.65	15203.27	18497.34
ii. By-product	3297.81	3414.97	2940.41	3287.36
iii. Total	22112.92	22618.62	18143.68	21784.70
Net Income [D-(B+C)]	13829.14	12200.75	10935.39	13057.30
Returns to Costs ratio	2.67	2.17	2.52	2.50

Note: Figures in parenthesis indicates percentage to total cost

Resource use efficiency in Bajra production

The extent of effective utilization of resources in bajra production is presented in Table 3. The estimated coefficient of multiple determination (adjusted) was found 0.83 signify that 83 per cent variation in gross returns was explained by the independent variables (extent, labour and rent paid for leased in land) incorporated in the model. The coefficient of extent, labour and rent paid for leased in land were found 0.024, 1.067 and 0.068, respectively that are significant at 5%, 1% and 1% level of significance indicating that for every one per cent increase in the use of extent, labour and rent paid for leased in land results in increase in gross return of bajra by 0.024, 1.067 and 0.068 per cent respectively, over and above the geometric mean level. The price of land was very high so it was considered in lakh rupees. The returns to scale was found 1.159. The F test showed that the estimated model was found significant at one per cent level of significance. The allocative efficiency (MVP/MFC) for extent (4.11) indicates that additional one lakh rupee expenditure incurred to procure land for bajra gross return will be increased the by 4.10 times.

Allocative efficiency for labour (5.20) and rent paid for leased in land (1.71) indicates that every one rupee increase in expenditure on labour and rent paid for leased in land, the gross returns will be increased by Rs. 5.20 and Rs. 1.71 respectively.

Table 3: Elasticity coefficients using Cobb- Douglas production function in Bajra production

Variables	Coefficients	t- Statistic	MVP/MFC
Intercept	2.68*	42.39	
Extent (acre)	0.024**	2.27	4.11
Labour (Rs.)	1.067*	639.69	5.20
Rent paid for leased in land (Rs.)	0.068*	2.45	1.71
∑bi	1.159		
R^2 Value	0.85		
Adjusted R^2	0.83		
F – value	4.084*		

*Significant at 1% level; **Significant at 5% level

Sustainability of growing cereal crops in the study area

A composite sustainability index of the identified cereal crops in the study was developed using multi criteria approach and presented in Table 4. The sustainability index was developed combining six components that are gross income per acre, ratio of output value to input cost, fertilizer productivity, pesticide productivity, percentage cost of eco-friendly inputs to total cost of cultivation and ratio of cost of owned inputs to the total cost of cultivation. Higher the value in sustainability index shows more sustainability of the crop. In the study area the sustainability index of paddy, wheat and bajra were found as 56.44, 34.64 and 36.33, respectively. Though production of bajra was found more remunerative in the study area, sustainability of paddy was higher. Paddy, being the staple food of the region majority of the farmer gave higher rank to the gross returns from paddy than other criteria used for computation of sustainability index.

Bajra production was found less sustainable across the study area with index value 44.10 for marginal and small farmers (Group I), 30.67 for semi-medium farmers (Group II) and 30.72 for medium and large farmers (Group III).

Table 4: Sustainability Index of the identified cereal crops i.e. paddy, wheat and bajra in the study area

Particulars	Group I	Group II	Group III	Overall
Paddy	56.11	58.21	56.77	56.44
Wheat	37.80	48.55	35.40	34.64
Bajra	44.10	30.67	30.72	36.33

Constraints faced by sample farmers in bajra production

The constraints faced in bajra production are presented in table 5. Lack of labour in peak season, high price of labour and high incidence of pest and diseases were the major three constraints face by bajra farmers with Garrett score 75.32, 69.70 and 60.58 respectively. Other constraints faced by bajra producers were lack of Govt./institutional support, low harvest season price of output, lack of availability of machinery and equipment during peak period, lack of capital, lack of information regarding improved seeds chemicals and scattered and fragmented field plots etc.

Table 5: Constraints faced by sample farmers of Koilwar block in production of bajra

Sl. No.	Constraints	Garrett Score	Rank
1	Lack of Labour in peak season	75.32	I
2	High price of labour	69.70	II
3	High incidence of pest and diseases	60.58	III
4	Lack of Govt./ Institutional support	59.30	IV
5	Low harvest season price of output	46.82	V
6	lack of availability of machinery and equipment in peak season	39.68	VI
7	Lack of capital	39.45	VII
8	lack of information regarding improved seeds chemicals, crop insurance	30.42	VIII
9	Scattered and fragmented field plots	29.73	IX

Constraints faced by different categories of sample farmers in production of bajra

The constraints faced by different categories of sample bajra producers are presented in table 6. The Group I farmers listed lack of labour in peak season, high price of labour and high incidence of pest and diseases as the three major problems with Garrett score 77.43, 70.90 and 60.30 respectively. Group II farmers identified lack of labour in peak season, high price of labour and lack of Govt. Institutional support as the major constraints with Garrett score 73.44, 70.44 and 66.50, respectively. High incidence of pest and diseases, high price of labour and lack of labour in peak season were the major constraints faced by Group III farmers with Garret score, 70.86, 68.71 and 68.43 respectively.

Table 6: Constraints faced by different categories of sample farmers of Koilwar district in production of bajra

Sl. No.	Group I			Group II			Group III		
	Constraints	Garrett Score	Rank	Constraints	Garrett Score	Rank	Constraints	Garrett Score	Rank
1	Lack of Labour in peak season	77.43	I	Lack of Labour in peak season	73.44	I	High incidence of pest and diseases	70.86	I
2	High price of labour	70.90	II	High price of labour	70.44	II	High price of labour	68.71	II
3	High incidence of pest and diseases	60.30	III	Lack of Govt. Institutional support	66.50	III	Lack of Labour in peak season	68.43	III
4	Lack of Govt. Institutional support	58.43	IV	High incidence of pest and diseases	56.75	IV	Scattered and fragmented field plots	68.00	IV
5	Low harvest season price of output	49.19	V	Low harvest season price of output	50.38	V	Lack of Govt. Institutional support	47.43	V
6	Lack of capital	42.86	VI	lack of availability of machinery and equipment in peak season	38.13	VI	lack of availability of machinery and equipment in peak season	46.57	VI
7	lack of availability of machinery and equipment in peak season	39.05	VII	Lack of capital	36.63	VII	lack of information regarding improved seeds chemicals, crop insurance	34.00	VII
8	lack of information regarding improved seeds chemicals, crop insurance	29.70	VIII	lack of information regarding improved seeds chemicals, crop insurance	30.50	VIII	Lack of capital	27.86	VIII
9	Scattered and fragmented field plots	23.14	IX	Scattered and fragmented field plots	28.25	IX	Low harvest season price of output	26.14	IX

Conclusion

The production of bajra has been taken up by the Koilwar farmers as an alternative crop to kharif paddy. Though bajra was not a traditional crop in the study area but lack of timely irrigation and low fertile soil prompted some farmers to take the opportunity of bajra production that have premier price in local market. Bajra was less dependent on external inputs but heavily dependent on manual labour from land preparation to harvesting and threshing operation. Thus, lack of Labour during peak season coupled with high wage was the major constraints found for the crop. Further, being a new crop in the region, it was very susceptible to pest and diseases affecting the yield. Lack of government support, scarcity of required machinery and technological backwardness were some other problems faced by the farmers.

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