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An Economic Analysis of Pearl Millet Crop in Rain-fed Micro Farming Situation in Zone IB of Rajasthan, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The present study was conducted in Hanumangarh district of Zone IB of Rajasthan. This district have Rainfed micro-farming situation. Hence, Hanumangarh district of Rajasthan was selected. In this district two villages were selected from Nohar tehsil. A sample of 25 farmers from each village was selected. The study was aimed at examining compound growth rate, cost and returns, resource use efficiency and farm income inequalities. Primary data were collected on pre-structured schedules for agriculture year 2017-18. In the study found that CAGR of area, production, and productivity in period first was positive but in period second this found was negative except positive productivity in Rajasthan. Average cost per hectare of pearl millet was ₹ 13955.07 and gross income on was ₹ 33646.67. The Cobb Douglas production function, revealed that in pearl millet crop weeding intercultural operation were underutilized. Gini coefficient in farm household was 0.311 in Rain-fed micro farming situation.

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1. INTRODUCTION

Rajasthan state covers an area of 3, 42,239 square kilometers or 10.4 percent of the total geographical area of India (Agriculture Census 2015-16) [1]. It is the largest Indian state by area and the seventh largest by population it comprises most of the wide Thar Desert (also known as the Great Indian Desert). In Gross Cropped Area, Rajasthan is having second position with 24.4 million ha (12.8 percent) gross cropped area among all States/UTs [2]. Rajasthan has been divided into ten agro-climatic zones. Zone 1-B is Irrigated North Western Plain Zone. North western parts of Rajasthan comprise Hanumangarh district. Hanumangarh districts have Rain-fed & Sandy soils. Major crop in Rain-fed & Sandy soils is pearl millet (Bajra) in kharif season. Agriculture nearly 86 million ha area is rain-fed of total net sown area of the country (According to the Union ministry of India). Over 70% area is rain-fed with average precipitation of 575 mm. The soils are coarse and poor in fertility and the cropping intensity is 125%.

Therefore, in light of the above facts, it is concluded that Zone 1-b, has diverse farming situations like dry land (Rain-fed) situations [3]. The present study will focus on comparative economics, and growth in area, production and productivity in these diverse situations. Due to diverse farming situations, the incomes accruing to farmers are different [4].

2. METHODS

2.1 Selection of Samples and Collection of Data

The present study was based on both primary as well as secondary data collected from the Rain-fed Micro farming situations in Hanumangarh district from zone I b of Rajasthan. In Hanumangarh district Nohar tehsil representing Rain-fed micro farming situation hence this tehsil was selected.

A sample of 50 farmers was selected for the present study. The farmers were divided into small, medium and large farms on basis of following criterion; Small (≤ 2 ha), Medium (>2 ha ≤ 4 ha) and Large (> 4 ha). A sample of 25 farmers was selected with probability proportional to the number of farmers in each size group.

Primary data were collected with the help of pre-structured schedules. The primary data regarding resources used in different crops, yields obtained and prices received were collected from the selected farmers by personal interview method. Secondary data in respect of area and production and productivity of selected crops, were collected from Directorate of Economics and Statistics, Govt. of Rajasthan, Jaipur.

2.2 Statistical Analysis

Following statistical tools has been carried out for the present study.

2.3 Estimation of Compound Growth Rates

CAGRs (Compound Annual Growth Rates) were computed by fitting exponential function to the figures of area, production and productivity.

$$Yt = ab^t U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

Where, Y_t = area/production/productivity of selected crop in time period t

t= time element which takes the value 1, 2, 3….n

a and b are parameters to be estimated and b = (1+g), where g is the rate at which y grows every year in relation to its value in preceding year.
U_t = is the disturbance term.

On logarithmic transformation of equation (i) we get

$$\text{Log } y_t = \log a + t \log b + \log U_t$$

This can be expressed as:

$$y^*_t = a^* + b^*t + U^*_t$$

Where $y^*_t = \log y_t$; $a^* = \log a$; $b^* = \log b$ and $U^*_t = \log U_t$

The estimate of compound growth rate can be obtained as:

$$g = (\text{anti log } b^* - 1) \times 100$$

The F test was used for testing significance of the CAGR.

Cost concepts analysis was done on various cost concepts basis.

2.4 Resource Use Efficiency

Cobb-Douglas production function was fitted to analyse the resource use efficiency. The model is as follows:

$$Y = a.X_1^{b1}X_2^{b2}X_3^{b3} \dots\dots\dots.X_n^{bn}U_i$$

Different variables uses in the production function are as under:

Where, Y = Output in quintals per hectare.
X_1 = Quantity of seed (kg) per hectare.
X_2 = Quantity of F.Y.M. (in quintal) per hectare.
X_3 = Quantity of Nitrogen (in kg) per hectare.
X_4 = Quantity of Phosphorus (in kg) per hectare.
X_5 = Human labour (Man days) used per hectare.
X_6 = Animal labour (days) used per hectare.
X_7 = Machine labour (hrs) used per hectare.
X_8 = Number of irrigations per hectare.
X_9 = Number of sprays per hectare.
X_{10} = Number of weedings per hectare.

Where: a = Constant

b_1, b_2, ….b_n = Regression coefficients / elasticises of production.

U_i = Error term.

The regression coefficients, their significance, standard error and co-efficient of multiple determination (R^2) were worked- out. Marginal physical product and marginal value productivity were worked out for each statistically significant input.

2.5 Marginal Physical Product and Marginal Value Productivity

The marginal physical product of the input, used in each crop was worked out with the help of following equation;

$$MPP = Bi\frac{\overline{Y}}{\overline{X}}$$

The MVP was worked out as follows:

MVP = MPP x Price/quintal

Where: b_i = Elasticity of production of *i^th^* input.
$\overline{Y}$= Geometric mean of output per hectare.
$\overline{X}$= Geometric mean of input per hectare.
MPP = Marginal physical product of *i^th^* input.
MVP = Marginal value productivity of *i^th^* input.

$$\text{Resource use efficiency} = \frac{MVP_{Xi}}{MFC_{Xi}} = 1$$

Where, MFC_{xi} is marginal factor cost

2.6 Income Inequality

To evaluate the distribution of income among different land holding size groups, Lorenz curves were drawn for each micro farming situation. A Lorenz curve relates cumulative percentage of income receivers to cumulative percentage of the aggregate income. Farther the Lorenz curve is from line of complete equality, the more is the inequality. The nearer it is to the line of equality, the less is the inequality. In order to show the extent of inequality in matter of possession of assets by the households in different regions of the districts, Gini concentration ratios were also worked out. The Gini ratio was invented by Corrado Gini in 1913. It is being used with increasing frequency as a measure of relative distributional inequality. This ratio can also be approximated from Lorenz curve. When approximated from Lorenz curve, it represents proportion of the area under the diagonal that lies between diagonal and Lorenz curve. For example, if the area inside the Lorenz curve is designated as A, and that outside the Lorenz curve as B, the Gini ratio would be A/(A+B). The range of this ratio varies from zero to one. Gini concentration ratio of zero indicates perfect equality and Gini ratio of one indicates perfect inequality. The following formula was used to compute Gini concentration ratio,

$$G = \frac{1}{2}n^2\mu\sum_{i=1}^{n}\sum_{j=2}^{n}(Y_1 - Y_2)$$

$$= 1 + (1/n)(2/n\mu)(Y_1 + 2Y_2) + \dots\dots..+nY_n$$

For$Y_1 \geq Y_2 \geq \dots\dots\dots \geq Y_n$

Where,

n = Sample size

μ = Mean income of the farmers

Y_1 =Income of the i^th^ farmers

3. RESULTS AND DISCUSSION

3.1 Growth in Area, Production and Productivity

The twenty years data on area, production & productivity was divided in to two periods, Period

I (1998-99 to 2008-09) & Period II (2009-10 to 2018-19).

In Table 1 shows that in the area of pearl millet registered positive and significant compound growth rates of 2.5, and 4.7 per cent in Rajasthan and Hanumangarh respectively. The growth rates of production during the same period were observed to be 11.4 and 32.3 per cent, and for productivity it was 8.7 and 26.3 per cent, respectively [5]. Table reveals that area, production and productivity of pearl millet showed positive and significant in during period I.

The Table 1 further indicates that area of pearl millet registered negative compound growth rate of -2.8 and -8.5 percent in Rajasthan and Hanumangarh and same trend also follow in production but in productivity show positive in Rajasthan but negative in Hanumangarh district during second period [6-8].

3.2 Cost of Cultivation of Pearl Millet Crop on Different Cost Concepts Basis

Various costs incurred in the cultivation of Pearl Millet on sample farms on different size holdings are presented in Table 2. On an average, the total cost per hectare of pearl millet cultivation was ₹ 13955.07. The major component of cost was Imputed value of family labour which contributed 28.13 per cent of total cost on an overall basis. Similar results major component of cost was Imputed value of family labour [9].

The comparative estimates of different costs incurred in pearl millet cultivation for different size groups are given in Table 3.

Table 1. Growth in area, production and productivity of Pearl Millet crop

Crop	Area		Production		Productivity	
	Rajasthan	Hanumangarh	Rajasthan	Hanumangarh	Rajasthan	Hanumangarh
	CAGR in Rajasthan during 1998-99 to 2008-09 (PeriodI).					
Pearl millet	2.5	4.7	11.4	32.3	8.7	26.3
	CAGR in Rajasthan during 2009-10 to 2018-19 (PeriodII).					
Pearl millet	-2.8	-8.5	-0.2	-12.8	2.6	-4.8

Table 2. Breakup cost of cultivation on different land size holdings in pearl millet

(₹ /ha)

Item	Size of holdings			Overall Average
	Small	Medium	Large	
Machine labour	2554.79 (20.32)	2812.76(19.69)	2880.90(19.18)	2749.48(19.70)
Casually hired labour	798.19 (6.35)	1871.70(13.10)	2389.05(15.90)	1686.31(12.08)
Imputed value of family labour	4232.80(33.67)	3894.09(27.27)	3650.39(24.30)	3925.76(28.13)
Seed	202.50 (1.61)	197.28(1.38)	204.92 (1.36)	201.56(1.44)
FYM	454.66 (3.61)	587.84(4.11)	555.07(3.69)	532.52(3.81)
Fertilizer	231.84 (1.84)	252.59(1.76)	263.26 (1.75)	249.23(1.78)
Plant protection chemical	1250.00 (9.94)	1385.60(9.70)	1464.61(9.75)	1366.73(9.79)
Irrigation charge	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Depreciation	350.00 (2.78)	550.40(3.85)	750.44(4.99)	550.28(3.94)
Land revenue	0.00 (0.00)	0.00 (0.00	0.00 (0.00)	0.00 (0.00)
Interest on working capital	68.64 (0.54)	88.84(0.62)	96.97 (0.64)	84.82(0.60)
Interest on fixed capital	225.00 (1.79)	437.50 (3.06)	562.50(3.74)	408.33(2.92)
Rental value	2200.00(17.50)	2200.00(15.40)	2200.00(14.64)	2200.00(15.76)
Total	12568.44 (100)	14278.63(100)	15018.14(100)	13955.07(100)

Table 3. Cost of cultivation of Pearl Millet on different cost concepts basis on different land size holdings

(₹/ha)

Cost	**Size of holdings**			**Overall Average**
	Small	**Medium**	**Large**	
Cost A_1	5910.64	7747.03	8605.25	7420.98
Cost A_2	5910.64	7747.03	8605.25	7420.98
Cost B_1	6135.64	8184.53	9167.75	7829.31
Cost B_2	8335.64	10384.53	11367.75	10029.31
Cost C_1	10368.45	12078.63	12818.15	11755.07
Cost C_2	12568.45	14278.63	15018.15	13955.07
Cost C_3	13825.29	15706.49	16519.96	15350.58

The Table 3 reveals that cost A_1, on an overall basis, was ₹ 7420.98. It increased with the increase in size of holding because of better resource endowment and higher use of casually hired labour on medium and large farms. Cost B_1 and B_2 worked out to be ₹ 7829.31 and ₹ 10029.31, respectively. The costs C_1 and C_2, on overall basis, were worked out to be ₹ 11755.07 and ₹ 13955.07, respectively. Cost C_3, which includes managerial cost, was worked out to be ₹ 15350.58 per hectare.

3.3 Productivity and Profitability

The productivity of pearl millet and gross returns on sample farms is given in Table 4.

The Table 4 reveals that on the overall basis, productivity of pearl millet was 17.25 quintals per hectare. The yield was highest (19.23 quintals) on large farms, followed by medium farms (17.20 quintals) and small farmers (15.33 quintals) which indicated that as the size of holding increased, the productivity of pearl millet also increased. The gross returns also increased with increase in the size of holding [10].

3.4 Income Measures

It is evident from the Table 5 that on an overall basis, gross income per hectare of pearl millet cultivation was ₹ 33646.67 on sample farms. It varied between ₹ 29900.00 to ₹ 37500.00 on different land size holdings [11]. The gross income per hectare of pearl millet cultivation was highest on large farms as compared to medium and small farms mainly because of higher productivity on large farms.

Farm business income represents returns over variable cost. On an average, the farm business income from pearl millet cultivation was worked out to be ₹ 26225.69. Among different land size holdings, it varied between ₹ 23989.36 on small farms to ₹ 28894.75 on large farms. The family labour income per hectare of pearl millet cultivation varied from ₹ 21564.36 on small farms to ₹ 26132.25 on large farms. On an overall basis, family labour income was worked out to be ₹ 23617.36 per hectare.

Net income, implies profit per hectare after deducting cost C_2 from gross income. The overall net income from pearl millet cultivation was ₹ 19691.59 per hectare. Among different size groups, it varied between ₹ 17331.55 per hectare to ₹ 22481.85 per hectare on different land size holdings. The overall returns to management from pearl millet cultivation were ₹ 18296.08 per hectare. Among different size groups, it varied between ₹ 16074.71 to ₹ 20980.04.

3.5 Resource Use Efficiency in Pearl Millet Production in Rain-Fed Micro-farming Situation

Production function analysis was carried out to determine the efficiency of various resources used in the production process. Cobb Douglas production function turned out to be the best fit because of high R^2. The estimates are presented in Table 6.

Table 4. Gross income of pearl millet on different land size holdings

Size of holdings	**Yield (qtls/ha)**	**Gross income (₹/ha)**
Small	15.33	29900.00
Medium	17.20	33540.00
Large	19.23	37500.00
Overall average	17.25	33646.67

Table 5. Return from cultivation of Pearl Millet on different land size holdings

(₹/ha)

Particulars	Size of holdings			Overall Average
	Small	Medium	Large	
Gross income	29900.00	33540.00	37500.00	33646.67
Farm business income	23989.36	25792.97	28894.75	26225.69
Family labour income	21564.36	23155.47	26132.25	23617.36
Net income	17331.55	19261.37	22481.85	19691.59
Return to management	16074.71	17833.51	20980.04	18296.08

The coefficient of multiple determinations was 0.660 which indicated that independent variables included in the model explained 66 per cent variability in the dependent variable. Weeding contributed significantly to the yield of pearl millet and human labour was negatively significant whereas seed, FYM, nitrogen, machine labour, and plant protection chemical turned out to be non-significant [12-14].

3.6 Marginal Value Productivity of Resource used in Pearl Millet Production in Rain-Fed Micro Farming Situation

The marginal value productivity of inputs which made significant contribution to the yield on aggregate level are presented in Table 7.

The marginal value productivity for weeding was ₹ 11215.29 the ratio of MVP_{xi} to P_{xi} indicates that there is further scope to increase the use of these inputs till it is equal to one. But in case of human labour, there is no scope for further increase as it is already in excess use.

3.7 Farm Income Distribution among Sampled Households in Rain-Fed Micro Farming Situation

The farm income distribution on sample farm in Rain-fed micro farming situation is given in the Table 8. The income of lowest 20 percent households was ₹ 47,099 per farm. The per farm income is highest on upper 20 percent households. They had per farm income of ₹ 4, 12,101 the results show existence of inequality in farm income distribution in Rain-fed micro farming situation [15,16].

To visualize the magnitude of inequality graphically Lorenz curve is depicted on Fig. 1. Gini coefficient (income inequality) in farm household was 0.311 in Rain-fed micro farming situation. The Lorenz curve shows a deviation from the line of complete equality and the Gini-coefficient value of 0.311 also indicates the

Table 6. Regression coefficient of resources used in pearl millet production in rain-fed micro farming situation

Variables	Regression Coefficient	S.E	t- Value	R^2
Seed	0.72	0.19	0.37	0.660
FYM	0.02	0.09	0.27	
Nitrogen	0.25	0.16	1.55	
Human labour	-0.82*	0.24	-3.48	
Machine labour	0.22	0.62	0.36	
Plant protection chemical	0.05	0.12	0.40	
Weeding	0.44*	0.08	5.81	

** Significant at 1% level of significance*

Table 7. Marginal value productivity of resource used in pearl millet production in rain-fed micro farming situation

Input	G.M	MPP_{Xi} (qtls.)	MVP_{Xi} (₹)	P_{Xi} (₹)	MVP_{xi}/P_{xi}
Yield	14.64	-	-	-	-
Human labour	48.97	-0.24	- 478.03	250.00	-1.91
Weeding	1.12	5.75	11215.29	1121.37	10.00

GM= Geometric mean, MPP= Marginal Physical Product, MVP_{xi}= Marginal Value Product, P_{Xi}= Price of additional unit of input

Table 8. Farm Income distribution among sampled household Rain-fed micro-farming situation

Farm Income (Percentile)	Average income (in ₹)	Gini-Coefficient
Lowest 20%	47,099	
Low-mid 20%	1,00,765	
Middle 20%	1,38,161	0.311
Upper-mid 20%	2,22,060	
Upper 20%	4,12,101	
Average	1,84,037	

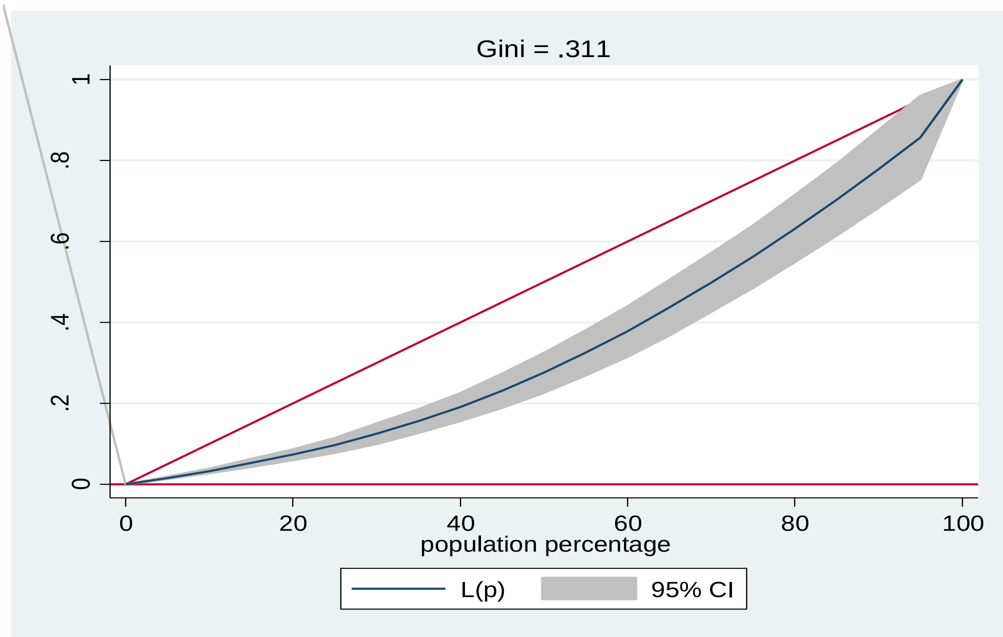

Fig. 1. Graphically Lorenz curve of GINI co efficient

presence of low farm income inequality among surveyed households in the Rain-fed micro farming situation. The inequality of income is mainly because of unequal distribution of land holding, thereby, restricting access of capital intensive inputs to small and marginal farmers.

4. CONCLUSION

It is concluded from the study that area, production and productivity of pearl millet in Nohar tehsil of Hanumangarh district and in Rajasthan was increased over the first period but in second period that was decreased. Total cost of cultivation was found on overall basis ₹ 13,955.07 per hectare in pearl millet. Coefficient of multiple determination (R^2) in the fitted Cobb-Douglas production was 0.66 indicating the included variable explained 66 percent variations in dependent variable. The Gini-Coefficient (0.311) is not much far from zero show existence of inequality (Mada, M. and Kumar, V. (2015). The inequality of income is mainly because of unequal distributions of land holding, there by restricting access capital intensive input to small and marginal farmers. The efforts should be made by policy makers to ensure equitable distribution of income amongst all micro farming situations by assisting farmers in land reclamation, conserving moisture, promoting sprinkler/drip irrigation in rain-fed areas and providing subsidies on diggies etc.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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