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Research Article

RESOURCE USE EFFICIENCY AND RETURNS TO INVESTMENT IN RESEARCH OF PEARL MILLET IN RAJASTHAN

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ABSTRACT

The present study was conducted in Jodhpur and Nagaur districts of Rajasthan under HOPE project funded by BMGF foundation. The average technical efficiency for rain-fed and irrigated farmers was 0.42 and 0.84 respectively. The results revealed that 78.38 percent rain-fed farms were operating at technical efficiency rating of ≤ 0.50 and 35.00 percent. Irrigated farms were found to operate at technical efficiency rating between 0.81 and 0.90. The returns to investment in research analysis revealed that NPV was estimated to be extent of ₹489.94 million. The internal rate of return to investment in research on pearl millet improvement was estimated to be 28 per cent. The B:C ratio was worked out to be 1.41 indicating that returns to investment in research on pearl millet improvement and release of HHB 67-Improved was highly profitable research investment contributing to the economic welfare to the society.

Key word: Technical efficiency, NPV, economic welfare and investment
JEL Classification: D24, D61

INTRODUCTION

Pearl millet is the most widely grown type of millet because of its tolerance to difficult growing conditions such as drought, low soil fertility and high temperature. It can be grown in areas where other cereal crops, such as maize (*Zea mays*) or wheat (*Triticum aestivum*), would not survive. Pearl millet is concentrated in the developing countries which accounts for over 95 per cent of the production and acreage. India continues to be the single largest producer of pearl millet in the world, although the area has been declining in the traditional growing states of Gujarat, Rajasthan and Haryana. Pearl millet is usually grown as a dry land dual purpose grain and fodder crop. Pearl millet grain is the staple diet for farm households in the world's poorest countries. In the Sahelian region of Africa and rural regions of

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northwestern India, pearl millet is an important cereal for consumption. Pearl millet stover is a valuable livestock feed in the growing regions in India and Africa. Pearl millet production in India was characterized by subsistence cultivation during 1970s with a small marketable surplus. But in recent years, it is being geared to a more market-oriented crop owing to the change in utilization from mainly food use to many other alternative uses such as animal feed, alcohol, processed food etc. The present study was an attempt to examine resource use efficiency and returns to investment in research of pearl millet in Rajasthan.

METHODOLOGY

HOPE Project (Harnessing Opportunities for Productivity Enhancement for Millets) was funded by ICRISAT, Hyderabad. The project clusters namely Kherapa in Jodhpur and Gotan in Nagaur were purposively selected as the HOPE project was running in these clusters. The project villages selected were Kherapa and Lavera Khurd in Kherapa cluster and Gotan and Talanpur in Gotan cluster.

Selection of Farmers

In to draw a representative sample the selection of farmers was done on the basis of different land size holdings using the standard classification criteria presented in Table 1. For the collection of the primary data, a sample of 120 farmers consisting 60 farmers each cultivating millet crop under rainfed and irrigated conditions were selected with probability proportion to number of farmers in each size group and detail is presented in Table 1.

Table 1: Average size of land holding and area under pearl millet on different land size holdings

(Ha)

Land size holding	Category of farmers	Number of the farmers	Average area under Pearl Millet
up to 2	Small	60	0.78
$>2 \leq 4$	Medium	39	1.13
>4	Large	21	1.78
Total	-	**120**	-

Collection of data

The primary data were used for the present study. Information regarding cost of inputs and prices obtained for output, resource use pattern and research cost for developing varieties was collected to assess impact of pearl millet high yielding varieties. The data were obtained from All India Coordinated Pearl Millet Improvement Project (AICPMIP) based at Jodhpur. The HHB 67-Improved was

released in 2005. The research and adoption cost estimates were obtained from the pearl millet project.

Techniques of Analysis

To analyze resource use efficiency of pearl millet hybrids across different farm size groups in rain-fed and protective irrigation conditions, the Frontier Production Function was used. To analyze the ability of farmers to achieve the maximum realizable pearl millet output (efficiency) with current level of input use under the existing situation and given technologies, a careful examination of farm specific technical efficiency of the farmers is necessary. The technical efficiency evaluates the farm's ability to obtain the maximum possible output from a given set of resources, while allocative efficiency explores the needed adjustments in equating the marginal revenue with the marginal cost for maximizing the profitability. The Cobb-Douglas Production Function does not discriminate between technical and allocative efficiency. It ignores the problem of technical inefficiency by assuming that all the techniques of production are identical across farms and every producer is technically efficient which may not be true always.

Timmer (1971) modified the procedure in a number of ways and imposed a Cobb-Douglas type of specification on the frontier and evolved an output based measure of efficiency.

The function in log form is as under.

$$nY = A + \sum_{i=1}^{n} \beta i \, In \, xi + U$$

$$\ln Y = A + \sum_{i=1}^{n} \beta_i \ln x_i + U \quad ; \quad U \leq 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The above model was estimated using corrected ordinary least squares (COLS) regression. As a first step, ordinary least square (OLS) was applied to the regression equation to yield best linear unbiased estimates of βi coefficient. The function estimated was in form of:

$$Log\,Y = \log a + \sum_{i=1}^{7} b_i \log x_i + e \ldots\ldots (2)$$

Where,

Y = Gross returns from pearl millet (₹ha^{-1})

a = Intercept

x_1 = Area under pearl millet (ha)

x_2 = Use of FYM (₹ha^{-1})
x_3 = Use of Seed (₹ha^{-1})
x_4 = Use of Urea (₹ha^{-1})
x_5 = Use of DAP (₹ha^{-1})
x_6 = Irrigation (₹ha^{-1})
X_7 = Use of Labour (₹ha^{-1})
b_i = Elasticity's of production (i = 1 to 7)
e = Error term

Equation (2) was estimated in log form using ordinary least squares method. The Frontier Production Function was derived from the Cobb-Douglas type of production function fitted to the gross income from pearl millet cultivation. The technical efficiency was worked out using potential output that can be realized from a set of inputs. The potential output is given by

$Y^* = Y + e_m$ ..... (3)

Where,

Y^*= Potential gross returns that could be derived from Pearl millet cultivation

Y= Estimated gross returns from Pearl millet cultivation.

e_m= Highest positive error term.

The intercept estimate 'α' was then corrected by shifting the function until no residual is positive and one observation becomes zero. This was done by the adding the largest error term of the fitted model to the intercept. The new production function with a shift in the intercept in the frontier production function gives the maximum output obtainable for given level of input and it would be of the form.

$$\text{Ln } Y^* = A + \Sigma\beta_i \ln X_i + U; \quad U \leq 0 \quad \text{..... (4)}$$

If the value of β_i is negative, then the geometric mean of i^{th} input X_i is taken instead of β_i in X_i. The Frontier Production Functions were estimated separately for Rain-fed and irrigated farms.

Timmer's measure of technical efficiency

It is the ratio of actual output to the potential output on the production function given the level of input use on the i^{th} farm.

Technical Efficiency of i^{th} farm = Yi / Yi*

Where,

Yi-is actual gross returns from Pearl millet cultivation on i^{th} farm

Yi*-is the potential gross returns attainable from Pearl millet cultivation on i^{th} farm.

For the most efficient farmer (Y=Y*), the technical efficiency will be highest being equal to one. In frontier approach, a producer is said to be technically efficient if the observed output is maximum for the given level of input. Thus, the production frontier is defined as the locus of maximum possible output for each level of input used. A failure on part of firm to produce the frontier level of output at given input level is attributed to technical inefficiency.

Allocative efficiency

The allocative efficiency or price efficiency is an economic measure as against technical efficiency, which is a physical measure. A production activity is allocative efficient when the value of the marginal product (VMP) of a factor is equal to the marginal factor cost (MFC).

The Cobb-Douglas type production function was fitted for pearl millet crop and used to compute the allocative efficiencies. The first differential itself was the VMP of the factor as the dependent variable was the gross returns from pearl millet cultivation. Since all the independent variables in regression are the cost of inputs, the MFC of all factors was unity. Thus the allocative efficiency measures of all factors are given by the equation:

$$\text{Allocative efficeincy} = \frac{VMPx_i}{MFCx_i} \text{.....(5)}$$

Where,

$$VMPx_i = \frac{\beta_i \overline{Y}_i}{\overline{x}_i} \text{.....(6)}$$

VMPi = Value marginal product of i^{th} input

βi = Regression co-efficient of i^{th} input

$\overline{Y}_i$ = Geometric mean of gross returns from pearl millet.

$\overline{x}_i$ = Geometric mean of i^{th} input

The value marginal product of the inputs was worked out by multiplying the respective input coefficient with the geometric mean level of output and divided by the geometric mean level of respective input.....(Equ. 6)

The allocative efficiency equal to unity represents the most efficient allocation or optimal allocation while less than or more than unity represents over or under use of the factor (sub-optimal use), respectively. The allocative efficiency of all the factors was computed at the geometric mean level of the inputs and the output for the rain-fed and irrigated farmers of Pearl millet crops and the same were compared.

Economic efficiency

Economic efficiency (EE) is the product of technical efficiency (TE) and allocative efficiency (AE)

EE = TE * AE ..... (7)

Returns to investment in research

To study economic impact of pearl millet HYVs, NPV, IRR and B: C ratio was worked out.

$$B:C\ ratio = \frac{\sum_{i=1}^{n} \frac{Bn}{(1+i)^n}}{\sum_{i=1}^{n} \frac{Cn}{(1+i)^n}}$$

Where,

BCR = Benefit Cost Ratio
i = Rate of interest used for discounting
Cn = Cost in nth the year
Bn = Benefit in the nth year
i = 1, 2, 3, 4.....n

$$NPW = \sum_{i=1}^{n} \frac{Bn - Cn}{(1+i)^n}$$

Where,

NPW = Net Present Worth
i = Rate of interest used for the discounting
Bn = Benefit in the nth year
Cn = Cost in the nth year
i = 1, 2, 3, 4.....n

$$IRR = \sum_{i=1}^{n} \frac{Bn}{(1+i)^n} - \sum_{i=1}^{n} \frac{Cn}{(1+i)^n} = 0$$

Where,

i = Rate of interest used for discounting (which is also the IRR of the project of this equation is satisfied)
B_n = Benefit in the nth year
C_n = Cost in the nth year
i = 1, 2, 3, 4.....n

RESULTS AND DISCUSSION

The results obtained from analysis of data are discussed under various sub-heads as follows:

Adoption Level of High Yielding Varieties of Pearl Millet

The perusal of Table 1 shows revealed that public hybrids dominated in rain-fed area (93.23 per cent) and private hybrids occupy most of irrigated area under pearl millet cultivation (70.37 per cent). However, public hybrids are also grown under irrigated conditions and cover 29.63 per cent of irrigated area.

Table 1: Percent area under pearl millet cultivation in HOPE Project clusters

Particulars	Rain-fed farms	Irrigated farms
Local varieties	06.79	-
Public Hybrids	93.21	29.63
Private Hybrids	-	70.37
Total	100.00	100.00

Resource Use Efficiency of Pearl Millet Hybrids

One of the major objectives of the study was to analyze resource use efficiency under rain-fed and irrigated conditions in pearl millet cultivation. The regression parameters of the estimated Cobb-Douglas production function are presented in the Table 2.

Table 2 Estimated production function for pearl millet cultivation in HOPE Project clusters

Particulars	Rain-fed farms	Irrigated farms
Constant	8.72*	5.83*
	(3.85)	(7.31)
Area under pearl millet	1.03*	0.38*
	(2.77)	(2.96)
FYM (₹)	-0.33	-0.04
	(-1.59)	(-0.60)
Seed (₹)	0.45*	0.25*
	(4.09)	(5.45)
Urea (₹)	-0.01	0.24**
	(-0.93)	(1.97)
DAP (₹)	.002	0.03
	(0.26)	(0.50)
Irrigation (₹)	-	0.08***
		(1.73)
Labour (₹)	-0.02	0.06
	(-0.09)	(0.83)
R^2	0.83	0.95
F-value	44.23	138.20

Figures in parentheses indicate t-stat value.

****, ** and * indicates significance at 10, 5 and 1 percent level.***

The coefficients of multiple determinations (R^2) were 0.83 and 0.95 for estimated production function of rain-fed and irrigated farms (Table 2). The high and significant F-values indicated that Cobb-Douglas production function was adequate in explaining 83 per cent and 95 per cent of the variation in output under rain-fed and irrigated conditions. The constant returns to scale were noticed in both the conditions since sum of elasticities was nearly equal to one. The constant value under rain-fed

and irrigated conditions indicated that the pearl millet output was positive and significant. Under rain-fed conditions, the coefficients like area under pearl millet and seed were positive and significant. Under irrigated conditions area under pearl millet, seed, urea and irrigation were positive and significant statistically.

To analyze the scope for intensification of resources in both conditions, the marginal value products (MVP) of resources were compared with the respective marginal factor cost (MFC). The MVP and MFC ratios for different resources under rain-fed and irrigated conditions are furnished in Table 3. The MVP-MFC ratios for seed were more than one on the rainfed farms (2.08) and irrigated farms (1.48). The corresponding figures for MVP-MFC ratios for FYM, urea and labour under rain-fed conditions were came out to be 0.57, 0.99, and 0.98 respectively. In the case of irrigated pearl millet, urea, DAP, irrigation and labour ratios were greater than one as such the corresponding were estimated to be 1.45, 1.06, 1.11 and 1.08 respectively.

Table 3: MVP and MFC ratios of resources rain-fed farmers in HOPE Project clusters

Particulars	Rain-fed			Irrigated		
	MVP	MFC	Ratio	MVP	MFC	Ratio
FYM (₹)	0.57	1	0.57	0.93	1	0.93
Seed (₹)	2.08	1	2.08	1.48	1	1.48
Urea (₹)	0.99	1	0.99	1.45	1	1.45
DAP (₹)	1.00	1	1.00	1.06	1	1.06
Irrigation (₹)	-	1	-	1.11	1	1.11
Labour (₹)	0.98	1	0.98	1.08	1	1.08

The technical efficiency of rain-fed and irrigated farms was worked out by using Timmer Method. The distribution of sample farmers according to different technical efficiency ratings along with average technical efficiency for both farms is presented in Table 4.

Table 4: Distribution of farmers according to technical efficiency in HOPE Project clusters

Farm category	Percent technical efficiency rating						
	≤ 50	51-60	61-70	71-80	81-90	> 90	ATE
Rain-fed	47 (78.38)	6 (10.00)	5 (8.33)	2 (3.33)	-	-	0.42
Irrigated	-	-	2 (3.33)	21 (35.00)	21 (35.00)	16 (26.67)	0.84

Figures in parentheses indicate percent farmers
ATE: Average technical efficiency

The average technical efficiency for rain-fed and irrigated farmers was 0.42 and 0.84 respectively. It was found that 78.38 percent rain-fed farms were found to operate at technical efficiency rating ≤ 0.50 and 35.00 percent irrigated farmers were found to operate at technical efficiency rating between 0.81 and 0.90. The technical efficiency of more than 90 per cent was achieved by 26.67 per cent of farms under irrigated conditions. However, there was none in this category under rain-fed conditions. Only 3.33 per cent farms under rain-fed conditions achieved technical efficiency between 71-80 per cent.

The perusal of Table 5 shows technical, allocative and economic efficiency of pearl millet cultivation. The results revealed that an allocative efficiency of rain-fed farms (0.50) was greater than that of irrigated farms (0.40), and the economic efficiency was less in the case of rain-fed farms (0.21) as compared to irrigated farmers (0.34) indicating that irrigated farms were more efficient in terms of input use.

Table 5: Technical, allocative and economic efficiency of pearl millet cultivation in HOPE Project clusters

Particulars	Farm category	
	Rain-fed	Irrigated
Technical efficiency	0.42	0.84
Allocative efficiency	0.50	0.40
Economic efficiency	0.21	0.34

Returns to Investment in Research

The economic impact of pearl millet high yielding varieties from 1999-2011 in Rajasthan is presented in Table 6. These cost estimates were discounted at 5 per cent rate of discount. The analysis of NPV, IRR and B: C ratio revealed that NPV was highly positive to the extent of ₹ 489.94 where as discounted total cost was ₹ 1203.82 million indicating that returns to investment in research were highly beneficial. Internal rate of return to investment in research on pearl millet improvement was 28 per cent and B: C ratio was worked out to be 1.41 indicating that returns to investment in research on pearl millet improvement and release of HHB 67-Improved was highly useful research investment contributing economic welfare to the society.

Table 6: Economic impact of pearl millet HYVs from 1999 to 2011 in Rajasthan: Local V/s HHB 67- Improved

Particulars	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Cost of cultivation of Local PM (₹ ha^{-1}) (a)								3226	3396	3574	3763	3961	4169	-
Cost of HHB 67 - Improved (₹ha^{-1}) (b)								4241	4464	4699	4947	5207	5481	-
Incremental Cost over Local (₹ha^{-1}) (c=b-a)	0	0	0	0	0	0	0	1015	1069	1125	1184	1246	1312	-
Improved Public bred hybrid area (000' ha) (d)	0	0	0	0	0	0	0	41	187	300	214	208	731	-
Adoption cost (₹ million)								41.62	199.83	337.46	253.39	259.25	959.07	**2050..64**
Discount factor @ 5 per cent (e)	0.95	0.91	0.86	0.82	0.78	0.75	0.71	0.68	0.64	0.61	0.58	0.56	0.53	-
Discounted adoption cost (₹ million)								28.17	128.82	207.17	148.15	144.36	508.62	**1165.29**
Mean Yield of Improved public bred hybrids (kgha^{-1}) (f)	0	0	0	0	0	0	0	648	648	648	442	589	610	-
Mean yield of local (kgha^{-1}) (g)								450	450	450	223	375	411	-
Yield Diff due to HHB 67 over Local (kgha^{-1}) (h=f-g)								198	198	198	219	214	199	-
Price of Pearl millet (MSP) (₹ tonne^{-1}) (i)	4150	4450	4850	4950	5050	5150	5250	5400	6200	8400	8600	8800	9800	-
Incremental return due to HHB 67 Improved (₹ ha^{-1}) (j=i×h)								1069	1228	1663	1883	1883	1950	
Total gain due to HHB 67 Improved in Rajasthan (₹ million)								43.84	229.56	498.96	403.05	391.71	1425.60	**2992.71**
Discounted Total gain due to HHB 67 Improved in Rajasthan (₹ million)								29.67	147.98	306.32	235.65	218.12	756.02	**1693.76**
Incremental net return due to HHB 67 Imp (₹ha^{-1}) (k=j-e)								54	159	538	699	637	638	-
Incremental net return in Rajasthan due to HHB 67 Imp (₹ million) (l=k×d)	-	-	-	-	-	-	-	2.21	29.73	161.50	149.65	132.45	466.52	**942.07**
Total research cost (m)	53.94													-
Apportioned research cost (n=m×0.75)	40.46													-
Discounted research cost , ₹ million (o=n×e)	38.53	0	0	0	0	0	0	0	0	0	0	0	0	-
Discounted Total cost, ₹ million (Adoption +Research cost)	38.53	0	0	0	0	0	0	28.17	128.82	207.17	148.15	144.36	508.62	**1203.82**
Discounted net return in Rajasthan due to HHB 67-I (₹ million) (l=k×d)	-38.53	0	0	0	0	0	0	1.50	19.16	99.15	87.50	73.76	247.41	**489.94**
NPV (₹ million)	**489.94**													-
IRR	**0.28**													-
B:C	**1.41**							1.05	1.15	1.48	1.59	1.51	1.49	-

CONCLUSIONS

The study concluded that average technical efficiency for rain-fed and irrigated farmers was 0.42 and 0.84 respectively. About 78.38 percent rain-fed farmers were found to operate at technical efficiency rating ≤ 0.50 and 35.00 percent. Irrigated farmers were found to operate at technical efficiency rating between 0.81 and 0.90. The returns to investment in research analysis revealed that NPV was highly positive to the extent of ₹489.94millions. Internal rate of return to investment in research on pearl millet improvement was 28 per cent and B: C ratio was worked out to be 1.41 indicating that returns to investment in research on pearl millet improvement and release of HHB 67-Improved is highly useful research investment contributing to the economic welfare to the society.

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