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Research Note

Impact Assessment of New Pearl Millet Technology in Arid Rajasthan§

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Abstract

This paper has assessed the impact of high-yielding short-duration pearl-millet hybrid on farmers' income in the arid region of Rajasthan. The decomposition of total change in net returns has shown that adoption of modern technology accounted for 86 per cent of the incremental net income, in which the share of varietal change was 58 per cent. This suggests that there is a considerable potential of raising farm income through widespread dissemination of modern pearl millet technology in Rajasthan.

Key words: Pearl millet, high-yielding varieties, technology, decomposition analysis, hybrid, Rajasthan

JEL Classification: Q12, Q16

Introduction

Rajasthan with land area of 3.42 lakh km^2 is the largest state of India and 61 per cent of the area has hot arid climate. The agriculture in the arid ecosystem is constrained by environmental limitations such as low precipitation, high temperature, high wind speed, high evapo-transpiration and poor soils. Pearl millet is the most dominant crop in arid Rajasthan, occupying about 41.1 lakh hectares, mostly under the rainfed conditions. The average yield of pearl millet in this region is 772 kg/ ha (GoR, 2011). It is lower than in other regions of the country and is also below the potential yield. This suggests a great potential for enhancing yield with the adoption of suitable high-yielding varieties and better management practices. The short-duration pearl-millet hybrids have helped in increasing yield, but their adoption has been far less than expected in the state. The present study has assessed the impact of short-duration pearl-millet hybrid HHB 67 on farm income and has analyzed its determinants.

Data and Methodology

The data on pearl millet (local variety) as well as hybrid (HHB-67) were collected from 60 and 50 farmers, respectively from two tehsils of Jaisalmer district during 2008-2010 using multistage stratified random sampling technique. The detailed data were collected for different inputs used in the production of these crops, marketing cost, sale prices, etc.

Analytic Approach

The production function approach was used to establish the input-out relationship for modern and traditional technologies. The term 'modern technology' used in the study includes adoption of hybrid (HHB 67) and associated modern package (seed rate and its treatment, method and time of sowing, method and time

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of fertilizer application and plant protection measures, etc.). The contribution of modern technology as well as increased use of inputs was studied by decomposing the output generated under the new technology.

Cobb–Douglas production function was used due to its simplicity and desirable neo–classical properties, viz. positive marginal product, and diminishing marginal product over the relevant range and non-specification of the degree of economies of scale. Separate crop production functions were estimated for modem and traditional technologies. The specification of per farm production functions used for modern technology, traditional technology and pooled for both modern and traditional technology is as follows:

$$\ln Y_m = \ln A_m + a_{1m} \ln X_{1m} + a_{2m} \ln X_{2m} + a_{3m} \ln X_{3m} + a_{4m} \ln X_{4m} + U_1 \quad \ldots(1)$$

$$\ln Y_t = \ln A_t + a_{1t} \ln X_{1t} + a_{2t} \ln X_{2t} + a_{3t} \ln X_{3t} + a_{4t} \ln X_{4t} + U_2 \quad \ldots(2)$$

$$\ln Y_p = \ln A_p + a_{1p} \ln X_{1p} + a_{2p} \ln X_{2p} + a_{3p} \ln X_{3p} + a_{4p} \ln X_{4p} + U_3 \quad \ldots(3)$$

where, the subscripts t, m and p indicate traditional technology, modern technology, and pooled for both modern and traditional technology, respectively.

Y = Net returns per farm (₹),

X_1 = Area under the crop (ha),

X_2 = Expenditure on fertilisers and manure (₹),

X_3 = Total labour used (human-days),

X_4 = Other expenses including depreciation on machine, cost of insecticide/pesticides, bullock labour, etc. (₹),

A = Scale parameter, and

U_1, U_2 and U_3 = Error-terms.

The production function approach which has been widely used to decompose the total change in output (Bisaliah, 1977; Gajja *et al*., 2008; Singh *et al.*, 2004; Kiresur *et al*., 1995) was followed. The specification of production functions used in decomposition analysis is as follows:

$$\ln Y_t = \ln A_t + a_1 \ln X_{1t} + a_2 \ln X_{2t} + a_3 \ln X_{3t} + U_1 \quad \ldots(4)$$

$$\ln Y_m = \ln A_m + b_1 \ln X_{1m} + b_2 \ln X_{2m} + b_3 \ln X_{3m} + U_2 \quad \ldots(5)$$

where, the subscripts t and m indicate traditional and modern technology, respectively.

Y = Net Income from crop (₹/ha),

X_1 = Expenditure on fertilisers and manure (₹/ha),

X_2 = Total human labour (human-days/ha), and

X_3 = Other expenses including depreciation on machine, cost of insecticide/pesticides, bullock labour, etc. (₹/ha)

The net income per ha was calculated after deducting all expenses incurred in cultivation of this crop from gross returns.

Results and Discussion

Production Response of Modern and Traditional Technologies

The production functions were estimated using ordinary least square (OLS) method separately for the traditional and modern technologies and results are presented in Table 1. The significance of ‘F’-test showed high degree of goodness of fit and indicated that the explanatory variables included in the model were adequate. A perusal of the production functions estimated for both modern and traditional technologies showed that the coefficients of all the explanatory variables were positive and significant at varying levels of significance. The production elasticity of all the variables was relatively higher in the modern technology of pearl millet production.

Structural Break and Nature of Technological Change

The existence of structural break was examined by conducting tests for equality of the regression coefficients. Chow’s test (1960), applied to find the equality of regression coefficients, revealed significance at 5 per cent level. This indicated that the shift in net return due to adoption of new technology of pearl millet crop caused the structural break. The nature of technological change was examined by testing the homogeneity of regression coefficients under study, while the constant terms (intercepts) in the two production functions were allowed to differ (Kiresur, 1995). The computed F-ratio was insignificant and the significance of dummy variable implied that the shift in production function was due to dummy variable,

Table 1. Estimates of per farm production functions in pearl millet crop in Rajasthan

Variable	Traditional technology (B_t)	Modern technology (Bm)	Pooled (B_t+ Bm)	Pooled (B_t +Bm) with intercept dummy
Dummy for Bm			0.2967***	0.2967***
			(0.0992)	(0.0992)
X_1 Area under the crop (ha)	0.4256***	0.4409***	0.4307***	0.3902***
	(0.1903)	(0.1911)	(0.1135)	(0.1104)
X_2 Expenditure on manure and fertilizer (₹)	0.0692**	0.0906**	0.0710**	0.0729**
	(0.0309)	(0.0428)	(0.0311)	(0.0311)
X_3 Total labour used (human-days)	0.3109***	0.3296***	0.3179***	0.2991***
	(0.1007)	(0.1214)	(0.1105)	(0.1107)
X_4 Other expenses (₹)	0.1984*	0.1998*	0.1945*	0.1807*
	(0.1011)	(0.1081)	(0.0992)	(0.1199)
A Scale parameter	6.1174	6.5094	6.0017	5.9902
R^2	0.7601	0.8114	0.8813	0.8779
Sample size (N)	60	50	110	110

Notes: Figures within the parentheses are the standard errors
***, ** and * indicate significance at 1per cent, 5 per cent and 10 per cent probability levels, respectively.

i.e. new technology of pearl millet crop. The analysis of covariance test revealed that the structural break (shift in the production) was due to significant change in the intercept rather than in the slope. To test the complete structural relationship, the production function parameters in the traditional and new technologies of pearl millet was estimated with both intercept and slope dummies and are presented in the Table 2.

The estimated production function had high value of the coefficient of determinants (R^2) which indicated a good fitness. All the dummy variables for each explanatory variable were non–significant but positive. This indicated that production elasticity was higher in the modern than in traditional technology of pearl millet.

Decomposition of Income Difference

The log-linear production function and geometric mean levels of input-use in different technologies were used for the decomposition analysis. The estimated production functions for different technologies are presented in Table 3. All the estimated production functions were significant at 1 per cent level of significance. The coefficient of determination (R^2) was 0.7756 and 0.8119 in the traditional and modern technology of pearl millet, respectively, indicating high degree of fitness. All the variables included in the production function were significant at various levels of significance. The constant term (intercept) in modern

Table 2. Testing of complete structural relationship between production functions of traditional and modern technologies of pearl millet in Rajasthan

Variable	Traditional (Bt) + modern (Bm) technologies
X_1 Area under the crop (ha)	0.3407***
X_2 Expenditure on manure and fertilizer (₹)	0.0619**
X_3 Total labour used (human-days)	0.2996***
X_4 Other expenses (₹)	0.1902*
Slope dummy for variable	
X_1 Area under the crop (ha)	0.1259 NS
X_2 Manure and fertilizer (₹)	0.0249 NS
X_3 Total labour used (human-days)	0.1107 NS
X_4 Other expenses (₹)	0.1174 NS
A Scale parameter	5.9903
Intercept dummy	0.2711
R^2	0.9207

Note: NS- Non-significant

Table 3. Estimates of per hectare production functions for different technologies of pearl millet crop in Rajasthan

Variable	Pearl millet (traditional)	Pearl millet modern (HHB-67)
X_1 Expenditure on manure and fertilizer (₹/ha)	0.1349**	0.1407***
	(0.0611)	(0.0584)
X_2 Total labour used (human-days/ha)	0.2485**	0.2614***
	(0.1107)	(0.1234)
X_3 Other expenses (₹/ha)	0.1149*	0.1282*
	(0.0581)	(0.0705)
A Scale parameter	6.0869	6.5119
R^2	0.7756	0.8119
No. of observations	60	50

Note: ***,** and * indicate significance at 1 per cent, 5 per cent and 10 per cent levels, respectively.

Table 4. Geometric mean levels of inputs used per hectare in pearl millet crop in Rajasthan

Variable	Pearl millet traditional	Pearl millet modern (HHB 67)
X_1 Expenditure on manure and fertilizer (₹/ha)	87.6	261.7
X_2 Total labour used (humandays/ha)	21.3	30.4
X_3 Other expenses (₹/ha)	870	1088

technology was more than the traditional technology of pearl millet. This upward shift in the production function indicated the positive effect of new technology. The mean levels of inputs used (Table 4) in modern technology of pearl millet were much higher than those used in the traditional technology of pearl millet crop.

Sources of Income Difference

The contribution of new technologies to additional income generation over the old technology was estimated and is presented in Table 5. The additional income generated was found to be 86 per cent by the new technology of pearl millet crop (HHB-67) over the traditional pearl millet crop. The contribution of technology was worked out to be 58 per cent and the remaining contribution was of increase in inputs used under the new technology of pearl millet crop. There was some discrepancy between observed change and estimated change (Table 5). This might be due to the random error-term which accounts for non-inclusiveness of some variables as well as rounding-off the figures used for analysis.

Table 5. Decomposition of income from modern and traditional technologies of pearl millet

Source of change	Per cent contribution Bm/Bt
A. Total observed change	85.67
B. Due to difference in technology	58.01
i) Neutral technological difference	47.56
ii) Non-neutral technological difference	
a) Fertilizer and manure (X_1) (₹/ha)	2.69
b) Total labour used (X_2) (human-days/ha)	3.75
c) Other expenses (X_3) (₹/ha)	4.01
C. Due to change in complementary inputs	27.56
i) Fertilizer and Manure (X_1) (₹/ha)	15.40
ii) Total labour used (X_2) (human-days/ha)	9.29
iii) Other expenses (X_3) (₹/ha)	2.87
D. Total estimated change in income	85.57

Bt - Bajra traditional, Bm- Bajra modern (HHB 67)

Conclusions

The study has assessed the impact of adoption of new technology on production of pearl millet crop in Rajasthan. The difference in per-ha productivity of pearl millet between modern technology and traditional technology has been estimated to be about 86 per cent. The major component of this productivity hike was the difference in varietal technology which contributed about 58 per cent and the remaining 28 per cent was shared by different inputs, viz. fertilizer & manure, human labour and other expenses, in terms of differences in their use levels between the modern and traditional pearl millet production technologies. The study has indicated that good potential exists for enhancing productivity and production of pearl millet in the arid regions of Rajasthan by extending more area under the improved hybrid HHB 67. The study has suggested that farmers should be made aware about the hybrid seed of pearl millet and its timely availability to farmers should be ensured to enhance farm income in Rajasthan.

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