Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(6): 2177-2180
Received: 16-09-2019
Accepted: 18-10-2019

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Production of maize in Northern Karnataka: decomposition analysis approach

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Abstract
The present study was conducted in two districts of Northern Karnataka, namely, Belagavi and Vijayapur. The required data was collected from 60 farmers practicing sprinkler system and 60 farmers practicing the conventional method of irrigation in the cultivation of maize. The data was analyzed using the output decomposition model developed by Bisaliah (1977). The study revealed that the adopters of sprinkler irrigation technology produced 21.79 percent higher income than the conventional method of irrigation. The increase in the income was further decomposed into different sources of change, such as the adoption of sprinkler irrigation technology and changed input levels. The sprinkler irrigation technology alone contributed 43.77 percent increase in income, while the contribution of change in input levels was found to be negative (-21.99 percent).

Keywords: Sprinkler irrigation, the conventional method of irrigation, decomposition analysis, maize

Introduction

Water is gradually becoming a scarce resource worldwide, especially in developing countries like India. With the increasing need for providing food and water security for an ever-increasing population, the availability, usability, and affordability of water is becoming a significant challenge. The efficient use of this resource is essential. However, this requires innovation and more precision in its utilization, mainly where it is used in abundance like agriculture. In spite of technological advancements in pressurized irrigation techniques, a substantial amount of land worldwide, especially in countries like India is still irrigated by surface irrigation. With agriculture being the most dominant water user, it is essential to develop and improve existing technologies for more efficient use of this precious resource. The application of irrigation water by conventional method causes up to 30 percent loss of water through deep percolation depending on the soil type. To overcome the problems of conventional methods of irrigation and to improve water use efficiency to achieve more crop yield per drop, the adoption of sprinkler irrigation gains greater attention. In light of the above and considering the relevance of the sprinkler irrigation system in maize cultivation in the state, the present paper is proposed to evaluate the structural break in the income generated from the sprinkler irrigation system over the conventional method of irrigation in the cultivation of maize in the study area.

Materials and Methods

Sampling procedure: The purposive multistage random sampling was followed for the selection of districts, taluks, villages, and sprinkler irrigation beneficiary farmers. The farmers practicing conventional methods of irrigation were selected from the selected villages randomly. Belagavi and Vijayapur districts were selected purposively for the detailed study. From each selected district, one major taluk in terms of no. of beneficiaries covered (sprinkler irrigation) under the project was selected purposively. Three villages from each taluk based on the availability of beneficiaries practicing sprinkler irrigation for raising the maize were selected purposively for the study. From each selected village, ten farmers practicing sprinkler irrigation and ten farmers practicing the conventional method of irrigation (furrow) were selected purposively. Thus the sample size was 60 in each irrigation method, and the total sample size was 120.

Analytical tool used: Decomposition analysis

Before going to the decomposition analysis of the income difference from maize between the Sprinkler Irrigation Farmers (SIF) and Conventional Irrigation Farmers (CIF), one must ensure whether there is structural break or not in the production relations between SIF and CIF. To identify the structural break, if any, in the production relations with the adoption of the sprinkler irrigation system, output elasticities were estimated by the ordinary least square method by fitting a log-linear regression separately for SIF and CIF. The pooled regression was run in combination with SIF and CIF, including dummy variables for farmers practicing sprinkler irrigation systems. The dummy variable was quantified as one for farmers practicing a sprinkler irrigation system and zero for farmers practicing the conventional method of irrigation.

For identifying the structural break in production with the introduction of sprinkler irrigation (new technology) in maize, the Cob-Douglas type of production function was used. Production function with technology dummy variable was fitted for identifying a structural break in production relations between the SIF and CIF. Production function with one for SIF and zero for CIF was estimated.

The following log linear estimable forms of equations were used for examining the structural break in production relation.

$$\ln y_1 = \ln A_1 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + U_i \ldots\ldots \quad (1)$$

$$\ln y_2 = \ln A_2 + b'_1 \ln X_1 + b'_2 \ln X_2 + b'_3 \ln X_3 + b'_4 \ln X_4 + b'_5 \ln X_5 + b'_6 \ln X_6 + b'_7 \ln X_7 + U_i \ldots\ldots \quad (2)$$

$$\ln y_3 = \ln A_3 + b''_1 \ln X_1 + b''_2 \ln X_2 + b''_3 \ln X_3 + b''_4 \ln X_4 + b''_5 \ln X_5 + b''_6 \ln X_6 + b''_7 \ln X_7 + e3d + U_i \ldots \quad (3)$$

Where,

Y = Gross return in rupees/hectare

a = Intercept

x_1 = Seed cost/ hectare

x_2 = FYM cost/ hectare

x_3 = Fertiliser cost/ hectare

x_4 = Human labour cost/ hectare

x_5 = Bullock and Machine labour cost/ hectare

x_6 = Plant protection chemicals cost/ha

x_7 = irrigation water applied in ha cm

e_i = Error term

b_i = Elasticity coefficients of respective inputs and summation of these gives returns to scale

Equations 1, 2 and 3 represent farmers following conventional method of irrigation, farmers following sprinkler irrigation system and pooled regression function with farmers following sprinkler irrigation systems as dummy variables, respectively.

$b_1, b_2, b_3, b_4, b_5, b_6, b_7, b'_1, b'_2, b'_3, b'_4, b'_5, b'_6, b'_7, b''1, b''_2, b''_3, b''_4, b''_5, b''_6, b''_7$

Represent individual output/income elasticity of respective input variable in equation (1), (2) and (3). 'd' in equation (3) represents dummy variable. If the regression coefficient of dummy variables is significant, then there is structural break in production relations with the adoption sprinkler irrigation system.

Output decomposition model

For any production function, the total change in income is affected by the change in the factors of production and in the parameters that define the function. This total change per hectare output/income is decomposed to reflect on the adoption of a sprinkler irrigation system. The output decomposition model developed by Bisaliah (1977) [1] is used in the study, which is depicted below.

The output decomposition equation used in this study can be written as

$$\ln Y\,SIF - \ln Y\,CIF = [\text{intercept SIF} - \text{intercept CIF}] + [(b_1' - b_1) \times \ln X_1\,CIF + \ldots\ldots + (b_7' - b_7) \times \ln X_7\,CIF] + [\{(b_1' (\ln X_1\,SIF - \ln X_1\,CIF + \ldots\ldots + (b_7' (\ln X_7\,SIF - \ln X_7 CIF)\}] \ldots \quad (4)$$

The decomposition equation (4) is approximately a measure of the percentage change in income with the adoption of a sprinkler irrigation system. The first bracketed expression of the right-hand side is the measure of the percentage change in income due to the shift in scale parameter (A) of the production function. The second bracketed expression is the difference between output elasticities, each weighted by natural logarithms of the volume of that input used under the non-adopter category, a measure of the change in output/income due to shifting in slope parameters (output elasticities) of the production function. The third bracketed expression is the sum of the natural logarithms of the ratio of each input of adopters to non-adopters, each weighted by the output elasticity of that input. This expression is a measure of the change in output due to change in the per hectare cost of seeds, FYM, fertilizers, human labour, bullock, and machine labour and water applied (ha cm).

Results and Discussion

Structural break in the production relation of Maize under the sprinkler and conventional method of irrigation

To identify the structural break in maize production relation with the introduction of sprinkler irrigation as new technology, direct estimates of Cobb-Douglas type of production function presented in Table 1 indicates that in case of new technology (sprinkler irrigation), the calculated 'F' value 219.33 was greater than the 'F' critical value (12.20) at one per cent for 7 and 52 degrees of freedom, the R^2 value 0.967 was statistically significant. The intercept value was 11.242. The regression coefficient for irrigation water applied (0.472) was statistically significant at 1 per level of significance, whereas the regression coefficient for fertilizer (-0.040) was found to be significant at ten per cent level of significance. The regression coefficients for remaining variables, namely seed (0.087), farmyard manure (-0.069), human labour (-0.156), bullock and machine labour (0.048), and plant protection chemicals (0.046) were found to be non-significant.

In the case of the conventional method of irrigation, the calculated 'F' value 326.33 was greater than the 'F' critical value (12.20) at one per cent for 7 and 52 degrees of freedom, the R^2 value 0.978 was statistically significant. The intercept value was 6.837. The regression coefficients for fertilizer (0.109), human labour (0.368), bullock and machine labour (-0.109) and irrigation water applied (0.113) were significant at one per cent level of significance whereas the regression coefficient for plant protection chemicals (-0.042) was significant at ten per cent level of significance. The regression coefficients for remaining variables, namely seed (0.074) and farmyard manure (0.015), were found to be non-significant.

In the case of the pooled maize production function with sprinkler irrigation as dummy variable was used for identifying structural break if any in production relation with the introduction of sprinkler irrigation as new technology. The regression coefficient for dummy variable (0.392) was significant at one per cent level of significance and calculated 'F' value (290.44) was greater than 'F' critical value (9.53) and is significant at one per cent for 8 and 111 degrees of freedom, so R^2 value 0.954 was statistically significant. The regression coefficients for bullock and machine labour (0.179), plant protection chemicals (-0.125) and irrigation water applied (0.326) and dummy variable (0.392) were significant at one per cent level of significance whereas regression coefficient for farmyard manure (-0.046) was significant at ten per cent level of significance. The regression coefficients of remaining variables such as seed (-0.049), fertilizer (0.008), and human labour (-0.004) were found to be non-significant.

Geometric mean levels of returns and cost involved in maize production under sprinkler irrigation and conventional method of irrigation

It is clear from table 2 that the gross returns under sprinkler irrigation (Rs. 97,169.65) were more compared to the conventional method of irrigation (Rs. 78,148.30). With respect to inputs, the sprinkler irrigation involves about 24.39 per cent less seed cost, 15.35 per cent less farmyard manure cost, 81.85 per cent less fertiliser cost, 3.81 per cent less human labour cost, 10.27 per cent less bullock and machine labour cost, 16.48 per cent less plant protection chemicals cost and 43.39 less irrigation water.

Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in the cultivation of maize

A perusal of Table 3 indicates that the adopters of sprinkler irrigation technology produced 21.79 per cent higher income from maize production than the conventional method of irrigation. The increase in income was further decomposed into different sources of change, such as the adoption of sprinkler irrigation technology and all other inputs. The sprinkler irrigation technology alone could contribute 43.77 per cent increase in income, while the contribution of change in input levels was found to be negative (-21.99%). Amongst the various inputs, seed (-2.42%), bullock and machine labour (-0.52%), plant protection chemicals (-0.82%), and irrigation water applied (-26.84%) contributed negatively to the income.

Table 1: Production function estimates in maize production under sprinkler irrigation and conventional method of irrigation in the study area (Per ha)

Sl. No.	Particulars	Parameter	Conventional method of irrigation	Sprinkler irrigation	Pooled
1	No. of observations	n	60	60	120
2	Intercept	a	6.837 (0.608)	11.242 (1.807)	10.291 (0.826)
3	Seed (Rs.)	X_1	0.074 (0.046)	0.087 (0.102)	-0.049 (0.061)
4	FYM (Rs.)	X_2	0.015 (0.028)	-0.069 (0.047)	-0.046* (0.026)
5	Fertiliser (Rs.)	X_3	0.109*** (0.025)	-0.040* (0.023)	0.008 (0.018)
6	Human labour (Rs.)	X_4	0.368*** (0.060)	-0.156 (0.256)	-0.004 (0.084)
7	Bullock and Machine labour (Rs.)	X_5	-0.109*** (0.037)	0.048 (0.058)	0.179*** (0.039)
8	Plant protection chemicals (Rs.)	X_6	-0.042* (0.021)	0.046 (0.062)	-0.125*** (0.031)
9	Irrigation water applied (ha cm)	X_7	0.113*** (0.034)	0.472*** (0.078)	0.326*** (0.050)
10	Dummy for sprinkler irrigation		-	-	0.392*** (0.039)
11	Coefficient of multiple determination	R^2	0.978	0.967	0.954
12	Adjusted R	R^2	0.975	0.963	0.951
13	F Value	F	326.33	219.33	290.44

Note: *** Significant at 1% level
** Significant at 5% level
* Significant at 10% level
Figures in parentheses indicate standard errors of coefficients

Table 2: Geometric mean levels of returns and cost involved in the production of maize under sprinkler irrigation and conventional method of irrigation in the study area (Per ha)

Sl. No.	Particulars	Conventional method of irrigation	Sprinkler irrigation	Difference (%)
1	No of observation	60	60	
2	Seed (Rs.)	4700.04	3553.92	-24.39
3	FYM (Rs.)	5840.79	4944.14	-15.35
4	Fertilizer (Rs.)	6647.28	1206.47	-81.85
5	Human labour (Rs.)	18992.01	18268.53	-3.81
6	Bullock and Machine labour (Rs.)	7698.15	6907.55	-10.27
7	Plant protection chemicals (Rs.)	1011.39	844.71	-16.48
8	Irrigation water applied (ha cm)	22.90	12.96	-43.39
9	Gross returns (Rs.)	78148.30	97169.65	24.34

Table 3: Decomposition analysis of total change in per hectare income between sprinkler irrigation and conventional method of irrigation in the cultivation of maize in the study area (Per ha)

Sl. No.	Particulars	Per cent contribution
	Total change in measured income	**21.79**
1	Sprinkler irrigation	43.77
	a. Neutral component	440.53
	b. Non-neutral component	-396.76
	Seed (Rs.)	10.20
	FYM (Rs.)	-73.18
	Fertilizer (Rs.)	-131.31
	Human labour (Rs.)	-516.03
	Bullock and Machine labour (Rs.)	140.59
	Plant protection chemicals (Rs.)	60.63
	Irrigation water applied (ha cm)	112.34
2	Input contribution	-21.99
	Seed (Rs.)	-2.42
	FYM (Rs.)	1.16
	Fertilizer (Rs.)	6.86
	Human labour (Rs.)	0.61
	Bullock and Machine labour (Rs.)	-0.52
	Plant protection chemicals (Rs.)	-0.82
	Irrigation water applied (ha cm)	-26.84
	Total estimated difference in the income	21.79

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