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SUBJECT I
INPUT DELIVERY SYSTEM INCLUDING IRRIGATION AND OTHER SERVICES AND THEIR EFFICIENCY – ROLE OF FINANCIAL SECTOR

Dynamics of Input Use Efficiency in Selected Crops Cultivation in India: A Temporal and Spatial Analysis

A. Narayanamoorthy*, R. Suresh* and P. Alli**

ABSTRACT

The issue of how efficiently farmers are using various farm inputs in crop cultivation has been an important topic of research over the years. Many studies from India seem to suggest that the farm inputs are mostly used sub-optimally. However, not many studies are available on the inputs use efficiency covering different crops and states using recent temporal data. In this study, therefore, an attempt has been made to find out the efficiency of different inputs used for cultivating six different crops, namely, paddy, wheat, gram, groundnut, cotton and sugarcane by utilising cost of cultivation survey data from 1985-86 to 2013-14. The study shows that the value of crop output (at 1986-87 prices) per unit of input generated in terms of rupees has not increased consistently over the years in both foodgrain and non-foodgrain crops. The efficiency of yield augmenting inputs such as fertilisers and irrigation either has declined or fluctuated in most crops and states. There is no conclusive evidence to show that the inputs are used more efficiently in high productivity states than that of the low productivity states in all the six crops considered for the analysis. In crops like gram and sugarcane, the low productivity states have outperformed the high productivity states not only in the overall resource use efficiency but even at the individual level input use efficiency. The regression analysis carried out to find out the efficiency of different inputs over time seems to suggest that the inputs have not been used efficiently in all the six crops. Even the yield augmenting cost-intensive inputs such as fertilisers, irrigation and seed seem to have not been used efficiently over time. This pattern is observed in both the high and low productivity states in all the six crops considered for the analysis. The study concludes that the sub-optimal price received by the farmers in the market may have dampened the efficiency of inputs used for crops cultivation.

Keywords: Cost of cultivation; Farm inputs use efficiency; Farm price; Indian agriculture.

JEL: Q12, Q13, Q15, Q18.

I

INTRODUCTION

The introduction of green revolution technology during the mid-sixties has brought dramatic changes in Indian agriculture. Not only the adoption of technological inputs such as high-yielding variety (HYV) seeds, fertilisers, pesticides has increased substantially, but the use of tubewell irrigation and machineries in crops cultivation has also become widespread. This has completely changed the scenario of food production of the country which was branded as living from ship-to

*Professor and Head and Assistant Professor respectively, Department of Economics and Rural Development, Alagappa University, Karaikudi (Tamil Nadu) and **Assistant Professor in Economics, Department of Social Sciences, Vellore Institute Technology, Vellore-632 014 (Tamil Nadu).

mouth during the fifties and sixties. Today, with about 265 million tonnes of production, Indian stands as one of the largest producers of foodgrains in the world (Government of India, 2016). While increasing the production of foodgrains and other agricultural commodities, the green revolution has also generated debates on its benefits. The debate on farm-size versus productivity relationship which started immediately after the introduction of green revolution technology has been continuing even today (Sen, 1964, Athreya *et al*., 1990; Haque, 1996, Tadesse and Krishnamoorthy, 1997). The issue of impact of green revolution on cropping pattern, favouring high value water-intensive crops and replacing low value crops, has also attracted the researchers (Rao, 1975; Chand and Haque, 1997; Bhalla and Singh, 2012).

The issue of how efficiently farmers are using various farm inputs in crop cultivation has been an important topic of research over the years (Channareddy, 1967; Sampath, 1979; Shapiro, 1983; Rao *et al*., 2003; Shanmugam and Venkataramani, 2006). It is theoretically expected that an efficient farmer tends to use all the resources required for crop cultivation in an optimal way so as to reduce the cost and maximise the income (Haque, 2006). But, in practice achieving high level of efficiency in resource use is very difficult as it is determined by various factors. Access to farm technology, cost of farm inputs, availability of credit, market facility, road and its related infrastructures, level of support prices announced by the government, procurement infrastructure, etc. play a pivotal role in determining the efficiency of input use. The efficiency of input use is measured in terms of returns from farming, where market condition plays a crucial role that is often not under the control of farmers. This means that even if the farmer uses the inputs efficiently in crop cultivation at farm level, there is no guarantee that the farmer can achieve the optimal level of economic efficiency in terms of returns.

Since efficiency of input use is determined by the returns from farming, quite a few studies have analysed the efficiency of farm inputs using micro and macro-level data over the years. Fertiliser is one of the important inputs of modern agriculture and therefore, many scholars have studied the efficiency of it in different crops. Though most studies on fertilisers seem to suggest a continuing decline in fertiliser response through the 1980s, Sagar (1995) showed a contrary result using field data. While analysing the productivity of agricultural credit in India, Narayanan (2015) concluded that "…….. input use is sensitive to credit flow, whereas GDP of agriculture is not. Credit seems therefore to be an enabling input, but one whose effectiveness is undermined by low technical efficiency and productivity" (p.1). Utilising panel data from India, Foster and Rosenzweig (2011) studied the mechanisation, agency costs and farm efficiency of Indian farmers. They concluded that although the small farmers have lower unit labour costs, large farms use substantially less labour per acre but are more mechanised and also more efficient.

As irrigation water is crucial in crop production, quite a few scholars have estimated the efficiency of water use in relation to productivity (Saleth, 2009; Sharma

et al., 2015). After making detailed estimates using state-wise data, Vaidyanathan and Sivasubramanian (2004) found a weak correlation between consumptive use rate of water and yield per millimeter (mm) of water use, meaning that the water use efficiency in terms of crop productivity is poor. With the use of farm level data from Gujarat, Kumar (2005) analysed the water use efficiency in terms of money value (Rs./m^3) among water sellers, water buyers and sharecroppers and found that water buyers are more efficient as compared to water sellers. Using farm level data, some studies have shown that drip method of irrigation helps to increase the efficiency of input use in different crops cultivation as compared to the conventional flood method of irrigation (Narayanamoorthy, 1997, 2003, 2004; Saleth, 2009; Narayanamoorthy *et al*., 2016).

Although a large number of studies have analysed the input use efficiency in crops cultivation, most of them are specific to an individual input (either for fertiliser or water or credit, etc.). Some studies have also used only one time point data to study the resource efficiency. But the input use efficiency is not static one but is instead dynamic in nature which may undergo changes due to various factors. For instance, fertiliser may turn out to be an inefficient input in paddy cultivation in a particular year say t1, but it may turn out to be the most efficient input in year t2 because the efficiency of the farm input is controlled by many exogenous factors (Tadesse and Krishnamoorthy, 1997). As Gulati and Sharma (1997) rightly mentioned, "Resource use efficiency is a dynamic concept which may undergo a change because of changes in factors such as technology, prices……" (p.1). Similarly, the efficiency of input use is also expected to vary from crop to crop, region to region and also between low and high productivity of crop. Not many studies are available on input use efficiency covering these aspects in India using temporal data. In this study, therefore, an attempt is made to find out the efficiency of different farm inputs used in six crops cultivation in different states covering data from 1985-86 to 2013-14.

II

DATA AND METHODOLOGY

The major objective of the study is to find out the dynamics of input use efficiency in six different crops over time, where time series data are essential for the analysis. In India, the time series data on input use (both in quantity and value terms) as well as on value of output for different crops and states are available only from the Cost of Cultivation Survey (CCS) published by the Commission for Agricultural Costs and Prices (CACP). This study has used CCS data for its entire analysis covering the period from 1985-86 to 2013-14. Apart from studying the changing nature of input use efficiency, the study also attempts to find out the nexus between the input use efficiency and productivity of crops, as it is generally believed that the efficiency in input use is better in the states where productivity of crop is higher. In

order to study this issue, two states have been considered for each selected crop, one from High Area with High Productivity (HAHP) and another one from High Area with Low Productivity (HALP). The states and crops selected for the analysis are presented in Table 1.

TABLE 1. CROPS AND STATES SELECTED FOR THE STUDY

Crop (1)	State selected (2)	Category of state (3)	Cropped area (mha) (average of TE 2013-14) (4)	Productivity (kg/ha) (average of TE 2013-14) (5)
Paddy	Andhra Pradesh	HAHP	4.03	3081
	Orissa	HALP	4.07	1695
Wheat	Punjab	HAHP	3.52	4880
	Madhya Pradesh	HALP	5.19	2414
Gram	Madhya Pradesh	HAHP	3.11	1115
	Rajasthan	HALP	1.54	871
Groundnut	Gujarat	HAHP	1.60	1623
	Andhra Pradesh	HALP	1.42	789
Cotton	Gujarat	HAHP	2.66	659
	Maharashtra	HALP	4.15	323
Sugarcane	Maharashtra	HAHP	0.96	80529
	Uttar Pradesh	HALP	2.20	59968

Sources: Computed utilising data from Government of India (2015) and www.dacenet.nic.in.

Notes: HAHP – high area with high productivity; HALP - high area with low productivity; mha-million hectares; TE- triennium ending.

In order to find out the dynamics of input use efficiency in different crops (after converting all the costs and income related data at 1986-87 prices using CPIAL deflator), two types of analysis have been carried out in this study. First, the efficiency of all the major inputs have been worked out by dividing the value of crop output (VCO) with the cost of each major input for four time points, namely, 1985-86, 1995-96, 2005-06 and 2013-14. This is expected to explain the average output per unit of input generated in terms of rupees in different time points. The major inputs considered for this analysis are human labour cost (HLC), machine labour cost (MLC), fertiliser and manures cost (FMC), irrigation cost (IRC) as well as all operational costs (A2+FL). Further to strengthen the analysis and also to find out the efficiency of different inputs over time, multiple regression model (OLS method) has been estimated for all the selected crops and states for the period 1995-96 to 2013-14. The specification of regression model used in the analysis is as follows:

$$VCO = \beta_0 + \beta_1 HLC + \beta_2 BLC + \beta_3 MLC + \beta_4 SDC + \beta_5 FMC + \beta_6 PIC + \beta_7 IRC + t \quad \ldots.(1)$$

where,

VCO = Value of crop output (Rs./ha at 1986-87 prices)
$\beta_0, \ldots\ldots, \beta_1$ = Parameters to be estimated
HLC = Human labour cost (Rs./ha at 1986-87 prices)
BLC = Bullock labour cost (Rs./ha at 1986-87 prices)
MLC = Machine labour cost (Rs./ha at 1986-87 prices)
SDC = Seed cost (Rs./ha at 1986-87 prices)

FMC = Fertiliser and manure cost (Rs./ha at 1986-87 prices)
PIC = Pesticides and insecticides cost (Rs./ha at 1986-87 prices)
IRC = Irrigation cost (Rs./ha at 1986-87 prices)
T = Time variable (1985-86 to 2013-14)

The above specified regression is estimated separately for each crop and for each state. By this estimation, we would obtain the regression coefficient that would reveal the efficiency of each input in determining the value of crop output in terms of money value. The regression coefficient would also allow us to compare the efficiency of the same input used among the high and low productivity states.

III

RESULTS AND DISCUSSION

Due to fast increase in the price of farm inputs, it is essential to attain high level efficiency in its use to harvest increased yield and profit. Attaining optimum level of efficiency in every input use is also very much needed to double the farm income, which is also the focus of the policy makers today. The recently published policy paper by NITI Aayog (2015) on *"Raising Agricultural Productivity and Making Farming Remunerative to Farmers"* has given lot of thrust to improve the efficiency of various farm inputs to translate farming into remunerative one. But, most studies have shown that the farmers often use resources sub-optimally due to various reasons. For instance, NITI Aayog's (2015) report mentions that India uses 2-3 times the water used to produce one tonne of grain in countries like China, Brazil and USA. Let us now analyse the results of the present study generated from CCS data.

Input Use Efficiency in Selected Foodgrain Crops

As mentioned in the methodology section, one of the aims of the study is to find out the varying nature of input use efficiency in different crops over time. To study this, we have computed the value of crop output generated from every rupee of cost in different inputs by dividing the value of output (Rs./ha) with the cost of each input. The input use efficiency generally varies from crop to crop because of varied use of irrigation and productivity of crops. The objective of the study is not only to analyse the input use efficiency over time but also to study the variations in it among different crops namely foodgrain and non-foodgrain crops. Table 2 presents the input use efficiency for three foodgrains crops, namely, paddy, wheat and gram for four time points: 1985-86, 1995-96, 2005-06 and 2013-14. It is evident from the results that the input use efficiency is not static, but very much dynamic in all the crops and in both HAHP states and HALP states. It is generally believed that the resources are used more efficiently in high productivity regions than that of the low productivity regions. But, the results of the study do not completely support this assertion. Even in low productivity state, the inputs seem to have been used more efficiently than in those states that have relatively less crop productivity in certain crops.

TABLE 2. INPUT USE EFFICIENCY (CROP OUTPUT PER RUPEE OF COST) FOR SELECTED FOODGRAIN CROPS

(*Rs. at 1986-87 prices*)

Crop (1)	States (2)	Cost (3)	1985-86 (4)	1995-96 (5)	2005-06 (6)	2013-14 (7)
Paddy	Andhra Pradesh	HLC	3.43	2.89	3.21	3.21
	(HAHP)	MLC	20.55	18.89	12.94	9.36
		FFC	6.56	7.61	10.07	10.64
		IRC	36.52	30.57	44.88	80.10
		All Cost (A2+FL)	1.52	1.76	1.83	1.92
	Orissa	HLC	2.68	2.50	2.04	1.41
	(HALP)	MLC	1692.05	155.88	27.68	19.09
		FFC	7.57	9.12	7.98	8.02
		IRC	180.05	358.41	129.84	472.52
		All Cost (A2+FL)	1.56	1.71	1.48	1.42
Wheat	Punjab	HLC	6.55	5.52	10.10	12.52
	(HAHP)	MLC	8.67	9.90	7.13	8.58
		FFC	7.08	6.33	10.22	13.44
		IRC	27.58	40.08	51.11	200.67
		All Cost (A2+FL)	1.80	1.62	2.18	2.56
	Madhya Pradesh	HLC	6.04	5.64	6.76	2.30
	(HALP)	MLC	30.79	13.46	9.20	5.23
		FFC	13.61	11.02	14.80	7.98
		IRC	14.20	12.60	11.10	7.91
		All Cost (A2+FL)	1.96	2.08	2.18	1.87
Gram	Madhya Pradesh	HLC	8.23	5.28	8.97	4.40
	(HAHP)	MLC	118.61	11.96	13.26	6.93
		FFC	52.68	14.32	38.35	17.27
		IRC	128.80	14.69	17.26	16.59
		All Cost (A2+FL)	2.76	1.79	2.60	1.71
	Rajasthan	HLC	8.10	4.88	6.42	3.44
	(HALP)	MLC	45.52	18.43	13.55	10.08
		FFC	175.14	109.34	99.18	50.11
		IRC	83.74	101.09	13.16	25.40
		All Cost (A2+FL)	3.24	3.09	3.40	3.06

Source: Computed using data from CACP (various years).

Paddy is one of the foodgrain crops where two states, namely, Andhra Pradesh (HAHP state) and Orissa (HALP state) are considered to study the input use efficiency across different time points. The results show that the overall resource use efficiency seems to be relatively better in HAHP state as compared to HALP state. The output generated from every one rupee of cost has increased from Rs. 1.52 in 1985-86 to Rs. 1.92 in 2013-14 for the farmers belonging to HAHP state, while the same has declined from Rs.1.56 to Rs. 1.42 for HALP state during the same period. However, the same trend is not observed among the different inputs considered for the analysis in paddy crop. Although the effect of human labour cost (HLC) and machine labour cost (MLC) on generating the crop output has declined in both HAHP and HALP states, fertiliser and manure cost (FFC) and irrigation cost (IRC) have showed improvement in generating crop output in both the states, albeit variation in different time points. Interestingly, the efficiency of irrigation cost in HALP state appears to be far better than HAHP state. On the whole, what is clear from the

analysis of paddy crop is that although the overall cost efficiency is better in HAHP state, HALP has equally achieved improved efficiency in certain farm inputs.

Punjab and Madhya Pradesh (MP) are considered as HAHP and HALP states respectively for studying the input use efficiency in wheat crop. Unlike paddy crop, wheat crop shows somewhat different results in input use efficiency. Of the four time points, the overall (total cost) input use efficiency of the low productivity state (HALP) is relatively higher than that of the high productivity state (HAHP) in two time points namely 1995-96 and 2005-06. This suggests that the input use efficiency need not always be higher in case of a HAHP state. Among the important inputs used for the cultivation of wheat crop, except for irrigation cost in Punjab, the efficiency of other inputs has not consistently increased in both the HAHP and HALP states. Contrary to the expectations of many, the efficiency of some of the inputs is much better in low productivity state than its high productivity counterpart.

The efficiency of different inputs used for gram cultivation is totally different from what is observed in paddy and wheat crops. In all the four time points, the total resource use efficiency is substantially lower in HAHP state (MP) as compared to HALP state of Rajasthan. For instance, the value of crop output generated from every rupee of cost is varying from Rs. 1.71 to Rs. 2.76 during the four time points for the farmers belonging to HAHP state, whereas the same is varying from Rs. 3.06 to Rs. 3.40 for the farmers belonging to HALP state during the same period. Of the four major inputs, the efficiency of FFC and IRC during certain time points seems to be substantially higher than the other two major inputs in both HALP and HAHP states. However, we do not observe any consistent increase in the output generated from every one rupee of cost in any of the inputs over time in both the states considered for the analysis. On the whole, the analysis on foodgrain crops shows that the efficiency of different inputs used for cultivation varies from crop to crop and there is no evidence to show that the inputs are used more efficiently by the high productivity states than that of the low productivity states.

Input Use Efficiency in Selected Non-Foodgrain Crops

The input use efficiency is expected to vary from crop to crop and therefore, after studying the foodgrain crops, we have studied three non-foodgrain commercial crops, namely, groundnut, cotton and sugarcane. This is done specifically to find out whether or not the pattern of input use efficiency of non-foodgrain crops is different from that of foodgrain crops. Generally, the non-foodgrain crops are cultivated for commercial purpose and therefore, not only the use of inputs would be higher for these crops but the expected income from these crops would also be higher. As a result of increased expected income, the resource use efficiency is also expected to be better among commercial crops.

Table 3 presents the amount of income generated from per unit of cost for different inputs and crops for four time points. Groundnut is one of the commercial crops considered for the analysis which shows that the overall resource use efficiency

of HAHP state (Gujarat) is relatively better in three out of four time points as compared to HALP state (Andhra Pradesh). However, the overall resource use efficiency has not increased consistently over time in both the states, which was also observed in foodgrain crops. Among the various inputs, irrigation (IRC) and machine labour (MLC) seem to have been used more efficiently than other inputs in groundnut cultivation in both the states. But, none of the inputs considered for the analysis has shown consistency in its efficiency over time in both the states. On the whole, the results of groundnut crop are not much different from that of foodgrain crops.

TABLE 3: INPUT USE EFFICIENCY (CROP OUTPUT PER RUPEE OF COST) FOR SELECTED NON-FOODGRAIN CROPS

(*Rs. at 1986-87 prices*)

Crop	States	Cost	1985-86	1995-96	2005-06	2013-14
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Groundnut	Gujarat	HLC	6.60	3.11	5.33	4.12
	(HAHP)	MLC	41.50	29.03	16.76	13.49
		FFC	9.62	8.19	14.32	13.39
		IRC	16.32	26.25	94.17	66.06
		All Cost (A2+FL)	1.72	1.33	2.02	1.84
	Andhra Pradesh	HLC	3.96	3.82	2.48	2.27
	(HALP)	MLC	50.63	30.85	19.10	16.03
		FFC	10.06	11.31	8.17	10.25
		IRC	43.97	97.07	73.30	41.60
		All Cost (A2+FL)	1.34	1.76	1.22	1.36
Cotton	Gujarat	HLC	3.44	4.37	4.20	2.65
	(HAHP)	MLC	37.85	21.72	22.31	25.26
		FFC	6.23	12.48	14.30	9.78
		IRC	9.56	22.85	27.92	36.18
		All Cost (A2+FL)	1.19	2.04	2.15	2.08
	Maharashtra	HLC	3.29	4.04	3.77	3.37
	(HALP)	MLC	65.64	59.02	38.01	23.51
		FFC	4.58	8.68	10.07	7.69
		IRC	75.09	125.32	70.50	63.27
		All Cost (A2+FL)	1.14	1.86	1.23	1.75
Sugarcane	Maharashtra	HLC	4.64	3.45	4.05	4.85
	(HAHP)	MLC	285.02	73.07	11.80	11.72
		FFC	9.10	8.42	6.98	10.51
		IRC	9.59	15.04	7.97	21.52
		All Cost (A2+FL)	1.84	1.71		2.17
	Uttar Pradesh	HLC	7.44	4.55	6.36	5.13
	(HALP)	MLC	143.19	82.13	56.46	124.46
		FFC	22.66	16.58	23.40	33.27
		IRC	25.17	32.02	25.82	27.76
		All Cost (A2+FL)	4.32	3.43	4.00	3.98

Source: Computed using data from CACP (various years).

Cotton is one of the important commercial crops cultivated predominantly under rainfed condition by the farmers in India. The introduction of Bt cotton seed in 2004 has brought substantial changes in its area and productivity (Narayanamoorthy and Kalamkar, 2006; Choudhary and Gaur, 2015). Therefore, we might expect interesting results on input use efficiency by studying cotton crop. As the introduction of Bt seed increased the productivity of cotton considerably, there is a possibility that this might

have helped to increase the overall resource use efficiency. But, against our expectation, the overall resource efficiency has not increased uniformly over time in both HAHP (Gujarat) and HALP (Maharashtra) states. In fact, the overall resource use efficiency was much better during 1995-96 as compared to the period of 2013-14 in both the states. It appears from these results that the farmers were able to generate more income from every rupee of cost that they had spent in growing cotton before the introduction of Bt seed. This apart, the efficiency in any of the major inputs used for cultivation has not increased consistently in both the states. Irrigation and machine labour seem to have generated more income for farmers cultivating cotton in both HALP and HAHP states. Again, the results from cotton too show an enormous inconsistency in input use efficiency over time in both high and low productivity states.

Sugarcane is another commercial crop selected for the analysis where Maharashtra and Uttar Pradesh are considered as HAHP and HALP states respectively. Unlike the other two commercial crops, the results of sugarcane crop show some definite pattern in inputs use efficiency. The overall resource use efficiency of HALP state is distinctly better than that of the HAHP state. For every rupee of cost, the farmers belonging to HALP state were to able generate an income of Rs. 3.43 to Rs. 4.32 during four time points considered for the analysis, whereas it varied only from Rs. 1.39 to Rs. 2.17 for HAHP state. It is also observed that the farmers belonging to HALP state seem to have achieved much better efficiency in almost all the inputs considered for the analysis than their counterparts in HAHP state of Maharashtra. On the whole, the analysis of six foodgrain and non-foodgrain crops suggests two important points: first, there is no clear pattern emerging in the overall resource use efficiency between high and low productivity states. Second, none of the major inputs considered for the analysis showed consistent increase in its efficiency over time in both low and high productivity states.

Input Use Efficiency Over Time – An Analysis of Regression Results

After studying the input use efficiency at different time points by computing average output (in terms of Rs.) generated from every rupee of investment (cost) for different inputs, an attempt is made to study the input use efficiency over time by employing multiple regression analysis, as specified in the methodology section. In this analysis, the costs of all the major inputs, namely, human labour (HLB), bullock labour (BLC), machine labour (MLC), seed (SDC), fertiliser and manure (FMC), pesticides and insecticides (PIC), irrigation (IRC) and time factor are treated as independent variables and value of crop output (VCO) as dependent variable. Regression analysis is carried for each crop and state separately covering data from 1995-96 to 2013-14. As the analysis focuses on efficiency of different inputs over time, all the values (in Rs.) have been converted into constant term at 1986-87 prices using CPIAL deflator.

The objectives of this analysis are to find out (a) whether or not the inputs are used efficiently in different crops over time, (b) Which is the farm input used more efficiently? (c) Are there variations in input use efficiency between HAHP and HALP states? (d) Is there any input which has showed consistency in positively influencing the value of output in all the crops selected for analysis? The results of regression model estimated for three foodgrain crops namely paddy, wheat and gram are presented in Table 4. It is evident from the regression results that the efficiency of different inputs is not the same in all the three crops and also between HAHP and HALP states. Also only a few inputs appear to have been used efficiently in all the three foodgrain crops cultivation. In paddy crop, seed cost followed by human labour cost (HLC) seem to have been used efficiently in HAHP state, but the same is not true with HALP state. In the case of wheat crop, only MLC seems to have been used efficiently in HAHP state (Punjab), whereas in case of the HALP state of Madhya Pradesh, both MLC and SDC have been used efficiently in cultivating the crop. Seed is the only input that seems to have been used efficiently in gram cultivation by both HAHP and HALP states. Not unexpectedly, in all the foodgrain crops considered for

TABLE 4. MULTIPLE REGRESSION RESULTS: EFFICIENCY OF DIFFERENT INPUTS USED FOR FOODGRAIN CROPS CULTIVATION DURING 1995-96 TO 2013-14 (DEPENDENT VARIABLE: VALUE OF CROP OUTPUT RS/HA AT 1986-87 PRICES)

	Paddy		Wheat		Gram	
Variables	Andhra Pradesh (HAHP state)	Orissa (HALP state)	Punjab (HAHP state)	Madhya Pradesh (HALP state)	Madhya Pradesh (HAHP state)	Rajasthan (HALP state)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
HLC	3.22	-1.77	2.14	-2.30	-0.11	0.07
	(1.94)[c]	(-1.35)[ns]	(0.65)[ns]	(-1.16)[ns]	(-0.03)[ns]	(0.03)[ns]
BLC	3.63	-1.44	6.47	-0.48	3.178	-3.39
	(0.89)[ns]	(-0.43)[ns]	(0.199)[ns]	(-0.13)[ns]	(0.534)[ns]	(-0.56)[ns]
MLC	-6.98	1.57	7.91	9.21	4.46	4.32
	(-1.36)[d]	(0.13)[ns]	(2.92)[b]	(2.61)[b]	(0.567)[ns]	(0.42)[ns]
SDC	6.45	26.21	-0.59	7.36	7.521	6.01
	(2.15)[b]	(0.958)[ns]	(-0.05)[ns]	(2.06)[b]	(3.17)[c]	(1.33)[ns]
FMC	3.17	2.82	1.56	0.015	0.18	3.59
	(1.07)[ns]	(0.45)[ns]	(0.32)[ns]	(0.004)[ns]	(0.02)[ns]	(0.179)[ns]
PIC	0.09	15.93	-3.96	-36.51	-5.04	-0.77
	(0.06)[ns]	(0.549)[ns]	(-0.52)[ns]	(-0.72)[ns]	(-0.55)[ns]	(-0.03)[ns]
IRC	-5.16	-45.69	-12.93	0.51	-0.90	2.31
	(-1.19)[ns]	(-1.41)[d]	(-1.28)[ns]	(0.23)[ns]	(-0.22)[ns]	(0.56)[ns]
time	328.03	225.37	-61.08	-48.03	-12.14	-45.69
	(2.17)[b]	(1.46)[d]	(-0.55)[ns]	(-0.39)[ns]	(-0.09)[ns]	(-0.50)[ns]
Constant	-2634.86	1604.46	812.91	314.17	-773.04	563.17
	(-0.53)	(0.35)	(0.11)	(0.16)	(-0.29)	(0.32)
R^2	0.79	0.61	0.72	0.94	0.701	0.68
Adjusted R^2	0.63	0.32	0.48	0.89	0.47	0.43
F-Value	4.83	1.55	3.15	18.64	3.02	2.68
D-W	1.91	1.96	2.56	1.86	1.89	1.77
N	19	17	19	19	19	19

Source: Computed using data from CACP (various years).

Notes: a, b, c and d are significant at 1, 5, 10 and 20 per cent level respectively; ns-not significant; figures in parentheses are 't' values.

the analysis, not even a single input seems to have been used efficiently and consistently over time from 1995-96 to 2013-14. The yield increasing inputs such as FMC and IRC too seem to have not been used efficiently in any of the foodgrain crops. While the regression coefficients of FMC (fertiliser and manure cost) turned out to be positive in all the three crops and in both HAHP and HALP states, IRC (irrigation cost) turned out to be negative in most cases, suggesting that the yield increasing inputs are used sub-optimally in foodgrains crops over time.

The pattern of input use efficiency of non-foodgrain crops is somewhat different from that of foodgrain crops. Human labour appears to have been used efficiently in all the three crops by both HAHP and HALP states (Table 5). But, this kind of consistency is not observed in any other inputs. For groundnut, besides HLC, seed cost appears to have been used efficiently by both HAHP and HALP states. Expectedly, pesticides and insecticides (PIC) have been used efficiently by both categories of states in cotton cultivation. For instance, one rupee increase in PIC in cotton cultivation seems to have increased the value of crop output by Rs. 14.94 in HAHP state and by Rs. 20.72 in HALP state. This could be due to the introduction of Bt seed in cotton crop, which has substantially reduced the consumption of pesticides

TABLE 5. MULTIPLE REGRESSION RESULTS: EFFICIENCY OF DIFFERENT INPUTS USED FOR NON-FOODGRAIN CROPS CULTIVATION DURING 1995-96 TO 2013-14 (DEPENDENT VARIABLE: VALUE OF CROP OUTPUT RS./HA AT 1986-87 PRICES)

	Groundnut		Cotton		Sugarcane	
Variables	Gujarat (HAHP state)	Andhra Pradesh (HALP state)	Gujarat (HAHP state)	Maharashtra (HALP state)	Maharashtra (HAHP state)	Uttar Pradesh (HALP state)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
HLC	6.08	1.45	3.69	1.97	4.18	10.38
	(2.07)[c]	(0.61)[ns]	(1.89)[c]	(2.72)[b]	(1.62)[d]	(2.42)[b]
BLC	6.16	8.44	-11.74	0.67	-5.66	-2.95
	(1.98)[c]	(1.24)[ns]	(-1.77)[d]	(0.54)[ns]	(-0.61)[ns]	(-0.24)[ns]
MLC	-0.94	8.12	10.32	-9.36	-2.38	26.19
	(-0.10)[ns]	(0.69)[ns]	(1.05)[ns]	(-1.10)[ns]	(-0.69)[ns]	(1.09)[ns]
SDC	5.46	12.71	0.27	-2.47	4.46	-1.89
	(1.64)[d]	(2.14)[c]	(0.08)[ns]	(-0.80)[ns]	(0.85)[ns]	(-0.32)[ns]
FMC	-11.19	-8.03	-12.60	-4.04	-2.87	-28.11
	(-1.38)[d]	(-1.32)[ns]	(-3.32)[a]	(-1.81)[c]	(-0.65)[ns]	(-2.07)[c]
PIC	-6.26	-1.49	14.94	20.72	-41.96	-97.55
	(-1.27)[ns]	(-0.07)[ns]	(2.40)[b]	(2.01)[c]	(-0.60)[ns]	(-1.68)[d]
IRC	-11.40	3.53	3.44	-1.08	-1.17	5.72
	(-1.42)[d]	(0.43)[ns]	(1.00)[ns]	(-0.23)[ns]	(-0.28)[ns]	(0.93)[ns]
time	-41.74	-347.51	305.62	353.18	1258.79	-266.26
	(-0.20)[ns]	(-1.69)[c]	(1.39)[d]	(2.44)[b]	(2.46)[b]	(-0.79)[ns]
Constant	-2650.53	-7501.41	-264.36	827.59	1608.09	3754.29
	(-1.034)	(-2.10)	(-0.07)	(0.34)	(0.17)	(0.38)
R^2	0.77	0.89	0.89	0.95	0.73	0.79
Adjusted R^2	0.59	0.80	0.79	0.89	0.52	0.64
F-Value	4.19	10.04	9.33	18.18	3.39	4.94
D-W	1.97	1.82	2.41	1.75	1.95	2.59
N	19	19	18	18	19	19

Source: Computed using data from CACP (various years).

Notes: a, b, c and d are significant at 1, 5, 10 and 20 per cent level respectively; ns-not significant; figures in parentheses are 't' values.

(for details see, Choudhary and Gaur, 2015). Since fertilisers are costly inputs that are also used heavily in sugarcane cultivation, we have expected that the yield increasing inputs such as FMC would have been used efficiently in sugarcane cultivation. But, contrary to our expectation, except HLC, none of the other inputs including fertilisers have been used efficiently. It is also surprising to observe that the regression coefficients of fertilisers estimated for non-foodgrain crops are totally different from the one estimated for foodgrain crops. While the coefficients of fertilisers turned out to be uniformly positive (though not significant) for all the three foodgrain crops and for both HAHP and HALP states, the same turned out to be negative for all the three non-foodgrains crops considered for the analysis. However, as in the case of foodgrain crops, irrigation seems to have been used sub-optimally in non-foodgrain crops as well, which is an unexpected result.

It is clear from the above analysis that the efficiency level of different inputs used over time is either very low or insignificant or negative in almost all the selected crops and also in both high and low productivity states. Does it mean that the inputs are not used efficiently for crops cultivation in India? One may not be able to make a firm conclusion that the inputs are not used efficiently in crops cultivation using the results arrived from this study. More than the exogenous factors, the endogenous factors play a paramount role in deciding the level of efficiency of different inputs. Market condition (factor and product) is one which plays a paramount role in deciding the input use efficiency (see, Deshpande, 1996). Because of the prevalence of imperfect agricultural market condition and poor procurement arrangements, most of the time farmers do not receive sufficient price for their produces that ultimately reduce their gross income from crop cultivation. As a result of sub-optimal price received by the farmers in the market, the efficiency of most of the inputs used for different crops cultivation turns out to be sub-optimal in most cases. Another important reason for the sub-optimal efficiency could be due to enormous increase in cost of inputs needed for farming especially after late 1990s. Studies carried out using cost of cultivation survey data emphatically show that the cost of cultivation for different crops has increased at a faster rate than the rate of increase in income from farming (see, Deshpande and Arora, 2010; Narayanamoorthy and Suresh, 2012 and 2013; Narayanamoorthy *et al*., 2015; Narayanamoorthy, 2007; 2013 and 2017). Since the efficiency of the inputs is measured by using its cost, the fast increase in inputs costs may have also dampened its efficiency. Therefore, given the excessive role of endogenous factors in deciding the efficiency of each input, it is possible that the efficiency level of farm inputs would be sub-optimal even if the farmers use the inputs efficiently at the farm level.

IV

CONCLUSION AND SUGGESTIONS

Achieving optimal level of efficiency in the use of various farm inputs for crops cultivation is essential to increase the farm profititability. Many studies from India

seem to suggest that the farm inputs are mostly used sub-optimally or not used efficiently. However, not many studies are available on the inputs use efficiency covering different crops and states using recent temporal and spatial data. In this study, therefore, an attempt has been made to study the efficiency of different inputs used for cultivating six crops, namely, paddy, wheat, gram, groundnut, cotton and sugarcane by utilising cost of cultivation survey data from 1985-86 to 2013-14. After converting the data on input costs and value of crop output into constant prices, the efficiency of different inputs has been worked out by two methods: (a) average output per unit of input has been calculated by dividing the value of crop output with the cost of each major input used for crops cultivation, and (b) multiple regression has been estimated separately for each crop by treating value crop output as dependent variable and all the major inputs costs as independent variables.

The study shows that the average crop output per unit of input cost has not increased consistently over different time periods in both foodgrain and non-foodgrain crops. The efficiency of yield augmenting inputs such as fertilisers and irrigation either has declined or fluctuated in most crops and states. There is no conclusive evidence to show that the inputs are used more efficiently in high productivity states than that of the low productivity states in all the six crops considered for the analysis. In fact, in crops like gram and sugarcane, the low productivity states have outperformed the high productivity states not only in the overall resource use efficiency (computed taking into account the total A2+FL cost) but even at the individual level input use efficiency. The regression analysis carried out to find out the efficiency of different inputs over time seems to suggest that none of the inputs have been used efficiently and consistently in all the six crops. For paddy crop, human labour and seed seem to have been used efficiently, whereas machine labour seems to have been used efficiently for wheat crop. Similarly, pesticides and insecticides appear to have been used efficiently for cotton crop, but seed seems to have been used efficiently for groundnut crop. Even the yield augmenting cost-intensive inputs such as fertilisers, irrigation and seed seem to have not been used efficiently in all the crops over time from 1995-96 to 2013-14. This kind of pattern is observed not only with the high productivity states but also with the low productivity states in all the six crops.

From these results, it is difficult to conclude that the inputs are not used efficiently in crops cultivation over time. This inefficiency may have occurred due to sub-optimal price received by the farmers from the market which is imperfect and dominated by the middlemen in India. There is a possibility that the farmers may have used the inputs efficiently at farm level and harvested increased productivity (kg/ha), but would not have achieved the desired efficiency in terms of resource use. Markets (factor and product) are possibly eroding the extra income generated through increased productivity. Therefore, in order to find out the real efficiency of different inputs used for crops cultivation, one must consider the optimal price of crop produce

(potential price) that the farmer supposed to get in a perfectly governed market and then estimate the inputs use efficiency.

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