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Measuring production factors productivity in Fars province sugar beet farms, Iran

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ABSTRACT

Production is hard to achieve by increasing cropping area due to limited water resources. So, increased yield per unit area may be the solution to increase production. Investigating productivity of production factors is very important in this context. The objective of this study is to measure the productivity of production factors in sugar beet production in Fars province. The data needed for the study was gathered by completing questionnaires among 65 sugar beet growers of Fars province in growing season of 2008. The polynomial production function of order three was used to estimate the applied inputs productivity. The results showed that marginal productivity of the inputs including irrigation times, hired labor, animal manure, phosphate fertilizer, poison and cropping area are 385, -28, -0.4, 14, 2574, and -1253, respectively. It was also found that 97.1 percent of the farmers have overused animal manure and the corresponding figure for water was 61.8 percent. Reduction in labor and animal manure use is recommended.

Keywords: productivity, production function, sugar beet, production factors

INTRODUCTION

Given the technological and scientific advances in today's world, identifying the production resources and the intelligent use of them is important factors in successful development, especially alleviating poverty and resolving the present food crisis, so that the economical prosperity and self-sufficiency of the nations depend upon the way they utilize all tangible and intangible facilities, capabilities and talents. A glance at the status of agriculture in developing countries shows that the lack of an in-depth knowledge of the production facilities and resources as well as low efficiency and productivity of agriculture production factors, particularly the lack of sound management, are the main causes hindering the realization of agriculture development goals (Ghorbani 1996).

In Iran, agriculture sector does not exploit all production capabilities and potentials as the status of the agriculture development witnesses. Therefore, any study on the inefficiency of production of agricultural products and any attempt to boost the efficiency and optimum exploitation of the resources will raise the productivity of agriculture production factors. In total, given the current facilities and limitations of agriculture sector in Iran, it can be said that the best way to increase the production and farmers' income is to correctly use the current production factors and to improve the productivity of these factors through sound management (Zibaei 1990-1993). The production can be promoted through two ways: exploiting production factors at the current technology level, and exploiting more efficient and better technological methods or in other words, improving the productivity of the production factors. Considering the scarcity of production factors, the production can be improved by better exploitation of less

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production resources (Seydan 2002). So, it should be tried to increase the yield by optimally exploiting the inputs and the advanced technologies. In addition to increasing the productivity of the land, alternative cultivation enhances the productivity of other inputs, too. Productivity is defined as the ratio of output to input (Anonymous 2001).

Productivity can be measured by estimating production function. Some studies in which productivity is examined by using production function include Serrao (2003); Mirotchi and Taylor (1993); Kiresur (1995); Lebel et al. (2007); and Luptacik et al. (2006). Also, some studies carried out in Iran are Akbari and Ranjkesh (2003); Mehrabi Boshrabadi (1995); Amirteimouri and Khalilian (2008); Fatahi (2006); and Hajrahimi and Karimi (1996) in which the productivity of production factors are measured on the basis of the production function. In their studies on total production of agriculture sector, Akbari and Ranjkesh (2003) and Amirteimouri and Khalilian (2008) evaluated the contribution of total labor of agriculture sector to negative production. Najafi and Farajzadeh (2010) is another example of studies in which the negative contribution of labor to the production of agriculture sector is used in estimating wheat production function. In contrary to these studies that evaluated the contribution of labor as to be negative at agriculture sector level, Mohammadi et al. (2005) analyzed the role of production factors in sugar beet production in Eqlid region of Fars province, Iran and found the effect of labor to be negative. In addition, Hajrahimi and Karimi (1996) measured productivity at selected poultry industry level in Kordestan province, Iran and evaluated the contribution of all production factors including labor to be positive. They estimated the productivity of labor in one poultry production cycle as to be 10229 kg. Fatahi (2006) evaluated the contribution of production factors used in the production of madder as to be positive in Yazd province, Iran. So, it is observed that the negative contribution of some production factors has been estimated to be higher in the studies that have used nation-wide data. However, it should be noted that at macro-level, the production factors are typically used in the form of two general categories: labor and capital.

The cultivation area of sugar beet is 153 000 ha in Iran which constitutes 2.8% of global sugar beet cultivation area. Sugar beet is cultivated in almost 25 provinces of Iran as an irrigated crop. According to the last census in 2008-2009, Khorasan-e-Razavi province has the highest cultivation area (19 892 ha) in Iran accounting for 35% of total sugar beet cultivation area in the country. Western Azerbaijan province has the second highest cultivation area (13 672 ha) which is 24% of total cultivation area of sugar beet. Fars province has the third highest cultivation area which is 11% of total cultivation area of this crop (Iranian Ministry of Agriculture 2009). According to the same census, Fars province has the capacity to increase its sugar beet production area. Considering that the knowledge of the pattern of exploiting production factors and studying their productivity are of crucial importance in increasing the production of sugar beet in Fars province, the present study was aimed at formulating the role of inputs in the production of sugar beet in this province by using the concept of productivity.

MATERIALS AND METHODS

In total, economists mainly consider two types of marginal and average productivity (Heydari 2009). Marginal productivity is defined as the output added by the last input unit to total output whereas the average productivity is defined as the output of input unit, that is, how much is, on average, added to the output by each unit of input. Productivity is measured by econometric or non-parametric methods. In econometric method, productivity is measured by estimating production function and/or a cost function. In non-parametric method, it is determined by mathematical programming and/or index calculation.

The production function selected for the present study was a third-order polynomial function because of its conformity with the available data and its advantages over Cabb-Douglas and transcendental production functions. The econometric attributes led to the selection of the third-order production function are discussed in Results and Discussion section.

Some attributes of third-order function are that it covers all three-fold sectors of production, that it adheres to the law of diminishing efficiency, and that substitution elasticity of inputs is not constant along production function. Eq. (1) shows the general form of this function.

$$Y = \alpha_0 + \sum_{i=1}^{n} \alpha_i X_i + \sum_{i=1}^{n} \beta_i X_i^2 + \sum_{i=1}^{n} \gamma_i X_i^3 \tag{1}$$

Where *y* is the production rate, and X_i is the factors affecting production or production inputs. The number of inputs in this function is *n*.

In addition, assuming that producers supply

Table 1. Results of estimating third-order production function in sugar beet farms of Fars province, Iran (2008)

Independent variable	Coefficient	Standard deviation	Statistic *t*
X_1	411.5**	221.2	2.41
X_2	33.4**	11.7	2.73
X_3	-0.56**	0.211	-2.86
X_4	9557.7***	2635.5	4.21
X_5	-3241.8***	826.1	-3.87
X_6	-5466*	2749.5	-1.65
X_1^2	-6.46**	2.16	-2.9
X_2^2	-0.03*	0.018	1.69
X_3^2	0.0007**	0.000035	1.97
X_4^2	-1349.09***	413.68	-3.44
X_6^2	1231.72*	688.63	1.85
X_1^3	0.032**	0.0076	2.88
X_4^3	57.87***	17.38	2.98
X_5^3	2.82***	0.57	4.98
X_6^3	-61.6*	30.24	-1.77
y-intercept	36375.6***	11826.23	3.79
R2		0.72	
R^2		0.62	
F		8.2***	

the production factors at a competing market, average productivity, marginal productivity, marginal production value, and production elasticity of different production factors are calculated by Eqs. (2)-(5), respectively.

$$MP_{ij} = \frac{\partial Y_j}{\partial X_{ij}} \tag{2}$$

$$VMP_{ij} = MP_{ij} \times P_Y \tag{3}$$

$$AP_{ij} = \frac{Y_i}{X_{ij}} \tag{4}$$

$$E_{X_{ij}} = \frac{MP_{ij}}{AP_{ij}} \tag{5}$$

where P_y is the selling price of one kg sugar beet by the producer of the region in question, MP_{ij} is the marginal productivity of the j^{th} producer from the i^{th} production factor, AP_{ij} is the average productivity of the j^{th} producer from the i^{th} production factor, E_{Xij} is the production elasticity of the j^{th} producer in relation to the i^{th} production factor, VMP_{ij} is the marginal production value of the j^{th} producer from the i^{th} production factor, Y_i is the sugar beet production of the j^{th} producer, and X_{ij} is the use rate of the i^{th} production factor by the j^{th} producer.

The data of the study were collected from 65 sugar beet growers of Fars province, Iran by questionnaire in 2008.

Results and Discussion

To study the productivity of product factors, production function was first estimated by ordinary least square method. As mentioned before, various functions were tested for obtaining production function and finally, the polynomial third-order function was selected owing the econometric attributes for a suitable estimation. These attributes which showed the superiority of third-order production function over Cabb-Douglas and transcendental production functions were considered on the basis of recognition statistics such as coefficient of goodness of fit, uniformityof the variance of error terms and normality of the distribution of error terms. Also, the statistical importance of variables was another criterion for selecting the third-order function.

The results of this assertion are given in Table 1. Considering that this assertion has various terms of each variable, the effect of these variables on production cannot be analyzed by the obtained coefficients alone. Therefore, the productivity of each input was calculated and analyzed too. This assertion can fit 62% of the variations of the production among the selected producers by the used variables, and the statistic A showed the significance of this assertion at 1% probability level.

The marginal productivity of each input was calculated on the basis of the estimated function by Eq. (2).

Marginal productivity of the frequency of irrigation

$$MP_{X5} = -3241 + 8.46X_5^2 \tag{8}$$

Marginal productivity of workingman labor

$$MP_{X1} = 411.56 - 12.8X_1 + 0.96X_1^2 \tag{9}$$

Marginal productivity of manure

$$MP_{X3} = -0.56 + 0.0014X_3 \tag{10}$$

Marginal productivity of phosphate fertilizer

$$MP_{X2} = 33.4 - 0.06X_2 \tag{11}$$

Marginal productivity of herbicide

$$MP_{X4} = 9557.7 - 2698.18X_4 + 173.4X_4^2 \tag{12}$$

Table 2. Productivity and production elasticity of inputs for sugar beet growers in Fars province, Iran (2008)

Parameters			Inputs					
			Labor	P fertilizer	Manure	Herbicide	Irrigation frequency	Cultivation area
Marginal productivity	Mean		-28	14	-0.4	2574	385	-1253
	Minimum		-185	-13	-0.45	-1025	-2033	-7150
	Maximum		315	22	0.31	5687	2366	1745
Mean productivity	Mean		650	143	6.6	10270	680	20546
	Minimum		123	29	0.27	1965	750	1222
	Maximum		7569	652	26	30524	3500	85066
Marginal productivity value	Mean		-476	6	-6	19	0.28	-0.1
	Minimum		-3700	-7	-14	-9	-2.8	-0.45
	Maximum		5670	25	18	78	4.5	0.111
Ratio of final production value to input cost	>1	Number	8	27	1	23	13	0
		Percentage	23.5	79.5	2.9	67.6	38.2	0
	<1	Number	26	7	33	11	21	34
		Percentage	76.5	20.5	97.1	32.4	61.8	100
Production elasticity			-0.15	0.07	-0.06	0.21	0.37	-0.1

Marginal productivity of cultivation area

(13) $$MP_{X6} = -5466 + 2462.44X_6 - 184.8X_6^2$$

Table 2 presents the results of the calculation of marginal productivity with Eqs. (8)-(13), average productivity with Eq. (4) and production elasticity with Eq. (5). As can be seen in Table 2, the productivity was calculated at three levels of mean, maximum and minimum. In other words, the productivity of an input was calculated on the basis of the mean, maximum and minimum use of a certain input in selected sample.

According to Table 2, the marginal productivities of irrigation frequency, workingman labor, manure, phosphate fertilizer, herbicide and cultivation area were 385, -28, -0.4, 2574 and -1253, respectively, showing that the productivities of labor, manure and cultivation area were negative. The negative marginal productivity of these three inputs suggests that they were used over-optimally and were located in the third sector of the production. The production elasticity of labor, phosphate fertilizer, manure, herbicide, irrigation frequency and cultivation area was -0.15, 0.07, -0.06, 0.21, 0.37 and -0.1. Total production elasticity was calculated as to be 0.34 which is less than unit suggesting diminishing efficiency as compared to scale. It implies that as the exploitation of the inputs is increased, their costs will increase exponentially.

As can be seen, 76.5% of sugar beet producers have overexploited and 23.5% have underexploited the labor. The amount of water used by 38.2% of producers was under-optimal, while 61.8% of producers have used over-optimal amount of water. Producers have overused manure too, so that the amount of manure used by 97.1% of them was over-optimal.

It was revealed that labor was used over-optimally. So, it is necessary to use less labor in input combination to maximize the return. If the labor is reduced, then it is possible to move from the third sector of production to the second sector (economists' recommendation) which will entail both the saving in expenses and the increase in production. Furthermore, phosphate fertilizer is applied under-optimally which should be increased. The increase in this input will increase its marginal productivity and the production of sugar beet crops. The negative impact of labor on sugar beet production was also observed in the study conducted by Mohammadi et al. (2005) in Eghlid region of Fars province, Iran.

The elasticity of cultivation area was negative too suggesting that the increase in cultivation area or the decrease in the use of production factors will increase the production per unit area. The increase in the cultivation area means the decrease in the use of other inputs per unit area, too because the coefficient of a certain variable is interpretable provided that the extent of the use of other variables is constant. Therefore, the increase in cultivation area may cause the negative contribution of labor and manure to be mitigated or even be changed to positive. Thus, it can be said that the negative impact of cultivation area on production is synonymous to increasing the extent of the exploitation of other inputs per unit area. Labor and manure clearly exemplify overexploitation of production resources in sugar beet production. Hence, it is recommended to extend cultivation area (if possible) and/or to limit the extent of the exploitation of the inputs, particularly labor and manure.

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