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A Determination of Suitable Sugar Cane Utilization System Using Total Factor Productivity (TFP) (Case Study: Imam Khomeini Cultivation and Processing Center in Khuzestan Province)

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ABSTRACT

Using productivity index for investigating a firms' performance makes it possible to evaluate efficiency of the production system and cost at the same time. In this study the Total Factor Productivity (TFP) of several sugar cane varieties in Imam Khomeini Cultivation and Processing Center in Khuzestan Province is compared. Two hundred and forty eight farms are categorized on the basis of variety years old and then Tornqvist-Tiel Productivity Index is employed for calculating TFP for each sugar cane farm. The investigated sugar cane varieties include CP57-614, CP69-1062 and CP48-103. Results revealed that year long utilization system gained the lowest TFP among utilization systems in all the mentioned varieties. The most suitable utilization system according to the TFP index is biennial for CP57-614 variety, triennial for CP69-1062 and five years for the CP48-103 variety. Triennial CP57-614 variety has the most partial productivity in fertilizer. On the other hand, the six year long plant of the forgoing variety exhibits the largest partial productivity in water. The largest partial productivity in machinery is shown in biennial CP69-1062 variety. Among these varieties, triennial CP48-103 one has the largest partial productivity per unit area cultivation.

Keywords: Khuzestan Province, Sugar cane varieties, Tornqvist-Tiel index, Total Factor Productivity (TFP).

INTRODUCTION

With widespread improvement of science and technology, identification of production resources along with proper utilization of those resources should be looked at as one of the essential factors for achieving success in economic development. As can be said political efflorescence and economic self sufficiency of any country depends on utilization manner and the use of facilities, affordability, as well as social, physical, and human capabilities. Observation of agriculture status in developing countries shows that misidentification of production resources and facilities along with low productivity and efficiency of agricultural production factors, have caused agricultural development aims not to be realized in such countries as they should (Chizari and Sadeghi, 1999). Economical growth requires increase in production, and according to production and supply theories, production growth is possible in one of the two ways of either using more production factors, or use of improved technology along with more efficient utilization of production factors. Productivity change is both the cause and

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the effect of the evolution of dynamic forces operating in an economy's technical progress, accumulation of human and physical capital, enterprise, and institutional arrangements. Assessment and interpretation of the behavior at micro and macroeconomic levels require the untangling of many complex factors; it is a task that has been a major challenge to economists and the final interest to entrepreneurs and government policy-makers (Ishaq Nadiri, 1970). In some developing countries such as Iran limitations in access to production resources have limited the economic growth by a first approach. Thereby, concentration on increase in Total Factor Productivity (TFP) is an inseparable essentiality for increase in commodity supply (Mojaverian, 2002). Productivity growth, as a management approach, is officially ordered to all the national executive institutions. So, they all must consider increase in TFP in their entire sub-sector growth.

Productivity assessment provides a key indicator for the performance of an agricultural activity across firm comparisons, and finally helps policy makers to design optimal policies to enhance productivity. As indicated by Ahearn *et al.* (1998), the most popular method of productivity measurement is the index number approach. In a major estimates of US agricultural productivity an index number approach is employed (Ahearn *et al.,* 1998). At present, some such specialized organizations as EPO, APO, OECD, and BLS are increasingly taking the advantages of using index number approach in studies related to productivity.

Several studies are done about TFP using Index Number in different economic sectors. Using Tornqvist-Tiel index, Huang determined productivity in food industry of the United States. Results from the study revealed that during the time period of 1975-97, up to the year 1979, total factor productivity in this sector had been increased by a rate of 1.8 percent and then, it had been decreased by the rate of 0.9 percent (Huang, 2002). In a research by Agnarsson, by using Divisia index, productivity growth in fish producing technology during the time period of 1985-95 in Island was studied. Results from the study showed that, on the average, productivity during those years had enjoyed a growth rate of 1.5% (Agnarsson, 2000). Piesse *et al.* (2000) investigated agriculture sector productivity and it's convergence in Botswana. Results from their studies showed that productivity growth in regions where livestock husbandry was prevalent was more than that in the other regions. On the other hand, some productivity growth in those regions was initiated from technological improvement (Piesse *et al*., 2000). Chapman *et al.* developed a technique to map spatial patterns in productivity growth in Australia. They emphasized on an identification of regional variations and an understanding of the factors that had likely contributed to their creation, as well as to predict future agriculture land use and production potentials (Chapman *et al.,* 2000). Salim measured productive efficiency of firms in Bangladesh food manufacturing sector. Results from his research revealed that wide variations in efficiency across firms may be attributed to firms' heterogeneity and that there is ample scope for increasing efficiency, using the available resources and technology (Salim, 2006). Using Tornqvist-Tiel index, Simeon *et al.* investigated gender productivity on crop production in Ethiopia, results of which implied that the variation in overall TFP can only arise due to difference in access to the quality of human and physical resources and services, as well as to different ways of control of the benefits arising from output by women versus men (Simeon *et al*., 2006). Other studies assess total and partial factor productivity by using parametric and non-parametric methods (Piesse *et al*., 2000; Tveteras and Heshmati, 1999; Daneshvare Ameri and Salami, 2004).

Sugar cane, with the scientific name of *Saccharum Officinarum*, is a gigantic plant in *Gramineae* genus that is cultivated for its stem sugar in a several year cultivation system. Sugar cane is grown in tropical and semi-tropical regions where monthly average temperature, at least during 8 months of the year is approximately 20 degrees centigrade. Sugar stem contains 90 per cent juice, 12-17 percent of which is Saguaros. About 85-110 kg of sugar can be obtained from a ton of sugar cane stems. According to the required temperature conditions for sugar cane cultivation, Khuzestan Province benefits from priorities for cultivation of sugar cane in Iran. Imam Khomeini Cultivation and Processing Center is 15,800 hectares in area and is 30 Km from Shooshtar. This Cultivation and Processing Center with 12,800 hectares of fertilized land dedicated to sugar cane cultivation, and a sugar processing factory with a production capacity of 100 thousand tons, is the main center for producing and processing sugar cane in Iran.

Sugar cane is a perennial plant. The more the number of productivity years of the plant with its renewed cultivation delayed, the less sugar cane production costs would be. The average number of years for a renewal cultivation of this plant, worldwide is more than ten. This is while, this number in Imam Khomeini cultivation and Processing Center reaches only 4.6 years. Results from this research show that the number of renewed cultivation years for each variety mustn't be less than those during which, that variety has the largest Total Factor Productivity. On the other hand, the cost price for producing sugar from sugar cane in Iran is more than the universal cost prices for producing the same product. Regarding the large investments in cultivation and production of this product, and its long record for being cultivated in Iran, it seems that the difference in production costs is often due to cultivation management. The present research is a study of the productivity of inputs and the effect of cultivation duration years on productivity of the inputs. It is attempted to identify a suitable system for putting this product to its utmost productivity.

According to the essentiality of the above matters, this study compares TFP of some varieties of 248 sugar cane farms including CP57-614, CP69-1062 and CP48-103 varieties in Imam Khomeini Cultivation and Processing Center in Khuzestan Province in 2006, and then identifies the productive utilization system through a comparison of the TFP in different years for the different studied varieties. On the other hand, by calculating partial factor productivity of several farms, and using productive cultivation model as well as farm management approach, increase in productivity conditions is realized.

MATERIALS AND METHODS

According to the economic theory, productivity is defined as the ratio of outputs to inputs. Productivity change is an important aspect of technological changes, so that productivity assessment plays a crucial role in assessing the effects of technological changes in agriculture. Total Factor Productivity, the productivity of all purchased inputs, is the broadest measure of productivity, and consequently, the most useful approach for productivity measurement when understanding the effects of technological changes is intended (Norsworthy and Jane, 1992). TFP is the ratio of total production quantity to total input quantity (Salami and Talachi Langeroodi, 2001). In principle, productivity addresses the relationship between input and output at micro, sectional or macro levels of the society. So, changes made in productivity due to shifting from a period to another, and/or the presence of gap in productivity among the firms within a defined period of time are indications of differences in technical potency, managerial levels, organizational structures, sectional and trans-sectional relationships and even natural and environmental effects of the firms, sectors or economy when inputs are changed into goods and services (Mohamadinejad and Shirinbakhs, 2002). In

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literature, productivity is measured in two ways, including parametric (econometric) and non-parametric methods. In parametric method, production or cost function is primarily estimated, and then a variable is entered into the estimated model on behalf of technology. How technology variable effect the rate of production, may be an indicative of changes in productivity or advancement in technology.

Non-parametric method is used in Mathematical Programming and Index Number approaches. In non-parametric method of calculating TFP by using Index Number, several indices can be used for measuring the total and partial factor productivity, that is to say, using one of the index forms, an index of outputs and of inputs is built according to which, the productivity index is determined. The level of different outputs and inputs can not be simply aggregated together. In doing so, Number Index, which is incompatible with production function, should be employed.

Laspeyers and Paasche indices are samples of used forms in productivity index measurement. Laspeyers and Paasche indices are in agreement with linear and Leontief production functions, respectively. Hence, these indices bear the undesirable properties of related production functions. Another index is Ideal Fisher Index. This index benefits from the properties of both linear and Leontief production functions (Diewert, 1992). The best form of index for measuring TFP is Tornqvist-Tiel index. It is in agreement with Translog production function properties. Translog production function is a flexible form and has the properties that exist in the real world. As outlined in Lawrence and McKay (1980), this index is based on a homogenous production function which provides a second-order approximation to an arbitrary production function at any given point. Diewert (1976) demonstrated that Number Index form is the superlative form if it is in agreement with Translog function.

This indexing procedure possesses a number of desirable technical properties which make it very suitable for calculating TFP. Mathematical form of Tornqvist-Tiel output index is determined as fallows (Simeon *et al.,* 2006):

$$Q_T(P^0, P^t, Y^0, Y^t) = \prod_{i=1}^{n} \left[\frac{Y_i^t}{Y_i^0} \right]^{\frac{1}{2}\left(R_i^t + R_i^0\right)} \quad (1$$

Where Q_T is output quantity index, P^t and P^0 are price of output in t_{th} and in reference firms, respectively. Y^t and Y^0 are production quantities of output in t_{th} and in reference firms, respectively and R_i^t and R_i^0 are finally the income share of i_{th} output in t_{th} and in reference firms, respectively. Income share of i_{th} output are calculated as fallows (Hall and Jones, 1997):

$$R_i^t = \frac{P_i^t \times Y_i^t}{\sum_i^n P_i^t \times Y_i^t} \quad (2$$

Quantitative index of Tornqvist-Tiel input is also determined as follows (Hall and Jones, 1997):

$$X_t(w^t, w^0, x^t, x^0) = \prod_{t=1}^{m} \left[\frac{X_i^t}{X_i^0} \right]^{\frac{1}{2}.(S_i^t + S_i^0)} \quad (3$$

Where X_T is input quantity index, w^t and w^0 are the input in t_{th} and in reference firms, respectively. X^t and X^0 are the consumed quantities of input in t_{th} and in reference firms, respectively, and S_i^t and S_i^0 are cost shares of i_{th} input in t_{th} and in reference firms, respectively. Cost share of the i_{th} input is calculated as fallows (Hall and Jones, 1997):

$$S = \frac{W_i^t \times X_i^t}{\sum_{i=1}^{m} W_i^t \times X_i^t} \quad (4$$

TFP index is obtained by dividing the total outputs' index by total inputs' index. If the used index in aggregation of inputs and outputs is in Tornqvist-Tiel form, TFP index is called Tornqvist-Tiel Total Factor Productivity Index (Hall and Jones, 1997) which is expressed as:

$$\frac{TFP_t}{TFP_0}=\frac{\prod_{i=1}^{n}\left[\frac{Y_i^t}{Y_i^0}\right]^{\frac{1}{2}\left(R_i^t+R_i^0\right)}}{\prod_{t=1}^{m}\left[\frac{X_i^t}{X_i^0}\right]^{\frac{1}{2}.(S_i^t+S_i^0)}} \quad (5$$

In order to calculate partial productivity index for each input, at first, in any group of inputs, given input share in Total Cost is calculated through Equation (4), and then input index is assessed through Equation (3). Calculation of partial productivity index of any input group takes place by dividing output index by input group index.

How we can aggregate heterogeneous inputs and outputs, is the most important aspect in using Index Number for calculating TFP. Tornqvist-Tiel is a discontinuous approximation of Divisia index and is adopted by Translog production function. Because of enjoying the foregoing properties, this index is considered a superior one (Diewert, 1981). Apart from the properties of Tornqvist-Tiel index, its use is associated with some limitations and assumptions in the present research. Tornqvist-Tiel index aggregates inputs under competitive conditions, constant return to scale, neutral technological changes and assuming the Separability of inputs and outputs. However, Caves *et al.* (1982) showed that even under such conditions as non homogeneity and variability of return to scale, Tornqvist-Tiel index form is in agreement with production structure.

Accrediting to the foregoing text, in this study, the mathematical form of Tornqvist-Tiel index is used for assessing the total input and output indices. In the present study uses 2006 cross-sectional data are employed from Imam Khomeini Cultivation and Processing Center of sugar cane in Khuzestan Province.

Since growth period of sugar cane in the 248 studied farms is different, in order to compare TFP's of different sugar cane varieties, the under study farms are divided into six groups. Accordingly, production productivity of 20 year long, 39 biennial, 27 triennial, 53 four year long old, 76 five year lsting and 33 six year lasting farms of CP57-614, CP69-1062 and CP48-103 varieties were investigated in six groups. Consumed inputs are categorized in four groups of: land (Ha), irrigation water (cubic meters), machinery (hours) and fertilizer (tons). Output is sugar cane (tons). The highest yield of CP57-614 variety was in biennial plant that was 100.76 tons while the yield for CP69-1062 and CP48-103 varieties were 173.63 and 121.83 tons for biennial and triennial plants, respectively. Standard deviation of varieties' yields in different age groups show that CP69-1062 variety with 22.74 has the highest production fluctuation. Table 1 shows the inputs and outputs of the understudy farms in the present research.

The advantages of the cross-sectional TFP accounting is that it does not impose a specific form on the aggregated output and input indices and does not require econometric estimation of parameters (Hall and Jones, 1997).

RESULTS

Due to the advantages of Tornqvist-Tiel index and its widespread application' in productivity analyses, it was applied for calculating TFP of sugar cane varieties in the present study. In this article the reference production firm was obtained from the average producers and was considered as the basis for calculations. That is to say, productivity of each understudy farm for each variety and in each age group is compared with the mean productivity of a group of farms of that variety within that age group.

At first, partial production factor productivities are assessed, then by using Tornqvist-Tiel index, partial productivities are found out the results of which are indicated in Table 2.

Results show that triennial CP57-614 variety has the highest partial productivity in fertilizer consumption. On the other hand, six year lasting plant of the foregoing variety shows the highest partial productivity

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Table 1. Output and input Data.

Age	Variety	Number of farm	Quantity	Product (Ton)	Fertilizer (Ton)	Machinery (Hour)	Water (m^3)	Land (ha)
1	CP57-614	8	Max	2359.63	118.8	139.5	1130844	24.6
			Min	1362.44	98.86	55	1081600	15.15
			Mean	1666.87	102.62	73.37	1115209	19.93
	CP69-1062	9	Max	4927.83	134.51	200	1586970	43.26
			Min	353.34	96.77	14.5	1020800	4.69
			Mean	2563.26	111.1	95.17	1315661	24.84
	CP48-103	3	Max	3033.57	133.73	108.5	1211250	25.3
			Min	1431.48	100	15	940500	14.03
			Mean	2463.5	114.39	51.83	1081900	21.41
2	CP57-614	22	Max	2488.73	134.51	110.5	1144100	26.03
			Min	1404.07	99.25	52	587808	16.31
			Mean	1859.67	105.08	67	787552.2	21.99
	CP69-1062	14	Max	2848.05	165.22	127	1275850	25.29
			Min	566.08	94.02	6	570000	4
			Mean	1880.37	120.85	62.25	827141.1	19.21
	CP48-103	3	Max	1915.85	117.84	195	890000	19.8
			Min	1629.94	101.01	21.5	821100	19.7
			Mean	1736.88	112.09	111.83	855566.7	19.77
3	CP57-614	5	Max	1385.05	134.72	62.5	931500	21.08
			Min	862.61	98.52	12	656240	18.6
			Mean	1056.59	117.04	37.9	778048	19.414
	CP69-1062	6	Max	1502.72	133.01	62	863750	25.06
			Min	926.14	95.72	28.5	593300	9.48
			Mean	1257.13	109.07	47.5	757841.7	20.37
	CP48-103	16	Max	2621.7	134.15	170.5	1027350	25.67
			Min	1427.27	115.71	30	659000	23.55
			Mean	2246.75	124.99	62.41	811509.4	25.02
4	CP57-614	18	Max	1885.47	134.59	118.5	912600	25.52
			Min	703.85	98.8	17	683592	17.5
			Mean	1433.40	129.35	62.22	807785.9	23.27
	CP69-1062	19	Max	3937.47	131.7	147	1212750	43.74
			Min	1956	99.05	11	863075	19.82
			Mean	2838.80	105.05	43.45	961259.2	27.33
	CP48-103	16	Max	2642.99	150.38	146.5	893700	25.96
			Min	568	99.8	28	573300	9.31
			Mean	1920.57	125.4	89.09	782721.9	23.56
5	CP57-614	24	Max	2023.93	134.18	303	959850	30.61
			Min	724.1	98.54	10	674500	14.43
			Mean	1331.19	107.2	111.60	868052.1	23.82
	CP69-1062	36	Max	2817.85	153.81	120.5	986700	25.91
			Min	447.28	87.28	37.5	625000	7.28
			Mean	2058.15	123.21	83.61	775783.3	23.16
	CP48-103	16	Max	2478.52	153.06	155	946350	25.35
			Min	840.28	98.27	42	640300	12.48
			Mean	1729.01	126.24	113.87	826193.8	22.51
6	CP57-614	3	Max	882.01	117.83	121.5	752400	24.72
			Min	743.12	100.7	91	652650	21.81
			Mean	818.91	112.01	107.5	698350	23.57
	CP69-1062	10	Max	2876.64	151.18	129	1149120	32.34
			Min	315.45	94.65	47	638000	2.18
			Mean	1821.77	118.42	79.2	807030	21.34
	CP48-103	20	Max	3538.31	155.29	151	1134000	36.41
			Min	1421.75	100.68	13	729100	13.41
			Mean	2011.53	127.09	95.3	888907	27.21

Source: Own results.

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Table 2. Input Partial Productivity Index.

age	Variety	Number of farm	quantity	Partial productivity of fertilizer	Partial productivity of machinery	Partial productivity of water	Partial productivity of land
1	CP57-614	8	Max	1.4366	1.3183	1.4049	1.1466
			Min	0.7060	0.4704	0.8060	0.8853
			Mean	1.0073	1.0801	0.9998	0.9987
	CP69-1062	9	Max	1.3954	1.2825	1.3611	1.1913
			Min	0.7884	0.5968	0.6627	0.8247
			Mean	1.0080	1.0150	1.0225	1.0004
	CP48-103	3	Max	1.1837	2.5784	1.4010	1.2318
			Min	0.7294	0.7165	0.7265	0.8630
			Mean	1.0022	1.2608	1.0135	0.9923
2	CP57-614	22	Max	1.3109	3.4429	1.5166	1.2410
			Min	0.6386	0.3452	0.5549	0.5693
			Mean	0.9909	1.2525	0.9980	0.9875
	CP69-1062	14	Max	1.6223	13.2206	1.4955	1.2991
			Min	0.5916	0.3130	0.5365	0.6520
			Mean	1.0105	1.880	1.0019	0.9958
	CP48-103	3	Max	1.1295	1.0719	1.0277	1.0976
			Min	0.8650	0.9529	0.9709	0.8843
			Mean	1.0061	1.0057	0.9994	1.0030
3	CP57-614	5	Max	2.5112	5.3899	1.7305	1.6829
			Min	0.1188	0.1887	0.1500	0.7302
			Mean	1.0370	1.5461	0.9737	1.0491
	CP69-1062	6	Max	1.5866	7.3647	1.8548	1.5396
			Min	0.3869	0.1993	0.3349	0.5580
			Mean	0.9934	1.8688	1.0456	1.0661
	CP48-103	16	Max	1.3621	1.4962	1.5268	1.6119
			Min	0.7597	0.5644	0.7015	0.6120
			Mean	0.9988	1.o472	1.0182	1.0942
4	CP57-614	18	Max	1.2204	3.8872	1.2968	1.2473
			Min	0.5823	0.2385	0.6306	0.6662
			Mean	1.0043	1.7611	1.0023	1.0129
	CP69-1062	19	Max	1.8066	2.6385	1.8172	1.2706
			Min	o.2637	0.1772	0.2204	0.6914
			Mean	1.0226	1.1387	1.0178	0.9934
	CP48-103	16	Max	1.6070	1.5787	1.4908	1.6955
			Min	0.1769	0.1739	0.1695	0.8169
			Mean	0.9815	0.9790	0.9965	1.1063
5	CP57-614	24	Max	1.2871	2.0079	1.4165	1.8867
			Min	0.6646	0.5882	0.5190	0.8867
			Mean	0.9838	1.4231	1.0091	0.9792
	CP69-1062	36	Max	1.2240	5.7375	1.1493	1.1011
			Min	0.8925	0.5381	0.9021	0.9368
			Mean	1.0296	2.6904	1.0122	1.0075
	CP48-103	16	Max	1.2604	2.0700	1.3003	1.1515
			Min	0.6378	0.3667	0.7183	0.6382
			Mean	0.9983	1.2215	1.0094	0.9885
6	CP57-614	3	Max	1.4788	2.1634	1.8788	1.3610
			Min	0.2466	0.4014	0.3045	0.5854
			Mean	1.0105	1.1298	1.0244	0.9847
	CP69-1062	10	Max	1.7827	1.7913	1.6726	1.2918
			Min	0.4029	0.6921	0.4242	0.5586
			Mean	1.0969	1.0690	1.0285	0.9861
	CP48-103	20	Max	1.9102	7.1342	1.8577	1.3413
			Min	0.5480	0.5732	0.6435	0.7206
			Mean	1.0316	1.5731	1.0253	1.0025

Source: Own results.

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in water consumption. Consequently, in comparison with other varieties in different age groups, triennial and six year old CP57-614 variety in lieu of consuming a firm of chemical fertilizer and water, make more sugar cane available, respectively. The highest partial productivity in machinery is obtained in biennial CP69-1062 variety. Among the varieties, the four year old plantation of CP48-103 variety has the highest partial productivity per hectare of cultivation. Therefore, in comparison with the other two varieties in different age groups, due to allocating each under cultivation firm to this variety at this age, more products can be achieved.

Since one can not discriminate the effects of input substitutions *vs.* technology and technical effects, we can not present a suitable estimation for technological improvement in different sugar cane varieties. So, according to the existent fault in partial productivity index and using different varieties of sugar cane as different technologies, we use TFP for a comparison of the three types of technology. Total output productivity index is calculated using Tornqvist-Tiel index and then through use of Equation (5), TFP is determined. Summaries for the results from the three types of the studied varieties are shown in Table 3.

Results indicate that the five year lasting CP48-103 variety has the highest TFP mean. This means that CP48-103 during the mentioned years bears the highest production potential, and in comparison with the other studied varieties, the consumed inputs are used in an optimized way. Findings revealed that the most suitable utilization system according to the mean TFP index, is the biennial of CP57-614, triennial of CP69-1062, and, the five year old variety of CP48-103.

CONCLUSIONS

Results suggest that in most productive year of utilization for each variety, management control must be made in a way that maximum possible usage of production capacity for each one of the studied varieties is accrued. Due to water scarcity, optimized usage of this input in production process is important. Absolute difference between maximum and minimum quantities of water partial productivity for CP57-614 in 1 through 6 harvesting years were 174, 273, 1153, 205, 273 and 617 percent. The foregoing differences for CP69-1062, and CP48-103 varieties were 205, 279, 554, 824, 127 and 394 percent *vs.*193, 105, 218, 879, 181 and 289 percent, respectively. These quantities that are indicative of capacity of productivity improvement in water consumption reveal the necessity for taking the advantages of superior farm water consumption model to reduce the gap between farms in optimized usage of water. Likewise, increase in partial such input productivity as chemical fertilizer plays an important role in decreasing the environmental risk.

One of the main aims of the present research is to study the fluctuations in TFP in farms with different variety crops of different age groups. Therefore, after determining TFP for each one of the farms the level of Standard Deviation for TFP of farms of each variety in each age group was calculated.

As clear from the Table 4, during the first up to the third harvest years, farms with CP69-1062 variety have the most TFP fluctuations. This is while, by reaching the most TFP for this variety in the third harvest year, the said variety has the least TFP fluctuations in the 4^{th} and 5^{th} harvest years. Seemingly, emphasizing on farm supervisions for the purpose of stabilizing production system on farms, this variety has been of crucial importance during the first through the third year and it will play a considerable role in improving the degree of productivity of this variety. Although, CP48-103 variety, on the average bears the most TFP during the fifth harvest year, it also bears the highest TFP fluctuations in the said year. Thus, in order to take the maximum level of advantages of productive capacity of

Table 3. Total factor productivity index.

Age	Variety	Number of farm	Quantity	Total factor productivity
1	CP57-614	8	Max	1.3776
			Min	0.8157
			Mean	0.9986
	CP69-1062	9	Max	1.6717
			Min	0.1603
			Mean	0.9620
	CP48-103	3	Max	1.3479
			Min	0.5561
			Mean	0.9899
2	CP57-614	22	Max	1.2503
			Min	0.7044
			Mean	1.0113
	CP69-1062	14	Max	1.7247
			Min	0.3738
			Mean	1.0101
	CP48-103	3	Max	1.1685
			Min	0.8954
			Mean	1.0161
3	CP57-614	5	Max	1.3195
			Min	0.7410
			Mean	1.0059
	CP69-1062	6	Max	1.5072
			Min	0.6992
			Mean	1.0161
	CP48-103	16	Max	1.2258
			Min	0.6954
			Mean	1.0000
4	CP57-614	18	Max	1.4372
			Min	0.5706
			Mean	0.9936
	CP69-1062	19	Max	1.2799
			Min	0.6244
			Mean	1.0019
	CP48-103	16	Max	1.6849
			Min	0.3221
			Mean	1.0061
5	CP57-614	24	Max	1.4644
			Min	0.5695
			Mean	0.9992
	CP69-1062	36	Max	1.6535
			Min	0.2489
			Mean	1.0049
	CP48-103	16	Max	1.5830
			Min	0.4538
			Mean	1.0195
6	CP57-614	3	Max	1.0491
			Min	0.9441
			Mean	0.9997
	CP69-1062	10	Max	1.3878
			Min	0.2030
			Mean	0.9665
	CP48-103	20	Max	1.7715
			Min	0.6722
			Mean	1.0183

Source: Own rsults.

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Table 4- Standard deviation of sugar cane farms TFP.

Age	Varieties		
	CP57-614	CP69-1062	CP48-103
1	0.1732	0.4603	0.4107
2	0.1643	0.4240	0.1440
3	0.2197	0.3311	0.1391
4	0.2377	0.1393	0.3503
5	0.2312	0.2268	0.3591
6	0.0527	0.3400	0.2721

Source: Own results.

this variety in the fifth harvest year, it is necessary to take steps to reduce these fluctuations by executing supervisory activities on the farms dedicated to this variety during the fifth harvest year.

Since, Imam Khomeini Cultivation and Processing Center enjoys suitable technology for producing sugar cane, enhancement of farm management quality is considered as the most important factor in competitive and economic production of this product in Iran.

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تعیین مناسب‌ترین نظام بهره‌برداری نیشکر با استفاده از بهره‌وری کل عوامل تولید (مطالعه موردی: کشت و صنعت امام خمینی خوزستان)

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چکیده

استفاده از معیار بهره‌وری در جهت سنجش عملکرد بنگاه‌های اقتصادی به طور همزمان بررسی کارایی سامانه تولید و هزینه را ممکن می‌سازد. پژوهش حاضر به مقایسه بهره‌وری عوامل کل تولید واریته‌های مختلف نیشکر در کشت و صنعت امام خمینی استان خوزستان پرداخته است. در این پژوهش ابتدا ۲۴۸ مزرعه، براساس سن واریته‌ها تقسیم‌بندی شده و سپس برای محاسبه‌ی بهره‌وری کل عوامل تولید نیشکر، از شاخص بهره‌وری ترنکوئیست- تیل استفاده شده است. واریته‌های مورد مطالعه شامل CP57-614، CP69-1062 و CP48-103 می‌باشد. یافته‌های پژوهش حاکی از آن است که برداشت واریته‌های مختلف مورد مطالعه در سال اول کمترین بهره‌وری کل عوامل تولید را عاید سامانه تولید می‌کند. بهترین نظام بهره-برداری براساس معیار بهره‌وری کل عوامل تولید برای واریته CP57-614 سال دوم، واریته CP69-1062 سال سوم و واریته CP48-103 سال پنجم کشت می‌باشد. واریته سه ساله CP57-614 بیشترین بهره‌وری جزئی نهاده کود شیمیایی را دارا بوده است. از سوی دیگر، رقم شش ساله واریته مذکور نیز بیشترین بهره-وری جزئی نهاده آب را به خود اختصاص داده است. بیشترین بهره‌وری جزئی ماشین آلات متعلق به رقم دو ساله CP69-1062 می‌باشد. در این بین، واریته CP48-103 سه ساله بیشترین بهره‌وری جزئی نهاده زمین را دارا است.

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