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Comparison of Production Productivity of 3 Rice Varieties Including Long Grain Good Quality, Long Grain High Yielding and Hybrid Rice in Iran (Case Study: Gilan Province)

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Abstract: Gilan province has 35 percent of Iran's rice production and 42 percent of rice acreages. In this study Total Factor Productivity of 3 rice varieties was investigated and compared by using Tornqvist-Tiel index. Requested data set were obtained by using questioner and interviewing with 542 individual farmers of Gilan province rice farming society. Results revealed that hybrid variety had the most partial and total factor productivity by mean. Total factor productivity is 1.052 percent by mean in hybrid variety which could be reached to 1.4 percent by treating farmers.

Key words: Total factor productivity · Tornqvist-Tiel Index · Rice · Gilan province

INTRODUCTION

Rice is the third much used agricultural product after wheat and tomato in Iran that has increasingly been consumed since 1950. Not so long after Iran has been one of the rice exporter countries until 1940, it became one of the rice importer countries. During the past three decades, under cultivation area, production and rice importing have experienced many changes in Iran, so that the demand for rice has considerably been increased in comparison with its production. This caused an increase in importing the rice in response to the quick demand for the rice. Since a long time ago, different factors have come together to create such abnormal usage pattern. Increase in oil incomes during the first years of 1950s and following it, the changes in patterns of rice usage - due to urbanism- have been among the most influential factors for increasing the rice importing during the years before Iran's revolution. But during the years after revolution, quick growth in the number of population from one hand and government's extreme interference in rice market and distribution of coupons for goods on the other, are among those factors that are considered effective in changing the rice usage pattern so that at the present time Iran is one of the most important countries in the world that import rice from other countries[1].

Iran, together with India, Pakistan, Korea, China, Taiwan and Thailand are some of the main rice producing countries in Asia. Per capita average usage of rice in the world ranges 80-90 kilograms; while this amount in Iran is 25-45 kg. The above mentioned product in Iran is the second source for supplying food after wheat. Because of increase in population, quick growth in per capita usage, lack of the lands that can be cultivated by rice, Iran's being located in semi-desert area and lack of mechanization in farmlands, the amount of rice importing has considerably been increased in recent years in comparison with the past[1].

The most amount of rice cultivation in Iran in three Northern provinces of Gilan, Mazandaran and Golestan takes place at 71 percent of the cultivable areas of the whole country. Diversity in local and improved rice varieties in these provinces are countless and all of them are classified in six groups of long grain good quality, long grain high yielding, average grain good quality, average grain high yielding, short grain good quality and short grain high yielding products. Gilan is one of the provinces that have attracted much attention regarding the agricultural products, especially the rice. Gilan province has allocated more the 35 and 42 percent of paddy production and under cultivation areas of the country to itself, respectively. In this province more than 181 exploiters on productive and talented areas with more than 230000 hectares, are busy rice farming. Indeed, rice cultivation is considered the most important agricultural activity in this province and the economy of the province

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Table 1: Gilan province and Rasht region rice production system characteristics at 2006

Description		Gilan province	Rasht region
Acreages (ha)	Long grain good quality	220324	54776
	long grain high yielding	17716	7560
Total (ha)		238040	62336
Production (ton)	Paddy rice	1070000	264838
	White rice	700000	176300
Number of farmers		300000	74000
Most cultivated Varieties	Long grain good quality	Sadri Varieties	Sadri Varieties
	long grain high yielding	Khazar Variety	Khazar Variety
Mean of per farmer land ownerships (ha)	0.8	1.18	
Yield (kg/ha)	Long grain good quality	4300	4100
	long grain high yielding	6300	5400

Resource: [3]

is also based on agriculture, with rice cultivation in top [2]. Table 1 shows the general information about the conditions of the rice cultivation in Gilan province.

Most of the under cultivation area of local varieties in Gilan are of two long grain good qualities including Hashemi and Ali Kazemi and Khazar variety is also among the most productive varieties that are cultivated. On the basis of offered statistics by Gilan province's agriculture organization the mean per capita ownership for each Gilanian rice farmer family amounts about 0.8 hectare. Some of the reasons for exploitation units to be small in area in Gilan province are as follows: the rice's being as a monoculture product as a dominant farming and worker-demand nature of this farming in traditional way of cultivation, smallness of the whole area of the province and farming lands being centered mostly at plain parts which constitute only 25 percent of the whole lands of the province and dividing the agricultural lands among the heirs after the death of the head of the beneficial family.

Due to the smallness of the farms and lack of other income sources for farmers, acceptance of modern agricultural varieties and technologies takes place in a very slow manner. Strong dependence of the farmers on income from rice cultivation as the only way of making a living causes farmers to sow variations in whose cultivation they have earned some experiences and not to accept the new and productive ones. The above problem beside the attempt from the side of government to reduce the import of rice and executing the self-sufficiency pattern in rice production reveals the necessity for applying new agricultural technologies on the way of increasing the performance and improving the living conditions of the farmers. During the recent years ministry of Jahad-Keshavarzi, by executing some plans including integration of rice farming lands, increasing the mechanization performance, education and propagation, reducing the wastes and improving the farm management and introducing the productive varieties is to realize the self-sufficiency in rice production. One of the most important plans of the above said institution is to develop and propagate the hybrid variety to gain the considered goal. Taking the advantages of the technology of hybrid production has come due to the fifteen years of research by the country's researchers. Hybrid variety is one of the productive varieties of rice that, regarding its heterocyst properties enjoys more performance than other productive varieties of rice such as Khazar, Sepidrood and Darfak. On the basis of studies taken place, the amount of performance in this variety is 30 percent more than that of other productive varieties, so that the average performance of this variety has been reported 9000 kilogram per hectare. Hybrid variety is generally more resistant against fungous diseases such as blast, brown stain on the grain and decay in curb than other local varieties of rice. Applying nitrogen, phosphorus, potassium fertilizers in this variety is more than that of other local varieties and the need for fertilizer in this variety for nitrogen, phosphorus and potassium fertilizers are 250, 100 and 300 kilograms per hectare. In agricultural year of 2006-2007 this variety was widely cultivated for the first time on the farms of Gilan province. Emphasis on development of hybrid rice cultivation is due to the point that in case of allocating 200 thousand hectares out of 600 thousand existing hectares of under cultivation area of Iran to this variety, the country becomes a self-efficiency one regarding the rice product[2].

Rare sources and production factors together with growth in population number of the societies have led to use and allocate the efficiency of limiting production source at any time. Limitations in production factors can be improved due to the good management and basic planning. Thus, regarding the importance of rice production in order for providing the food requirements of the society, optimized exploitation of the production source in the production system of this product are widely needed and necessary. So, in the present study, using the Tornqvist-Tiel index, total factor productivity of three varieties of long grain good quality, long grain productive and hybrid rice has been studied and compared.

Productivity measurement provides a key indicator of the performance of an agricultural activities, comparisons across firms and finally to help policy makers to design optimal policies to enhance productivity. As mentioned by Ahearn *et al*. [3], most popular method of productivity measurement is the index number approach. In USA major estimates of agricultural productivity use an index number approach. Several studies are done about TFP using Index Number in different economic sectors. Piesse *et al*. [4] investigated agriculture sector productivity and it's convergence in Botswana. They indicated that the productivity growth in livestock husbandry regions is more than other region. In other hand, productivity growth in forgoing regions is derived from technological improvement. Chapman and *et al*. developed a technique to map spatial patterns in productivity growth in Australia. They emphasized that identifying regional variation and then understanding the factors that are likely to have contributed to its creation, could predict future agriculture land use and production potential [5]. Salim [6] measures productive efficiency of firms in Bangladesh food manufacturing. Other studies revealed that wide variations in efficiency across firms attributable to firms' heterogeneity and there is ample scope for increasing efficiency from the given resources and technology [7]. Simeon *et al*. [1] investigate gender productivity on crop production in Ethiopia, using Tornqvist-Tiel index. Results imply that the variation in overall TFP can only arise due to differential in access to the quality of human and physical resources and services and differential control of the benefits from output by women versus men [6]. Other studies are assessed the total and partial factor productivity by using of parametric and non-parametric methods [8,9]. Concerning the productivity and the proficiency of using the sources, Hossain [10] performed a study in Bangladesh. The required information was gathered in 1981-1982 through interviewing with 2400 farmers in 133 villages and by using this information and applying Cub-Douglas production function, the effects of growth in applying modern technology on factor productivity were identified. On the basis of the results, the sum of elasticity of production factors for land and labor force was calculated as 1. The land's production elasticity for new variations was greater than that of local ones and vice versa concerning the labor force. On the whole, the effect of new technology on increasing productivity of the labor force was less. So, development of new technology influenced on the effective supply of the land by reducing the cultivation of the land in comparison with the whole land in aridity season and increased the marginal production of the land but this had not more effect on marginal production of the labor force and this is because of the fewness of the expenses for family labor force occasions. Using the chemical fertilizers on farms in which the modern technology is used is more effective than that of traditional lands [11]. Seiiedan [9] analyzed factor productivity in case of sugar beet cultivation. Results from his studies showed that the number of irrigation times in sample units were very close to economical optimize and using the labor force and animal fertilizer is more than that of the economical optimize. Also, 76.1 percent of the farmers are to use the land at the third phase of the production function. Comparing the small and large farmers also shows that exploiters who have more under cultivation area use the production inputs in a very good manner. In this group, only phosphorus fertilizer input is used more than the optimized amount so that final productivity of this factor in 67.7% of the samples is negative.

According to the essentiality of mentioned matters, this study is arranged for comparison TFP of some varieties of rice include long grain good quality, long grain high yielding and hybrid in Gilan province at 2006-2007, then with comparison of TFP for different studied varieties, productive variety are identified. In other hand, by calculating partial factor productivity in studied farms, increasing of productivity condition using productive cultivation model and farm management approach are provided.

MATERIALS AND METHODS

In order to gather the required data in this study, information related to 542 farms in sixteen regions of Gilan province during the agricultural year 2006-2007 was

studied. Cultivated varieties in these farms include long grain good quality, long grain high yielding and hybrid varieties. After information gathering about farms and grouping the farms into three groups on the basis of the variety, total factor productivity was calculated using the Tornqvist-Tiel Index. The number of under study sample includes: 477 exploiter of long grain good quality variety, 15 exploiter of long grain high yielding variety and 50 exploiter of hybrid variety. Required information including the amount of paddy production, the amount of consuming the inputs and expense of consuming the input was gained through filling the questionnaire and in presence interviewing with farmers.

According to production supply theories, production growth in a sector or an economical corporation is possible through two ways. The one is production increasing through applying more productive factors and inputs in the frame of existing technology; and the other is gaining access to more production by applying modern and working production methods and using new technology in the frame of existing inputs. Regarding the limitations in sources and productive inputs growth in production is not possible in long term by using more production factors. Thus, in order for increasing the production, necessary steps should be taken for applying new production technologies and production working methods and improving and developing the productivity for taking the advantages of production factors. If production factors and productive capacities are not used in sectors and economical agencies in their optimized ways, this can have unwanted effects on income and profitability of the economical unit and if this is continued, it can change active units into inactive ones, waste the sources and reduce the production. Quantitative analysis of productivity and effective factors on it can be beneficial for planners and authorities to increase production and reach the potential production level by improving productivity and using production factors in their optimized manners.

Productivity is defined as the amount of output produced from a certain amount of one or more inputs. Productivity is classified into two categories of total productivity and partial productivity. Partial productivity is the ratio of produced output in a productive unit to an input. Partial productivity index cannot separate the substitutional effects of inputs from the effects of technology and technical proficiency. Therefore, this index cannot offer a good estimation about the advancement in technology in production unit [4,7]. But total factor productivity includes all of the produced outputs and used inputs in production unit. Total Factor Productivity, the productivity of all purchased inputs, is the broadest measure of productivity and is clearly the most useful approach to productivity measurement when the objective is to understand the effects of technological change [12]. Productivity growth in a productive unit is calculated by dividing the growth rate of the output into the growth rate of the input during two periods of time and/or between the two productive units. The growth rate of partial productivity can be due to the growth rate in an omitted input, therefore, it cannot be considered as a good guide. For this reason, in measuring the amount of growth in productivity, total factor productivity should be considered. In this way all of the input will simultaneously and together be considered. Therefore productivity changing from one period to other period or existing gap in firms' productivities in one period addresses the differences in technical affordability, management levels, organization structure, section and ultra section relations and even natural and environment effects of that firm, section or economy of inputs conversion to goods and services[13].

In literature, productivity is measured in two ways. These two ways are: parametric way of measurement (econometrics) and non-parametric way of measurement. In parametric method, at first production function or expense function is estimated and entered into the estimates model of variable on behalf of technology. The way variable of technology effects on the amount of production, can express changes in productivity or advancement in technology. In non-parametric way of measurement for calculating total factor productivity index, different indexes can be used to calculate the partial productivity of production factor and total factor productivity using the index number. In doing so, using one of the forms of the index, an index of output and also of inputs is built and on its basis, productivity index is calculated. Laspeyers and Paashe Indexes are among the forms that are used in calculating the productivity index. Laspeyers and Paashe Index form is in agreement with linear production function and Paashe Index is in agreement with Leontif production function and consequently, they bear unwanted characteristics of these functions with themselves. Fisher index is another ideal index. This index offers both linear function characteristics and Leontif function characteristics. The best index form to calculate the total factor productivity index is Tornqvist-Tiel Index. This index is in agreement with characteristics of Translog production function and this form is a function of flexible forms and bears the

logical characteristics of production world. As outlined in Lawrence and McKay [13], this index is based on a homogenous production function which provides a second-order approximation to an arbitrary production function at any given point [13]. Mathematical form of Tornqvist-Tiel quantitative output index has been offered as follows [6]:

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

Q_T is output quantitative index, P^t and P^o are the prices of product in production unit t and source production unit, R_i^t and R_i^0 are income shares of the i^{th} product in production unit t and source production unit. Income share of the product is calculated as follows [14]:

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

Tornqvist-Tiel quantitative output index is calculated as follows [14]:

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

X_t is quantitative index of input, w^t and w^o are the price of input in production unit t and source production unit, X_i^t and X_i^0 are the amount of input usage in production unit t and source production unit, S_i^t and S_i^0 are expense share of the i^{th} input in production unit t and source production unit. The share of input expense is also calculated as follows [14]:

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

Total factor productivity index is calculated by dividing total output index into total input index. If Tornqvist-Tiel index form is the applied index form in summing inputs and outputs, then total factor productivity index will also be called Tornqvist-Tiel total factor productivity index and this index is expressed as follows [14]:

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

How we can aggregate heterogeneous inputs and outputs, is the most important aspect in using Index Number for calculating TFP. Tornqvist-Tiel is discontinuous approximation of Divisia index and is adopted by Translog production function. Forgoing properties are made this index as superior index. Accrediting to the forgoing text, in this study, we use Tornqvist-Tiel index mathematical form for measuring of total input and output indices.

RESULTS AND DISCUSSION

Consumed inputs were classified into six groups of labor force in terms of individual-day, under cultivation area in terms of hectare, usage amount of chemical fertilizer in terms of kilogram, work-time hours for machinery, usage amount of pesticides in terms of liters and seed usage amount in terms of kilogram. Statistical results of the information gained from the amount of producing paddy rice of under study varieties are shown in Table 2.

Regarding the obtained results in Table 2, the average performance per hectare for hybrid variety is the highest amount in comparison with those of two other varieties and this shows that due to hybrid cultivation, in average, 6649 kilograms paddy are obtained in understudy sample. Performance standard deviation per hectare among exploiters shows that exploiters using hybrid variety experience more fluctuations in production than those who use other varieties and this shows the difference among producers of this variety and the difference is due to lack of enough knowledge about the way of cultivation with this variety. Results obtained in understudy sample shows that due to the right education for exploiters production performance per hectare can be reach its highest amount i.e. 8570 kilogram per hectare. The average usage amount of inputs that are used in producing different understudy varieties is shown in Table 3.

Hybrid variety has allocated the least under cultivation area to itself. Long grain good quality variety bears the most under cultivation area. In average, seed used in hybrid variety, in comparison with two other

Table 2: Yield characteristics of sample farms

Description	Long grain good quality	long grain high yielding	Hybrid
Mean	3813.6	5236.9	6649.0
Minimum	1666.6	4500.0	4750.0
Maximum	5900.0	5846.0	8571.4
Standard Error	428.9	465.2	1212.0

Table 3: Mean usage of inputs in investigated farms

Description	Acreages (m^2)	Labor (individual-day)	Machines (work hours)	Seed (kg)	Chemical Fertilizer (kg)	Chemical Pesticides (lit)
Long grain good quality	10518	77.5	18.8	187.8	269.4	3.50
long grain high yielding	4200	32.9	8.7	46.2	46.2	1.78
Hybrid	2555	34.5	5.1	6.3	167.0	2.92

Table 4: Inputs cost shares in producing mentioned varieties (percentages)

Description	Labour	Land	Machines	Chemical fertilizer	Chemical Pesticides	Seed
Long grain good quality	40.0	38.5	12.6	0.7	0.3	7.2
long grain high yielding	43.5	38.0	13.3	1.1	0.4	3.8
Hybrid	33.7	52.5	10.4	0.8	0.8	1.8

Table 5: Output index (percentages)

Description	Long grain good quality	Long grain high yielding	Hybrid
Mean	1.00	1.00	1.00
Minimum	0.11	0.24	0.05
Maximum	6.35	3.38	3.30
Standard Error	1.25	0.70	1.07

Resource: Research findings

varieties, has allocated the least usage amount to itself and in case of long grain good quality one it has allocated the most usage amount to itself. By studying usage and expense amount of inputs in producing the yield, the usage position of inputs in production can be understood. Total expense for paddy producing came from the filled questionnaires and then, using the total expense of production, expense share of each group of inputs was calculated. Table 4 shows the percentage share of using the inputs.

Among the three understudy varieties, labor force in hybrid variety with expense average share of 33.7, bears the least expense amount. Expense share of the used seed in case of long grain good quality variety is 7.2% and this is the highest share among the understudy varieties and the share of seed expense in hybrid variety is 1.8% that has allocated the least share to itself.

Regarding the advantages of Tornqvist-Tiel Index and its wide usage in productivity analysis, using this index, total factor productivity among the producers of three varieties of rice was calculated. In this study the average number of producers constitutes the source production unit and this has been used as a source and basis in calculating the index. At first, partial factor productivity was calculated. In order to calculate the partial productivity index for each input group, at first, using the equation 4 concerning the input group share of the total expense Tornqvist-Tiel Index in that input group was calculated and then, using the relation 3, input index was calculated. After calculating the output index, partial productivity index of each input group has come from dividing the output index into the considered input group index. Table 5 shows the amount of index of understudy varieties of the output. Table 6 shows the summary for statistical results of Tornqvist-Tiel Index for partial productivity of input groups.

Results show that in average, hybrid variety bears the highest partial productivity index in all of the input groups and the other two varieties bear similar productivity index. Average partial productivity for labor force of hybrid variety is 1.022. The average amount of partial productivity of seed in hybrid variety is 1.016 and

Table 6: Partial productivity index of inputs (percentages)

Long grain good quality	Description	Labour	Land	Machines	Chemical fertilizer	Chemical Pesticides	Seed
	Mean	0.999	0.995	1.021	1.124	1.103	0.995
	Minimum	0.465	0.435	0.469	0.217	0.256	0.435
	Maximum	1.882	1.539	2.595	5.778	14.147	1.539
	Standard Error	0.233	0.106	0.241	0.557	0.750	0.106
long grain high yielding	Mean	0.960	0.982	1.010	1.008	1.146	0.982
	Minimum	0.686	0.843	0.699	0.496	0.630	0.843
	Maximum	1.403	1.095	1.478	1.810	1.829	1.095
	Standard Error	0.212	0.081	0.186	0.393	0.340	0.081
Hybrid	Mean	1.022	1.022	1.021	1.043	3.015	1.016
	Minimum	0.731	0.731	0.731	0.753	0.125	0.490
	Maximum	1.318	1.318	1.318	1.355	6.781	2.837
	Standard Error	0.181	0.181	0.181	0.179	1.998	0.431

Table 7: Total Factor Productivity index (percentages)

Description	Long grain good quality	Long grain high yielding	Hybrid
Mean	0.962	0.927	1.052
Minimum	0.464	0.748	0.766
Maximum	1.613	1.217	1.404
Standard Error	0.132	0.125	0.188

Resource: Research findings

this amount of partial productivity is the highest amount of seed productivity in comparison with other varieties. The highest amount of partial productivity index of seed input in hybrid variety is 2.837. The average amount of partial productivity index of consumed seed input in long grain high quality variety is 0.99. The highest amount of partial productivity index of seed input in long grain high quality variety is 1.095 and as Table 5 shows the highest partial productivity index of consumed seed input in long grain high quality variety is less than that of this index in hybrid variety.

Partial productivity index cannot separate the substitutional effects of inputs and the effect of technology and technical proficiency from each other; therefore, the above said index cannot offer a right estimation about the technology advancement in production unit. Consequently, regarding the existing defect in partial productivity index and applying different rice varieties in understudy sample as different under use technology among the exploiters, in order to compare these three kinds of seed technology, total facto productivity index should be used. Total productivity index of the input was calculated using the Tornqvist-Tiel Index and then, using the relation 5, total factor productivity index was calculated. Table 7 shows the summary of statistical results in three kinds of understudy varieties.

Results show that in average, hybrid variety bears the highest amount of total factor variety and the long grain good quality variety bears the least amount of total factor productivity. Total factor productivity index in hybrid variety is 1.052 in average, while total factor productivity index in long grain high quality variety is in average 0.962. The highest amount of total factor productivity index in hybrid variety is 1.404 and this means that the said variety bears production potential and optimized use of consumed inputs in comparison with other varieties. Average deviation of total factor productivity index in two kinds of long grain good quality and long grain high yielding varieties are 0.132 and 0.125, respectively, which shows a similar standard deviation among the understudy samples. Average standard deviation of total factor productivity index in hybrid variety is 0.188. The amount of standard deviation in this study shows that paddy farmers who cultivate long grain high quality and long grain high yielding varieties bear the experience of cultivating these varieties but hybrid variety bears more standard deviation among the paddy farmers and this, shows that hybrid variety exploiters bear no scientific and experimental knowledge about the cultivating method of and working with this variety and due to right education standard deviation among the producers can be reduced and in this case, advancement towards the highest amount of production concerning this variety will be possible.

CONCLUSION

Results from partial productivity index and total factor productivity show that hybrid variety, because of its productivity, is the best kind of rice variety, so that in average performance of hybrid variety in understudy samples is 6649 kilograms per hectare and due to the right education, the farmers will be able to improve it to 8571.42 kilograms per hectare. Partial productivity index of inputs in hybrid variety bears the highest productivity amount in average in comparison with long grain good quality and long grain high yielding varieties. Total factor productivity index shows that in comparison with other varieties, hybrid variety enjoys more productivity and also in production, the said variety inputs have been used more effectively. Due to the education and optimized management for the purpose of using inputs, total factor productivity can be increase to 1.4 % in hybrid variety. Taking the obtained results into account, hybrid variety is the best kind of productive variety that bears the highest performance and productivity and consequently, the highest amount of profitability among the three kinds of understudy varieties. Due to offering the right education concerning the plantation and consuming the inputs, performance and productivity amount of this variety can be reached its highest amount.

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