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Determining the Best Variety of Rice for Cultivation Using Kataoka's and Telser's Risky-linear Programming Methods-Case Study of Gilan Province 2000-2006

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ABSTRACT

Gilan Province is among the most important regions of Iran for rice production. The general aim of this research is to determine the best variety of rice for planting, so that the minimum level for farmer's expected living gross margin can be provided. On the other hand, determining the best variety with regard to the risk in price is another aim of this research. To this end two risk models based on Telser and Kataoka linear programming were used. Data needed for seven understudy varieties in this research during 2000-2006 were connected from 7 representative farms at the Gilan Province level. Taking the related risk-rows to gross margin per hectare of the 7 varieties under study during the aforesaid years, and using the Kataoka model, the highest amount of living gross margin per hectare at different probability levels was calculated. On the other hand, through the Telser model the area under planting of optimized varieties over different probability levels, showing that the probability of the gross margin per hectare of rice farming is less than the highest amount of living gross margin, was calculated. The results showed that at different levels the gross margin of the aim, considering the probability constraints, the two items Hashemi and Ali Kazemi were the best ones for achieving the aforesaid goals.

Keywords: Gilan province, Kataoka model, Rice, Safety-First conditions, Telser model.

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INTRODUCTION

Rice stands in third place after wheat and tomato among the mostly used agricultural products in our country, and its use has been considerably increased since 1995. The main region for rice cultivation is Southeast Asia. Paddy fields originated in India and Burma and, little by little, found their way to other parts of the world. Nowadays, rice planting has become an integral part of millions of people's lives all over the world. At the present time, 90% of the world's rice is produced in China, India, Japan, Korea, and Southeast Asia. According to the latest statistics from FAO in 2005 the area of rice planted lands around the world was about 151 million hectares. India and China with 74 million hectares have allocated about 50% of the world's rice planting to themselves. This product provides more than a half of food materials for people living in hot and semi-hot places. It also provides more than 80% of calories and 75% of protein for people living in Asia (Food and Agriculture Organization, 2005).

Together with India, Korea, China, Taiwan, and, Thailand, Iran is one of the main producers of this crop in Asia. Average annual consumption of rice in the world amounts to 80-90 kilograms per year, while this amount in Iran is 25-45 kilograms per year. Considered as a main source for supplying food, this crop stands in second place after wheat in Iran and, because of the

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increase in the size of population and rapid growth in annual consumption, limitations of acreages on which rice could be planted, Iran's geographical position in a semi-desert region and non-mechanized farms, imports of rice has increased considerably in comparison with the last years. The greatest amount of rice cultivation in Iran has been in the three northern provinces of including Gilan, Mazandaran, and Golestan, so that 71% of lands under rice cultivation belong to these three provinces. Variety in local items and their improved varieties is very great and all items have been classified into six groups. Gilan Province, with more than 35% production and 42% acreages of Iran's paddy-rice. In this province more than 300,000 farmers in areas with more than 240,000 hectares of productive and favorable lands are busy with rice cultivation. Indeed, rice cultivation is the most important agricultural activity in this province; the economy of the province is also based on agriculture, with rice production at the top. The largest area of lands under cultivation among different rice varieties belongs to the two local varieties of Hashemi and Ali Kazemi and, among productive varieties, the Khazar variety has also allocated most land under cultivation for itself. According to the statistics provided by the Ministry of Jihad-e-Agriculture the annual ownership for each rice-farmer family in Gilan is about 0.8 hectares (Ministry of Jihad-e-Agriculture, 2006). The reasons why the area of exploitation units in Gilan Province is small, are as follows: rice being available as a single predominant crop, the labour-intensive nature of the cultivation in traditional working and cultivation methods, small size of the whole area of the province, intensive concentration of agricultural lands in plain regions that form 25% of the whole agricultural lands of the province, and division of the agricultural lands among heirs after the death of the guardian of the exploiter family. Because of the restricted size of the lands and lack of other revenue sources for farmers, admission of new varieties and agricultural technologies takes place at a very low level. Being highly dependent on revenue from rice cultivation as a sole means for living, farmers have to take the Safety-First conditions and price risk into account. In this research, using the Kataoka and Telser risk programming models and taking into consideration the Safety-First conditions for realizing the expected gross margin per hectare for each farmer as well as the price risk, the most suitable rice variety for rice cultivation – so that all of the aforesaid aims can be achieved – is proposed. Many studies have taken place to analyze the decisions made by farmers regarding risk (Torkamani, 1996; Tauer, 1983; Rudel, 2000; Adesina and Ouattara, 2002). On the other hand, using Safety-First models in most studies to describe the farmers' behaviors have been of more use (Patrick *et al*., 1985; Roy, 1952; Atwood *et al*., 1988).

In this research, using the linear form of lower partial moment inequality in the risk models of Telser and Kataoka, the Safety-First conditions in the case of these models were taken into account. Furthermore using the amounts of the gross margin per hectare for each one of the aforesaid under-study varieties during 2000-2006 as a risk limitation, the price risk was also considered in selecting the optimized variety of rice for being cultivated. The goal of the present study was to determine the best varieties of rice for cultivation taking into consideration price risk during 2000-2006 and taking account of Safety-First conditions.

MATERIALS AND METHODS

In order to collect the required information and data for this research, information about 104 farms in 16 divisions of Gilan Province during 2000-2006 were studied. Cultivated varieties in these farms during the aforesaid years included the local varieties of Hashemi, Hassani, Ali Kazemi, Tarom, Binam, and productive varieties of Khazar and Sepidrood. Since attention is paid to the

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selection of the optimal variety regarding the price risk, 7 farms which were experiencing lower fluctuation of production and used a standard pattern of cultivation during 2000-2006 were selected as representative farms. Computing the gross margin per hectare for these farms using the price for wholesale trade of the varieties under study took place during the period after harvesting, during which many farmers have sold their products. For calculating the gross margin of all the farms under study in each year, the total revenues of rice cultivation less the variable costs include labour, pesticides, fertilizers and water costs was used.

Safety-First models have long been used as models for decision making under uncertainty conditions. Using the two Telser and Kataoka models, this research introduces the most suitable rice varieties to realize the preset aims. In this research, the selection of the optimized varieties regarding the risk rows, which include the gross margin per hectare for each one of the varieties under study during 2000-2006 and realization of the revenue goals of the farmer, has been accomplished. The expected gross margin in the Telser model, regarding the rows of gross margin risk per hectare of each variety during the years under study and with the limitation of Safety-First conditions, reaches its highest point and maximum amount. In the Kataoka model, the rate of gross margin per hectare is determined at a maximum amount as g in which the probability of the gross margin declining per hectare and reaching to the amount lower than g, is less than the previously determined probabilities. Both the Telser and Kataoka models include probability constraints for considering the Safety-First conditions in the following form:

$$Pr(Z \prec g) \leq 1/L^{*} \qquad (1$$

In which $\Pr(Z \prec g)$ is the occurrence probability of $Z \prec g$. Z and g are random variables of the gross margin per hectare and the gross margin per hectare of the goal, respectively. $1/L^{*}$ is the upper limit for $\Pr(Z \prec g)$.

Regarding the suppositions of the model, different methods may be used to enter the Safety-First conditions or probability constraints. In Constrained-Chance programming a common way is to change the probability constraints into a given limitation (Charnes and Cooper, 1959). Another method requires the supposition that the E-V series is in multi-normal form and the ability to design them so that they are more effective than the responses. Pyle and Turnovsky have taken the advantages of this way of calculation to compare the results from the two methods of expected maximum desirability and Safety-First (Pyle and Turnovsky, 1970). The third way is the imposition of a probability constraint using probable inequality. For the first time, Berk and Hihn used the non-linear form of lower partial moment inequality (Berk and Hihn, 1982). Creating the conservative confidence interval is one of the difficulties of using the aforesaid non-linear form. Atwood presented a special form of Chebychev linear inequalities that created a lower confidence interval (Atwood, 1985). This inequality has continuous distribution in which the lower partial moment has been used. In the present research, this probable inequality has been applied to consider the Safety-First conditions in the two risky models of Telser and Kataoka. Lower partial moment is defined as follows:

$$R(a,t) = \sum (t - z_i)^{a} f_i \qquad (2$$

In which R(a,t) is lower partial moment. t in R(a,t) is the amount of gross margin in a hectare where the deviations are measured at a level lower than it, and z_i is the representative of z (expected gross margin) when the i^{th} step occurs. a (a>0) is the power which- regarding it - deviations lower than t are created, and in f_i it is the amount of probability that - regarding it – i occurs. In order to enter the probable inequality into the linear planning model the following relation can be used:

$$Pr(Z \leq t - pQ(a,t)) \leq (1/p)^{a} \qquad (3$$

In the above formula $Q(a,t) = \left[R(a,t)\right]^{1/a}$ and its amount is always greater than zero. p is also a constant and positive amount. If p is defined as *P= (t-g)/Q(a,t)*, and if t>f, then equation 3 can be expressed as follows:

$$Pr(Z \leq g) = Pr(Z \leq t - pQ(a,t)) \leq \left[Q(a,t)/(t-g)\right]^{a} \quad (4$$

In order to use the above probable inequality in a linear planning model, a must be assumed equal to 1 hence, at the above relation, Q(t) can be used instead of *Q(1,t)* or *R(1,t):*

$$Pr(Z \leq g) = Pr(Z \leq t - pQ(t)) \leq Q(t)/(t-g) \quad (5$$

Finally, t-LQ(t)≥g is used in expected risky planning models to consider the probability constraint of the Safety-First conditions (Pr (Z<g) ($\Pr(Z \prec g) \leq 1/L^{*}$) in risky planning models. After determining the above probability constraint, Telser risky planning can be defined as follows (Atwood, 1985):

$$\begin{array}{ll} Max\ E(z)= E'yx & (6 \\ st: & \\ Ax \leq b & (6.a) \\ Yx-t= Id \geq 0 & (6.b) \\ r'd-Q(t)= 0 & (6.c) \\ t-LQ(t) \geq g & (6.d) \\ X,d \geq 0 & (6.e) \end{array}$$

In the above model E(Z) is the expected and accumulated gross margin and $E'y$ is the transpose vector of the expected gross margin for any activity and x is the vector of levels of the activities. The sequence of activities defined in risky programming models include the five local rice varieties of Hashemi, Ali Kazemi, Tarom, Binam, and Hassani, as well as the two productive varieties of Khazar and Sepidrood. A shows the matrix of technical coefficients and b shows the *RHS* amounts. In the present research land, nitrogen fertilizer, phosphor fertilizer, potassium fertilizer and labour were all treated as limitations in risky programming models. Y is the matrix of gross margin amounts for each activity in 2000-2006, t is resource level for gross margin and d is a vector with i elements that show the deviation from the level t when the gross margin per hectare is less than t and zero when the gross margin is greater than t. r′ is a transposed vector from probability levels and r′d is equal to Q(t). The (6.d) limitation also shows the probability constraint of considering the Safety-First conditions. The system of the above equations after selecting the amount of gross margin of the aim (g) and the amounts of the lower partial moment selects varieties that maximize the expected and accumulated gross margin and at the same time take account of the Safety-First conditions. In Kataoka the aim is to find the maximum amount of g. Limitations considered in this system have no differences with the Telser model, and the only probability constraint relating to Safety-First conditions changes into the form of $t - LQ(t) - g \geq 0$. Results from the Kataoka system offer the maximum amounts of gross margin of the aim regarding the limitation of price risk or matrix of amounts of gross margin of each activity during the years 2000-2006 (Y).

RESULTS

As was noted previously, by selecting the amount of gross margin per hectare of the aim and the lower partial moment amounts, the optimized levels of activities that are the amount of areas under cultivation of different rice varieties are determined by the Telser model. In this direction, the five amounts 8.4, 7.9, 7.4, 6.9, and 6.4 Million Rials were selected for the gross margin per hectare of the aim based on 2006 prices. For each amount of the gross margin three probability levels of 0.25, 0.30, and 0.35 were assumed. These probability amounts show the probability for the expected and accumulative gross margin per hectare to be less than the level of gross margin per hectare of the aim, i.e. to be less than 0.25, 0.30, or 0.35. Table 1 contains the conclusions of the Telser model. At the first step with the selection of 8.4 Million Rials

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as the gross margin per hectare of the aim and giving the numerical amount 4 to L in order to obtain the probable amount of 0.25, the areas under cultivation of optimized varieties were determined. Therefore, taking this aim into account that the amount of the gross margin per hectare of rice cultivation based on the price for the year 2006 with a 0.25 probability should not be less than 8.4 Million Rials, the varieties of Hashemi, and Ali Kazemi, were selected as optimal varieties. The amounts of areas under cultivation for the varieties of Hashemi and Ali Kazemi per hectare required in order to reach the aforesaid objective are 0.37 and 0.63 hectares, respectively. The average of the expected and accumulative gross margin per hectare using the optimized varieties in cultivation is 15.214 Million Rials. In the next step, to approach the target of not to be less than 8.4 Million Rials of expected accumulated gross margin of rice cultivation per hectare over the probability levels of 0.3 and 0.35, L is changed to 3.33 and 2.587 in order to obtain these probability levels. By replacing the new probable amounts in the model, the amount of optimized levels of activities was changed so that, at probable level 0.3, the areas under cultivation for varieties of Hashemi and Ali Kazemi per hectare required to gain the expected aim were 0.43 and 0.57 hectare, respectively. On the other hand, at this level the gross margin per hectare of the aim and selection of the probable amount 0.35, the optimized levels under cultivation for Hashemi and Ali Kazemi varieties in order to gain the aim were determined as 0.55 and 0.45, respectively. The average amount for the expected and accumulative gross margin per hectare with optimized varieties under cultivation and with the probable amounts 0.3 and 0.35 are 15.387 and 15.787 Million Rials, respectively. By changing the gross margin per hectare of the aim into 7.9 Million Rials, the previous steps will be repeated to gain the optimal levels of the activity. When the aim is expected and the accumulative gross margin per hectare resulting from rice cultivation with a probability of 0.25 of 7.9 Million Rials not to be lessened, the Hashemi and Ali Kazemi varieties were selected as optimized varieties. Levels of optimized activities are 0.53 and 0.47 hectare, respectively. The average amount of expected and accumulative gross margin per hectare with the cultivation of optimized varieties at the aforesaid probable level is equal to 15.717 Million Rials. Regarding the probable

Table 1. Results from Telser's model**.**

Gross margin goal (Million Rials)	Probability constraint 1/L	Optimal varieties		Average gross margin (Million Rials)
		Acreage Hashemi (ha)	Acreage Ali Kazemi (ha)	
8.4	0.25	0.37	0.63	15.214230
8.4	0.30	0.43	0.57	15.387350
8.4	0.35	0.55	0.45	15.787900
7.9	0.25	0.53	0.47	15.717240
7.9	0.30	0.59	0.41	15.923410
7.9	0.35	0.85	0.15	16.746020
7.4	0.25	0.64	0.36	16.064090
7.4	0.30	0.76	0.24	16.461520
7.4	0.35	1	0	17.240
6.9	0.25	0.74	0.26	16.410940
6.9	0.30	0.92	0.08	16.995820
6.9	0.35	1	0	17.240
6.4	0.25	0.85	0.15	16.757790
6.4	0.30	1	0	17.240
6.4	0.35	1	0	17.240

Source: Findings from the research.

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amounts 0.3 and 0.35 as well as 7.9 Million Rials as the gross margin of the aim, Hashemi and Ali Kazemi varieties were again selected as the optimized ones. Optimized levels of the activities in the probable amount of 0.3 is equal to 0.59 hectare for the Hashemi variety and 0.41 hectare for the Ali Kazemi one. On the other hand, by selecting the probable amount 0.35, the optimized amount of the areas under cultivation for Hashemi and Ali Kazemi varieties to gain the expected aim were determined as 0.55 and 0.45, respectively. The average amount of expected and accumulative gross margin per hectare with cultivation of optimized varieties, regarding the probable amounts 0.3 and 0.35, are 15.923 and 16.746 Million Rials, respectively. Comment on results for other levels of gross margin per hectare of the aim, concerning the rice cultivation, is also similar to the aforementioned items.

Using the Telser model, which contains a probable inequality for considering the Safety-First conditions, has allowed the farmer to choose the most suitable variety taking his life situation as well as gross margin per hectare of the aim into account and measuring a wide spectrum of rice varieties. Another model that was studied in the present research is the Kataoka system. The aim function in this model is to maximize the amounts of gross margin of the aim per hectare. In other words, after determining the probability amounts. This model offers the maximum amounts of gross margin of the aim per hectare within the feasible answer while considering the matrix of gross margin amounts for each activity during 2000-2006 that has been considered in the model. Table 2 contains results from the Kataoka model. As can be seen there is a direct relationship between the probable levels and the amount of gross margin of the aim offered by the Kataoka model, so that an increase in the amount of probability of decreasing the expected and accumulative gross margin resulting from the rice cultivation from that of the aim, the amount of gross margin of the aim offered by this model is increased. By selecting the probable amount 0.25, the gross margin of the aim per maximum hectare will be 8.428 Million Rials.

This amount was obtained when the average amount of gross margin per hectare with the cultivation of optimized varieties was 15.1739471 Million Rials and the area under cultivation of Hashemi and Ali Kazemi varieties as optimized activities were 0.36 and 0.64 hectares, respectively.

Lack of change in the levels of optimized activities and the average amount of gross margin in different probable amounts is an indication of caution in the results of this model. The case was so that by selecting the probable amount 0.45, the above mentioned amounts have not been changed, although the amount of gross margin of the aim has been increased. In other words, regarding the matrix for the amounts of gross margin of each activity during 2000-2006 for different probable amounts, Kataoka model offers the maximum gross margin of the aim per hectare.

Table 2. Results from Kataoka's model.

Maximum gross margin goal (Million Rials)	Probability constraint 1/L	Optimal varieties		Average gross margin (Million Rials)
		Acreage Hashemi (ha)	Acreage Ali Kazemi (ha)	
8.428734	0.25	0.36	0.64	15.173947
8.598858	0.30	0.36	0.64	15.173947
8.720397	0.35	0.36	0.64	15.173947
8.811494	0.40	0.36	0.64	15.173947
9.065562	0.45	0.36	0.64	15.173947

Source: Findings from the research.

CONCLUSION

Results from the models applied in this research introduced the two varieties of Hashemi and Ali Kazemi, which are among local varieties, as optimized varieties for realizing the revenual objectives of the farmer and regulating the effects of price risk. These results confirm the farmers' behavior in lack of reception regarding productive and new varieties. The case is such that 93% of farmlands in Gilan Province has been allocated for cultivation of local varieties. Meanwhile, among other local varieties, the two varieties of Hashemi and Ali Kazemi have the maximum amount of areas under cultivation. Taking the present conditions into account and on the basis of findings of the research and the available reality at Gilan Province level, decision making regarding the cultivation varieties among farmers can be optimized. Productive varieties can widely be accepted in cultivation models of the farmers only when, regarding current prices, they enjoy high revenue or are not much different from local varieties. In this way the revenual objectives of the farmers will be realized. Introducing Hybrid varieties and extending the manner of cultivating such varieties could help farmers to obtain greater profits by cultivating rice. Hybrid varieties bearing high revenue from that of current productive varieties may be an appropriate option for realizing the farmer's revenue objectives. They also can be useful in governmental planning for increasing rice production in the country.

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تعیین مناسب ترین رقم برنج با استفاده از روش‌های برنامه‌ریزی خطی ریسکی *Kataoka* و *Telser* برای کشت (مطالعه موردی: استان گیلان)

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چکیده

استان گیلان از جمله مهمترین مناطق تولید برنج کشور محسوب می‌شود. هدف کلی از این پژوهش تعیین مناسبترین رقم برنج برای کاشت می‌باشد، بنحوی که حداقل سطح سود ناخالص معیشتی مورد نظر زارع تأمین شود. از سوی دیگر تعیین این رقم با توجه به ریسک قیمتی نیز از جمله اهداف این پژوهش است. در این راستا، دو مدل برنامه‌ریزی خطی ریسکی *Telser* و *Kataoca* به کار گرفته شد. اطلاعات مورد نیاز مربوط به ۷ رقم مطالعه شده در این پژوهش طی سالهای ۱۳۷۹ تا ۱۳۸۵ از ۷ مزرعه نماینده در سطح استان گیلان جمع‌آوری شد. با استفاده از الگوی *Kataoka* ، حداکثر مقادیر سود ناخالص معیشتی در هکتار را در سطوح احتمالاتی مختلف با توجه به ردیفهای ریسک مربوط به سود ناخالص در هکتار ۷ رقم مطالعه شده، طی سالهای مذکور محاسبه شد. از سوی دیگر با به‌کارگیری الگوی *Telser* مقدار سطح زیر کشت ارقام بهینه در مقادیر مختلف احتمالاتی که نشان‌دهنده احتمال کمترشدن سود ناخالص در هکتار زراعت برنج از حداکثر مقادیر سود ناخالص معیشتی است، محاسبه شد. نتایج تحقیق نشان داد که در سطوح مختلف سود ناخالص هدف و با درنظرگرفتن محدودیتهای احتمالاتی، دو رقم هاشمی و علی کاظمی مناسبترین ارقام برای نیل به اهداف مذکور می‌باشند.

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