Paddy Rice Production Costs and Factors Affecting Paddy Rice Productivity: Case Study in Sinop Province, Turkey

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Abstract

The study was carried out to determine the paddy rice production costs in Sinop province, Turkey and the factors affecting the paddy rice yield. A face-to-face questionnaire was conducted with 164 producers determined using the proportional sampling method. Socio-economic characteristics of the producers and other characteristics of paddy rice production were analyzed with simple descriptive statistics, and production cost and profitability were determined with economic calculations. The factors affecting the paddy rice yield were determined using the Cobb-Douglas production model. The average size of paddy rice production field in Sinop province was 41.65 decares. Total cost of paddy rice production per unit area was $1,414.74. The variable costs constituted 83.74% of total production costs of the producers, while 16.26% were the fixed costs. Maintenance costs constituted 41.63% of the variable costs. The highest share in maintenance costs was fertilization (44.84%) and spraying (29.26%). The results revealed that the size of cultivation area and irrigation had a negative impact on paddy rice yield, while the age of producers and fertilization had a positive effect on yield. Determining the production cost helps small farmers to select suitable inputs to reduce their risk associated with climate change or market fluctuation. Therefore, the findings of production cost studies should be disseminated to producers through extension staff. In addition, the importance of record keeping for the production costs should be explained to the producers and the records of previous season may help the producers to be cautious about the future production costs. Extending extension services in the region may help producers adopting good agricultural practices on paddy rice production and increase the profitability.

Keywords: Production cost. Productivity. Cobb-Douglos. Rice.

1. Introduction

The word “paddy” was derived from the Malay word meaning “rice plant” derived from the Proto-Austrronesian pajay (rice in the field) (Anonymous, 2022). The paddy rice has been cultivated since the ancient times, and oryza is the Latin word for rice (Anonymous, 2022a), and sativa means cultivated (Anonymous, 2022b). Asian rice, known as ***Oryza sativa***, is the most widely used rice type and originates from Southeast Asia (Mahajan et al., 2017). The rice varieties are quite common and the rice was first grown in a field 13500-8200 years ago in the Yangtze River basin of China (Dennis, 1997). Most rice varieties are grown for product quality and yield, while some varieties are grown for special characteristics such as texture, flavor and firmness. There are four main rice categories in the world namely Indica, Japonica, aromatic and glutionous. Various researchers have reported that these varieties cannot interchange in terms of food or agricultural production (Yang et al., 2007; Yang and Hwa, 2008; Ashrafuzzaman et al., 2009).

More than half of the population in the world meets their 80% of the food calorie requirements from rice (Ben-Chendo et al., 2017). Total rice cultivated land in the world is 164.192 thousand ha and 85.55% of the rice cultivated area is located in the Asian continent (140.463.627 ha), 10.46% is in the African continent (17.174.644 ha) and the remaining rice cultivation takes place in America (5.906.725 ha), Europe (637.872 ha) and Oceania (9,296 ha) continents (FAO, 2022). The largest rice producing countries of the world are India, China, Bangladesh, Indonesia, Thailand, Vietnam, Myanmar, Nigeria, Philippines and Pakistan, respectively. Turkey is not an important paddy rice producing country in world, while, rice is one of the main grain crops produced and makes a significant contribution to the economy of the country.

Turkey is suitable for cultivation of different agricultural crops due to the appropriate climate and geographical conditions. In Turkey, which is an important producing country in many crops, 1 million tons of paddy rice was produced in a 130 thousand ha land in 2021-2022 rice growing season (Anonymous, 2022b). The highest paddy rice production in Turkey takes place in Edirne (41.2%), Samsun (15.3%), Balıkesir (13.7%), Çorum (5.9%), Sinop (2.8%), Çankırı (2.2%), Bursa (2.0%), Kırklareli (1.7%) and Tekirdağ (1.6%) provinces, respectively (TUIK, 2022). In the first 8 months of the 2021-2022 production season; Turkey imported 6846 tons of paddy rice, 113953 tons of semi/fully milled rice and 3.47 tons of brown rice, while exported 151686 tons of semi/fully milled rice. The rice was imported from

China (52.3%), India (13.0%), Uruguay (10.5%), Italy (5.7%) and other countries (18.5%) (Anonymous, 2022c). The rice production in Turkey is not at the desired level due to the effects of climate change, low fertility level of paddy rice cultivation fields, risk attitudes of farmers, small size of paddy rice cultivation areas and the personal problems of farmers. Grains (rice, wheat, corn, etc.), which are durable and profitable products compared to the other agricultural crops, are important agricultural crops in increasing the international competitiveness of the countries. Structural changes in the agricultural sector affect the production costs of cereals, which is important to reduce poverty, thereby increasing the survival of farmers and increasing international competitiveness. Therefore, determining the production costs is needed to evaluate the financial strength of farms. In addition, determining the costs for different crops can help farmers make better plans on agricultural crop production. The production costs also allow small farmers to choose suitable inputs to reduce their risk associated with climate changes or market fluctuations. This research was carried out to determine the factors affecting the paddy rice production cost and productivity of the producers in Sinop province, which is one of the intensively rice producing provinces of Turkey.

2. Literature Review

Numerous studies have been carried out in different disciplines on paddy rice cultivation in the world. Previous studies on paddy rice were examined in different categories within the scope and the purpose of this research. The literature review on paddy rice cultivation revealed that several studies have been conducted on various subjects and purposes such as increasing rice yield by adopting modern technologies and innovations (Saka et al., 2005; Singh and Varshney, 2016; Nzonzo and Mogambi, 2016; Donkor et al., 2018), economics of rice production, factors affecting yield, cost and return analysis, scale efficiencies (Coelli et al., 2002; Adhikari, 2011; Falola et al., 2013; Ohen and Ajah, 2015; Ben-Chendo et al., 2017; Zhang et al., 2019; Chanda et al., 2019; Wagan et al., 2019; Semerci, 2020; Ankrah et al., 2022), growth and yield characteristics of different rice varieties (Janaiah et al., 2006; Hussain et al., 2014), marketing and problems in rice production (Chaudhary et al., 2001; MacRae, 2011; Alamyar and Boz, 2018; Sapkota et al., 2018).

Adhikari (2011) conducted a study to evaluate the organic paddy rice economy due to the increasing interest in organic agriculture in Nepal. The researcher reported that the average yield of organic rice production (3.15 Mt/ha) was consistently higher than the

national average. Falola et al. (2013) evaluated the economic performance of young paddy rice producers in Kwara state. Gross margin invested by farmers, return to farm management and labor force, gross rate, operating rate and return to capital were determined as N53,654.16/ha, N35,053.33/ha, 0.59, 0.36 and N1.80/ha (1 USD = NI58). Chanda et al. (2017) used the benefit-cost ratio technique to cover the costs and revenues of different rice varieties (Aus, Aman and Boro) in the Sirajganj region. The researchers indicated that Australian and Aman rice varieties are more profitable than Boro rice variety. In addition, the researchers recommended the cultivation of Australian and Aman rice varieties in Bangladesh due to less risk against natural disasters such as floods and hail, environmentally friendly nature and requirement of less groundwater. Wagan et al. (2019) applied stochastic nerve analysis and data envelopment analysis to compare production efficiency estimates of rice producers in Kambar and Shahdadkot and Badin. Farmers in Kambar and Shahdadkot had high technical productivity as they use more technology and machinery than the farmers in Badin. Semerci (2020) investigated the economic aspects of paddy rice production in Çanakkale province of Turkey. The paddy rice had the highest cultivation area in the province. The average size of paddy rice production area in Çanakkale province was 14.14 ha and the yield per farm was calculated as 7.582 tons/ha. Paddy rice production cost was $2,906/ha, gross profit was $2,072.47/ha and net profit was $1,254.85/ha. Ankrah et al. (2022) investigated the factors affecting the production efficiency and technical efficiency of paddy rice producers. The researchers stated that the productivity of producers is below the production limit. The results showed that the average difference in irrigation, access to extension services, credit and vehicle ownership between some households and farm characteristics was significant, while the difference in the education level was not significant.

In addition, the studies on energy gas, greenhouse gas emissions and the cost of collecting rice straw (Van Nguyen et al., 2016), the potential use of rice husk as a bio sorbent (Chuah et al., 2005), the potential of rice industry biomass as a renewable energy source (Mofijur et al., 2019), land suitability criteria for paddy rice cultivation (Sezer and Dengiz, 2014) and physical land evaluation for paddy rice cultivation (Dengiz et al., 2010) are available in the literature.

3. Research Methodology

3.1. Context of research area

This study was carried out in Sinop province, located in the Central Black Sea Region of Turkey. The city that was always kept in the castle throughout history has the typical characteristics of a port city. Climatic characteristics of the province are intertwined and the temperature difference between seasons is not very high (Anonymous, 2022). Total land suitable for agriculture in the Sinop province is 174.117 ha, of which 81,629 ha are being cultivated. Twenty seven thousand ha of agricultural lands are allocated for fallow, 73 thousand ha for field cultivation, about 3 ha for orchards, 3 ha for vegetables and greenhouses (356 decares). In the Sinop province, 5,514 farms carry out agricultural production on a total of 22,064 ha land. The field size of most farms (2.250) ranges between 20 and 49 decares. The most intensively produced crops in Sinop province are corn (76,014.13 tons), wheat (49,599,65 tons) and paddy rice (35,943,45 tons). The most economically important crops in terms of cultivation area are wheat (18629 ha), barley (3613 ha), corn (6460 ha) and paddy rice (4230 ha) (Anonymous, 2022d).

3.2. Data, data collection and sample design

The core material of the study was the primary data obtained by face-to-face interviews with paddy rice producers in Sinop province. In addition, previous studies, reports of relevant public institutions and organizations, experiences of academics studying on similar issues, observations of researchers, data of Food and Agriculture Organization of the United Nations (FAO), Turkish Statistical Institute (TSI) and Ministry of Agriculture and Forestry (MAF) constituted the secondary data of the study.

The most appropriate data collection method to achieve the purpose of the study is the questionnaire. The questionnaire consisted of three parts, which are the social and economic characteristics of the producers, the production costs and the factors affecting the production. The questionnaires were completed in September 2020. A cross-section research method was used in the study. The number of people to be surveyed was determined using proportional sampling method (Newbold, 1995). In this context, stratified sampling technique was applied and the following equation of Yamane (2001) was used to determine the final sample size.

$$n = \frac{Np(1-p)}{(N-1)\sigma_p^2 + p(1-p)}$$

In the equation; n is the sample size; N is population size; p is the ratio pf estimation (maximum sample size 0.5); and σ_p^2 represents the rate variances. The table value should be 1.96 and have a 95% confidence interval with a 10% margin of error to obtain the maximum sample size. The characteristics of farms in the main mass were not known at the beginning of the study. Therefore, the p value was used as 0.5 to maximize the sample size, and the number of farmers to be surveyed was determined as 164.

3.3. Method of analysis

The information on social and economic characteristics of the producers and the paddy rice production activities of producers have been analyzed using the descriptive statistics (frequency, percentage, average). The alternative cost principle was used to determine the rice production cost. The variable and fixed costs were calculated independent from the paddy rice production processes.

Factors affecting the paddy rice productivity were evaluated using the Cobb-Douglas production function model. The model was adapted from the work of Shahbaz et al. (2017) and various variables were included to the model. For example, fertilizer consumption in paddy rice production is very high in Sinop province. The other inputs are family labor and paid labor. In this model, the explanatory power (R2) was expected to be low due to the fewer number of inputs affecting the paddy rice productivity. Farm structure and variability in farmer's decision may affect the paddy rice productivity. The model used in the study is as follows:

$$Y=f(X_iD_j)$$

In the model; Y is paddy rice production per unit (da) of land, X_i is vector of a quantitative variable i= 1, …, 5, D_j is vector of a qualitative variable and j refers to 2, …, 5.

The model can be written more specifically as follows:

$$\text{Log } Y = \beta_0 + \beta_1 \text{Log}X_1 + \beta_2 \text{Log}X_2 + \beta_3 \text{Log}X_3 + \beta_4 \text{Log}X_4 + \beta_5 \text{Log}X_5$$

Note: The dependent variable was calculated as described by Dube and Guveya (2014).

In the equation; X_1= total land (cultivated area), X_2= fertilizer (kg/da), X_3= irrigation (kg/da), X_4= disinfection (kg/da), and X_5= age of a farmer (year)

As indicated in the equation, 5 independent variables affect the rice yield in this study.

4. Results

4.1. Social economic characteristics

Some characteristics of the producers should be determined to better interpretate the results. Some social and economic characteristics of the paddy rice producers are given in Table 1.

Table 1: Some socio-economic characteristics of paddy rice producers

		Frequency	Percent (%)	Mean
Age				54.85
Educational Status of the Operator	Primary School	63	38.41	
	Secondary School	48	29.27	
	High School	41	25.00	
	Graduate	12	7.32	
Non-agricultural work	Yes	113	68.90	
	No	51	31.10	
Income (Gros) ($/year)	Income from Agricultural Activities			59.064,63
	Non-Agricultural Income (all salaries and other income in households)			28.174,91
Land Size (For paddy rice)	Decare			41.65

1 $ equals to 5.75 TL in September (CBRT, 2019)

The average age of producers in the study area is 55. The average age of paddy rice producers in previous studies have been reported between 44 and 47 (Coelli et al., 2002; Wagan et al., 2019). Unlike the average age of producers in Sinop province, Ankrah et al. (2022) reported that average age of producers was 40. The results revealed that 38.41% of the producers in the study area were primary school graduates. The producers have a minimum of 5 years of education. In a previous study, the education level of producers was stated as an average of 4 years (Wagan et al., 2019). The average education level of rice producers in Ghana was reported as 8 years (Ankrah et al., 2022). The ratio of producers who earn their living only from agricultural production was 31.10%, while 68.90% of them work in various jobs with insurance in addition to the agricultural production. The annual income of the producers from agricultural activities was $59,064.63 and from non-agricultural incomes was $28,174.91. The average size of paddy rice production field in the study area was 41.65. The paddy rice field size reported in previous studies was lower compared to the field size in this study (Coelli et al., 2002; Wagan et al., 2019; Ankrah et al., 2022).

The information on paddy rice production and the problems of producers faced are given in Table 2.

Table 2: Other characteristics of the paddy rice producers

		Frequency	Percent (%)
Crop rotation status	Practicing	164	100.00
	Not practicing	-	-
Status of having pollution in irrigation water	Have a pollution	145	88.41
	Don't have a pollution	19	11.59
Status of having a soil analysis	Yes	11	6.71
	No	153	93.29
The major problems of the producers	Weed management	76	46.34
	Increased costs	45	27.44
	Price policy	28	17.07
	Market problem	15	9.15

All paddy rice producers in the region apply crop rotation. Majority of producers (88.41%) stated a pollution problem in irrigation water, while a very few of the producers (6.71%) apply fertilizers based on soil analysis results (Table 2). The biggest problem faced by 46.34% of producers in paddy rice production was weed control. In addition, 27.44% of the producers stated that they had difficulties due to increased costs, and 17.07% of the producers complained from the price policy. Similarly, Falola et al. (2013) reported that the most important problems faced by young paddy rice producers are lack of capital, insufficient information on paddy rice production, low farmer price, high input cost and difficulties in transportation.

4.2. Cost of paddy rice production

Paddy production costs were calculated by considering the cost items and presented in Table 3. Total cost of paddy rice production per unit area is $1,414.74. The variable costs composed of 83.74% of total paddy rice production costs, while 16.26% of the total costs are the fixed costs.

Although varies proportionally, most of the variable costs are the maintenance costs, which composed 41.63% of the variable costs. The fertilization (44.84%) and pesticide spraying (29.26%) had the highest share in maintenance costs. Similar results have been reported in other studies conducted on investing the paddy rice production cost (Coelli et al., 2002; Mahajan et al., 2017; Semerci, 2020). Harvest (11.88%) and soil tillage (9.20%) constituted the second largest share of the variable costs. The highest ratio in the fixed costs was the field lease (55.89%), followed by other expenses (28.65%). Maintenance costs (41.63%) had the highest share in the total production costs, followed by fertilization costs.

The producers in the study area mostly use their own seeds; therefore the seed cost (0.39%) had the lowest ratio in the total costs.

Table 3: Costs of paddy rice production

Cost Items		Cost per unit area ($ / da)	Share in production cost (%)	Share in production total cost (%)
Variable Costs				
Material costs (seed)		**5.57**	**0.47**	**0.39**
Tillage cost	1. tillage	59.82	54.90	4.23
	2. tillage	49.15	45.10	3.48
Tillage cost		**108.97**	**9.20**	**7.71**
Sowing cost		**54.06**	**4.56**	**3.82**
Maintenance (da/TL)	Fertilizer	263.97	44.84	18.67
	Irrigation	152.45	25.90	10.78
	Pesticide spraying	172.24	29.26	12.18
Maintenance cost		**588.66**	**49.71**	**41.63**
Fuel		**76.57**	**6.47**	**5.41**
Harvest		**140.67**	**11.88**	**9.95**
Threshing, Cleaning and Storage		**63.15**	**5.33**	**4.47**
Transport		**54.55**	**4.61**	**3.86**
Drying		**92.06**	**7.77**	**6.51**
Variable Cost Total (A)		**1184.26**	**100.0**	**83.74**
Fixed Costs				
General Administrative Expenses (A*3%)		35,53	15.46	**2.51**
Field lease		128.48	55.89	**9.09**
Other costs		65.87	28.65	**4.66**
Total Fixed Costs (B)		**229.88**	**100.0**	**16.26**
Total Production Costs (A + B)		**1,414.14**	**-**	**100.00**

1 $ equals to 5.75 TL in September (CBRT, 2019)

The profit status of producers versus the costs of paddy rice production is given in Table 4. Average paddy rice yield of producers is 798 kg/da. The selling price of producers per kg of paddy rice is an average of $3.12 and the producers earn an average of $2,487.74 per decare paddy rice production. The producer earns $1,132.02/da in paddy rice production and the net profit is $897.00 (Table 4). Proportional profit value shows that a profit of $1.12 is gained for one dollar of production cost.

Table 4: Profitability in paddy rice production

Yield (kg/da)		798.48
Sale Price ($/kg)		3.12
Income per Decare (sales revenue) ($/da)	(A)	2,487.74
Production Cost per Decare ($/da)	(B)	1,590.74
Variable Cost Total ($/da)	(C)	**1,355.72**
Gross Profit ($/da)	(A – C)	1,132.02

Net Profit ($/da)	(A – B)	897.00
Proportional Profit	(A / B)	1.56
Net profit per kilogram ($/kg)		1.12

1 $ equals to 5.75 TL in September (CBRT, 2019)

4.3. Factors affecting the paddy rice production

The variables affecting the paddy rice yield were determined by the Cobb Douglas function. The independent variables in the model where the dependent variable was paddy yield (kg/da) were the items in the maintenance costs (fertilization, irrigation and pesticide spraying), which have the highest share in the paddy rice production cost items, the size of paddy rice cultivation area and the age of producers. The results of the model are given in Table 5.

Table 5: Factors affecting the paddy rice productivity

	β	Std. Error	p-value (Sig.)
Constant	6.745	0.409	<0.001***
Cultivation area (X_1)	-0.286	0.097	0.004**
Fertilization (X_2)	0.233	0.262	0.005**
Irrigation (X_3)	-0.156	0.163	0.040*
Pesticide Spraying (X_4)	-0.239	0.614	0.697
Age of Producers (X_5)	0.259	0.267	0.033*

Note: *, **, *** ; Significance at 5%, 1%, %0.1 level

The coefficient of determination (R^2) reveals the proportion of the variance in the dependent variable (Y) that is explained by the independent variable. The results indicated that 69% (R^2=0.69; p<0.01) of the changes in paddy rice yield can be explained by the independent variables.

The sum of the independent variables coefficients was calculated as 0.19. The sum of independent variables coefficients in Cobb-Douglas production analysis less than 1 indicates decreasing returns to the scale. This result suggested that 1% increase in the independent variables will cause a 1% decrease in the paddy rice yield.

The cultivation area, irrigation and pesticide spraying have negative impact on the paddy rice yield, while the age of producers and fertilization have a positive effect. The significant variables in terms of econometrics are cultivation area, fertilization, irrigation and the age of the producers (Table 5). Previous studies revealed that the important (P<0.01) factors in paddy rice production of farmers are amount of seed, farm size, labor, age, education level, experience of farmers and access to extension services (Falola et al., 2013). The factors affecting the rice production in Ghana were reported as education, irrigation, access to extension services, credit and vehicle ownership status (Ankrah et al., 2022).

5. Conclusion and Recommendation

In this study, social and economic characteristics of the paddy rice producers in Sinop province of Turkey, the knowledge of farmers on paddy rice production activities, production costs and the factors affecting the productivity were determined. The average age of paddy rice producers in Sinop province is 55, the producers are mostly composed of primary school graduates, and majority of them (68.90%) have a non-agricultural job in addition to the paddy rice production. The average size of paddy rice production fields in the study area is 41.65 da. All the paddy rice producers surveyed apply a crop rotation system, which is important for increasing the crop yield. Majority of the producers (88.41%) stated a pollution in the irrigation water.

The factors affecting the paddy rice productivity are the age of producers, irrigation, fertilization and the size of cultivation area. The findings revealed that one unit increase in paddy rice cultivation area will cause a 29% decrease in yield. In other words, expanding the paddy rice cultivation area may cause a decrease in yield. Large paddy irrigation pools on field surfaces complicate the control in flood irrigation. The water in large paddy pools undulates in windy weather and young plants are damaged, which cause yield losses. The small sized-pans slow down the maintenance, harvest and threshing processes in paddy rice cultivation field (Hortiturkey, 2022). Therefore, studies should be carried out to determine the optimum size of cultivation area. A significant ($p<0.05$) negative correlation was recorded between irrigation cost and paddy rice yield. Rice plant is grown under surface ponded water conditions either by continuous or intermittent irrigation. In rice irrigation, a period 10-12 days before tillering and 30-day period, which covers 20 days before flowering and 10 days after flowering are extremely important. Soil moisture should be kept at a certain level, especially in pre-harvest grain filling period. Otherwise, crop yield losses may occur due to the breakage of grains (Hortiturkey, 2022). The findings indicated a problem in irrigation; therefore, informative meetings or trainings on irrigation are needed in the region. Determining the irrigation periods and duration of irrigations specific to the regions will increase the crop yield. Fertilization cost causes a significant ($p<0.05$) positive increase in paddy yield. Each unit increase in fertilization cost may cause a 23% increase in paddy rice yield. However, fertilizers should be applied based on the soil analysis of the paddy rice field. Excess fertilization can also cause yield losses; therefore, the producers should be informed

on importance of appropriate fertilization, which is extremely important to increase crop yield.

The aforementioned factors are associated with experience, and a significant ($p<0.05$) relationship was obtained between the age of producers and the paddy rice yield. Each one year increase in the producers age may cause a 26% increase in the rice yield. The experience in agricultural activities increases with the age of producers. The results showed that the experience has a positive effect on crop productivity. For this reason, the paddy rice production with the support of experts, consultants or experienced producers will increase the crop yield.

Total cost of paddy rice production per unit area in Sinop province is $1,414.74. Most of the production costs are variable costs such as maintenance, harvesting and drying. The field lease covers a large part of the fixed costs. The producers often do not keep the records of their farm activities, therefore, the information on cost of production for different activities and the income obtained for that expense is not known. Therefore, similar studies should be carried out on a crop basis in each region and the findings should be shared with the producers. In addition, farmers should be helped and trained to organize themselves. The consumption of imported rice, which is available in the market and is cheaper compared to local rice, negatively affects the consumption of local rice. Therefore, policy interventions aiming to protect local rice production are also needed to increase the profitability of farmers.

The producers generally do not have enough information about paddy rice production activities. The results of rice productivity studies revealed that access to extension services is one of the important factors affecting the paddy rice productivity. Therefore, the knowledge and experience related to the activities carried out in paddy rice production should be shared with the farmers through the extension studies such as field days, village meetings, demonstrations, farmer courses, and individual interviews with agricultural consultants.

6. Limitations

The main limitation of this study is focusing only on one region. However, the findings of the study provide valuable information that will shed light on the researchers and experts interested in similar issues. New researches in the future can be conducted in different paddy rice production regions of Turkey using the findings of this research.

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