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RESEARCH ARTICLE

Relationships between irrigation systems, crop patterns and land sizes of farmers in coastal areas in terms of agricultural water management

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ABSTRACT

Population growth and climate change require efficient use of water resources per unit area. In this study, the relationships between irrigation systems, land sizes and crop patterns of farmers in coastal areas were determined to provide useful information for better agricultural water management. A survey study was conducted with 170 farmers determined using the stratified sampling method. The relationship between crop varieties, land sizes and irrigation methods was determined by log-linear model. The farmers were middle-aged with an average 6.5 years of education. The average land size of farmers is 62 acres. Red pepper, watermelon and corn are the most commonly grown crops in the region. The effects of crop variety*irrigation and crop variety*land size interactions were significant ($p<0.05$), while the effect of land size*irrigation was not statistically significant ($p>0.05$). The probability for the use of drip irrigation method by the farmers was 7.50 ($e^{2,015}$) times higher than the sprinkler irrigation method. Drip irrigation is both economically profitable and important for water conservation and is ideal for vegetable crops for better plant growth. Therefore, the government incentives should encourage the use of drip irrigation method by the farmers in the region.

Keywords: Agriculture; Coastal Areas; Irrigation System; LogLinear; Water Management

INTRODUCTION

Selecting the suitable crop patterns, using proper irrigation methods and understanding the crop-water-soil relationships and determining the right amount of production would contribute to the sustainability of family farms, particularly in developing countries. Determining the appropriate crop pattern in agricultural operations significantly affects the environmental and economic sustainability of farming environment. For this reason, farmers should be cautious in choosing the most suitable crop pattern to sustain agricultural production (Qureshi et al., 2018). Farmers in developing countries need a crop selection decision support system to increase income sources by providing up-to-date information on present season crop coverage, climate and soil conditions. The information helps farmers to determine the appropriate crop varieties and to make better production plans (Abacı, 2018; Managave and Kumbhar, 2020). Various research have been conducted to develop decision support systems to ultimately help farmers select the most appropriate crops and increase productivity and efficiency. Recently, a decision support system has been introduced by Prabakaran et al. (2018) to improve crop productivity and fertilizer efficiency. Similar decision support systems were developed to help farmers in different issues. For example, Nam et al. (2012) and Raman et al. (1992) developed decision support systems for drought management. The decision support system of Qureshi et al. (2018) and Salleh (2012) focused on crop selection. Agronomic decision making considering the climate change was investigated by Kadiyala et al. (2015), while Papageorgiou et al. (2011) developed a decision-making system for precision farming practices in cotton production.

Global warming and climate change reveal the importance of water conservation as well as crop production considering the productivity and profitability. Unconscious irrigation in agricultural production may cause water scarcity, which threatens significantly the sustainable agricultural production. Surface irrigation, that is the most

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commonly applied irrigation method in Türkiye, causes high water loss compared to drip and sprinkler irrigation systems. Therefore, the studies on production models, planting and irrigation systems, production support and applications for the sustainable use of water by decision makers have increased (Kaltu and Güneş, 2010).

The rapid recent economic development in Türkiye increased the water demand in agricultural production. Agricultural productivity and crop diversity need to be increased to meet the food demand of growing population. One of the most important elements of increasing productivity in agricultural production is the conservation of water resources and improvement of water use efficiency in irrigated agricultural lands. In this context, irrigation is very important, and the current inefficient water use is a significant obstacle to increase the productivity in agriculture. Insufficient coordination among irrigation association employees, farmers, and institutions; political interventions; lack of farmer and employee training; salinity and alkalinity problems; excessive use of inappropriate irrigation and agricultural practices; illegal use of irrigation wells; the use of polluted groundwater; inadequate water pricing; high levels of evaporation; and leakages from open irrigation water canals, low water use efficiency are the main issues need to be solved to conserve water resources in Türkiye (Cakmak, 2010).

Water use in agricultural crop production should be appropriately managed to solve water problem in the world and Türkiye. Application of sufficient amount of water depends on the establishment of necessary infrastructure and technology in agricultural fields. Re-use of infrastructure and technology are also important protect the environment and improve rural development. Therefore, the knowledge on soil characteristics, climatic conditions, plant species to be grown, and crop water consumption are needed in sustainable management of water resources. In addition, pressurized irrigation systems should be adopted by the farmers to improve water use efficiency (Hazneci and Kizilaslan, 2017; Guvercin ve Boz, 2003). The lack of knowledge and experience of farmers on modern irrigation systems are the major reasons for insufficient use of irrigation potential in Türkiye. The absence of research, training, and extension services result in insufficient knowledge of farmers on plant-soil-water relations in irrigated agriculture and their consequences on human and the environment. For this reason, farmers often use flood irrigation and do not take necessary precautions to prevent land structure and soil quality (Guvercin and Boz, 2003).

Farm size is another important factor affecting the crop productivity. The results of a study conducted by Chand et al. (2011) revealed that small farms in India exhibited higher yield per hectare but the productivity per capita was lower, causing higher poverty for smallholdings. Similar findings in India had been reported by Carter (1984), who also showed an inverse relationship between the farm size and the productivity. A study using the Ethiopian Rural Household Survey (Savastano and Scandizzo, 2017) indicated that the relationship between farm size and productivity varied among different farm size groups. A positive relationship was determined between very small farm groups and the productivity, while a negative relationship was recorded between medium farm size groups, and a positive relationship for the large farm size groups. Most studies reported inverse relationships between farm size and productivity, while some studies showed the opposite results. For example, a study conducted in Malawi (Dorward, 1999) indicated a positive relationship between farm size and productivity in both labour-scarce and land-scarce smallholder farming. A study conducted in Australia by Sheng and Chancellor (2019) showed a positive relationship between farm size and productivity, and the researchers reported the effect of farmer capital choice on productivity. The study revealed that the productivity was high when farmers used the self-owned capital in large farms. In contrast, the productivity was significantly low when farmers used contract services instead of self-owned capital.

The studies in different parts of the world and Türkiye emphasized that the importance of amount and quality of irrigation water in the production of high quality and efficient agricultural products. The most significant variables influencing productivity in irrigated farms using groundwater India were reported as land fragmentation, land ownership, and product diversity (Manjunatha et al., 2013). The small farms in India were more efficient due to their relatively efficient use of resources. Large size farms in India encounter land fragmentation problem more frequently compared to the small farms. Therefore, the researchers concluded that the yields of farmers using groundwater in irrigation were not related to the farm sizes. The findings of previous studies showed that this issue is related to the socio-cultural and socio-economic aspects of the country, therefore, the results may differ in a broad sense depending on the region or the place where the agricultural production are carried out. In this context, this study aimed to determine the relationships between the crop patterns, land sizes and irrigation methods chosen by the farmers in the Bafra district of Samsun province, Türkiye.

MATERIALS AND METHODS

Research area

The Bafra district and the plain are located in the northern coastal area of the Black Sea Region of Türkiye. The study area consists of 56000 ha of agricultural land along with the Kızılırmak river. The plain consists of quite fertile soils, allowing the cultivation of a large variety of vegetables and fruits as well as field crops such as wheat, maize, and rice. The Bafra plain is one of the most important delta plains in Türkiye, contributing to agricultural production and value addition not only for Samsun province but also for the entire country, especially for the Black Sea Region. The Bafra district is 45 km away from Samsun province. There are 119 villages whose residents are mostly engaged in farming activities. Total population of the district is 142,761, of which approximately 40% live in rural areas. The average age of population in rural areas is over 50 (Middle Black Sea Development Agency [MBSDA], 2018). Approximately 80% (48830.6 ha) of the total agricultural land in the plain is used in grain and other crops production. High ratio of grains in the plain is related to the extensive paddy rice cultivation along with wheat. Vegetable cultivation has a share of 13% (7572.3 ha), and the fruit cultivation takes place in 4% (2520.7 ha) of the plain. Fallow lands consists of approximately 2.5% (1500 ha) in Bafra plain. In addition to widespread paddy rice cultivation, winter vegetable production of Bafra comes to the fore in Türkiye (MBSDA, 2018).

Livestock also has an important place in the livelihood of the local people. Although paddy rice cultivation is an alternative activity to animal husbandry in the villages around the wetlands, animal husbandry is still widely practiced by the local people of the district. Nine producer unions and 13 agricultural development cooperatives are active in the district. Bafra Chamber of Agriculture [BCA], has approximately 20,000 active members of in agricultural production in the region. The number of producers registered in the Farmer Registration System in 2018 was 6,276. The land registered in the system was 34494.5 ha in 2018. The coverage area of land registered in the Farmer Registration System constitutes 51% of the total agricultural land in the region (Aydin, 2021; MBSDA, 2018).

Population and sampling

The target population of the study was all farmers active in the Bafra district. A sampling procedure was necessary to appropriate representation of the population. Therefore, the participants were determined using a stratified sampling method. The number of farmers determined using the sampling method was 170. Twenty two villages were determined in advance considering their proximity to the city center, agricultural potential, and the number of active farmers active in these villages to obtain an accurate sample size that would represent the farmer population of the district. The recommendations of the technical staff in the district directorate of the Ministry of Agriculture and Forestry helped to determine the villages. The lists of farmers in the selected villages formed the accessible population. Farm size was taken into account, and three strata were created based on the frequency distribution of farm size in the accessible population. An accurate sample size in the study was calculated using the equation 1 (Yamane, 2001).

$$n = \frac{N \Sigma N_h S_h^2}{N^2 D^2 + \Sigma N_h S_h^2}, \quad D^2 = \frac{e^2}{t^2} \tag{1}$$

In the equation: N is the number of farmers in the stratified sample, n is the sample size, S_h is the standard deviation within a stratum, D^2 is the desired variance, N_h is the number of farmers in each stratum, e is the error accepted from the mean of the accessible population, and t is the t-table value of the accepted confidence level.

The sample size was calculated as 170, assuming a 5% error from the mean and a 95% confidence level (t = 1.645). The number of farmers was proportionally distributed among the three predetermined strata, and the participants for each stratum were randomly selected. When specific respondents could not be found in the sample or refused to participate in the study, the substitute respondents were also predetermined and contacted.

Data collection

Obtaining reliable information on the farmers by removing the doubts of producers are important issues in field surveys. Farmers in Türkiye are always suspicious of public personnel due to the negative impression adopted for many years. Therefore, in order to get reliable information from the farmers, we received help from the Provincial and District Directorates personnel of the Ministry of Agriculture and Forestry to contact with the leading producers who are known and trusted by all the producers. Data were gathered using a well-structured questionnaire developed after considering the agricultural characteristics of the region as well as the findings of local and international studies. The questions were technically designed as open-ended or closed-ended. The questionnaire included two sections: the first part covered questions regarding the social and economic characteristics of farmers, and the second part included questions about farm characteristics and agricultural production practices. The findings of earlier studies carried out by of Budak et al. (2012), Boz et al. (2011), Boz and Akbay (2005), and Guvercin and Boz (2003) were explicitly utilized to prepare the questionnaire. The validity of the instrument was assessed by a panel of experts consisting of two professors, two research assistants, and two irrigation experts employed by the irrigation association. The reliability of the questionnaire was assessed by conducting a pretest procedure with

10 respondents. The questions misunderstood by the respondents were slightly changed based on the pretest results. The questionnaires obtained in the pretest period were not included in the real data analysis. The data were collected in summer 2015. The questionnaires were filled out during the farmer visits, which mostly took place in farm houses or teashops in the villages. Each questionnaire took approximately half an hour

Data analysis

Descriptive statistics (means, standard deviation, frequencies, percentages) were used to describe the socio-economic characteristics of farmers. The relationship between the crop varieties selected by the farmers for summer crops, the land sizes, and the irrigation methods was revealed using a log-linear model. Field observations of the researchers were also used to enrich the information gathered through questionnaires and to make the study more informative.

Log-linear model (LLM), also called multiway frequency analysis (MFA), is a special case of the general linear model (GLM, that includes ANOVA and regression models), which was developed to better analyze binary and categorical variables. In its most general form, the LLM is used to determine the relationships in the categorical variable set (Spicer, 2005). The LLM also deals with the relationship between categorical or grouped data, assesses all levels of possible main and interaction effects. The primary purpose of the LLM is to find the most parsimonious model, which is not significantly different from the saturated model, by comparing the saturated model with reduced models, which predict the cell frequencies in a table (Garson, 2012). The concepts of "saturated model" and "unsaturated model" differ considering the number of parameters included in the model. The saturated model includes all interaction effects between main effects, and the number of independent variables is equal to the number of cells in the contingency table. The model created by deleting some interaction effects that are insignificant in the saturated model is called the "unsaturated model" (Agresti, 2002; Koleoglu, 2018). An example of a saturated model for three-way LLM is as follows:

$$lnf_{ijk} = \lambda_0 + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB} + \lambda_{ik}^{AC} + \lambda_{jk}^{BC} + \lambda_{ijk}^{ABC} \quad (2)$$

Where; λ_0 is the constant parameter that can be also expressed as the general mean; $\lambda_i^A, \lambda_j^B, \lambda_k^C$ are the effects of i is level of category A, j is level of category B, and k is level of category C, respectively. λ_{ij}^{AB}, λ_{ik}^{AC}, λ_{jk}^{BC} refer to double and λ_{ijk}^{ABC} triple interactions.

First, the standardized estimate of each λ in the saturated model is calculated in the LLM. Then, a list including the most important effects is prepared. Finally, a hierarchical model that includes as few terms as possible and contains a list of their significant effects, is chosen. The suitability of the model obtained is tested using the chi-square test (χ^2) and likelihood-radio (LR) statistics (G^2). The goodness of fit test must be statistically insignificant (p>0.05) for the model to be used. Otherwise, additional effects are added until the model is statistically relevant (Hintze, 2007).

$$\chi^2 = 2\sum_{i,j,k} \frac{(f_{ijk} - \hat{m}_{ijk})^2}{\hat{m}_{ijk}} \quad G^2 = 2\sum_{i,j,k} f_{ijk} ln\left(\frac{f_{ijk}}{\hat{m}_{ijk}}\right) \quad (3)$$

Where; f_{ijk} is the cell frequencies, $m_{ijk} = E\left(f_{ijk}\right)$ the expected cell frequency. When the m_{ijk} is estimated using maximum likelihood, the results are shown $\hat{m}_{ijk}$. Chi-square test (χ^2) and LR statistics are distributed as a chi-square random variable, when N is large and neither of the m_{ijk} is small. If some of the m_{ijk} are small, then the chi-square approximation is still quite close. They also have n-p degrees of freedom, where n is the number cells in the table and p is the number of parameters in the model the was developed based on the m_{ijk} (Hintze, 2007).

The most suitable model in the study was determined to obtain the interactions between the crop varieties selected by the producers, land sizes and irrigation types.

$$lnf_{ijk} = \lambda_0 + \lambda_i^A + \lambda_j^B + \lambda_k^C + \lambda_{ij}^{AB} + \lambda_{ik}^{AC} \quad (4)$$

Where; λ_0 is a constant parameter, that can be also expressed as the general mean; $\lambda_i^A, \lambda_j^B, \lambda_k^C$ are the effects of i. level of summer crops, j. level of land size, k. level of irrigation types, respectively. λ_{ij}^{AB} is the interactions effects of summer crops*land size and λ_{ik}^{AC} summer crops*irrigation types. The model obtained was considered insignificant according to the results of goodness of fit criteria and the results are given in Table 1 (p>0.05). Thus, that the model was considered suitable for the estimation.

RESULTS AND DISCUSSION

Socio-economic characteristics of farmers

Socioeconomic characteristics of the farmers in the Bafra district are given in Table 2. The variables of age, education, farming experience, total operating land, and the number of parcels were used as continuous data, while the variables of income level, keeping farming records, and facing water scarcity were considered as categorical variables. The farmers were reluctant to give specific information about their amount of income, therefore, this question was not asked directly. Instead, the question was rephrased as: "If farmers of your village are divided into three income categories, as low, medium, and high, what would be your income category?

The average age of farmers who participated in the survey was 48.38 years, the average education period of farmers was 6.5 years, and the farmers had an average of 25 years of farming experience. The majority of farmers in Indonesia were between 39-46 age and had 23 years of agricultural experience (Tafarini et al., 2021). The farmers in the study area cultivated average of 62 decares of agricultural land in five different plots per year. In addition, 77.1% of the farmers were classified in the middle-income category and 5.9% of them were in the high-income category. The results shows that 65.9% of the farmers did not keep farming records regarding their farming activities, while 34.1% of the farmers kept these records. Of the total farmers, 81.2% did not suffer from water shortages, and 18.8% did.

Table 1: Goodness of fit criteria results for the model

Test	Value	df	*p*
LR	0.747	5	0.980
Pearson Chi-Square	0.651	5	0.986

Table 2: Socioeconomic characteristics of the participants

Variables	Mean	Std Dev.	Min	Max
Age (Years)	48.38	12.40	22	74
Education (Year)	6.54	2.62	5	16
Farming experience (Year)	24.83	14.11	1	60
Total operating land (da)	61.99	46.99	6	300
Number of parcels	5	4	1	25
Income level	**n**		**%**	
Low	29		17.1	
Medium	131		77.1	
High	10		5.9	
Keeping farming records				
No	112		65.9	
Yes	58		34.1	
Facing water shortages				
No	138		81.2	
Yes	32		18.8	

The results of logarithmic linear analysis

The results of logarithmic linear analysis are given in Table 3. The first part of the table examines K-direction and upper-level interactions while the second part examines only the K-directions.

When the first row (K=1) of the findings regarding K-direction and higher interactions in Table 3 is examined, the LR and the χ^2 test result of the main effects ($\lambda_i^A, \lambda_j^B, \lambda_k^C$), the effect the second-order interaction ($\lambda_{ij}^{AB}, \lambda_{ik}^{AC}, \lambda_{jk}^{BC}$), and the effect of the third-order interaction (λ_{ijk}^{ABC}) were statistically significant (p<0.05). In the second line (K=2), the LR and the χ^2 test results for the effects of the second-order interaction ($\lambda_{ij}^{AB}, \lambda_{ik}^{AC}, \lambda_{jk}^{BC}$), and the effect of the third-order interaction (λ_{ijk}^{ABC}) were statistically significant (p<0.05). In the third line (K=3), the effect of the third-order interaction (λ_{ijk}^{ABC}.) was insignificant (p>0.05).

When the K-directed interactions were examined, the main effects and second-order interaction effects were significant (p<0.05). In contrast, the effects of third-order interaction were insignificant (p>0.05), according to the LR and χ^2 test results. The results showed that the most suitable model would be the unsaturated hierarchical linear model with the main effects and second-order interaction parameters. The partial chi-square and probability values of the effects and interactions were used to evaluate the second-order interaction parameters in the examined model, which are given in Table 4.

The main effects of land size, irrigation method, and crop variety; and the second-order interactions of crop variety*irrigation method, and crop variety*land size were significant (p<0.05) (Table 4). However, the interaction effect of land size*irrigation was found to be insignificant (p>0.05). The parameter estimates of the main effects and two-way interactions were given in Table 5 where some parameters had the value of zero (0) because they were found to be unnecessary.

The main effect of cultivating red pepper (1), watermelon (2), and maize (3) in the model were statistically significant

Table 3: Summary table for three-way effect

	K	df	LR		Pearson	
			Chi-square	*p*	Chi-square	*p*
K-direction and higher interactions	1	19	188.979	<0.001	180.268	<0.001
	2	13	112.755	<0.001	124.719	<0.001
	3	4	0.660	0.956	0.544	0.969
K-direction interactions	1	6	76.224	<0.001	55.549	<0.001
	2	9	112.095	<0.001	124.175	<0.001
	3	4	0.660	0.956	0.544	0.969

LR: Likelihood Ratio K: Way df: degree of freedom; *p*: Significance

(Table 5). Red pepper production was 58.21 ($e^{4,064}$) times higher; watermelon production was 16.36 ($e^{2,795}$) times higher, and corn production was 195.78 ($e^{5,277}$) times higher than tomato production. Melon production was insignificant ($p>0.05$). The probability of using drip irrigation method (1) was statistically significant and expected to be 7.50 ($e^{2,015}$) times higher than sprinkler irrigation method (2). The probability of farming in less than 10 decares (1) was statistically significant and expected to be 16.00 ($e^{2.773}$) times higher than the probability of farming in more than 10 decares (2).

Table 4: Significance of the main effects and two-way interactions

Effect	df	Partial Chi-square	p
Crop variety*land size	4	17.089	0.002**
Crop variety*Irrigation method	4	85.694	<0.001***
Land size*Irrigation method	1	0.087	0.768
Crop variety	4	39.764	<0.001***
Land size	1	3.566	0.049*
Irrigation method	1	32.894	<0.001***

*p<0.05; **p<0.01; ***p<0.001; df: degree of freedom; *p*: Significance

The interactions between crop variety and land size indicated that the probability of producing red pepper in less than 10 decares land is 10.80 ($1/(e^{-2,380})$) times lower than the probability of producing tomatoes in less than 10 decares. The comparison of the probabilities for producing watermelon, corn, and melon in less than 10 decares land with the tomatoes revealed that the probabilities were statistically significant and 14.85 ($1/(e^{-2,698})$) times lower for watermelon, 30.78 ($1/(e^{-3,427})$) times lower for corn, and 8.42 ($1/(e^{-2,131})$) times lower for melon ($p<0,05$).

The results of second interactions between crop varieties and irrigation methods. showed that significant interaction occurred only between drip irrigation and corn production. The use of drip irrigation in corn is 87.53 (1/(e-4,472) times less and statistically significant than the probability for the use of drip irrigation in tomatoes (Table 5).

This study investigated the relationships between crop patterns, land sizes, and irrigation methods in the Bafra district of Samsun province, Türkiye. A general profile of

Table 5: Parameter estimates of the model

Examined Effects	Parameter	Coef.	SE	Z	p	%95 confidence interval	
						Lower	Upper
	Constant	-2.140	1.200	-1.783	0.075	-4.493	0.213
Crop variety	Red pepper (1)	4.064	1.234	3.294	0.001	1.646	6.482
	Watermelon (2)	2.795	1.308	2.137	0.033	0.232	5.359
	Maize (3)	5.277	1.218	4.332	<0.001	2.890	7.664
	Melon (4)	2.462	1.325	1.857	0.063	-0.136	5.059
	Tomatoes (5)	0	.	.	.	.	.
Irrigation method	Drip irrigation (1)	2.015	0.753	2.677	0.007	0.539	3.490
	Sprinkler irrigation (2)	0	.	.	.	.	.
Land size	<10 (1)	2.773	1.031	2.690	0.007	0.752	4.793
	≥10 (2)	0	.	.	.	.	.
Crop variety*Land size	11	-2.380	1.060	-2.244	0.025	-4.458	-0.301
	12	0	.	.	.	.	.
	21	-2.698	1.066	-2.531	0.011	-4.788	-0.609
	22	0	.	.	.	.	.
	31	-3.427	1.086	-3.155	0.002	-5.555	-1.298
	32	0	.	.	.	.	.
	41	-2.131	1.102	-1.933	0.053	-4.291	0.030
	42	0	.	.	.	.	.
	51	0	.	.	.	.	.
	52	0	.	.	.	.	.
Crop variety*Irrigation method	11	-0.936	0.803	-1.165	0.244	-2.511	0.639
	12	0	.	.	.	.	.
	21	0.511	0.915	0.558	0.577	-1.282	2.304
	22	0	.	.	.	.	.
	31	-4.472	0.964	-4.640	<0.001	-6.360	-2.583
	32	0	.	.	.	.	.
	41	-0.182	0.926	-0.197	0.844	-1.996	1.632
	42	0	.	.	.	.	.
	51	0	.	.	.	.	.
	52	0	.	.	.	.	.

Coef: Coefficients, SE: Standard Error; *p*: Significance farmers in the region was of a medium-aged (46-year old) male with 6.5 years of formal education. Each boy in a village is raised as a farmer, had enough farming experience. The average farm size was 62 decares and composed of five parcels, which indicated a serious land fragmentation. A farmer within the medium income category had no tendency to keep farm records for farming activities. The villages usually have sufficient water sources and appropriate irrigation infrastructure; therefore, they did not suffer water shortages. Earlier research in the region indicated that the average age of farmers was 55, the majority of farmers were elementary school graduates, and they had 37 years of farming experience (Aydin, 2021).

The results of this study showed that red pepper, watermelon, and corn were the main crops significantly produced in the region. In particular, red peppers produced in the Bafra plain stand out for their taste and quality. The most important buyers of red pepper, which is used in tomato paste and spice production, are the Southeast provinces of Turley. According to Bafra Chamber of Agriculture (BCA), the producers in the region are quite satisfied with the capia pepper production. Average yield per acre is over 3 tons, and approximately 75 thousand tons of capia pepper was harvested in 2019 and reached 112 thousand tons in 2021 (Turkish Statistical Institute [TURKSTAT], 2022).

Bafra watermelon is grown on 27 thousand decares of land and is able to find buyers even in the field before the harvest. The Bafra watermelon has a distinct aroma and flavor; therefore, consumers prefer to buy Bafra watermelon. Most of the watermelon is produced with "good agricultural practices" which is quite reasonable for farmers. Good agricultural practices have been adopted to the region both for environmental awareness to grow healthy products and receive support payments, and also obtain higher yield and ensure work security (Aydogan et al., 2019).The watermelon harvest in 2021 reached 109 thousand tons (TURKSTAT, 2022). Every day during the harvest season, 30-40 trucks leave the district and transport thousands tons of watermelon from the Bafra market to 81 provinces of Türkiye (BCA, 2019).

The third significantly cultivated crop in the region is corn, which was also proven as the most favorable crop contributing to the agricultural income of the farmers in the region (Torun, 1999; Sezer et al., 2019). A total of 14.000 decares of land was allocated to corn production for grain, and 81.000 decares for silage (TURKSTAT, 2022). The district is very popular for buffalo breeding, and dairy products of buffalo are demanded by local and national customers. Corn silage provides a nutritious diet for buffalos, and increases both the quantity and quality of milk production. In addition to local consumption, corn produced in Bafra district finds buyers from other parts of the country, and this offers further economic possibilities for the district.

CONCLUSION

Agricultural water management should be well planned to mitigate water scarcity that may be caused by climate change, population growth and environmental problems and surface (furrow) irrigation. Therefore, the information on relationship between the crop variety determined in the study area and the irrigation methods is important. The results revealed that high quality irrigation can be possible in more lands with the implementation of irrigation according to crop water requirement and the adaptation of irrigation methods that may control water consumption. In addition, the relationship between crop variety and land size is also important in the study area. Determining the crop pattern according to the land size highlights the importance of planned production. The water requirement of each crop is different, therefore, the use of same irrigation methods in the crops with higher quality will help the efficient use of soil resources.

Drip irrigation is becoming more popular in the region. Governmental subsidies and promotion programs have convinced many farmers to adopt drip irrigation which enables farmers both to obtain higher yield and to use water resources more efficiently. The size of agricultural fields to be irrigated with the same amount of water used in the furrow irrigation can be increased with the use of sprinkler and drip irrigation methods. The planning and implementation of modern irrigation techniques require a certain level of knowledge; therefore, government and policy makers need to increase their supportive practices to widespread the use of pressurized irrigation system. Agricultural production in less than 10 decares land is easy for farmers, because farmers can allocate all of the land to one crop production. Cultivation of more than one crop in smaller parcels increases farmers ability to combat with economic risks which occur in some years particularly causing dramatic falls at market prices. However, the probability of tomato production in agricultural lands larger than 10 decares in Bafra plain was higher compared to the red pepper, watermelon and maize. Tomatoes easily finds buyers for both table consumption and industrial processing as tomato paste, therefore, devoting more than 10 decares to tomato cultivation is less risky by the local farmers.

The results of study may call attention to the researchers to focus on determining the technical and economic efficiency of crops such as red pepper, watermelon, corn and tomato grown in the region. In addition, sustainable use of soil and water resources by protecting from agricultural point of view and determining the irrigation systems for the crops will also be beneficial for the future irrigation projects. In addition, a detailed examination of the factors affecting the adoption of pressurized irrigation methods in the region will provide useful information for the implementation of support and extension programs that can be developed in this regard.

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Declaration of competing interest

The authors declare no conflict of interest

Authors' contributions

Data collection and statistical analysis were carried out by Nur Ilkay Abaci. Nur Ilkay Abaci and Ismet Boz designed the research, interpreted the data and wrote the article.

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