The effects of different irrigation techniques on the cost of production of sweetcorn: sample case from Çumra District of Konya, Turkey

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Abstract

The aim of this study is to set forth the effect of a given irrigation technique on productivity and profitability, by making a cost analysis of farms producing sweetcorn via different irrigation techniques. Data of this study consists of results of the questionnaires conducted on farmers producing sweetcorn by using pivot irrigation, drip irrigation and overhead irrigation techniques. According to the survey results, the production cost of 1 kilogram of sweetcorn is 0,135 $ in overhead irrigation technique, 0,122 $ in drip irrigation technique and 0,121 $ in pivot irrigation technique. The relative profit of irrigation techniques are calculated as 0,241 $ in overhead irrigation technique, 0,266 $ in drip irrigation technique and 0,269 $ in pivot irrigation technique. In terms of relative profit, it can be said that the most profitable technique is pivot irrigation technique. Taking into consideration the geographical and topographical features, it is believed that opting for the drip irrigation technique in smaller fields and opting for pivot irrigation technique in larger fields would contribute to increase productivity and decrease costs in farms.

Keywords: Sweetcorn. Irrigation Techniques. Economic Analysis. Turkey.

1. Introduction

Water is a substance that is not substitutable, it ranks first among the indispensable matter for living beings and the demand for it is constantly increasing. Although water is being used as an input in levels of production, it is a compulsory subsidiary in agriculture (Minibaş 2008). Nowadays, as famine and scarcity are posing an ever-increasing threat all over the world, soil and water are deemed as the most important strategic resources. Due to the global warming and irresponsible use of water, there has been a shortage of water and consequent droughts, which threat life in critical dimensions. Hence, local and national courses of action are being set forth to tackle issue. In recent times, the number of precautions taken in agricultural sector, where water is intensely used, as well as the number of practices related to using different irrigation techniques are increasing. Speaking in general, sustainable agriculture requires a decrease in the rising pressure exerted by the sector over the water resources (Kaltu and Güneş 2010). Sweetcorn (Zea mays L.) is an agricultural product whose demand is constantly rising due to the expanded areas of use all over the world. Nowadays, in addition to being used directly for human nutrition, sweetcorn is also being used as a raw material in food industry and in recently established energy related industries. Sweetcorn is a plant that is widely grown in mild and tropic regions of the world (Dağdelen and Gürbüz 2008).

In recent years, the plantation of sweetcorn in irrigable fields has become widespread because of the sugar beet quota and the decreased profitability of wheat and barley production in Central Anatolia Region. In the southern and western regions of Turkey, where extensive sweetcorn plantation fields can be found, high temperatures, radiation and low humidity lead to significant water loss from soil surface and plant leaves. It is very important to provide the plants with sufficient amount of water through irrigation to ensure high productivity levels in these regions. Considering that water shortages are going to increase in future due to global warming, irrigation in sweetcorn production is getting more vital than ever in Turkey, as a country located in an arid and semi-arid climate zone (Atalık 2005). In agricultural sector, productivity is generally affected by several different factors such as irrigation, fertilizers, pesticide, seed, labour force, soil, the usage of tools and machinery as well as other factors such as product transportation, storage, marketing, input price, product price, tax, incentives, support purchases, the size of the farms, fragmented land, land ownership, organizational behaviour of the farms, social structure, training and opportunities, soil structure and climate

(Çelik 2000). Although different economic analyses for different products have been conducted in this region there have been a very limited number of studies about the effect of different irrigation techniques on the cost of production.

The aim of this study is to determine the effect of different irrigation techniques on the cost of production of sweetcorn. It is also aimed to present the effects of different irrigation techniques on cost, productivity, income and profitability of sweetcorn production.

2. Literature Review

One of the most important issues in agricultural economics is to make the economic analysis of agricultural farms. There are various sources available in literature to make such analyses and the evaluations (Kadayıfçılar and Dinçer 1972, Dinçer 1976, Açıl and Demirci 1984, Erkuş et. al. 1990, Erkuş et. al. 1995, Karagölge 1996, Oğuz and Mülayim 1997, İnan 1999, Kıral et. al. 1999, Bayramoğlu 2010, Çelik 2014, Oğuz and Bayramoğlu 2015). It is most necessary to conduct studies about water management because management of water usage, which is among the scarcest resources in the world, is the main factor that increases the input cost for agricultural farms (Kaltu and Güneş 2010, Bayramoğlu and Bozdemir 2017, Ağızan 2018). Changing climate conditions have brought forward the issues of water productivity of farms and the cost related demands of farmers (Lamaddalena 1997). Taking into consideration that the initial investment cost of pressurized irrigation systems is high, it is really crucial to be able to water the products and develop different irrigation systems. Therefore, it is necessary to address the effect of different irrigation techniques on productivity and cost (Beyribey and Balaban 1992). As our country is located in an arid and semi-arid climate zone, the importance of irrigation is even more significant. As it is well known, the most important factor that limits the growth of plants in arid and semi-arid climate zones is the lack of useful water in the root (Falkenmark and Rockström 1993, Lal 1991). Because of the extended amount of watered fields and the effective usage of water, it is expected that in future there will be more food produced and the global demand for water would increase significantly (Yudelman 1994). Even though the size of economically irrigable fields has been calculated as 8,50 million hectares in Turkey, this number could possibly rise up to 25,75 million hectares with the help of new irrigation techniques. Areas that were not irrigated in the past due to soil-topography conditions and lack of drainage are now being irrigated through certain techniques such as drip irrigation and mini-overhead

irrigation. In this sense, it has become compulsory to practice certain effective methods such as over-head irrigation, drip irrigation and pivot irrigation in order to be able to water more than 8,50 million hectares with the available water resources (Kanber et. al. 2005). A study has conducted a financial comparison of sweetcorn production through subsurface drip irrigation and centre-pivot over-head irrigation under North Kansas conditions and it has been reported that if the lifetime of the subsurface drip irrigation system is below 10 years in that region, it will be more economic to use the centre-pivot over-head irrigation technique in sweetcorn production (O'Brien et. al. 1998). In another study, fixed overhead irrigation system has been evaluated in terms of factors that have an impact on irrigation costs (Montero et. al., 2004). In a study based on cauliflower production, low cost drip irrigation, traditional drip irrigation and hand irrigation techniques have been compared. This study has concluded that traditional drip irrigation is not economical in cauliflower production, hence low cost drip irrigation and hand irrigation techniques can be used in the production process (Westarp et. al. 2004).

A study carried out in India conducted a financial comparison between drip irrigation and flood irrigation techniques in cotton farming and this study has concluded that net income per unit area of drip irrigation system is 31,2 times more than flood irrigation system (Narayanamoorthy 2008). In another study held in Pakistan, a financial comparison of various techniques such as traditional flooding irrigation, perforated pipe irrigation and drip irrigation in wheat production has been conducted (Bakhsh et. al. 2015). In a study held in Brazil, different techniques such as surface irrigation, sub-surface irrigation, drip irrigation and traditional overhead irrigation have been compared in terms of costs involved in broccoli production (Oliveira et. al. 2016). Cost analyses of some vegetables (potatoes, tomatoes, turnip and cabbage) that are grown with different irrigation techniques have also been conducted (Baranchuluun et. al. 2015).

3. Material and Methods

3.1. Material

The main material of this study consists of data collected from 30 farms in Çumra, in Konya. These farms have been producing sweetcorn by using different irrigation techniques chosen as samples. Secondary data acquired from previous studies and from different organizations have been used along with the primary data. Basic statistical analysis methods

and cost analysis were used to analyse the data. All data belong to the production season of 2019.

3.2. Sampling Method

The town of Çumra has a total of 209.063,8 hectares of usage area. This corresponds to 5,12% of the usage area of Konya, 4,21% of the usage area of TR52 region and 6,50% of the usage area of Central Anatolian Agricultural Basin. Çumra has 151.687,80 hectares of agricultural area. 133.057,40 hectares are irrigable (87,71%) and 18.640,40 hectares are terra firma (12,29%) (Anonymous, 2014). Sweetcorn production is being performed in 31% of the total irrigable area. In terms of total sweetcorn production, Konya is the second biggest province while Çumra is the biggest sweetcorn producing district in Konya (Anonymous 2018). Besides, farmers are open to innovations and they use modern irrigation techniques. 30 farms using overhead, drip and pivot irrigation techniques have been selected in the area on a voluntary basis. Farms in the research area have been examined in terms of population, education level, age and gender. Whilst calculating the available male force, the population in the farms has been taken as male labour force (MLF). Whilst converting to male labour force, coefficients that reflect labor force achievement in terms of gender and age groups have been used (Açıl and Demirci 1984). Coefficient 0,50 has been used for men and women in the age group of 7, coefficient 0,75 has been used for women between the ages of 15-49, coefficient 1,50 has been used for men between the ages of 15-49, coefficient 0,50 has been used for women over the age of 50, and coefficient 0,75 has been used for men over the age of 50.

3.3. The method used for economic analysis

In the cost accounting of agricultural products, the production expenses are divided into two categories as fixed and variable costs. Cost accounting differs according to its target and this current study has employed partial budget analysis. Partial analysis is used to define a certain part of an enterprise or the organizations performed on a certain production activity of an enterprise. When calculating production expenses, the only costs taken into consideration are the costs incurred or the production activity subjecting to the study and the costs corresponding to the same production activity from the joint costs of the whole enterprise (Oğuz and Bayramoğlu 2015). The factors that affect the variable production expenses of

sweetcorn for the farms are soil preparation, maintenance, harvest, threshing, working capital interest and the expenses of repair and maintenance of the equipment and machines. The factors that affect the fixed production expenses of sweetcorn for the farms are general management expenses, the rent of the land, interest on equipment-machine capital, amortization on equipment-machine capital, repair and maintenance expenses of the building, interest on building capital, amortization on building capital, and family labour force price. In this study, the amortization on equipment-machine for the sweetcorn production is calculated without including the amortization of tractor. And the amortization of tractor is calculated separately from all the equipment-machine capital that is used in plant production because the tractor has been used in all production levels of the farms (both animal production and plant production).

Gross profit has been calculated by subtracting the variable expenses from gross output value. It is accepted that gross profit is an important standard for assessing the competitive capacity of the productive activity and the success of the farms (Erkuş et. al. 1990). Relative profit specifies the extend of the return at the end of the season based on the expenses incurred at the beginning of the season. The analysis of the net profit is not always a good criterion for the success of the farms. Activity analyses of agricultural enterprises should take into account relative profit as an important element. Regarding the analysis of annual activity results of the farms, gross Production value (GPV), production expenses, gross profit, relative profit and net profit have been calculated and evaluated (Parlakay and Gozener, 2016; Canan and Ceyhan, 2016; Örs and Oğuz, 2019)

- The Amortization on Equipment-Machine = [(Total Equipment-Machine Capital x 10 % / Sweetcorn Production Rate (%)) / Sweetcorn Production Area]
- The amortization on tractor = [(Value of the Tractor x 10%) x (Total GPV/ Sweetcorn GPV)/ Sweetcorn Production Area]
- Interest on Equipment-Machine Capital= [(Total Equipment-Machine Value/2) x Interest Rate x Sweetcorn Production Rate (%) / Sweetcorn Production Area]
- Tractor Capital Interest Rate = [(Tractor Value/2) x Interest Rate x (Total GPV/ Sweetcorn GPV)] / Sweetcorn Production Area]
- GPV = Amount of the Product x Price of the Product
- Gross Profit = GPV – Variable Expenses

- Net Profit = GPV – Production Expenses
- Relative Profit = GPV / Variable Expenses

4. Research Findings and Discussions

Analysing the studied farms in the research area in accordance to their product types indicates that sweetcorn, sunflower, wheat, barley and sugar beet constitute 92,04% of the cultivation areas. In a study conducted in the region, it has been determined that the majority of the plant pattern is cereal, sweetcorn, sugar beet and beans (Bah 2017). Overhead irrigation techniques are being widely used in the research area. In another study, conducted in the field of research, it has been determined that 63,6% of the farms use overhead irrigation technique and 28,2% use both overhead and drip irrigation technique (Keleş and Hacıseferoğulları 2016).

Table 1: Distribution of the Farm Land in the Research Area by Production Pattern

Product	Overhead Irrigation		Drip Irrigation		Pivot Irrigation		Business Average	
	Area (da)	Rate (%)	Area (da)	Rate (%)	Area (da)	Rate (%)	Area (da)	Rate (%)
Sweetcorn	30,55	47,62	51,90	46,63	69,60	32,24	152,05	38,85
Sunflower	13,50	21,04	30,30	-	40,00	18,53	83,80	21,41
Wheat	-	-	8,30	-	40,00	18,53	48,30	12,34
Barley	11,00	17,14	10,40	9,34	21,50	9,96	42,90	10,96
Sugar Beet	7,00	10,91	7,80	7,01	18,40	8,52	33,20	8,48
Pumpkin	-	-	-	-	14,30	6,62	14,30	3,65
Bean	-	-	-	-	12,10	5,60	12,10	3,09
Hungarian	-	-	-	-	-	-	2,60	0,66
Clover	2,11	3,29	2,60	-	-	-	2,11	0,54
Total	64,16	100	111,30	100	215,90	100	391,36	100

In the research area, the land width of farms producing with overhead irrigation technique is 64,16 decares, the average land width of farms producing with drip irrigation technique is 111,30 decares, and the average land width of farms producing with pivot irrigation technique is 215,90 decares. The total average land width of the studied enterprises

is 391,36 decares. Regarding the parts where sweetcorn is produced, irrigation technique used is used overhead irrigation in 47,62%, drip irrigation in 46,63% and pivot irrigation in 32,24% (Table 1).

In the studied farms, calculated labour costs include all production processes from soil preparation to harvest of sweetcorn production only. It has been determined that the labour costs of the overhead irrigation technique are higher than other irrigation techniques. The technique with the lowest labour cost has been observed to be the pivot irrigation technique.

Table 2: Sweetcorn Production Costs in Accordance to Irrigation Techniques Used by Agricultural Farms

Cost Elements	Overhead Irrigation		Drip Irrigation		Pivot Irrigation		Business Average	
	Value ($/decare)	Rate (%)	Value ($/decare)	Rate (%)	Value ($/decare)	Rate (%)	Value ($/decare)	Rate (%)
Soil Preparation	44,36	21,3	42,43	21,93	41,91	20,96	42,9	21,39
Maintenance	69,35	33,3	55,93	28,92	49,64	24,83	58,31	29,07
Harvesting Threshing	11,01	5,29	11,01	5,69	11,01	5,51	11,01	5,49
Circulating Capital Interest	7,48	3,59	6,56	3,39	6,15	3,08	6,73	3,36
Tool Machine Repair Maintenance Costs	3,87	1,86	3,87	2	7,72	3,86	5,15	2,57
Total Changing Costs	**136,08**	**65,33**	**119,81**	**61,94**	**116,44**	**58,23**	**124,11**	**61,88**
General Administrative Expenses	4,08	1,96	3,59	1,86	3,49	1,75	3,72	1,86
Field Rent	50,7	24,34	50,7	26,21	50,7	25,35	50,7	25,28
Interest on Equipment-Machine Capital	2,31	1,11	3,54	1,83	7,05	3,53	4,3	2,14
Amortization on Equipment-Machine	4,61	2,22	7,07	3,66	14,1	7,05	8,59	4,28
Building Repair Maintenance Cost	2,23	1,07	2,23	1,16	2,23	1,12	2,23	1,11
Interest on Building Capital	0,42	0,2	0,42	0,22	0,42	0,21	0,42	0,21
Amortization on Building	0,33	0,16	0,33	0,17	0,33	0,17	0,33	0,17
Family Labor Reserve	7,52	3,61	5,74	2,97	5,2	2,6	6,15	3,07
Total Fixed Costs	**72,2**	**34,67**	**73,63**	**38,06**	**83,52**	**41,77**	**76,45**	**38,12**
Total Production Costs	**208,28**	**100**	**193,44**	**100**	**199,96**	**100**	**200,56**	**100**

Variable costs constitute 65,33% of total production costs and fixed costs constitute 34,67% in farms using overhead irrigation techniques. Variable costs in farms using drip irrigation techniques have been calculated as 61,94% and fixed costs as 38,06%. Variable costs constitute 58,23% and fixed costs constitute 41,77% of the total expenses in farms using pivot irrigation technique (Table 2).

Table 3: Sweetcorn Production Costs and Profitability in Accordance to Irrigation Systems in the Research Area

Process Production	Overhead Irrigation	Drip Irrigation	Pivot Irrigation	Business Average
Variable Costs ($)	136,080	119,811	116,437	122,206
Fixed Costs ($)	72,191	73,626	83,521	77,614
Production Costs ($/decare)	208,271	193,437	199,958	199,820
Yield (kg/decare)	1.548,680	1.591,550	1.665,630	1.601,000
Price ($/kg)	0,185	0,185	0,185	0,185
GPV ($/decare)	288,077	294,937	308,666	296,689
Gross profit ($/decare)	151,995	175,126	192,229	174,483
Net profit ($/decare)	79,804	101,500	108,708	96,869
1 kg Production Cost ($/kg)	0,135	0,122	0,121	0,124
1 kg Production Price ($/kg)	0,185	0,185	0,185	0,185
1 kg Production Net Profit ($/kg)	0,051	0,063	0,065	0,061
Relative Profits ($)	0,241	0,266	0,269	0,259

In sweetcorn production; cost varies according to GPV, net profit, gross profit and relative profit irrigation techniques. In farms using overhead irrigation technique, the cost of 1 kg of sweetcorn is $ 0,135, and 1 kg of sweetcorn net profit is $ 0,051. In farms using drip irrigation systems, the cost of 1 kg of sweetcorn is $ 0,122 and 1 kg of sweetcorn net profit is $ 0,063. Average productivity per decare has been calculated as 1.591,550 kg. It has been observed that the reasons for producers to prefer drip irrigation techniques are increased productivity, decreased irrigation costs, and savings in labour costs after the installation phase of the facility. In addition, farmers are required to use drip irrigation technique in order to benefit from the subsidy for deficiency payments in sweetcorn due to the water restrictions placed by the Ministry of Agriculture and Forestry, making it one of the factors that lead the producers to use the drip irrigation technique. In farms using pivot irrigation technique, the cost of 1 kg of sweetcorn is $ 0,121 and 1 kg of sweetcorn net profit is $ 0,065. Average productivity per decare has been calculated as 1.655,630 kg (Table 3). Pivot irrigation

technique is a less preferred system compared to other irrigation systems since the first installation cost is high. However, productivity, water savings and low labour costs make the pivot irrigation system attractive for the producers. Moreover, it has been determined that the use of pivot irrigation system has become widespread due to the fact that consolidation is completed to a large extent in the research area.

Based on net profit and relative profit outcomes, it can be said that pivot irrigation system is more profitable than other irrigation systems. The profit of the business administrators can be raised by increasing the gross proceeds or by reducing the production costs. However it is not enough for a farmer involved in agricultural production to solely think about absolute profit in his activities. He should also consider the relative profit (Oğuz and Bayramoğlu 2015). When the relative profits of the farms are examined, it is determined that the relative profits of the farms that cultivate sweetcorn with overhead irrigation system is $0,241, the relative profits of the farms that cultivate sweetcorn with drip irrigation system is $0,266, the relative profits of the farms that cultivate sweetcorn with pivot irrigation system is $0,269. Some studies have been carried out to measure the productivity, cost and profitability of different irrigation systems in sweetcorn production. Humphreys et al. (2005) have calculated the productivity per decare as 1150 kg (at 12 % moisture) in drip irrigation, 1030 kg in overhead irrigation, and 990 kg in cab legation. When comparing the subsurface drip irrigation system and the centre-pivot overhead system; centre-pivot irrigation system has been determined to be more economical in sweetcorn production if the underground drip irrigation system has a lifetime of less than 10 years (O' Brien et al. 1998). Circular and linear moving irrigation systems, which are among the irrigation systems in the region, have been determined to be more advantageous than other irrigation systems. With the spread of these irrigation systems, it is estimated that the irrigation efficiency will increase and afterwards, a number of problems such as drainage, salinity and high ground water will be possibly eliminated (Bayramoğlu and Ağızan 2018).

5. Conclusions and Recommendations

In order to compare the effects of irrigation techniques on the production cost of sweetcorn and profitability levels in agricultural farms, farms using overhead, drip and pivot irrigation techniques have been examined. It has been calculated that the variable costs in farms using overhead irrigation system are higher than farms using drip and pivot irrigation

techniques. It has been determined that the variable costs of the producers using overhead irrigation technique are higher than those using other irrigation techniques due to labour and irrigation expenses. Moreover the average productivity per decare is lower when compared to other irrigation techniques. Overhead irrigation technique is being widely used and it is seen as the traditional irrigation technique in the study area.

It has been identified that the reason for producers to use drip irrigation system is to increase productivity, decrease irrigation costs, and make savings on labour costs after the plant installation phase. In a study held in Gökhüyük, Çumra, drip, sub-tree micro overhead and cab legation techniques have been compared in an orchard consisting of apple, pear, quince, cherry, plum and peach trees, and drip or under-tree micro overhead irrigation technique has been proposed for cases where water supply is limited (Yıldırım 1994). In another research, cab legation, overhead and drip irrigation techniques have been investigated in sweetcorn production under the conditions of Central Anatolia and especially Ankara, production cost, productivity and profitability levels have been revealed and as a conclusion, profitability from sweetcorn production irrigated by drip irrigation has been found to be higher than other irrigation techniques (Kaltu and Güneş 2010). The majority of the farms using drip irrigation technique have switched to this system to benefit from the 50% grant support scheme offered by the Ministry of Agriculture and Forestry. Furthermore, as the Ministry of Agriculture and Forestry considers Çumra within the water restriction area, this system has become attractive because the difference payment premium support is granted only to the farms that use drip irrigation technique.

It has been determined that the ratio of variable costs to production costs in farms using pivot irrigation technique is lower than those using other irrigation systems, while fixed costs are higher. It has also been determined that pivot irrigation system is a less favoured system when compared to other irrigation systems since the first facility cost is high. However, productivity, water saving and lower labour costs makes the pivot irrigation technique attractive for producers. In addition, it has been determined that the usage area of pivot irrigation system has increased due to the fact that consolidation has already been completed to a large extent in the research area. It has also been determined that the Ministry of Agriculture and Forestry excludes farms using the Pivot irrigation system from the scope of premium payment support and this has a limiting effect on this system.

With regards to sweetcorn production, this study has concluded that pivot irrigation system should be used in larger areas in the region where consolidation has been largely completed, drip irrigation system should be used in smaller areas, and this study has also

revealed the importance of using water more efficiently, as climate change is felt more intensely in the world nowadays. It has been observed that drip and pivot irrigation systems have higher labour productivity and production efficiency per decare than overhead irrigation system. Also, in order to encourage farms to use modern irrigation techniques, more importance should be given to farmer education and scope of trainings should be expanded. Based on current circumstances, it is estimated that making pivot irrigation technique included in irrigation techniques that benefit from sweetcorn premium support will be effective in converting to modern irrigation techniques in sweetcorn production in the region.

It is anticipated that the economic life of drip irrigation technique is 15 years, the economic life of pivot irrigation technique is 30 years, and the drip irrigation technique will generate double facility costs within 30 years, and the depreciation and interest costs will increase (Ağızan 2018). For this reason, pivot irrigation technique is considered to be more advantageous. In addition, examining relative profitability has yielded that pivot irrigation system is more profitable. Considering the geographical and topographic features, it is considered that drip irrigation technique in small areas and pivot irrigation technique in larger areas are more beneficial in terms of increasing productivity and profitability in the farms. In another study held in the area, it has been concluded that 84 % of the producers do not know the level of quality of irrigation water, 24% determine the irrigation time by looking at the state of the soil, 64% by looking at the plant development and 12% base on their experience, while 93% do not have any idea about the beneficial water capacity of the soil (Kaya 2017). It has further been observed that irrigation is not done by conforming to the water requirement of the plant, sometimes under-irrigation but generally over-irrigation is done, which increases both the waste of resources and the costs of the farms. Raising awareness on irrigation management by training the producers will better protect soil and water resources.

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