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Full Length Research Paper

The effects of irrigation methods on input use and productivities of sugarbeet in Central Anatolia, Turkey

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Today, global climate change and the decrease in ground and surface water sources have increased the importance of the rational and economic use of water as a scarce resource. The selection of irrigation systems in the cultivation of agricultural products is also very important. In this study, sugarbeet which is one of the first established agricultural industries, forms the basis of contract-based production, constitutes a substantial share of farmers income, and requires a great amount of water during its growing stage is examined. The effects of irrigation systems on cost, productivity and level of input use are examined within the scope of Central Anatolia in Turkey where sugarbeet is grown on the largest scale. A comparative calculation is made for irrigation methods widely used in the region, such as sprinkler, furrow and with its increase in recent years, drip irrigation to determine their effect on input use, productivity level and profit in sugarbeet production. It is found that drip irrigation in sugarbeet production allows for saving in input use more than sprinkler and furrow irrigation systems, and that it increases productivity and profit. The spread of especially drip irrigation in sugarbeet production has increased the economic use of water and profitability, through savings in input and reduction of costs.

Key words: Sugarbeet, irrigation, input, net income, Turkey.

INTRODUCTION

The strategic importance of water as a vital source for all organisms has increased in the process of global climate change. In this process, countries plan the use of the water they possess. The increases in especially population and production, as well as the diversity in agriculture lead to an increase in water consumption. Annual global water consumption that was approximately 1000 km^3 in 1940, quadrupled and reached 4130 km^3 in 1990. Water used in agriculture accounts for 70% of this value; for Europe it is 33% (WWF, 2009). Countries are classified according to the water sources they have; countries with a per capita annual average of usable water of 1.000 m^3 and less are classified as “water poor”, those of 2.000 m^3 or less as “water scarce” and those of 8.000-10.000 m^3 or more as "water rich".

Turkey, with its water wealth value of 1.430 m^3 does not fall into the category of water rich countries. The usable surface and ground water potential of Turkey is annually 112 billion m^3, 98 billion of which is surface water and 14 billion m^3 ground water. In addition, the precipitation pattern in Turkey exhibits considerable seasonal and regional variety with an average of 643 mm. In Turkey, 75% of water is used for irrigation purposes and mainly in agriculture. Although it is economically possible to irrigate 8.5 million hectares of the 25.8 million hectares of cultivated land, only 4.5 million hectares is irrigated (GDSHW, 2001, 2009).

Whereas in the past furrow irrigation was widely used on irrigated agricultural lands in Turkey, today in some regions the use of sprinkler irrigation is observed as well. As today water is considered as a scarce factor due to global warming, the planning of water use in agricultural production has come on the agenda and irrigation systems are questioned due to the decrease in water wealth resulting from wrong or irresponsible water use. These developments have supported the tendency to move from furrow to sprinkler irrigation at first and then to drip irrigation in Turkey. The high initial investment cost and the misconceptions as to low productivity due to lack of water, hinder the spread of the drip irrigation system. Yet, the recent support to investments provided through

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loans without interest, the savings in input and increase in profit have encouraged the installation of drip irrigation systems in areas where crops that require large amounts of water, such as sugarbeet, are grown.

In Turkey, 80% of the approximately 500 thousand agricultural holdings involved in sugarbeet production own land smaller than 10 decare (TSI, 2001). In recent years, after the quota production in 1999 (Anonim, 2006) sugarbeet production has dropped in the sugar industry in Turkey, which is the most important sugarbeet producing country after Germany and France in the EU (424 thousand hectares of planted land in 1999 dropped to approximately 315 thousand hectares in 2007; in the same years production dropped from approximately 17 million tonnes to 12 million tonnes) (FAO 2008, TSI 2001). However, when related industries and the used input markets are considered, Turkey maintains its importance.

While in Turkey furrow and sprinkler irrigation systems are widely used in sugarbeet production, positive developments are observed in the conversion to drip irrigation. Depending on the availability and need for water, sugarbeet is irrigated 5 - 6 times on average during its production period. While excessive irrigation leads to rotting of roots, insufficient irrigation results in losses in productivity. Therefore, the irrigation system selected is expected to save in water and input and to increase productivity and profitability. However, especially the furrow irrigation system requires huge amounts of water, and this reduces the level of groundwater from which it is obtained. In the case of insufficient precipitation, this type of irrigation leads to a rapid decrease in water sources. When the nature of today's developing sugar production industry in Turkey is considered, it appears that increasing efforts should be made to encourage the use and spread of sprinkler and especially drip irrigation systems in sugarbeet production. In this study, this change is examined especially with reference to the effect of decreasing input use on sustainable production and on economic profitability, and its results are discussed.

MATERIALS AND METHODS

In this study, the sugarbeet producing agricultural holdings located in Cumra, Beysehir, and Eregli, all of which fall within the limits of the province Konya in Central Anatolia, Turkey are included (Figure 1). Through a questionnaire administered to 55 randomly selected holdings sugarbeet production cost for the period 2007/2008 was determined and physical and financial input use was calculated from the data obtained. In the research area 55 holdings were examined and it was found that 35 used sprinkler, 15 used furrow, and 5 used drip irrigation. While sugarbeet in Beysehir and Eregli was irrigated through sprinkler and furrow irrigation, drip irrigation was used in holdings operating in Cumra.

The research area is a region where sugarbeet production is intensive and where sugar processing plants are located. Droughts due to global warming in recent years affect agricultural production and therefore, the regulation of irrigation systems and attempts related to especially sugarbeet irrigation form the agenda. Due to the small amount of precipitation, the decrease in water sources and the drop in the groundwater level in the region, the economic effects of irrigation systems in sugarbeet production need to be investigated.

Through the questionnaires conducted with the farmers in the holdings examined, the sugarbeet production costs with furrow, sprinkler, and drip irrigation systems were determined in physical and financial values, and the the effect of irrigation on cost, productivity, and profitability were evaluated. The basic cost items used in the calculation of production costs required for determination of net income received from sugar beet were rent of land, labor costs, current expenses, depreciation, interest calculated on capital, and general administrative costs. As current expenses, cost of seeds, fertilizer, pesticide, water, fuel, oil, loading-unloading and other charges used as input in production were considered (Acıl 1976; Kıral et al. 1999). Interest rate for working capital was calculated according to the interest rate of the Turkish Agricultural Bank applied for loans supporting plant production, that is, 18%, and interest rate for working capital was taken as average 9% bearing in mind the duration in which capital is kept within the enterprise and the fact that its utilization is dispersed within this period. Concerning general administrative costs which were spent for management of the enterprise, social services and expenditures for common services related with common production activities, 3% of variable costs were taken. At the end of the study, for each irrigation system the productivity level per decare, labor (manpower), horsepower and input costs in sugarbeet production were determined, costs and net profit levels were compared and for different irrigation systems first the use of water and then fertilizer, pesticide, labor,energy use and saving rates were determined.

RESULTS AND DISCUSSION

The research area with its average annual precipitation of 300 mm is an area where grain and sugarbeet are grown the most intensively. In sugarbeet production, where in the past furrow irrigation was used, sprinkler irrigation has become more widespread over the last years. Today efforts are made to increase the number of drip irrigation systems and their use is demonstrated. Subsidies, interest rate supports and reductions aimed at the initial investment cost of drip irrigation systems are provided. In 2008, a 100% interest rate cut was introduced for investments in the field of modern pressurized irrigation systems- sprinkler irrigation and drip irrigation (Anonymous, 2009a). This is expected to accelerate the transition to drip irrigation in sugarbeet production. In fact, the positive effects of sprinkler and drip irrigation on cost, productivity and input saving lead to changes in producer behavior.

The production cost, net profit, and differences in productivity levels of holdings using furrow, sprinkler and drip irrigation in sugarbeet production and the economic effects of irrigation sytems on different factors are presented in Tables 1, 2 and 3. In sugarbeet production the cost elements preparation of the land, sowing, care (fertilizer, ploughing, pesticide and irrigation (6 times), harvesting-gathering, loading-unloading and interest on working capital constitute the variable expense total; general administrative costs, rent of land and water

Table 1. Production cost of sugar beet in 2007 - 2008 ($/decar) (Furrow irrigatıon).

Production activities	Processing date / number	Manpower and horsepower				Used equipment	Used material			Total cost ($)
		Unit manpower		Unit horsepower						
		Hours	Price ($)	Hours	Price ($)		Material	Amount (kg)	Total value ($)	
Preparation of soil										
First ploughing	October - November	0.30	0.8	0.30	12.3	plow				13.1
Second ploughing	January	0.54	1.4	0.54	6.7	plow				8.1
Third plough	February	0.26	0.7	0.26	5.7	rake				6.4
Fourth plough	April	0.23	0.6	0.23	3.3	rolling pin				3.9
Cultivation	April	0.44	1.2	0.44	4.3	sowing mach.	Seed	0.34	9.1	14.6
Maintenance										
Fertilizing	April	0.90	2.4	0.90	2.7	fertilizer spreader	15X15	30.1	15.1	20.1
	May	0.90	2.4	0.90	2.7		%26 Nitrat	20.5	10.0	15.0
Hoing and ploughing	May (3)	30.30	50.5	3.80	5.0	hoeing machine				55.5
Applying pesticides	April - May	1.89	5.0	1.89	2.7	holder	Weed	0.09	2.7	10.4
							Insect	0.37	2.5	2.5
Irrigation	May (6)	16.40	41.5	2.85	3.3	forrow	Water		6.2	51.0
							Oil/electiric		25.9	25.9
Harvesting										
Threshing	September - October	13.30	35.5	3.50	3.7	Threshing machine				39.1
Loading/unloading/carrying		2.50	4.7	2.50	5.3					10.0
Interest of Working Capital		67.96	146.7	18.11	57.7					23.4
										299.3
A. Total valuable cost ($)										
a. General Administrative costs (A × 3%) ($)										9.0
b. Land rent ($)										83.3
c. Depreciation and interest of irrigation system * ($)										44.4
										136.76
B. Total fıxed cost ($)										
C. Total productıon cost ($) (A+B)										436.9
D. Sugar beet yıeld (kg/da)										6.000.00
F. Sugar beet prıce ($/kg)										0.1
G. Sugar beet ıncome ($/da)										440.00
H. Treacle ıncome ($)da)										13.9
I. Total ıncome ($/da) (G+H)										453.93
Net ıncome ($/da) (I-C)										17.03

installation depreciation and interest constitute the constant expense total.

In sugarbeet production, irrigation contributes to productivity, which has been proven in many studies. Babovic et al. (2009) has found irrigation to increase productivity 1,9 times. Not only irrigation itself, but also the difference in irrigation system has been found to affect productivity. In the research area productivity of an average of 6 tonnes/da with furrow irrigation, rises to 6.25 tonnes/da with sprinkler irrigation, and to 7.5 tonnes/da with drip irrigation. In a study conducted in Yozgat in Central Anatolia, Turkey, it was found that with sprinkler irrigation productivity was 4 tonnes/da, while this value reached 7 tonnes/da when drip irrigation was used (Anonymous, 2009b). In pilot studies conducted in Konya-Kulu and Aksaray-Eskil, productivity in sugarbeet production rose from 5 - 6 tonnes/da to 8 tonnes/da when drip irrigation was adopted (Anonymous, 2009d) Similarly, Sakellariou et al. (2002) state that drip irrigation results in higher productivity and higher water saving than is the case with other irrigation systems.

Different profits were obtained from sugarbeet produced in the research area where different irrigation systems were used. With the furrow

Table 2. Production cost of sugar beet in 2007 - 2008 ($/decar) (Sprınkler ırrigatoın).

Production activities	Processing date / number	Manpower and horsepower				Used equipment	Used equipment			Total cost ($)
		Unit manpower		Unit horsepower						
		Hours	Price ($)	Hours	Price ($)		Material	Amount (kg)	Total value ($)	
Preparation of soil										
First ploughing	October - November	0.30	0.8	0.30	12.3	plow				13.1
Second ploughing	January	0.54	1.4	0.54	6.7	plow				8.1
Third plough	February	0.26	0.7	0.26	5.7	rake				6.4
Fourth plough	April	0.23	0.6	0.23	3.3	rolling pin				3.9
Cultivation	April	0.44	1.2	0.44	4.3	sowing mach.	Seed	0.34	9.1	14.6
Maintenance										
Fertilizing	April	0.75	2.0	0.75	2.0	fertilizer spreader	15X15	20.6	10.3	15.0
	May	0.75	2.0	0.75	2.0		%26 Nitrat	15.2	7.1	11.8
Hoing and ploughing	May (3)	23.70	39.5	0.80	3.3	hoing machine				42.8
Applying pesticides	April - May	1.76	4.7	0.76	2.7	holder	Weed	0.07	1.6	9.0
							Insect	0.3	2.1	2.1
Irrigation	May (6)	11.40	22.8	1.45	3.3	Sprinkler	Water		6.2	32.3
							Oil/electiric		21.6	21.6
Harvesting										
Threshing	September - October	18.60	49.6	1.50	3.7	Threshing machine				53.3
Loading/unloading/carrying		2.50	4.7	2.50	5.3					10.0
İnterest of Workingl Capital		61.23	130.0	10.58	54.7					20.7
										264.7
A. Total valuable cost ($)										
a. General administrative costs (A × 3%) ($)										7.9
b. Land rent ($)										83.3
c. Depreciation and interest of irrigation system * ($)										52.1
										143.38
B. Total fıxed cost ($)										
C. Total productıon cost ($) (A+B)										408.04
D. Sugar beet yıeld (kg/da)										6.250.00
F. Sugar beet prıce ($/kg)										0.1
G. Sugar beet ıncome ($/da)										458.33
H. Treacle ıncome ($)da)										13.9
I. Total ıncome ($/da) (G+H)										472.26
Net ıncome ($/da) (I-C)										64.22

Table 3. Production cost of sugar beet in 2007-2008 ($/decar) (Drıp irrigatıon).

Production activities	Processing date / number	Manpower and horsepower				Used Equipment	Used equipment			Total cost ($)
		Unit Manpower		Unit Horsepower						
		Hours	Price ($)	Hours	Price ($)		Material	Amount (kg)	Total value ($)	
Preparation of soil										
First ploughing	Oct-November	0.30	0.8	0.30	12.3	Plow				13.1
Second ploughing	January	0.54	1.4	0.54	6.7	Plow				8.1
Third plough	February	0.26	0.7	0.26	5.7	Rake				6.4
Fourth plough	April	0.23	0.6	0.23	3.3	Rolling pin				3.9
Cultivation	April	0.44	1.2	0.44	4.3	Sowing mach.	Seed	0.34	9.1	14.6
Maintenance										
Fertilizing	April	0.45	1.2	0.45	2.7	Fertilizer spreader	15X15	0.4	8.5	12.4
	May	0.45	1.2	0.45	2.7		%26 Nitrat			3.9
Hoeing and ploughing	May (3)	14.60	24.3	0.29	3.3	Hoeing machine				27.7
Applying pesticides	April-May	0.32	0.9	0.32	2.7	Holder	Weed	0.065	1.6	5.1
							Insect	0.267	2.1	2.1
Irrigation	May (6)	3.63	9.7	1.45	3.3	Drip irrigation	Water		6.2	19.2
							Oil/electiric		11.3	11.3
Harvesting										
Threshing	Sep.-October	23.60	62.9	1.50	3.7	Threshing machine				66.6
Loading/unloading/carrying		3.50	6.5	3.50	8.0					14.5
İnterest of Working Capital		48.32	111.4	9.73	58.7					17.8
										226.7
A. Total valuable cost ($)										
a. General Administrative costs (A × 3%) ($)										6.8
b. Land rent ($)										83.3
c. Depreciation and interest of irrigation system * ($)										139.2
										229.3
B. Total fıxed cost ($)										
C. Total productıon cost ($) (A+B)										456.01
D. Sugar beet yıeld (kg/da)										7.500.00
F. Sugar beet prıce ($/kg)										0.1
G. Sugar beet ıncome ($/da)										550.0
H. Treacle ıncome ($)da)										13.9
I. Total ıncome ($/da) (G+H)										563.93
Net ıncome ($/da) (I-C)										107.9

irrigation system net profit was 17.0 $/da (Table 1), with the sprinkler system it was 64.2 $/da (Table 2), and with the drip irrigation system it was 107.9 $/da (Table 3). It is seen that despite the high installation cost of sprinkler and drip irrigation systems, the relatively high productivity and rapid compensation of installation costs result in relatively high net profit in a short time.

In sugarbeet production, input use lower for sprinkler and drip irrigation when compared to furrow irrigation (Table 4). Compared to furrow irrigation, sprinkler irrigation increases net profit 3.7 times, reduces water use by 30%, weeding costs by 15% and ploughing costs by 22.8%. However, a far more remarkable difference is observed when a transition from furrow irrigation to drip irrigation is made. When drip irrigation is used, productivity increases by 25 and 40% is

Table 4. Comparison of income and input saving of different irrigation systems on sugar beet.

Agricultural inputs / yield	Irrigation systems			Determined changes from furrow to sprinkler İrrigation (%)	Determined changes from furrow to drip İrrigation (%)	Determined changes from sprinkler to drip İrrigation(%)
	Furrow	Sprinkler	Drip			
Manpower (hour/da)	45,31	40,82	32,21	-9.9	-28,9	-21.1
Horsepower (hour/da)	23,45	12,28	9,73	-47.6	-58,5	-20.8
Net income ($/da)	17,03	65,71	107,92	285.8	533,7	64.2
Used water (m^3)	2.117,60	1.482,50	931,20	-30.0	-56,0	-37.2
Weed cost ($/da)	12,97	11,03	7,65	-15.0	-41,0	-30.6
Hoing cost ($/da)	55,50	42,83	27,67	-22.8	-50,2	-35.4
Fertilizer-fertilizing cost. ($/da)	35,16	25,39	16,27	-27.8	-53,7	-35.9
Irrigation cost ($/da)	76,91	58,17	45,05	-24.4	-41,4	-22.6
Harvesting cost ($/da)	39,13	53,27	66,60	36.1	70,2	25.0
Yield (kg/da)	6.000,00	6.250,00	7.500,00	4.2	25,0	20.0
Used oil ($/da)	-	16,2	8,5			-47.5
Used electric energy ($/da)	-	317,9	173,3			-45.5

saved in total input use. Moreover, compared to sprinkler irrigation, drip irrigation saves 21.1% in labor, 20.8% in horsepower, 37.2% in water consumption, 30.6% in weed removal expenses, 35.4% in ploughing, 35.9% in fertilizer, 22.6% in irrigation expenses, 47.5 and 45.5% in fuel and electricity, respectively (Table 4). Thus, through support provided to modern irrigation systems and the education of farmers, the spread of sprinkler and drip irrigation methods is likely to occur in sugarbeet production in Turkey.

The findings obtained are comparable to those of other studies conducted in this geographical area and other regions in the world. For example, in a study conducted in Yozgat it was calculated that when drip irrigation was adopted instead of sprinkler irrigation, 70% was saved on irrigation labor expenses and 60% on fuel expenses (Anonymous, 2009b). Similarly, studies conducted in Konya-Kulu and Aksaray-Eskil it is stated that drip irrigation saves 25 - 30% on energy and labor expenses (Anonymous, 2009c). In a study in Altınekin, the use of water and fuel in sugarbeet production decreased and through the drip irrigation project carried out 46% was saved on energy and 17% on fertilizer. In a study carried out by Tognetti et al. (2003) in northern Italy, drip irrigation is stated to save 25% on water use compared to low-pressure sprinkler irrigation. In a study conducted in Wyoming by Sharmasarkar et al. (2001) it is found that compared to furrow irrigation, drip irrigation results in higher productivity, lower total variable expenses and higher net profit. In their study, Soydam and Cakmak (2006) found that with the drip irrigation method has a higher cost-benefit ratio than the sprinkler irrigation method. When the cost systems of wild, furrow and sprinkler irrigation are considered, it is observed that wild irrigation is more costly than furrow irrigation, and Edmundo and Gabriel (2003) observe that energy expenses are high in sprinkler irrigation. It is stated that especially subsurface drip irrigation results in higher productivity and more saving of water than is the case with surface drip irrigation (Sakellarıou et al., 2002). In studies carried out by Eckhoff and Bergman (2001); Tohidloo et al. (2004) and Nicholson et al. (2009), the yield and product quality in different irrigation systems were found to be different. It is argued that irrigation positively affects productivity, quality and net profit (Knox and Weatherhead 2009) and that modern irrigation techniques bear economic and social importance (Frank et al., 2008).

Government has given subsidies for irrigation investments since 2006 in Turkey. That's why there is an increasing tendency to move from furrow irrigation to sprinkler and drip irrigation systems in sugarbeet production. Considering the fact that furrow irrigation reduces net profit by increasing energy and input expenses, that it increases overuse of scarce water, and that it, accompanied by insufficient precipitation, causes

Figure 1. Location of the research area in Turkey.

a drop in the level of ground water, this development is considered desirable in terms of sustainable agricultural production and the environment. The sustainability of production of sugarbeet, which is a basic produce in the geographical area of the research, largely depends on whether planned and controlled use of water is ensured. Sustainable sugarbeet production is important for large agricultural holdings that develop in the industry and for farmers who want to increase their income level. Thus, conversiton to drip irrigation needs to be encouraged and spread in the region.

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