Economic effects of changes of surface irrigation To micro irrigation systems in Mashhad plain, Iran (Case Study)

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ABSTRACT

In order to investigate the effects of changing surface irrigations to micro irrigation methods concerning water consumption, yield, water use efficiency (WUE) and its economic results, a study on 30 fields was conducted in Mashhad Plain, Iran for 2 consecutive years (2009-2010). The results of the study showed that, after changing the irrigation methods, the average amount of water used in summer's farming , and orchards decreased 27.5 percent has decreased. The mean of total yields of total products, about 36% and the average of water use efficiency 95.1% has increased. Partial budgeting and project evaluation methods were used to evaluate farms economically. Economic calculations were performed based on three main scenarios (benefit and cost calculated base on 1- increase in yield and surface cultivation, 2- increase in yield and 3- increase in yield and sales of water). The average rate of return in three scenarios, was obtained , 678, 219 and 292 percent, respectively. Although, based on the rate of return index, the products' arrangement in all scenarios has approximate similarities, but the rate of return in all scenarios, was high and economically acceptable and the changes in irrigation methods, has had a very positive impact on the livelihood and income of farmers.

Keywords: Drip irrigation, Surface irrigation. Yield, Water used, Economic evaluation, partial budgeting.

1. Introduction

In many countries of the world, limitation of fresh water resources is a serious problem, and overshadowed development of these countries. Middle East region is seriously faced with limitation of freshwater resources ;and many experts predict that, in future many confilicts take place over ownership of water resources of region , like oil (Ehsani & khaledi. 2003).

High extraction of ground water in the Mashhad and Fariman plains, since 1991 to 2001, Caused ground water level drop of about 13.9 meters and, is expected, to have the same trend from 2001 to 2011 and underground reservoirs of water level will drop 14.5 meters (Hosseini. 2008). .

Total cultivated fields of Khorasan Razavi province are about 1112000 hectares, that about 865,000 is irrigated and about 247,000 hectares are dry farmed and until 1389, for irrigation of 75,954 hectares of them, have been used pressurized irrigation systems (Jahad Agriculture Khorasan Razavi Organization).

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Baghani and Khazaii (1999) and Baghani and Bayat (1999), compared two methods of drip and furrow irrigation with three levels of water supply plant needs (50, 75 and 100 percent) on watermelon and melon farming in the Torogh Agricultural Research Station was compared and concluded that, the yield and water use efficiency in drip irrigation better than furrow irrigation and In addition, fruits shape were better and the weeds were less. Darwish et al. 2002, were investigated the effect of drip and sprinkler irrigation methods on yield of potato in Lebanon. Results showed that, there was not significant difference in yield of irrigation methods, while the amount of water used in sprinkler and drip irrigation methods, was 859 and 496 mm/ha, respectively. Weather head et al. 2002, doing research on drip irrigation methods in potato farming, announced: experiments conducted in the UK and other parts of the world, confirming, there are positive effects of drip irrigation on potato. Semert et al. 2004, had a research during the spring of 2000 to 2002 in the Hataya province in West Mediterranean region of Turkey. In this study, Surface drip and subsurface drip irrigation methods, yield and yield components were investigated. Irrigation treetments were 100, 66 and 33 percent of the plant water requirements and no irrigation. Total amount of water applied in 2000 and 2002 were 102 to 302 and 88 to 268 mm respectively. The yield of two methods of surface irrigation and subsurface were similar and had not been significant different. The effect of irrigation at year, yield and yield components was significant. The 33% water supply treatment, was not advisable. The water use efficiency of surface irrigation method was higher than subsurface irrigation and had the highest water use efficiency. Boujelben and M'barek. 2004, conducted an experiment on potatoes with surface irrigation (closed end furrow) and drip irrigation in the form of a randomized complete block (with three replications and irrigation water volume of 4000 cubic meters per hectare) test conducted. Statistical analysis results showed that, irrigation method, had not significant effect on the number of stems per plant, but difference of yield per plant unit in drip irrigation (1.16 kg) and furrow irrigation (0.836 kg) were significant. Baghani. 2006, had a study on 15 farms in Khorasan Razavi province, which they had changed surface irrigation system to drip irrigation. In fields studied, potato (21%) and sugar beet (9%) had the highest and lowest percentage increase in product yield, respectively. The farm of maize (49%) and potato (34%), had the highest and lowest percentage of water consumption decreased respectively. Irrigation water use efficiency in forage maize was increased 116%.
In the year 2009, a study was conducted on the cultivation, yield, water consumption, water use efficiency of 30 farms (that they had changed their surface irrigation method to drip irrigation) in Mashhad and Fariman plains. The results of analysis data taken from fields has been discussed in this article.

2. Material and methods

In this study, first, prepared a list of farmers specification that (since 2003) used pressurize irrigation systems for their farms. Then based on the ownership level, the amount of water and facilities, farms were selected. Fields visited and the desired parameters such as geographical coordinates, the amount of discharge wells and cultivation were measured and questionnaires that had already been developed was completed. Finally, the data obtained from 30 farms were analyzed. For economic evaluation , partial budgeting and project evaluation methods were used to evaluate farms economically.

3. Results and discussion

Average results of data, collected from relevant authorities, visiting farms, interviews and discussion with farmers, and wells flow measurements were compared.

Results indicated, before using pressurized irrigation systems, the amount of water extracted from underground resources by 30 wells, was 15,945,000 cubic meters, and after using pressurize irrigation systems (with a 10.9% reduction), was 14200000 cubic meters. However, the hours worked in the wells, was low 0.9%

3. 1 Yield, water consumption and water use efficiency

The weighted average yield of sugar beet crops, forage corn, potato, onion, tomato and cereals before and after the change of irrigation methods, are shown in Figure 1. The yield of onion, forage maize and sugar beet has increased respectively 79.4, 52.4 and 35.2 percent and Total weighted average yield of total farm products, before and after the change of irrigation methods, has increased from 260 ha to 354 ha (36 percent).

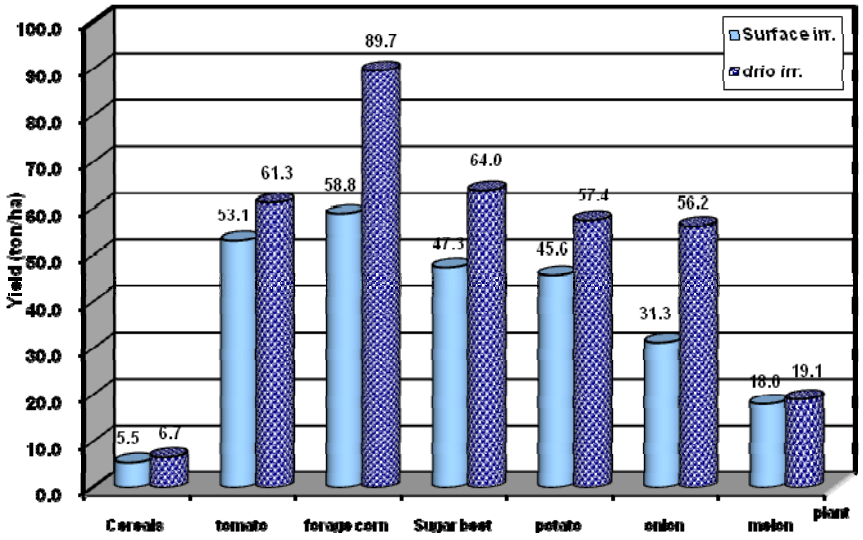

Figure 1. Comparison of yields in surface and drip irrigation (Comparer les fonctions dans l'irrigation et l'irrigation de surface)

In furrow irrigation, the average of water consumption of onion, sugar beet, potato and tomato farms, was 15,359, 14,955, 14,955, 13,563 and 7649, m3/ha respectively.

Before and after changing method of irrigation, cereals water consumption did not change and amount of water of other agricultural was decreased, 27.5 percent/(unit area).

In the surface irrigation methods, the irrigation water use efficiency of products was between 0.72 to 5.75 kg/m3, but in drip irrigation methods, that was between 4.3 to 7.5 kg/m3. By changing irrigation methods, the water usage efficiency of summer products had increased 95% and the creals water use efficiency (0.9 kg/m3) was lower than all products (Figure 2).

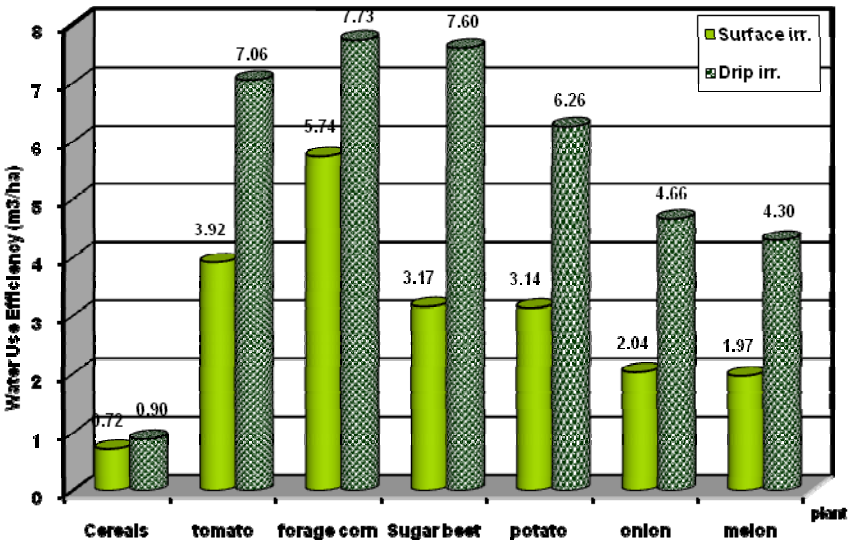

Figure 2. Comparison of Water use efficiency in Surface and drip irrigation (Comparaison de l'efficacité de l'irrigation de l'eau l'irrigation et l'irrigation de surface)

3. 2 Change area

Summary, the total acreage farms studied was 1532 ha and with Changing the irrigation method, the amount of acreage has increased to 1759 ha. Although, removal of water from underground sources has dropped 10.9%, but the total area under cultivation farms, is more 14.8%.

3. 3 Economic Analysis

In order to evaluate systems economically, partial budgeting and project evaluation methods were used (Hajjarn. 1989). In this method , changes in benefit and cost due to irrigation methods were compared .
According to six drip irrigation projects with a discount rate equal to 10% and the following specifications, the annual cost of installations calculated.

- Mean field area, 45 hectares and the area to install irrigation equipment, 27 hectares.
- One hectare cost drip irrigation equipment equals 28079190 Rials/hectare.
- Depreciation period of an irrigation system, 20 years.
- Price of type pipe, 5182770 Rials/hectare.
- Depreciation period of type pipes equal, two years.

In order to facilitate calculation, the cost of surface irrigation system workers was considered ,the same as, workers collecting and spreading tube and increase of electricity consumption in the drip irrigation system (Baghani and Zarea. 2002).
Production cost per hectare (except water and land) was obtained from publicated statistics in the 2008-2007 by Ministry of Jehad-e-Agriculture.
Considering the difference in yield per hectare in both irrigation systems, the necessary adjustments in relation to the cost of harvesting were done. However, these costs, were considered in the increased cultivation revenue increases of drip irrigation. To calculate the investment return rate, was used the following equation.

$$\text{Rate of Return} = \frac{\text{Total net incom) -(Total net incom surface irr. Sys.) (drip irr. Sys.}}{\text{Net increase in cost drip irrigation than surface irrigation}} *100$$

Due to the benefits from irrigation systems with different crops is different, and surplus of water is useable in two way include, for additional cultivation or can be sold, so calculations are done based on the following scenarios.

- Calculation of benefits and costs based on increasment in yield and cultivated areas
- Calculate the benefits and costs, just based on increasment in yield
- Calculate the benefits and costs, based on increasment in yield and selling water
- Calculate the arithmetical average of all products in every three first scenario
- Calculate the weighted average of all three products in each first scenario, considering the area under crops.

The results of calculations are in Tables 1, 2 and 3.

As can be seen, the average rate of return in three scenarios, is 678, 219 and 292 percent respectively. Although the price per cubic meter of water has been considered equal to 1000 rials, but the difference between the rate of return between the sales option and increased under cultivation, (first and third scenarioes) is enormous, Which shows, the shadow price of water is very high for studied products and irrigation systems. In all scenarios, the order of rate of return of products, is similar but certainly, changing the method of irrigation from surface irrigation to drip irrigation, have a very high rate of return, and is quite economical.

Table 1. Economic evaluation of drip and surface irrigation systems for various products, according to the first scenario.

Investment rate of return (%)	Total Net income	Income due to increased cultivation	Increased cultivation	net Income/ha	Gross Income/ha	Total costs	Curent cost of installation	Annual fixed cost (installation)	Cost (other than land	Price of product	Yield (Kg)	Water consumption	Area under cultivation	Irrigation method	plant
277	3190595	1368209	0.7763	1822386	3328600	1506214	237750	329817	938647	52.0	63979	8419	71	Drip	Sugar beet
	1619298	0	0.0000	1619298	2462596	843297	0	0	843297	52.0	47333	14955	120	surface	
702	9797742	3495766	0.5600	6301977	8878723	2576746	237750	329817	2009179	144.7	61344	8694	416	Drip	Tomato
	5815625	0	0.0000	5815625	7689715	1874090	0	0	1874090	144.7	53129	13563	324	surface	
804	9379431	3440528	0.5852	5938904	9453921	3515017	237750	329817	2947451	164.7	57387	9169	244	Drip	Potato
	4813633	0	0.0000	4813633	7515172	2701539	0	0	2701539	164.7	45619	14535	129	surface	
127	2350500	265345	0.1310	2085155	3059221	974066	237750	329817	406499	34.1	89654	10250	26	Drip	Corn forage
	1629825	0	0.0000	1629825	2006946	377121	0	0	377121	34.1	58816	11593	19	surface	
1092	10790360	2320172	0.2759	8470188	11534956	3064768	237750	329817	2497201	205.4	56154	12038	26	Drip	Onion
	4593853	0	0.0000	4593853	6428344	1834491	0	0	1834491	205.4	31294	15359	17	surface	
250	3595187	1822529	1.0642	1772659	3427867	1655208	237750	329817	1087641	179.9	19051	4427	88	Drip	Melon
	2177653	0	0.0000	2177653	3243549	1065896	0	0	1065896	179.9	18027	9138	37	surface	
542	6517303	2453206	1	4398545	6613881	2215336	237750	329817	1647770			8833	145	Drip	Arithmetic mean
	3441648	0	0.0000	3441648	4891054	1449406	0	0	1449406			13191	108	surface	
678	8322633	3006287	1	5316346	7942293	2625947	237750	329817	2058380	145	56868	8520	871	Drip	Weighted Average
	4472403	0	0	4472403	6228888	1756485	0	0	1756485	132	48135	13752	646	surface	

Table 2. Economic evaluation of drip and surface irrigation systems for various products, according to the second scenario.

Investment rate of return (%)	net Income/ha	Gross Income/ha	Total costs	Curent cost of installatio	Annual fixed cost (installatio	Cost (other than land	Price of produc	Yield (Kg)	Water consumption	Area under cultivatio	Irrigation method	Plant
36	1822386	3328600	150621	237750	329817	938647	52.0	63979	8419	71	Drip	Sugar beet
	1619298	2462596	843297	0	0	843297	52.0	47333	14955	120	Surfac	
86	6301977	8878723	257674	237750	329817	2009179	144.7	61344	8694	416	Drip	Tomato
	5815625	7689715	187409	0	0	1874090	144.7	53129	13563	324	Surfac	
198	5938904	9453921	351501	237750	329817	2947451	164.7	57387	9169	244	Drip	Potato
	4813633	7515172	270153	0	0	2701539	164.7	45619	14535	129	Surfac	
80	2085155	3059221	974066	237750	329817	406499	34.1	89654	10250	26	Drip	Corn forage
	1629825	2006946	377121	0	0	377121	34.1	58816	11593	19	Surfac	
683	8470188	11534956	306476	237750	329817	2497201	205.4	56154	12038	26	Drip	Onion
	4593853	6428344	183449	0	0	1834491	205.4	31294	15359	17	Surfac	
	1772659	3427867	165520	237750	329817	1087641	179.9	19051	4427	88	Drip	Melon
	2177653	3243549	106589	0	0	1065896	179.9	18027	9138	37	Surfac	
169	4398545	6613881	221533	237750	329817	1647770			8833	145	Drip	Arithmetic mean
	3441648	4891054	144940	0	0	1449406			13191	108	Surfac	
219	5316346	7942293	262594	237750	329817	2058380			8520	871	Drip	Weighted Average
0	4472403	6228888	175648	0	0	1756485			13752	646	Surfac	

Table 3. Economic evaluation of drip and surface irrigation systems for various products, according to the third scenario

Investment rate of return (%)	Total net income	income from water sale	Increased cultivation	net Income/ha	Gross Income/ha	Total costs	Curent cost of installation	Annual fixed cost (installation)	Cost (other than land	Price of product	Yield (Kg)	Water consumption	Area under cultivation	Irrigation method	plant
151	2475986	653600	0.7763	1822386	3328600	1506214	237750	329817	938647	52.0	63979	8419	71	Drip	Sugar beet
	1619298	0	0.0000	1619298	2462596	843297	0	0	843297	52.0	47333	14955	120	Surface	
171	6788877	486900	0.5600	6301977	8878723	2576746	237750	329817	2009179	144.7	61344	8694	416	Drip	Tomato
	5815625	0	0.0000	5815625	7689715	1874090	0	0	1874090	144.7	53129	13563	324	Surface	
293	6475504	536600	0.5852	5938904	9453921	3515017	237750	329817	2947451	164.7	57387	9169	244	Drip	Potato
	4813633	0	0.0000	4813633	7515172	2701539	0	0	2701539	164.7	45619	14535	129	Surface	
104	2219455	134300	0.1310	2085155	3059221	974066	237750	329817	406499	34.1	89654	10250	26	Drip	Corn forage
	1629825	0	0.0000	1629825	2006946	377121	0	0	377121	34.1	58816	11593	19	Surface	
741	8802288	332100	0.2759	8470188	11534956	3064768	237750	329817	2497201	205.4	56154	12038	26	Drip	Onion
	4593853	0	0.0000	4593853	6428344	1834491	0	0	1834491	205.4	31294	15359	17	Surface	
12	2243759	471100	1.0642	1772659	3427867	1655208	237750	329817	1087641	179.9	19051	4427	88	Drip	Melon
	2177653	0	0.0000	2177653	3243549	1065896	0	0	1065896	179.9	18027	9138	37	Surface	
245	4834311	435767	1	4398545	6613881	2215336	237750	329817	1647770			8833	145	Drip	Arithmetic mean
	3441648	0	0.0000	3441648	4891054	1449406	0	0	1449406			13191	108	Surface	
292	5243432	417303	1	5316346	7942293	2625947	237750	329817	2058380	145	56868	8520	871	Drip	Weighted Average
0	3568364	0	0	4472403	6228888	1756485	0	0	1756485	132	48135	13752	646	Surface	

4. CONCLUSION AND RECOMMENDATIONS

In studied farms that was changed the surface irrigation to drip irrigation methods irrigation:
The amount of water consumed cereals did not change. Overall, the average amount of water studied farms, were less 27.5% .
The average value of water use efficiency in studied farms, had more 95.1% . The total area cultivation has increasd from 1532 to 1759 hectar (14.8%).
The weighted average of water consumption of studied farms, was redused 27.5% (per unit area).
Removal of underground water resources has decreased 10.9% per year that has not Related to changed irrigation method. Economically, in the three scenarios examined, the average of rate of return has been 678, 219 and 292 percent respectively. But surely, the change of surface irrigation to drip irrigation method, is quite economically with very high rate of return. Generally, changing irrigation method has very positive effect on livelihood of farmers.

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