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Determine water use efficiency to select the appropriate crop (Case study: Jirof region)

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Abstract

In order to select appropriate crops for cultivation of potatoes, wheat, sugar beet and maize in Jiroft region, this research was conducted in years 2009 and 2010. The research methodology in this study was based on field studies, including the estimated volume of water, crop yield, water use efficiency, net benefit per drop and the water economic efficiency of the production. The results showed that maximum water use efficiency was in sugar beet cultivation (5.2 kg/m^3) and the minimum was in wheat (0.49 kg/m^3). Potatoes had the highest net benefit per drop (53 Milion-Rial) and wheat had the lowest net benefit per drop (10 Milion-Rial). Water economic efficiency of potato than in all of the four fields were examined further. Indicating more profitable than other crops in potato fields is investigated. Therefore according to the results of this study in terms of water use efficiency, net benefit per drop and water economic efficiency can be said the cultivation of potato products is preferred and is recommended for planners and operators.

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Introduction

New crises related to natural resources and their stability all over the world have created concerns and new attitude to natural resources problems. So that, sustainable agriculture has been developed as dominant system in current debates regarding to expansion of debates about stability. Water as the most effective factor in production of agricultural products, not only limits agricultural activities, but also limits other economic and social activities. Todays, most of dry and semi-dry regions all over the world like most regions of Iran faced with inefficient water supply and the other side these region face high demands for agricultural water that its main reason is high difference between payment price and obtained production value of it (Saberi *et al.*, 2006).

Despite of Iran important status in producing of some of agricultural products in the world, but neglect to recognize advantages of products in different regions has led to non-optimal- allocation of production resources in different parts of the country and the other side, the status of exporters has been weakened in foreign markets compared other producer countries. Thus, it is necessary to plan for cultivation and provide sufficient scientific guidelines production of the agricultural products by regarding to their relative and economic advantages in different parts of the country, so that, it can be produced the products with higher -economic advantages in the region and can export them to regions with lower advantages. Finally, we can decrease production costs, significantly (Abdolahi and Javanshah, 2007). Thus, it can be adopted the correct and optimal strategy to develop cultivation in different regions by determining optimal cultivation pattern in different parts of the country in addition to determining the export potentials.

Regarding to increased cost of water losses and demand for increasing cultivated areas, it is important to optimize utilization of water resources, increasing production rate for every unit of using water. The management effect of the irrigation water on efficiency of water consumption has been discussed in different aspects on different cultivated products (Zwart and Bastiansen, 2004). Sepahvand (2009) in his study about comparison water need and efficiency of water used between two Wheat and Canola crops stated that the averages of water use efficiency in Wheat and Canola are 1.64 and 0.6 kg/m^3, respectively. Regarding to water consumption rate and water use efficiency of these two crops, Wheat cultivation had more advantages than Canola. Peji *et al* (2011) in study the effect of different levels of irrigation on yield and water use efficiency suggested that the highest water use efficiency is related to 55% treatment of need water with 22.1 kg/m^3 and the lowest water use efficiency is related to control treatment with 11.1kg/m^3.

One of effective strategies on increasing economic production rate for per unit of water consuming in pricing and receiving water rate. Water pricing follows three purposes: economic efficiency, income distribution and conservation of water resources for next generations (Sepahvand, 2009). Statistic and planning office of agriculture ministry makes a list of agricultural products and costs of energy consuming such as water by developing a filling questionnaires, every year (Chizari and Mirzaei, 1998). Also it is important to analyze water value in production of agricultural products. One of the determining water price is estimation of its supply and distribution costs that includes investment and operative costs (ShamsAldin *et al.*, 2010). Most of studies emphasized on the importance of production function shape. For example, Marvdashti & Farjood (2007) in their study stated that the price of per cubic meter of water with 20% interest rate is 63.3 Rial, in Fars province.

Regarding to mentioned matters, it can be said that numerous studies have conducted to calculate efficiency of water consuming for cultivated products all over the world. But economic efficiency of water for cultivated products is more important than water use efficiency. In economic view, increasing of efficiency of water consuming is not enough, but product should have economic value or significant

income for farmer. Economic efficiency of water means the price of product for per unit of water consuming that can be stated in Rial/m^3 (Sepahvand, 2009). There are no significant studies related to economic evaluation of water in agriculture and it is necessary to pay attention to economic efficiency of water used in dry and semi-dry regions all over the world, like Iran.

Since, cultivated products (such as; Wheat, Sugar beet, Potato and Corn) have occupied highest relative advantage position among cultivated products of Kerman province (Karbasi *et al.*, 2009) and also regarding to expanding drip irrigation in Jiroft city and lack of enough information about efficiency of water consuming for different agricultural products, current study was done aimed to determine water use efficiency in agricultural products, efficiency of water consuming in Rial, economic efficiency of water and determining cultivation model fitted to this region corresponding to economic efficiency of water.

Materials and methods

Experimental regions

Jiroft city located in 245 km distance from in southeast of Kerman province with 50000 km^2 area. This region has semi-warm and semi-wet climate. Jiroft is 650m above sea level. Its longitude and latitude are 57^o 25' and 27^o 30', respectively. Thus, to choose the best cultivated crop, 4 farms equipped with drip irrigation system, were selected randomly in different parts of Jiroft. Then, general information were collected including; information about quality of irrigation water, Pedagogical information, characteristics of irrigation system, farm management, operation rate and price of product selling (tables 1 & 2).

Methodology

In this study was used Equation 1 to changing costs in to base year (2011) and unified annual cost (Peji *et al.*, 2011):

$$EUAC = P\left(\frac{A}{P},\%\, i, n\right) - SV\left(\frac{A}{F},\%\, i, n\right) \quad (1)$$

Where, EUAC: equivalent uniform annual cost (in Rial), P: investment value (in Rial), (A/P,%i,n): transforming factor of unified annual cost, i: interest rate, sv: scrap value, n: system lifetime and (A/F,%i,n): transforming factor of future value to unified installments. It should be mentioned that in these measurements has considered 10 years lifetime for pomp engine and its equipment's and 20 years lifetime for water transfer grid.

In this study to calculate total price of water, at first, uniform annual cost of water extracting and transfer was calculated by using developed questionnaires by the ministry of energy for 4 farms with 15% interest rate (figure1), then volume of pumped water from every well (real usage rate) was calculated by these questionnaires (table 3) and finally price of every cubic meter of water was calculated by dividing total annual cost on volume of pumped water (figure 2). As figure2 shows, the highest total price of water with 15% interest rate (common interest rate in all banks) in experimental regions is 304.2 Rial that belongs to forth farm. In this farm maintenance cost of irrigation was more than other farms, because of undesirable water and also management of farm by smallholder. Khalilian & Zare (2005) estimated value of every cubic meter of water to produce wheat equal 278.34 Rial by using production function in Kerman.

In this study, water use efficiency, net income per unit volume of water and economic efficiency of water were calculated from 2, 3 and 4 equations, respectively.

$$WUE = \frac{Y}{WU} \quad (2)$$

$$NBPD = (Y \times P_c) - C \quad (3)$$

$$WP_e = \frac{NBPD}{WU} \quad (4)$$

In these equations; WUE: water use efficiency (kg/m^3), Y: yield (kg/hec), WU: total water used (m^3), Pc: product price (Rial/kg), C: total production cost (Rial), NPBD: net income per every unit of water

volume (Rial) and WP_e: economic efficiency of water (Rial/m^3).

Results and discussion

One the most important agricultural products is maize that plays main role to provide nutrition and livestock products, in addition to job creation in agriculture, industry and commerce departments (Hernandez *et al.*, 2010). Cultivation of this plant has been expanded all over the world, because of its high compatibility with different climate (Lamm and Trooien, 2003). But, because of its high senility to drought (Payero *et al.*, 2006), one of problems of farmers in dry and semi-dry regions is to provide desirable conditions specially , supply enough water during growing period of maize. Shaozhong *et al.* (2000) reported that water used rate is between 6386-8394 m3 and efficiency of water consuming is between 0.88-1.52 kg/m^3 in hectare, during growing season. Also, operation rate varies between 9.7-11.85 ton/hectare. In current study, average of water used was considered in farms as had been calculated by voltmeter and it is about 7700m^3/hec, also efficiency of water consuming is consistent with other studies (table 4).

Tables 1. General characteristics of the experimental farms.

Farm	Region	Position relative to the city of Jiroft	The dominant culture	Type Manager
1	Anbar-Abad	30 km southwest	Cucumber, sugar beet, wheat, onions, potatoes, corn and canola	smallholder
2	Rodbar	90 km southeast	Potatoes, onions, tomatoes, eggplant, canola, wheat and corn	Main owner
3	Jahad-Abad	40 km south	Alfalfa, wheat, sugar beet, potatoes and corn	Main owner
4	Khaton-Abad	Border city	Onions, sugar beet, corn, wheat, potatoes and canola	smallholder

Table 2. Some chemical characteristics of water.

Farm	EC (dS/m)	pH	Mn^{+2}	Fe^{+2}	Na^{+}	Ca^{+2}	Mg^{+2}	SO_4^{-2}	Cl^{-}	HCO_3^{-}
			meq/L							
1	0.85	7.6	0.007	0.064	51	9.7	16.3	24	46.7	4.7
2	1.52	7.2	0.012	0.084	57	11.4	17.9	37	47.2	5.5
3	1.93	7.1	0.009	0.065	41	9.4	17.6	34	37.8	5.1
4	3.8	4.9	0.0007	0.042	46	9.1	15.9	31	45.7	3.1

Sugar beet cultivated area was about 10100 hectare with operation mean 25 ton.hec in Jiroft city of Kerman in 2010. Sugar beet is one of plants that needs high water. Thus, its growing in dry regions is faced with numerous problems (Sharmasarkar *et al.*, 2001). Tognetti *et al* (2003), compared corrugation irrigation and drip irrigation in sugar beet cultivation. In surface irrigation method with consuming 11200 m^3 water, operation rate obtained 58 ton.hec tubers and in drip irrigation method with consuming 7700 m^3 water, obtained 57ton/hectare tubers. Also, Fabrio *et al.* (2003) reported efficiency of water consuming to cultivate sugar beet in drip irrigation method 2.9 times water consuming in traditional irrigation method. The average of water used rate in cultivated sugar beet farms in current study is about 7950 m^3/hec that in compared with irrigated farms by traditional irrigation method, water consuming rate decreased about 30%. Regarding to table 5. Efficiency of water consuming varies between 3.5 - 5.2 m^3/hec, in sugar beet cultivated farms.

Table 3. Extracted water volume from every well (m^3/year).

Farms Study	Farm 1	Farm 2	Farm 3	Farm 4
Extracted water volume	1194521	1014897	1075422	1186894

Table 4. Calculating economic efficiency of water (Rial/m³) in corn cultivation.

Farm	WUE (kg/m³)	Pc* (Rial/kg)	price of every cubic meter of water (Rial)	Yield (Kg.hec)	C (Rial)	Net Income (Rial)	WP_e: (Rial/m³)
1	1.61	3150	271.1	12297	2087470	36963080	4800
2	1.18	3500	266.7	9086	2053590	29747410	3836
3	1.23	3300	267.5	9471	2059750	29194550	3791
4	1.35	3350	304.2	10395	2342430	32480910	4218

*: Price of the product is determined by its quality and Time sale at each farm.

Potato have the wastes cultivated areas after Rice, maize and wheat all around the world. this agricultural product are cultivated in 145 countries and plays important role in nutrition of the people all over the world.290 milion ton potato tubres are produced from 21 milion cultivated areas in the world (Yuan *et al.*, 2003). Senility of potato plant to water tension is more than other plants because of have low, thin roots that can grow in compressed soil. This senility can effect on abstained income, because of water tension and marketing of this product will be faced serious problems (Kashyap and Panda, 2003). Akhavan *et al* (2007), considered three irrigation levels (70,100 and 125% evaporation from evaporation pan) as main factor and four treatments (side middle type strips on the soil surface, middle type strips in depth of 5cm, side strips on the soil surface and furrow irrigation) as sub factor on potato function. Results showed that as water consuming increases, potato crop increases. Among different irrigation levels, maximum production (32.4 ton.hec) was related to 125% treatment and minimum production (21.3 ton.hec) was related to 75% treatment. Among sub factor treatments , maximum and minimum production in hectare were related to type irrigation (back furrow middle in 5cm depth) and furrow irrigation methods 28.9, 21.3 and 32.5 ton.hec, respectively. The highest efficiency of water consuming (4.98 kg/m³) was related to type irrigation method (back furrow middle in 5cm depth) and lowest efficiency of water consuming related to furrow irrigation method (3.3 kg/m³). In current study, the mean of water used rate was about 7600m³/ hec in experimental farms. Also, efficiency of water consuming rate is consistent with other studies (table 6).

Table 5. Calculating economic efficiency of water (Rial/m³) in sugar beet cultivation.

Farm	WUE (kg/m³)	Pc * (Rial/kg)	price of every cubic meter of water (Rial)	Yield (Kg.hec)	C (Rial)	Net Income (Rial)	WP_e: (Rial/m³)
1	5.2	820	271.1	41340	2155245	31743555	3993
2	3.5	950	266.7	27825	2120265	24313485	3058
3	3.8	1000	267.5	30210	2126625	28083375	3533
4	4.5	950	304.2	35775	2418390	31567860	3971

*: Price of the product is determined by its quality and Time sale at each farm.

Table 6. Calculating efficiency of economic water (Rial/hec) in potato cultivation.

Farm	WUE (kg/m³)	Pc * (Rial/kg)	price of every cubic meter of water (Rial)	Yield (Kg.hec)	C (Rial)	Net Income (Rial)	WP_e: (Rial/m³)
1	4.82	1450	271.1	36632	2060360	51056040	6718
2	4.06	1570	266.7	30856	2026920	46417000	6108
3	4.39	1650	267.5	33364	2033000	53017600	6976
4	4.67	1550	304.2	35492	2311920	52700680	6934

*: Price of the product is determined by its quality and Time sale at each farm.

Wheat is one of strategic agricultural products in the region that, until numerous studies have been conducted about water used and efficiency of water consuming. For example, conducted study by SepahVand (2009) that compared needed water, water use efficiency and economic efficiency of water

used to produce wheat in west region of the country in years with high rainfall rate. In this study water used rate was 5000m³/hec and water use efficiency varied between 0.6-1.4 kg/m³ in hec, during growing season. Also, economic efficiency of water consuming calculated equal to 2228 Rial/m³ in wheat cultivation.

In current study, mean of water used estimated 5600m³/hectare during two years. Also, regarding to table 7. Water use efficiency and economic efficiency of water used varied between 0.49-0.83kg/m³ in hectare and between 1742-2924 Rial/m³, respectively.

Table 7. Calculating efficiency of water (Rial/m3) in wheat cultivation.

Farm	WUE (kg/m³)	Pc * (Rial/kg)	price of every cubic meter of water (Rial)	Yield (Kg.hec)	C (Rial)	Net Income (Rial)	WP_e: (Rial/m³)
1	0.83	3850	271.1	4648	1518160	16376640	2924
2	0.49	4100	266.7	2744	1493520	9756880	1742
3	0.56	3950	267.5	3136	1498000	10889200	1945
4	0.71	4000	304.2	3976	1703520	14200480	2536

*:Price of the product is determined by its quality and Time sale at each farm.

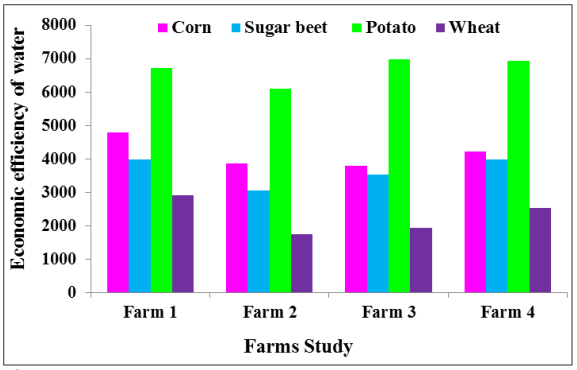

Fig. 3. Determining the cultivation model based on economic efficiency of water.

Regarding to drought, the agricultural product should be placed in priority of cultivation which has highest economic efficiency of using water in addition to maximize income (George *et al.*, 2013). According to it, optimal cultivation model for cultivate different agricultural products in Jiroft has been showed in figure 3. The results show that the highest economic efficiency of water used belonged to potato cultivation and after it to flint corn in all farms. Also, wheat cultivation had lowest economic efficiency of using water in all farms. Now, regarding to mentioned matters, the priority of cultivation was determined as potato, corn, sugar beet and wheat cultivation, respectively.

Conclusion

In current study, sugar beet with 5.2kg/m³ water use efficiency and wheat with 0.49 kg/m³ water use efficiency occupied highest and lowest positions among all farms, respectively. Also, potato with about 53 milion Rial net income and wheat with about 10 milion Rial net income obtained highest, lowest income rate, respectively. According to this results, the mean of economic efficiency of water used for potato cultivation is more that corn, sugar beet and wheat in all experimental farms during two years. It shows that potato cultivation is more profitable than the other cultivated products in all experimental farms. Thus, regarding to obtained data from this study, in view of water use efficiency, net income and economic efficiency of water used , we can said that, potato cultivation is preferable on the other products and it is recommended for planners and farmers.

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