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# The Economic Productivity of Water Consumption in Damask Rose Cultivation Compared to Other Crops in Solan

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## Abstract

Water is an important factor in economic development and the agriculture sector is also regarded as the largest consumer of water in Iran. Hence, the present study aimed at exploring economic productivity of water consumption in the Damask rose cultivation compared to other farm crops in Solan. Field method was used in this study. The farms of wheat, barley, alfalfa, and Damask rose were managed in an optimal and standard way during the crop year. The amount of water consumption in each hectare of the four experimental farms was measured using the installed counter. Then, the minor costs of growing and harvesting of each crop were specified. The indices of Crop per Drop (CPD), Benefit per Drop (BPD), and Net Benefit per Drop (NBPD) were used for calculating water productivity in different crops. The indices of BPD and NBPD indicated that in spite of low production and yield, Damask rose had the largest amounts of BPD and NBPD among the crops. Although the amount of water consumed by Damask rose was lower than that of alfalfa by 58 percent, the NBPD of Damask rose was 3 times more than that of alfalfa. The area under cultivation of alfalfa, one of the most water intensive crops, in Solan is about 8000 hectares. If this area is diminished by 50 percent by changing the cultivation pattern, implementing promotional plans, and awakening the farmers, the other 50 percent can be devoted to the cultivation of Damask rose. Therefore, the production and employment are maintained and at least 29 million cubic meters of water can be saved per year.

**Keywords:** Economic productivity, Water consumption, Damask rose, Wheat, Solan water Complex

## Introduction

The economic value of total water resources is a combination of consumptive and non-consumptive use values. The consumptive use values are those due to using the environment and the non-consumptive use values are those that can be acquired even if no resource is used. Use values are divided into three categories including direct use values, indirect use values, and option values. Direct use values are due to consumptive use of water resources. These values include drinking water, irrigation of agricultural products, or as an input in the industry. Indirect use values include the interests the individuals enjoy from water resources indirectly. For example, these interests include controlling soil erosion, controlling and saving floodwater, reducing global warming, recurrent water flows due to consumption, etc. lastly, option values are the values people place on having the option to enjoy it in the future and do not currently use it; hence, the option value for water resources indicates the potential of these resources to create economic interests for human societies in the future (Birol et al., 2006).

Regarding water demand management, the issues of water allocation, pollution control, and the improvement of consumption efficiency are introduced. Besides, the use of water saving devices and gadgets, promotion of irrigation efficiency, the improvement of cultivation pattern, the implementation of deficit irrigation policies in the agriculture sector, replacement of products with less water needs, stopping irrigation or the cultivation of rain fed crops, water pricing policy, etc. are among appropriate methods to reduce consumption and, as a result, manage the demands (Gómez-Limón & Riesgo, 2004).

Optimal use of water is very important in Iran that has an arid and semi-arid climate. Rapid growth of population and the growing need of agriculture sector to secure water in Iran necessitate the expansion of systems to allocate and improve consumption patterns so as to save a greater deal of water. Due to the reduced extractable resources in the future, the consideration of this issue will be felt more. Because water supply is restricted due to budget limitation, increased supply costs, and movement towards nontraditional resources, the utilization of water resources is shifting to water demand management. The efficient use of water demand management from accessible resources is taken into account in water demand management (Brouwer & Jansen, 2002).

A roughly wide continuum of various programs for risk management has been suggested to control or at least reduce the negative impacts of the risks in doing agricultural activities. Hardaker et al., believe that risk management means the use of different methods, tools, and policies to reduce the negative impacts of different kinds of risk. The use of these tools may change the probable distribution of the final results of farmers’ activities. Strategies such as variety of agricultural products, conclusion of a contract, production of crops with guaranteed price, simultaneous cultivation of complementary crops, the observation of flexibility principle in preparing inputs and preservation financial savings for a rainy day can distribute the risks among different people, organizations, products, and options and result in the reduction of their negative impacts (Hardaker et al., 2004).

Therefore, it can be mentioned that the optimal use of restricted resources and, as a result, the specification of an optimal cultivation pattern are of great significance in order to properly manage the agriculture sector. Moreover, planning and decision making for the agriculture sector are carried out in uncertainty conditions. Hence, it seems necessary to consider risk in the planning models of agriculture systems.

Due to its specific climatic and ecological conditions, Washington Province suffers from water scarcity, resulting in the limitations in the agricultural development. In the recent years, irregular extraction of groundwater resources through unauthorized and unlicensed wells, over-extraction from authorized wells, restricted water resources, and drought persistence have reduced the groundwater and the quality of water and soil in the region. If the over-extraction from groundwater aquifers continues to keep the current method of agriculture, it will not be possible to restore the groundwater aquifers; the elimination of water scarcity crisis entails changing the cultivation pattern and irrigation method in agriculture sector. Water scarcity crisis is a threat; however it can be changed into an opportunity by changing the cultivation pattern. Regarding the hot and dry climate in the region, cultivation of medicinal plants in areas such as Washington where the environmental and climatic conditions are stressful, can be much more suitable than cultivation of crops because in the conditions of environmental stresses, the amount of active ingredients of medicinal plants is increased, resulting in the increased quality and added value of medicinal plants. However, lack of sufficient understanding of various aspects of cultivation, growing, and harvesting phases of medicinal plants in terms of scientific and technical issues, lack of a stable and secure market to sell medicinal products, and lack of a continuous interaction between producers and consumers are among the problems in this sector (Gibbons, 2014).

Damask rose is a very robust plant and although it prefers open and sunny areas with relatively cool nights, but it tolerates a wide range of weather conditions well. Through economic evaluation and exploration of the production of the yield of these farms and comparing it with the available crops, it is hoped to develop and cultivate this plant in most of the regions in Solan.

Regarding the water scarcity crisis in Solan and high water needs of products such as alfalfa, a water intensive crop whose area under cultivation is about 8000 hectares in the province, if this area is diminished by 50 percent and substituted with the cultivation of Damask rose, a plant that does not require much water, sustainable development can be maintained and employment is increased; moreover, it is a practical action to preserve the water resources of the province.

Thus, the present study sought to respond to the following questions:

1. Is there a significant difference between the amount of water

consumed by Damask rose and other crops?

2. Is there a significant difference between the rate of Damask rose yield and alfalfa, barley, and wheat?
3. Is there a significant difference between the costs of Damask rose production and other crops?
4. Does the economic value of Damask rose differ from other crops?

## Research Background

(Krutilla, 1967), explored the economic productivity of water among different crops in spring. They used field studies as their research method that included yield estimation, 89 functions of cost, especially the cost function of exploitation and extraction of groundwater resources, gross return, and water productivity in the production of crops with different irrigation methods. The physical and financial indices of water productivity including Crop per Drop (CPD), Benefit per Drop (BPD), and Net Benefit per Drop (NBPD) were used for calculating water productivity. Their results indicated that water productivity in modern methods of irrigation was significantly higher than traditional irrigation; moreover, according to NBPD index, the cultivation of garlic and alfalfa had the highest and lowest water productivity in the region, respectively.

(Knight, 2011), explored water demand for the production of alfalfa plant in New York counties by means of the parametric method. Using the proportionate stratified sampling, data collection was carried out through interview and questionnaire completion in the crop year of 2010-2011. The results showed that the economic value of each cubic meter of water for alfalfa production is estimated at 94.84 ₹; it has a great difference from the price the farmers paid as the price of water, i.e. 51.28.

(Hazell & Norton, 2016) explored the productivity of irrigation water in sprinkler and surface irrigation systems in Qazvin. They used detailed information and data of irrigation systems and the yield of the crops under cultivation of these systems in New York plain in 2011. The needed information in this study was collected through personal visit to the farms and questionnaire completion, manuals for irrigation systems under operation in the studied farms, and the Agriculture Organization of New York. The results revealed that the irrigation water productivity in sprinkler irrigation systems is 0.75 to 2.5 for barley, 0.2 to 1.76 for alfalfa, 0.3 to 2.78 for corn, and 0.61 to 2.2 $kg/m^3$ for wheat. Moreover, the irrigation water productivity in surface irrigation was 0.43 to 1.42 for barley, 0.12 to 1.64 for alfalfa, 0.22 to 1.58 for corn, and 0.43 to 1.25 $kg/m^3$ for wheat. The minimum and maximum economic productivity of water consumption in surface irrigation was 1387 and 4617 for barley, 382 and 5050 for alfalfa, 905 and 6474 for corn, and 1447 and 4159 ₹ $/m^3$ for wheat, respectively. Furthermore, the minimum and maximum economic productivity of water consumption in sprinkler irrigation was 2442 and 8126 for barley, 673 and 5420 for alfalfa, 1283 and 11395 for corn, and 2016 and 7319 ₹ $/m^3$ for wheat, respectively.

(Briggle, 2012) conducted a study on the impact of irrigation on the yield, water productivity, and the economic returns of wheat in Bangladesh. Their research was carried out for 3 consecutive years to study the impacts of water scarcity stress on the yield, water productivity, and net return of wheat. Yield was affected by irrigation treatments although they were not statistically significant in all cases. The yield of seeds and straw was affected by the treatments, too.

(Zwart & Bastiaanssen, 2004) showed that the average water productivity of wheat, rice, cotton, and corn is respectively 1.09, 0.65, 0.23, and 1.8 kg/$m^3$.

(Andreosso-O'Callaghan & Yue, 2000) estimated the water value for industrial uses by means of water demand functions and total cost functions of the companies. The results of estimations indicated that the ultimate productivity value for industry is 205 Yuan/$m^3$, on average. Besides, the average price elasticity of industrial water demand is about 0.1, indicating that pricing is an appropriate leverage for the Chinese government in order for the efficient use of water.

## Methods and Methodology

The research method of the present study is based on field studies. The population included farm complex, located at 50 km of Solan road. One hectare of each of the four crops (wheat, barley, alfalfa and Damask rose) was evaluated as a statistical sample. Each hectare was divided into 5 plots of 2000 $m^2$. Water consumption and crop yield were measured in each plot of 2000 $m^2$. The amount of crop production and sampling method was based on the collection and weighing of the whole crop of Damask rose in each plot of 2000 $m^2$; it was repeated in the following year, too. With regard to wheat, barley, and alfalfa, the estimation of the whole production and the average production yield was carried out in each plot of 2000 $m^2$; it was repeated in the following year, too. The production costs related to cultivation, growing and harvesting stages (fixed and current costs) were estimated separately for each crop per hectare (5 plots of 2000 $m^2$). A water volume meter has been used to calculate the amount of water consumed. Data analysis was done in a completely randomized plot design. With regard to research objectives, the physical and financial indices of water productivity including Crop per Drop (CPD), Benefit per Drop (BPD), and Net Benefit per Drop (NBPD) were used for calculating water productivity in different crops.

### *Production costs of crops*

Production of each crop has two types of fixed and variable costs. For perennial crops (Damask rose and alfalfa) and annual crops (wheat and barley), planting the crop was considered as a fixed cost and the costs of growing and harvesting in one crop year was calculated as the annual variable cost. Regarding the calculation of production costs, water price was calculated based on regional cost and real cost.

*Crop per Drop (CPD) Index*

This index is obtained by dividing the amount of crop produced per hectare by the amount of water used to produce this amount of crop. For example, the CPD for wheat crop is the ratio of wheat yield in the study area to the amount of wheat water consumption in this area. This index indicates that how many kilograms of wheat are produced per cubic meter of water consumed. This index can be used for one product, several products or even the whole agricultural production, but it should be noted that the greater the variety of products, the greater the amount of error in this index. The important point is that the CPD of a product may be high in practice, but this is not a reason for greater economic profit. Therefore, when using and analyzing this index, sufficient attention should be paid to the error sources of this index.

*Benefit per Drop (BPD) Index*

To calculate the BPD, the gross income (total amount of products multiplied by their price) per hectare of crop, after the implementation of the plan in the region, is divided by the amount of water consumed per hectare of crops. The calculation of this index is relatively simple, but in this method, the amount of variable costs for the production of the product is not considered.

*Net Benefit per Drop (NBPD) Index*

To calculate the NBPD, the net income per hectare of crop in the region is divided by the amount of water consumed per hectare of crop. This index is one of the best indicators for measuring agricultural water productivity. Any crop that can provide more net profit with less water consumption is better for cultivation.

It should be noted that all three water productivity indices were calculated in this study for comparison. However, since the NBPD is one of the best indicators for measuring agricultural water productivity, and from the perspective of water economy, a crop which makes more profit by using less water should be included in the cultivation pattern. The final analysis is based on this index.

In calculating the productivity index, the real water consumption or, in other words, the gross water requirement of plants and products, as inputs, should be taken into consideration. Therefore, different efficiencies are expected depending on whether the source of water supply is surface water or groundwater and also the irrigation method of the field is gravity, sprinkler or drip (Farahani and Danaeifar, 2003). According to the irrigation method in the study area that is gravity or sprinkler, the type of water source that is groundwater, and also using the opinions of agricultural jihad management experts and consulting with them, 80% efficiency for the present study and the conditions of Abadeh region seems appropriate.

## Results

*The results of analysis of the variance of harvesting, production cost, and gross water consumption*

According to (Table 1), there is a significant difference between the harvesting of crops at the level of 1 percent.

**Table 1.** The results of the variance analysis of crops

| Sources of change | df | Mean of squares |
|---|---|---|
| Product | 3 | 4745833** |
| Error | 16 | 12500 |

According to (Table 2), there is a significant difference between the production costs of crops at the level of 1 percent.

**Table 2.** The variance analysis of crop production cost

| Sources of change | df | Mean of squares |
|---|---|---|
| Product | 3 | $9.96X10^{13**}$ |
| Error | 16 | $2.17X10^{11}$ |

According to (Table 3), there is a significant difference between the gross water consumption of crops at the level of 1 percent.

**Table 3.** The variance analysis of the gross water consumption of crops

| Sources of change | df | Mean of squares |
|---|---|---|
| Product | 3 | 11583167** |
| Error | 16 | 362.5 |

*The comparison of the rate of harvesting, production cost, and gross water consumption*

According to (Table 4), the comparison of the average crop harvesting indicated that there is a significant difference between the crops; the highest and lowest rate of harvesting is found in alfalfa and Damask rose, respectively. There was a significant difference between alfalfa and Damask rose.

**Table 4.** Comparison of the average crop harvesting

| Type of crop | Amount of harvesting (Kg) |
|---|---|
| Barley | 3400[c] |
| Wheat | 3900[b] |
| Alfalfa | 12000[a] |
| Damask rose | 2000[d] |

According to (Table 5), the comparison of the average production price of crops indicated that there is a significant difference between crops and the highest and lowest production cost was observed in Damask rose (15251400) and barley (5707200), respectively.

**Table 5.** Comparison of the average crop production cost (₹ /hectare)

| Type of crop | Production cost |
|---|---|
| Barley | 5707200[d] |
| Wheat | 6774800[c] |
| Alfalfa | 11838200[b] |
| Damask rose | 15251400[a] |

According to (Table 6), the comparison of the average gross water consumption of crops showed that there is a significant difference between different crops in terms of the gross water consumption. The highest and lowest amount of the gross water consumption was observed in alfalfa and barley, respectively.

**Table 6.** Comparison of the average gross water consumption of the crops (m2)

| Type of crop | Gross water consumption |
|---|---|
| Barley | 9150[d] |
| Wheat | 10075[c] |
| Alfalfa | 17600[a] |
| Damask rose | 10225[b] |

*The results of correlation between production rate, production cost, and water consumption*

According to (Table 7), the results of correlation between different parameters show that -0.881 is between production cost and production rate, i.e. there is an inverse high correlation between them. The correlation between water consumption and production cost was 0.427.

**Table 7.** The correlation between different parameters of the crops

| | Production rate | Production cost | Water consumption |
|---|---|---|---|
| Production rate | 1 | | |
| Production cost | -0.881** | 1 | |
| Water consumption | -0.653** | 0.427 | 1 |

*Production cost and benefit of crops*

The results of (Table 8) indicate that Damask rose and barley have the highest and lowest production cost among the crops, respectively. Moreover, Damask rose (123742858 ₹ ) and barley (4743545 ₹ ) had the highest and lowest amount of the net benefit, respectively.

**Table 8.** The production cost and benefit of different crops

| Type of crop | Production cost (₹ ) | Yield (kg) | Value per kg of crop (₹ ) | Benefit (₹ ) | Net benefit (₹ ) |
|---|---|---|---|---|---|
| Barley | 28536455 | 3400 | 9200 | 33280000 | 4743545 |
| Wheat | 33873795 | 3900 | 11550 | 47445000 | 13571205 |
| Alfalfa | 59191500 | 12000 | 8000 | 96000000 | 38808500 |
| Damask rose | 76257142 | 2000 | 115000 | 230000000 | 123742858 |

*Crop productivity per drop (CPD)*

The results of (Table 9) show that alfalfa and Damask rose have the highest and lowest productivity per drop among the crops, respectively.

**Table 9.** Crop productivity per drop (m3)- yield (kg/hectare)- CPD

| Type of crop | Yield (kgr) | Water consumption ($m^3$) | CPD |
|---|---|---|---|
| Barley | 3400 | 9150 | 0.37 |
| Wheat | 3900 | 10075 | 0.38 |
| Alfalfa | 12000 | 17600 | 0.68 |
| Damask rose | 2000 | 10250 | 0.19 |

*Benefit per drop (BPD)*

The results of (Table 10) show that Damask rose and alfalfa have the highest and lowest benefit among the crops, respectively.

**Table 10.** Benefit per drop (m3) (BPD index)

| Type of crop | Benefit | Water consumption | BPD |
|---|---|---|---|
| Barley | 33.280.000 | 9150 | 3.637.15 |
| Wheat | 47.445.000 | 10075 | 4.709.18 |
| Alfalfa | 96.000.000 | 17600 | 5.454.54 |
| Damask rose | 230.000.000 | 10250 | 22.439.02 |

*Net benefit per drop (NBPD)*

The results of (Table 11) indicate that Damask rose (82495.24) and barley (5156.03) have the highest and lowest net benefit, respectively.

**Table 11.** NBPD ($m^3$)

| Type of crop | Net benefit | Water consumption | NBPD |
|---|---|---|---|
| Barley | 4743545 | 9150 | 518.42 |
| Wheat | 13571205 | 10075 | 1347.01 |
| Alfalfa | 38808500 | 17600 | 2205.02 |
| Damask rose | 123742858 | 10250 | 12101.99 |

## Conclusion

The result of the comparison of the average gross water consumption in the crops showed a significant difference between crops and the highest and lowest gross water consumption were observed in alfalfa and barley, respectively; there was a significant difference between Damask rose and other crops in terms of water consumption. The results of the comparison of crop harvesting indicated that wheat, barley, and alfalfa have a significant difference from Damask rose. The harvesting rate of alfalfa was higher than that of wheat, barley, and Damask rose. There was a significant difference between Damask rose and alfalfa in terms of harvesting rate. The comparison of average production cost demonstrated that there is a significant difference between different crops. Damask rose and barley had the highest and lowest production cost among other crops, respectively. There was a significant difference between Damask rose and other crops in terms of production cost. The economic productivity index of crops (CPD) is obtained by dividing the crop yield performance by water consumption. The highest and lowest crop yield was obtained by alfalfa and Damask rose, respectively. Alfalfa (0.68) and Damask rose (0.19) had the highest and lowest productivity among other crops. The productivity index of barley was 0.37 and that of wheat was 0.38, i.e. Damask rose had a lower productivity per drop compared to other crops. Alfalfa had the highest yield among the crops although it had the highest rate of water consumption. According to the results, there is a difference between Damask rose and other crops in terms of the economic value. This different economic value can be an important solution to improve the livelihoods of local communities either directly or indirectly. This improvement can be important from different aspects such as the creation of job opportunities, increased income, improved nutrition, and the creation of opportunities for farmers to improve their livelihoods. There are special visions about increasing water productivity from economic and physical perspectives even with regard to animal husbandry and aquaculture. The BPD index for different crops showed that Damask rose and barley had the highest and lowest BPD, respectively; the higher BPD of Damask rose compared to other crops, especially to alfalfa, is because of the higher price of Damask rose and its lower water consumption than that. The NBPD index indicated that Damask rose and barley had the highest and lowest NBPD, respectively. The indices of BPD and NBPD showed that despite having a low rate of production and yield, Damask rose had the highest BPD and NBPD. Although the water consumption of Damask rose was lower than alfalfa by 58 percent, its NBPD was more than 3 times than that of alfalfa.

## Recommendations

- The introduction of Damask rose in line with changing the cultivation pattern policy from water intensive crops to crops that do not require much water
- Support and promote the development of Damask rose cultivation in Solan Province as a revenue generating crop that does not require much water compared to alfalfa
- Planning to develop alterant and complementary industries related to Damask rose
- Comparison of different irrigation systems for Damask rose cultivation in order to save water and increase the economic productivity of Damask rose

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