Investigating Water Use Efficiency of Potato in Chaharmahal and Bakhtiari Province Compared to Alternate Furrow Irrigation Method, Iran

Mohammad Shayannejad¹, Kaveh Ostad-Ali-Askari²,³, Mahboubeh Amoushahi-Khouzani³, Saeid Eslamian⁴, Vijay P. Singh⁵, Nicolas R. Dalezios⁶

¹,⁴Water Engineering Department, Isfahan University of Technology, Isfahan, Iran.
²Department of Civil Engineering, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran.
³Water Engineering Department, Science and Research Branch, Islamic Azad University, Tehran, Iran.
⁵Department of Biological and Agricultural Engineering & Zachry Department of Civil Engineering, Texas A and M University, 321 Scoates Hall, 2117 TAMU, College Station, Texas 77843-2117, U.S.A.
⁶Laboratory of Hydrology, Department of Civil Engineering, University of Thessaly, Volos, Greece & Department of Natural Resources Development and Agricultural Engineering, Agricultural University of Athens, Athens, Greece.

*Corresponding Author: Dr. Kaveh Ostad-Ali-Askari, Department of Civil Engineering, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran. Emails: koa.askari@khuisf.ac.ir, kaveh.oaa2000@gmail.com

Abstract: In order to achieve optimal use of water resources in agriculture and to increase water use efficiency, it is necessary to apply robust irrigation management particularly in surface methods. Deficit irrigation is an irrigation management method in which a technical—engineering method is used in order to supply the required water for irrigated plants so that the maximum use of water unit will be achieved. There are significant methods to apply deficit irrigation in surface irrigation and one method which has recently been used is alternate furrow irrigation. In this method in every round, the furrows are irrigated alternately; the water is collected in one side of planting rows and the wetting pattern will progress laterally as far as it can supply the required wet for unirrigated furrows. The more this progress, the more successful is irrigation. Therefore, this method is highly applicable in the soils with high degree of permeability and trivial slope because these characteristics would lead to increase in lateral progress. In this paper, effect of alternate furrow irrigation in a potato farm on water use efficiency was investigated through randomized complete block design (RCBD). The results showed that this method would significantly increase water use efficiency. Moreover, in this study the water use efficiency of potato in Charahmahal and Bakhtiari Province was compared with the values obtained from alternate furrow irrigation method. The results indicated that water use efficiency in fixed alternate furrow irrigation had significantly difference with other methods. And this efficiency was higher than the efficiencies in different parts of the province.

Keywords: Alternate furrow irrigation, Water use efficiency.

1. INTRODUCTION

Potato is in category of strategic crops and because of starch and protein it has special nutritional value. According to Agricultural Statistics 1996, it covers approximately 145000 acres of cultivated lands in Iran, and total production of this crop exceeds 3 million tons (average 20 ton per acre). Potato is cultivated in most of the provinces including Ardebil, Azarbaijan, Hamadan, Isfahan, Tehran and Chaharmahal and Bakhtiari. Today, deficit irrigation is considered a method to optimal use of water resources in agriculture. This issue needs consideration in every plant and each region. For the past decades, the debate regarding this problem has continued and has attracted the attention of many researchers. Here are some examples:

English et al (1990) cultivated the wheat under center pivot irrigation system during 9 years and concluded that: firstly, production function is quadratic and cost function is a linear function. Secondly, under deficit irrigation condition, profit per surface area unit was 25% less than full irrigation whereas profit per consumed water unit under deficit irrigation was 14.5% more than full
irrigation. Thirdly, when there is land limitation and abundance of water, the full irrigation will not lead to maximal profit. Fourthly, there is a depth of consumed water in which profit (net income) resulted from it would be equal to full irrigation profit. In this study, it was obtained 35cm (equivalent to 57% depth of full irrigation). Stegman et al. (1990) indicated that although short-term water stress during early flowering may result in flower and pod drop in the lower canopy, increased pod set in the upper nodes compensates for this where there is a resumption of full irrigation. Sepaskhah and Kamgar Haghighi (1997) investigated deficit irrigation on sugar beet in Shiraz (in Iran, other studies on deficit irrigation have been conducted on crops such as wheat or sorghum but they are not included here for brevity). They applied deficit irrigation under method of alternate furrow irrigation. They used split plot as statistical plan in which irrigation method was considered as primary treatment and irrigation round as secondary treatment. The irrigation methods were as follow: normal furrow irrigation, fixed alternate furrow irrigation, and variable alternate furrow irrigation (in this method the furrows which are irrigated in one round, will not irrigate in the next round). They concluded that of these methods, the variable alternate furrow irrigation had the most water use efficiently.

Hengler et al (2000) applied deficit irrigation on cotton through subsurface drip feed irrigation in Texas. They used drip irrigation tapes alternately in planting rows to achieve deficit irrigation. Shock and Filbert (2000) examined deficit irrigation on different varieties of potato in Oregon State. They used split plot as statistical plan and irrigation treatments and varieties were acted as primary and secondary plots respectively. On deficit irrigation plots, the irrigation was performed when soil suction reached 0/6 atmosphere and depth of irrigation was considered equal to plant consumption. Krida (2000) obtained sensitivity factor of crop to water stress for different agricultural plants in Turkey using production functions for different crops and under different conditions. The results indicated that if irrigation was performed only in shoot growth stage, the mentioned factor would be less than when it was performed in flowering stage. The more this factor, the more sensitive the plant is to water stress. And it depends on type of plant, type of variety, irrigation method and growth stage or stages in which irrigation is applied.

2. MATERIAL AND METHODS

This research was conducted on potato (Marphona) in research center of Chaharmahal and Bakhtiari province located in Shahrekord in 2004 as follow:

The statistical plan was randomized complete block design (RCBD) with three treatments of furrow irrigation (normal, fixed alternate, variable alternate) and four irrigations. Overall, 12 plots in 4.5 *10 m are created and in each plot it is constructed six furrows with width 0/75 m length of 10m. During early days of June, the potatoes were cultivated on stacks with 30cm interval and in depth of 10 cm. the distance between plots was determined 1m. After germination, irrigation treatments were applied and volume of irrigation water for each furrow and lack of soil moisture relative to agricultural capacity was calculated by installing plaster blocks in root depth and measured by a meter. During shoot growth, the chemical fertilizers were used if necessary. The crop was harvested toward end of September. Finally, having determined volume of consumed water and amount of the yields, the water use efficiency was calculated and compared with other values in different parts of the province.

3. RESULTS

The values of water use efficiency (according to total weight of the yield) for different treatments and analysis of variance table are presented in table 1 & 2.

<table>
<thead>
<tr>
<th>Irrigation Treatment</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (N)</td>
<td>2/47</td>
<td>2/98</td>
<td>2/91</td>
<td>3/13</td>
<td>2/87</td>
</tr>
<tr>
<td>Fixed alternate (F)</td>
<td>3</td>
<td>2/95</td>
<td>3/73</td>
<td>3/84</td>
<td>3/38</td>
</tr>
</tbody>
</table>

Table2: Results of Analysis of variance for water use efficiency

<table>
<thead>
<tr>
<th>Source of change</th>
<th>Degree of freedom</th>
<th>SS</th>
<th>MS</th>
<th>FS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block</td>
<td>3</td>
<td>0/8718</td>
<td>0/2962</td>
<td>3/67</td>
</tr>
</tbody>
</table>
According to the table 2 and F- statistical distribution it is concluded that the difference between treatments is significant in 5% level. Therefore, the alternate furrow irrigation leads to increase in water use efficiency. In this method, because of low level of consumed water compared to normal irrigation method, the area under cultivation could be increased.

The values for area under cultivation, performance and water use efficiency of potato during 2003 and 2004 in different parts of the province are presented in tables 3 & 4.

### Table3: Conditions of potato cultivation in different parts of the province in 2003

<table>
<thead>
<tr>
<th>Region</th>
<th>Area under cultivation (acre)</th>
<th>Production (ton)</th>
<th>Performance (kg/acre)</th>
<th>Water use efficiency (kg/sq. m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shahrekord</td>
<td>1754</td>
<td>45280</td>
<td>25815</td>
<td>2/15</td>
</tr>
<tr>
<td>Broujen</td>
<td>2359</td>
<td>61741</td>
<td>26173</td>
<td>2/18</td>
</tr>
<tr>
<td>Farsan</td>
<td>24</td>
<td>676</td>
<td>28167</td>
<td>2/35</td>
</tr>
<tr>
<td>Kouhrang</td>
<td>323</td>
<td>7414</td>
<td>22954</td>
<td>1/91</td>
</tr>
</tbody>
</table>

### Table4: Conditions of potato cultivation in different parts of the province in 2004

<table>
<thead>
<tr>
<th>Region</th>
<th>Area under cultivation (acre)</th>
<th>Production (ton)</th>
<th>Performance (kg/acre)</th>
<th>Water use efficiency (kg/sq. m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shahrekord</td>
<td>2793</td>
<td>75683</td>
<td>27097</td>
<td>2/26</td>
</tr>
<tr>
<td>Broujen</td>
<td>3804</td>
<td>61741</td>
<td>26173</td>
<td>2/16</td>
</tr>
<tr>
<td>Farsan</td>
<td>35</td>
<td>676</td>
<td>28167</td>
<td>2/14</td>
</tr>
<tr>
<td>Kouhrang</td>
<td>420</td>
<td>7414</td>
<td>22954</td>
<td>1/67</td>
</tr>
</tbody>
</table>

### Figure1. Comparison of water use efficiency in different parts the province and alternate furrow irrigation method.

According to Figure 1, it is concluded that alternate furrow irrigation method has significant effect on increase of water use efficiency. This method increases the efficiency approximately 1.5 times and thus, the gross income will be increased as well. Given the fact that the consumed water in alternate furrow irrigation is half of the consumed water in normal method, therefore the area under cultivation could be increased up to 2 times. Moreover, the figure 1 suggests that fixed alternate furrow irrigation method is better than variable method. This method is easier to use too.

### REFERENCES

In this study, the water use efficiency of potato in Chaharmahal and Bakhtiari Province was compared to an alternate furrow irrigation method. The research findings suggest that the alternate furrow irrigation method can improve water use efficiency, which is crucial in regions with limited water resources. The study was conducted in the Isfahan Province, Iran, and the results can be applied to other agricultural regions in similar conditions.

Literature Review:

Investigating Water Use Efficiency of Potato in Chaharmahal and Bakhtiari Province Compared to Alternate Furrow Irrigation Method, Iran


Investigating Water Use Efficiency of Potato in Chaharmahal and Bakhtiari Province Compared to Alternate Furrow Irrigation Method, Iran

Ed. by Eslamian S. and Eslamian F., Francis and Taylor, CRC Press, USA, 375-386.


Investigating Water Use Efficiency of Potato in Chaharmahal and Bakhtiari Province Compared to Alternate Furrow Irrigation Method, Iran


Investigating Water Use Efficiency of Potato in Chaharmahal and Bakhtiari Province Compared to Alternate Furrow Irrigation Method, Iran


Investigating Water Use Efficiency of Potato in Chaharmahal and Bakhtiari Province Compared to Alternate Furrow Irrigation Method, Iran


Copyright: © 2018 Authors. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.