



Original Article

## The Impacts Economic Analysis of Deficit Irrigation and Integrated Application of Biological Fertilizers on Cultivation of Borage in Iran

Enayatollah Tafazolli<sup>1\*</sup>, Yaghoob Zeraatkish<sup>2</sup>, Seyed Nematollah Moosavi<sup>1</sup>

<sup>1</sup>Islamic Azad University, Marvdasht Branch, Marvdasht, Iran

<sup>2</sup>Islamic Azad University, Science and Research Branch, Tehran, Iran

Article History: Received: 05 April 2015/Accepted in revised form: 11 February 2016

© 2013 Iranian Society of Medicinal Plants. All rights reserve

### Abstract

Experiment was conducted as split plot in a randomized complete block design with three replications in Kermanshah to shed lights on economic analysis of deficit irrigation and integrated application of biological and chemical fertilizer son cultivation of medicinal plant Borage (*Borago officinalis* L). Irrigation tritments include: a) 30% less water than crop requires invegetative, b) inreproductive,c) in vegetative+reproductive and d) control (100% crop water requirement). Fertilizer treatments include applying 100% chemical fertilizer, 50% chemical fertilizers+biological fertilizers and 25% chemical+biological fertilizers. The results showed that grain yield was decreased under low irrigation. Low irrigation during vegetative and reproductive stages was found to 9.5 and 15.7%. Low economic efficiency of low irrigation water in vegetative stage was much more than reproductive and vegetative growth less up to 32.2% and 27.1% respectively. Integrated use of organic and chemical fertilizers by 50% and 25% alleviated cost of fertilizer to 38% and 63% respectively. Among deficit irrigation treatments, vegetative low irrigation treatment had net and gross income to low reproductive irrigation and low vegetative reproductive irrigation. The 50% chemical+bio fertilizers in comparison with 100% chemical fertilizers had higher net and gross income than vegetative, reproductive and vegetative+reproductive stages. The mentioned treatments compared with 100% chemical fertilizers improved benefit-cost ratio to control treatment and vegetative deficit irrigation 27% and 15.7% respectively. Based on results, vegetative deficit irrigation showed the better economic indexes in comparison with other treatments. However, in case deficit irrigation is necessary, the vegetative deficit irrigation and using 50% chemical biofertilizer are recommended.

**Keywords:** Borage, Economic analysis, Net income, Gross income

### Introduction

In order to achieve food security, agriculture production shall satisfy the needs of society in addition to adopting good policies and having adequate resources. Agricultural production requires two production factors: first, the physical factors of production such as land, seed, water, labor, etc., as prerequisite or qualitative and quantitative production and second, non-physical factors of production rooted in agriculture management and economy [1]. Considering the importance and the need of agriculture

management and economics this factor is considered as a sufficient condition to produce, good agricultural optimization. [2]. The full attention to the cost of inputs and the price of the product is essential. The main goal of producing more profit and reduce risk and minimize fluctuations in income and the availability of capital to exploit this is sustainable and therefore, in addition to optimal use of inputs, using methods and new technologies in the production has great special importance [1]. In this regard outreach methods to optimize resource consumption of chemical fertilizers combined with low irrigation

\* Corresponding author: Islamic Azad University, Marvdasht Branch, Marvdasht, Iran  
Email Address: etafazolli@yahoo.com

and fertilizer use is vital. Iran is characterized with arid and semi-arid country with limited water resources and abundant fertile agricultural lands [2]. The contribution of agriculture in total water extracted is 72 billion cubic meters (94%) and at the same time, the main production obstacle is the lack of water [3] of 37.5 million hectares of land found only 20 million hectares has irrigation potential, but however only 7.7 million hectares (21% of agricultural land) is under irrigation [4]. Undoubtedly, changing production per unit area to "production per unit of water consumed is necessary" in the management of water resources [6]. Deficit irrigation strategies in this regard have been served as an economic benefit, with the aim of maximizing the consumed water volume [6]. Low irrigation or water savings can be served as agricultural water management and assist in determining the optimum cropping pattern. Less irrigation water restrictions and a strategy of economic benefits step towards sustainable production of agricultural products knowingly allowed the plants receive less water than water requirements, to reduce their production. As a result, water savings could be used to increase the acreage and other applications [5,16]. English venas [7] reported that applying deficit irrigation on wheat crop water use led to savings and the volume of water savings can be raised from 92 to 143 acres under cultivation increased, this practice also improves net profit to 42%. Ghahreman and Sepaskhah [8] stated that the low frequency of irrigation in cotton and potato acreage of these crops can be increased to about 10 to 25 percent. They stated that those treatments are recommended that their benefit-cost ratio is 5:1. In the model proposed by English [9] to determine the economic analysis of low water, the total efficacy changes given to increased acreage and changes in net profit were studied and it has been reported that these changes the amount of water consumption and water use savings, water and irrigation costs, product prices and environmental conditions. In recent years the use of organic fertilizers to increase their impact on quantitative and qualitative characteristics of agricultural products has been studied. Biofertilizer are consisted of bacteria and fungi that are useful for any specific purpose, such as nitrogen fixation, plant growth regulator synthesis, insoluble compounds in the soil solution and phosphate ions, potassium, iron, etc. Usually these microorganisms are colonized around the

roots of plant in nutrient improving uptake and growth [10]. According to the mentioned issues and the importance of medicinal plants borage (*Borago officinalis* L.) in traditional medicine and medicinal products, the aim of this study is to evaluate the economic effects of deficit irrigation and integrated use of chemical fertilizers and biological cultivation of medicinal plants in the borage to determine the optimal level of deficit irrigation and amount of chemical fertilizers and economic aspects as well as to determine the profit.

## Materials and Methods

An experiment was arranged as split plot in a randomized complete block design with three replications in Kermanshah to shed lights on economic analysis of deficit irrigation and integrated application of biological and chemical fertilizer son cultivation of medicinal plant Borage. deficit irrigation include:a) 30% less water than crop requires in vegetative b) inreproductive,c) in vegetative+reproductive and d) control(100% crop water requirement). 30% less irrigation in vegetative, reproductive, vegetative+reproductive and control treatments and fertilizer treatments include applying 100% chemical fertilizers, 50% chemical fertilizers+biological fertilizers and 25% chemical+biological fertilizers. The use of chemical fertilizers, urea, triple super phosphate and potassium sulphate,100, 200 and 50 kg/ha were determined based on soil tests done in shiraz university soil lab.

In this experiment Nitroxin biofertilizer (containing nitrogen-fixing bacteria such as *Azotobacter brasilinum* and *Azospirillum crococom*) the rate of 2 liters per hectare [5] and organic fertilizer biophosphate (Containing soil phosphate solubilizing bacteria including *Pseudomonas bacillus* to 100 grams per hectare and seed mixing method was used. Each plot consisted of 5 to 6 meters long row, row spacing of 30 cm rows between distance 50 cm were considered. Irrigation was done 7 to 12 day as normal practice intervals during the growing season and soil moisture at field capacity was achieved. This was performed using polyethylene pipes and the volume of water used in irrigation was determined using flow meters. There was no effective rainfall during the growing season. To determine final yield, in full ripening stage, each plot was harvested about 2 m<sup>2</sup> and grain yield was

measured. To evaluate the economic deficit irrigation, fixed and variable costs, revenue and net profit according to the model proposed by English (10) and based on the information obtained in the course of the project area was calculated. Fixed costs include rent land for planting one-hectare borage, planting, 61000000 Rial respectively. Variable costs include water, irrigation and fertilizer costs, respectively. Price per cubic meter of water equal to 1500 dollars, the price of 2,000,000 rials per kg product borage seed was considered. Cost (C), gross income (R), net income (NP), economic output per cubic meter of water (ER), the volume of water savings (WE), the new land that can be cultivated in water savings (A) and Benefit-Cost Ratio (B/C) in each treatment was calculated using equations 1 to 6 [8].

$$B / C = \frac{R}{C} \quad \begin{array}{l} (1) C = FC + VC \\ R = Y \times P (2) \\ (3) NP = R - C \end{array}$$

$$(4) ER = \frac{NP}{WU}$$

$$(5) WE = WU_{FI} - WU$$

$$(6) A = \frac{WE}{WU}$$

Where FC: fixed cost, VC: variable costs, Y: yield P: Price of the product and WU: WUFI water consumption and water consumption by irrigation is complete. Statistical analysis of the scheme by using SAS software and means were compared using the least significant difference at the 5% level.

## Results and Discussion

**Table 1** Analysis of variance of the combined effects of deficit irrigation and use of biological and chemical fertilizer on economic indicators

MS								
cv	DF	Grain yield	Total cost	Gross income	Net income	Cost-benefit ratio	Water use efficiency	Equivalent land
replicates	2	336.36**	27526406 <sup>ns</sup>	138906250000 <sup>ns</sup>	282742527778 <sup>ns</sup>	0.45 <sup>ns</sup>	73562*	0.000001 <sup>ns</sup>
deficit	3	9316.2**	1.13**	3.709**	3.581**	7.09**	640841016**	0.24**
Error type 1	6	229.75	27389506.2	63906250000**	86539935185**	0.35*	4120	0.00002
Fertilizer (F)	2	2163.2	1.098**	8.681*	8.554**	1.36*	249087883*	0.00003 <sup>ns</sup>
D × F	6	650.78**	8560.2 <sup>ns</sup>	2.665*	2.67**	0.46*	65049748*	0.000011 <sup>ns</sup>
Error type 2	16	73.45	8448.11	1406250000	7030583333	0.004	7124	0.0000003

\*, \*\* represent significance at probability level of 1 and 5 %

## Grain Yield

Based on variance analysis, deficit irrigation treatments had significant effect on borage seed yield (Table 1).

The highest and lowest yield grain was observed in irrigated and non-irrigated vegetation + lowest low reproductive yield (Table 2).

Treatments had a significant effect on the performance of borage (Table 1). Meanwhile, the highest grain yield (144.22 kg/ha), using an integrated use of 50% chemical+ organic fertilizers and minimum (68.11 kg per ha) by applying 25% + chemical-organic fertilizers were observed (Table 2). Interaction between low levels of irrigation and fertilizer treatments on borage seed yield was significant (Table 1). Yield in low water and using 50% of chemical + biological fertilizers was max and under deficit vegetative irrigation + RS for 25% of chemical fertilizers + biological of grain production in the lowest level was recorded (Figure 1). The results suggest that grain yield decreased with low resonance. The highest yield was obtained under conditions of low water. J Katerji *et al* [11] reported that environmental stress such as reduced soil moisture deficits due to current photosynthesis, reduced seed weight and seed yield reduction eventually. Low compared to the low-water irrigation vegetative and reproductive stage was less effective final performance.

It seems the effects of deficit irrigation on grain yield is more effective in the reproductive stage of the life cycle as low stress leading to low stress vegetative and reproductive 37.4 and 18.8 percent yield loss (Table 2).

Shortening the duration of grain filling and ripening earlier under deficit irrigation treatments can be effective in reducing grain yield. The treatments also use a combination of 50%+organic fertilizers can improve performance somewhat lower than water resistance of plants to improve growth so that the grain yield of 50% + organic fertilizers 13.3 percent growth in stress conditions relative to the use of chemical fertilizers increased by 100 percent. It seems that in addition to promoting the integrated treatment plant tolerance to water deficit during the vegetative stage of chemical fertilizers was reduced to the half. Pankovic *et al* [12] performed a study on vegetables, sunflower, cow pea, maize and millet and it was found that the use of bio fertilizer and organic manure fertilizer increased soil absorption. The irrigation cost, fertilizer costs and total costs Among treatments the highest and lowest irrigation cost was attributed to low irrigation treatment (control) and deficit irrigation in vegetative and reproductive stages (Figure 2). Low-cost vegetative and reproductive irrigation water accounted for 9.5% and 15.7%, respectively compared to the control. Reduce irrigation costs and low total cost of irrigation has been reported by many investigators such as Arabzadeh and Tavakoli, [14], Soleimanipoor and Fardad, [15], MajdSalimi *et al.*, [1]. The highest and lowest cost of fertilizers and manure per hectare were obtained for the treatment of 100% of treatments, use of chemical fertilizers and the lowest 25% + organic fertilizers, respectively. Integrated use of organic fertilizers and chemical fertilizers by 50 and 25%, respectively 38% and 63% further reduce the cost of fertilizer per hectare (Table 3). Based on the analysis of data, treatments had significant effects on total costs (Table 2). The most common treatment for low total cost of irrigation and the use of chemical fertilizers (100%) and the lowest total cost of deficit irrigation treatments + vegetative reproduction and the use of chemical fertilizers, 25% of life + was obtained. In general, it can be said that deficit irrigation practices and use a combination of treatments to reduce costs.

#### Net income and Gross Income

According to the analysis of variance, net income and gross income were affected from borage seed treatments (Table 1). The highest and lowest net income and gross were obtained under low irrigation treatments (Table 2). Among low irrigation treatments, low irrigation had much more

net and gross income than low vegetative irrigation and low vegetative+reproductive irrigation treatments so that net and gross profit for low irrigation treatment was much more than low reproductive irrigation about 32 and 22% respectively (Table 2). Tavakoli and Fardad [14] also reported that maximum yield of beet was obtained in full irrigation but maximum net income was achieved by 31% reduction in water consumption. Arabzadeh and Tavakoli [14] reported that low irrigation in rice dry farming increased the ratio of gross benefit to cost, net income per unit of water. Among the treatments the highest net and gross income was attributed to combined treatment with 50% chemical and organic fertilizers. The net income and gross treated with 21 and 14 to 100% uniform application of chemical fertilizers improved (Table 3). The experiment was based on the results of the interaction of the pure and impure in low water conditions combined with the use of 50%chemical-biological fertilizers. It should be noted that the treatment 50% chemical organic fertilizers under low vegetative irrigation and vegetative +reproductive resulted in higher net and gross income than 100% application of chemical fertilizers. The positive effect of this treatment in deficit irrigation was much more in borage plant growth stage.

#### Benefit-Cost Ratio

Benefit to cost ratio represents the cost efficiency. Based on the analysis of experimental data with low irrigation and fertilizer treatments had significant effects on the cost-benefit ratio (Table 1). Though the highest benefit-cost ratio of full irrigation was observed (Table 2) However, the proportion of low water deficit irrigation treatments, growth was higher than other irrigations (Table 2). As a low cost-benefit ratio was 3.42 irrigation vegetative and reproductive growth deficit irrigation treatments, while the ratio of 2.66 and 2.18, were calculated respectively (Table 2). A study on tea plant also has the highest ratio of benefit to cost at least irrigation treatments were observed, although this treatment accounted for the highest cost [1]. Given means separation of economic indices, the highest benefit-cost ratio was recorded in treatments chemical organic fertilizers followed by 100% chemical fertilizers and 25% chemical organic fertilizers (Table 3). Also, due to the interaction of treatments combined use of chemical fertilizers+50% in the low-water

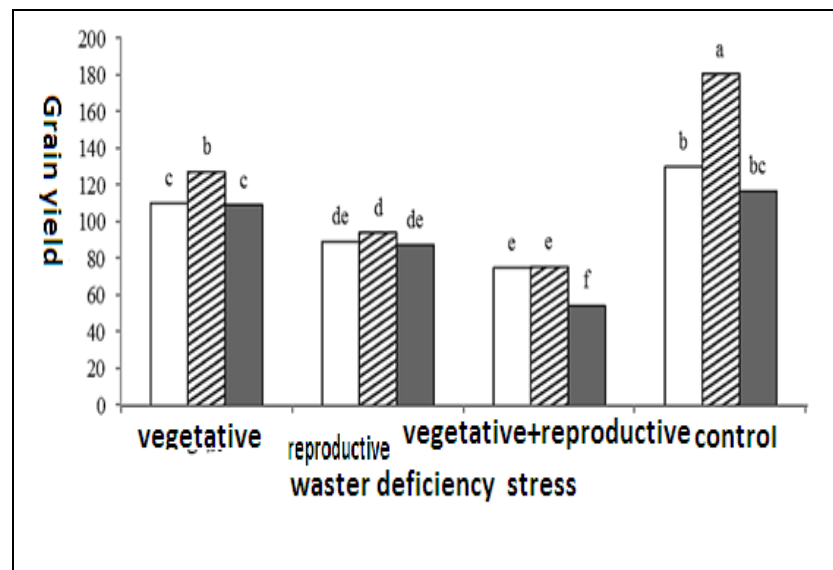
ecosystems and low water consumption is higher than the growth of the cost-benefit ratio was 100% chemical fertilizers. Benefit-cost ratio in the treatment of low-water and low-water vegetation and 15.7 percent were 27 to 100 percent of fertilizer consumption.

#### Water Savings and Economic Efficiency of Water

The volume of water consumed per hectare for deficit irrigation treatments vegetative, reproductive, reproductive and vegetative+low

water was 5556, 5502, 4616 and 6452 cubic meters per hectare respectively.

According to calculations by the volume of water savings compared to control deficit irrigation treatments vegetative, reproductive and vegetative +reproductive was found to be 886, 950 and 1836 cubic meters per hectare, respectively. Low irrigation treatment reduced water use efficiency to 13 and 14.7% than control. According to the results in terms of low irrigation efficiency in the highest, and then return to economic growth next in the irrigation water is low (Table 2).



**Fig. 1** Interaction of deficit irrigation and fertilizer on grain yield of borage

**Table 2** Comparison of mean low water effect on economic indicators in agriculture borage seed

treatments	Grain yield(kg/ha)	Grain yield(kg/ha)	Water use efficiency	Cost-benefit ratio	Net income(Rial)	Gross income (Rial)	Total cost (Rial)
Low vegetative irrigation	115.46b	115.46b	28587.02b	3.42b	159524222b	230700000b	71334000b
Low reproductive irrigation	88.98c	88.98c	19365.18c	2.66c	106948111 c	178008333c	71238000c
Vegetative and reproductive low irrigation	68.11d	68.11d	14132.07d	2.18d	65550444 d	135466667d	69909123d
irrigation control	142.22a	142.22a	32610.53a	4.21a	210692000a	283466667a	72663185a

**Table 3** Comparison of the mean effect of treatments on economic indicators in agriculture borage seed

Treatments	Cost-benefit ratio	Net income (Rial)	Gross income (Rial)	Total cost (Rial)	Grain yield (kg/ha)
101.05b					
100% fertilizer	22803.58b	3.00b	374000b	201589583b	72302713a
118.25a					
50% organic +chemical fertilizers	28602.04a	3.50a	164966417a	236070833a	71152759b
91.79c					
25% organic +chemical fertilizers	19615.49c	2.85c	112695667c	183070833c	70402759c

It should be noted that the economic efficiency of low irrigation water was highest followed by vegetative in deficit irrigation treatments. Water efficiency in vegetative treatment to reproductive and vegetative reproductive was more about 32.2 and 27% (Table 2). Given means separation of economic indices, the highest benefit-cost ratio was recorded in treatments chemical organic fertilizers followed by 100% chemical fertilizers and 25% chemical organic fertilizers (Table 3).

According to the results in terms of low irrigation efficiency in the highest, and then return to economic growth next in the irrigation water is low (Table 2). Based on the interaction of experiment can be seen that in 50% of the integrated treatment of chemical organic fertilizers the economic efficiency of water use by deficit irrigation on growth and lack of deficit irrigation treatments (control) were found (Table 2).

#### Equivalent Land Surface

According to results, deficit irrigation treatments increased equivalent surface so that low irrigation treatments equivalent surface was increased to 0.39 acres of land. This amount of deficit irrigation treatments on vegetative and reproductive low water was found to be 0.16 and 0.17 ha respectively (Table 2). This suggests that low irrigation treatment elevates cultivated area with the same water. This is reported by some researchers. English *venas* [8] reported that applying deficit irrigation on wheat crop water use led to savings and the volume of water savings can be raised from 92 to 143 acres under cultivation increased, this practice also improves net profit to 42%. Ghahreman and Sepaskhah [16] stated that the low frequency of irrigation in cotton and potato acreage of these crops can be increased to about 10 to 25 percent. Fardad and Golkar [4] reported that low irrigation can increase area under cultivation to three times. This is in line with present findings.

#### Concluding Remarks

In light of foregoing discussion, grain yield was decreased under low irrigation. Low irrigation during vegetative and reproductive stages was found to 9.5 and 15.7%. Low economic efficiency of low irrigation water in vegetative stage was much more than reproductive and vegetative growth less up to 32.2 and 27.1 respectively. Integrated use of organic fertilizers and chemical fertilizers by 50 and 25% alleviated cost of

fertilizer to 38% and 63% respectively. Among deficit irrigation treatments, vegetative low irrigation treatment had net and gross income to low reproductive irrigation and low vegetative reproductive irrigation. The 50% chemical + bio fertilizers in comparison with 100% chemical fertilizers had higher net and gross income at vegetative, reproductive and vegetative + reproductive stages. The mentioned treatments compared with 100% chemical fertilizers improved benefit-cost ratio in control treatment and vegetative deficit irrigation 27 and 15.7 respectively. Based on results, vegetative deficit irrigation showed the better economic indexes in comparison with other treatments. However in case deficit irrigation is necessary, the vegetative deficit irrigation and using 50% chemical+biofertilizer are recommended.

#### References

1. MajdSalimi B, Salavatian F. Effect of sprinkler irrigation frequencies on tea plant productivity qualitative characteristics of the economic evaluation. *J. water & soil*,2010;24:845-854.
2. Asadi H, Neishaboori MR, Siadat H. Evaluating the Wheat Response Factor to Water (Ky) in Different Growth Stages in Karaj. *Iranian, J. Agric. Sci.* 2003;34:579-586.
3. Hamzeii Y, Rahim F, Khoeizedeh G, Moghadam K. Response of potato cultivars with different amounts of water. *J. Agric Know*, 2005;15:65-75.
4. Fardad H, Golkar HR. Economic analysis branch deficit irrigation of wheat. *J. Agric Sci*, 2002;33:305-312.
5. Noorju A, BahghaeKia J. Effects of deficit irrigation on the quantity and quality of sugar beet in the mentioned area. *Sugar b mag*, 2006;22:53-66.
6. Fereres E, Soriano MA. Deficit irrigation for reducing agricultural water use. *J. Exper Bot*, 2007;58:147-159.
7. SalimiKoorosh M, Amiri E. Economic productivity analysis of water and nitrogen fertilizer for tea production with sprinlerirrigation system, *J. soil and water res conv*, 2014;3:37-45
8. English M, Nuss GS. Designing for deficit irrigation. *Irrig and drain*, 1982;108:91-106.
9. Sepaskhah AR, Boersma L. Shoot and root growth exposed to several levels of matric potential and NaCl induced osmotic potential of soil water. *Agron. J.* 1979;71:746-752.
10. English M. Deficit Irrigation: Analytical framework. *J. Irrig drain eng*, 1990;116:399-412.
11. Katerji N, Van Hoorn JW, Hamdy A, Mastrorilli M, Karama F. Salinity and drought, a comparison of their

- effects on the relationship between yield and evapotranspiration. *Agric Water Man*, 1998;36:45-54.
12. Pankovic D, Sakac Z, Kcvrosan S, Plesnicar M. Acclimation to long term Water deficit in the leaves of two sunflower hybrids: photosynthesis, electron transport and carbon metabolism. *J. Exp. Bot*, 1999;50:127-138.
  13. Tavakoli A, Fardad h. Effects of deficit irrigation on sugar beet and determine its function. MSc Thesis Irrigation and Reclamation Engineering, Tehran University. 1996.
  14. Arabzadeh A, Tavakoli AR. Economic Analysis of deficit irrigation in rice cultivation doing laundry. *J. Agric Eng Res*. 2006;7:99-110.
  15. Soleimanipoor A, Farhadi A, Bagheri. Economic Analysis of ethylene in Cucumber. *Res and cons*. 2004;65:58-66.
  - 16-Ghahraman B, Sepaskhah AR. Optimal allocation of water from a single purpose reservoir to an irrigation project with pre-determined multiple cropping patterns. *Irrig Sci*. 2002;21:127-137.