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The Effects of Water Stress and Harvest Seasons on Yield and Biochemical Compositions of *Aloe Vera* L

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***Abstract*:** *Aloe vera is one of the most economically important medicinal plants in many countries. In order to study the effects of water stress and harvest seasons on yield and biochemical compositions of Aloe vera. An experiment was conducted in research greenhouse of Faculty of Agriculture, Tarbiat Modares University, Tehran, Iran in 2013 and 2014. The experimental design was a randomized complete block design arranged in split- plot treatments included water stress (20, 40, 60 and 80% of the filed capacity (FC) and harvest seasons (summer, autumn and winter). the highest leaf and gel fresh weight were observed in the winter when plants were irrigated after depleting 40% of the filed capacity. In addition, the results indicated that the maximum aloin concentration and proline accumulation were obtained in the summer when the plants were irrigated after depleting 80 and 60 % of the FC, respectively. Leaves collected in winter and Irrigation after 80% depletion of the FC resulted in highest fructose and glucose content. Finally, irrigation after depleting 40% of soil water content was the best treatment for yield, also depleting 80% of soil water content was the best treatment for biochemical compositions at three different seasons.*

Keywords: *Aloe vera, Field capacity, Harvest Seasons, Yield, Biochemical Compositions.*

1. Introduction

Aloe vera L. (syn. *Aloe barbadensis* Miller.) is a fleshy perennial plant originated from Africa which is cultivated widely in warm and dry regions of the world. The plant belongs to Xanthorrhoeaceae family and includes more than 548 species [1, 2] used in pharmaceutical and food industries. Extracted gel and sap are also used commercially in cosmetics and alternative medicine industries [3]. Water is one of the most limiting factors in crop production worldwide [4]. It is also one of the main factors affecting plant growth and development as well as morphological and physiological adaptation to environmental conditions. It has been reported that crop yield, especially in arid and semi-arid regions, strongly correlates water availability of and seasonal changes [1]. Although *A. vera* is a drought tolerant species, its water requirement depends on soil water holding capacity [5]. It has been stated that *A. vera* growth and yield would decrease with reducing soil moisture content [6]. Considering the fact that the major components in *A. vera* are made of polysaccharides and aloin [7]. gel production and phytochemicals are highly affected by environmental factors and growth stages [8]. The objective of this study was to effects of water stress and harvest seasons on yield and chemical compositions of *A. vera.*

2. Material and Methods

The current experiment was carried out as a randomized complete block design arranged as a spilt- plot with four replications treatments included water stress (20, 40, 60 and 80% of the filed capacity (FC) and harvest seasons (summer, autumn and winter). The plants were grown in research greenhouse of Faculty of Agriculture,

Tarbiat Modares University, Tehran, Iran in 2013 and 2014. Mean, maximum and minimum temperatures in the greenhouse were 18, 33.3 and 15 ^{o}C with 65% relative humidity.

Four plants from each treatment and replicate were selected for harvest, the leaves (harvested 3 h after sunrise) were transferred to the laboratory where weight was determined, and then the parenchymatous tissue was manually removed to obtain the gel from each leave.

The analytical determinations in the gel were: Soluble sugars content and aloin by HPLC
Proline content was determined according to Bates et al. (1973) method by spectrophotometer at 520 nm.

3. Results and Discussion

3.1. Leaf And Gel Fresh Weight

Leaf and gel fresh weight were affected by water deficit stress and harvest seasons. Comparison of means showed that leaf and gel fresh weight increased with increasing water availability. The maximum value was observed when plants were irrigated after depleting 40% of the filed capacity. Whereas, winter season or 270days after imposing the treatments (Table 1).

TABLE I:: Means comparison of the influence of water stress and season harvest on yield of *A. vera* plants (n=4)

	Harvest Seasons					
	Summer		Autumn		Winter	
Water stress (FC %)[A]	fresh weight of leaf (g)	fresh weight of gel (g)	fresh weight of leaf (g)	fresh weight of gel (g)	fresh weight of leaf (g)	fresh weight of leaf (g)
20	238.09a	145.18[a]	342.26a	200.53[b]	467.35b	281.13[ab]
40	251.63a	146.08[a]	373.64a	224.41[a]	523.72a	321.06[a]
60	186.08b	113.14[b]	303.56b	181.76[b]	417.91b	270.1[b]
80	154.26c	95.5[b]	242.40c	149.53[c]	321.58c	183.11[c]
mean	207.51[C]	124.97[C]	315.46[B]	189.05[B]	432.64[A]	263.85[A]

Means within a column followed by the same letter are not significantly different at the level of 5%. Different capital letters amongst seasons show significant differences.[A] FC (%): Irrigation after depleting 20, 40, 60 and 80% of the filed capacity

3.2. Soluble Sugars

According to injection's standard, glucose and fructose were the only detected sugars in dried gel. As can be seen from Table 2 there was more fructose than glucose in samples. Results were indicating that the amount of fructose was much higher in *A. vera* plants compared to glucose. The highest fructose and glucose content was obtained when plants were irrigated after depleting 80% of the filed capacity in winter, respectively (222.84 and 80.35 mg g DW^{-1}).

3.3. Proline

Proline accumulation increased with increasing water stress (Table 4). In all seasons, the highest proline content was obtained when plants were irrigated after depleting 60% of the filed capacity. The highest and lowest proline accumulation was observed in winter and winter, respectively (Table 2).

3.4. Aloin Concentration

Aloin Water deficit stress and season had significant effect on aloin content *A. vera*. Aloin content increased with increasing water stress intensity. The highest aloin content was found in plants which were irrigated after depleting 80% of the field capacity in summer (20.64%). There was a negative correlation between yield and aloin content (table 2).

TABLE II:: Means comparison of the influence of water stress and season harvest on phyto and biochemical compositions of *A. vera* plants (n=3)

	Harvest Seasons											
	Summer				Autumn				Winter			
Water stress (FC%)[A]	Aloin (%)	Proline (mg [g FW]$^{-1}$)	Glucose	Fructose	aloin (%)	proline (mg [g FW]$^{-1}$)	Glucose	Fructose	Aloin (%)	proline (mg [g FW]$^{-1}$)	Glucose	Fructose
			mg g DW^{-1}				mg g DW^{-1}				mg g DW^{-1}	
20	16.12^{d}	0.69^{c}	58.37^{d}	27.76^{c}	13.58^{b}	0.64^{c}	43.66^{d}	24.36^{c}	11.96^{d}	0.68^{c}	55.93^{d}	33.74^{c}
40	17.48^{c}	0.73^{c}	67.75^{c}	29.95^{c}	15.77^{c}	0.59^{c}	68.48^{c}	24.87^{c}	13.15^{c}	0.66^{c}	70.23^{c}	35.73^{c}
60	18.96^{b}	1.28^{a}	94.87^{b}	36.83^{b}	17.65^{a}	1.15^{a}	83.71^{b}	29.75^{b}	16.22^{b}	1.1^{a}	100.69^{b}	42.64^{b}
80	20.64^{a}	1.17^{b}	214.43^{a}	74.36^{a}	18.65^{a}	0.92^{b}	155.68^{a}	66.62^{a}	17.99^{a}	0.99^{b}	222.84^{a}	80.35^{a}
Mean	18.30^{A}	0.97^{A}	108.86^{B}	42.23^{B}	16.41^{B}	0.83^{B}	87.88^{A}	36.40^{C}	14.83^{C}	0.87^{B}	112.42^{A}	48.12^{A}

Means within a column followed by the same letter are not significantly different at the level of 5%. Different capital letters amongst seasons show significant differences.[A] FC (%): Irrigation after depleting 20, 40, 60 and 80% of the filed capacity

5. Discussion

The results showed that leaf and gel yield affected by severe water stress and harvest seasons, this result is in agreement with findings of other researchers [6] have reported that low soil water potential decreases leaf and gel yield. The yield loss in winter harvest was more than the summer and autumn harvest that similar results have been reported by Delatorre-herrera et al., (2010) who studied the effect of soil moisture content on *A. vera* leaf yield. *A. vera* keeps its stomata open under water deficit stress conditions and continues CO_2 fixation [2]. *A. vera* plants under water restriction increased the levels of soluble sugars, soluble sugars improve water stress resistance and increase water use efficiency [5]. Soluble sugars are the most important compounds in *A. vera* gels [7]. Also, soluble sugars play a critical role in cell division and leaf growth. Previous findings indicate that soluble sugars would increase in warm seasons compared with other seasons [10]. On the other hand, proline as an important amino acid plays a pivotal role in plants grown under drought stress conditions, Increase in proline accumulation in water stressed plants has been reported by [5], in the current study *A. vera* plants under water restriction increased their levels of proline. Aloin is one of the most important compounds found in *A. vera* , It has been reported that aloin content would increase in warm seasons of the year [10]. This might be due to more light in summer and its effect on secondary metabolites synthesis, in most cases environmental stresses increase aloin content [8]. According to the previous results, aloin content in young leaves is more than old ones; in addition, aloin synthesis in summer is more than other seasons [8, 1].

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