

## INTRODUCTION

- Lettuce is an important crop which is cultivated worldwide and is one of the most widely consumed leafy vegetables highly appreciated for its taste and high nutritive value (Melajane et al., 2018).
- Plant biostimulants are a wide category of substances and microorganisms produced from organic and biological sources that may enhance crop quality and development, nutrient uptake, and/or resistance to biotic and abiotic stress (du Jardin, 2015).
- The aim of the present study was to evaluate the effect of deficit irrigation and biostimulant application on lettuce plants grown directly in soil under protected environment.

## METHODOLOGY

- Two cultivars were selected (one Romaine and one Batavia type)
- Young seedlings were transplanted directly in soil 7 weeks after sowing.
- Three irrigation treatments were applied based on field capacity (FC) of soil, namely Control (100% FC), I1 (70-75% FC) and I2 (46% FC). The cumulative supply of water were for 1940 m<sup>3</sup>/ha for full irrigation, 1400 mm m<sup>3</sup>/ha for 66% FC and 1070 m<sup>3</sup>/ha for (50-55% FC).
- Six biostimulant treatments were applied, namely NB (no biostimulants added), AGR109 (seaweed and plant extracts and microminerals), AGR110 (humic and fulvic acids), AGR111+112 (Si and Ca mobilization agent, Ca and Zn) AGR113 (Si) and AGR114 (mixture of 20 L amino acids), The biostimulants were provided by Agrology S.A., Greece.
- Chlorophyll content (SPAD index) and plant height were recorded at three sampling dates (one week after each biostimulant application), while yield and growth parameters (number of leaves, fresh and dry weight of leaves, leaf area (LA) and specific leaf area (SLA) were recorded at harvesting.
- The experimental layout was designed according to split-plot design, using the irrigation treatment as the main plot and the biostimulant treatments as the subplot for each of the tested cultivars.

## CONCLUSIONS

- It is necessary to conduct further research on both deficit irrigation and biostimulants application in order to provide useful data for better water use efficiency, as well as for the mitigation of water scarcity effects on crop yield.
- In our research, in most of the cases, the deleterious effects of water stress were alleviated by the use of biostimulants.
- The combinatory application of mild water deficit (I2) and biostimulants showed promising results as an innovative agronomic tool for sustainable water management, since significant increases in WUE values were recorded for both types of lettuce.

## RESULTS AND DISCUSSION

**Table 1.** Growth parameters of Batavia type lettuce.

Biostimulant	Irrigation regime	Fresh weight		Leaves No	LA (cm <sup>2</sup> )	Dry matter (%)	SLA (m <sup>2</sup> /kg)
		(g)	leaves (g)				
NB	Control	263.4abcA	237.7cB	16.7bAB	3421aA	6.0aB	57.1bcA
	I1	273.7aA	298.4aA	17.3cA	4084abA	6.5aB	62.6bA
	I2	106.1bB	103.1dC	14.2cB	1530aB	9.0aA	17.8cB
AGR109	Control	235.8bcB	215.7dA	17.5bAB	2988aA	6.2aB	47.9dA
	I1	298.5aA	217.0dA	18.8abcA	2916bA	6.7aB	44.3dA
	I2	139.1abC	133.7bB	16.5abcB	1965aB	8.2aA	24.7aB
AGR110	Control	225.3cB	214.6dB	17.3bB	3808aAB	6.5aB	60.4bB
	I1	303.3aA	291.2aA	19.7abA	4665aA	6.3aB	74.1aA
	I2	145.8abC	121.1cC	16.8abcB	1885aB	9.4aA	21.0bC
AGR111+ AGR112	Control	281.2abA	234.6cA	19.2aA	3011aA	5.8aB	52.0cdA
	I1	289.2aA	242.4cA	18.3bcA	3624abA	6.6aB	55.2cA
	I2	166.0aB	141.2aB	18.0abA	2037aB	8.1aA	25.0aB
AGR113	Control	315.4aA	313.7aA	18.3abAB	4439aA	6.0aB	76.1aA
	I1	291.9aA	265.5bB	18.7bcA	4608aA	6.2aB	76.9aA
	I2	136.8abB	131.2bC	16.2bcB	1921aB	8.4aA	23.4abB
AGR114	Control	259.9bcB	282.4bA	17.9abB	3821aA	6.4aB	60.2bA
	I1	317.9aA	258.6bB	20.9aA	3268abA	6.2aB	52.0cA
	I2	158.4aC	109.7dC	19.2aAB	1761aB	9.4aA	21.8bB

\*Different small Latin letters in the same column indicate differences between the means of different biostimulant products for the same irrigation according to Duncan Multiple Range test (p=0.05). Different capital Latin letters in the same column indicate differences between the means of different irrigation regimes for the same biostimulant according to Duncan Multiple Range test (p=0.05)

- Results revealed that the studied factors had a variable effects on leaf chlorophyll content and plant height during the course of the growth season for both cultivars.
- The mild water stress (I1) resulted in similar or higher yields compared to full irrigation, especially in the case of AGR109. AGR110 and AGR114 in Batavia lettuce and AGR110 in Romaine lettuce.
- The highest yields in Batavia lettuce were recorded for AGR113 (315.4 g per plant) and AGR114 (317.9 g per plant) at 100% FC and 66% FC, respectively, while AGR111+112 resulted in the highest yield at 46% FC. According to the literature, the use of seaweed extracts and protein hydrolysates considerably increased yield values of baby leaf lettuce plants cultivated under greenhouse conditions (Di Mola et al., 2020). Roupael et al. (2017), supported that protein hydrolysates may increase marketable yield of lettuce plants, especially under stress conditions which is in line with the results of our study recorded for AGR114 treatment.
- On the other hand, the highest yield in Romaine lettuce was recorded for the control treatment (NB; 297.5 g per plant) and AGR109 (292.6 g per plant) at 100% FC, while the same biostimulant (AGR109) resulted in the highest yield at I1 irrigation level. AGR113 treatment was the most productive at I2 irrigation level.
- A varied response to irrigation regime and biostimulant application was also observed for the number of leaves, LA and SLA values; although in most cases the application of biostimulants alleviated the negative effects of water stress.
- The highest water use efficiency (WUE) was recorded at I1 irrigation level for both lettuce types, especially in the case of AGR114 (WUE=36.3 kg/m<sup>3</sup>) for Batavia type and AGR109 (WUE=33.3 kg/m<sup>3</sup>) for Romaine type suggesting alleviating effects of biostimulants on crop yield under mild water stress that could improve the sustainable management of irrigation water.

## REFERENCES

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**Table 2.** Growth parameters of Romaine type lettuce.

Biostimulant	Irrigation regime	Fresh weight		Leaves No	LA (cm <sup>2</sup> )	Dry matter (%)	SLA (m <sup>2</sup> /kg)
		(g)	leaves (g)				
NB	Control	297.5aA	271.3bA	27.6abA	3818aA	5.9aB	64.9aA
	I1	229.6abB	241.1bB	24.6bA	3458aA	6.2abB	57.7bA
	I2	109.4bcC	93.9cC	23.5aA	1599bcB	9.4aA	17.5bB
AGR109	Control	292.6aA	274.9bA	25.5bcA	3969aA	6.0aB	66.9aA
	I1	291.3aA	271.8aA	29.3aA	3089aB	5.1bB	67.3aA
	I2	132.5abB	133.4aB	26.0aA	2188aC	8.2bcA	26.9aB
AGR110	Control	178.6bB	141.4dB	21.9bB	2195bcB	6.6aB	33.4cB
	I1	243.5abA	194.1dA	27.0abA	3015aA	7.2aB	41.9dA
	I2	115.8bC	88.7cC	20.1bB	1543bcC	8.6abA	18.2bC
AGR111+ AGR112	Control	160.2bA	127.2eB	27.3abcA	2039cB	7.1aC	28.6cB
	I1	199.4bA	199.3cdA	25.1abA	3045aA	6.0abB	50.8cA
	I2	72.7dB	54.9eC	18.9bB	1167cC	9.1abA	12.7cC
AGR113	Control	279.2aA	323.8aA	30.9aA	4354aA	6.2aB	73.1aA
	I1	246.8abA	204.9cB	27.0abAB	3415aB	6.2abB	68.2aA
	I2	146.2aB	105.6bC	24.6aB	1855abC	7.6cA	24.6aB
AGR114	Control	221.2abA	175.1cB	25.3bcA	2951bA	7.0aB	42.1bA
	I1	224.3abA	204.8cA	27.1abA	3136aA	6.7aB	48.4cA
	I2	83.5cdB	65.2dC	20.4bB	1150cB	9.2abA	12.5cB

\*Different small Latin letters in the same column indicate differences between the means of different biostimulant products for the same irrigation according to Duncan Multiple Range test (p=0.05). Different capital Latin letters in the same column indicate differences between the means of different irrigation regimes for the same biostimulant according to Duncan Multiple Range test (p=0.05)

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