The Effects of Biostimulant Application on Growth Parameters of Lettuce Plants Grown under Deficit Irrigation Conditions

Spyridon A. Petropoulos*, Christina Chaski

University of Thessaly, Department of Agriculture, Crop Production and Rural Environment, Fytokou Street, 38446, Volos, Greece
*Corresponding author: spetropoulos@uth.gr

INTRODUCTION

- In horticultural crops, including leafy vegetables, deficit irrigation and generally inadequate water supply have been reported to disrupt several morphological, biochemical and physiological processes leading to delayed plant development and reduced crop productivity (Rouphael et al., 2015).
- Biostimulants are capable to enhance flowering, plant growth, fruit set, crop productivity, and nutrient use efficiency especially under biotic and abiotic stressors (Colla and Rouphael, 2015). Their main components may be microelements, hormones, enzymes, proteins, vitamins, amino acids, and other compounds (Edmeades, 2002).
- Lettuce is an important crop which is widely consumed in various salad mixes. Therefore, its demand is constantly increasing since it contributes to the nutritional part of the diet (Kenny and O'Beirne, 2009).
- In the present study, we evaluated the effect of five biostimulant products with varied composition, including the control treatment with no biostimulant application, on field grown lettuce plants (*Lactuca sativa* L.: Romaine type cv. Doris) under deficit irrigation conditions.

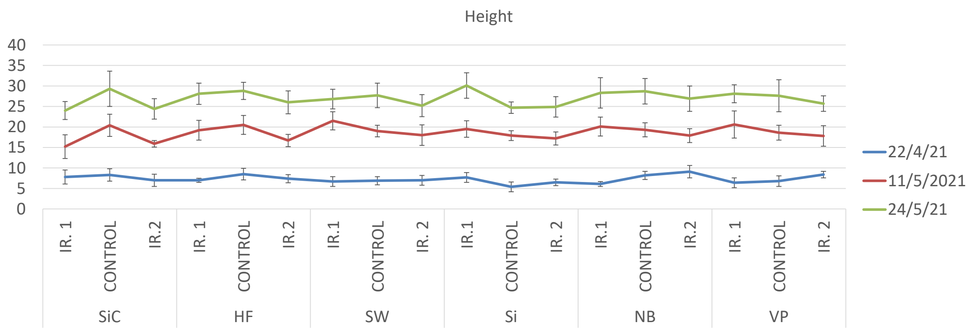
METHODOLOGY

- The experiment took place at the experimental farm of the School of Agricultural Sciences of the University of Thessaly. Lettuce (*Lactuca sativa* L.) plants from the Romaine type variety cv. Doris were transplanted on April 1, while harvest took place on May 27.
- In the present study five biostimulant products with varied composition were evaluated (e.g. seaweed extracts+macronutrients+amino acids (SW); humic+fulvic acids (HF); Si+Ca (SiC); Si (Si); vegetable proteins+amino acids (VP)) and control treatment (no biostimulant added (NB)). The biostimulants were provided by Agrology S.A., Greece. The frequency of biostimulant application was 5 days, 15 and 25 days after transplantation. The lettuces were under deficit irrigation conditions (Control treatment: rain-fed plants; I1: 50% of field capacity; I2: 100% of field capacity).
- All treatments were applied with foliar spraying except for biostimulants containing humic-fulvic acids (e.g. HF) and those contained CaO and SiO_2 + Calcium Utilization, Mobilization and Translocation Factor (e.g. SiC) which were applied through fertigation.
- The growth parameters tested were plant weight (aerial part), number of leaves, fresh and dry weight of leaves, leaf area index (LAI), specific leaf area (SLA), and SPAD index.

Image 1. Romaine type: cv. Doris

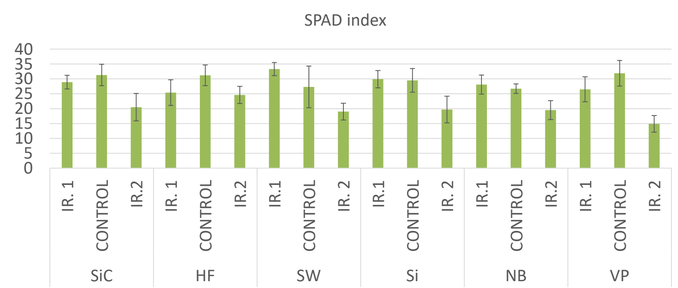
RESULTS AND DISCUSSION

Figure 1. Plant height fluctuation of lettuce plants at three sampling dates.



- After each application of the tested biostimulants, the height of lettuce plants was recorded as shown in Figure 1. According to this Figure, at all three dates it was observed that the biostimulants SiC and HF resulted in the highest plant height under rain-fed conditions. In addition, in case of deficient irrigation the biostimulant Si presented the highest plant height.
- In the last sampling date, the treatments of the SiC, SW, HF, NB as well as of the VP were are not statistically significantly different in the case of plants that were rain-fed.

Figure 2. SPAD index values of lettuce plants at harvesting.



- Figure 2 presents the chlorophyll content (SPAD index values) in lettuce leaves before at harvest. SPAD values increased when plants treated with vegetable proteins+amino acids (VP) at rain-fed conditions or seaweed extracts+macronutrients+amino acids (SW) at deficit irrigation (I1: 50% of field capacity).
- A noteworthy observation is that all biostimulants showed higher levels of chlorophyll under the rain-fed conditions compared to full irrigation as well as in relation to the treatment without biostimulants which yielded the highest levels of chlorophyll under deficient irrigation.

Table 1. Growth parameters of Romaine lettuces.

Romaine type: cv. Doris	IRRIGATION	PLANT WEIGHT	NUMBER OF LEAVES	WEIGHT OF LEAVES	LAI	% DRY WEIGHT	SLA
SiC	IR. 1	312.9±11.0Cik	44±1.8Aab	257.8±13.9Chi	4630.9±198.6Bi	6.9±0.6Bc	27.8±2.9Bhi
	CONTROL	429.1±12.8Abc	43.6±1.3Bbc	346.6±18.5Ac	5997.0±129.7Ad	7.4±0.7Ab	23.9±2.6Cl
	IR.2	348.1±8.1Bgh	36.2±1.3Ch	280.4±14.7Bfg	4808.8±109.0Bh	5.6±0.5Cf	32.1±1.9Ade
HF	IR.1	438.9±14.2Aab	37.6±1.0Cfg	355.5±12.4Abc	6472.7±193.1Ac	6.2±0.4Be	30.0±1.6Bf
	CONTROL	392.1±10.4Be	45.4±1.6Aab	322.5±9.2Bd	6375.5±120.8Ac	6.6±0.6Ad	31.0±1.0Bef
	IR. 2	311.5±8.4Cik	42±1.8Bcd	253.0±8.7Chi	4813.7±163.3Bh	5.5±0.5Cf	35.3±2.0Ac
SW	IR. 1	460.5±10.4Aa	42.6±1.9Ac	379.3±8.0Aa	6928.8±147.6Aa	6.4±0.7Bd	28.8±1.9Bgh
	CONTROL	323.6±18.8Chi	41.2±2.2Ade	260.4±12.9Bhi	5176.5±198.0Bg	6.9±1.4Ac	29.5±1.2Bfg
	IR. 2	440.1±14.4Bab	37.2±1.6Bfg	362.8±7.5Aab	6718.7±146.3Aab	4.2±0.5Ci	44.5±1.9Ab
Si	IR.1	451.2±12.8Aa	46.8±1.0Aa	357.3±7.3Abc	6542.8±109.4Abc	6.2±0.7Be	30.3±1.8Bf
	CONTROL	325.4±11.2Chi	43.2±1.8Bbc	267.5±6.4Bgh	5392.1±118.0Bf	8.1±1.7Aa	25.8±1.9Ck
	IR. 2	361.3±11.8Bfg	40.4±1.9Ce	283.4±5.2Bef	5167.4±124.9Bg	5.6±0.7Cf	33.1±1.7Ad
NB	IR.1	437.4±10.6Aab	42±1.4Acd	362.4±6.9Aab	6647.6±108.3Ab	5.0±0.3Bg	36.6±1.5Bc
	CONTROL	402.7±12.0Bde	36±1Bh	298.5±7.1Be	5905.4±173.6Bd	8.3±3.9Aa	26.8±1.2Cik
	IR.2	363.1±18.3Cf	36.8±1.6Bgh	284.8±5.9Bef	5209.1±134.9Cfg	3.8±0.8Ck	51.1±1.6Aa
VP	IR.1	381.3±13.8Bef	39.6±1.4Be	297.3±9.9Be	5125.4±152.7Bg	6.9±0.4Ac	25.4±1.5Ck
	CONTROL	417.9±19.1Acd	41.2±1.6Ade	324.9±6.7Ad	5679.3±109.1Ae	4.5±1.7Ch	46.8±2.0Ab
	IR.2	302.7±14.2Ck	37.4±1.10Cfg	245.6±1.0Ci	4495.3±105.8Ck	5.2±0.6Bg	36.1±1.4Bc

*Means in the same column of the same biostimulant treatment followed by different capital letters are significantly different according to Tukey's HSD test at p=0.05. Means in the same column followed by different capital letters are significantly different according to Tukey's HSD test at p=0.05.

- In general, the biostimulant with humic+fulvic acids (HF) yielded positive results in irrigation 1 in terms of plant weight, leaf weight, LAI as well as in rain-fed plants in the case of number of leaves and the dry matter content. On the other hand, the SLA was found to increase under full irrigation conditions.
- Equally positive results were presented by the vegetable proteins+amino acids (VP) in the case of rain-fed plants regarding the total number of leaves, total weight of leaves and the SLA values, while in the case of LAI and dry matter content the deficient irrigation (I1) recorded the best results.
- Total plant weight, weight of leaves and LAI were the highest under the half irrigation treatment (I1) for plants treated with the seaweed extracts+macronutrients+amino acids (SW) treatment.
- The number of leaves increased for the plants that received half irrigation (I1) and Si.
- The highest dry matter content and SLA values were recorded for plants that did not receive biostimulants (NB) under rain-fed or full irrigation (I2) conditions, respectively.
- Comparing the weight of leaves for each biostimulant and irrigation level, the results between the biostimulants HF, SW, Si as well as the NB treatment did not differ significantly in the case of deficit irrigation, as well SiC and VP in the case of rain-fed conditions.

CONCLUSIONS

- In summary, our results indicate that the biostimulant with seaweed extracts+macronutrients+amino acids (SW) combined with deficient irrigation (I1) presented the highest values in terms of plant weight, leaf weight, LAI as well as the chlorophyll content in lettuce plants.
- According to SPAD values, the biostimulants treatments performed higher values of chlorophyll in the case of rain-fed plants compared to those that were fully irrigated (I2). This finding indicates that biostimulants alleviated water stress which did not affect the plant's normal functions.
- Also, the biostimulant with Si presented the higher plant height under deficit irrigation (I1) as also the greatest number of leaves.
- In general, all biostimulants showed a better response to deficit irrigation and to rain-fed plants compared to those with full irrigation in almost all measurements.
- Each biostimulant may act differently depending on the irrigation conditions as well as on the tested species or variety. Therefore, continuous research on biostimulants as well as on deficit irrigation is needed in order to provide useful information regarding the water use efficiency of crops and the alleviation of the effects of water shortages on crop productivity.

REFERENCES

1. Colla, G.; Rouphael, Y. Biostimulants in horticulture. Sci. Hortic. 2015. 196, 1–2. doi: 10.1016/j.scienta.2015.10.044.
2. Edmeades, D.C. The effects of liquid fertilizers derived from natural products on crop, pasture, and animal production: a review. Australian Journal of Agricultural Research. 2002. 53: 965-976.
3. Kenny, O.; O'Beirne, D. The effects of washing treatment on antioxidant retention in ready-to-use iceberg lettuce. Int. J. Food Sci. Technol., 44 (6). 2009. pp. 1146-1156.
4. Rouphael, Y.; Franken, P.; Schneider, C.; Schwarz, D.; Giovannetti, M.; Agnolucci, M.; De Pascale, S.; Bonini, P.; Colla, G. Arbuscular mycorrhizal fungi act as biostimulants in horticultural crops. Sci. Hortic. (Amsterdam).2015. 196, pp. 91-108, 10.1016/j.scienta.2015.09.002.

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