

Electromagnetic Saline Water for Potato Growth and Water Relations [†]

Rawaa Akrimi ^{1,*} , Hichem Hajlaoui ¹ , Mounir Denden ² and Mahmoud Mhamdi ²

¹ Regional Center of Agricultural Research of Sidi Bouzid (CRRRA) PB 357, Sidi Bouzid 9100, Tunisia; hajlaoui2001@yahoo.fr

² Institut Supérieur Agronomique Chott Meriem, Sousse 4042, Tunisia; abidi_k@yahoo.fr (M.D.); mhamdimahmoud@yahoo.fr (M.M.)

* Correspondence: akrimirawaa2017@gmail.com

[†] Presented at the 2nd International Laayoune Forum on Biosaline Agriculture, 14–16 June 2022;

Available online: <https://lafoaba2.sciforum.net/>.

Abstract: Under water insecurity conditions, electromagnetic saline water may be experienced in irrigation. This study examined the impact of electromagnetic saline water on three potato varieties (Spunta, Bellini and Alaska). The trial includes three treatments; ground water (T1: 2.2 ms cm⁻¹ EC), saline water (T2: 8.5 ms cm⁻¹ EC) and saline water having undergone electromagnetic treatment (T3: 8.5 ms cm⁻¹ EC) with Aqua-4D. The results revealed an improvement in yield with T3 compared to T2. Spunta and Alaska were more responsive to T3 than Bellini. The approving response of Alaska was associated with effective adjustment with proline, while Spunta was more efficient in water use.

Keywords: electromagnetic treatment; growth; potato; salinity; water status



Citation: Akrimi, R.; Hajlaoui, H.; Denden, M.; Mhamdi, M. Electromagnetic Saline Water for Potato Growth and Water Relations. *Environ. Sci. Proc.* **2022**, *16*, 57. <https://doi.org/10.3390/environsciproc2022016057>

Academic Editor: Abdelaziz Hirich

Published: 16 June 2022

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1. Introduction

Water scarcity is a worldwide problem for agricultural production. Tunisia is currently considered a food-deficit nation with an increasing trend in food imports due to lack of rainfall [1]. Additional brackish water supply can meet crops' water needs [2]. In this way, the valuation of saline water is gaining increasing attention in many countries suffering from salinization [2]. Efforts are now intended at identifying inexpensive desalination techniques that respect the environment and ensure crop productivity. Physical treatment of saline water is a recommended option. However, most of the considered methods have some drawbacks regarding energy consumption, costs, long reaction time for the treatment etc. [3]. One advantaged strategy, adopted in agricultural irrigation, is electromagnetic treatment [4]. Magnetic treatment consists of passing water through an electromagnetic softener, where a Lorentz force is exerted on each ion which is in the opposite direction to each other. The redirection of the particles increases the collisions between ions and therefore precipitates formation. Additionally, magnetic fields decrease salt hydration and enhance salt solubility, coagulation and crystallization [5].

It was found that electromagnetic saline water improved plant growth, water and ions uptake [6]. In this context, an attempt was made to test whether electromagnetic saline water can alleviate salinity impacts on potatoes. We supposed that electromagnetic saline water may enhance plant-water relations, growth and yield. The applicability of this technique may be supportive in case of dry conditions of the Tunisian spring season.

2. Material and Methods

2.1. Experimental Details

The present investigation was carried out at the Regional Center of Agricultural Research of Sidi Bouzid (CRRRA-Sidi Bouzid), Tunisia during March–June season of 2014–2015. The experimental layout had a factorial arrangement on the basis of a randomized complete

block design with three replicates for each treatment. Potato varieties (Spunta, Bellini and Alaska) were irrigated with three irrigation treatments, T1 ground water (2.2 ms cm^{-1} electrical conductivity (EC)), T2 saline water (8.5 ms cm^{-1} EC) and T3 electromagnetic saline water (8.5 ms cm^{-1} EC). Electromagnetic treatment was done with an Aqua-4D[®] device which is composed of an electromagnet tube 60E (external diameter 65 mm, passage diameter 100 (DN 25) of 436 mm length and 60 L min^{-1} maximum flow, designed for transmitting the electromagnetic signals into the water and coupled to an electromagnet box (Command 60E Pro) intended to generate electromagnetic signals. The experimental area had a semi-arid climate with 200 mm mean precipitation and 1200 mm mean evapotranspiration. Crop water requirement (ETc) was estimated as reference evapotranspiration (ET0) multiplied by the potato crop coefficient (Kc).

2.2. Agronomic Parameters

Plant height (cm), fresh weight (FW) (g plant^{-1}) and dry weight (DW) (g plant^{-1}) were measured at the tuber initiation stage. The tuber weight per plant was determined at harvest.

2.3. Plant Water Status and Proline Determination

Leaf-relative water content (RWC) was calculated as follows:

$$\text{RWC} = \frac{\text{FM} - \text{DM}}{\text{TM} - \text{DM}} \times 100,$$

where FM is leaf fresh mass, DM is leaf dry mass determined after oven-drying at 75°C for 24 h and TM is the turgid mass of the leaf, determined after the immersion of the fresh leaves in distilled water for 12 h. The leaf water potential (ψ_w) was determined before sunrise using a pressure chamber (Scholander model M-1000). Photosynthetic water use efficiency (PWUE) was calculated as the ratio between the amount of CO_2 fixed by photosynthesis (Pn) to the transpiration rate (E): $\text{PWUE} = (\text{Pn}/\text{E})$.

Proline was extracted from the leaves using the sulphosalicylic acid method. A solution of the obtained extract, glacial acetic acid and ninhydrin (1:1:1) was incubated at 100°C for 1h and the absorbance was determined at 546 nm.

2.4. Statistical Analysis

The data were analyzed with SPSS 20 and the means were separated by the Duncan test ($p \leq 0.05$). The means were subjected to a three-way analysis of variance (ANOVA).

3. Results

3.1. Agronomic Traits

From Table 1, electromagnetic saline water (T3) increased the plant height (PH) of Spunta and Alaska by 34% and 41%, respectively. In addition, Alaska had the highest values of plant height. Hence, ANOVA results revealed that the PH was significantly affected by irrigation treatments and the variety factor. The T3 treatment enhanced the FW accumulation of Bellini and Alaska and the DW of Spunta and Alaska as compared to saline water (T2). The tuber yield varied significantly among the varieties and was increased with T3, but values do not exceed those obtained under ground water (T1).

Table 1. Changes in plant height (PH), fresh weight (FW), dry weight (DW) and yield of potato varieties (Spunta, Bellini and Alaska), for each irrigation treatment.

	Treatments	PH (cm)	FW (g Plant ⁻¹)	DW (g Plant ⁻¹)	Yield (g Plant ⁻¹)
Spunta	T1 (2.2 ms cm ⁻¹)	17.12 ± 0.95 ^a	868.36 ± 51 ^a	135.03 ± 11 ^a	1205.88 ± 41.86 ^a
	T2 (8.5 ms cm ⁻¹)	12.25 ± 1.34 ^b	772.36 ± 32 ^b	113.53 ± 8 ^b	918.72 ± 60.38 ^c
	T3 (8.5 ms cm ⁻¹)	16.50 ± 1.22 ^a	733.00 ± 40 ^b	131.16 ± 12 ^a	1016.97 ± 69.82 ^b
Bellini	T1 (2.2 ms cm ⁻¹)	18.75 ± 1.44 ^a	757.63 ± 51 ^a	141.2 ± 11 ^a	1088.00 ± 76.01 ^a
	T2 (8.5 ms cm ⁻¹)	9.52 ± 0.33 ^b	556.43 ± 32 ^b	100.13 ± 8 ^b	656.52 ± 75.41 ^c
	T3 (8.5 ms cm ⁻¹)	9.37 ± 1.18 ^b	482.30 ± 40 ^c	92.46 ± 12 ^b	865.50 ± 67.08 ^b
Alaska	T1 (2.2 ms cm ⁻¹)	22.50 ± 0.62 ^a	1136.13 ± 51 ^a	187.3 ± 11 ^a	1592.78 ± 92.62 ^a
	T2 (8.5 ms cm ⁻¹)	12.25 ± 0.72 ^c	675.66 ± 32 ^c	110.3 ± 8 ^c	914.24 ± 40.73 ^c
	T3 (8.5 ms cm ⁻¹)	17.37 ± 1.68 ^b	740.47 ± 40 ^b	144.16 ± 12 ^b	1380.08 ± 67.17 ^b
ANOVA	T	18.25 **	6.77 **	2.9 *	14.69 **
	V	52.25 **	1.7 ^{ns}	0.76 ^{ns}	29.36 **
	T × V	6.07 **	1.47 ^{ns}	0.54 ^{ns}	3.26 *

Different letters represent significant difference between treatments. T1: Ground water; T2: Saline water; T3: Electromagnetic saline water; T: Treatment; V: Variety. ns: not significant, * $p \leq 0.05$, ** $p \leq 0.01$.

3.2. Plant Water Status

The relative water content in potato leaves was in the order T1 > T3 > T2 (Table 2). The registered values of Ψ_w and PWUE increased with T3 in Spunta and Alaska. Alaska had the highest PWUE values, while Spunta had the highest RWC and Ψ_w . The RWC and Ψ_w were significantly influenced by water treatments.

Table 2. Changes in relative water content (RWC), water potential (Ψ_w) and photosynthetic water use efficiency (PWUE) of potato varieties (Spunta, Bellini and Alaska), for each irrigation treatment.

	Treatments	RWC (%)	Ψ_w (Bar)	PWUE
Spunta	T1 (2.2 ms cm ⁻¹)	88.37 ± 11.79 ^a	−1.37 ± 0.20 ^a	4.74 ± 0.20 ^a
	T2 (8.5 ms cm ⁻¹)	71.92 ± 5.54 ^b	−3.5 ± 0.40 ^c	4.29 ± 0.32 ^c
	T3 (8.5 ms cm ⁻¹)	88.20 ± 11.60 ^a	−2.15 ± 0.50 ^b	4.43 ± 0.36 ^b
Bellini	T1 (2.2 ms cm ⁻¹)	84.24 ± 22.04 ^a	−1.65 ± 0.14 ^a	4.43 ± 0.08 ^a
	T2 (8.5 ms cm ⁻¹)	71.83 ± 10.18 ^c	−3.25 ± 0.50 ^b	4.11 ± 0.31 ^b
	T3 (8.5 ms cm ⁻¹)	81.63 ± 23.01 ^b	−3.5 ± 0.65 ^b	4.05 ± 0.35 ^b
Alaska	T1 (2.2 ms cm ⁻¹)	84.82 ± 5.44 ^a	−2.25 ± 0.72 ^a	5.01 ± 0.34 ^a
	T2 (8.5 ms cm ⁻¹)	74.07 ± 4.09 ^c	−3 ± 0.50 ^b	4.17 ± 0.64 ^c
	T3 (8.5 ms cm ⁻¹)	82.84 ± 5.37 ^b	−2.75 ± 0.95 ^a	4.56 ± 0.58 ^b
ANOVA	T	29.78 **	13.40 **	0.18 ^{ns}
	V	1.74 ^{ns}	0.68 ^{ns}	1.14 ^{ns}
	T × V	0.96 ^{ns}	2.05 ^{ns}	0.31 ^{ns}

Different letters represent significant difference between treatments. T1: Ground water; T2: Saline water; T3: Electromagnetic saline water; T: Treatment; V: Variety. ns: not significant, ** $p \leq 0.01$.

3.3. Proline Content

The proline content in the Alaska leaves was set in the following decreasing trend T2 > T3 > T1 (Figure 1). However, there is no significant difference between T2 and T3 in Spunta and Bellini.

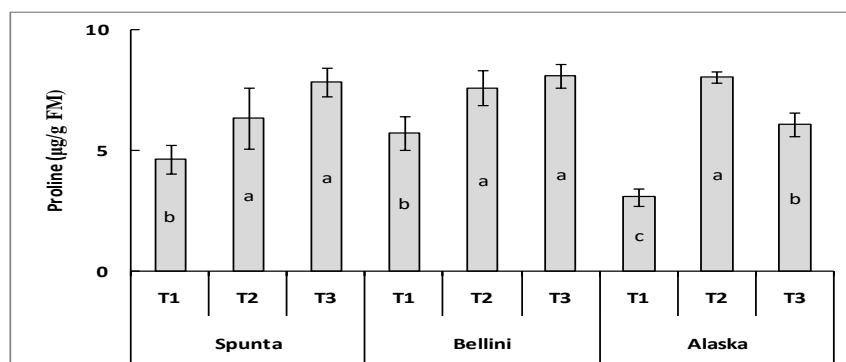


Figure 1. Changes in proline content of potato varieties under each irrigation treatment. Different letters indicate significant difference between treatments according to Duncan test ($p \leq 0.05$). T1: Ground water; T2: Saline water; T3: Electromagnetic saline water.

4. Discussion

Irrigation is an important determinant of potato development during the dry season of spring due to negligible rain. Moreover, the salinization of water resources makes the valuation of saline water very wanted. The present study showed that potato growth (plant height, FW and DW) and yield may be enhanced with electromagnetic saline water, depending on the assessed variety. These results agree with what [4,7]. The data of the present study may be due to the reduction of the soil sodium concentrations with electromagnetic water, by leaching it below the root zone [8]. Additionally, electromagnetic fields change the physical parameters of water (salt's solubility and electrolytic potential), which improved water and nutrient uptake, and therefore plant growth [7]. Spunta and Alaska were more responsive to electromagnetic saline water while Bellini plant height and DW were not affected by T3. This may be caused by high transpiration rate of Bellini, as demonstrates the low PWUE values of this variety. This is indicative of more susceptible water relations in Bellini. In fact, the RWC, Ψ_w and PWUE of Spunta and Alaska were higher than Bellini and were enhanced by T3. This result point to a stronger photosynthetic activity of Spunta and Alaska compared to Bellini [7]. The data also shows that the effective adjustment with proline may be a key criterion in maintaining growth under saline conditions of Alaska. Instead, the highest values of the Ψ_w and RWC of Spunta under T1 and T3 suggest that it was more efficient in water use.

5. Conclusions

Electromagnetic water improved the RWC and Ψ_w of Spunta and Alaska. Thus, plant height and fresh and dry biomass accumulation were enhanced. The yield of the three studied varieties was increased with T3 compared to untreated saline water. However, further research is required to ensure the safe use of electromagnetic saline water and to identify the exact mechanisms that direct plant response.

Author Contributions: R.A.; methodology, original draft preparation, H.H. and M.M.; editing, M.D.; supervision. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Regional Center of Agricultural Research of Tunisia.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Acknowledgments: The authors would like to thank Planet Horizons Technologies SA Ecoparc de Davala 9, 3960 Sierre, CH for supplying the Aqua-4D® 60E series device.

Conflicts of Interest: The authors declare no conflict of interest.

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