DOI: https://doi.org/10.17921/1415-6938.2024v28n3p394-400

Reorganized Water and Efficiency in Soybean Plant Nutrition

Água Reorganizada e a Eficiência na Nutrição de Planta de Soja

Danielly Wisoczynski De Sene[a]; Nathalia Dutra Lameu[a]; Leopoldo Sussumu Matsumoto[a]

[a]Universidade Estadual do Norte do Paraná. PR, Brasil
*E-mail: leopoldo@uenp.edu.br

Abstract

Most of the nutrients necessary for plant metabolism are absorbed by the soil solution. Thus, the translocation of these nutrients through water can benefit from the physical alteration of water molecules. The use of water reorganized in irrigation can be considered a physical factor that positively assists in absorption and assimilation of nutrients and consequently in plants' growth and development. The aim of this study was to evaluate the efficiency of reorganized water in plant nutrition in initial phase. The study was conducted in laboratory, and plants were grown in 700 mL plastic cups in a liquid medium formulated with natural (nRW) and reorganized (RW) water, with addition of algae extract and soil suspension, isolated and combined, totaling 8 treatments and 7 repetitions. The physical-chemical characteristics of the water (nRW and RW), germination test, agronomic evaluations of the soybean plant and NPK content in the plant were evaluated. The results demonstrate that the reorganized water (AR) increased the water alkalinity and hardness, improving seed germination and the development of the soybean plant by 15%, however, the reorganized water, with the addition of soil nutrients and algae extract, did not influence the plant development. Consequently, the content extracted from NPK by plants was not greater. It is concluded that the reorganized water promotes the growth of soybean plant, however, it did not influence the greater absorption of nutrients by the plant.
Keywords: *Glycine max*. Seaweed Extract. Soil Suspension. Plocher Agro-kat.

Resumo

Maior parte dos nutrientes necessários para metabolismo das plantas é absorvido da solução do solo. Assim a translocação desses nutrientes pela água pode ser beneficiada com alteração física das moléculas da água. O uso de água reorganizada na irrigação pode ser considerado um fator físico que auxilia positivamente na absorção e assimilação de nutrientes e consequentemente no crescimento e o desenvolvimento das plantas. Assim, o objetivo do trabalho foi avaliar a eficiência da água reorganizada na nutrição da planta na fase inicial. O estudo foi conduzido no laboratório, e as plantas foram cultivadas em copos plásticos de 700 mL em meio líquido formulado com água natural (AnR) e reorganizada (AR), com adição de extrato de algas e suspensão de solo, isolado e combinado. Totalizando 8 tratamentos e 7 repetições. Foram avaliadas as características físico-químicas das águas (AnR e AR), teste de germinação, avaliações agronômicas da planta soja e conteúdo de NPK na planta. Os resultados demonstram que a água reorganizada (AR) aumentou a alcalinidade e a dureza da água, melhorando em 15% a germinação das sementes e o desenvolvimento da planta de soja, porém, a água reorganizada, na adição de nutrientes do solo e extrato de algas, não influenciou o desenvolvimento da planta. Consequentemente, o conteúdo extraído do NPK pelas plantas não foi maior. Conclui-se que a água reorganizada promove o crescimento da planta de soja, porém, não influenciaou na maior absorção de nutrientes pela planta.
Palavras-chave: *Glycine max. Extrato de Alga. Suspensão do Solo. Plocher Agro-kat.*

---

1 Introduction

The success of agriculture is related to use of irrigation and proper management of natural resources, generating potential conditions for high productivity (Silva *et al*., 2008). Irrigation aims to meet water demand of plants and needs to be applied in correct amount. When insufficient, it harms development of the root system and when in excess, it causes waste of water, energy and nutrients in soil (Rezende, 2017).

The significant effects of interaction between water and reorganization of its molecules still have their causes little elucidated, performance of this set presents several positive results in agriculture, providing an increase in the quality of characteristics of different cultures, both in growth factor and in production (El Sayed; El Sayed, 2015).

There are two main models that help to elucidate the water characteristics. The Continuous Model, formed by a flexible network of hydrogen bonds between water molecules and, when disturbed, can suffer local distortions (Generoso, 2016; Porto, 2007). The Mixture Model, composed of a mixture of clusters of different sizes, formed by hydrogen bonds and free water molecules, that is, that are not connected by hydrogen bonds (Generoso, 2016; Porto, 2007).

The modification of the Plocher System in water defines orientation and alignment of clusters and ions present in the water, because this technology generates order in its molecules and its system is based on procedures of physical concentration and transmission of data and energy (Integral Plocher Technology, 2017). The change is related to physical behavior, which does not affect the water chemical structure and its ions, not forming new compounds (Boso; Broetto, 2018).

When water is exposed to reorganizer, intermolecular hydrogen bonds are weakened or broken. By adopting the mixture model, it is possible to have a new arrangement of clusters of smaller sizes, which have greater mobility to permeate some barriers, which can circulate through plant structures, loaded with free radicals and nutrients (Generoso, 2016; Porto, 2007). Factors that suggest improvements in economy and agricultural production (Generoso, 2016).

In addition to reorganized water being an improvement option for agriculture, use of seaweed extract as a biofertilizer can also help to correct limiting factors for agriculture, such as soil fertility (Norrie, 2008). Seaweeds have been recognized as excellent fertilizers and natural biostimulants for plants, as they synthesize plant hormones (Silva *et al*., 2016).

Biofertilizer refers to mixtures of plant regulators with other compounds of a different biochemical nature. Use of this technique is an alternative that has shown good results in growth and development of crops (Cecato; Moreira, 2013).

The objective of this study was to evaluate the efficiency of reorganized water in germination and in the initial nutrition of soybean, in presence of seaweed extract and soil suspension.

2 Material and Methods

2.1 Characterization of the experiment and experimental design

The experiment was conducted at Universidade Estadual do Norte do Paraná – UENP, Campus Luiz Meneghel, in the city of Bandeirantes – PR, at the Laboratory of Soil Microbiology (Lab MicroS).

The assay was carried out in transparent containers with a 750-mL capacity, containing eight treatments and seven replications (Table 1), totaling fifty-six plants in suspension and liquid solution. The experimental design was completely randomized.

2.2 Germination Test

The germination test (GT) was performed in sand according to Brasil (2009). Four replications of 50 soybean seeds (*Glycine max* (L.) Merrill) of the cultivar M6410IPRO were used. Two polyethylene trays were watered with reorganized water from Plocher System and other two trays were watered with tap water.

The germination in first five days, after sowing, was evaluated according to irrigation, both by reorganized water (RW) and by unreorganized water (nRW), taking into account germination percentage (GP) (Brasil, 2009) for both treatments. Seed germination was considered when cotyledonary leaves appeared, counting number of seedlings in relation to number of seeds.

Each 750-mL container received a total of 500 mL of liquid solution/suspension and seedlings that showed better vigor and with similar cotyledons were transferred from sand during their vegetative development stage, to containers with liquid solutions/suspensions, in their respective treatments (Table 1).

Table 1 - Description of treatments to evaluate the efficiency of reorganized water in nutrition of the soybean plant (*Glycine max*), in the presence of seaweed extract and soil suspension

Trat	Water	Seaweed Extract	Soil Suspension
1	nRW		
2	RW		
3	nRW	Seaweed extract	
4	RW	Seaweed extract	
5	nRW		Soil Suspension
6	RW		Soil Suspension
7	nRW	Seaweed extract	Soil Suspension
8	RW	Seaweed extract	Soil Suspension

Dados**:** (RW) = Reorganized Water; (nRW) = Unreorganized Water.
Source: research data.

The test was kept in a controlled environment, inside soil laboratory, under a 14-hour photoperiod of light from eight ultraviolet LED lamps, with a relative humidity of 53% and an average temperature of 25 ± 2 ºC.

The liquid solutions/suspensions of all treatments were redone after 92 hours, because the Plocher reorganizer promises reorganization of water molecules within this period of time.

2.3 Reorganized Water

To obtain reorganized water, the Plocher Agro-Kat® reorganizer was used. According to company Integral Plocher Technology (2017), the equipment uses a physical information process, which is used for targeted catalytic activation of biological processes. The equipment works without electricity and has the capacity to reorganize up to 2500 liters of water per hour.

2.4 Physicochemical analysis of water

In 500-mL containers, a sample of ordinary tap water was collected and another using reorganizer attached to same tap, both being sent for analysis at Autonomous Water and Sewage Service (SAAE) of the municipality of Bandeirantes - PR. The following parameters were analyzed: pH, alkalinity, conductivity and hardness.

2.5 Nutritive Solution

All treatments received 5 mL of complete nutrient solution in suspensions and liquid solutions, with the aid of a micropipette. Nutrient solutions were prepared as recommended by Hoagland and Arnon (1950).

2.6 Soil Suspension

For preparation of the soil suspension (SS), the eutroferric red LATOSOL was used, which presented the following chemical characteristics: pH – 6.5; Ca^{2+} – 8 .7; Mg^{2+} – 2.9; K^+ – 0.14; Al^{3+} – 0.00 $cmol_c$ dm $^{-3}$; P – 58.8 mg dm $^{-3}$ and M.O. – 26.9 gk g $^{-1}$.

Soil was collected in the 0-20 cm layer in a permanent preservation area at Universidade Estadual do Norte do Paraná – UENP, Campus Luiz Meneghel (50º29’44.09” – 50º09’42.56” W and 23º17’ 5.10” – 23º00’58.40” S).

The ratio of soil and water was made in the proportion of 1:10. The suspensions were shaken and after substrate had already been decanted, contents were filtered through filter paper and added to the recipients of treatments 5, 6, 7 and 8 (Table 1).

2.7 Seaweed Extract

500 µL of seaweed extract of the species *Ascophyllum nodosum* (L.) Le Jolis was diluted in 1 L of water, both reorganized and ordinary water, following treatments 3, 4, 7 and 8 (Table 1).

2.8 Analysis of agronomic parameters

At 31 days of development, the plants were submitted to evaluation of parameters of shoot height (cm), root length (cm), fresh mass (g) and dry mass (g) of the plant (Silva, 2009).

The height of aerial part was obtained with aid of a tape measure, being measured from neck to apex of the largest stem. The same procedure was applied to root, measuring from base of stem to apex of the root.

The fresh mass of the plants was determined by weighing on a semi-analytical balance and, soon after, they were subjected to drying at a temperature of 60 °C in a forced air circulation oven until constant mass, for later weighing and determination of dry mass.

2.9 NPK determination

The contents of Nitrogen, Potassium and Phosphorus of plant tissue were evaluated. After process, the plants were ground in a mortar until obtaining a fine powder.

Nitrogen content was determined by Kjeldahl method according to Embrapa (Silva, 2009). To determine phosphorus content, technique of spectrophotometry with molybdenum blue was used and for potassium, technique of flame photometry (Silva, 2009).

2.10 Statistical analysis

The results were submitted to Analysis of Variance (ANOVA) and the means were compared using Tukey Test at 5% probability, with SISVAR Software (Ferreira, 2019).

3 Results and Discussion

3.1 Physicochemical analysis of Unreorganized and reorganized water

In physicochemical analyzes of nRW and RW, no significant difference was observed between the treatments (Table 2), since the results obtained, even if varied, are within known parameters, determined by CONAMA resolution 357/2005 (Brasil, 2005), CNNPA Resolution No. 12 (Anvisa, 1978) and Funasa (Brasil, 2013).

Table 2 - Quality of physicochemical parameters of Unreorganized water (nRW) and of reorganized water (RW) used

Parameters	Unit	Analitics Results	
		nRW	RW
pH		8,81	8,30
Alkalinity	mg L^{-1} $CaCO_3$	56,00	70,72
Conductivity	mS cm^{-1}	0,15	0,15
Hardness	mg L^{-1} $CaCO_3$	50,00	58,00

Data: Reference method: Standard Methods for the Examination of Water and Wastewater (Baird; Eaton; Clesceri, 2012).
Source: research data.

The pH of water showed a minimal variation between them, but both are within the ideal range for development of plants. Other studies obtained the same answer when analyzing common water and reorganized water, where they did not show discrepant differences in pH factor (Generoso, 2016; Figueiredo *et al*., 2019; Santos *et al*., 2020). Generoso (2016), evaluating different types of water, including magnetized water, with no change in pH, and Santos *et al.,* (2020) treating lemon balm with magnetized water did not observe any change in the water pH.

Alkalinity expressed in RW and in nRW varied significantly, both within principle cited by CNNPA Resolution No. 12 (Anvisa, 1978), where waters must meet up to 120 mg L in terms of $CaCO_3$.

Conductivity obtained in analysis was 0.15 mS cm^{-1} for both nRW and RW, results that corroborate research carried out in cultivation of lettuce, melissa, peas and celery, where no difference was observed significant difference in conductivity between compared variables (Mendonça; Garcia; Aguiar, 2008; Santos *et al*., 2020).

The analyzed water samples (nRW and RW) did not show hardness (Table 2), meaning that there was no greater accumulation of minerals (Flores, 2019).

There is controversy over chemical parameters of reorganized water. Alleman (1985), Gruber and Carda (1981), agree that there were no significant changes in chemical properties of RW in their research. Factors such as pH, alkalinity, electrical conductivity and hardness were some of equal and/or similar parameters in RW and nRW.

3.1 Germation Rate

Seeds irrigated with RW achieved 78% germination on fifth day after sowing, while seeds irrigated with nRW reached 63% (date no showed). Studies with different crops, such as arugula, lettuce, sorghum, celery, peas, cotton, tomato and corn, have shown that germination rate using reorganized water is higher when compared to germination rate using conventional water for seed irrigation (Flores, 2019; Ismail *et al.,* 2020; Mghaiouini *et al*., 2020; Zhang *et al*., 2021).

The mechanisms that improve germination of seeds irrigated with RA are still poorly understood, but reorganization of water molecules is believed to influence vital physiological processes of seeds (Abobatta, 2019; Hozayn *et al*., 2019). According to Hozayn *et al*. (2019), the reorganization of water molecules can act as a facilitator on transport of ions and electrons, producing a significant effect on germination rate.

Reorganization of water molecules accelerates seed metabolism, increasing germination process, in addition to causing an increase in permeability of seed cell membranes and inhibiting growth of microorganisms that tend to be harmful to germination processes and plant growth (Abobatta, 2019).

3.3 Analysis of agronomic parameters

Soybean plant development in RW cultivation (control) was significantly higher in root length (32.0) and plant fresh mass (2.16) compared to control treatment in nRW.

For treatments with addition of seaweed extract, soil suspension and addition of both, no difference was observed between nRW and RW, with exception of root length, which in treatment with only soil suspension was greater in RW and in relation to nRW (Table 3).

Table 3 - Agronomic attributes of soybean plant (*Glycine max* (L.) Merrill) cultivated in unreorganized water and reorganized water, with addition of seaweed extract and soil suspension

Assays	**Shoot (cm)**		**Root (cm)**		**Fresh Mass (g)**		**Dry Mass (g)**	
	nRW	**RW**	**nRW**	**RW**	**nRW**	**RW**	**nRW**	**RW**
Control	45,5 Ba	55,8 Ba	26,3 Ab	32,0 ABa	0,87 Cb	2,16 Ba	0,26 Ba	0,40 Ba
SE	40,5 Ba	38,0 Ba	25,0 Aa	23,3 Ca	1,39 Ca	1,83 Ba	0,30 Ba	0,37 Ba
SS	110,0 Aa	99,8 Aa	26,8 Ab	34,0 Aa	8,02 Aa	6,43 Ab	1,27 Aa	1,19 Aa
SE + SS	108,8 Aa	100 Aa	30,0 Aa	26,5 BCa	6,73 Ba	6,42 Aa	1,12 Aa	1,08 Aa
C.V.	13,92		12,92		13,10		17,63	

Data: Unreorganized Water (nRW); Reorganized Water (RW); Seaweed Extract (SE); Soil Suspension (SS). Means followed by the same uppercase letter in the column and lowercase letter in the row in the attribute do not differ by 5% by Tukey's Test.
Source: research data.

Other studies also found no significant differences in shoot height, root length, fresh and dry weight of plants irrigated with reorganized water (Sarraf *et al.,* 2020). The influence of treatments within each variable (RW and nRW) showed different responses in plants. Results indicate that treatment that received soil suspension (SS) regardless of addition of seaweed extract was one that most statistically differed from others, favoring plant development.

This differential behavior can be attributed to effect of soil suspension on variables studied, directly reflecting on attributes height and dry mass, which were significantly higher than others.

It is important to note that treatment that received only seaweed extract, both in variable nRW and in RW, did not improve plant development, which leads to consider a greater influence of soil suspension as an indicator of soybean development (Table 3).

However, research carried out with commercial marine seaweed extract is based on beneficial results, such as improvement in the plant physiological processes, nutrient absorption and photosynthesis. Different crops such as *Annona glabra* and *Ipomoea batatas*, when exposed to SE, showed a significant positive increase in plant height, root length and consequently an increase in fresh and dry mass (Neumann *et al*., 2017; Oliveira; Araujo; Lourenço, 1991; Silva *et al*., 2016), different from the results obtained in this work (Table 3). However, we must emphasize that application of seaweed extract is recommended mainly in the foliar application, and in the present study it was diluted in solution and absorbed by the root. This fact may have influenced the results obtained.

On the other hand, in agreement with the results obtained here, different studies showed that there was no significant increase in parameters of height, fresh mass and dry mass of the plants, when submitted to treatments with application of seaweed extract (Tímbola *et al*., 2020). Several works show that use of this biofertilizer can benefit the development of plants and absorption of nutrients by them. Factors such as soil, cultivars, climate and product used may also have influenced the result of these works, requiring further studies on seaweed extracts in order to obtain more information about their action on plant development (Tímbola *et al*., 2020).

It is known that development of shoot plant depends mainly on an abundant root system, capable of exploiting soil particles and absorbing water and nutrients. However, it is important that there is availability and absorption of these nutrients in ideal volumes, through the soil or through solutions (Fernandes, 2006).

The increase in plant development obtained with presence of soil suspension may have occurred as a consequence of the microbial activity that acts on the decomposition of organic matter with the release of low and high molecular weight organic compounds, acting on availability of nutrients in the soil (Pavinato; Rosolen, 2008). Such action is related to adsorption of ions, which help action of functional groups of soil microorganisms, making nutrients more free in solution (Fernandes, 2006). It is necessary to consider decomposition of organic material as an important source of nutrients in the soil, since its decomposition results in mineralization of nutrients from plant tissues in the soil (Pavinato; Rosolen, 2008).

3.4 Analysis of nitrogen (N), phosphorus (P) and potassium (K)

The extracted content of nitrogen (N), phosphorus (P) and potassium (K) from dry matter of evaluated plants were significantly higher in treatments with soil suspension cultivation in the presence and absence of seaweed extract. Among variables nRW and RW, extracted contents were not significant (Table 4).

Table 4 - Content of Nitrogen (N), Phosphorus (P) and Potassium (K) extracted by soybean plant grown in normal and reorganized water, with addition of seaweed extract and soil suspension

TRAT.	**N (%)**		**P (mg kg $^{-1}$)**		**K (g kg $^{-1}$)**	
	nRW	**RW**	**nRW**	**RW**	**nRW**	**RW**
Control	5,5 Ba	8,6 Ba	3,9 Ba	6,2 Ba	0,02 Ba	0,05 Ba
SE	4,9 Bb	19,7 Aa	7,6 Ba	10,2 ABa	0,05 Ba	0,09 Ba
SS	36,1 Aa	23,7 Ab	31,9 Aa	14,5 Ab	0,23 Aa	0,22 Aa
SE + SS	39,7 Aa	18,5 Ab	23,9 Aa	18,0 Aa	0,26 Aa	0,24 Aa
C.V.	16,88		24,19		20,09	

Data: Unreorganized Water (nRW); Reorganized Water (RW); Seaweed Extract (SE); Soil Suspension (SS). Means followed by the same uppercase letter in the column and lowercase letter in the row in the attribute do not differ by 5% by Tukey's Test

Source: research data.

Considering the variables (nRW and RW) and the treatments, which did not show a statistically significant difference in the extracted content, it may be associated with lower plant development in relation to height and root length observed in Table 3, a behavior that justifies the low performance of plants from control treatment (C) and seaweed extract treatment (SE), in height, root length, fresh and dry mass, since low availability and/or absence of nitrogen negatively affects the plant growth (Almeida *et al*., 2011). In the absence of this nutrient, main biochemical process impaired is protein synthesis, affecting precisely the plants' agronomic parameters (Mendes, 2007), reducing the number of leaflets, which consequently provides less light interception and a lower photosynthetic rate (Sainju; Dris; Singh, 2003).

In the same way, for phosphorus (P) and potassium (K), the treatments that presented lower results in extracted contents (Table 4), are reflected in Table 3, since low levels of P and K affect growth. Since phosphorus is directly linked to the plant structure, in the mechanism of energy transfer and storage, it affects metabolic processes, such as protein and nucleic acid synthesis (Almeida *et al*., 2011; Cecílio Filho *et al*., 2020). K, on other hand, participates in and regulates essential processes such as photosynthesis, opening and closing of stomata, and water absorption, that is, when scarce, it harms the plant development (Cecílio Filho *et al*., 2020).

K is not part of any structure and/or organic molecules in the plant, such as N and P. The amount of K^+ in solution necessary for plant growth depends on the species and its developmental stage (Fernandes, 2006).

Extracted content of both elements provided a significant reduction in plant development, as each nutrient has a specific role in metabolism. Imbalance in proportions can cause limitations to plant development, that is, when nutrients limit plant growth, in particular N and P, the roots tend to become draining sources of carbohydrates, causing greater limitation in shoot growth (Fernandes, 2006).

Treatments with soil suspension (SS) and seaweed extract plus soil suspension (SE+SS) showed statistically higher extracted contents for elements analyzed in nRW and RW. Behavior that is consistent with the best development of plants (Table 3).

As previously discussed, extracted content of N, P and K in the proper proportion between them in the soil are important factors in processes of plant growth and development (Moreira, 2002). In the soil, the main source of N is organic matter, so its dynamics are closely associated with dynamics of organic matter (Ceretta, 2000).

Microorganisms, in addition to playing key roles in increasing availability of P from soil to plants, can facilitate its absorption and accessibility through various mechanisms that affect structure, chemistry, biochemistry and physiology of system root formation of plants (Moreira, 2002; Fernandes, 2006).

The decomposition of organic material should also be considered an important source of nutrients in the soil, as its decomposition results in mineralization of nutrients and in plant tissues. Through these, the best development of the plants is confirmed, in those treatments that received suspension of soil in liquid solution.

4 Conclusion

Reorganized water increases germination of seeds and growth of plants; however, reorganization of water molecules did not favor the nutritional aspect of the plants.

Soil suspension treatments promove greater plant development and although reorganized water is a technique that presents some beneficial results, more research is needed to understand this mechanism.

Acknowledgement

Fundação Araucária; the Brazilian National Council for Scientific and Technological Development (CNPq), for granting a scientific initiation scholarship; and the Brazilian Coordination for the Improvement of Higher Education Personnel (CAPES), for granting a master's scholarship.

References

ABOBATTA, W. F. Overview of role of magnetizing treated water in agricultural sector development. Adv. Agricul. Technol. Plant Sci., v.2, n.1, p.180023, 2019.

ALMEIDA, T.B. et al. Avaliação nutricional da alface cultivada em soluções nutritivas suprimidas de macronutrientes. Biotemas, v.24, n.2, p.27-32, 2011. https://doi.org/10.5007/2175-7925.2011v24n2p27

ALLEMAN, J.E. A performance evaluation for magnetic water treatment. In: Fourth Domestic Water Quality Symposium, ASAE and Water Quality Association, v. 16, n. 3, p. 203-235, 1985.

ANVISA. Agência Nacional de Vigilância Sanitária. Resolução – CNNPA n° 12, de 24 de julho de 1978. Comissão Nacional de normas e padrões para alimentos, Brasília: Anvisa, 1978.

BAIRD, R.B.; EATON, A.D.; CLESCERI, L.S. Standard methods for the examination of water and wastewater. Washington: American Public Health Association, 2012.

BOSO, A.C.M.R.; BROETTO, F. Utilização de água magnetizada. In: BROETTO, F.; MINHONI, R.T.A.; OLIVEIRA, D.P.F. Seminários em Irrigação e drenagem, Fepaf, v.3, n.1, p.67-71, 2018.

BRASIL. Conselho Nacional de Meio Ambiente – CONAMA, (2005). Resolução 357, de 17 de março de 2005. Diário Oficial da República Federativa do Brasil, Brasília, Brasília: Conma, 2005.

BRASIL. Ministério da Agricultura e Reforma Agrária. Regras para análise de sementes. Brasília: SNDA/DNDV/CLAV, 2009.

BRASIL. Fundação Nacional de Saúde – FUNASA. Manual Prático de Análise de Água. Funasa, Brasília, Distrito Federal, 2013.

CECATO, A.; MOREIRA, G.C. Aplicação de extrato de algas em alface. Cultivando o Saber, v.6, n.2, p.89-96, 2013.

CERETTA, C.A. Dinâmica do nitrogênio em sistemas de produção na região Sul do Brasil. Dourados: Embrapa Agropecuária Oeste, 2000.

CECÍLIO FILHO, A.B. et al. Sintomas de deficiência de macronutrientes em alface. Científica, v.48, n.3, p.271-290, 2020. doi: https://doi.org/10.15361/1984-5529.2020v48n3p271-290

CONAB - Companhia Nacional de Abastecimento. Acompanhamento safra brasileira de grãos - Safra 2020/21 Dispoonivel: em: https://www.conab.gov.br/info-agro/safras.

EL SAYED, H.; EL-SAYED, A. Impact of magnetic water irrigation for improve the growth, chemical composition and yield production of broad bean (Vicia faba L.) plant. Nat. Sci., v.4, n.4, p.107-110, 2015.

FERNANDES, A.S. Nutrição mineral de plantas. Viçosa, Minas Gerais, 2006.

FERREIRA, D.F. SISVAR: A computer analysus sytem to fixed effects split plot type designs. Rev Bras. Biom., v.37, n.4, p.529-535, 2019. https://doi.org/10.28951/rbb.v37i4.450

FIGUEIREDO, R.O. et al. Análise da resistência de argamassas fabricadas com água submetida a campos magnéticos de diferentes magnitudes. Rev. Bras. Inic. Cient., v.6, n.4, p.4-17, 2019.

FLORES, L.A.E. Efeitos da água corrigida por magnetismo e infravermelho longo na germinação e relações hídricas. Maringá: UEM, 2019.

GENEROSO, T. N. Efeito da magnetização nas características da água e nos parâmetros de transporte de fósforo no solo. [Dissertação de mestrado, Universidade Federal de Viçosa, Viçosa, Minas Gerais], 2016.

GRUBER, C.E.; CARDA, D.D. Measurable parameters in water conditioning equipment as determined in laboratory simulations at Rapid City, South Dakota. South Dakota School of Mines and Technology, v.3, n.1, p.21, 1981.

HOAGLAND, D. R.; ARNON, D. L. The water culture methods for growing plants without soil. Berkeley: University of California, v. 342, n. 2, p. 32, 1950.

HOZAYN, M. et al. Enhancement in germination, seedling attributes and yields of alfalfa (Medicago sativa, L.) under salinity stress using static magnetic field treatments. Euras. J. Biosci., v.13, n.1, p.369-378, 2019.

Integral Plocher Technology, (2017). Plocher energy system. 2017. Disponivel em: https://www.plocher-international.com. Acesso em: 5 maio 2024.

ISMAIL, W.H. et al. Effect of magnetized water on seed germination, growth and yield of rocket plant (Eruca sativa, Mill). SSRG Int. J. Agricult. Environ.l Sci., v.7, n.2, p.1-5, 2020.

MENDES, A.M.S. Introdução a fertilidade do solo. In: Curso de manejo e conservação do solo e da água, Embrapa Semi-Árido; Embrapa Solos-UEP, 2007.

MENDONÇA, R.M.; GARCIA, C.C.; AGUIAR, J.A. Uso de água imantada no cultivo de alface em sistema hidropônico NFT. Rev FAZU, v.2, n.5, p.30-33, 2008

MGHAIOUINI, R. et al. Influence of the electromagnetic device aqua 4D on water quality and germination of lettuce (Lactuca sativa L.). Int. J. Curr. Eng. Technol., v.10, n.1, p.19-24, 2020. doi: https://doi.org/10.14741/ijcet/v.10.1.4.

MOREIRA, F.M.S. Microbiologia e bioquímica do solo. Lavras, Minas Gerais, 2002,

NEUMANN, E.R. et al. Produção de mudas de batata doce em ambiente protegido com aplicação de extrato de Ascophyllum nodosum. Rev Horticul. Brasi., v.35, n.4, p.490-498, 2017. doi: https://doi.org/10.1590/S0102-053620170404.

NORRIE, J. Advances in the use of Ascophyllum nodosum seaplant extracts for crop production: linking laboratory and field research. Scottsdale, v.5, n.3, p.1-6, 2008.

OLIVEIRA, A.J.; ARAUJO J.D.; LOURENÇO, S. Métodos de pesquisa em fertilidade do solo. Embrapa-SEA, 1991, 392 p.

PAVINATO, P.S.; ROSOLEM, C.A. Disponibilidade de nutrientes no solo: decomposição e liberação de compostos orgânicos de resíduos vegetais. Rev Bras. Ciênc. Solo, v.32, n.3, p.911-920, 2008. doi: https://doi.org/10.1590/S0100-06832008000300001.

PORTO, M.E.G. Novos conceitos sobre água e possibilidades de aplicação. Cultura homeopática, v.8, n.21, p.19-23, 2007.

REZENDE, M.S. Potencial de água na folha do cafeeiro irrigado com diferentes lâminas de água com e sem eletromagnetização Monte Carmelo Universidade Federal de Uberlândia, Minas Gerais], 2007.

SAINJU, U.M.; DRIS, R.; SINGH, B. Mineral nutrition of tomato. Food Agricult. Environ., v.1, n.2, p.176-183, 2003.

SANTOS, B.L. et al. Irrigação com água tratada magneticamente na cultura de Melissa officinalis L. Braz. J. Develop., v.6, n.3, p.14657, 2020. https://doi.org/10.34117/bjdv6n3-364.

SARRAF, M. et al. Magnetec field (MF) applications in plants: an overview. Plants, v.9, n.9, p.1139, 2020. https://doi.org/10.3390/plants9091139.

SILVA, A.C. et al. Produtividade e potencial hídrico foliar do cafeeiro Catuaí, em função da época de irrigação. Rev Bras. Eng. Agríc. Amb., v.12, n.1, p.21-25, 2008. https://doi.org/10.1590/S1415-43662008000100003.

SILVA, F.C. Manual de análises químicas de solos, plantas e fertilizantes. Embrapa Informação Tecnológica, 2009.

SILVA, C. C. et al. Extrato da alga Ascophyllum nodosum (L.): Le Jolis na produção de porta-enxertos de Annona glabra L. Rev. Ciênc. Agrár., v.39, n.2, p.234-241, 2016. doi: https://doi.org/10.19084/RCA15057.

TÍMBOLA, F.et al. Uso de extrato de algas em aplicações foliares no trigo. Rev Cultivando Saber, v.13, n.4, p.117-123, 2020.

ZHANG, J.et al. of magnetized fresh water on seed germination and seeding of cotton. Water Supply, v.7, n.2, p.1-12, 2021. doi: https://doi.org/10.2166/ws.2021.051.