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Proceeding Paper

Management and Quality Assurance of Irrigation Water in the Sustainable Production of Selenium-Enriched Rice (*Oryza sativa* L.) †

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Abstract: There is a growing need for strategic actions involving efficient water use, sustainable agricultural production, and food security. Agricultural productivity can be improved through good agricultural practices based on water-quality management, new genetically modified resources, and using precision agriculture. This study aimed to monitor the crop water (supply, irrigation, and flooding) of an advanced rice (*Oryza sativa* L.) line of the breeding program (OP 1509) subjected to Selenium (Se) enrichment. Water lines in a paddy rice field were monitored by Unmanned Aerial Vehicles (UAVs). The parameters of pH, pHs, electrical conductivity, temperature, HCO_3^-, Cl^-, SO_4^{2-}, PO_4^{3-}, Na^+, K^+, Ca^{2+}, and Mg^{2+} were analyzed. According to the Piper diagram, the samples were classified as sodium chloride bicarbonate (supply) and sodium bicarbonate chloride (irrigation and flooding). The Langelier Saturation Index (LSI) was calculated and indicated that waters are good to use in agricultural practices. According to the Wilcox classification, regarding agriculture use, the samples were classified as C2S1 (supply and irrigation) and C3S1 (flooding). The Selenium contents were analyzed by atomic absorption and significant differences were observed in rice grains, with a maximum content of 10 mg.kg^{-1}. In conclusion, the water quality is in accordance with the parameters for use in this crop and the workflow used improved the grain quality.

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1. Introduction

There is a growing need for strategic actions involving the efficient use of water, sustainable agricultural production, and food security, considering climate change [1]. Efficient use and sustainable supplies of water in the agriculture, aquaculture, livestock, and agroforestry sectors are the future [1]. Rice (*Oryza sativa* L.) is one of the most important crops in the world [2] and requires a high amount of water to grow [3]. For this reason, it is important to determine the quality of water prior to its use. Water can be classified according to the chemical composition by Piper or/and Stiff diagrams in functions of the relative predomination of specific ions, namely of the main anions and cations. The suitability of the water for agricultural use is based on the Wilcox diagram where the conductivity ranges between classes C1 and C4 and the Sodium Adsorption Ratio index (SAR) between classes S1 and S4. The SAR index is very important for the classification of irrigation waters, considering that if it is high in Na^+ and low in Ca^{2+}, the cation exchange complex can become saturated with Na^+ [4] in water and affect crop growth. Thus, the use of good agricultural practices based on pest control, soil, and water management using precision agriculture, and new genetic materials can contribute to increased productivity. Plant breeding allows the development of plants with desirable agronomic characteristics, such as tolerance to climatic conditions, disease resistance, and higher grain yield. In this way, it is possible to improve the quality of the final product [5]. Biofortification is an effective and sustainable method for increasing micronutrient levels in rice to mitigate deficiencies in people who primarily eat rice [6].

In this sense, this study aims to manage irrigation water based on its composition and pick up culture images with drones to support the sustainable production of rice with added value.

2. Materials and Methods

2.1. Experimental Fields and Biofortification Workflow

In a paddy rice field located at the center of Portugal (Salvaterra de Magos), an advanced rice line (OP 1509) of the breeding program carried out by Instituto Nacional de Investigação Agrária e Veterinéria (INIAV) was tested. The experimental design was a factorial arrangement involving 2 concentrations (0 and 300g $Se.ha^{-1}$), 2 Se forms (sodium selenate and sodium selenite), and 4 replicates in a total of 16 plots. Selenium applications included 3 foliar applications, which occurred at the end of booting, anthesis, and at the milky grain stage. The 1st application was 500 g $Se.ha^{-1}$; however, the plants showed symptoms of toxicity, which is why the remaining applications contained only 300 g $Se.ha^{-1}$. The trial was carried out from 4 June to 23 October 2019.

2.2. Precision Agriculture–Characterization of Water Lines

The flow of the experimental rice field was monitored with Unmanned Aerial Vehicles (UAVs) synchronized by Global Position System (GPS), according to Coelho et al. [7]. The flight was carried out (18 July) after crop implementation to classify surface water drainage (water lines) in the experimental paddy rice field according to Direção Geral de Agricultura e Desenvolvimento Rural [8].

2.3. Water Analysis

Physical parameters (pH, electrical conductivity, and temperature) were measured with a multiparameter analyzer (Consort C6030) coupled with SP21 and SK20 T electrodes. The chemical parameters, such as the bicarbonate (HCO_3^-) content, were analyzed by titration using 100 mL of sample, 0.1% methyl orange, and 0.1 N hydrochloric acid as the titrant [9]. Photometry was carried out using a spectroquant (NOVA 60, Merck, Darmstadt–Germany) to quantify the anions, such as chloride (Cl^-), sulfate (SO_4^{2-}), and phosphate (PO_4^{3-}) using the specific kits 1.14897, 1.14779, and 1.14842, respectively. Ionic chromatography was used to measure cations calcium (Ca^{2+}) magnesium (Mg^{2+}), sodium (Na^+), and potassium (K^+) using a chromatograph (Metrohm, 761 Compact IC) and pre-column (Metrosep cation 1-2, 6.1010.000). The 10 µL of sample previously prepared in eluent was injected at a flow rate of 1.00 mL/min. [10]. The water composition was projected via a Piper diagram in order to classify the water facies hydrochemistry [11], via a Wilcox diagram (considering the Sodium Adsorption Ratio—SAR) to assess the water irrigation purposes [12], and via a Stiff diagram, which represents an irregular polygonal pattern of anion and cation abundance and allows water samples to be compared [4]. The Piper, Wilcox, and Stiff diagrams were obtained using the Grapher software (version 16.3.410). The Langelier Saturation Index (LSI) and equilibrium pHs were calculated to assess the corrosive or incrusting action [13].

2.4. Atomic Absorption–Quantification of Selenium in Paddy Rice Grains

Selenium content was analyzed by atomic absorption spectrophotometry (Perkin Elmer AAnalyst 200), according to the methods described by Carrondo et al. and Reboredo et al. [14,15]. In short, an acid digestion procedure was carried out with a mix of HNO_3–HCl with a ratio of 4:1.

2.5. Statistical Analysis

Data were statistically analyzed using a One-way ANOVA ($p \leq 0.05$) to assess differences among treatments. A Tukey's test was performed for mean comparison using the IBM SPSS Statistics 20 program.

3. Results

The geomorphology of the experimental rice field is characterized by different elevations, with the eastern part being higher (Figure 1). Thus, the elevation was measured to determine water drainage trends. Accordingly, the water lines created in the experimental field follow a westerly direction (Figure 1).

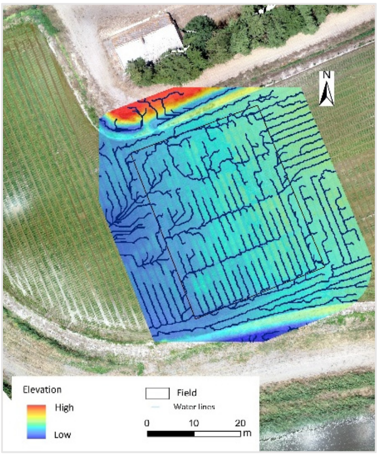

Figure 1. Orthophotomap of elevation and water lines in paddy rice field of OP 1509 genotype on 18 July.

The pH of the water samples ranged from 6.3 to 6.9, while the pHs ranged between 8.4 and 8.9 (Table 1). The electrical conductivity of the water varied from 376 µS/cm to 420 µS/cm in supply (A), and irrigation (B), respectively. Moreover, a high EC (800 µS/cm) was observed in flooding (C) samples (Table 1). In sample A, the concentration of bicarbonate (HCO_3^-), chloride (Cl^-), and sulfate (SO_4^{2-}) was 1.1 meq/L, 1.4 meq/L, and 0.9 meq/L, respectively (Figure 2). Regarding samples B and C, the concentration of HCO_3^-, Cl^-, and SO_4^{2-} ranged from 0.9 to 1.4 meq/L, 2.1 to 3.7 meq/L, and 0.8 to 1.5 meq/L, respectively.

In both water samples, the concentration of phosphate (PO_4^{3-}) was low (<0.04 meq/L). Additionally, the Langelier Saturation Index (LSI) was the same for samples A and C (−1.8), while that of sample B was −2.6 (Table 1).

Table 1. Values of temperature (°C), pH, electrical conductivity (EC, µS/cm), anions (meq/L), cations (meq/L), pHs, and Langelier Saturation Index (LSI) in the water supply (A), irrigation water (B), and flooding water (C) samples from the paddy rice field of OP 1509 genotype.

Parameter	A	B	C
Temperature	20	20	20
pH	6.9	6.3	6.6
EC	376	420	800
HCO_3^-	1.1	0.9	1.4
Cl^-	1.4	2.1	3.7
SO_4^{2-}	0.9	0.8	1.5
PO_4^{3-}	<0.04	<0.04	<0.04
Ca^{2+}	0.5	0.7	1.4
Mg^{2+}	0.4	0.4	0.6
Na^+	1.3	1.7	2.7
K^+	0.2	0.06	0.4
pH’s	8.4	8.9	8.4
LSI	−1.8	−2.6	−1.8

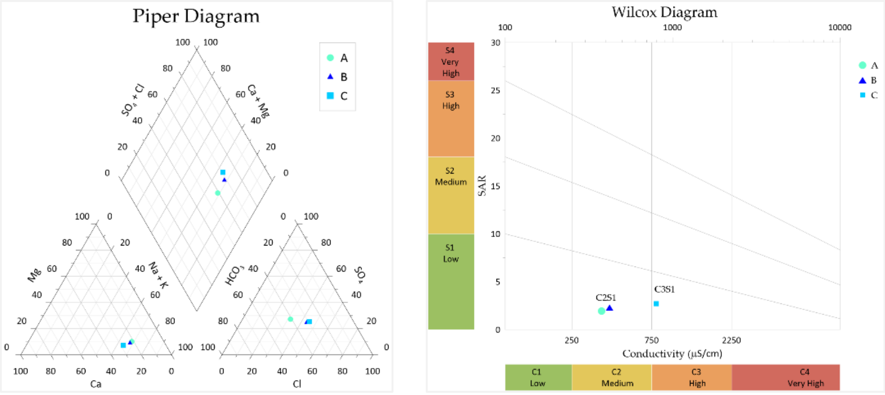

Figure 2. Classification of hydrochemical facies of waters (samples A, B, and C) and its adequation of irrigation purposes by Piper and Wilcox diagrams.

According to the Piper diagram, the chemical composition of the water samples was sodium chloride bicarbonate (A) and sodium bicarbonate chloride (B and C) (Figure 2). By Wilcox classification, water samples A and B are C2S1 while sample C is C3S1. Thus, the Sodium Adsorption Rate Index (SAR) is 1.93, 2.29, and 2.70 for samples A, B, and C, respectively (Figure 2).

The Stiff diagrams show that Cl^- is the dominant anion, and the same is true for cation Na^+ followed by Mg^{2+} and Ca^{2+}, in both samples (Figure 3). The highest concentrations (cations and anions) are observed in sample C.

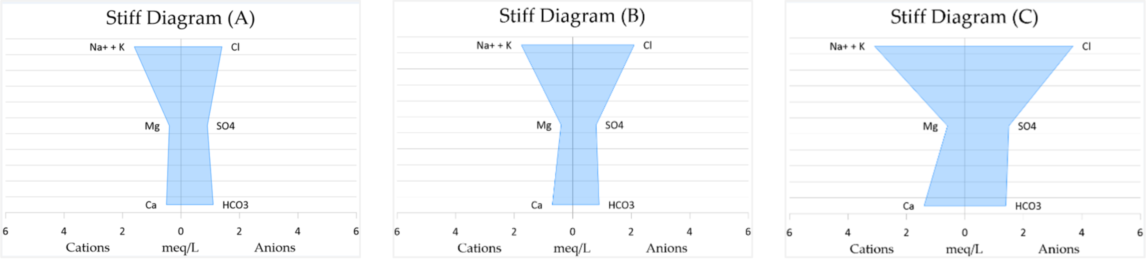

Figure 3. Representation of water samples ((**A**), (**B**), and (**C**)) in Stiff diagrams.

In the control, Selenium (Se) content was not detected; however, in biofortified grains, significant differences were reported (Table 2). Selenite application showed a 10.10 $mg \cdot kg^{-1}$ increase, while selenate showed a 6.00 $mg \cdot kg^{-1}$ increase.

Table 2. Mean of values (n = 4) ± standard error of Se content in paddy rice flour of OP 1509 genotype. Letters a and b reveal significant differences between treatments ($p \leq 0.05$).

Treatment	Concentration ($mg \cdot kg^{-1}$)
Control	-
Na_2SeO_4 (300g $Se \cdot ha^{-1}$)	6.00 ± 1.09 b
Na_2SeO_3 (300g $Se \cdot ha^{-1}$)	10.10± 0.75 a

4. Discussion

The quality of water used in agriculture affects crops. Thus, to increase macro- or microelement contents in a crop, such as rice (*Oryza sativa* L.), it is necessary to preserve the quality of the water used. Therefore, it is extremely important to evaluate the suitability of irrigation water. All crops take water from where it is most readily available (within the rooting depth); however, each crop has its absorption pattern [16]. The geomorphology of the paddy rice field was characterized by an orthophotomap in which the elevation and the water lines created in the experimental field were observed. The lower elevation zone (west zone) corresponds to the flatter surface and is more favorable to water accumulation and, consequently, greater infiltration (Figure 1). The higher areas of the experimental field (east zone) represent areas that promote surface-water runoff and, consequently, reduced water infiltration (Figure 1). If surface drainage occurs, it follows the direction of the estimated water lines. The samples showed a pH ranging from 6.3 to 6.9 (Table 1), which is in line with their use for agricultural purposes [16]. A value outside the normal range may cause a nutritional imbalance or may contain a toxic ion [13]. The salinity hazard is measured by the increase in electrical conductivity (EC) because it has the greatest influence on the water quality in crops. In our study, the increase in EC in samples A (376 µS/cm), B (420 µS/cm), and C (800 µS/cm) was probably caused by the incorporation of salts from fertilizers applied in the paddy rice field, which were moved at the time of drainage. According to the literature, EC below 1000 µS/cm is adequate for agriculture [17]. Rice is moderately sensitive to salinity and when exposed to 3000 µS/cm, a reduction in plant growth occurs [18]. Similar to the effects of EC, the concentration of anions and cations was higher in sample C (Table 1). The high concentration of bicarbonate (HCO_3^-) in water can increase the sodium (Na^+) content in the soil due to the precipitation of calcium (Ca^{2+}) and magnesium (Mg^{2+}). In this study, the HCO_3^- content does not present a degree of restriction for the use of water in irrigation because it is below 1.5 meq/L [13]. Also, through the Langelier Saturation Index (LSI), which relates pH to equilibrium pH (pHs), the values are < 0. Thus, the results suggest that water is undersaturated in calcium carbonate (CO_3Ca), with a high tendency for corrosive action when circulating in pipes with this composition [19]. According to the Piper diagram, based on the contribution of the cations and anions, the samples were classified as sodium chloride bicarbonate (A) and sodium bicarbonate chloride (B and C) (Figure 2). To classify the water as suitable for irrigation, the Wilcox diagram was plotted [20]. The EC was plotted against the Sodium Adsorption Rate (SAR) index (relative proportion of Na^+ to Ca^{2+} and Mg^{2+} concentration), which represents the suitability of the water for agricultural use [12]. The values ranged from 1.93 to 2.70 for samples A and C, respectively (Figure 2). According to the Wilcox classification, all samples have a low sodium hazard (S1). Regarding the salinity hazard, samples A (C2S1) and B (C2S1) have medium salinity, while sample C (C3S1) has high salinity. Thus, water with a C2 rating (250–750 µS/cm) can promote plant stress due to the accumulation of salts in the soil and should be used whenever there is a moderate degree of leaching. Also, water in the C3 class (750–2250 µS/cm) affects most plants, requiring good drainage, leaching, and careful irrigation. According to the Stiff diagram, the evolution of anions and cations from sample A to B is observed (Figure 3). Rice plants are the most sensitive to humidity, temperature, and water conditions [21]. Based on this, breeding techniques ensure the availability of varieties adapted to different environmental conditions [5]. The increase in Se depends on the characteristics of each variety, the form of Se used, and the concentration [22]. Independently of the foliar pulverization, the results showed a Se increment of 10.10 $mg \cdot kg^{-1}$ (sodium selenite) and 6.00 $mg \cdot kg^{-1}$ (sodium selenate) in paddy rice grains (Table 2). Our findings concur with the literature that points to selenite as more effective than selenate [23].

Considering that part of the plant development cycle takes place in water, the conditions of irrigation water, supply, and waterlogging are very important for obtaining quality grain. Thus, water monitoring for parameters such as pH, EC, pHs, ISL, and the quantification of anions and cations is important, allowing corrective action to be taken in a timely manner.

5. Conclusions

This study focused on monitoring the water management and quality of an experimental field of an advanced rice (*Oryza sativa* L.) line that was part of a breeding program (OP 1509) subjected to Selenium (Se) enrichment. The water lines were monitored using Unmanned Aerial Vehicles (UAVs). Water samples were collected from the water supply (A), irrigation water (B), and flooding water (C), and the physicochemical composition (pH, EC, anions, and cations concentration) of all three samples was monitored. The pH at the equilibrium point (pHs) and Langelier Saturation Index (LSI) were also considered. According to the Piper diagram, the samples were classified as sodium chloride bicarbonate (sample A) and sodium bicarbonate chloride (samples B and C), and their suitability for agricultural use was classified as C2S1 (samples A and B) and C3S1 (sample C) according to the Wilcox diagram. Thus, the use of quality water contributed to the production of rice grain enriched with Se (up to 10 mg.kg-1).

Supplementary Materials: The presentation materials can be downloaded at: https://www.mdpi.com/article/10.3390/IOCAG2023-17335/s1.

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References

1. Food and Agriculture Organization of the United Nations (FAO). *Coping with Water Scarcity in Agriculture*; FAO: Rome, Italy, 2012. Available online: https://www.fao.org/3/i6459e/i6459e.pdf (accessed on 26 July 2023).
2. Fukagawa, N.K.; Ziska, L.H. Rice: Importance for global nutrition. *J. Nutr. Sci Vitaminol.* **2019**, *65*, S2–S3. [CrossRef]

3. Mallareddy, M.; Thirumalaikumar, R.; Balasubramanian, P.; Naseeruddin, R.; Nithya, N.; Mariadoss, A.; Eazhilkrishna, N.; Choudhary, A.K.; Deiveegan, M.; Subramanian, E.; et al. Maximizing water use efficiency in rice farming: A comprehensive review of innovative irrigation management technologies. *Water* **2023**, *15*, 1802. [CrossRef]
4. Singh, A.K.; Kumar, S.R. Quality assessment of groundwater for drinking and irrigation use in semi-urban area of Tripura, India. *Ecol. Environ. Conserv.* **2015**, *21*, 97–108.
5. Dantas, S.J. From conventional to genomic: A review on rice breeding methods. *SouzaEAD* **2023**, *61*, 1–17.
6. Das, K.; Roy, P.; Tiwari, R.K.S. Biofortification of rice, an impactful strategy for nutritional security: Current perspectives and future prospect. In *Plant-Based Diet*; IntechOpen: London, UK, 2023. [CrossRef]
7. Coelho, A.R.F.; Lidon, F.C.; Pessoa, C.C.; Marques, A.C.; Luís, I.C.; Caleiro, J.; Simões, M.; Kullberg, J.; Legoinha, P.; Brito, M.; et al. Can foliar pulverization with $CaCl_2$ and $Ca(NO_3)_2$ trigger Ca enrichment in *Solanum tuberosum* L. tubers? *Plants* **2021**, *10*, 245. [CrossRef] [PubMed]
8. Direção Geral de Agricultura e Desenvolvimento Rural. *Carta de Capacidade de Uso do Solo de Portugal—Bases e Normas Adotadas na Sua Elaboração*, 6th ed.; Ministério da Economia, Secretaria de Estado da Agricultura, Serviço de Reconhecimento e de Ordenamento Agrário: Lisboa, Portugal, 1972; pp. 25–26.
9. Rodier, J.; Legube, B.; Merlet, N. *L'Analyse de l'Eau*, 9th ed.; Dunod: Paris, France, 2009; p. 1579. ISBN 9782100072460.
10. Simões, M. Métodos cromatográficos, volumétricos e potenciométricos para análise química quantitativa de água subterrânea e sua aplicação no aquífero cenozóico da Bacia do Baixo Tejo, Portugal. *Geociências Rev. Unesp. São Paulo* **2008**, *27*, 161–169.
11. Piper, A.M. *A Graphic Procedure in the Geochemical Interpretation of Water Analyses, Ground Water Note 12*; US Geological Survey: Washington, DC, USA, 1953.
12. Wilcox, L. *Classification and Use of Irrigation Waters*; Circular, N. 969; USDA: Washington, DC, USA, 1955.
13. Oliveira, I.; Varela, M. A qualidade da água dos pequenos regadios individuais do Alentejo. In Proceedings of the I National Congress of Irrigation and Drainage, Beja, Portugal, 5–7 December 2005; pp. 5–8.
14. Carrondo, M.; Reboredo, F.; Ganho, R.; Santos Oliveira, J.F. Heavy metal analysis of sediments in Tejo estuary, Portugal, using a rapid flameless atomic absorption procedure. *Talanta* **1984**, *31*, 561–564. [CrossRef] [PubMed]
15. Reboredo, F.H.S.; Ribeiro, C.A.G. Vertical distribution of Al, Cu, Fe and Zn in soil salt marshes of the Sado estuary, Portugal. *Int. J. Environ. Stud.* **1984**, *23*, 249–253. [CrossRef]
16. Ayers, R.; Westcot, D. *Water Quality for Agriculture*; Food and Agriculture Organization of the United Nations: Rome, Italy, 1985; Volume 29, p. 174.
17. Decreto-Lei n°236/98.Diário da República. I Série A-176, 01 August 1998, 3677–3722. Available online: https://diariodarepublica.pt/dr/detalhe/decreto-lei/236-1998-430457 (accessed on 1 April 2024).
18. Tanji, K.K.; Kielen, N.C. Agricultural Drainage Water Management in Arid and Semi-Arid Areas. *FAO Irrig. Drain.* **2002**, *61*, 188.
19. Granjeiro, M.L.; Santiago, M.M.F.; Silva, C.M.S.V.; Frischkom, H.; Teixeira, Z.A.; Mendes Filho, J. Razões iónicas e índices de Langelier e Larson no estudo hidrogeoquímico das águas subterrâneas no município de Quixeré–Ceará. In Proceedings of the XVIII Simpósio Brasileiro de Recursos Hídricos, Campo Grande, Brazil, 22–26 November 2009; pp. 1–16.
20. Singh, K.K.; Tewari, G.; Kumar, S. Evaluation of groundwater quality for suitability of irrigation purposes: A case study in the Udham Singh Nagar, Uttarakhand. *J. Chem.* **2020**, *2020*, 6924026. [CrossRef]
21. Ray, M. Influence of Different Weather Parameters on Rice Production-A Review. *Adv. Life Sci.* **2016**, *5*, 5776–5782.
22. Wang, Y.D.; Wang, X.; Wong, Y.S. Generation of selenium-enriched rice with enhanced grain yield, selenium content and bioavailability through fertilisation with selenite. *Food Chem.* **2013**, *141*, 2385–2393. [CrossRef]
23. Li, H.F.; McGrath, S.P.; Zhao, F.J. Selenium uptake, translocation and speciation in wheat supplied with selenate or selenite. *New Phytol.* **2008**, *178*, 92–102. [CrossRef] [PubMed]