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The Effect of Selenium Sources and Rates on Cowpea Seed Quality

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Abstract: Selenium (Se) is a beneficial element for plants and is essential for human nutrition. In plants, it plays an important role in the formation of selenocysteine and selenomethionine and in the activation of hydrolytic enzymes, which can aid in seed germination and reduce abiotic stress during germination. The objective of this study was to evaluate the effects of the application of selenium sources and rates to the soil on the physiological quality of cowpea seeds. The experimental design was a randomized block with four replications and a factorial scheme (7 × 2). Two sources of Se (sodium selenate and sodium selenite) and seven rates (0, 2.5, 5, 10, 20, 40 and 60 g ha^{-1}) were used. Physiological characterization was carried out by first counting of germination, germination, emergence, accelerated aging, cold testing, electrical conductivity, length and dry biomass of shoots and roots. Germination after accelerated aging increased with selenate, even at higher rates, whereas selenite provided benefits at lower rates. Selenation linearly increased germination after the cold test and linearly reduced electrolyte leakage as the Se rate increased. The soil application of Se is beneficial for cowpea seed quality. Compared with those treated with sodium selenite, cowpea plants treated with sodium selenate through the soil produce more vigorous seeds. The application of 10 g ha^{-1} Se in the form of sodium selenate provides seedlings with faster germination and root development and is an alternative for rapid stand establishment.

Keywords: sodium selenate and sodium selenite; soil application; *Vigna unguiculata* L. Walp.; seed vigor; seed physiological potential

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1. Introduction

Cowpea (*Vigna* L. 'Walp.') belongs to the Fabaceae family and consists of four subspecies, of which unguiculata is the most widely cultivated in the world [1]. Its seeds contain an average of 20 to 25% protein and 45 to 55% carbohydrates, and it is an alternative source of protein for low-income populations, particularly in continents such as Africa and Latin America [2]. However, technological and management problems have been identified as the main factors for the low productivity observed in the country, and several authors point to the low quality of seeds as one of the main obstacles to the development of the crop [3].

The use of seeds with good physiological quality is a critical factor in establishing crop cultivation. Seeds with low germination potential and vigor are among the factors influencing low productivity and, consequently, low economic returns. Adequate plant nutrition is also essential for obtaining high-quality seeds. Among the beneficial elements that can be supplied and have the potential to produce a satisfactory response in terms of seed quality is selenium (Se) [4].

Despite its importance for some crops, the range between deficient and toxic levels of Se is narrow [5]. High concentrations of Se can affect plant development, seed germination and vigor. The tolerated concentrations of Se, as well as the mechanisms of Se toxicity, vary among species [6]. The application of low concentrations of Se had a positive effect on seed germination and physiological quality in rice [7,8] and increased the antioxidant properties of higher plants, as reflected in the reduction in reactive oxygen species (ROS) [2].

However, high concentrations of Se can be toxic to plants because of the high generation of ROS, such as hydrogen peroxide, and can induce high rates of lipid peroxidation in cell membranes [9], as well as interfere with germination by acting to inactivate carbohydrate hydrolysis enzymes, which can lead to embryo death [7,10]. Studies with cowpea have shown that foliar Se application at the dose 50 g ha^{-1} is responsible for increase Se levels in shoots and grains, without causing symptoms of toxicity or causing oxidative damage in plant leaf cell. Also, the intake of more than 50 g per day of biofortified cowpea with Se in the mentioned dosage can meet the recommended recommendation for adults (0.1 mg Se per day) [4]. The effects of Se on the physiological quality of cultivated plant seeds are not yet fully understood, and further studies are needed. It is hypothesized that Se applied via the soil to cowpea crops could improve the physiological quality of the seeds obtained, especially when they are exposed to low and high temperatures during germination.

The aim of this work was to study the effects of the sources and rates of soil Se on cowpea cultivation and its effects on the physiological quality of seeds.

2. Materials and Methods

2.1. Experimental Setup

The experiment was carried out in 2016 in an experimental area located in the municipality of Selvíria-MS, south of the central-western region of Brazil, with geographical coordinates of 51°22′ W and 20°22′ S and an altitude of 335 m. According to a survey using the Brazilian soil classification system [11], the soil in the experimental area is called Dystrophic Red Latossoil, corresponding to Typic Haplorthox, according to the international classification [12]. The climate of the region is Aw, defined as tropical humid with a rainy season in summer and a dry season in winter, with an average annual temperature of 25 °C and rainfall of 1313 mm (average of the last 25 years). A meteorological station is located close to the experimental area, and data from this station were used to monitor rainfall and maximum and minimum air temperatures over the period of the experiment (Figure 1).

Before the experiment was conducted in the field, the soil was sampled from the 0–0.20 m layer for chemical analysis according to the method described by [13], and the results were as follows: pH (CaCl2 0.01) 5.2; phosphorus (resin) 34 mg dm^{-3}; sulphur (calcium phosphate) 8 mg dm^{-3}; potassium (resin) 2.7 mmol dm^{-3}; calcium (resin) 14 mmol dm^{-3}; magnesium (resin) 14 mmol dm^{-3}; H+Al (SMP buffer) 26 mmol dm^{-3}; SB 30.7 mmol dm^{-3}; CTC 56.7 mmol dm^{-3}; base saturation 54%; boron (hot water) 0.19 mg dm^{-3}; copper (DTPA) 2.7 mg dm^{-3}; iron (DTPA) 19 mg dm^{-3}; manganese (DTPA) 12.4 mg dm^{-3}; zinc (DTPA) 6.1 mg dm^{-3}; and organic matter 18 g dm^{-3}. The concentration of available Se was 3.6 µg kg^{-1} according to the methodology described by [14]. In previous years, the soil was cultivated with annual crops in a conventional cropping system, with beans (*Phaseolus vulgaris* L.) being grown between 2013 and 2015.

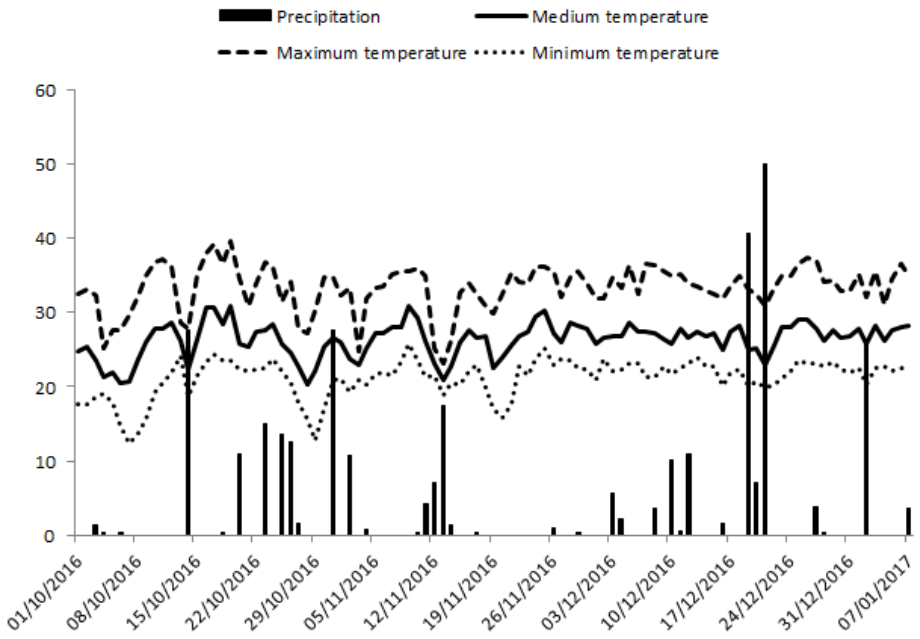

Figure 1. Precipitation (mm), maximum and minimum air temperature (°C) during the experiment period.

The treatments used were as follows: selenium sources [sodium selenate (Na_2SeO_4) and sodium selenite (Na_2SeO_3)] and seven Se rates (0, 2.5, 5, 10, 20, 40 and 60 g ha^{-1}). Each experimental plot consisted of five rows three meters long, resulting in a total usable plot area of 6.75 m^2.

The soil in the experimental field was prepared via one plowing operation (disc plow) and two harrowing operations (intermediate harrow and grader). Sowing was carried out with a row spacing of 0.45 m and a sowing density of 11.2 seeds m^{-1}. In accordance with the soil analysis and fertilization recommendations for the crop [15], fertilization was carried out in the furrow with 20 kg ha^{-1} K_2O and 20 kg ha^{-1} P_2O_5 in the form of KCl (33 kg ha^{-1}) and simple superphosphate (110 kg ha^{-1}). Cowpea seeds of the BRS-Tumucumaque variety were used and its characteristics are indeterminate growth, semi-erect size with uniform branching, purple pods and white, slightly reniform seeds, small, light brown hilum and a cycle of 65 to 70 days [15].

The seeds were treated with the fungicide carboxin + thiram at a rate of 200 mL 100 kg $seed^{-1}$. After drying, the seeds were inoculated with a peat inoculant for cowpea (strain SEMIA 6462 with 2.0 × 109 colony forming units g^{-1}) at 8 g kg^{-1} seed. The inoculant was dissolved in a 10% sugar solution and gradually added and mixed with the seeds in a concrete mixer machine at a constant speed of 18 rpm for five minutes. Emergence started four days after sowing (DAS).

The treatments were applied to the soil 40 days after emergence (DAE). A solution of Se diluted in 2 L of deionized water was prepared for each treatment. Five hundred milliliters of the solution was prepaired to each plot, 100 mL of which was used. The crop was harvested at 75 DAE. The phytosanitary treatments were carried out according to the needs and recommendations for the cowpea crop [16]. The first herbicide application was performed at 17 DAE, using the active ingredients fomesafen plus fenoxaprop-p-ethyl, both at a rate of 1 L ha^{-1} of the commercial product (c.p.). Fungicides were applied at 22 and 35 DAE with thiophanate-methyl at 140 g ha^{-1} c.p. and mancozeb at 2 kg ha^{-1} c.p., respectively. At 28, 42 and 52 DAE, insecticide applications were made with acephate, chlorpyrifos and beta-cyfluthrin at rates of 1.4 kg ha^{-1}, 1.25 L ha^{-1} and 100 mL ha^{-1} c.p., respectively, for each date and product.

After harvest, the seeds were subjected to germination and vigor tests (first count of germination, emergence, accelerated aging, cold test, electrical conductivity, length and dry biomass of the roots and shoots of the seedlings).

2.2. Germination, First Count of Germination and Seedling Emergence Analysis

The germination test was carried out with four replicates of 50 seeds per treatment, using germination paper as the substrate, consisting of two sheets of germination paper on which the seeds were placed and one to cover them. The sheets were previously moistened with distilled water at a rate of 2.5 times the mass of the unmoistened paper, and after the rolls were made, they were kept in the germinator at a temperature of 25 °C. The first and last germination counts were performed on the fifth and eighth days, respectively, and the average percentage of normal seedlings was calculated according to the criteria established by the Rules for Seed Analysis [17]. Germination percentage was considered the sum of both counts.

Four replicates of 50 seeds per treatment were used for seedling emergence. Seeds were sown in commercial substrate in expanded polystyrene boxes and watered twice a day. Emergence was assessed on the tenth day after sowing.

2.3. Seed Stress Resistance Analysis

The accelerated aging test was carried out with four replicates of 50 seeds for each treatment, in which 200 seeds were placed on the stainless steel mesh of a plastic box containing 40 mL of distilled water. After being covered, the boxes were placed in a germinator set at 41 °C where they remained for 48 h. After this period, the seeds were sown as described for the germination test [17], and normal seedlings were assessed on the fifth day after the sowing.

For the cold test, four replicates of 50 seeds were used for each treatment. The seeds were sown on moistened germ paper rolls and kept at a constant temperature of 10 °C for seven days. At the end of this period, the rolls were held at a constant temperature of 25 °C for another seven days and evaluated according to the same standards as those used for the germination test [17].

2.4. Biometric Analysis of Seedlings

Root and shoot lengths were measured with four replicates of 20 seeds for each treatment, following the same pattern as the germination test. After germination, the seedlings were measured with a ruler graduated in mm from the tip of the root to the neck for root length and from the neck to the insertion of the cotyledons for shoot length.

Immediately after the length measurements, the roots and shoots of the seedlings were separated and dried in a forced-air oven at 65 °C until they reached a constant weight. The samples were weighed, and the data are expressed in g plant^{-1}.

2.5. Biochemical Seed Testing

The electrical conductivity test was carried out with four replicates per treatment of 25 seeds, and the biomasses were measured on an analytical balance to an accuracy of four decimal places. The seeds were placed in plastic cups, soaked in 75 mL of distilled water and placed in the BOD incubator for 24 h at 25 °C. After this period, the electrical conductivity was read with a conductivity meter, and the values were expressed in μS cm^{-1} g^{-1} of seed.

2.6. Statistical Analysis

R software, version 4.0.4 [18], was used to perform the statistical analysis. A variance analysis was performed for the data, following the factorial model using seven Se rates × two selenium sources, randomized block design with four replications and for significant results, a Tukey test ($p \leq 0.05$) was performed to evaluate the mean differences across the treatments. A principal component analysis for the data was performed via RStudio, version 1.4.1103.

3. Results

3.1. Germination, First Count of Germination and Seedling Emergence

The first count of seeds obtained from the cowpea crop was significantly influenced ($p \leq 0.05$) by the interaction between sources and rates of soil-applied Se (Table 1). No significant fit was obtained for the polynomial regressions (first- and second-degree regressions).

Table 1. Summary of the analysis of variance for first count (FC), total germination (G), emergence (E), accelerated aging (AA), cold test (CT), electrical conductivity (EC), shoot length (SL), root length (RL), shoot dry biomass (SDM) and root dry biomass (RDM) of cowpea as a function of selenium sources and rates.

FV	FC	G	E	AA	CT
			(%)		
Sources (S)	9.15 *	0.12 ^{ns}	4.65 *	10.26 *	2.76 ^{ns}
Rates (R)	2.54 *	6.19 *	2.04 ^{ns}	22.50 *	22.33 *
SxR	12.65 *	1.30 ^{ns}	0.60 ^{ns}	7.81 *	16.08 *
CV (%)	15.56	9.02	6.82	19.83	17.62
	EC	SL	RL	SDM	RDM
	(μS cm^{-1} g^{-1})		(cm seedling^{-1})		(mg seedling^{-1})
Sources (S)	2.85 ^{ns}	34.88 *	31.87 *	0.77 ^{ns}	0.63 ^{ns}
Rates (R)	1.74 ^{ns}	10.34 *	3.79 *	17.32 *	6.32 *
SxR	4.83 *	2.23 ^{ns}	2.36 ^{ns}	4.97 *	5.37 *
CV (%)	9.34	12.01	8.42	18.90	19.34

ns and *: not significant and significant at the 5% probability according to the F test, respectively; CV: coefficient of variation.

However, at the lowest rate (2.5 g ha^{-1}) and rates of 20, 40 and 60 g ha^{-1}, the supply of sodium selenate as a source of Se resulted in higher values for the first count than did selenite, whereas at rates of 5 and 10 g ha^{-1} Se, sodium selenite resulted in higher FC values than did sodium selenate (Figure 2A). The total germination was significantly influenced by the Se rate, but there was no fit to the regression models considered (Table 1). In terms of seedling emergence, the results obtained with sodium selenate were better than those obtained with sodium selenite (Figure 2B).

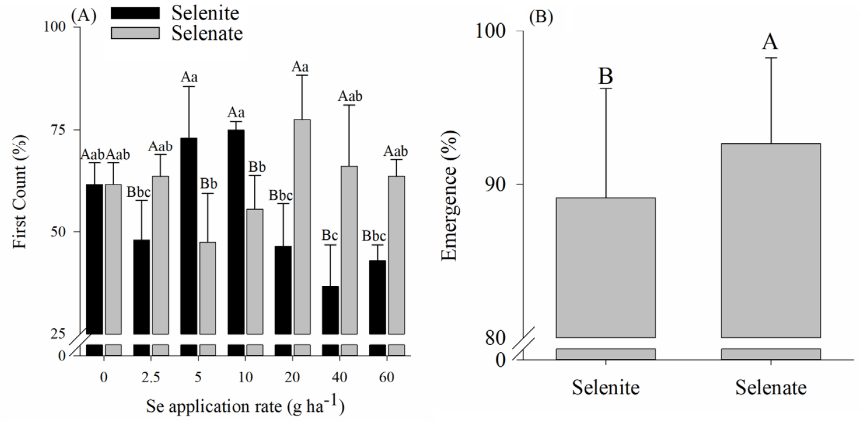

Figure 2. Interaction between Se sources and rates for first count germination (**A**) and comparison of means between Se sources for seedling emergence (**B**) in cowpea. Different uppercase letters indicate differences between sources at each rate, and lowercase letters indicate differences among application rates at each source. (Tukey test, $p \leq 0.05$).

3.2. Seed Vigor and Stress Resistance Testing

In the accelerated aging test, with the exception of the 20 and 60 g ha^{-1} rates, sodium selenate resulted in higher germination values for seeds exposed to high-temperature and high-humidity conditions, and for the 5 and 10 g Se ha^{-1} rates, the seeds with Se presented greater germination rates than did the control (Figure 3A).

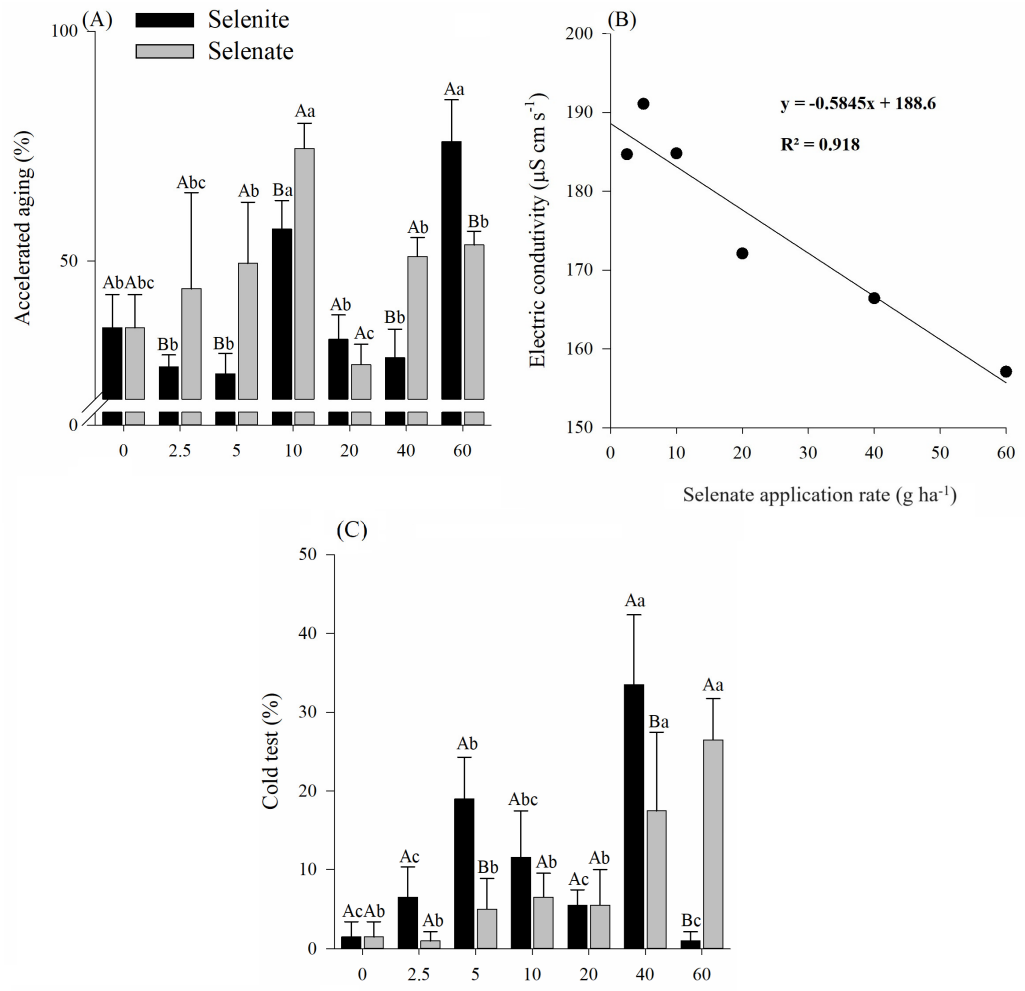

Figure 3. Interaction between Se sources and rates for the accelerated aging test (**A**), regression analysis for the cold test under sodium selenate application rates (**B**) and interaction between Se sources and rates for the cold test (**C**) in cowpea seeds. Different uppercase letters indicate differences between sources at each rate, and lowercase letters indicate differences among application rates at each source. (Tukey test, $p \leq 0.05$).

For sodium selenate, the means fit an increasing linear equation in the cold test, indicating an increase in the germination percentage of seeds exposed to low temperatures during germination with increasing rates of Se applied via the soil (Figure 3B). On the other hand, there was no regression equation for sodium selenite. The application of sodium selenite resulted in higher germination values for cowpea seeds than did the application of sodium selenate at rates of 5 and 40 g ha^{-1}, but at the highest rate of Se, sodium selenate resulted in higher germination values at low temperatures (Figure 3C).

3.3. Seedling Biometric Measurements

The length and dry biomass of the shoot and root were significantly influenced by the Se rate, but there was no significant fit for the regression models considered (Table 1).

Sodium selenate had better results than did sodium selenite for the shoot length of the seedlings (Figure 4A), and the rates of 2.5, 10, 20 and 40 g Se ha^{-1} were greater than those of the control (Figure 4B). Selenate resulted in better results than selenite for root length at rates of 2.5, 10, 20 and 40 g Se ha^{-1} (Figure 4C).

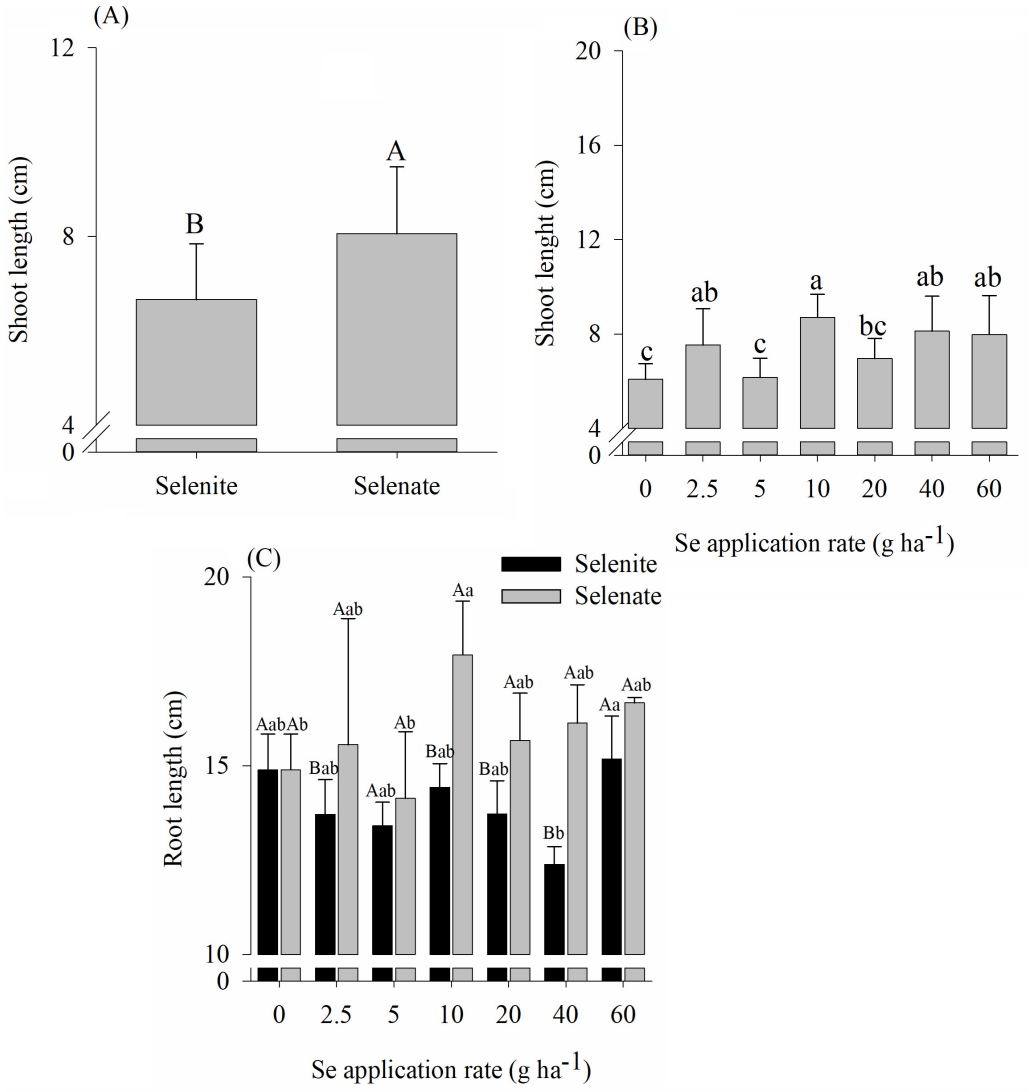

Figure 4. Comparison of means between Se sources for shoot length (**A**), between Se rates for shoot length (**B**) and between the interaction of Se sources and rates for root length (**C**) of cowpea seedlings. Different uppercase letters indicate differences between sources at each rate, and lowercase letters indicate differences among application rates at each source. (Tukey test, $p \leq 0.05$).

With respect to the shoot dry biomass of cowpea seedlings, there was no regression model for Se rates, regardless of the source used. The rates of 2.5 and 40 g ha^{-1} Se, when selenate was used, resulted in greater accumulation of dry biomass than did selenite, while at a rate of 5 g ha^{-1}, sodium selenite resulted in greater shoot dry biomass than did selenate (Figure 5A).

At the lowest Se rate (2.5 g ha^{-1}) and the 20 g ha^{-1} rate, the highest root dry biomass values were obtained via sodium selenate, and at the 5 g ha^{-1} rate, sodium selenite resulted in greater accumulation of dry biomass than did sodium selenate (Figure 5B).

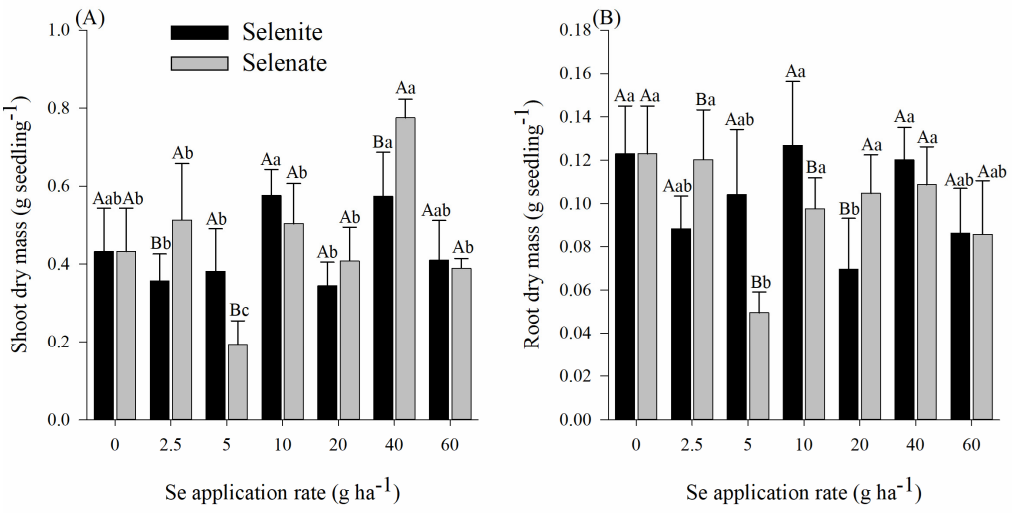

Figure 5. Interactions between Se sources and rates for shoot dry biomass (**A**) and root dry biomass (**B**) of cowpea seedlings. Different uppercase letters indicate differences between sources at each rate, and lowercase letters indicate differences among application rates at each source. (Tukey test, $p \leq 0.05$).

3.4. Biochemical Seed Testing

The electrical conductivity of the soaking solution decreased linearly with increasing Se rates when sodium selenate was used as the source of this element (Figure 6A). For sodium selenite, there was no significant fit to the linear and quadratic regression models. At rates of 5 and 10 g ha^{-1}, sodium selenite caused less electrolyte leakage from the seeds into the soaking solution, whereas at the highest rate of Se (60 g ha^{-1}), the lowest electrical conductivity was obtained when sodium selenate was used as the Se source (Figure 6B).

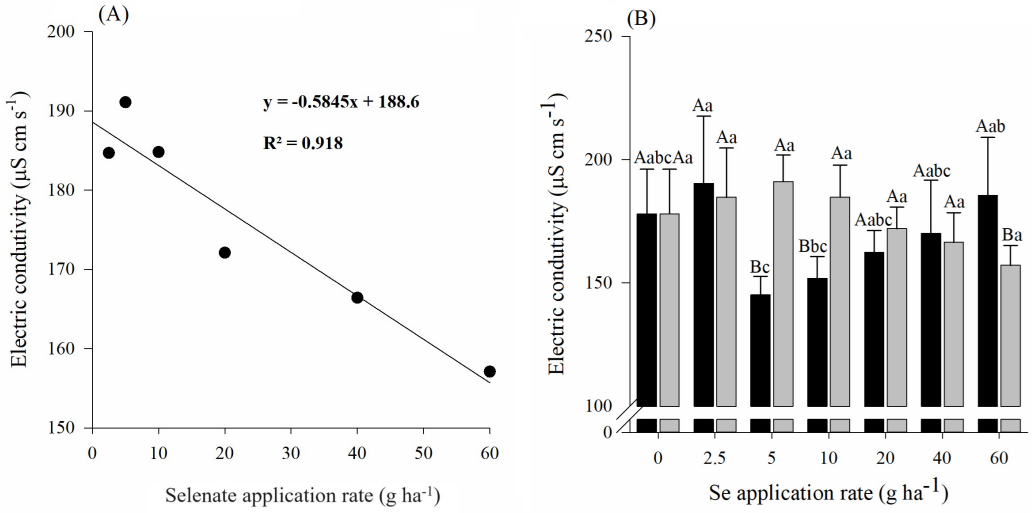

Figure 6. Regression analysis for electrical conductivity under different sodium selenate application rates (**A**) and interactions between Se sources and rates for electrical conductivity (**B**) in cowpea seeds. Different uppercase letters indicate differences between sources at each rate, and lowercase letters indicate differences among application rates at each source. (Tukey test, $p \leq 0.05$).

3.5. Principal Component Analysis

A principal component plot was constructed to assess the relationships between the analyzed variables and the Se sources and rates (Figure 7). Most of the variable vectors were close to selenate at rates of 10 g ha^{-1} (FC, SDM and RDM), 40 g ha^{-1} (E) and 60 g ha^{-1} (EC). Only selenite at 2.5 g ha^{-1} was close to AA. These findings indicate that selenate

provides good results for most of the physiological variables of cowpea seeds. Considering that the initial stand is fundamental for planting the crop, the 10 g ha^{-1} rate of sodium selenate provided seedlings with good root development and good first count germination, indicating faster seedling establishment.

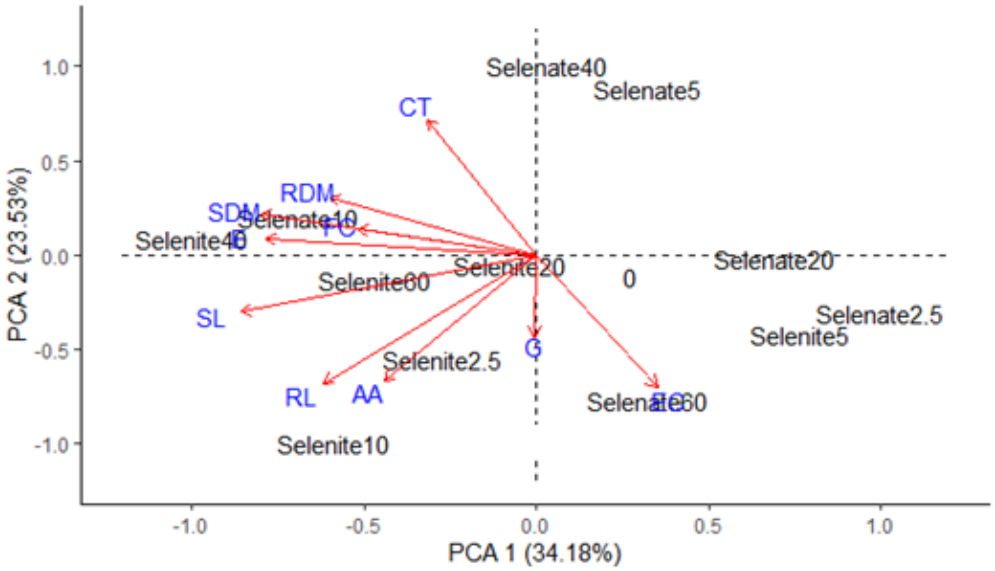

Figure 7. Principal component analysis for the seed physiological variables first germination count (FC), germination (G), emergence (E), electrical conductivity (EC), cold test (CT), accelerated aging (AA), shoot length (SL), root length (RL), shoot dry biomass (SDM) and root dry biomass (RDM) tests, and sources and rates of Se in cowpea seeds.

4. Discussion

Although Se is not considered a nutrient, it is beneficial for various crops [6]. Its benefits are related to increasing the capacity of the plant's enzymatic and nonenzymatic antioxidant system; amino acid and protein synthesis; the photosynthetic rate; nitrate and sugar reductase; and increased nodulation in legumes [14,19–24].

As selenate is more easily transported in plant tissues, it can reach higher concentrations in drainage pathways [5]. Selenite has greater potential to cause phytotoxicity than selenate because of the rapid conversion of selenite to selenoamino acids, which can then be incorporated into plant proteins [25]. According to [26], the lack of incorporation of selenoamino acids such as selenomethionine (SeMet) and selenocysteine (SeCys) into proteins is the factor that contributes the most to Se toxicity in plants.

Therefore, while selenate is more rapidly absorbed by plants than selenite is, the assimilation of selenite is faster than that of selenate [6]. The presence of free Se in leaf tissue from selenate can stimulate oxidative stress mitigation mechanisms [27]. On the other hand, selenite is rapidly converted to organic compounds such as SeCys and SeMet, which in excess contribute to increased toxicity. This may explain the increase in plant emergence and development with selenate application and the decrease with selenite application.

Selenate is a source of Se with the capacity to be absorbed more rapidly by plants, as its behavior is similar to that of sulfate; therefore, it is absorbed through sulfate transport pathways [28]. Notably, selenate is a highly oxidized compound that requires it to undergo numerous processes to become organic Se, such as SeCys and SeMet, increasing its ability to be translocated through plant tissues [6]. Selenite, on the other hand, is translocated via phosphate transporters, and because it is less oxidized than selenate is converted to organic forms more quickly, meaning that it is less translocated in the plant and takes longer to reach leaves and seeds [5]. Notably, the behaviors of selenite and selenate in the soil differ, as selenite is more easily adsorbed by soil colloids, whereas selenate remains in the soil solution, especially in soils with high clay contents [14]. Therefore, plants absorb Se in the

form of selenate more efficiently than selenite. This may be the reason for the better results with selenate than selenite in this study.

Owing to the high translocation capacity of selenate through the xylem and its low adsorption in the soil, it is possible that relatively high concentrations of Se are transported to the seeds during the pod-filling process. [29] reported that Se concentrations in turnip (*Brassica napus* L.) seeds were greater in plants treated with selenate than in those treated with selenite. [30] reported that when 30 g ha^{-1} Se was applied foliarly to a lentil crop (*Lens culinaris* Medikus), the concentration of Se in seeds was significantly greater in those treated with selenate (1.4 mg kg^{-1}) than in those treated with selenite (0.9 mg kg^{-1}).

In previous studies in legume plants, Se application demonstrated the capacity of increase the concentration of sugars and N-compounds in seeds, which might explain the effect of the element in seeds quality. In a pot experiment with 29 cowpea genotypes, Se application ate the rate of 12.5 μg dm^{-3} enhanced the concentration of sugar and n-compounds in seeds [31]. The effect of Se increasing sugars in cowpea was also observed in a field experiment using two different cultivars at the application rates of 5, 20 and 20 mg Se ha^{-1} [32]. In mungbean, the application of 30 g ha^{-1} of exogenous Se upregulated protein production in seeds [33].

Selenium can also affect the production of hormones, such as gibberellin, an important hormone for initiating the germination process, in seeds [34]. Physiological conditioning of *B. napus* seeds with Se resulted in an increase in the expression of gibberellin production genes [35]. These authors reported an increase in the expression of five genes related to gibberellin production, even in the first 24 h after sowing.

Studies using Se solution conditioning have shown that low concentrations of this beneficial element (15–60 μmol L^{-1}) promote greater germination of rice seeds. This was attributed to the synthesis of germination-promoting substances and the efficient activity of hydrolytic enzymes, which can stimulate the efficient mobilization and utilization of seed reserves (mainly starch amylase activity), as well as membrane reorganisation and reduced leakage of metabolites in seeds in solution. The positive effect of Se on seed germination is also associated with an increase in the antioxidant activity of glutathione peroxidase and the activation of the ascorbate-glutathione cycle [7].

Both selenate and selenite can cause changes in plant membranes; therefore, the same can be inferred in the process of membrane organization during seed formation. The increased release of solutes is directly proportional to the decrease in germination and seedling vigor; higher conductivity values indicate less vigorous seeds, and lower values, corresponding to less release of exudates, indicate high physiological potential. The antioxidant effects of Se application during cowpea cultivation may have favored the formation and integrity of seed membranes during the grain-filling period, which may have had a positive influence on reducing electrolyte leakage during seed imbibition.

Under stress conditions, whether due to heat and moisture, as in accelerated aging tests, or cold, high Se concentrations in tissues can lead to the release of superoxides, which can catalyze the increased expression of antioxidant enzymes and regulate metabolic disorders [36]. Se can also have a positive effect on seed germination under stressful abiotic conditions such as excessive salinity, heavy metal exposure and water deficit [37].

Complex interactions between Se and other nutrients can occur during plant metabolic processes, especially in relation to micronutrients. Se sources clearly behave differently in terms of plant metabolic processes, indicating that several important factors need to be considered for agricultural selenium supplementation.

Selenium is considered beneficial for plants as an antioxidant that provides tolerance to biotic and abiotic stresses [4,6,26,38]. Its use can reduce the effects of abiotic stress on both plants and seed germination, as presented in this work. Notably, if any type of stress is not properly regulated, excessive ROS can damage phospholipid membranes, proteins or DNA, thus inhibiting signaling pathways and, in general, cell function [36], a fact related to the electrical conductivity of seeds. The supply of Se during crop development can promote

fewer biotic and abiotic perturbations in plants, without interfering with seed development and contributing to an increase in their physiological potential.

Compared with the use of sodium selenite, the use of sodium selenate as a source of Se improved the physiological quality of cowpea seeds. Seed germination after accelerated senescence stress is increased by the use of sodium selenate, even at relatively high rates, whereas selenite provides beneficial results at relatively low rates. Sodium selenate linearly increased seed germination after the cold test and linearly reduced seed electrolyte leakage with increasing Se rates.

5. Conclusions

The soil application of Se is beneficial for cowpea seed quality. Compared with those treated with sodium selenite, cowpea plants treated with sodium selenate in the soil produced more vigorous seeds. The application of 10 g ha^{-1} Se as sodium selenate provides seedlings with faster germination and root development and is an alternative for rapid stand establishment.

As a perspective, we show that soil application of Se at low concentrations can be used to improve physiological quality and induce tolerance to abiotic stress in cowpea seeds. Selenium provides a better initial development for cowpea seedlings, this is crucial for a faster plant development in stressful conditions, specially considering cowpea importance as a low-income crop, thus, being more susceptible to sub optimal growth conditions.

Is noteworthy that future investigations must be performed to further elucidate selenium effect on cowpea seeds quality. The present data states that selenate is more fitted as a Se-source than selenite, however, future studies with different genotypes could enhance the knowledge. In addition to that, wider and longer field experiments would also help to further investigate the residual effect of Se in cowpea seed over the years.

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