EFFECT OF SELENIUM ON GROWTH AND YIELD OF TOMATO PLANTS

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Abstract

Selenium (Se) has been reported to mitigate abiotic stress effects on various plant species, including drought. This study aimed at exploring the potential impacts of Se at three levels (0, 20, and 40 mM of sodium selenate) applied in two methods (soil addition or foliar spraying) on growth, yield and its quality, physio-biochemical attributes, and components of the antioxidant defense system in tomato plant growing under irrigation water deficit (from 100% to 60% of soil field capacity; SFC) during the 2017 and 2018 seasons. For the application of Se to soil, the concentration of Se in the tested soil was also evaluated at the end of the experiments, and the results obtained showed that soil Se concentration was significantly increased. Reducing irrigation water from 100% to 60% of SFC led to a marked increase in electrolyte leakage (EL) and oxidative stress biomarkers (malondialdehyde; MDA, hydrogen peroxide; H_2O_2, and superoxide; $O_2^{\bullet-}$), which associated with increased contents and activities of osmoprotectants and components (enzymatic and non-enzymatic) of the antioxidant defense system. In contrast, growth traits, relative water content (RWC), membrane stability index (MSI), photosynthetic efficiency, contents of N, protein and Se, and yield and its fruit Se content were decreased in both seasons. Both 20 and 40 mM Se significantly increased contents and activities of osmoprotectants and components of the antioxidant defense system, which were reflected in reduced EL and oxidative stress biomarkers and increased growth traits, RWC, MSI, photosynthetic efficiency, contents of N, protein and Se, and yield and its quality. Compared to foliar spray, better results were obtained with Se application to the soil. The interaction among the three factors; water deficit, Se level, and Se application method was significant. The combination of irrigation at 60% of SFC × Se foliar application at 40mM 0r Se soil application at 40mM was preferable, which can be recommended to use for maximizing the productivity and quality of tomato crop in the dry environment.

***Keywords*: Tomatoes, Drought, Selenium, Application methods, Yield quality, Antioxidant defense system.**

SUMMARY

Two pot experiments were implemented during two consecutive seasons (7 September 2017 and 5 September 2018) at the experimental farm of the Faculty of Agriculture located at South East Fayoum; 29° 17'N; 30° 53'E, Egypt. Five-week old tomato seedlings, cv. Lojain 935 (Enz Zaden Company, obtained from Nurseries of the Ministry of Agriculture, Cairo, Egypt) were utilized for transplanting in black colored-plastic pots (40 cm inner diameter and 42 cm in depth). The current study was implemented to investigate the protective role of Se application in two methods (soil addition with irrigation water and foliar spraying) in alleviating the adverse influences of irrigation water deficit (drought) stress by improving the growth characteristics, physiological and biochemical attributes, and the activity of the components of the antioxidant defense system associating with the suppression in the oxidative stress biomarkers in tomato plant. The obtained results are summarized as follows:

- **For irrigation regime (100% or 60% of soil field capacity; SFC) applications:**

Decreasing the irrigation regime from 100% to 60% of SFC significantly decreased the following parameters: number of leaves plant^{-1} , shoot fresh weight (SFW, shoot dry weight (SDW), relative water content (RWC%), membrane stability index (MSI%), *Fv/Fm*, performance index (PI_{ABS}, SPAD values, nitrogen (N) content, protein content, selenium (Se) content, average fruit weight, number of fruits plant^{-1}, fruits weight plant^{-1}, fruit Se content, and soil Se concentration in both 2017 and 2018 seasons, respectively. In contrast, reducing the irrigation regime from 100% to 60% of SFC significantly increased the following parameters: electrolyte leakage (EL%), lipid peroxidation in terms of malondialdehyde (MDA) content, hydrogen peroxide (H_2O_2) content, superoxide ($O_2^{\bullet-}$) content, total soluble (TS) sugars content, free proline content, ascorbate (AsA) content, glutathione (GSH) content, α.tocopherol (α.TOC) content, superoxide dismutase (SOD) activity, catalase (CAT) activity, ascorbate peroxidase (APX) activity, fruit lycopene content,

fruit AsA content, fruit total soluble solids (TSS) content, fruit titratable acidity, and fruit firmness in both seasons.

- For selenium (Se) level (0, 20, or 40 mM) applications:

Both levels of Se; 20 and 40 mM significantly increased number of leaves plant^{-1}, SFW, SDW, RWC, MSI, *Fv/Fm*, PI, SPAD values, the contents of N, protein, Se, TS sugars, proline, AsA, GSH, and α.TOC, the activities of SOD, CAT, and APX, and fruit yield components and the contents of fruit Se, fruit lycopene, fruit AsA, fruit TSS, fruit titratable acidity, and fruit firmness, and soil Se concentration compared to the control (0 mM Se). However, the level of 40 mM Se significantly exceeded the level of 20 mM Se for both seasons. In contrast, the level of 40 mM Se significantly reduced EL%, the contents of MDA, H_2O_2, and $O_2^{\bullet-}$ for both seasons, respectively compared to the control (0 mM Se).

- For selenium (Se) application (foliar spray or soil addition with irrigation water) methods:

There were no significant differences between the two application methods (with slight preference of Se soil addition) for tomato plant growth traits, photosynthetic efficiency indices, N and protein contents, oxidative stress biomarkers contents (MDA, H_2O_2, $O_2^{\bullet-}$), antioxidant system component activities with some fluctuations, fruit yield components, and fruit quality; lycopene, AsA, TSS, titratable acidity, and fruit firmness contents, while there were significant differences for MSI%, EL%, and soil Se concentration in both seasons of 2017 and 2018 in favor of the Se soil addition compared to the Se foliar spraying.

- For the interaction among the three factors; irrigation regimes, Se levels, and Se application methods:

There were significant differences among the combined treatments, especially stressful treatments. For combined treatments under 100% of SFC (normal condition), the best treatment was irrigation at 100% of SFC ($Irrig_{100}$) × Se application at 40 mM (Se_{40}) × Se application through soil (SA) or foliar spray (FS) for all the tested parameters. For combined treatments under 60% of SFC (stressful condition), the best treatment was $Irrig_{60}$× Se_{40}× SA. This

combined treatment significantly increased growth traits; number of leaves plant^{-1}, SFW, SDW, RWC%, MSI%, *Fv/Fm* by, PI_{ABS}, SPAD values, N content, protein content, Se content, TS sugars content, free proline content, AsA content, GSH content, α.TOC content, SOD activity, CAT activity, APX activity, average fruit weight, number of fruits plant^{-1}, fruits weight plant^{-1}, fruit Se content, fruit lycopene content, fruit AsA content, fruit TSS content, fruit titratable acidity content, fruit firmness, and Se concentration in the soil by, while significantly decreased EL%, MDA content, H_2O_2 content, and $O_2^{\bullet-}$ content in both 2017 and 2018 seasons compared to the corresponding control.

From the results obtained in the current study, it has been concluded that soil supplementation with Se through irrigation water was more effective than foliar supplementation with Se in mitigating the adverse effects of irrigation water deficit stress conditions. Higher activities of the components (enzymatic and non-enzymatic compounds) of antioxidative defense system in tomato plant were obtained in association with the increase of Se content in plant tissues, especially under stress conditions. In addition, the higher contents of osmoprotectants were associated with higher cellular relative water content and membrane stability index against electrolyte leakage, lipid peroxidation and other oxidative stress biomarkers; MDA, H_2O_2, and $O_2^{\bullet-}$ produced under drought stress. This protective status indicates that the effect of Se on one parameter under stress directly affect others due to the regulatory role of Se in water deficit-stressed plants. Therefore, the supplementation of soil with Se may be utilized as a useful strategy to minimize the adverse impacts of irrigation water deficit stress for sustainable tomatoes productions under the scenario of growing climate change induced drought stress.