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Application of Selenium A Useful Way to Mitigate Drought Stress; A Review

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Abstract

The water scarcity is the most important problem for the countries which are negatively affected due to climate change. The water or drought stress negatively affects plant mechanisms such as formation of proteins, nucleic acid, lipids and carbohydrates which reduces the final crop growth and production. Selenium plays a significant role in improving crop growth, decreases oxidative stress damage, increasing contents of chlorophyll, improving senescence and increasing tolerance of plants to water stress by regulating the status of water. Keeping in mind the importance of selenium, the present review focuses on effect of drought on agriculture crop production and role of selenium for improving crop production under drought conditions.

Keywords: Drought; Selenium; Agriculture; Crop Production

Introduction

Globally, different abiotic stresses like heat, heavy metals, flooding, salinity, cold and drought are the major reasons for reduction in development, growth and agriculture crop production [1]. Among all these different abiotic stresses the drought or water scarcity is the most important factor which limits the agriculture crop production [2]. Insufficient availability of water during crop life cycles limits the crop growth and never allows crop to shows its full genetic potential. Mostly every crop is very sensitive to drought stress, mainly during the stage of flowering to seed development. Even drought-resistant crops are negatively affected due to scarcity of water at reproductive and seed development stage [3]. The starting response of drought is closure of stomata which decreases the ability of photosynthesis and final dry matter [4]. Crop gathers proteins and osmolytes mainly intent resilience of stress under conditions of water deficiency and reduces the damage. In addition, plant tolerance equilibrium acts as radicals scavenging and decreases the harmful effects of the cells in abiotic stress conditions [5]. The attributes related to crop morphology such as thickness of roots and its development like ability of crop roots to break compact soil layers, its biomass and depth reduces stress tolerance [6]. It results in lessened germination, growth and seedling development [7] causes death of plant at premature stage [8] and reduces the plant harvestable yield [9]. Many researchers reported the negative effects of water stress on seed germination, growth and development of many crops like sugar beet [10], sunflower [11], kochia [12], sorghum [13] and maize [14]. Therefore, it desired to study the drought mechanism and adopt some strategies to combat drought stress to improve crop production. There are many methods to improve drought tolerance in the crops but

application of selenium under drought stress is the best and most economical way to improve drought tolerance and reduce yield losses caused by water scarcity. Selenium is quite similar with Sulphur in several ways such as atomic size, electronegativity and both have similar oxidation states [15]. The Se antioxidant and physiological properties increased the oddity of many agriculture scientists in last few decades. While it does not directly take part in different process of metabolism of plants but helps to decrease the damage of crops under many physiological stresses [16,17].

Different studies confirmed the Se positive role against different abiotic stresses like, high temperature [16], salt [18], senescence [19], cold [20] UV-B [21], heavy metals [22], low water and excess water [23]. Several reports on selenium role for improving drought resistance are scanty. Se can regulate the status of water [24] and significantly increases production of biomass [25] by antioxidant apparatus activation of plants facing water stress. In past few decades literature shows positive effects of selenium at very low concentration in increasing tolerance of plant to drought and improving plants growth [26], increasing carotenoids and chlorophyll contents in leaves of plants [27], regulating status of water [28], compatible solutes accumulation and antioxidant machinery activation. Keeping in mind the importance of selenium, the present review focuses on effect of drought on agriculture crop production and role of selenium for improving crop production under drought conditions.

Hazardous Impacts of Drought stress on Crops

Plants are the organism which are often exposed to different kind of stresses [29] which includes both abiotic and biotic [30]. From all of them drought or water scarcity is one of the most

vital abiotic stress which negatively affects the plant germination, growth and development [31]. Mostly, physiological and agricultural point of view, water stress occurs when the amount of available water decreased in the soil and not available to the plants at a certain period of time [29]. But, there are a lot of reasons which cause drought stress, like high light intensity, high temperature at growth stages, dry wind seasons, increase in evaporation and evapotranspiration. Furthermore, all of these factors increases the plant water losses and causes drought stress to plants [32]. The drought symptoms in plants varies from specie to specie, crop developmental stage, environmental factors and growth conditions [33]. Basically, the symptoms of drought include drooping of leaves, leaf turgor loss, wilting, yellowing, etiolation and leaf downfall [34].

In addition to this under extreme drought conditions the death of whole plant occurs [35]. Furthermore, the water stress conditions seriously alter the plant growth and development [36]. The drought condition can significantly reduce the quality and quantity plants yields, specifically crops [37]. It can influence many plant aspects, anatomical and morphological. Leaf anatomy and its structure are mostly significantly influenced due to severe drought conditions [38]. The photosynthesis reduction and inhibition is one of the most important effect of drought in plants [39]. In addition to this decrease in the leaves chlorophyll contents are another most important factor that reduce the rate of photosynthesis under drought conditions [29].

What is Selenium

Se is quite similar with Sulphur in a lot of ways such as, atomic size, electronegativity and both have similar states of oxidation. It was known as toxic and undesirable element for higher organisms but in 20th century [40] stated that Se low concentration are very important for dietary and vitamin E. After that in 1973, it was noted that being a very important component of glutathione peroxidase (GPX) enzyme, it prevents the cells from the oxidative damage [41].

Role of Selenium under Abiotic Stresses

Se is may be a very important component to combat abiotic stresses in plants [42]. Treatment of selenite was proved to improve toxic effects, as plants of lettuce displayed higher malondialdehyde (MDA) and H₂O₂ accumulation than non-treated control plants. Application of Se at 10 and 50µM enhanced the growth, development and levels of proline and photosynthetic pigments in cucumber leaves subjected to the salt stress [43]. Wheat plants when exposed to cold stress, treatment of Se at 1.0 mg kg⁻¹ decreased the MDA content and accumulation of ROS by an increase in phenolics, flavonoids and anthocyanins. Antioxidant enzymes activities such as CAT and POD was also improved. This may cause peroxidation declining of the membrane lipids. [44] verified the beneficial effect of Se application for protecting the lead and cadmium toxicity in Brassica napus. Application of Se is very favorable for wheat seedling growth under water stress conditions, but the physiological and growth responses of seedling were very different, depending on the concentration of Se. [45] stated that addition of Se in small concentration increased the contents of selenium in the lettuce and enhanced the growth of lettuce. Furthermore, he also concluded that Se has the great ability to regulate the water under drought circumstances.

Beneficial effects of Selenium on crops

Selenium acts as a very beneficial in plants such as lettuce (*Lactuca sativa*) and ryegrass (*Lolium perenne*) at very low concentration (0.1mg kg⁻¹) [46]. The stimulatory impact of its foliar application is reported for potato [47], lettuce, ryegrass, green tea leaves [48] and soybean [49]. Moreover, it can promote plant growth by delaying senescence and aging in plants. [50] described that priming of bitter melon (*Momordica charantia*) with selenite increase the germination percentage at unfavorable soil environment. Furthermore, its large addition to the soil promotes the roots volume. It increased the potato photoassimilate allocation for the growth of tuber and created a very strong source and sink for upper young leaves, tubers, roots and stolons. Moreover, potato plants senescence also delayed due to Se antioxidant properties. Se application significantly increased the pepo plants yield [51].

Role of Selenium in improving drought tolerance in plants

Application of Se employs many beneficial impacts on the growth and stress tolerance mechanism by improving the antioxidant properties of plants [52]. Researches carried out in past few decades elaborate that application of Se not only enhance the plant growth but also increase the drought resistance and antioxidant ability of plants. In last few decades the antioxidant and physiological characteristics of Se increased interest of many biologicals and agriculturists. While it never takes parts in any plant metabolic process but can only reduce the physiological stresses damage. Several researches have confirmed Se positive role against different abiotic stresses such as high temperature, cold, UV-B, heavy metals, salt, senescence, desiccation and excess water [53]. Though, the reports on the Se role under drought conditions are very small. It may regulate the status of water in plants and improves the production of biomass by antioxidant apparatus activation in water stresses crops and plants.

Se use in spring wheat displayed directed antioxidant effect on decreased intracellular active oxygen species concentration by making peroxidase and proline production. In rye grass (*Lolium perenne*) the GPX activity increased significantly by the application of 1.0 mg Se. [54] noted upsurge in lipid peroxidation at higher Selenium concentrations that diminish the lettuce yield. They recommend low Se dose for improving the antioxidants activity and reported that application of Selenium as selenite is more promising for improving Se translocation and levels of selenium in shoot biomass. The more uptake of selenite and translocation is may be due to more sulphate transporters affinity for selenite [55]. On the other hand, [56] stated that selenite was much effective that selenite for increasing enzymatic activity. Few studies confirmed positive effect of Se fertilization in different crops like maize [57], rice [58], wild barley [59] and soybean [60]. The foliar application of Se has significantly been reported to promote growth of vegetables like carrot leaves and roots [61], onion leaves and bulbs [62], garlic bulbs and in cereal crops wheat [63].

Conclusion

This review demonstrates that low dose of Selenium (Se) is a very useful option to combat drought stress by enhancing the growth, development and yield. However, the available data regarding Se is insufficient to fully understand the role of selenium

to improve drought tolerance mechanism of plants. Therefore, in future more research is required to better understand the role of selenium to improve drought tolerance mechanism.

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