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Thiourea: A Smart Alternative for Drought Tolerance

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SUMMARY

Continuously changing climate is the greatest threat to global food security. To meet the need of food for increasing population is the major challenge for agricultural researchers. At present, many researchers are extensively trying to get maximum agricultural production under various biotic and abiotic stresses. Among all stresses, water deficit condition is always emerged as the major obstacle in getting good quality produce. To tackle this water scarcity conditions, researchers are trying to implement various ideas and technologies, which may include identification of stress tolerant germplasm lines, use of different water saving technologies, adaptation of various cultural practices which mitigate water stress. Among all these technologies, application of plant bio-regulators found to be most promising under water deficit conditions. Application of thiourea regulate the physiological processes of plants under drought like conditions. This helps to get sustainable yield even under stressful environment.

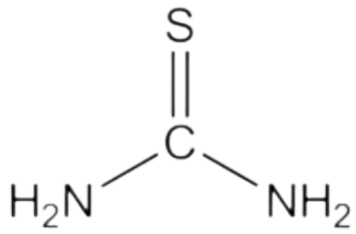
INTRODUCTION

Climatic changes and increasing climatic unpredictability has emerged as a great threat to the global food security. Intergovernmental Panel on Climate Change (IPCC) revealed that climate change affects crop production in several regions of the world, with more often negative effects as compared to positive ones, and developing countries are highly prone to intense negative impacts (IPCC 2014). Hence, continuously changing climate is a major concern for agriculture and livelihood. The changes leading to variety of adverse conditions which are categorized under biotic and abiotic stresses. These stresses greatly affect the agricultural production and livestock, making adverse impact on socio-economic status of the farmers.

Abiotic factors majorly consist of water stress (deficiency or excess), edaphic stresses, atmospheric stresses like high or low temperature, heavy metal toxicity and so on (George *et al*. 2017). Almost 90% of arable lands are prone to one or more of the above-mentioned stresses (Dos Reis *et al*., 2012), which trigger up to 70% yield losses in major food crops (Mantri *et al*., 2012). Among all the abiotic stresses, water stress is the most responsible factor for reduction in crop yield (Francini and Sebastiani, 2019; Parthasarathi *et al*. 2012). Water is a critical input into agriculture in nearly all its aspects having a determining effect on the eventual yield. Water stress is ever intensifying in regions such as China, India, and Sub-Saharan Africa, which contains the largest number of water stressed countries of any region with almost one fourth of the population living in a water stressed country. Annually, around 1 million people suffer the serious consequences of water scarcity. In addition to affecting the huge rural and urban population, the water scarcity in India also extensively affects the ecosystem and agriculture. India shares only 4% of the world's fresh water resources despite a population of over 1.3 billion people (Khalid *et al*. 2019; NITI Aayog, 2019). Water deficit stress alters the physiology of crop plant which ultimately declines the crop yield (Ferguson, 2019). The alteration in plant physiology is majorly characterised by impaired photosynthetic function, hampered vegetative and phenological growth, and damaged cellular homeostasis of plant (Akram *et al*. 2013; Dhaka *et al*. 2006). Many agricultural researchers are implementing various ideas and technologies with an aim to get sustainable crop yield under water stress conditions. Researchers are mainly focusing on identification of water stress tolerant genotypes by employing conventional as well as high throughput plant phenotyping tools (Babar *et al*. 2021; Zia *et al*. 2013; Romano *et al*. 2011). This breeding approach requires longer time; it is necessary to adopt different cultural practices which may impart some kind of tolerance to particular genotypes. These technologies make use of grafting, application of polymers like hydrogel into soil, and anti-transpirants and various plant bioregulators (Wakchaure *et al*. 2020; Nirmala and Guvvali, 2019; Billore, 2017; Kumar *et al*. 2017). From the aforesaid technologies, applications of chemical based plant bioregulators *viz*., Thiourea ($CS(NH_2)_2$), Salicyclic acid ($C_7H_6O_3$), Potassium permanganate ($KMnO_4$) and Hydrogen peroxide (H_2O_2) have been shown beneficial for crop growth under stressful conditions (Srivastava *et* *al*. 2016). Thiourea is a thiol compound (Gyorgy *et al*. 1943; Jocelyn 1972) and there are sufficient evidences available to support the role of thiol compounds in plant stress tolerance (Zagorchev *et al*. 2013). In this article, application of thiourea as a chemical-based plant bioregulator under drought stress is briefly discussed.

Thiourea : Plant bioregulator

Thiourea ($CS(NH_2)_2$) is an organosulfur compound also known as *Thiocarbamide*. It is structurally analogous to urea, except that the oxygen atom is replaced by a sulphur atom, but the properties of urea and thiourea differ significantly. It appears as white crystals which is combustible and on contact with fire gives off irritating or toxic fumes. It acts as a precursor to sulphide (https://pubchem.ncbi.nlm.nih.gov/compound/thiourea). It consists of three functional groups such as amino, imino and thiol, each has specific biological roles. Thiourea is being increasingly used to improve plant growth and productivity under normal and stressful conditions especially under water stress (Wahid *et al*. 2017).



The ability of thiol compounds towards mitigating water stress has been proven in various crops with pre-sowing seed treatment of dithiothreitol, thioglycolic acid, thiourea and cysteine. These compounds could improve the functions of important enzymes of superoxide scavenging system that include superoxide dismutase, glutathione reductase and glutathione-S-transferase (Nathawat *et al*. 2007). Due to this, plants can perform its physiological activities normally even under stressful conditions. Several studies report thiourea as an efficient alternative to alleviate drought, salinity and heat stress, and enhance the crop yield when applied through foliar sprays and also by other means. Thus, it is considered as an effective bio-regulator that regulates cell metabolic activities and restores cellular redox homeostasis in crop plants under stressful conditions. Hence, thiourea has a significant potential for mitigating the adverse effects of dater deficit conditions on agricultural productivity.

Performance of Thiourea Under Water Deficit Conditions

Irrigation water demand would increase with rising temperature (Raftery *et al*., 2017) and increasing evapo-transpiration in plants, which will eventually pressurise and lower of the already depleting groundwater resources (Woldeamlak *et al*., 2007). Consequently, decreasing water will significantly affect the agricultural production and subsequently creating a great threat to national as well as global food security. To cope this recurrent issue of water scarcity, application of different plant growth regulators have gained a significant interest. A number of chemical compounds, known as plant bioregulators (PBRs), regulate plant responses to biotic and abiotic stresses at the cellular, tissue, and organ levels. Thiourea is an important synthetic PBR, consisting nitrogen (36%) and sulphur (42%) that has earned extensive consideration for its role in plant stress tolerance (Waqas *et al*., 2019). Efficacy of thiourea under stressed conditions is highlighted below with some case studies. For instance, Hassanein *et al*. (2015) conducted a pot experiment on wheat (*Triticum aestivum* var. Gimaza 9) to study the influence of thiourea on wheat under drought like conditions. From the data, it is evident that seedlings treated with thiourea shown higher enzymatic activities, along with increased total phenols and flavonoids which is a symptom of active stress tolerance. Effect of thiourea (500 ppm) under deficit irrigation are also reported in onion, where the tolerance mechanism was attributed to lowered canopy temperature, improved leaf water content along with the improved yield contributing traits and physicochemical attributes (Wakchaure *et al.* 2018). Similarly, supplemental deficit irrigation treatments given to wheat along with exogenous sprays of different PBRs including thiourea (10mM) also exhibited beneficial interactions under stressful condition by regulating various physiological processes *viz*., controlling canopy temperature, opening and closing of stomata with improved water use efficiency (Wakchaure *et al.* 2016). Sahu and Singh (1995) reported that foliar spray of thiourea increased individual grain weight of wheat under drought stress. Wakchaure *et al*. 2016 conducted an experiment on sorghum with exogenous application of PBRs included 10 μM salicylic acid (SA), 100 mg L^{-1} sodium benzoate (SB), 500 ppm thiourea (TU), 1.5% potassium nitrate (KNO_3) at seedling elongation (20DAS), reproductive (50 DAS), and panicle emergence (75 DAS) stages; the results demonstrated that the foliar application of PBRs alleviated water stress and improved gain yield by 6.8–18.5%. SA was more effective under moderate (IW/CPE 0.79–0.50), while SB and TU were better under severe water deficits (IW/CPE 0.49–0.05). Plants sprayed with PBRs found to be maintaining their higher leaf water content; lower canopy temperature modulated the stomatal opening and ultimately the source – sink relations – thereby improving the yield and water productivity under deficit irrigation. Kumar *et al*. 2016 studied influence of 10mM thiourea and 32ppm Ortho-Silicic Acid (OSA) on five wheat cultivars (HD2189, LOK1, NIAW301, NIAW34 and PBW550) under various water stress conditions. From the findings, it might be concluded that foliar application of thiourea at root crown initiation, flag leaf and grain filling stage improved yield by 12-17% under severe water stress conditions. Thiourea induced more water use efficiency in plants through increased RWC, modulating stomatal activities and maintaining canopy temperature of plant.

CONCLUSION

Water stress is the key hurdle in getting enough food production for global population. Many researchers have demonstrated the significance of thiourea as remedy for this everlasting problem of water deficiency. Thiourea improves nutrient uptake, and modulates the biosynthesis of plentiful secondary key metabolites, osmolytes, and phytohormones, and regulates various metabolic activities to induce tolerance under water stress. Thiourea facilitated benefits are not only restricted to stress conditions, but also improve plant performance in normal conditions, using the same principal mechanisms.

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