The Role of Sulfate of Potash for Drought Tolerance

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Effective water management for crops goes beyond the amount of water supplied to the crop through rainfall and irrigation. Nutrient management is essential for achieving proper water management. Potassium and sulfur play vital roles in water and nutrient use within plants.

Potassium

Potassium is not a constituent of any of the cell organelle, but it has a substantial regulatory role in the growth and development of plants. Since K^+ is involved in more than 60 enzymatic systems in plants, it is often referred to as "the regulator." Potassium helps with the synthesis of carbohydrates, regulates the opening and closing of stomata and affects root growth — all of which are required for efficient water use by the plant. The K^+ stimulates active sites of enzymes for reaction. The concentration of K^+ in the cell determines activation and rates of chemical reaction of enzymes. Therefore, the rate of a given enzymatic reaction is regulated by K^+ entering the cell.

When K^+ moves into the guard cells around the stomata, the cells accumulate water and swell, causing the pores to open and allowing gas exchange with the atmosphere. When the water supply is short, K^+ is pumped out of the guard cells. Under water stress, stomata close tightly to prevent excessive loss of water (Murrell, et al. 2021).

As K^+ accumulates within the plant root cell a greater osmotic gradient is created, causing the cell to attract water from the soil and better control its water loss (Armstrong, 1998). Plants are more prone to drought stress when they are deficient in K^+ and unable to absorb water. Sufficient K^+ induces solute accumulation thus improving the ability of plants to tolerate drought stress (Wang, et al. 2013).

Sulfate Sulfur

Sulfur (S) is an important secondary macronutrient that interacts with several stress metabolites to improve performance of crops under various environmental stresses including drought. Increased S supply influences uptake and distribution of essential nutrients to achieve nutritional equilibrium in plants exposed to limited water conditions. The regulation of S metabolism in plants, resulting in synthesis of numerous S-containing compounds, is crucial to the crop response to drought stress (Usmani, et al. 2020, Khan, et al. 2014). Elemental S must go through an oxidation process to become plant available sulfate, SO_4, and this process is driven by bacteria in warm, moist soil conditions (Lamond 1997, Mullen, et al. 2016). Dry soils will result in a reduction of the microbial activity and oxidation of S to SO_4 making it even more important to select a fertilizer with sulfur already in the form of sulfate.

Salt

Crops respond not only to the total concentration of dissolved salts in the water but also to specific ions. Osmotic effects occur because the concentration of salt in the soil solution is excessive for optimal production or crop quality. Therefore, excess fertilizer salts can suppress crop growth. High concentrations of sodium can also cause nutritional imbalances in the plant. Although difficult to quantify the contribution of growth suppression by either osmotic or specific ion effects, osmotic effects are thought to be the dominant growth suppressing effect in annual crops, while specific ion effects can become the dominate growth suppressing effect in tree and vine crops. Specific ion effects occur due to chloride (Cl^-), sodium (Na^+) and/or boron (B) that accumulate in the plant causing specific damage or visual injury. The degree to which growth is reduced by salinity differs greatly with species and to a lesser extent with varieties within a species. The severity of salinity response is also mediated by environmental interactions such as precipitation, relative humidity, and temperature (Grattan, 2015).

Stress Management

Potassium has a vital role in regulating plant turgor pressure and water movement through the plant. Potassium is a competitor of sodium ions under saline conditions (Waraich, et al. 2011); providing the right source of potassium is critical for managing water use efficiency.

Plant growth under salinity and water stress is influenced by the ability of plant to control K^+/Na^+ ratio in the tissues (Jatav et al. 2014). Severity of deleterious effects of sodium are greater under low potassium concentrations and plants having efficient activity of potassium transporters maintain optimal levels of potassium required for normal growth under such conditions (Bacha et al. 2015). A review by Ahanger, et al. (2017) included the possible alleviation of ill effects of abiotic stress by added potassium. This becomes more of a serious issue in permanent crops in deficit irrigation years, salt levels increase as less water is available to leach through the root zone.

Avoiding potassium fertilizers that have a high salt index or contain a high chloride concentration can have a large impact on a plant's ability to tolerate drought stress. Table 1 shows the wide variability in chloride concentration and relative salt index among potassium fertilizer sources.

Table 1

Fertilizer	Cl^-	Salt Index (SI)	SI per Unit K_2O
MOP (0-0-60)	47%	116.2	1.936
SOP (0-0-50-17S)	< 1%	42.6	0.852
NOP (13-0-46)	~ 0%	69.5	1.219
KTS (0-0-25-17S)	2%	68.0	2.720
Sul-Po-Mag (0-0-24-10.8Mg-22S)	4%	43.4	1.971
Polyhalite (0-0-14-17Ca-6Mg-19S)	5%	62.0	4.428

(Adapted from Fernandez, 2010)

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Managing plant health during drought is challenging. Utilizing a fertilizer source that does not compound the stress on your crop, and actually improves drought tolerance, is critical. Sulfate of potash (SOP) is an ideal fertilizer source because it not only contains both plant-available potassium and sulfate sulfur needed to lessen the impacts from environmental stress, but it also has the lowest salt index per unit of K_2O and is essentially chloride free.

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