Early Sowing Combined with Adequate Potassium and Sulfur Fertilization: Promoting Beta vulgaris (L.) Yield, Yield Quality, and .K- and S-Use Efficiency in a Dry Saline Environment

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Abstract

Field trials for two seasons (2018/2019 and 2019/2020) were conducted to investigate the influence of the addition of three levels of potassium (K) (K_1 = 60, K_2 = 120, and K_3 = 180 kg K_2O ha^{-1}) and/or sulfur (S) (S_1 = 175, S_2 = 350, and S_3 = 525 kg $CaSO_4$ ha^{-1}) to the soil, as well as the sowing date (the 1st of September, D_1; or the 1st of October, D_2) on the potential improvement of physiology, growth, and yield, as well as the quality characteristics of sugar beet yield under soil salinity conditions. With three replicates specified for each treatment, each trial was planned according to a split-split plot in a randomized complete block design. The results revealed that early sowing (D_1) led to significant improvements in all traits of plant physiology and growth, in addition to root, top, and biological yields and their quality, gross and pure sugar, and K- and S-use efficiencies based on root yield (R-KUE and R-SUE). The K_3 level (180 kg K_2O ha^{-1}) positively affected the traits of plant physiology, growth, yield and quality, and R-SUE, and reduced the attributes of impurities, impurity index, and R-KUE. Additionally, the S_3 level (525 kg $CaSO_4$ ha^{-1}) affirmatively affected plant physiology, growth, yield and quality traits, and R-KUE, and decreased impurity traits, impurity index, and R-SUE. The interaction of $D_1 \times K_3 \times S_3$ maximized the yield of roots (104–105 ton ha^{-1}) and pure sugar (21–22 ton ha^{-1}). Path coefficient analysis showed that root yield and pure sugar content had positive direct effects with 0.62 and 0.65, and 0.38 and 0.38 in both studied seasons, respectively, on pure sugar yield. Significant ($p \leq 0.01$) positive correlations were found between pure sugar yield and root yield ($r = 0.966^{**}$ and 0.958^{**}). The study results recommend the use of the integrative $D_1 \times K_3 \times S_3$ treatment for sugar beet to obtain maximum yields and qualities under salt stress (e.g., 8.96 dS m^{-1}) in dry environments.