In arid and semiarid lands, canopy transpiration and its dynamics depend largely on stomatal sensitivity to drought. In this study, the sap flow of a dominant species, *Haloxylon ammodendron* growing in Central Asian deserts, was monitored using Granier-type sensors, from which the canopy stomatal conductance was derived. The responses of canopy transpiration and stomatal conductance to environmental variables during the second half of the growing season, when annual prolonged drought occurred, was analyzed for four continuous years, from 2013 to 2016. A soil water content (SWC) of 3% was identified as the lower soil water threshold for this species, below which the plant lost the ability for stomatal regulation on water loss and suffered the risk of mortality. Above this threshold, the sensitivity of canopy transpiration to vapor pressure deficit, VPD (K), was linearly correlated with SWC, which mainly resulted from different stomatal behaviors at varying drought intensities. Stomatal sensitivity to VPD (m/G_{sref}) increased linearly with soil moisture deficit, inducing a shift from more anisohydric to a more isohydric stomatal behavior. The flexibility of stomatal behavior regarding soil drought was one key element facilitating the survival of *H. ammodendron* in such an extreme dry environment.