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Can deep water and nutrient uptake prevent drought stress in Chicory?

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Introduction: Water scarcity is a major limitation to crop production worldwide. Deep-rooted crops can potentially allow exploitation of water that more shallow-rooted crops cannot access. Several agricultural crops grow roots of several meters depth within a growing season and thereby get access to water originating from wet season surplus precipitation stored in the soil. The aim of this study was to test the hypotheses 1) chicory roots can grow below 3 m within a growing season and 2) topsoil drought, as well as interspecific competition, causes an increased uptake of water and nutrients in the deeper part of the root zone as a compensation for the restricted topsoil uptake.

Methods: Chicory (Cichorium intybus L.) was grown in 4 m tall rhizotrons in monoculture under dry or wet conditions and intercropped with either ryegrass (Lolium perenne L.) or black medic (Medicago lupulina cv Virgo Pajbjerg). Rhizotrons were placed outside and the growing medium was field soil. Rainout shelters and irrigation allowed controlled water supply, and water content sensors in three depths continuously logged soil water content. The rhizotrons allowed continuous non-destructive inspection of root development. Depth controlled injection of 2H-enriched water was used to trace species-specific water uptake from 2.3 m, and injection of nutrient-analog tracers was used to trace nutrient uptake from several depths of the soil profile.

Findings: Chicory roots were observed below 3 m in July both years, which was 2 and 5 months after transplanting in the two years respectively. Root growth below 2 m was limited throughout the season both years and still, the tracer studies showed significant tracer uptake by chicory from 2.3 m. Black medic and ryegrass, which are known to be shallow rooted, did not take up 2H-enriched water tracer from 2.3 m. Significant water and nutrient uptake from the lower part of the root zone were observed, but contrary to expectations no increase in deep water uptake was found as a result of drought nor competition. This finding emphasizes the important contribution of deep roots to water and nutrient supply during topsoil drought, but also calls attention to the limitations of deep roots to prevent drought stress.