Soil Health in Alfalfa Receiving Full & Deficit Irrigation

Michelle Leinfelder-Miles[1], Umair Gull[2], Veronica Suarez Romero[2], Daniel Putnam[2], Daniel Geisseler[2], William Horwath[2], Isaya Kisekka[2]

Soil health has been described as the ability of soil to function and is characterized by chemical, biological, and physical soil properties that are sensitive to changes in management. We evaluated soil health properties in alfalfa receiving full and deficit irrigation. The objectives of the trial were to 1) quantify a suite of chemical, biological, and physical soil properties under three deficit irrigation treatments compared to a fully-irrigated control over two cropping seasons; and 2) develop guidelines to support grower decision-making on how to manage water, when limited, to support soil health.

The trial took place on a 1.2 ha site in Davis, California, USA during the 2019 and 2020 cropping seasons. The soil type at the site is a deep alluvial Yolo silt loam soil (Order Entisol, Subgroup Typic Xerothents), and the Mediterranean climate mostly confines precipitation to the period of late October to early May, with mean annual rainfall of 498 mm. Alfalfa was identified as a model crop for studying soil health under restricted water conditions because practices like crop rotation and tillage do not occur over the four or more years of an alfalfa stand, and therefore, would not confound the water deficit treatments. The experimental design was a randomized complete block design with four treatments, replicated four times. The treatments were: 1) full irrigation (100 percent of crop evapotranspiration, ETc), 2) full irrigation at the beginning of the season with a sudden cutoff toward the end of the season (60 percent ETc CT), 3) sustained deficit where each irrigation imposes restriction (60 percent ETc SD), and 4) more-severe sustained deficit (40 percent ETc SD). The irrigation treatments were applied by low elevation spray application (LESA), using an 8000 series Valley 152-m, four-span linear-move system. Soil sampling occurred twice each year – in the spring before seasonal irrigation began and in the fall after the last irrigation. We conducted a comprehensive nutrient analysis, as well as tested organic matter, total carbon (C) and nitrogen, salinity, compaction, bulk density, N mineralization, and active C.

Chemical and biological soil health were impacted by deficit irrigation. When the trial began in Spring 2019, there were no differences in rootzone salinity or active C among treatments. After two cropping seasons where deficits were imposed, the 60 percent ETc treatment with the water cut-off toward the end of the season (CT) resulted in significantly higher rootzone salinity down to the 36-inch depth compared to all other treatments ($P=0.0024$). Active carbon, which is the fraction of soil organic matter that is readily available as an energy source for soil microorganisms and is a proxy for soil microbial activity or biomass, was also impacted by deficit treatments. After two cropping seasons, active C was statistically lower in the 40 percent ETc treatment compared to the fully-irrigated control ($P=0.0363$). Therefore, the timing of the deficit was more important than the amount of deficit for salinity, and applying water throughout the season – even if the amount was severely reduced – mitigated salt build-up. On the other hand, the amount of deficit, and not the timing, impacted active C.

This trial has shown how imposing varying levels of deficit at different stages of the cropping season impact soil health properties. Deficit irrigation strategies may come with trade-offs, but understanding the trade-offs can inform decision-making and help to optimize management for soil health outcomes. The deficit treatments also serve as a proxy for drought and could demonstrate how water use prioritization in a changing climate may impact soil conservation.

---

[1]University of California Cooperative Extension-San Joaquin County; [2]University of California-Davis;