Intermittent Groundwater Recharge Strategies on Alfalfa for Sustainable Production & Water Conservation in the Central Valley of California

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Alfalfa (*Medicago sativa* L.) is a major field crop in California and vital to the state's dairy industry, but is challenged by periodic drought. Although alfalfa requires large water supplies annually, it also possesses drought tolerance traits that may make it a suitable crop for deficit irrigation strategies. Additionally, in many areas, excess winter rain and snow melt is not captured for agricultural, environmental or urban use. Applications of such waters to agricultural lands could re-charge subsoil aquifers for pumping during dry periods. Our objectives were to determine alfalfa's suitability to a combination of summer-imposed drought and winter flooding to recharge soil aquifers. A field study was conducted at the University of California Kearney Agricultural and Extension Center, Parlier, California on a sandy-loam soil type in 2019-2021. Two groundwater recharge strategies (flooding and no flooding) and two summer irrigation treatments (deficit and full irrigation) were implemented in a Randomized Complete Block Design. Groundwater recharge treatments were implemented between early February and early April at a frequency ranging from one to two applications per week, totaling 1550 to 2,060 mm (5 to 6.8 ac-ft/ac) of water applied during this period. Summer irrigation treatments included standard irrigation (full irrigation) to satisfy crop evapotranspiration (ET_c) during April through October growing season, and deficit irrigation treatment with irrigation termination imposed after the August cutting (5th cutting) after which no additional water was applied. Alfalfa was harvested on a 28-day cutting schedule. Applied water was measured using flow meters, and soil matric potential values were determined using Irrometer Watermark soil moisture sensors. Actual evapotranspiration (ET_a) values were estimated using Tule Technologies stations and climatic data were obtained from a California Irrigation Management Information System (CIMIS) weather station located at Parlier. Results from the 3-years experiment showed that the seasonal average ET_a ranged from 1,102 mm to 1,174 mm. Only small differences in ET_a from the Tule systems were observed between full and deficit irrigated treatments. Alfalfa yields were sometimes improved by winter flooding treatments, or had no effect, depending upon year. Summer deficits reduced yields, but not to the degree of water savings, which were significant. With careful monitoring of soil oxygen levels, we did not observe crop damage from the winter flooding treatments on these soils. Only small effects on forage quality were observed. Winter or early spring flood treatments have the advantage of filling the soil profile to cope with late summer droughts. It appears that it is feasible to implement intermittent groundwater recharge during winter (dormant) periods on alfalfa, combined with summer dry-downs as needed, as a method to cope with highly variable water supplies.

Keywords: Groundwater recharge, Alfalfa water use efficiency, Crop water productivity, Sustainability, Water conservation, Nutritional quality