Deficit Irrigation Strategies for Subsurface Drip-Irrigated Alfalfa

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Summary

This subsurface drip-irrigated study was conducted from 2020 to 2021 at the Kansas State University Northwest Research-Extension Center near Colby, KS, to evaluate five deficit irrigation strategies for alfalfa. All strategies were irrigated similarly (100% of Evapotranspiration (ET) minus Rain) through the first seasonal cutting. Following the first cutting, treatments were 1) Irrigate to replace 85% ET minus Rain; 2) Irrigate to replace 50% ET minus Rain between Cutting 2 and 3, then 85% ET-Rain; 3) Irrigate to replace 50% ET minus Rain between Cutting 2 and 4, then 85% ET-Rain; 4) Irrigate to replace 70% ET minus Rain between Cutting 2 and 4, then 85% ET-Rain; and 5) Irrigate to replace 25% ET minus Rain between Cutting 2 and 3, then 85% ET-Rain. Average alfalfa forage dry matter yields varied less than 5% across treatments (9.52 vs. 9.94 ton/a) while irrigation requirements varied 20% (17.50 vs. 22.03 inches). Overall, the best treatments appeared to be treatments 2 and 3, obtaining both good yields and greater water productivity.

Introduction

Alfalfa is an important irrigated crop in the United States and it is often the most economically profitable irrigated agricultural crop, excluding horticultural crops. Although many are not aware, it is also an extremely drought-tolerant crop due to its deep and extensive root system and through its ability to go dormant and wait for water. The first harvest (late May or early June in the Central Great Plains) is usually the greatest and can be 30 to 40% of the annual yield. Some irrigation management strategies intentionally allow water deficits for alfalfa during the summer slump period when forage yields and water productivity are greatly reduced.

Results (2005–2007) from a subsurface drip irrigation field study of alfalfa at the K-State Northwest Research-Extension Center near Colby, KS, indicated that yields were not greatly affected by irrigation levels ranging from replacement of 70 to 100% of calculated evapotranspiration (ET) minus precipitation, and that improvements in alfalfa quality partially compensate for lower yields when deficit irrigated. It was concluded that a subsurface drip irrigation (SDI) regime of 85% ET minus precipitation appears reasonable on deep silt loam soils in the Central Great Plains region. Further work was initiated in 2019 to evaluate strategies for in-seasonal deficit irrigation adjustments that might reduce irrigation during the summer slump period.

[1] Sadly, Freddie Lamm passed away during the process of publishing this report, May 26, 2022.

Experimental Procedures

Alfalfa (Pioneer 54VR70) was planted on May 6, 2019, at a seeding rate of approximately 18 lb/a. Due to an insufficient and irregular stand, a second planting was interseeded on July 1, 2019 at the same seeding rate. After the second seeding, hand-set sprinkler lines were used to periodically apply small irrigation events (≈0.25 to 0.5 inches) over an approximately two-week period to help assure good establishment. For the remainder of 2019, the alfalfa was uniformly irrigated as needed with SDI and was harvested when it reached the 10% bloom stage and immediately prior to fall freeze-up. No study yields were measured during this establishment year. Phosphorus fertilizer (APP 10-34-0) was applied at a rate of 90 lb P_2O_5/a prior to planting in 2019. Soil water was monitored periodically to an 8-ft depth in 1-ft increments with neutron moderation techniques. Forage yields were determined from cutting samples at 10% bloom, weighing the entire wet sample, drying a subsample to determine the forage moisture content, and converting the measured wet yield to dry matter yield. Crop water use was determined as the sum of the seasonal soil water change, irrigation, and rainfall. Crop water productivity was calculated as alfalfa dry matter yield/crop water use.

Subsurface driplines at a depth of approximately 15 inches were spaced 5 ft apart with 4 driplines for each plot. All five strategies received 100% of calculated evapotranspiration (ET) minus rain from spring green-up through the first cutting. Then the strategies differed and were:

1. 85% of ET - Rain.
2. 50% ET - Rain for 2nd through 3rd cutting and then 85% of ET - Rain thereafter.
3. 50% ET - Rain for 2nd through 4th cutting and then 85% of ET - Rain thereafter.
4. 70% ET - Rain for 2nd through 4th cutting and then 85% of ET - Rain thereafter.
5. 25% ET - Rain for 2nd through 3rd cutting and then 85% of ET - Rain thereafter.

An additional 2.5 inches of irrigation was applied in November each year to conduct some pressure and flow testing for the SDI system and to wet the soil profile prior to freezing.

Results and Discussion

Growing conditions were favorable for alfalfa production in both years of the study. Precipitation during the April through October growing period was 10.87 and 13.27 inches for 2020 and 2021, respectively, and was drier than normal (16.00 inches, long-term average). Irrigation requirements varied between years, but the requirement was greatest for 2020 (Table 1).

Average alfalfa forage yields were 9.73 ton/a during the study (Table 1) but varied between years (Figure 1). Yield differences between the irrigated strategies were very small with treatment 2 having the greatest yield (9.94 ton/a) and treatment 5 having the lowest yield (9.52 ton/a). Crop water productivity was greatest for treatments 3 and 5 (Table 1 and Figure 1), and, because overall yield differences were small for all treatments, treatments 2, 3, and 5 appear to be the best balance between yield and water productivity.

The study will be continued in 2022 and the stands are being monitored for losses due to insufficient water and due to winterkill.

Acknowledgments

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Table 1. Irrigation amounts, annual alfalfa forage yields, total crop water use, and water productivity in a subsurface drip-irrigated study, Kansas State University Northwest Research-Extension Center, Colby, KS

Irrigation treatment	Irrigation amount (inches)	Dry matter yield (ton/a)	Water use (inches)	Water productivity (ton/acre-in.)
2020 crop year				
1	22.50	10.09	40.19	0.251
2	20.40	10.05	38.83	0.259
3	18.95	9.81	37.19	0.264
4	21.00	9.66	39.07	0.247
5	18.55	9.68	37.18	0.260
Mean	20.28	9.86	38.49	0.256
2021 crop year				
1	21.55	9.70	40.60	0.2390
2	18.80	9.84	36.87	0.2668
3	16.95	9.51	34.25	0.2778
4	19.60	9.60	37.67	0.2550
5	16.45	9.36	34.09	0.2749
Mean	18.67	9.60	36.70	0.2627
Mean 2020 to 2021				
1	22.03	9.89	40.39	0.2450
2	19.60	9.94	37.85	0.2628
3	17.95	9.66	35.72	0.2708
4	20.30	9.63	38.37	0.2512
5	17.50	9.52	35.63	0.2676
Mean	19.48	9.73	37.59	0.2595

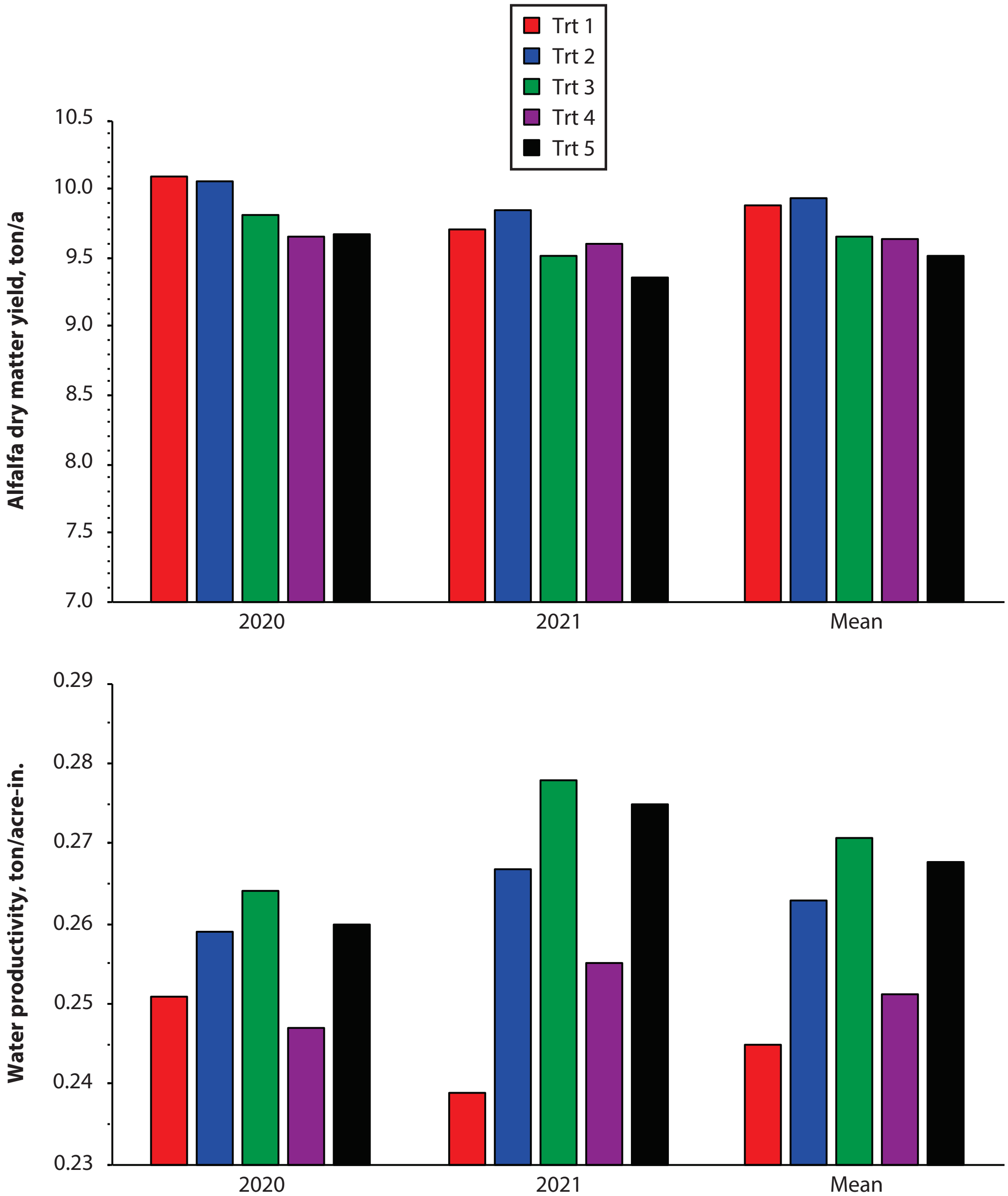

Figure 1. Alfalfa yields (upper panel) and water productivity (lower panel) for 2020 and 2021 in a subsurface drip-irrigated study examining five different irrigation strategies, Kansas State University Northwest Research-Extension Center, Colby, KS.