

MANAGING ALFALFA PRODUCTION WITH LIMITED IRRIGATION WATER

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ABSTRACT To investigate the effects of mid-summer water management on alfalfa productivity, a large scale field trial was conducted on a Hanford sandy loam at the Kearney Agricultural Center in Fresno County, California. Treatments included a standard of two irrigations between cuttings, an "excess" treatment of three irrigations between cuttings, a single irrigation between cuttings, an irrigation cut off in July and August, and a July termination of irrigation until the following spring. Hay yields were greatly reduced by deficit irrigation and cutoff treatments. After two years of differential irrigation, all treatments were irrigated twice per cutting for the third year of production during which all treatments produced as well as the standard.

Key Words: alfalfa, irrigation, management, drought, hay quality, water use

INTRODUCTION In the central and southern San Joaquin Valley, the water requirement for alfalfa can range between 40 to 50 inches per year. Unlike some crops which can be stressed for water at particular growth stages with no decrease in yield, alfalfa forage yields are directly related to available soil moisture for vegetative growth. Although yields are decreased by moisture stress, alfalfa plants survive and recover once water is again supplied.

From an economic viewpoint, water can be the largest single cost in alfalfa production and the profitability of an alfalfa operation can depend on the price of water. Based on experience with seed alfalfa, it is known that the plant can survive very dry, abusive conditions. Much of the seed acreage in the San Joaquin Valley is not irrigated after early July to facilitate seed production. Seed fields are also desiccated chemically before harvest.

This trial was initiated to evaluate severe alfalfa hay management options to be faced if the cost of water was high or if, in the case of drought, the water supply was limited. Questions that were addressed include: what would happen if alfalfa was not irrigated in July and August when hay quality and prices are usually lower, and how would severe drought conditions during two seasons influence hay yields in the third year of production?

PROCEDURES The trial was conducted at the Kearney Agricultural Center in Fresno County on a Hanford sandy loam soil with scattered hardpan. Each plot consisted of a check 24 ft. X 857 ft. and treatments, listed below, were replicated four times

Wet - irrigated two times per cutting in May and September and 3 times per cutting in June, July and August

Standard - irrigated two times per cutting throughout the season

Single - one irrigation per cutting throughout the season

July/Aug Cutoff - irrigated twice per cutting in May, June and September; not irrigated in July and August

July Termination - irrigated twice per cutting in May and June, and no water except for rain until the following spring

All treatments except for the July Termination received an irrigation after the last fall harvest. Because of unseasonably, cool weather in July 1986 and August 1987, the Wet treatment was irrigated only twice in those months.

Flow meters were installed in gated pipe to measure the amount of water applied per irrigation. Irrigation amounts were estimated on the total applied water divided by the number of checks in each irrigation set. There was no run-off ditch at the end of the field. Careful irrigation prevented excess standing water at the tail end of the checks.

After three years only 20 to 30 feet from the tail end of the field showed evidence of occasional standing water. There was evidence of some limited lateral movement of water between irrigated and dry checks.

The field was planted in October 1985 with CUF 101. The winter of establishment was quite wet with 14.5 inches of precipitation. Irrigation treatments were imposed the following spring. During the 1986-87 and 1987-88 winters, it rained 9.2 and 6.2 inches, respectively. For the 1988 hay season, two irrigations per cutting were applied to all checks to evaluate long term effects from the previous two years of differential irrigation.

The alfalfa plots were cut with a sickle bar in 1986 and 1987. In 1988 a commercial swather was used to harvest plots. Raking and baling were done by standard equipment. Yields from the first cutting in 1986 were not measured because of weed populations. After that, at each cutting average bale weights were determined and bales were counted to determine yields. Core samples from random bales were taken for moisture determination and for quality analysis by Near Infra-red (NIR) instruments at Dairymen's Creamery Cooperative Association in Tulare, California.

Standard weed and insect control measures were applied each year

RESULTS - A summary of yield results and applied water for the three years of the trial are presented in Table 1a, b, c. In 1986, there were no differences among treatments until the late July cutting. By then water had been cut off in two treatments and the single irrigation treatment was falling behind the evapotranspiration needs of the crop. Even without any irrigation for that cutting, the two cut off treatments yielded almost a ton of dry matter per acre. In the late August cutting differences among treatments were more pronounced. The two cut off treatments each produced about one-third of a ton of dry matter per acre. The Single Irrigation treatment produced .9 ton per acre which was .4 ton/acre less than the Standard and Wet treatments. After this cutting, water was applied to the July/August cutoff treatment. Although its regrowth was slightly delayed compared to treatments which had been irrigated all summer, it yielded as well as the Single Irrigation treatment. There was practically no growth in the July Termination treatment. For each cutting and for total yields for that year, the Standard treatment, with 14 less inches of water produced as well as the Wet treatment.

There was a treatment effect at the first cutting in 1987. The Standard treatment produced more hay than the July/August Cutoff and the July Termination treatments. There were no differences among treatments in the second, third, or fourth cuttings. After the fourth cutting, water was not applied to the Cutoff and Termination treatments. At the next harvest, yields from these plots were less than those from irrigated treatments. In the sixth cutting (early September), yields from non-irrigated plots continued to decline. The Single irrigation treatment still produced as well as the Standard and the Wet Treatments. However, in the last cutting, production from the Single Treatment dropped compared to the Standard and Wet treatments. The July/August Cutoff treatment, which had received water for this cutting, yielded as well as the Single Treatment. For the season, the Wet and Standard treatments produced significantly more alfalfa than the Single Treatment. The two cutoff treatments were the lowest yielding treatments.

In the third year of production, all plots were irrigated uniformly with one exception, the July Termination treatment did not receive a late fall irrigation in 1987. This treatment produced significantly less than the others in the first cutting of 1988. By the second cutting however, it had recovered to produce comparable to other plots and in the third cutting it out-produced the Wet and Standard treatments. There were no differences in subsequent cuttings. After two years of extremely contrasting irrigation regimes, total hay yields in the third year of production from the Wet and July cutoff treatments did not differ significantly.

In general, quality did not differ significantly until water stress became severe. In the first year, differences did not occur until the late August cutting at which time the July/August Cutoff and the July Termination treatments had not been irrigated for two months (Table 2). In these plots, fiber analysis (both modified crude and acid detergent) were lower than the Standard and Wet treatments. Total Digestible Nutrients (TDN) was higher but percent crude protein was reduced. When plots had been dry for three months (last cutting for the July Termination treatment), fiber increased significantly and TDN and protein decreased. In the July/August Cutoff treatment, protein was higher and

acid detergent fiber lower when cut for the first time after irrigation had been restarted. This isn't surprising as the regrowth for this treatment was delayed compared to the other treatments and at harvest these plants were not as mature.

Only the Standard and the July Termination treatments were analyzed for quality at the first cutting in 1987 (Table 3). The July Termination treatment had significantly higher TDN, crude protein, and acid detergent fiber, and significantly lower modified crude fiber compared to the Standard. There were no differences among treatments in quality for May, June, or July cuttings. For the August cutting, only acid detergent fiber, which tended to be higher in the wetter treatments, varied significantly. In the October cutting, the July/August Cutoff treatment showed higher quality for all measurements. At this cutting there was hardly any growth in the July Termination treatment and quality samples represented very few bales. In general, protein was lower and fiber higher in this very stressed hay, consistent with observations from the previous year.

In 1988, quality samples were taken only at the first cutting (Table 4). The July Termination treatment had higher protein and TDN and lower fiber than the Wet, Standard, and Single Irrigation treatments. Samples were not taken for the July/August Cutoff treatment.

DISCUSSION In general, quality differences measured after baling were not evident when hay was only slightly stressed. When hay was severely stressed, quality declined. There was a trend of higher quality the first cutting after irrigation was resumed to cutoff treatments. In these treatments regrowth was delayed and higher quality measurements may be attributed to less maturity at time of harvest.

Water management affected yield much more than quality under the conditions of this trial. The effects on quality of raking and conditions at baling are probably greater than those caused by water stress.

In this trial the alfalfa stand was able to undergo severe drought and recover when irrigated. After a "drought" period it usually took one cutting to yield equivalently to well watered treatments, but otherwise there were no long term effects on yield.

To determine whether or not mid-summer irrigation cutoff is of economic advantage, yield differences and hay prices need to be considered. Yields presented in this paper for cutoff treatments are probably "optimistic." In commercial situations where entire fields were not irrigated, there would be no growth at all or what little growth that might appear would not justify harvesting. Growers must weigh the potential loss in yield against water availability and labor, harvesting, and water costs before making irrigation management decisions.

Should California experience another extremely dry year, growers can be assured that imposed drought by mid-summer termination of irrigation on established stands will not affect the following year's production.

The authors wish to express our appreciation to Dairymen's Creamery Cooperative Association for the analysis of hay samples over the course of this study. We also thank the field staff at the Kearney Agricultural Center, especially John Peterson, for their assistance in conducting this experiment.

TABLE 1 - a, b, c

1986, 1987 and 1988 YIELD RESULTS FROM ALFALFA IRRIGATION MANAGEMENT TRIAL, KEANEY AG CENTER

a) 1986	5/28	6/24	7/25	8/27	10/8	Total	Water Applied		Applied Water + Rain		
							in Season				
-----Tons Dry Matter -----											
Wet	1.70	1.71	5.51a	1.33a	1.04a	7.28a	51		65		
Standard	1.86	1.93	1.39ab	1.24a	1.00a	7.42a	37		51		
Single	1.79	1.65	1.20 bc	.90 b	.78 b	6.32 b	23		37		
July/Aug Cutoff	1.82	1.75	0.97 c	.31 c	.74 b	5.59 c	19		33		
July Termination	1.77	1.67	0.95 c	.38 c	.06 c	4.83 d	15		29		
LSD .05	NS	NS	.19	.28	.17	.20					
%CV	8.5	8.5	10.0	21.5	14.9	6.3					
b) 1987	4/2	5/7	6/11	7/9	8/5	9/4	10/9	Total	Applied in	Plus 1986	Applied Water + Rain
									Season	Late Fall	
									(inches)	(inches)	(inches)
Wet	0.90ab	1.22	1.75	1.40	1.3a	1.19a	0.94a	7.81a	47	54	63
Standard	1.00a	1.37	1.69	1.39	1.34a	1.17a	0.96a	7.91a	39	46	55
Single	.96ab	1.13	1.62	1.32	1.19a	0.98a	0.78 b	7.04 b	30	37	46
July/Aug Cutoff	.83 bc	1.20	1.57	1.35	0.85 b	0.45 b	0.76 b	6.17 c	26	33	42
July Termination	0.72 c	1.32	1.52	1.32	0.90 b	0.41 b	0.15 c	5.63 c	23	23	32
LSD .05	0.13	NS	NS	NS	.17	0.22	0.11	.67			
%CV	9.8	9.6	6.7	7.3	10.3	18.8	11.8	6.7			
c) 1988 ¹	3/25	5/16	6/8	7/7	8/4	9/1	Total	Applied in	Plus 1987	Applied Water + Rain	
								Season	Late Fall		
								(inches)	(inches)	(inches)	
Wet	1.10	1.58	1.14 cd	1.14	1.30	0.84	7.07 bc	28	31	31	
Standard	1.11a	1.66	1.24 bcd	1.14	1.22	0.86	7.22abc	28	31	37	
Single	1.12a	1.70	1.35ab	1.21	1.29	0.96	7.64a	30	33	39	
July/Aug Cutoff	1.07a	1.66	1.33abc	1.11	1.27	0.88	7.32ab	30	33	39	
July Termination	0.83 b	1.50	1.47a	1.16	1.27	0.92	7.15 bc	30	30	36	
LSD .05	0.14	NS	0.20	NS	NS	NS	0.45				
%CV	9.4	6.2	10.4	9.3	8.3	10.9	4.2				

All plots were irrigated the same in this year

TABLE 2. QUALITY ANALYSIS OF 1986 HARVESTS, ALFALFA IRRIGATION MANAGEMENT TRIAL
KEARNEY AGRICULTURAL CENTER

Treatment	TDN (90% DRY MATTER BASIS)				
	5/28	6/24	7/25	8/27	10/8
Wet	53.3	52.6	51.3	52.2 b	53.0 b
Standard	52.8	51.4	50.8	53.0 b	54.4a
Single	52.8	52.5	51.6	52.7 b	53.7ab
July/Aug Cutoff	52.6	51.8	49.6	54.8a	53.9ab
July Termination	52.2	52.2	52.0	54.8a	(49.8)*c
LSD .05	NS	NS	NS	1.73	0.91
%CV	1.3	2.0	2.1	2.1	1.1
% CRUDE PROTEIN (90% DRY MATTER BASIS)					
Wet	18.65	18.11	16.67	18.38a	18.20 c
Standard	18.38	18.11	15.86ab	18.50a	19.46 b
Single	18.56	17.93	16.22a	17.03 b	18.92 bc
July/Aug Cutoff	18.11	18.38	14.59 b	16.58 b	21.08a
July Termination	17.84	18.74	16.22a	16.94 b	(13.15)* d
LSD .05	NS	NS	1.24	1.14	.96
%CV	2.9	3.6	5.1	4.2	3.4
% MODIFIED CRUDE FIBER (90% DRY MATTER BASIS)					
Wet	22.97	24.95	25.32	24.32a	23.3 b
Standard	23.60	25.23	25.95	23.42a	21.71 c
Single	23.60	24.86	27.30	21.17 b	22.34 bc
JulyCutoff	23.87	24.86	27.30	21.17 b	22.34 bc
July Termination	24.23	23.32	24.50	21.26 b	(27.11)*a
LSD .05	NS	NS	NS	2.01	1.13
%CV	3.5	4.8	5.0	5.8	3.1
ACID DETERGENT FIBER (90% DRY MATTER BASIS)					
Wet	31.53	34.32	33.69	34.59a	34.32 b
Standard	32.16	34.23	33.69	32.97a	31.44 c
Single	31.89	33.15	33.15	32.52a	32.61 bc
July/Aug CutOff	32.70	33.87	34.95	37.84 b	31.89 c
July Termination	32.61	33.60	32.16	28.65 b	(37.30)*a
LSD .05	NS	NS	NS	3.04	2.09
%CV	2.6	3.4	34.6	6.3	4.1

* Quality samples for this treatment at this cutting were based on very few bales due to low production.

TABLE 3 QUALITY ANALYSIS OF 1987 HARVESTS, ALFALFA IRRIGATION MANAGEMENT
KEARNEY AGRICULTURAL CENTER

Treatment	TDN (90% DRY MATTER BASIS)						
	4/2/87	5/7/87	6/11/87	7/9/87	8/5/87	9/4/87	10/9/87
3X Wet	----	54.50	51.74	50.48	52.20	53.02	55.17
2X Standard	52.88	53.58	51.99	51.10	51.40	53.15	54.54
1X Single	----	54.05	52.41	51.15	52.22	52.82	53.37
July/Aug Cutoff	----	54.22	52.24	50.82	52.58	54.30	55.92
Cut Off July Termination	56.30	53.35	52.69	51.18	52.45	53.95	53.76
LSD .05	***	NS	NS	NS	NS	NS	NS*P=(.053)
%CV	.49	1.5	0.8	1.6	1.0	1.8	1.3
% CRUDE PROTEIN (90% DRY MATTER BASIS)							
Wet	----	20.42	17.93	17.50	18.45	19.10	20.15 b
Standard	18.48	19.75	18.85	18.20	18.38	19.12	19.67 bc
Single	----	20.48	18.83	17.98	18.45	19.05	19.65 bc
July/Aug Cutoff	----	20.50	18.55	18.00	17.88	18.55	22.30a
July Termination	21.25	19.30	18.88	18.35	17.88	18.55	18.17 c
LSD .05	****	NS	NS	NS	NS	NS	1.65
% CV	1.4	3.1	2.7	3.8	2.8	4.2	5.0
MODIFIED CRUDE FIBER (90% DRY MATTER BASIS)							
Wet	----	21.60	24.81	26.28	24.32	23.32	20.80 bc
Standard	23.48	22.68	24.51	25.52	25.18	23.15	21.53ab
Single	----	24.38	23.99	25.52	24.25	23.50	20.53 bc
July/Aug Cutoff	----	21.85	24.22	25.88	23.82	21.78	19.88 c
July Termination	19.48	22.92	23.66	24.42	23.98	22.20	22.42a
LSD .05	***	NS	NS	NS	NS	NS	1.42
% CV	1.2	10.8	2.1	3.6	2.7	4.9	4.0
ACID DETERGENT FIBER (90% DRY MATTER BASIS)							
Wet	----	34.22	36.91	37.98	35.18ab	35.72a	32.69ab
Standard	0.54	35.12	36.29	37.28	36.12a	35.42a	33.24a
Single	----	34.90	36.34	37.40	34.60ab	35.02a	31.26 bc
July/Aug Cutoff	----	34.55	36.06	38.05	33.70 b	31.70 b	30.82 c
July Termination	0.58	35.58	35.59	37.05	33.52 b	32.08 b	32.01abc
LSD .05	***	NS	NS	NS	1.79	2.91	1.77
%CV	0.001	3.5	1.8	3.5	3.4	5.7	3.4

* Quality samples for this treatment at this cutting were based on very few bales due to low production.

TABLE 4 QUALITY ANALYSIS OF 1988 FIRST CUTTING, ALFALFA IRRIGATION MANAGEMENT TRIAL, KEARNEY AGRICULTURAL CENTER

90% DRY MATTER BASIS

<u>Treatment</u>	<u>TDN</u>	<u>% Crude Protein</u>	<u>% Modified Crude Fiber</u>	<u>Acid Detergent Fiber</u>
Wet	55.60 b	17.84 b	20.29a	31.71 b
Standard	55.90 b	18.15 b	19.95a	31.04a
Single	56.15 b	18.42 b	19.66a	31.03a
July Termination	57.58a	19.77a	18.04 b	28.94 b
LSD .05%	1.36	1.04	1.59	1.79
%CV	1.5	3.5	5.1	3.6