Managing Alfalfa Production with Limited Irrigation Water

Carol Frate and Bruce Roberts[1]

ABSTRACT

To investigate the effects of midsummer 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 skip 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.

---

[1]Corresponding Author: Carol Frate, Farm Advisor, University of California Cooperative Extension, Agricultural Building, County Civic Center, Visalia, CA 93291-4584. Bruce Roberts, Farm Advisor, University of California Cooperative Extension, Kings County.

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

Standard - irrigated two times per cutting throughout the season

Dry - one irrigation per cutting throughout the season

July/August Skip - 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 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 runoff 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.

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 Infrared (NIR) instruments at Dairymen's Cooperative Creamery 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 is presented in Table 1a, b, c. In 1986, there were no differences among treatments until late July. By then water had been cut off in two treatments and the dry or single irrigation treatment was falling behind the evapotranspiration needs of the crop. Even without any irrigation for that cutting, the skip and

cutoff treatments yielded almost a ton of dry matter per acre. In the late August cutting differences among treatments were more pronounced. The skip and cutoff treatments produced about one third of a ton of dry matter per acre. The dry 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 skip treatment. Although its regrowth was slightly delayed compared to treatments which had been irrigated all summer, it yielded as well as the dry 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 skip 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 skip 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 nonirrigated plots continued to decline. The dry or single irrigation treatment still produced as well as the standard and the wet treatments. However, in the last cutting, production from the dry treatment dropped compared to the standard and wet treatments. The July/August skip treatment, which had received water for this cutting, yielded as well as the dry treatment. For total season forage production, the wet and standard treatments produced significantly more than the dry treatment. The skip and 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 outproduced 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, skip, and termination 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 skip and 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 in 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 skip 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 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, 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 skip 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 skip treatment.

DISCUSSION

Water management affected yield much more than quality under the conditions of this trial. In general, hay quality was not significantly affected by irrigation treatments except when water stress became severe and then quality declined. The commercial practices of raking and baling used for this study would have masked minor differences in quality due to water stress. However, better hay quality was detected for skip and termination treatments in the first harvest following reirrigation.

Results from this trial indicate that alfalfa planted in early fall can survive induced first and second year midsummer drought from irrigation cutoff and subsequently return to normal production within two cuttings after rewatering. Following two years of imposed summer drought, stressed treatments produced yields equivalent to the standard treatment in the third year of production during which all treatments were irrigated normally.

Results from this study could also be useful in helping growers make management decisions on how to utilize limited water resources. Yield responses to different management strategies, water costs, and alfalfa hay prices must all be considered in order to determine which method is most profitable.

The authors wish to express our appreciation to Dairymen's Cooperative Creamery 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.

This research has also been published in *California Agriculture*, 1991, Vol. 45, No. 3.

TABLE 1 - a, b, c. 1986, 1987, and 1988 Yield Results from Alfalfa Irrigation Management Trial, Kearney Ag Center

a) 1985	5/28	6/24	7/25	8/27	10/8	Total	Water applied In season	Applied water + rain
	Tons Dry Matter						(inches)	(inches)
Wet	1.70	1.71	1.51 a	1.33 a	1.04 a	7.28 a	51	65
Standard	1.86	1.93	1.39 ab	1.24 a	1.00 a	7.42 a	37	51
Dry	1.79	1.65	1.20 bc	.90 b	.78 b	6.32 b	23	37
July/Aug Skip	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 season	Plus 1986 late fall irrigation	Applied water + rain
									(inches)	(inches)	(inches)
Wet	0.90 ab	1.22	1.75	1.40	1.30 a	1.19 a	0.94 a	8.63 ab	47	54	63
Standard	1.00 a	1.37	1.69	1.39	1.34 a	1.17 a	0.96 a	8.85 a	39	46	55
Dry	.96 ab	1.13	1.62	1.32	1.19 a	0.98 a	0.78 b	7.94 b	30	37	46
July/Aug Skip	.83 bc	1.20	1.57	1.35	0.85 b	0.45 b	0.76 b	6.95 c	26	33	42
July Termination	0.72 c	1.32	1.52	1.32	0.90 b	0.41 b	0.15 c	6.30 c	23	23	32
LSD .05	*0.13*	*NS*	*NS*	*NS*	*.17*	*0.22*	*0.11*	*.75*			
% CV	*9.8*	*9.6*	*6.7*	*7.3*	*10.3*	*18.8*	*11.8*	*6.3*			

c) 1988[1]	3/25	5/16	6/8	7/7	8/4	9/1	Total	Applied In season	Plus 1987 late fall irrigation	Applied water + rain
								(inches)	(inches)	(inches)
Wet	1.10	1.58	1.14 cd	1.14	1.30	0.84	7.07 bc	28	31	37
Standard	1.11 a	1.66	1.24 bcd	1.14	1.22	0.86	7.22 abc	28	31	37
Dry	1.12 a	1.70	1.35 ab	1.21	1.29	0.96	7.64 a	30	33	39
July/Aug Skip	1.07 a	1.66	1.33 abc	1.11	1.27	0.88	7.32 ab	30	33	39
July Termination	0.83 b	1.50	1.47 a	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*			

[1] All plots were irrigated the same in this y

TABLE 2. Quality Analysis of 1986 Harvests, Alfalfa Irrigation Trial, Kearney Agricultural Center

Treatment	5/28	6/24	7/25	8/27	10/8
			TDN (90% Dry Matter Basis)		
Wet	53.3	52.6	51.3	52.2 b	53.0 b
Standard	52.8	51.4	50.8	53.0 b	54.4 a
Dry	52.8	52.5	51.6	52.7 b	53.7 ab
July/Aug Skip	52.6	51.8	49.6	54.8 a	53.9 ab
July Termination	52.2	52.2	52.2	54.8 a	*(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 a	18.38 a	18.20 c
Standard	18.38	18.11	15.86 ab	18.50 a	19.46 b
Dry	18.56	17.93	16.22 a	17.03 b	18.92 bc
July/Aug Skip	18.11	18.38	14.59 b	16.58 b	21.08 a
July Termination	17.84	18.74	16.22 a	16.94 b	*(13.15) d
LSD .05	NS	NS	1.24	1.14	0.96
% 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	24.32 a	23.30 b
Standard	23.60	25.23	25.95	23.42 a	21.71 c
Dry	23.60	24.86	27.30	21.17 b	22.34 bc
July Skip	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	34.59 a	34.32 b
Standard	32.16	34.23	33.69	32.97 a	31.44 c
Dry	31.89	33.15	33.15	32.52 a	32.61 bc
July/Aug Skip	32.70	33.87	34.95	37.84 b	31.89 c
July Termination	32.61	33.60	32.16	38.65 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 Trial, Kearney Agricultural Center

Treatment	4/2/87	5/7/87	6/11/87	7/9/87	8/5/87	9/4/87	10/9/87
				TDN (90% NIR)			
Wet		54.50	51.74	50.48	52.50	53.02	55.17 ab
Standard	52.88	53.58	51.99	51.10	51.40	53.15	54.54 bc
Dry		54.05	52.41	51.15	52.22	52.82	53.37 ab
July/Aug Skip	---	54.22	52.24	50.82	52.58	54.30	55.92 a
July Termination	56.30	53.35	52.69	51.18	52.45	53.95	53.76 c
LSD .05	***	NS	NS	NS	NS	NS	NS*
% CV	.49	1.5	0.8	.6	.0	1.8	*P=(.053) 1.3
				% Crude Protein (90% 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
Dry	---	20.48	18.83	17.98	18.45	19.05	19.65 bc
July/Aug Skip		20.50	18.55	18.00	17.88	18.55	22.30 a
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% 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	21.53 ab
Dry	---	24.38	23.99	25.52	24.25	23.50	20.53 bc
July/Aug Skip		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	22.42 a
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% Basis)			
Wet		34.22	36.91	37.98	35.18 ab	35.72 a	32.69 ab
Standard	32.90	35.12	36.29	37.28	36.12 a	35.42 a	33.24 a
Dry		34.90	36.34	37.40	34.60 ab	35.02 a	31.26 bc
July/Aug Skip	---	34.55	36.06	38.05	33.70 b	31.70 b	30.82 c
July Termination	29.20	35.58	35.59	37.05	33.52 b	32.08 b	32.01 abc
LSD .05	***	NS	NS	NS	1.79	1.77	
% CV	0.001	3.5	1.8	3.5	3.4	5.7	3.4

TABLE 4. Quality Analysis of 1988 First Cutting, Alfalfa Irrigation Trial, Kearney Agricultural Center

Treatment	TDN	% Crude protein	% Modified crude fiber	Acid detergent fiber
		90% Dry Matter Basis		
Wet	55.60 b	17.84 b	20.29 a	31.71 a
Standard	55.90 b	18.15 b	19.95 a	31.04 a
Single	56.15 b	18.42 b	19.66 a	31.03 a
July Termination	57.58 a	19.77 a	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