GROWING ALFALFA ON HEAVY CLAY SOILS OR WHATEVER

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Do alfalfa varieties differ in their response to fertilizer programs?

Will response to banded P and K last 4 years or more?

Can you measure increased tissue levels of P without corresponding increases in yield?

How does management or environment affect the response to increased fertility?

Can alfalfa be grown in soils with density ratings of 2?

How do you manage fields of alfalfa when the field has both heavy clay soi and gravelly soil?

What varieties are best adapted to fields of multi-textured soils?

What factors prevent re-seeding of established stands of alfalfa in the Sacramento Valley?

What happens to the calcium-phosphorus ratio during the growing season under low fertility? High fertility?

Do higher fertility rates affect invitro digestibility of alfalfa?

These and other questions were addressed in 1975 when the Rehse Ranch Alfalfa Project was established by Roland Meyers, UC Soils Specialist, Herb Schulbach, UC Area Soils and Water Specialist and myself in the Sacramento Valley near Orland, California.

Neither time nor space allows me to report all our findings and the collected data However, I will briefly go over a few of the findings relative to yield responses.

The conditions couldn't have been more suitable. A small isolated flood irrigated field of approximately 4 acres containing soils of two distinct textures. Up slope where Trial I was established, the soil was a dense clay that showed fractures even when wet. Alfalfa roots grew primarily in these fractures with considerable branching of the tap root near the surface. Over-rooting (roots growing above the crown) was found to be present in about 10% of the 3-year old Washoe and Apollo plants growing in Trial I. Other varieties have not been examined for this characteristic at this time.

Down slope the soil became sandy gravelly with some large cobbles present. This soil presented water penetration problems the 1st year, however, root penetration "opened" the soil to the extent that it was difficult to carry the water through some checks the 4th year. Special irrigation techniques had to be adopted.

Soil phosphorus (P) levels (determined by the bicarbonate extraction method) ranged from less than 6 ppm in the clay to 7 ppm in Trial I and better than 13 ppm in the sandy gravelly soil of Trial III. The pH levels ranged from 6.6 to 6.9.

Potassium levels (K) (ammonium acetate method of extraction) were above those usually considered threshold response levels.

These soils were contained in a small field approximately 800' long and 200' wide. The 224 plots in Trial I contained 100 square feet while the 336 plots in Trial III contained 180 square feet each. In Trial I each variety was represented 16 times, in Trial III, 24 times. Fertilizer treatments were replicated 4 times.

Thermograph stations were located in both soil types and gypsum block moisture sensors were located with the thermographs and at various other sites where soil differences occurred. Irrigation was scheduled when moisture sensors indicated a need-if water was available. Though irrigation needs could be anticipated water was not always available. The crop was sometimes stressed and early blooms would result. Irrigation scheduling was based on the needs of Trial III, which was located on the sandy gravelly soil, at 50% of field capacity at 18" depth - approximately 2 bars. Trial I soil moisture seldom if ever dropped below .6 bars and usually carried between saturation and .4 bars at a 18" depth. During late June, July and August water was applied 3 days out of 10 in order to gain water penetration. Total time water covered the soil in the 3 days was 10 hours in a 6 hour - 2 hour - 2 hour bump pattern.

While most of the water penetration problems existed in the sandy gravelly soils, the dense clay also presented problems if allowed to dry to 50% of field capacity at 18" depth. Depth of water penetration in Trial I and III ranged from 18" to 3' or more following the usual summer irrigation. Winter irrigations mid-October to March in general would penetrate to 3' or more in all areas.

With the exception of the first year, soil temperatures at crown depth rarely rose above 90° F which according to Evenson[1] may be a desirable level. However, July 25th of 1975, soil temperatures in Trial III rose to 112° F at crown depth and temperatures at 8" were above 90° F in the May seeded stand. Soil temperatures in Trial I were generally 8-10° F cooler at crown depth and 4-6° F cooler at 8" during this period. Water was not as available in 1975 as it was in subsequent years for soil cooling and bump irrigations.

Harvest of the plots was accomplished by a 3' Mathews Suburban flail chopper which was mounted as part of a trailer and towed by a John Deere M across the checks. Dry matter determinations were made on each individual sample. Field clean-up was accomplished by a 12' swather followed by raking. A self-propelled chopper delivered the material into 40' self-propelled vans. Nearly every square foot of the plots had wheel tracks!

Stand observations were made on each plot in Trial I and III. Visual ratings were based on: <u>general appearance</u> - leaf size, shade of green color, uniformity of plants; <u>height</u> - average height of stems; <u>stand density</u> - based primarily on number of stems per square foot. Stand observations 7/21/75 indicate at the 5% level that alfalfa in the un-fertilized plots in Trial I scored higher in appearance 4.1 vs. 3.9 and height of stems 3.2 vs. 2.8. (200 pounds of 6-20-20 had been applied as a starter to both Trial I and Trial III.) Observations made on 10/14/75 showed no significant difference between fertilized and un-fertilized plots except for height. Here a reversal occurred and fertilized plots rated 12.75 vs. 10.67 (sig. at 5%). A definite "rowing" of plants was noted in the banded plots. While initially it was observable in both Trial I and III it was only in the 4th year that it was no longer apparent in Trial III where plant survival was much better.

TABLE 1
1976 - Trial I
Fertilizer vs. No Fertilizer

Cuts Date	(1) 4/29	(2) 6/14	(3) 7/19	(4) 4/30	(5) 10/11	Year Total
	Mean lbs. of dry matter increase above no fertilizer					
All Varieties X Fertilizer	489	N.S.	N.S.	N.S.	N.S.	N.S.
1 Resistador 2						
2 WL 309						
3 WL 318						
4 AtCal-1		550				
5 Vernal						
6 WL 214		722				
7 AS 63	1423	1058		312		3066
8 DK 153	1217	700				2096
9 DK 123						
10 DK 131						
11 Gladiator	821					1485
12 Apollo						
13 Washoe						
14 El Dorado R				378		

Differences significant at 5% level.

TABLE 2
1977 - Trial I
Fertilizer vs. No Fertilizer

Cuts Date	(1) 5/5	(2) 6/14	(3) 7/26	(4) 9/7	(5) 10/10	Year Total
	Mean lbs. of dry matter increase above no fertilizer					
All Varieties X Fertilizer	606	189	238	252	N.S.	1321
1 Resistador 2						
2 WL 309			568	440		4736
3 WL 318			525			
4 AtCal-1						
5 Vernal						
6 WL 214	752					
7 AS 63	1316	845		530	141	3185
8 DK 153	976	556	503			2303
9 DK 123						
10 DK 131						
11 Gladiator	1015			397		
12 Apollo						
13 Washoe					164	
14 El Dorado R		409				

Differences significant at 5% level.

TABLE 3
1978 - Trial I
Fertilizer vs. No Fertilizer

Cuts Date	(1) 4/24	(2) 6/5	(3) 7/19	(4) 8/29	(5) 10/4	Year Total	3 Year Total
	Mean lbs. of dry matter increase above no fertilizer						
All Varieties X Fertilizer	191	434	N.S.	573	294	1643	3493
1 Resistador 2							
2 WL 309			779			2021	
3 WL 318		694					
4 AtCal-1							
5 Vernal	387	501		1122	493	3035	
6 WL 214	293	617		950		2457	
7 AS 63	386	854		1368	413	3142	9001
8 DK 153		545		1111		2269	6551
9 DK 123		414					
10 DK 131		438				1879	
11 Gladiator	355	431		725		1838	
12 Apollo							
13 Washoe		722.3			865	2236	5221
14 El Dorado R							

Differences significant at 5% level.

TABLE 4
1977 - Trial III
Fertilizer vs. No Fertilizer

Cuts Date	(5) 10/76	(1) 5/4	(2) 6/13	(3) 7/26	(4) 9/6	(5) 10/11	Year Total
	Mean lbs. of dry matter increase above no fertilizer						
All Varieties X Fertilizer	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
1 Resistador 2							
2 WL 309		470					
3 WL 318		953	446	553			2056
4 AtCal-1		929	353	138			1377
5 Vernal		589					
6 WL 214		494					
7 AS 62		496					
8 DK 153		759		589			1842
9 DK 123		486					
10 DK 131							
11 Gladiator				69			
12 Apollo							
13 Washoe							
14 El Dorado R	194						

Differences significant at 5% level.

TABLE 5
1978 - Trial III
Fertilizer vs. No Fertilizer

Cuts Date	(1) 4/24	(2) 6/5	(3) 7/19	(4) 8/29	(5) 10/5	Year Total	3 Year Total
	Mean lbs. of dry matter increase above no fertilizer						
All Varieties X Fertilizer	229	N.S.	N.S.	N.S.	N.S.	N.S.	
1 Resistador 2							1792
2 WL 309	243						2673
3 WL 318	238						2807
4 AtCal-1							
5 Vernal	280						1458
6 WL 214							
7 AS 63	347						
8 DK 153	283						
9 DK 123							
10 DK 131							
11 Gladiator							1297
12 Apollo	328						
13 Washoe							
14 El Dorado R							

Differences significant at 5% level.

Yield Response to Fertility. Tables 1, 2 and 3 showing seasonal relationship, outline the yield responses from increased fertility for the 14 varieties growing in the heavy soil (Trial I) during the 3-year period. When these are compared to the results of the well drained soil of Trial III (tables 4 and 5) is apparent that a number of the varieties did not significantly respond in increased yield (despite increased tissue levels, tables 6 through 10) to the banded P and K under the environmental conditions imposed. When fertility response is compared to varietal over-all performance, tables 11 through 14, it is also interesting to note that the most adapted varieties were not the most consistent in their response to the banded P and K. One might also infer from the accumulated data that the over-all response was greater in 1978 than any proceeding year perhaps indicating that the lower P and/or K levels of un-fertilized plots were taking their toll in the 4th year. This is not unexpected and it is often observed that under commercial conditions fields fall apart in the 3rd year. The test field received as much or perhaps more wheel traffic than is normal for commercial fields during harvest. If soil compaction increased as a result, root exploration may have decreased thus increasing the importance of an easily available source of P and K to some varieties. The fact that more varieties responded to higher P and K at the 1st cut is not all together unexpected. It is well documented that P and K availability to alfalfa roots is affected by low soil temperature. During the growing season preceeding the 1st cut, soil temperatures at 8" and crown depth were generally below 55° F. However, the lack of response to P and K and corresponding low yields the 1st cut of 1978 may have been due to a wet spring and cold water soaked soils which may have prevented adequate nitrogen fixation and root hair development.

The 2000 pounds of 6-20-20 banded on 12" spacings was placed at 8" pre-plant. Soil settling probably resulted in a shallower depth. A 1976 attempt to locate the face of bands to determine outward movement of P and K in the heavy soil failed but may be attempted again this winter. Random soil sampling taking 10 cores from 0-5" from 16 plots in the heavy soil turned up only one fertilized plot that showed higher P and K levels than might be expected. This could be taken to indicate that the bands were generally below the 5" settled depth.

TABLE 6
1977 - Trial I
WL 318 Harvested Tops

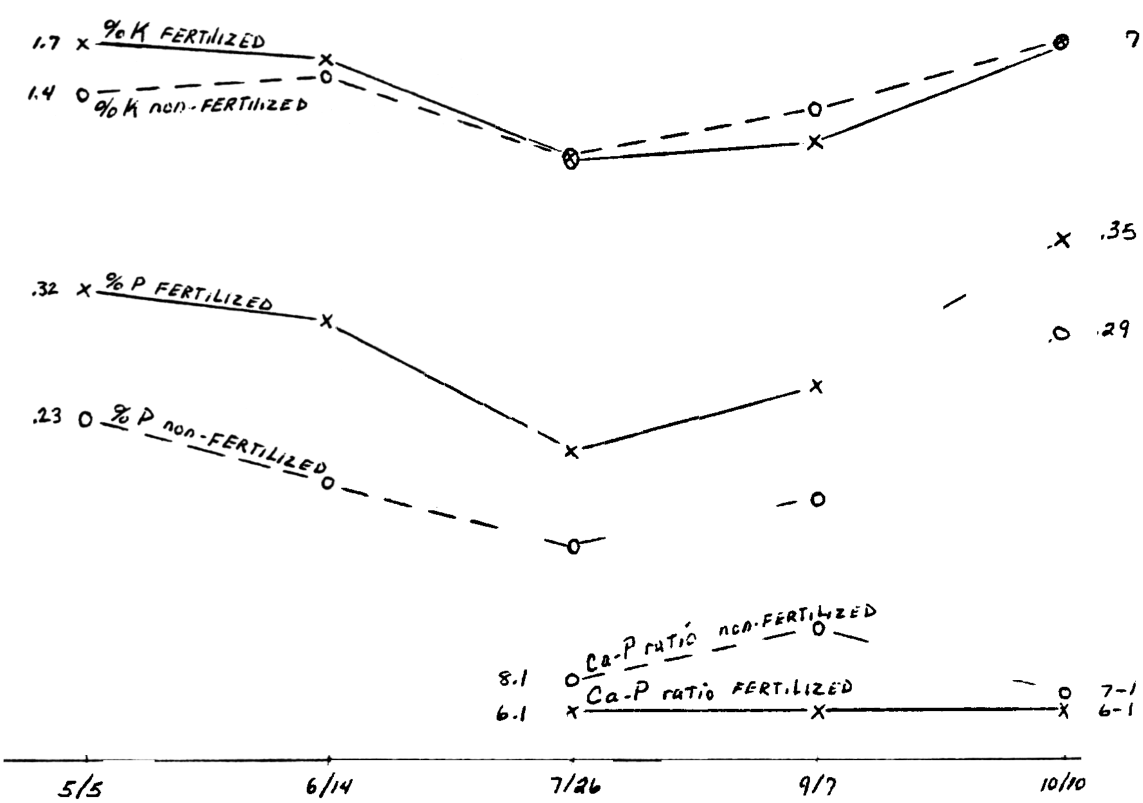

TABLE 7
1977 - Trial III
WL 318 Harvested Tops

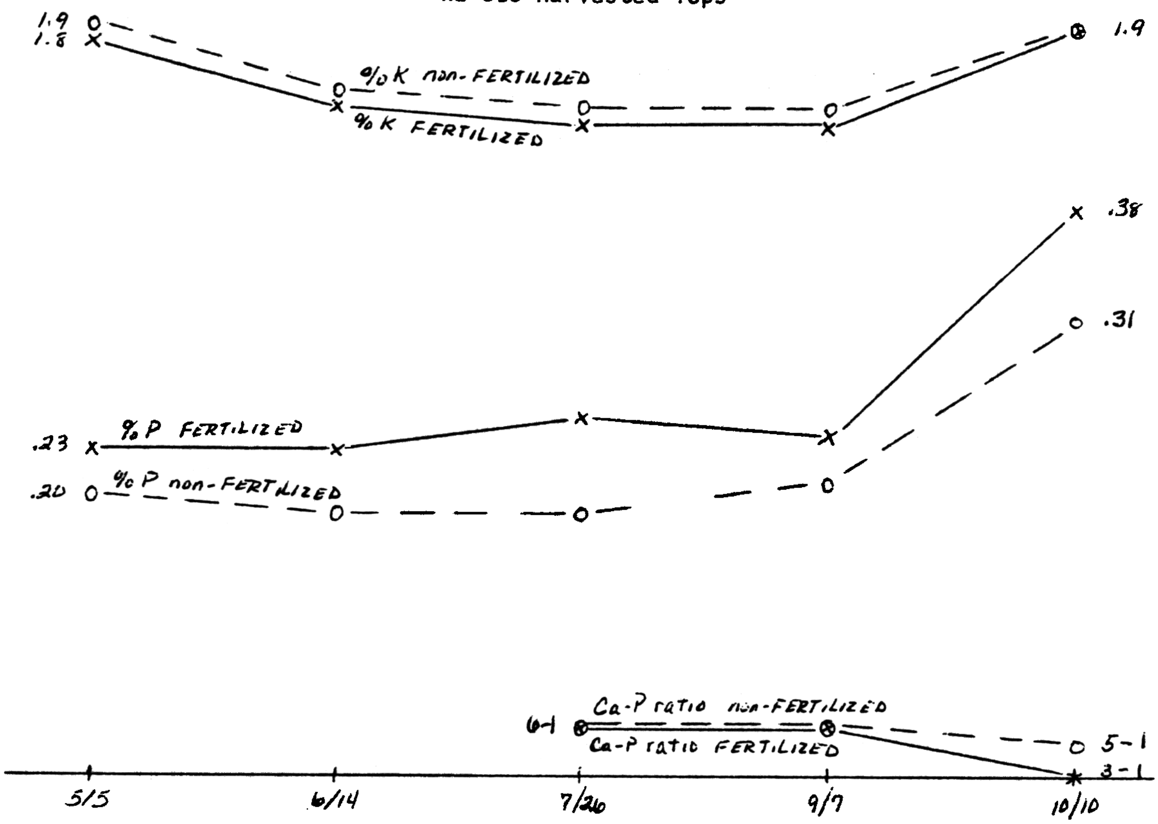

TABLE 8
1977 - Trial I
WASHOE Harvested Tops

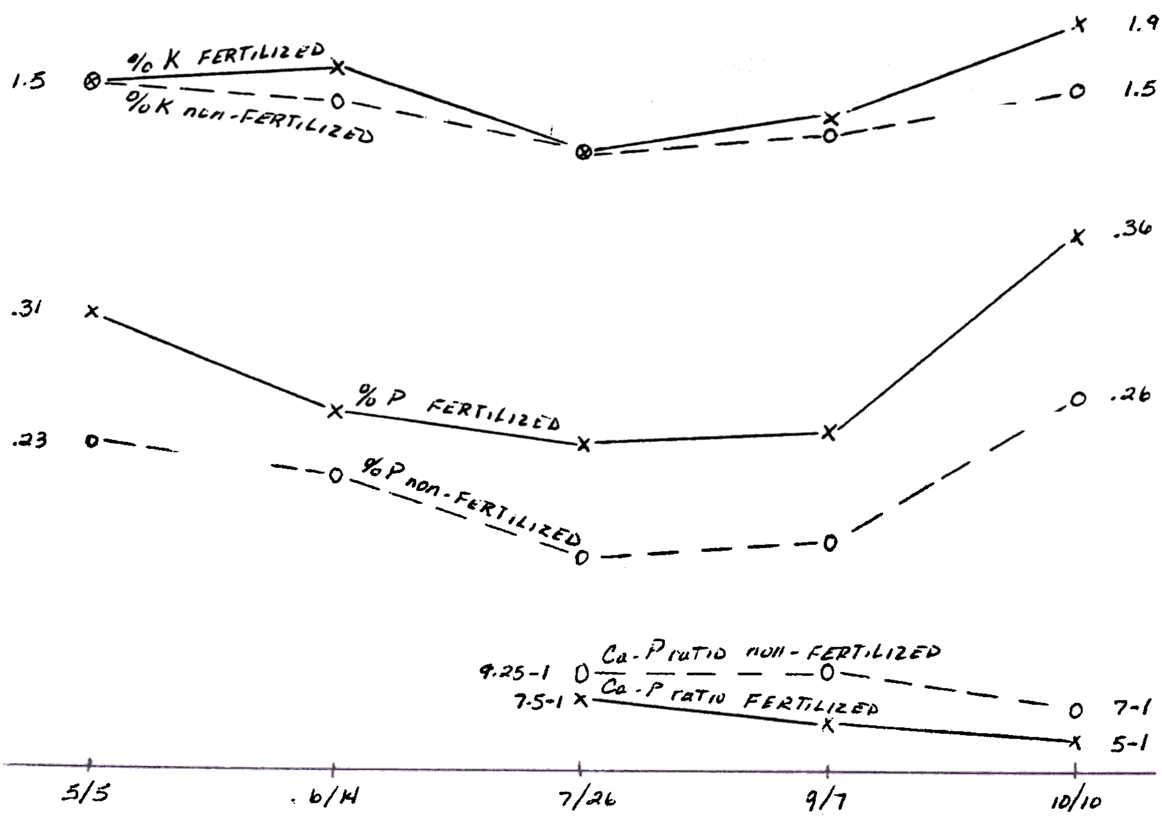

TABLE 9
1977 - Trial III
WASHOE Harvested Tops

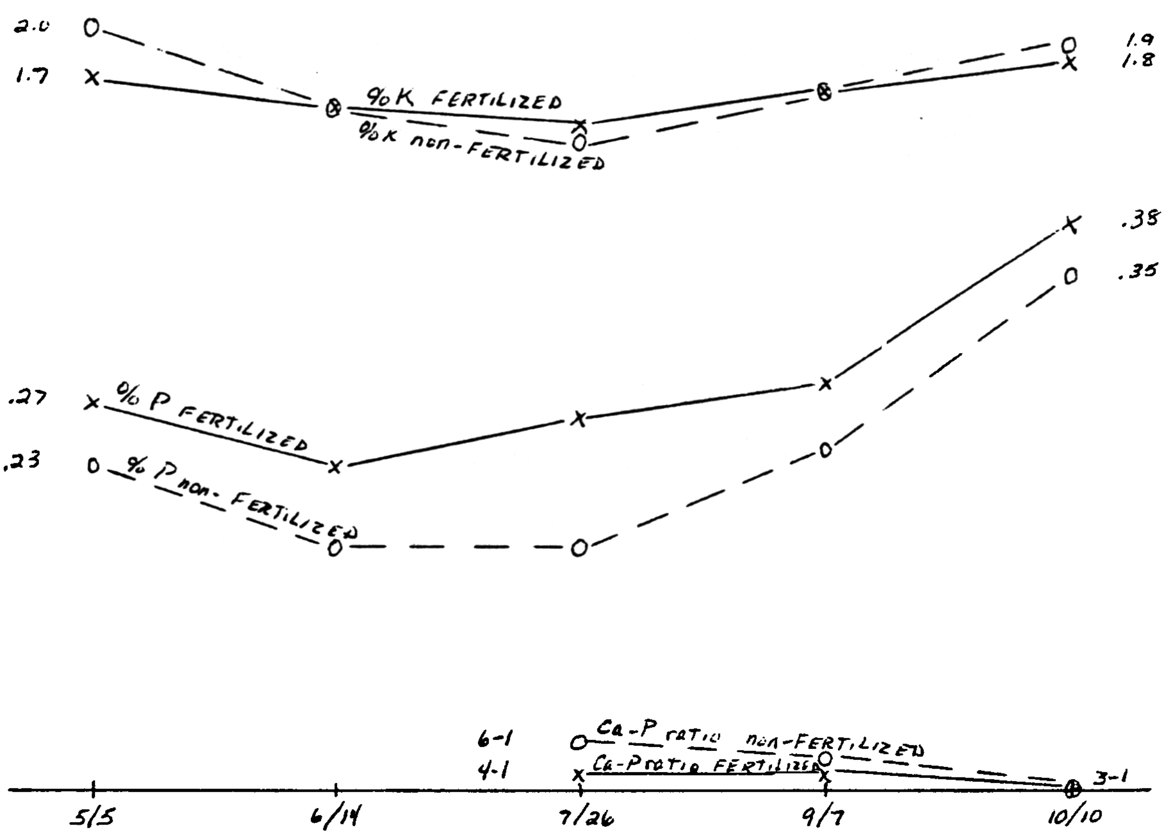

TABLE 10
Trial II
Variety - WASHOE

Plot	2nd Cut DM Yield ton/A	Season DM Yield ton/A	Mid stems PO_4P (ppm)	K%	SO_4S (ppm)	Treatment
135	2.48	8.02	680	1.14	4060	Fertilizer
216	2.14	8.17	1120	1.26	4320	Fertilizer
149	1.68	6.03	360	.90	4720	0-Fertilzer
198	1.69	6.24	350	.82	4540	0-Fertilizer

Varietal Performance. The success of a planting on problem soils such as those represented in this project is dependent on varietal adaptability. Total yields do not always represent total income as premiums are often paid for lower fiber hay which usually, in dormant varieties, occurs in cuts 1, 2 and 5. Since the cutting schedule was adapted to maturity of dormants, the non-dormant El Dorado R was usually in 25-50% bloom at mid-summer cutting, dormants Washoe and DK 131 were often 10-20% bloom. All others were late bud. Re-growth was a totally undependable guage for maturity in mid-summer in the dormants. Many cuts were made without any signs of re-growth in the trial with the exception of El Dorado R. If moisture stress did occur during the growth cycle, re-growth was usually present at the mid-summer cut as was early bloom.

The long cutting schedule may account for unexpected stand longivity of the non-dormant El Dorado R which has been observed to be susceptible to winter kill in water soaked soils. In the spring of 1977 (last year of drought), El Dorado R growing in Trial III, developed stems to exceed 50" in length. Though spring lodging was a problem with most varieties no dormant was equal in stem length to El Dorado R. Since 1977 was the 2nd year of the drought, moisture sensors were read throughout the winter and spring and irrigations scheduled when soil moisture levels required it in November, December and February.

TABLE 11
1978 - Trial I
Total Yield (5 cuts)

Duncans Multiple Range Test of Mean Difference - Varieties -

Variety	Mean Lbs. Dry Matter	Homogeneous sub-groups 1	2	3	4	5
Washoe	14626.283	V				
WL 318	14061.101	V	W			
Apollo	13918.957	V	W			
El Dorado R	13865.760	V	W			
WL 309	13573.273	V	W	X		
Resistador 2						
WL 214	12879.156		W	X	Y	
Vernal	12586.668		W	X	Y	Z
AS 63	12513.564		W	X	Y	Z
DK 123	12021.723			X	Y	Z
DK 131	11036.462			X	Y	Z
Gladiator	11674.312				Y	Z
AtCal-1	11463.680					Z
DK 153	11064.207					Z

Significance at 5%.
L.S.D. = 1489.02833.
Yields averaged from fertilized and non-fertilized plots.

TABLE 12
1976-1978 -- Trial I
Total Yield (15 cuts)

Duncans Multiple Range Test of Mean Difference - Varieties -

Variety	Mean Lbs. Dry Matter	Homogeneous sub-groups 1	2	3	4	5	6
WL 318	42695.958	U					
Apollo	41576.164	U	V				
Washoe	41249.021	U	V	W			
El Dorado R	40391.077	U	V	W	X		
WL 309	40078.076	U	V	W	X		
Resistador 2	39542.461	U	V	W	X		
WL 214	38315.409		V	W	X		
AS 63	37909.010		V	W	X	Y	
DK 153	37613.485			W	X	Y	
DK 131	36634.381				X	Y	Z
Gladiator	34467.067					Y	Z
Vernal	33738.953						Z
AtCal-1	33298.897						Z
DK 153	33199.574						Z

Significance at 5%.
L.S.D. = 3278.15083.
Yields averaged from fertilized and non-fertilized plots.

TABLE 13
1978 - Trial III
Total Yield (5 cuts)

Duncans Multiple Range Test of Mean Difference - Varieties -

Variety	Mean Lbs. Dry Matter	Homogeneous sub-groups 1	2	3	4	5
WL 318	14817.864	V				
Apollo	14794.533	V				
Washoe	14138.404	V	W			
WL 309	13914.438		W	X		
El Dorado R	13568.488		W	X	Y	
Resistador 2	13376.253		W	X	Y	Z
AS 62	13214.613			X	Y	Z
WL 214	13047.265				Y	Z
DK 131	12890.805				Y	Z
DK 123	12838.595				Y	Z
AtCal-1	12824.654				Y	Z
Gladiator	12698.301				Y	Z
DK 153	12663.637				Y	Z
Vernal	12501.317					Z

Significance at 5%.
L.S.D. = 774.53954.
Yields averaged from fertilized and non-fertilized plots.

TABLE 14
1976-1978 -- Trial I
Total Yield (11 cuts)

Duncans Multiple Range Test of Mean Difference - Varieties -

Variety	Mean Lbs. Dry Matter	Homogeneous sub-groups 1	2	3	4	5
WL 318	32074.922	V				
Apollo	31931.659	V				
WL 309	30600.774	V	W			
Washoe	29945.412		W	X		
AS 63	29632.590		W	X		
DK 131	29378.396		W	X	Y	
WL 214	29302.400		W	X	Y	
El Dorado R	29137.885		W	X	Y	Z
Resistador 2	28716.228			X	Y	Z
DK 123	28588.304			X	Y	Z
DK 153	28548.058			X	Y	Z
AtCal-1	28356.633			X	Y	Z
Gladiator	27797.383				Y	Z
Vernal	27410.938					Z

Significance at 5%.
L.S.D. = 1542.25985.
Yields averaged from fertilized and non-fertilized plots.

Other factors such as durability and competitiveness against weeds are also factors to consider. See tables 15 and 16. Ratings of: health (evaluation of visual disease symptoms eveness of growth, leaf size and color); summer weed population (evaluation of weed pressure) taken in August 1978was submitted to Duncans Multiple Range Test. Similarities are seen in Trial I between the ratings and the 1978 seasons yield.

Spring vigor among the dormants was important factor in 1st cut's insect control. Only two of the three spring cuttings required an insecticide and then only one treatment. Blue aphids, spotted alfalfa aphid, alfalfa weevil were major spring pests. Alfalfa caterpillar and stripped army worms were the major summer pests.

In Summary. Some of the answers to our questions have been presented to you. We were successful in harvesting up to 8 tons of commercial hay/acre/year under very adverse conditions. We have demonstrated that varieties are available with enough disease tolerance to perform well under adverse conditions. That P and K banded prior to planting will continue to influence yields through the 4th year and perhaps longer and that varieties do indeed differ in their response to fertility programs. That response is relative to the total environment in which the soil itself plays an important part.

[1] Evenson, P. D., Ag. J., Vol. 71, 1979

TABLE 15
9/11/78 - Trial I
Weed Score

Duncans Multiple Range Test of Mean Difference - Varieties -

Variety	Mean Score	Homogeneous sub-groups 1	2	3	4	5	6
Washoe	9.281	U					
Apollo	8.688	U	V				
WL 318	8.406	U	V	W			
El Dorado R	8.156	U	V	W			
Resistador 2	7.906		V	W	X		
WL 214	7.313			W	X		
WL 309	6.875				X		
DK 123	5.500					Y	
DK 131	5.500					Y	
AS 63	5.500					Y	
Vernal	5.500					Y	
AtCal-1	5.500					Y	Z
DK 153	4.438					Y	Z
Gladiator	3.938						Z

Significance at 5%.
L.S.D. = 1.07510
Includes scores from fertilized and non-fertilized plots

TABLE 16
9/11/78 - Trial III
Weed Score

Duncans Multiple Range Test of Mean Difference - Varieties -

Variety	Mean Score	1	2	3	4	5	6
Apollo	9.729	U					
Washoe	9.563	U	V				
WL 318	9.458	U	V	W			
El Dorado R	9.417	U	V	W			
Resistador 2	9.375	U	V	W			
WL 309	9.167	U	V	W	X		
WL 214	8.979		V	W	X	Y	
AtCal-1	8.928		V	W	X	Y	
AS 63	8.854			W	X	Y	
DK 131	8.813			W	X	Y	
Vernal	8.667				X	Y	
DK 153	8.542				X	Y	
DK 123	8.396					Y	
Gladiator	7.625						Z

Significance at 5%.
L.S.D. = 0.60329.
Includes scores from fertilized and non-fertilized plots.

Typical size of 1 year old Apollo plant (1st cut, 1976). Note branched root which was typical of root systems in the trial.

1st cut 1976 indicating windrow size from 12' swather "cleaning up" following plot harvest.