THE USES OF LAND LEVELING, IRRIGATION, AND VARIETIES IN THE REDUCTION OF SUMMER STAND DECLINE OF ALFALFA IN DESERT AREAS

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Summer stand decline has long been considered the most important limiting factor of alfalfa production in the low desert valley areas. For many years (until about 1960), alfalfa was grown much like an annual crop because of the severe stand loss occurring during the summer months. For example, most alfalfa growers stopped irrigating alfalfa in late July or August. In about mid-September these dry alfalfa fields would be renovated, leveled, seeded, and then irrigated during the first part of October to restart production of alfalfa again. Some growers still follow this practice or modifications of it today. One commonly followed modification is to irrigate all summer, but after the alfalfa is mowed in September the areas in the field where there are few or no plants are renovated, reseeded, and irrigated some time after the first of October.

Ways of reducing certain aspects of summer stand decline that have plagued alfalfa growers for so long are being found and recommended. They are: (1) more uniform land leveling, (2) improved irrigation techniques, and (3) improved varieties with resistance to factors causing stand decline.

Improved Land Leveling

One way to reduce summer decline available now is improved land leveling. I think most growers are making use of it. In the past when the land was reclaimed from the desert, horse-drawn equipment was used, limited amounts of soil were moved, existing grade was usually used, and filled areas often settled causing depressions. All of these factors contributed to the summer stand decline problem. Today motorized equipment can be used to move large amounts of soil to a precise level and grade. This provides us with tools to alleviate the stand decline problem which were unavailable to growers earlier in this century.

The studies reported by Dr. Erwin (Erwin, et al. 1959 and Lehman, et al. 1968) have shown that summer stand decline is related to repeated over-irrigation and soil saturation for more than 36 hours. Several ways can be used to reduce these problems.

(1) The land should be well leveled so there are no depressions in which water will be collected and held.

(2) There should be good surface and subsurface drainage which will eliminate standing water. We realize that few farmers have the advantage of surface drainage from tail ditches, but excess surface water can be largely eliminated by careful irrigation, return flow systems, drainage to an area unaffected by excessive water, and perhaps other means. Subsurface drainage is largely dependent on existing soil type, but tiling and deep tillage help remove excess subsurface water.

(3) Land should be leveled with a fall which should allow the water to irrigate and drain without standing for long periods. A grade of about 1.5 to 2 feet per 1,000 (0.0015 to 0.002) seems best for alfalfa. Leveling land with poor subsurface drainage to 0 grade seems to be a poor procedure for alfalfa production. However, the main factor to consider is the length of time the alfalfa roots must remain under water-saturated conditions in the soil. If this can be reduced to a satisfactory period of time, the alfalfa should survive. Due to variations in grade and soil type, it is difficult to place a time period on this control measure.

Improved Irrigation

Improved irrigation is a second way of eliminating summer stand decline. This is also largely available to us today if we wish to use it. Many are doing this and are getting maximum production and maintaining their stands. On the other hand, many are doing a very poor job of irrigating. They may habitually over-irrigate or irrigate on a calendar basis whether irrigation is needed or not, excessive drain water may accumulate, gates may be left open too long, the runs may be too long, and most importantly, often the laziest and least imaginative man in the crew may do the irrigating because he has a hard time doing anything else right.

Before discussing irrigation it might be good to consider certain information that might be helpful in understanding irrigation for the alfalfa plant. (1) Studies discussed previously by Dr. Erwin have shown that excess water from frequent irrigation, poor drainage (surface and subsurface) will result in conditions favorable for the development of root rots and scald (summer flooding injury). (2) Alfalfa is normally a deep-growing, tap-rooted plant. Alfalfa roots have been found growing as deep as 20 to 40 feet (Bolton 1962 and Hanson 1972). (3) If there is a permanent or semi-permanent water table, alfalfa roots will grow no deeper than about one foot above the water table (Luthin and Bianchi 1954). Deep rooting crops such as alfalfa are hurt most by a high water table (Luthin 1957). A temporary or perched water table may develop under certain soil conditions with excessive irrigation. Under the conditions of a temporary water table healthy roots found in this area may rot and probably become infected with fungi that cause diseases. The roots may later grow into this area if the plants survive and the water table should recede. (4) Alfalfa roots may be shallower than we think. In irrigation studies we have conducted on heavy soil with restricted subsurface drainage, we found that 72 and 92% of the alfalfa roots were in the upper 12 and 24 inches of the soil, respectively, (Lehman, et al. 1968). This meant that we should irrigate to this area. It also meant that we would have to watch our irrigation timing carefully because the actual soil mass utilized by the plant is shallow and might dry rapidly.

On the basis of this information certain recommendations can be made on irrigation of alfalfa. However, since soil type has an important influence on irrigation, it is difficult to be specific. Growers will necessarily have to tailor these recommendations to their own fields and set of conditions. In fact, each alfalfa field and areas within a field may also be different. In addition, it will be almost impossible to follow all recommendations on every field in a day-to-day farming operation. Instead, they are given as guidelines which might be followed when other conditions permit.

(1) Irrigate the crop when it needs irrigation. Too much water when temperatures are high causes scald, and fungi that cause root rots are favored; too little water results in lower yields. You will have to find the optimum rate for your fields. Use all the signs and information you can obtain such as color of the plants (light color indicates a wet condition, dark color indicates a dry condition), moisture in the soil, cracking of the soil, history of the field, rainfall, humidity, and instruments (tensiometers). Avoid irrigation on a calendar basis, dumping water from another crop, re-irrigating borders, and irrigating too early or too late so that the alfalfa can be irrigated with another crop.

Tensiometers can be used effectively in determining irrigation schedules. They will tell you the moisture conditions one or more feet below the surface of the soil where you normally have no idea of what is happening. We have used them successfully to solve irrigation problems. Once we learned the soil, plant reaction, and average time between irrigations, we were able to irrigate successfully without them. Individuals using them may become irritated because they require much attention, but like any instrument they must be maintained correctly. Information on the use of tensiometers in alfalfa is found in Appendix 1 following this article.

(2) Watch the length of time that water runs into each border or land. Leaving water run for excessively long periods may saturate the soil at the head end of the field. When the water is shut off, it may take a long time before the excess water in the soil percolates to lower depths. Higher levees, a larger head of water, and a shorter irrigation run might help alleviate this problem.

(3) Start irrigating at different locations in the field if the head of water being turned into the field from the district ditches builds up slowly. It is possible to have water flowing into the first border(s) twice as long as the other lands which may be irrigated later.

(4) Try to irrigate and manage your alfalfa crop during August and September with stand survival as your primary concern. Irrigate slightly less frequently but avoid hurting the crop. Let your crop go longer before cutting--perhaps six weeks after the August cut. Hay quality from that cutting may be very poor, but you may go into the new crop year with a better, stronger stand.

(5) Try to have some regrowth on the plants before applying your first irrigation after mowing during the summer. Scald is much more severe on freshly mowed plants or on plants crushed by tractor or truck wheels.

(6) Cut as soon as possible after the last irrigation, but avoid damaging the field by driving on it when wet. If the field is cut when there is still sufficient soil moisture, growth will be uninterrupted and there should be sufficient regrowth to resist scald. Stressing the plants in any way seems to interrupt growth and reduce yield.

Resistant Varieties

A third way to reduce summer stand decline is to plant resistant varieties. Unlike land leveling and irrigation techniques, practical results in the form of better varieties are probably just starting to become available.

Until recently, the nondormant or winter-growing alfalfa varieties which we use in these desert areas have been noted particularly for their short life. Examples of these varieties would be Arizona 21-5, Hairy Peruvian, African, and Indian. Moapa, which was developed in 1957 and widely planted by 1960, was released for its resistance to the spotted alfalfa aphid, but it was also found to have a slightly better stand life than the varieties previously planted. The slightly longer stand life of Moapa is probably the main reason for the wide acceptability it enjoys today.

Moapa was selected from an old stand of African alfalfa which was thinned by the spotted alfalfa aphid and also root rots. Root rot resistance was obtained by accident. Today we no longer need to depend entirely on chance to obtain root rot-resistant varieties because new information and techniques have been developed and are available.

The first step in the development of root rot-resistant varieties was the discovery of the major diseases causing root rots, such as Phytophthora root rot, Rhizoctonia root rot, and scald (Erwin 1954, Smith 1943 and 1945, Erwin, et al. 1959). Of these diseases, Phytophthora root rot has been considered as the most important root rot especially in the fall, winter, and spring in the southwest deserts and in the spring, summer, and fall in areas with more moderate temperatures.

The next step in developing resistant varieties was to find plants or germplasm (varieties or seed mixtures) with resistance to the identified diseases. Germplasm with resistance to Phytophthora root rot was first found by Erwin in the varieties Lahontan, Hilmar, and Arabian (Erwin 1966). Since then, plants resistant to Phytophthora root rot have been selected from many sources by plant breeders throughout the United States. No proven sources of resistance have been found for Rhizoctonia root rot and scald. Almost all organizations working on alfalfa improvement in the southwest are working on resistance to Phytophthora and other root rots. I have seen most of these programs. They are good, promising programs. New techniques using both greenhouse and field have been developed and are being used. Many superior varieties with resistance to root rots and, hopefully, summer stand decline can be expected soon. However, UC Salton is the only named variety adapted to the low desert valley areas which has been shown to have more resistance (less susceptibility) than Moapa to the low desert valley summer disease complex or summer stand decline.

UC Salton is the fifth generation of a broad-based germplasm pool which was developed in the Imperial Valley under conditions where there was severe natural and artificial selection for root rots, the spotted alfalfa aphid, and unknown desert problems (Lehman, et al. 1973). Germplasm came from many sources including old adapted varieties, unadapted varieties, and selected lines from the University of California breeding program. Germplasm from African, Sirsa, and Lahontan are probably found in greater amounts than other varieties. It seems likely that Lahontan might be the main source of resistance to Phytophthora root rot. UC 66, now being called UC Cargo, is closely related and similar to UC Salton. It is now being increased for possible release.

Varieties being actively marketed in the low desert valley areas have been tested at the University of California Imperial Valley Field Station and other locations in California. A good differential for reaction for the summer disease complex or summer decline was obtained in a hay production field at the Imperial Valley Field Station near El Centro which was accidently over-irrigated through increases in frequency and irrigation time. Results are shown in Table 1. In this trial UC Salton had better stand and growth than all other named varieties tested. Two experimental varieties in the test also performed well. One of them was UC Cargo and the other was UC 60 which was developed from Phytophthora-resistant germplasm selected from the variety Arabian by Drs. Erwin and Stanford in the late 1950s.

The root rots identified in the field near El Centro (Table 1) at the time the plants started to die were Rhizoctonia root rot and scald. To date we have been unable to test individual plants for resistance to each of these diseases and, therefore, are unable to say what level of resistance UC Salton might have to these root rots, if any. This is an area where more work might be done in the future.

It appears Phytophthora root rot could have contributed to the loss in the El Centro field through weakening the plants in the spring and early summer. The effect, if any, of a high-temperature Phytophthora root rot which is suspected of being important is unknown. Again, more work is needed.

Other unknown factors such as resistance to diseases and insects might also have allowed UC Salton, UC Cargo, and UC 60 to survive when other varieties were killed. One example of this is a very preliminary test on alfalfa mosaic virus conducted by Dr. C. Summers and Dr. W. McClellan of the University of California. In their test they found that UC Cargo and UC Salton might be less susceptible than Moapa and Lahontan to alfalfa mosaic virus. This indicates again that resistance to summer stand decline is complex and that resistance to several factors will be needed before the problem is solved.

Stand survival and appearance were also found to differ among varieties in a field near Woodland, California, which had an irrigation problem. In this field the stand and general appearance of UC Salton was equal to or better than all other varieties in the trial (Table 2). Lahontan and Washoe also appeared similar to UC Salton, but they do not produce winter growth and are therefore unadapted to the low desert valley areas. UC Cargo which is being considered for release received a score slightly higher than UC Salton, Washoe, and Lahontan. The main root rotting organism in this field at the time of the problem was identified as Phytophthora root rot.

Field tests for resistance to Phytophthora root rot were conducted on a limited number of varieties at the University of California, Davis (Table 3) and the University of Minnesota (Table 4). The winter-dormant varieties (Lahontan and Agate) had the best scores. UC Salton and UC Cargo were equal to or better than the other varieties in Tables 3 and 4. Although the degree of resistance to Phytophthora root rot in UC Salton and UC Cargo is low, it seems to be a useable level of field resistance.

In tests for Phytophthora root rot conducted thus far, UC Salton and UC Cargo have about 10 to 17% resistant plants, Lahontan, Washoe, and Agate 35 to 50%, and most other varieties between 0 and 8%. These are all fairly low levels of resistance from what might be expected. One of the best varieties tested to date is Agate, a variety from Minnesota (Table 4). Within Agate, 48 to 54% of the plants were resistant to Phytophthora root rot. In the same test 36% of the Lahontan plants were resistant. Many researchers expect to obtain high levels of resistance to Phytophthora root rot in most of the future varieties. I feel we may get good field resistance from levels similar to Agate and could spend our time better if we developed resistance to other factors affecting stand decline. For the low desert valley areas these are Rhizoctonia root rot, scald, alfalfa mosaic, alfalfa weevil, alfalfa caterpillar, and high summer temperatures.

In yield tests conducted near El Centro, California, under relatively normal conditions, the production of all named varieties in the tests was similar (Table 5). Resistance of nondormant varieties to the spotted alfalfa aphid, pea aphid, and downy mildew are shown in Table 6.

Summer stand decline has been and continues to be a very severe problem of alfalfa in the low desert valley areas. Land leveling techniques and equipment are available today to eliminate many of the problems with the soil surface. Good irrigation techniques can be learned, but cultural problems and our natural inclination to take the easy way out or delegate the problem to someone else often interferes with our ability to solve the problem through effective irrigation. Varieties resistant to the low desert valley summer stand decline are being released now. More and better varieties can be expected in the next few years.

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Table 1. Data on alfalfa varieties growing in an over-irrigated hay production field near El Centro, California.1/

Variety	Green weight per plot 8-4-71	Ave. height of 150 plants 8-4-71	Plants per square foot2/ 10-31-71
UC Salton	13.2	16.3	4.5
Sonora	5.9	9.6	0.0
Moapa	6.9	10.3	0.1
Mesa Sirsa	9.8	11.0	2.8
El Unico	7.7	9.6	0.6
Bonanza	7.5	9.0	1.7
El Camino Brand	8.8	9.6	0.4
Niagra N71 Brand	7.3	9.6	0.4
UC Cargo (UC 66)	15.6	16.3	5.1
UC 60	14.8	17.3	4.4
LSD (.05)	4.8	4.5	1.0

1/ Problems identified were primarily flooding injury (scald) and Rhizoctonia root rot.
2/ Average of 8 square feet per plot.

Table 2. Stand evaluations of alfalfa varieties growing in a hay production field with an irrigation problem near Woodland, California.1/

Variety	Stand evaluation score2/	Variety	Stand evaluation score2/
UC Salton	1.8	Germain's Eldorado R	2.3
Moapa	2.7	DeKalb Brand 183	2.8
Moapa 69	2.7	Niagra N78 Brand	3.3
Washoe	1.5	AS13	2.7
Lahontan	2.0	AS49	3.5
Caliverde 65	4.7	Joaquin II	2.8
		UC Cargo (UC 66)	1.3
LSD (.05)	.06		

1/ The main problem causing stand reduction was Phytophthora root rot.
2/ Score of 1 = good, 3 = average, and 5 = poor stand.

Table 3. Reaction of six alfalfa varieties to <u>Phytophthora megasperma</u> in a field test at Davis, California, in 1972.

Variety	% plants surviving	% healthy plants surviving
UC Salton	80.6	13.8
Mesa Sirsa	66.5	6.2
Moapa	60.8	3.5
Moapa 69	55.1	4.0
Lahontan	93.7	79.4
UC SW 44	66.8	15.1

Table 4. Reaction of alfalfa varieties to *Phytophthora megasperma* in the USDA-University of Minnesota 1972 and 1973 Phytophthora root rot tests.1/

Entry	Percent plants in severity classes2/			Average severity
	1 + 23/	3 + 4	5 + 6	
	1972			
UC Salton	17	66	16	3.59
Lahontan	36	47	17	3.14
Saranac (susceptible)4/	7	54	39	4.26
Vernal4/	12	49	39	4.09
Agate (resistant)4/	54	37	9	2.69
LSD (.05)				0.36
	1973			
UC Salton	10	66	25	3.81
UC SW 44	12	59	29	3.78
UC Cargo (UC 66)	17	59	23	3.54
Saranac (susceptible)4/	2	48	49	4.38
Vernal4/	5	55	41	4.17
Agate (resistant)4/	48	40	12	2.80
LSD (.05)				0.50

1/ Data from Dr. D. K. Barnes and Dr. F. I. Frosheiser, USDA, and the University of Minnesota, St. Paul, Minnesota.
2/ Plants scored 1 to 6: 1 = no symptoms; 6 = plant dead.
3/ Plants scored 1 + 2 are considered resistant.
4/ Check varieties were included twice (8 reps instead of 4).

Table 5. Forage production of alfalfa varieties in two trials at the University of California Imperial Valley Field Station, El Centro.1/

Variety	Yield in % of UC Salton			
	1969	1970	1971	Total 3 years
		Test 1		
UC Salton	100	100	100	100
Sonora	92	92	93	93
Mesa Sirsa	95	92	94	94
El Unico	95	94	100	96
Bonanza	97	95	101	98
El Camino Brand	92	92	98	93
Niagra N71 Brand	99	93	103	98
Caliente	96	103	96	98
		Test 2		
	1970	1971	1972	
UC Salton	100	100	100	100
Mesa Sirsa	99	93	89	94
Hayden	98	91	87	93
Niagra N71 Brand	98	100	92	97

1/ Four cutting dates (2 early, 1 mid-season, 1 late) were used to represent the year. This schedule was used because a high correlation (r = 0.95) was found between the 4-cut schedule and all cuts.

Table 6. Ratings of alfalfa varieties for reaction to spotted alfalfa aphid Ent F, pea aphid, and downy mildew.1/

Variety	Spotted alfalfa aphid Ent F2/	Pea aphid3/	Downy mildew4/
UC Salton	1.2	1.9	2.5
Moapa	4.8	2.5	3.8
Moapa 69	-	2.5	2.8
Mesa Sirsa	2.8	-	1.5
Sonora	2.8	-	-
Sonora 70	-	3.4	-
El Unico	2.0	3.0	1.7
Hayden	-	3.4	1.3
Bonanza	1.7	-	1.0
El Camino Brand	2.8	-	1.8
Niagra N71 Brand	1.3	1.5	1.6
Caliente	3.2	-	1.6

1/ Rating of 1 = good; 5 = poor
2/ El Centro, California
3/ Five Points, California
4/ Data from W. Sallee, former Farm Advisor, Tulare County

APPENDIX I

THE USE OF TENSIOMETERS IN ALFALFA

Reprinted from

Lehman, W. F., S. J. Richards, D. C. Erwin, and A. W. Marsh. 1968. Effect of irrigation treatments on alfalfa (*Medicago sativa* L.) production, persistence, and soil salinity in southern California. Hilgardia 39: 277-295.

Tensiometers may be more difficult to manage in alfalfa fields than in other crops (Richards and Marsh, 1961). The main reason is that the fields must be harvested several times a year. Tensiometers must be protected to prevent damage during harvest operations. This requires either an above-ground enclosure which may be a nuisance or an underground emplacement with protective coverage. Devices for the latter have become available since this experiment was conducted. In addition, the tensiometers must be read frequently, especially during the summer, and kept in an operating condition. These instruments would be of value in many alfalfa fields. However, the extra work involved in reading and maintaining them may discourage many potential users.

Even though tensiometers may not be generally accepted, they would have definite value in certain alfalfa fields where:

1. Grower's experience or knowledge is limited and a means to evaluate the effects of irrigation is useful.

2. Problems of root and water penetration exist.

3. Unknown dry layers or perched water tables might develop.

4. Excessive soil wetness may occur and persist after irrigation.

Experience obtained in this trial indicates that tensiometers can be helpful, but they must be used along with other criteria generally used in determining an irrigation date. Some of these are crop response, prior personal experience in irrigating alfalfa, and knowledge of the area and the field. Because of soil differences many tensiometers should be used until representative tensiometers can be isolated. Defective tensiometers should not be used. In this trial tensiometers were at times suspected of being defective, but generally the tensiometers were found to be in working condition and correctly reflected true water condition of the soil in which they were placed. The only problem was that the soil was actually wetter or drier than anticipated.

Richards, S. J. and A. W. Marsh. 1961. Irrigation based on soil suction measurements. Soil Sci. Soc. Amer. Proc. 25: 65-69.

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A relatively simple way to place tensiometers in a field is to use six tensiometer locations. Three locations should be evenly spaced about 100 feet in from the intake end of the field. The other three should be evenly spaced about 100 feet in from the drain end of the field. The tensiometer locations should be placed near a levee so they can be read when the field is wet.

Two tensiometers should be at each tensiometer location. One should be about one foot deeper than the other. For an average field on a heavy soil we would try tensiometers at 12 and 24 inches below the surface of the soil.

We would probably irrigate the field when the average reading of the 12-inch tensiometers reached about 45. The 24-inch tensiometers would be used primarily to monitor the moisture level at this depth. However, it could also be used in scheduling irrigations.

Mark, and perhaps protect, your tensiometer locations well. You will need to locate them and the equipment operators must know where they are to avoid damaging them.

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