MANAGING ALFALFA UNDER SALINE CONDITIONS

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As good quality irrigation water becomes less abundant and the price of water increases, the need for conservation becomes a necessity. In the process of conserving water, salinity becomes an ever increasing problem and the severity of this problem is dependent upon on-farm water management.

In 1980, California growers had slightly more than 1.1 million acres devoted to alfalfa hay and seed production (13). Most of this acreage was under irrigation. Consequently, many growers already have or can have a potential salinity problem.

Salt Tolerance

Alfalfa plants, when subjected to salinity, are smaller and darker bluish-green in color than those grown under non-saline conditions. This becomes most evident with increasing salinity. In all other respects, the plants appear normal.

Some of the earliest research done to determine the salt tolerance of alfalfa was by Brown and Hayward (5) at the U.S. Salinity Laboratory in the mid 1950's. The varieties they tested, most of which are no longer grown, showed vast differences in salt tolerance. Unfortunately, the differences could be attributable to poor adaptation to the hot, dry southern California climate. Ladak, a winter-hardy variety, which is well adapted to the cold, dry conditions of the northern great plains did poorly under saline conditions. However, California Common which is well adapted to the California climate grew very well over the salinity range tested. Consequently, the importance of growing a variety which is adapted to a particular geographical area can not be over emphasized when salinity is a problem.

Maas and Hoffman (11), after compiling all known salt tolerance data, judged alfalfa to be moderately sensitive to salinity (Table 1).

Table 1. Expected alfalfa yield reduction in relation to soil salinity (EC_e) and irrigation water (EC_{iw}).

Expected yield[1] reduction (%)	Ave. Rootzone[1] [illegible]	Irrigation[2] Water (EC_{iw}) (dS/m)
0	2.0	1.3 (Colorado River)
10	3.4	2.2
20	4.8	3.2
30	6.1	4.1
40	7.5	5.0
50	8.8	5.9

Based on data from Maas and Hoffman (11).

[2] Based on 15-20% leaching fraction .5 $EC_{iw} = EC_e$ (1).

Their calculations showed that with an average EC_e greater than 2.0 dS/m in the rootzone, alfalfa yield would be reduced. This reduction was estimated to be 7.3% for each unit increase in salinity greater than 2.0 dS/m. The irrigation water salinities were calculated by assumming a leaching percentage of 15 - 20% (1).

Those growers currently using Colorado River water (1.3 dS/m) who are achieving 15-20% leaching, and are using the currently accepted management practices, are probably very close to the threshold value of 2.0 dS/m. If the increasing salinity levels in the Colorado River continues and remedial methods are not implemented to slow or reverse this trend, the projected salinity of the river water, at the Imperial Dam, by the year 2000 will be 2.0 dS/m (6). Based on the data presented in Table 1, this irrigation water which will be the best available, will reduce yields approximately 10%.

Nodulation

Bernstein and Ogata (4) tested the effects of increasing salinity levels on alfalfa nodulation and nitrogen fixation. They reported that salinity levels as high as 8.9 dS/m (EC_e) reduced nodule production by less than 20%. They further reported that nitrogen percentages within the plants were not significantly affected by increasing salinity levels. Thus, over the salinity range sufficient to reduce yields by 50% nodule formation and subsequent nitrogen-fixation was not impaired.

Air Pollution

Ozone, one of the major components of air-pollution, can cause severe injury to alfalfa leaves. This injury first appears as white chlorotic spots on the upper leaf surface followed by necrotic spotting, and eventual leaf drop. Hoffman, Maas, and Rawlins (10) reported a strong interactive effect of salinity and ozone on alfalfa. Ozone damage became less severe as salinity levels increased. Ozone levels of 10, 15, and 20 parts per hundred million, and salinity at moderate but not detrimental levels reduced forage yields by 11, 14, and 23%, respectively. However, these same ozone levels, without salinity, reduced yields by 16, 26, and 39%, respectively.

The fact that higher alfalfa yields were obtained because of this salinity-ozone interaction may be agronomically important in production areas with air-pollution. However, salinity is not a cure-all for plant injury from ozone. Very little is known about the interaction of salinity and other phytotoxic air pollutants that are frequently present with ozone. In addition, environmental factors such as temperature, humidity, light intensity and duration, and soil water stress can also influence oxidant damage to plants (9).

Boron Tolerance

Boron toxicity is confined primarily to a few irrigated areas in the western United States. Although excess boron problems do not involve a large area, plant injury and yield decline can be severe.

Eaton's (7) early work on boron tolerance listed alfalfa in the semi-tolerant category. He achieved his best growth when the soil solution contained 10 ppm boron. However, at 15 ppm boron the older leaves exhibited tip and marginal chlorosis, and occasionally mild necrosis. In classifying critical levels of boron in irrigation waters, Wilcox (15) reported that for alfalfa the concentration should not exceed 2-4 ppm boron.

Since considerable boron is held on the soil exchange once it is in the soil, leaching considered adequate for salinity is ineffective with boron. When boron in the soil solution is leached out of the rootzone, additional boron comes into solution, off the exchange, thus maintaining a nearly constant concentration in the soil solution.

At the present time, there are no economically feasible methods to remove boron from irrigation water. Similarly, there are no chemical or soil amendments that can be added to the soil to render the boron nontoxic. However, under boron-toxicity conditions crops will grow better and show somewhat less injury if adequately fertilized. The best alternative a grower has to prevent a boron problem from developing is an alternate source of irrigation water low in boron.

Sprinkler Irrigation

Severe damage to alfalfa has been reported when applying saline water, as low as 1.2 dS/m, by sprinkler irrigation (12). The damage is most severe when the sprinkling is done during periods of high temperatures - low humidity when evapotranspiration is at it's highest. On one occasion, all above ground plant growth was killed within 24 hours after sprinkling with 4.0 dS/m water. The weather was windy, skies were clear, and the temperature was above 90' F. (12).

Damage first appears as slightly bleached leaf margins which later become necrotic. Plants most affected are those between sprinkler lines where water application may be light. Evaporation of the water on the leaves causes a concentration of the salt which thereby causes the injury.

The grower who sprinkle irrigates with saline water must minimize the adverse effects from the salty water coming in contact with the leaves.

Options available are:

1. Irrigate at night when temperatures are lower and humidity higher.
2. Irrigate during cloudy weather.
3. Irrigate prior to early spring growth to fill soil profile and after each cutting.
4. Apply enough water uniformly to wash salt off leaves.
5. Be sure sprinkler heads rotate fast enough to prevent wetting and drying between rotations.

In general, poorer quality irrigation water can be used for surface irrigation than can be used for sprinkler irrigation.

Leaching for Salinity Control

In the past, crop response to salinity was related to the average salinity in the rootzone rather than the salinity of the irrigation water. Evidence now indicates than with frequent irrigations, plants respond more to the salinity of the irrigation water than to the more saline soil water at the bottom of the rootzone.

A number of leaching experiments with alfalfa over the last 10 years (2, 3, 8) have shown that high salinity in the lower portion of the rootzone has only minimal effect on yield provided the upper portion of the rootzone is maintained at a relatively low salinity level (i.e., near the salinity of the irrigation water).

The salinities in the lower rootzone increase with decreasing leaching percentages. Tests have shown that although high levels of salinity are present in the lower rootzone, overall transpiration and water uptake remain unchanged. The plants apparently compensate for the reduced water uptake from the highly saline zone by increasing water uptake from the zone low in salinity. Consequently, if low salinity is to be maintained in the upper rootzone under low leaching percentages, it becomes necessary to irrigate more frequently.

A four year alfalfa field trial conducted near Tacna, Arizona (14), showed no significant differences in yield among leaching treatments of 5, 10, and 20%. These data support earlier studies that indicate as little as 5% leaching results in yields equally large as those with 20% leaching.

Another study (3) was conducted in lysimeters with 60, 120, and 180 cm (2, 4 and 6 ft) soil depths to determine whether restricted rooting depths, such as shallow soils, affect alfalfa yield when using low leaching percentages. A 2.0 dS/m irrigation water with 6% leaching resulted in the development of comparable salinity profiles for all soil depths. The harvested yields were not significantly different among soil depths. Therefore, soil depth does not appear to be a significant factor when using low leaching percentages.

In conjunction with the earlier study (2), it was also determined that leaching every irrigation was not necessary. Yields were comparable when leaching was done every third or sixth irrigation instead of every irrigation, as long as the same average leaching percentage was maintained.

In a subsequent study (8) with the 60, 120, and 180 cm soil depth lysimeters, alfalfa was grown without leaching to determine how much salt could be stored in the lower rootzone without affecting alfalfa yield. The nonleached treatments were compared with 6% leached control treatments and both were irrigated with 1.0 dS/m water. Yield from the nonleached treatments was only reduced 25% below the leached controls after 9, 14, and 20 months (9th, 15th, and 22nd harvest) for the 60, 120 and 180 cm soil profiles, respectively. This study demonstrated that considerable salt can be stored in the lower rootzone when not leaching, as long as the upper part of the rootzone is maintained at a low salinity level. The deeper the soil the greater the capacity to store salt with minimal yield reduction. However, once the storage capacity is exceeded and salinity starts to build up in the upper rootzone, yield is drastically reduced.

The advantages of minimizing leaching are many.

1. A substantial savings in water.
2. Fertilizers are not readily leached from the rootzone.
3. Better aeration to the roots, since the fields do not remain excessively wet as long.
4. Plant loss from scalding and Rhizoctonia is reduced when the amount and duration of irrigation are reduced.
5. The capacity of artificial drainage systems need not be as large since drainage volumes are less.
6. Additional leaching, if needed, can be accomplished during the winter or off season when water is more readily available.

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