GROWING ALFALFA ON SHALLOW SOILS

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I have been presented to you as an expert on growing alfalfa in problem soils. I hope you haven't traveled great distances to listen to my talk because I am not really an expert It just so happens I work in an area that has some stubborn soils with high densities, poor water pentration etc. These soils are owned by some stubborn farmers that not only insist on growing alfalfa but also insist that I should know how to help them grow alfalfa in such conditions.

It was no problem to advise on alfalfa culture when the only soil alfalfa was grown on was deep class 1 soils but these have long ago disappeared beneath almonds, walnuts, prunes and pear orchards. I would suppose from the calls I receive that this displacement is happening in other areas of California and may be even occurring in intensely farmed countries in other parts of the world. This thought was brought home to me while I talked with an Australian alfalfa grower who came to my area to see firsthand how we could grow alfalfa under less than ideal conditions. He concluded that an important part of the package is variety adaptability.

Frankly I find in our present pool of alfalfa varieties, plants that are adapated to a wide range of conditions and will do well with shallow roots under good water management. In fact the plants may be far more adaptable than the average farmer who grows them. Alfalfa culture has had very little innovative thinking. If we are to grow alfalfa under less than ideal conditions, we are going to need to be innovative in solving problems.

At one time alfalfa seed production was very important in my area. The longest lived stands have been dormant varieties grown for seed. In most cases these were growing on poorly drained low fertility soils. Due to our 15-28" of rain these soils tend to be super saturated with water most of the winter. Even so it is not unusual to take 2 tons of hay in April from these thin stands. In some instances stands lightly sown for dormant variety seed production emerged with such vigor that they were not suitable for seed so were maintained as profitable hay fields. Now this should have told us something if we had stopped to think about it, but we didn't. That is, until three years ago when we had a very wet winter and 90% of the growers with non dormants found themselves out of the hay business. The non-dormant survivors were on the sandy loams or fields with steeper than normal slopes The dormant varieties on poorly drained soils yielded 2½-3 tons of hay in mid-April that year (see picture 1). Now that was something we couldn't ignore.

Fortunately I had a field project to determine the reason for "summer slump" when the calamity struck. Picture 3 depicts summer slump fourth cutting while picture 4 shows fall cutting same field same area. The "slump" project involved digging in fields all over the countryside to find the most active alfalfa root zone in various problem soils. I also wanted to observe the rooting characteristics of different alfalfa varieties in these soils at various times of the year. These root studies were coupled with fertility studies which were involved with alfalfa's response to surface applications of nitrogen and potassium and lack of response to surface application of phosphorus. Some 15 commercial fields were studied.

We found ourselves predicting the calamity that was apparent that spring because of the high degree of winter crown rot in non-dormants and the nearly complete loss of feeder roots Picture 6 is of 1- and 2-year-old non-dormant plants while pictures 5 and 7 are of the semi-dormants growing in different soils. Arrows point to root lesions. We found that some non-dormant plants in an effort to support the winter growing top sent out fine feeder roots in the zone just under the field duff and in many cases these roots were nodulated.

As a result of our efforts we found that most of our alfalfa was shallow rooted, less than 2 feet, with a high percentage of the main tap roots branched less than 1 foot below the crown (picture 7 shows extreme branching of 2- and 3-year-old plants). The classic deep tap root was found in only two fields; one a sandy soil and the other, surprisingly, an extremely heavy, deep, fertile clay in which 100 acres of dormant alfalfa, Vernal and Cody grew for four profitable years on 60' beds in rice paddys, a marvel to a who saw (picture 8 shows one of the paddys in its second spring).

Our root studies showed that in the summer the major portion of feeder roots were in the zone starting 2" below the soil surface and above the 12" depth. The only root activity above 2" was found in the early spring and late fall when fine roots could be found near the soil surface.

Careful and tedious sampling in our numerous test plots where we used 1/2 ton rates of single superphosphate showed that the broadcast phosphorus was not moving down through the soil. It wasn't until we reached rates over 1 ton/acre that we had significant movement. Most, if not all, of phosphorus applied at the 1/2 ton rates was held in the top 2" of soil (picture 9 shows the soil jig in position for sampling a test plot). In most all instances the top 2" of unfertilized soil in established stands was more fertile than the soil below. Since we found no root activity in the 0-2" zone in the summer the change in root activity to deeper zones could contribute to the so-called summer slump when plants are seen to lose their early spring vigor.

About the same time I became interested in soil temperatures and initiated a project to see what sort of temperature patterns we might expect and why some fields appeared to have "better" nodulation than others. Again, we surprised ourselves when we found the extremes of summer soil temperatures. At the 2" depth temperatures could peak at 112°F and 89°F at the 8" depth following windrowing. Clearly that soil was not an ideal environment for root function or for nitrogen production by rhizobium. We did find that our soils varied considerably in temperature response. One soil we observed never exceeded 80°F at 8" regardless of low moisture level or lack of shading. We observed that considerable variations could occur within the same field and as close as 150'. (Picture 11 shows graphs from two stations 150' apart recording temperature differences at both the 2" and 8" depths. Picture 12 shows what happened during the third season in the field shown in picture 4.) The significance of this needs to be explored but the limited amount of past and ongoing research in various parts of the world points out that there is an optimum soil temperature for alfalfa and nitrogen fixing bacteria which is related to maximum yield. The optimum may be different for alfalfa crowns than the roots and may even vary with variety.

In our studies of soil temperature we were fortunate to record cultural practices that occurred in picture 12. We found that these were definitely related to soil temperatures as was anything that interfered with the sun's rays striking the ground; be it the development of dense foliage or dense clouds. Irrigation and evaporation also had a cooling effect We observed the effect of prolonged soil exposure in mid-summer during the curing process and speculate that in some instances we could have reduced the rise in soil temperature by at least 15°F by conditioning the hay at windrowing and field chopping which would allow us time to irrigate sooner.

We have also initated projects in monitoring water penetration in problem soils. Picture 4 shows a field with severe problems that we were able to correct with bump irrigations Some soils we have had to bump (repeating irrigations 24-36 hours apart) as much as twice following the initial irrigation in order to obtain water pentration to 2' or 3'. However, in some fields Phytophthora root rot problems prevent us from using this method.

By this time I think you will agree that we probably have isolated some of the causes of winter kill and summer slump in alfalfa in our area. What I have proposed to growers in my area is to plow down or band into cooler soil zones enough phosphate fertilizers at planting time to last the stand for 4 or 5 years. We see this as 200-300 lbs. of P_2O_5/acre. I have also proposed that they use dormant or semi-dormant alfalfas to lessen the effects of winter kill from super saturated soils. Dormants give them the additional bonus of lower harvest costs, less soil compaction, less crown damage because of one less cutting per year, and because they start growing in mid-February, one less spraying for alfalfa weevil. In addition, dormant-type plants generally form larger widespreading crowns which fill in when neighboring plants die (picture 15 is of a 6-month-old dormant-type, note branched tap root). This helps to suppress summer weeds. Our plant breeders have come up with some real promising dormants for Sacramento Valley conditions but only a few are spotted alfalfa aphid resistant and have a high degree of tolerance to Photophthora root rot. I have encouraged growers with very heavy soils to use some type of bed to provide drainage for the crowns. (Picture 13 taken in April shows fall seeded stand survived on the tops of shallow beds on a very heavy clay soil after a very wet winter. Picture 14 was taken three seasons later.)

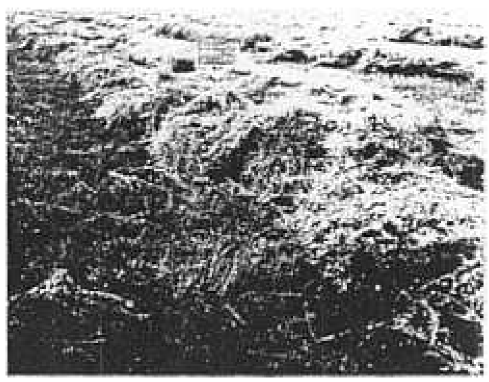
I also propose that they purchase windrowers that have full width crimpers that will handle a 2-3 ton hay crop. The engineers are not helping us here. So far our highest capacity machine is a 12' PTO driven windrower with a 9' 6" crimper. These are marketed by most equipment manufacturs. Growers are buying them. They like to be able to bale heavy yielding alfalfa in 3-4 days and sudan or oats in 5 days.

Though we have problem soils yielding 8-10 tons of hay per year we are far from having all the answers, hence, we have established a 3½-acre research plot on problem soils (pictures 15, 16 and 17). We are now looking at dormant variety response to low fertility levels vs. high fertility levels on heavy, medium and light textured soils. We are interested in the effectiveness of three different strain combinations of nitrogen-fixing rhizobia. Interestingly we have observed that several varieties appear to perform better on clay soils than sandy soils and just the opposite for others. All varieties do better under high fertility but some do better under low fertility than others. So far no yield measurements have been taken. We do intend to take some yield and quality measurements but these will be limited due to lack of funds. It is unfortunate that much of the opportunity of this project will be ignored.

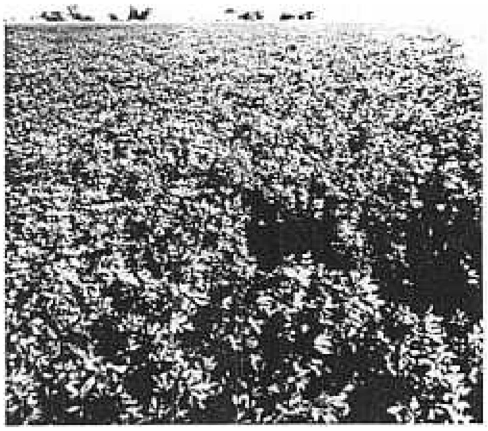
It appears to me that we have only begun to scratch the surface of the problem of growing alfalfa on problem soils. We need to develop varieties of alfalfa that will be better scroungers for nutrients, more resistant to crown diseases, Phytophthora and scald, and more resistant to equipment passage. We need better equipment that will speed up harvest, do less damage to the crowns and the shallow roots. We need the development of new strains of nitrogen-fixing bacteria that are more productive in a wider range of soil temperatures and compatible with all varieties. Frankly, I don't expect it to happen overnight.

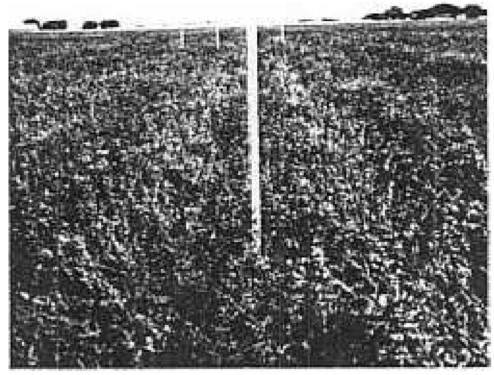
To summarize this--if you as a grower really are interested in growing 10 tons of alfalfa on problem soils you will have to question most of your present practices, make trial plantings, watch the plants from the roots up and have a lot of luck.

Picture 1. Mid-April growth of 5-year-old Vernal stand after a very wet winter of 30+ inches of rain--first cutting yielded near 3 tons.

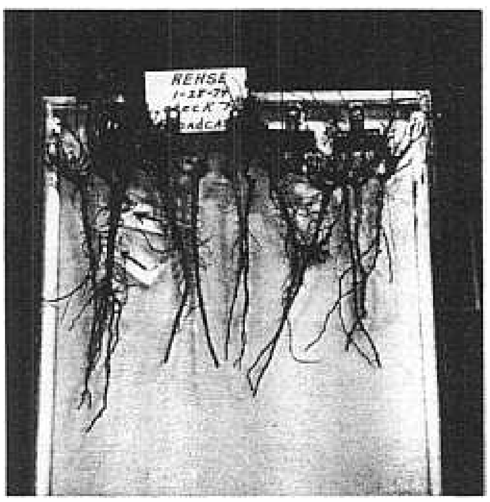


Picture 2. Mid-summer cutting of first-year Washoe on a silt loam. Depth of water penetration with one irrigation was limited to 5". When bumped once penetration increased to 12-16". Water was found to channel along roots. Penetration improved as stand increased in age.



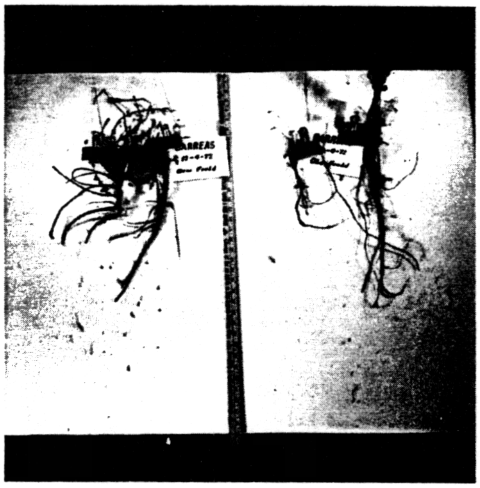


Pictures 3 and 4. Vigorous fall cutting (left) shows recovery from mid-summer slump (right) which resulted in about 50% grass. Lath stakes mark path of one-way subsoiling on 4' centers which only showed up in mid-summer.

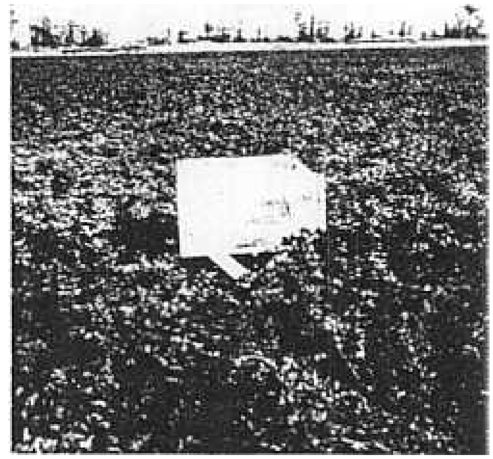


Picture 5. 3rd year plants taken from field shown in Picture 2. Note crown damage thought to be caused by swather. Field used up or tied up 1/2 ton/acre of disced in single superphosphate in 3 years.

Picture 6. 1st and 2nd year non-dormant plants taken from heavy clay. Arrows point to root rot lesions. Yield up to 4th year was far above average. Intense fertility program was used involving yearly applications of P and K and water water runs of NH_3 every cutting.

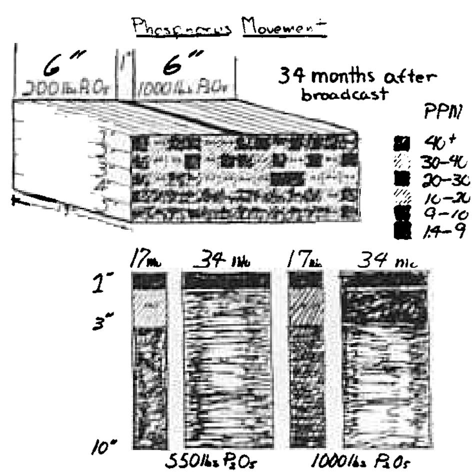


Picture 7. 2nd and 3rd year Washoe stands growing under low K and P and high soil densities.

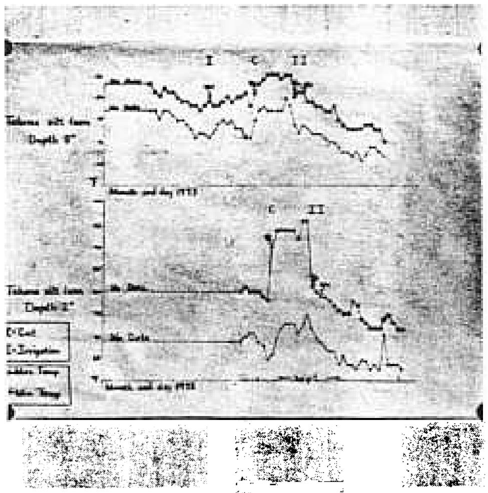


Picture 8. 2nd year Cody (a dormant) mid-March growing on 60' beds in a rice paddy on an extremely heavy clay

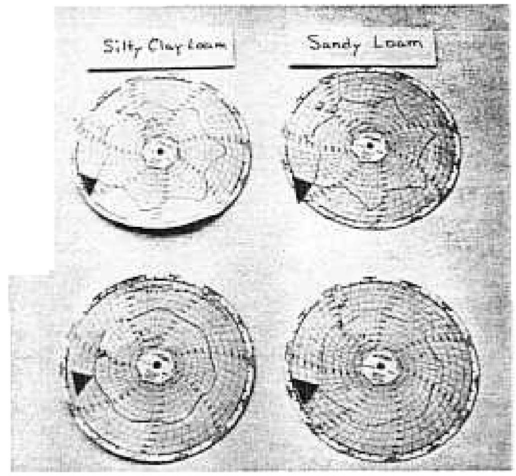
Picture 9. Soil jig used as a guide to core high density silty clay loam low in P and K (Washoe) on a horizontal plane with a wood bit. Twine divided fertilizer plots. Only visual response to P was observed in the spring. Visual N response showed up in mid-summer.



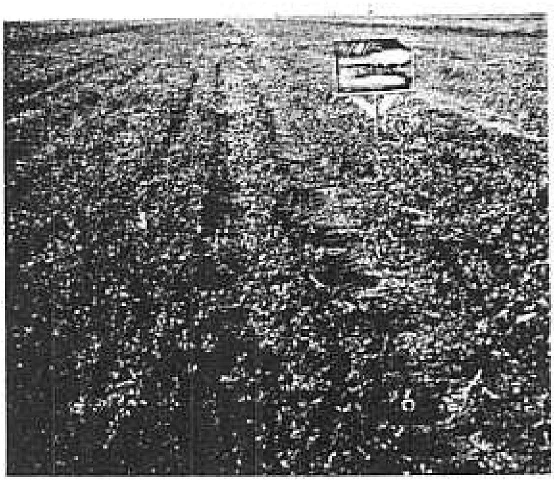
Picture 10. Top shows analysis of core samples taken with soil jig. "P" levels in 4th inch were below 10 ppm. Bottom indicates average test of cores taken 17 months and 34 months after application. In soil zone 3-10" test averages showed decrease 8.0 ppm-3.0 ppm in 550 lbs/acre treatment and 9.8 ppm to 7.0 ppm in 1000 lbs/acre. Treatment level at 0-1" remained quite high.



<u>Picture 11</u>. Thermograph 7 day recordings of 2" (upper) and 8" (lower) depths. Peak highs for week incurred by cutting the stand are indicated by arrows. Irrigation on following day depressed temperature.



<u>Picture 12</u>. Thermograph recordings from silty clay loam field shown in picture 4. Soil temperatures were relative to soil moisture conditions and exposure to solar radiation. Peak was brought on by harvest and reduction in temperature by irrigation.



<u>Picture 13</u>. April picture of fall seeded Washoe, solid seeding. Plants died in the bottom of the shallow furrows made with a heavy harrow. This is the bottom of the field of very heavy clay.

<u>Picture 14</u>. Three years later, October 1975, about the same location as picture 13. Furrows are still noticeable.

Picture 15. An October picture of a dormant-type alfalfa plant irrigated up May 1. Note the numerous fine stems spreading about 28" and the taproot branched about 2" below the crown.

Picture 16. High yielding dormant-type alfalfas have a tendency to lodge. This can present a harvest problem when low capacity swather-windrowers are used.

Picture 17. Taken in our research plots to show the size of crowns of dormant types that can develop in one summer in problem soils. Note the tape measure half hidden in one of the cracks.