Cultural practices affect alfalfa soil temperatures

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High soil temperatures in root zones can reduce alfalfa growth. The answer seems to be water management and short harvest periods.

Much of the new land being developed in Glenn County is comprised of Tehama and Kimball series soils, which, because of their structure and other profile characteristics, are often considered problem soils. Alfalfa hay yields on these soils range from less than 4 tons to 8½ tons per acre, depending on management. The alfalfa is generally rooted in less than 2 feet of soil; in summer, primary feeder roots are in a zone usually below 2 inches and above 12 inches.

This report is part of a joint effort to identify conditions affecting growth of shallow-rooted alfalfa. The soil-temperature studies were in conjunction with fertility and irrigation studies also made under grower conditions in several fields of Tehama and Kimball soils. This report is confined to the relation of cultural practices (such as irrigation and harvesting) to soil temperature in various alfalfa rooting zones in two of the many fields studied.

Soil temperatures have not been considered important in management of established alfalfa, because alfalfa is generally thought to be rooted in zones of stable soil temperatures. However, recent work by Evenson at the South Dakota Research Station indicated that lowering soil temperatures at crown depth in July by mulching with straw increased dormant-type alfalfa yields as much as 17 percent. Evenson recorded temperatures as high at 103° F at a 1-inch depth in a loam soil in July. Nielson in Canada showed that the optimum temperature for root growth of alfalfa potted in silt loam was 67° F. In Riverside, California, greenhouse studies, Erwin found the optimum root temperature of an African-type alfalfa to be between 72° and 81° F. Numerous studies have shown that higher soil temperature may reduce phosphorus availability to plants by immobilizing and chemically fixing phosphorus in the soil.

Gibson, an Australian researcher, studied how time of exposure to unfavorable root temperatures affects symbiotic nitrogen fixation by subclover (*Trifolium subterraneum* L.). The longer the soil was held at 73° F, the greater the amount of nitrogen fixed during that period. Gibson also showed that optimum soil temperature ranges varied among strains of nitrogen-producing bacteria.

In preliminary studies of various Glenn County soils, alfalfa was found to be primarily shallow rooted. Average root depths were about 2 feet with primary feeder roots in the 2- to 12-inch zone. Evidence indicated that root rot and/or dense subsurface soil zones and inadequate water percolation were the primary causes of shallow rooting.

Two-year field study

An intense two-year study of trends and differences in temperatures in Kimball and Tehama series soils during the growing season was initiated in two fields with shallow alfalfa rooting.

The significant characteristics of the soil series in the two fields are generally as follows. The Tehama series is formed from alluvial material of schistose and sedimentary rocks. The surface soil is medium textured (loams to silt loams) and pale brown to brown in color. The subsoils are lighter colored clay loams to silty clay loams. The soils are well drained. They lack stable structure, and the surface tends to seal over when irrigated, which causes the soils to be slowly permeable. When dry, the surface is dense and hard. The soil is medium acid at the surface, becoming slightly calcareous to moderately calcareous in the subsoil. The soils are of moderate fertility, and phosphorus is the most limiting nutrient.

Co-author Herb Schulbach with two soil thermographs in a test plot near Orland, Glenn County.

The Kimball soil series is formed from mixed alluvial sedimentary materials. The soils are well drained. The surface is a medium-textured, loam, brown to reddish-brown soil. The subsoil is a dark reddish-brown or yellowish-red dense clay. The dense claypan is very slowly permeable. The soil is medium acid at the surface, becoming less acid in the subsoil. The soils are of low fertility, and phosphorus levels are very low.

For both series the surface foot has an estimated moisture-holding capacity of about 1.5 inches, and the estimated average infiltration rate is about 0.05 inch per hour.

Both south-sloping fields were flood irrigated. To monitor the effectiveness of typical irrigation practices, tensiometers were installed at depths of 10 and 20 inches at each of three locations in several checks in the Tehama-soil field. The tensiometers were specially made so that the porous cups could be placed in the field and the mercury gauges at the border.

Plants in these fields had similar shallow-rooting characteristics. Alfalfa growing in Kimball loam was nondormant DeKalb 183; that growing in Tehama silty loam was semidormant Washoe. Root nodulation by nitrogen-fixing rhizobia was noticeably different in sample plants. Those growing in the low pH (5.6) Kimball loam contained an abundance of pink nodules, some of which were in extremely large clusters (up to 1 cm in

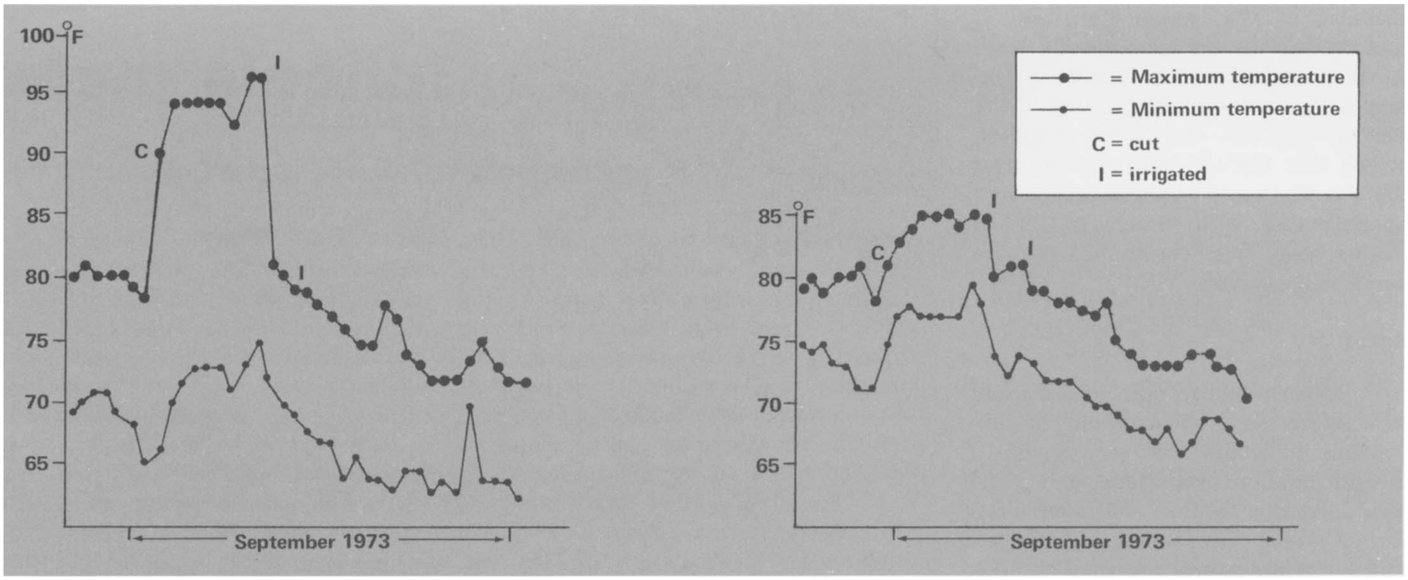

Fig. 1. Soil temperatures in Tehama silt loam at 2- and 8-inch depths.

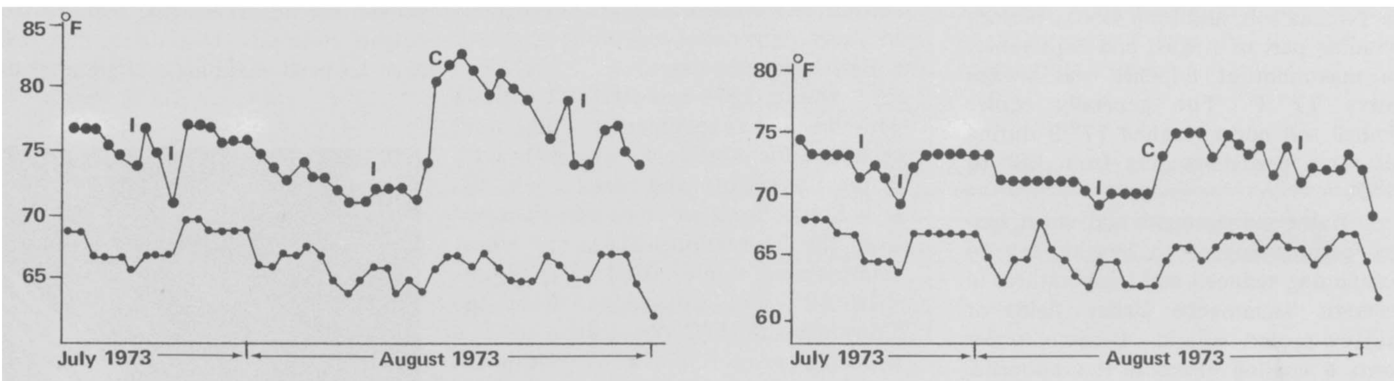

Fig. 2. Soil temperatures in Kimball loam at 2- and 8-inch depths.

diameter); nodules on plants growing in the more neutral Tehama were small and less profuse.

To record temperatures at the upper level and the middle zone of the alfalfa's primary feeder-root zone, seven-day recording thermometers with remote sensors were installed at depths of 2 and 8 inches in close proximity to one of the tensiometer stations. Records of temperature and cultural practices were kept for most of the growing season.

Daily temperature trends at 2-inch depths generally corresponded with the position of the sun; trends at 8-inch depths were generally the opposite—coolest during the day and warmest at night. Temperatures of both soils at the 8-inch depth were much higher than anticipated throughout the period studied. Temperature peaks during mid-summer were higher for the Tehama silt loam than for the Kimball loam at both depths in each of the two years. In both soils, temperatures began to increase immediately after cutting. In 1974 maximums at the 2-inch depth in the Tehama soil leveled off at 102° F for three days, beginning nine days after the mid-July cutting. Maximums in the Kimball soil reached a plateau of 85° F five days after cutting and remained at that level for three days, beginning July 30.

Reduction of soil temperature, other than from plant shade, at 2- and 8-inch depths in all fields studied appeared to be caused by irrigation, rain or clouds, and residual soil moisture. Peak soil temperatures at the 2-inch depth dropped from 102° to 86° F following irrigation with 68° F water in the Tehama soil, while a drop from 85° to 77° F was measured in the Kimball soil.

On August 30, 1973, Tehama soil temperature at 2 inches rose 12° F in 24 hours after the stand was cut. Soil moisture at 14 inches was low. Cutting when the soil surface was dry caused an abrupt increase in soil temperature, but cutting when the soil surface was slightly damp caused slower increases. Maximum increases measured under more favorable moisture conditions never exceeded 7° F in 24 hours.

Bump irrigations (irrigating one or more times in a short span of time) helped to decrease soil temperature and to increase water penetration and storage. In July one bump irrigation on shaded Kimball soil reduced soil temperature at 2 inches 3° F below the maximum of the first irrigation measured three days before. However, the maximum temperature had increased each of the two days following the irrigation so the second irrigation reduced soil temperature at 2 inches by 7° F and at 8 inches by 5° F. The day after the bump irrigation, maximums increased by 7° F for the 2-inch level and 5° F for the 8-inch level.

Tensiometer and soil-temperature data followed similar curves in the Tehama soil, showing a relationship between the soil's water content and its temperature, except that temperatures tended to fluctuate more widely. Lack of adequate water penetration and storage kept the soil-suction range above the capability of the tensiometer; thus it failed to provide adequate weekly readings that could be plotted without too many assumed values. Excavations in the Tehama soil one day after irrigation showed that the soil surrounding larger alfalfa feeder roots was iron-stained and supersaturated with water; soil 1 to 2 inches away from the roots was more normal in appearance.

Summary

Deeper zones in both soils reached temperature levels that could be unfavorable to alfalfa root growth and to nitrogen fixation by bacteria, and could cause increased fixation and immobilization of phosphorus applied in the zones. Peak soil temperatures exceeded 86° F at the 8-inch depth in September 1973 in the Tehama soil, and for a 42-day period, including part of August and September, the maximum at 8 inches was always above 77° F. The generally cooler Kimball soil never reached 77° F during this same period—ranging from 68° to 75° F.

Water management and short harvest periods appear to be the key to maintaining reduced soil temperatures in northern Sacramento Valley fields of shallow-rooted alfalfa. Because water exerts a cooling effect as it evaporates, the immediate result of an irrigation is reduced soil temperature. Infrequent irrigations, poor water penetration, and low soil moisture-holding capacity reduce plant growth and yield in addition to the problems caused by unfavorable soil temperatures.

The Tehama series reached higher peak temperatures than did the Kimball series and was generally warmer, thus indicating that a soil's physical makeup contributes to its temperature patterns. Shading by both plants and clouds greatly influenced temperatures. After cutting, the rise in soil temperature was influenced by availability of soil moisture. Because temperature rises more rapidly in soil of low moisture content, irrigation should be as near to cutting as practical without increasing soil compaction or delaying hay curing. Midsummer harvest should be accomplished in as short a time as possible to prevent extreme temperature rises in these soils.

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Triticale shows

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The development of triticale, a cross of wheat and rye, has spanned many years. Recently, however, the efforts have been widely publicized, creating interest among agricultural scientists and arousing the curiosity of growers and consumers. In the past 10 years triticale has shown some promise of becoming a crop for California.

Since 1967, when the first modern triticale variety for North America was released by the University of Manitoba, the Department of Agronomy and Range Science at Davis has maintained programs to study its genetics and to develop and evaluate new varieties.

During 1974 and 1975, 11 triticale varieties and experimental lines were evaluated for possible use as a grain crop in the Sacramento and San Joaquin valleys. Entries for these trials were obtained from the International Maize and Wheat Improvement Center (CIMMYT) (Armadillo 107 and Cinnamon), from the University-CIMMYT cooperative triticale breeding project (UC 8567, UC 8614, UC 8825, and UC 56558), and from B. C. Jenkins (JFR varieties, 6TA-204, 6TA-419, 6TA-558, 6TA-565, and 6TA-624). The hexaploid triticales were compared with two of the state's leading wheat varieties—Anza and INIA 66R.

Replicated trials were conducted in the Sacramento and San Joaquin valleys at four locations in 1974 and at five in 1975. The trial sites were in Kings, Fresno, Sacramento, Yolo, and Sutter counties. All trials were grown in irrigated crop areas, but crop irrigations were made only at the Kings, Fresno, and Yolo County locations.

Seed was drill-planted at about 90 pounds per acre in 1974 and at 100 pounds per acre in 1975 in plots 4 feet wide and 24 feet long. Grain yields were obtained by harvesting with a small combine. The planting dates and other cultural practices for each test site were those generally used for wheat culture. These conditions may have had some effect on the relative performance of the two crops, although no strong evidence exists that triticale would benefit greatly from special cultural practices in the trial areas.

Yearly yields are summarized in tables 1 and 2. The results show some limited promise for triticale relative to wheat at individual test sites but, on average, strongly suggest that wheat is more productive. Over the two years the best triticale yielded 22 percent less than the average of the two wheat varieties (table 3), although the yields were somewhat improved over earlier triticale trials reported in *California Agriculture*, September 1969 and February 1972.

Triticale varieties have been improved for bushel weight, reduced plant height, resistance to lodging, and resistance to head snapping and grain shatter-