SOIL STRENGTH

modification of root develop

and soil water extract

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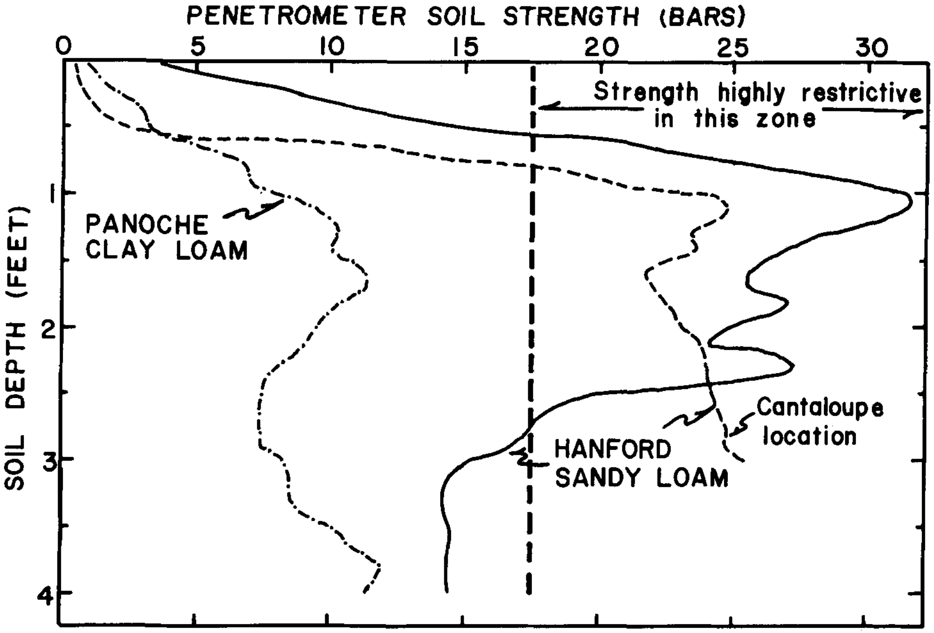
GRAPH 1. PENETROMETER SOIL STRENGTH PROFILES ON THE PANOCHE CLAY LOAM AND HANFORD SANDY LOAM SOILS OF THE STUDY*



* Strength determinations were made with a 30° 0.2-square-inch cone when soils were of a uniform moisture content three days after an irrigation.

The root development of cotton (tap root system) and corn (fibrous root system) in field studies was greatly restricted on a high-strength Hanford sandy loam, compared with that on a low-strength Panoche clay loam. The high strength of the Hanford soil prevented significant root development below two feet, with the result that as much as 80% of extraction of soil water was from the surface foot of soil only.

PLANT ROOT GROWTH may be reduced or prohibited by soil properties which result in high mechanical resistance to the developing plant roots. Not only is the depth of root growth in the soil profile affected, but also the proliferation of roots within a given soil volume. The result is that the effective storage capacity of a soil for water and nutrients is reduced, which may extensively modify the management practices associated with a particular soil system. Soil strength may be as important as texture and density (the properties normally considered) in determining the effective volume of water retained by a soil for plant use.

A measure of soil strength may be obtained by determining the resistance offered by soil to a penetrating steel cone of known dimensions. Since the strength or resistance of a soil increases as the water content is reduced, it is necessary to make the measurements when soils have comparable water contents. Measurements may be considered comparable when made following an irrigation after downward movement of water in the soil has essentially stopped. The studies of this report were conducted to evaluate the influence of wide differences in soil strength on the root growth of two major crops of different root types, and to determine whether planting geometry influenced root development.

Field plots of cotton (SJ-1) and corn (SX17) were established at two University of California field stations in the spring of 1971, on Hanford sandy loam at the Kearney Horticultural Field Station, and on Panoche clay loam at the West Side Field Station, respectively in eastern and western Fresno County. Each crop at each location was grown in separate but adjacent blocks, with planting patterns consisting of two plant densities in each of two row widths (20 and 40 inches between rows) for both crops. Treatments were established in duplicate plots in randomized complete blocks.

Root development was determined four times during the growing season by collecting soil cores in one-foot increments three to four inches to the side of rows at an equal distance from plants down the row. The total length of plant roots in a sample was determined and converted to

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Penetrometer soil strength was measured with the recording cone penetrometer shown. This modification of the cone penetrometer was developed by Lyle Carter, ARS, USDA.

centimeters of plant roots per gram of soil. Two varieties of cantaloupe from a separate experiment at the Hanford soil site were sampled similarly at the end of the growing season to determine root depth-proliferation profiles.

Soil water extraction was determined with a neutron moisture probe for cotton and corn.

Penetrometer soil strength

Soil strength was measured with a recording soil penetrometer having a 30° tapered cone with a 0.2-square-inch area. Each site was characterized when at a uniform water content three days after an irrigation, but with no crop actively growing.

Graph 1 shows the penetrometer soil strength of the Panoche and Hanford soil sites. Laboratory studies have shown soil strength values in excess of about 18 bars (1 bar = 14.5 lbs per square inch) to be extremely restrictive to elongation of plant roots. Both locations on the Hanford soil show strength values that are expected to be restrictive to root elongation in a zone extending from 6 to 8 inches through 2½ to 3 ft. The strength characteristics of the Panoche soil are not expected to impede root development in any depth zone measured.

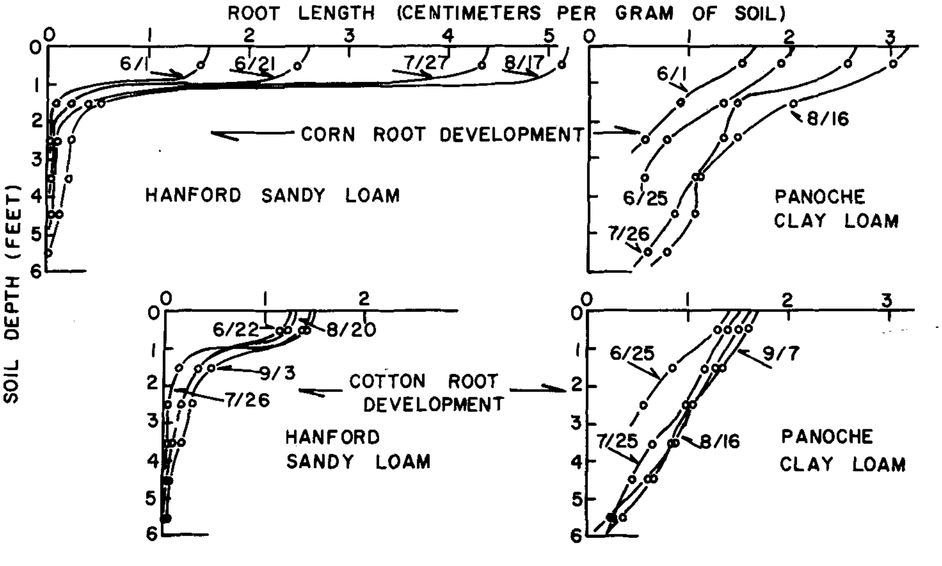
Root development

Graph 2 shows plant root development for cotton and corn on the two contrasting soils. The high strength of the Hanford soil was found to be restrictive to both depth and proliferation of roots 2 ft and lower in the soil profile. In the low-strength Panoche soil the fibrous corn root system continued to grow in both depth and intensity as the season progressed. In the high-strength Hanford soil, root proliferation appears accelerated in the surface foot of soil when it is restricted at 2 ft and below. In contrast to corn, the tap root system of cotton was established earlier in the growing season, with continued proliferation at a reduced rate. High soil strength greatly impeded root development but cotton roots did not proliferate, as did corn, in the lower-strength surface foot of soil when severely restricted at a lower depth. The rooting intensity of cotton was approximately equal in the surface foot of both soils, although the Hanford soil measured considerably greater in penetrometer strength.

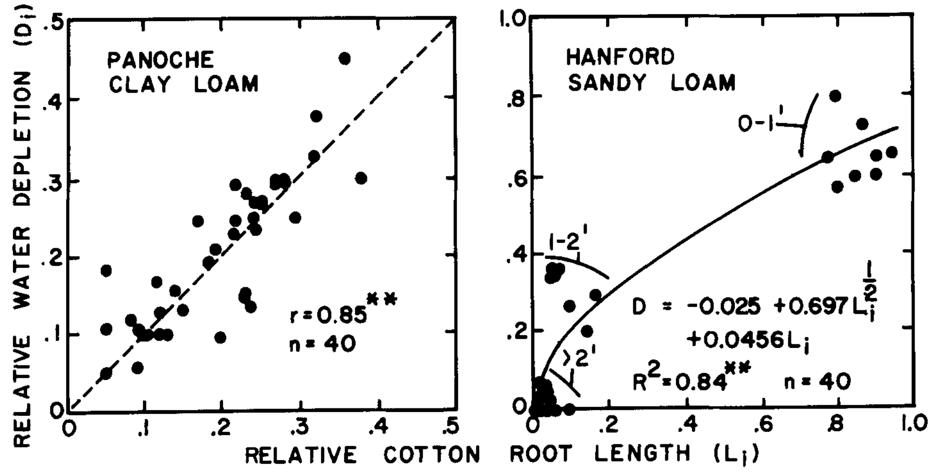
Water extraction

Water depletion from the soil covering a period of several days was determined near the July 29 and July 26 sampling dates on the Panoche and Hanford soils, respectively. To facilitate a comparison of soil water depletion and root development, the fractional part of water depletion at any one-foot soil increment through a depth of 5 ft, in relation to total water depletion through the 5 ft depth, was calculated from $D_i \sum_{0}^{5} / D^i$, where D_i is water depletion by one-foot increments. Rooting intensity by one-foot increments as a part of the total rooting intensity was calculated in a similar way

GRAPH 2. COTTON AND CORN ROOT DEVELOPMENT IN TWO SOILS HAVING WIDE DIFFERENCES IN STRENGTH CHARACTERISTICS AT FOUR SAMPLING DATES IN 1971



GRAPH 3. THE RELATION BETWEEN COTTON ROOT DEVELOPMENT AND SOIL WATER DEPLETION FOR THE PANOCHE AND HANFORD SOILS*



* Relative root length as calulated from $L_i/\epsilon L_i$, where L_i is root length (cm/g of soil, by 1-foot increments, and relative water depletion was determined from $D_i/\epsilon D_i$, where D_i is water depletion by 1-foot increments.

from $L_i\sum_{0}^{5}/L_i$, where L_i is the average root length (cm per g of soil) in any one-foot soil depth (i = soil depth at 0–1, 1–2, . . 4–5 feet).

Graph 3 shows the relation between relative water depletion (D_i) and relative cotton root length (L_i) for the two soils. In the low-strength Panoche soil, water extraction was related linearly to rooting intensity, with soil water depletion at any depth directly proportional to plant root proliferation at that soil depth. In the high-strength Hanford soil, the plant extracted essentially all of its water from the surface foot of soil. The water removed from the second foot of soil was disproportionate to rooting intensity at that depth, because this was practically the only water available after the water was used from the surface foot of soil. Below 2 ft, water extraction and root development were slight. Plants in the high-strength soil were consequently under greater water stress even though an effort was made to compensate by irrigating more often.

Cantaloupe root development

The 'PMR-45' and 'Top Mark' varieties of cantaloupe show little or no difference in soluble solids (sugar) on low-strength soils, but large differences on the high-strength Hanford soil. Evidence indicates that the low sugar level of 'PMR-45' is related to early dying of leaves associated with high mechanical impedance of soil. 'Top Mark' grown on the same soil is affected by this symptom at a later date than is 'PMR-45'. Soil samples were collected from an experiment on the Hanford soil in 1971 at the end of the growing season to establish root development profiles for these two varieties (Graph 4).

The 'Top Mark' variety shows more intensive rooting than 'PMR-45' at all depths sampled. The more intensive root system may account for this variety's ability to accumulate sugar under the adverse soil conditions. If this interpretation proves true, high soil strength will harm this crop directly. Damage from high soil strength is usually attributed to a reduced water and nutrient supply. This aspect is being investigated further.

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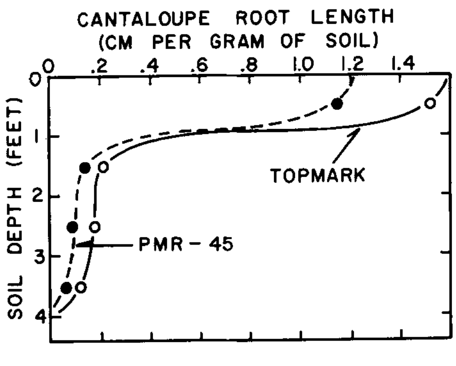
GRAPH 4. ROOTING INTENSITY OF TWO CANTALOUPE VARIETIES ON THE HIGH-STRENGTH HANFORD SOIL



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High levels of rice straw can be utilized by wintering cattle provided that the straw is fortified with appropriate protein, mineral and vitamin supplements. The rations should preferably be cubed to prevent the animals from sorting out the ingredients—and a binder is needed to prepare a good quality cube.

Population pressures and increased concern for the quality of the environment may force California rice producers to look for methods other than field burning in the disposal of rice straw. The incorporation of a high proportion of rice straw into rations for cattle may provide one alternative. Rice straw as a cattle feed is high in fiber and silica, and low in protein and essential minerals such as phosphorus. Previous studies have shown that untreated rice straw is of low digestibility and palatability.

To assess the potential value of rice straw as a major component in wintering rations for cattle, a trial was con-

TABLE 1. COMPOSITION OF RICE STRAW RATIONS*

Feed ingredient	Crude protein	Ration 83	75	70
	% (N × 6.25)	(% rice straw)		
Rice straw	5.3	83.0	75.0	70.0
Barley	10.0	–	9.0	15.0
Cottonseed meal	40.0	10.0	9.0	8.0
PMS†	30.0	5.0	5.0	5.0
Urea	260.0	1.0	1.0	1.0
Trace mineralized salt	–	0.5	0.5	0.5
Gypsum	–	0.25	0.25	0.25
Dicalcium phosphate	–	0.25	0.25	0.25
TOTAL‡		100.0	100.0	100.0

* All rations were cubed in a John Deere Stationary cuber.

† PMS—Liquid feed supplement containing molasses, urea and phosphoric acid which also acts as a binder.

‡ 200,000 IU of Vitamin A per lb of ration added.