show that the intake rate in the stream channel, where no surface sediments had accumulated, was approximately 50 times as great as it was in the pond. It was also evident that the surface sediment layer is the restricting layer, since the rate of intake in the pond, when the layer of surface sediment in the infiltrometer was removed, was equal to the rate in the channel.

The rate of water delivery to the spreading area was maintained at approximately 300 cubic ft per second during the period of the study. This rate had been maintained for some weeks prior to the study, and thus the average intake rate of the spreading grounds is approximately 1.2 ft per day.

An analysis of the texture of pond sediments was made and the data indicate that the sediments were uniform in texture over the area sampled and also from the top of the layer to the bottom. Averages of all samples showed 5% sand, 60% silt, and 35% clay.

Ponding, and the use of interconnecting stream channels for water spreading, (under the circumstances investigated), greatly increase the area needed for recharging a gravel aquifer. The decrease in intake rate in the pond, as compared with the channel, is due to the surface layer of fine sediments which is formed by the deposition of the fine material which is scoured loose in the flowing stream above the spreading area and between ponds. To insure effective use of the ponds, the water must be desilted at the top of the spreading area and kept free of suspended fine sediments as it is moved from pond to pond in the spreading area. An alternative approach, and probably a more practical one, would be to remove the silt in a single large pond and then spread the water out into small parallel shallow streams so that the water velocity remains low. The low velocity would reduce both the amount of scouring and the amount of sediment—thus keeping the rate of infiltration high. The expense of spreading under this system should also be less than with the present ponding system.

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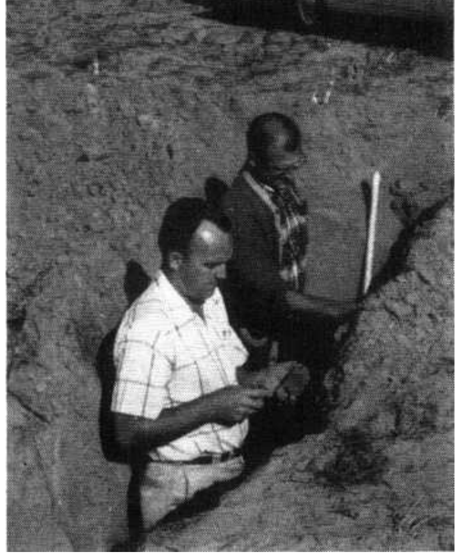

Observations of soil compaction and water penetration problems in orchard photo above were made possible by backhoe trenching.

BACKHOE *orchard analysis and water*

J. L. MEYER

OBSERVATIONS made possible by excavating with a tractor-mounted backhoe in the Stanislaus area of the San Joaquin Valley indicate that perhaps 10% of the vineyards and orchards are located on nonproductive areas of compacted soil. As much as 25% of the alfalfa acreage is productive for only one to two years because of compaction and poor water penetration.

An increasing number of compaction problems are being recognized on soils that have been thought of as very productive. Hanford sandy loam soils are known throughout the San Joaquin Valley as Class 1, deep permeable soils. Their excellence is recognized by the high crop yields, as well as the ease with which they are cultivated. However, these soils are among those being irreversibly abused with cultivation and land-grading equipment.

Mechanical analyses have shown that these sandy soils, which are most compact in fill areas, could be very effectively used to produce the best adobe bricks. Contrary to public opinion, good adobe bricks contain proportionately very little clay or silt. The Hanford soil mentioned above contains fractions within the textural zone that engineers call excellent for adobe brick production, that is 8 to 10% clay, 75 to 80% sand, 10 to 15% silt, and 1 to 2% organic matter.

When a sandy soil that has been growing pasture or sod crops is suddenly covered by grading to the bottom of a fill, the organic content is relatively high and the size of particles is ideal for adobe brick. If in addition the area is compacted as large land-grading equipment is moved across it, then all elements of adobe brickmaking are employed at the surface of the old soil and it is irreversibly compacted.

Blue layers

Furthermore, in a deep fill of 2 to 5 ft, oxygen is often excluded from the old compact soil surface, allowing the anaerobic bacteria to begin to work, and a blue color or gleyed condition develops. The addition of water percolating slowly through the soil excludes even more oxygen and accentuates the blueing or gleying. Existing ferric iron becomes reduced to ferrous iron with the aid of an organic substrate and the iron becomes more soluble and moves down through the profile in this condition with the slowly percolating water. It becomes reoxidized as soon as it reaches a less compact, and consequently less reduced, zone. The ferric iron, having a lower solubility, again is redeposited as ferric oxide or common rust and consequently starts to fill up pores, which reduces and restricts the percolation of water. These rusty lenses are apparent to the naked eye in at least half of the profiles examined. The authors believe that chemical analysis shows that these iron oxide *horizontal* lenses exist in every case of fill compaction in sandy soils. This process probably explains the origin of iron-cemented hardpans.

Deep fills

From county roads, discernible deep fills are often seen (many 20 to 40 years old), that have reduced crop yields. Fills of 2 to 5 ft are compacted to the point that the fill material becomes anaerobic, blue-black in color and often with iron-brown streaks of staining. No roots are found in these layers and bulk densities are high.

Water intake rates are very low in these soils and most often wet layers or perched water tables are found at the interface or

SLOTS *for planting, and of soil compaction penetration*

Tractor-mounted backhoe seen above was used in making excavations for tree planting and analysis of soil compaction and water penetration in this orchard study.

JAMES MC LAUGHLIN

intersection of new fill material and the old soil surface.

Plots were established in 1963 in a sandy compacted soil. One of these was in an area where the classical deep fill was made over a sodded pasture. The problem was recognized by the unthriftiness of about one acre in a field of grapes that otherwise looked very vigorous. Small auger holes revealed the compaction and a gleyed zone to about 4 ft in depth. The characteristic reddish zone existed beneath the gleyed area. The soil was Hanford fine sandy loam.

Auger holes

In an attempt to improve the low vigor, auger holes were dug about 12 inches from the vines. The auger holes were 18 inches in diameter and 36 inches deep. The holes were then backfilled with various treatments of fertilizer, soil and sawdust. All treated vines soon gained in vigor. A cut across these holes in 1967 revealed that roots had entered the holes and grown well. Bulk-density samples revealed a striking increase in pore space in the backfilled auger hole. The most important feature of this experiment, however, was that very few roots had moved outside of the original auger hole and that the irreversible compacted zone outside the hole had not been influenced by adjacent treatment.

Experience by some farmers of sandy soils in the Ballico area of eastern Merced County has shown that the growth rate of trees and at least their early production are enhanced appreciably if the compact areas are backhoed just below the tree before planting. Preplant backhoeing began in 1960 in this area. Because of this success in an otherwise unmanageable compact sand fill situation, the recommendation of preplant backhoeing has followed. A fairly large acreage of trees planted in backhoe slots are now available for observation. All early results look good; that is, most trees that have the advantage of a root zone which was provided by the backhoe-and-refill method are growing much like normal trees in good soil. Adjacent trees planted above a compact soil are distinctly noncommercial in production.

In several Stanislaus County vineyards, compact soils have been pulverized before planting by using a trenching machine directly below the vines in hope of providing an adequately expanded root zone to grow healthy vines. This treatment is also under investigation.

A new tool known as a slip plow is also being used in compact soils. The slip plow treats a 10-inch-wide section of soil much like a trencher or backhoe but is capable of treating much wider areas. The slip plow brings the bottom (noncompacted) soil to the surface and then both the compact surface soil and noncompact deeper soil are mixed as it falls back into the 10-inch slot provided by the slip plow. The compact soil adjacent to the slip plow is also shattered at the same time the slip plow moves through the ground. Hopefully this adjacent shattering is adequate to allow lateral root penetration. Numerous sites subjected to this treatment are presently under observation.

The only remaining acreages of excellent (Class 1) and often sandy soils that are not now intensively farmed in the San Joaquin Valley have fairly rolling topography. These soils are prime targets of deep land grading. It is therefore recommended that alternatives of deep land grading be seriously considered until more experience with these remedial treatments is available for grading sandy soils. It must be assumed that deep fill compaction is irreversible.

Though sprinkler irrigation systems are slightly higher in initial cost, they may eliminate the much more costly irreversible deep fill compaction problems. Most important to all growers is the knowledge that organic material cannot be buried below normal cultivation zones. Land grading, when necessary, must be carried out in such a fashion as to avoid covering over sod and to avoid soil damage by wet filling.

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Planting slots to correct soil compaction and water penetration conditions in orchard soil were made possible with backhoe excavations seen in photo below.