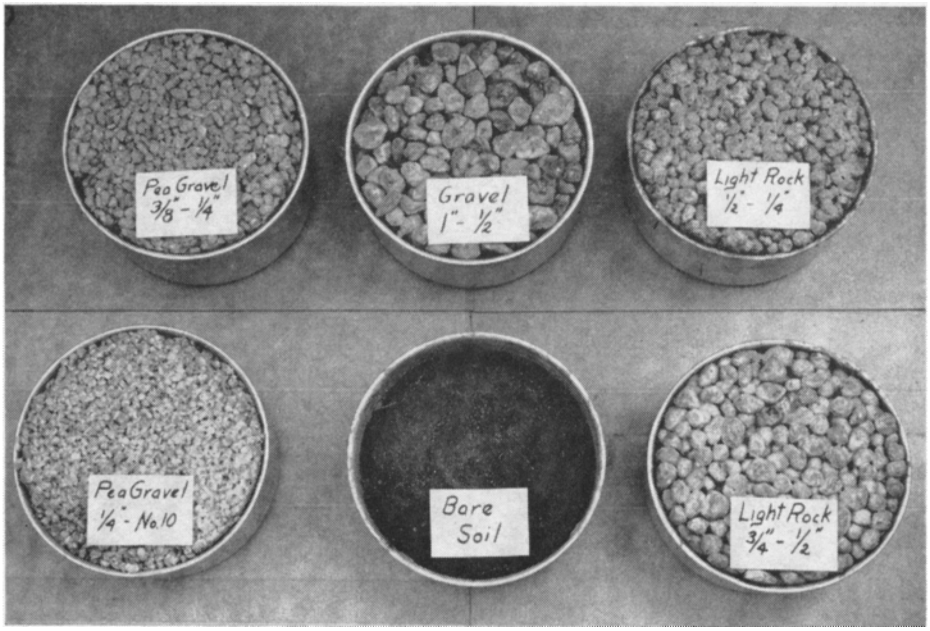


Examples of porous block mulch made from commercial grades of aggregate. The samples are shown fitted to pans of soil used in tests for measuring evaporation.

POROUS

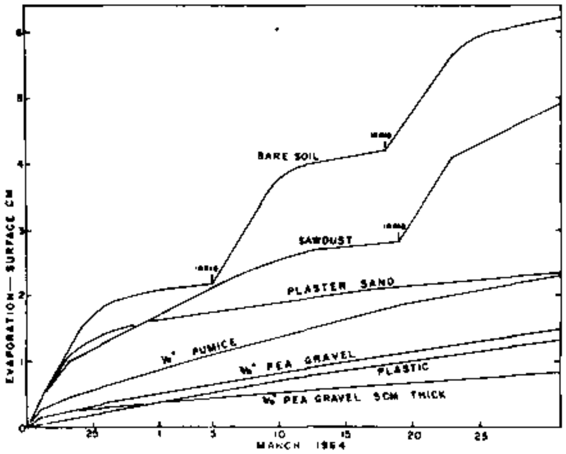
WATER EVAPORATION losses from the soil surface constitute one of the inevitable inefficiencies of irrigation. Many types of soil coverings or mulches have been investigated for reducing evaporation losses. Studies have shown that a porous mulch can be made by cementing pea gravel with a small amount of fine sand and cement mortar to hold the gravel grains in a solid array without filling the pores between grains. Such a mulch has favorable characteristics not only for water conservation, but for reducing salinity hazards, preventing soil compaction and minimizing weed control. Water conservation and salinity become even more important in arid or desert areas. For ornamental plantings, such a mulch can be cast in block form for use over the soil surface much like stone or concrete blocks.

The favorable property of this solid mulch is related to the size of the pores. Optimum dimensions of the irregular pores cannot be accurately specified, but within broad limits, the pore dimensions are fixed by the size of the aggregate or gravel used. The basic theory involved is that the mulch is highly permeable to water added from above as rainfall or irrigation. If essentially all of the pores are larger than a given minimum, all of the pore space will drain free of water following an irrigation. The small amount of water held in the mulch would then occur as a thin layer over the porous surfaces. As evaporation takes place, this thin water layer dries without being replaced by liquid water drawn from the moist soil below. The unsaturated conductivity of a coarse porous medium is so small that liquid films cannot be maintained, hence evaporation from the mulch surface soon becomes negligibly small.

The only other mechanism for moving water away from the soil is by evaporation at the soil surface and diffusion as water vapor through the pores of the mulch into the atmosphere. This diffusion process is retarded by the irregular and tortuous shapes of the air voids in the mulch. When the mulch is made from gravel larger than pea size, evidence indicates that, even though the pore volume is not markedly changed, the pores are larger and more continuous and vapor loss from the mulch is greater.

A photograph is included showing several test "blocks" cast in a circular shape to fit the aluminum pans. The blocks were made from commercial gravels. with the size specifications as given in

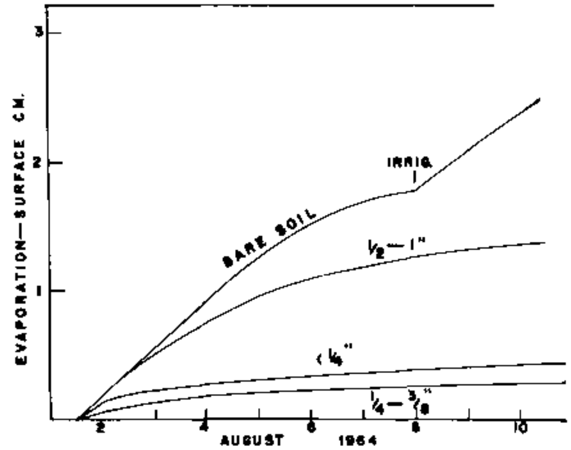
GRAPH 1



Graph 1.—Effects of various mulches on cumulative evaporation relative to bare soil. Except for the plastic sheet and the pea gravel labeled 5 cm thick, the various mulches were all 2.5 cm thick.

Graph 2.—Cumulative evaporation affected by porous block mulches 5 cm thick made from different grades of commercial gravels.

GRAPH 2



BLOCK MULCH*

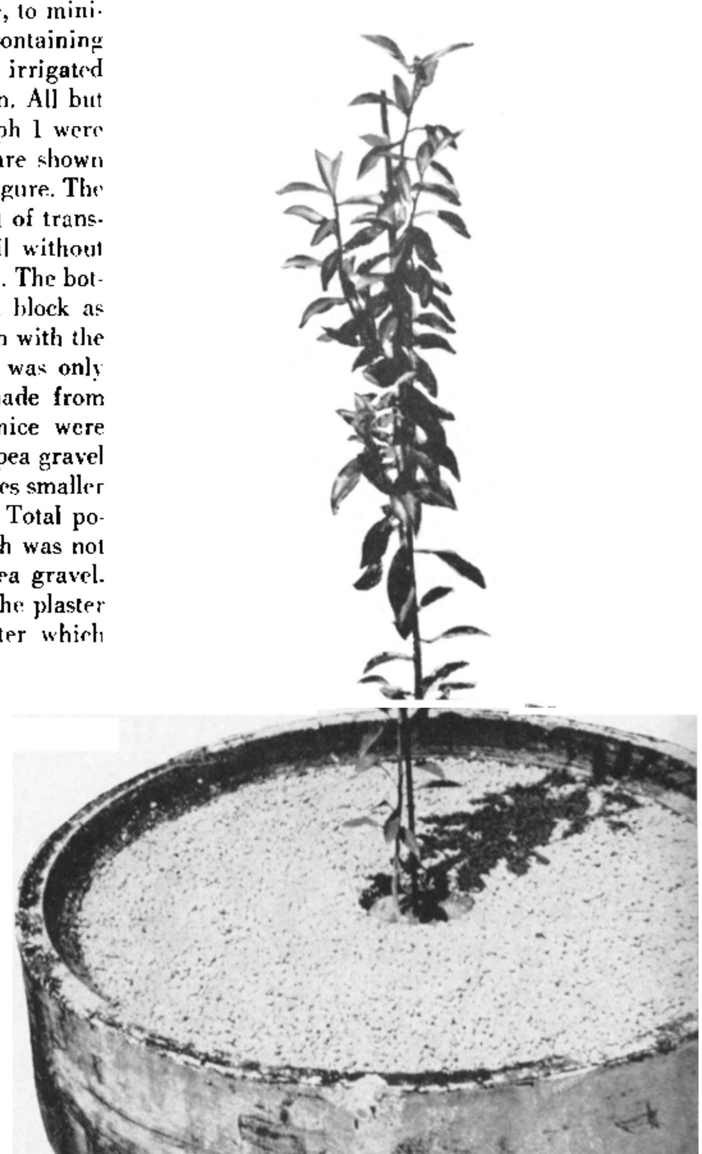
for Ornamental Plantings

S. J. RICHARDS

the figure, by using 10% fine sand and 10% plastic cement and mixing with a minimum amount of water. The two samples labeled "Light Rock" were made from a light weight porous aggregate formed into rough spheres and given a water-proof coating. These blocks have adequate properties as a mulch but whether the advantage of transporting lighter blocks justifies the additional cost of the light weight aggregate is yet to be determined.

Each of the pans, as shown in the photo, was filled with a soil to a 7.5 cm depth before placing the block firmly on the soil. Water was added through the mulch until some outflow occurred through a drainage hole in the pan. After outflow ceased, the pans were weighed and placed on a laboratory bench under a bank of fluorescent lights. Daily weighings were made thereafter. Room temperature and humidity were not controlled, hence with each test run a pan of soil without mulch was used as a check to compare relative rates of evaporation loss with that from a bare soil.

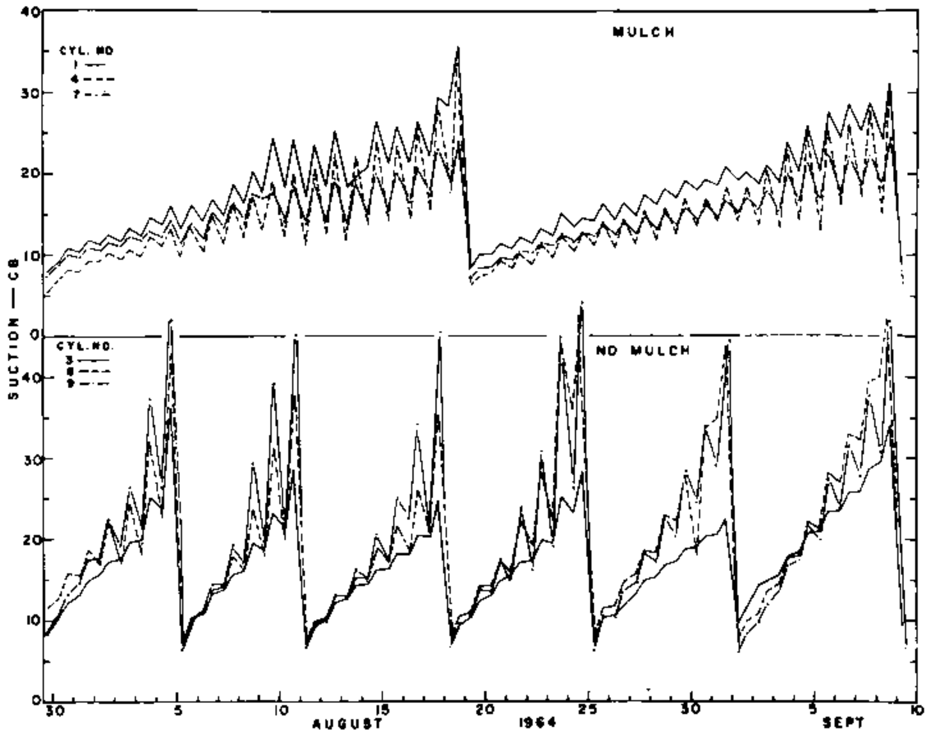
Graph 1 shows accumulated evaporation losses from several kinds of mulching materials as compared with porous blocks made from pea gravel. The quantity of water evaporation is expressed as equivalent depth of water in centimeters over the surface area of the soil. It is well established that as a wet soil dries by evaporation, the rate is initially controlled by the air environment. Later the evaporation loss is controlled by transfer rates in the soil. Hence, to minimize the latter effect, the pans containing soil and sawdust mulch were irrigated during the test period as shown. All but two of the mulch layers in graph 1 were 2.5 cm thick. The exceptions are shown in the two lower curves of the figure. The plastic mulch was a 4-mil sheet of transparent plastic covering the soil without sealing the edge to the pan wall. The bottom curve is for a 5-cm thick block as labeled and shows a comparison with the other pea gravel mulch which was only 2.5 cm thick. The mulches made from plaster sand and $1/8$-inch pumice were cast in the same manner as the pea gravel and show the effects of pore sizes smaller than the acceptable minimum. Total porosity of the plaster sand mulch was not markedly different from the pea gravel. The effect of smaller pores in the plaster sand mulch was to retain water which



Soil container and young citrus seedling showing the porous mulch cast in place over the soil surface.

**Patent applied for by The Regents of the University of California.*

in turn evaporated and, for some time following an irrigation, liquid water could be transferred upward away from the soil surface due to the upward hydraulic gradient.



Graph 3.—Tensiometer records of suction at a 10 cm soil depth for three replicated citrus seedlings growing with and without porous block mulch. Two irrigations with mulch were equivalent to six irrigations without mulch.

Evaporation

Graph 2 gives the results of a test showing the effect on evaporation where the pore dimensions were larger than the optimum dimension. All three blocks in this test were 5 cm thick. Three commercial grades of gravel were used with the nominal dimensions as given on the corresponding curves. The two smaller dimensions are both called pea gravel and show little difference in their effects on controlling evaporation. Blocks made from ½- to 1-inch gravel provide pores large enough for evaporation rates to approach that of the bare soil.

Following the laboratory tests, an out-of-door demonstration was arranged. Cylindrical concrete soil containers, 90 cm in diameter by 120 cm in depth were recessed to about 90 cm in the surrounding soil. A photograph of one such cylinder is shown with the soil surface covered with mulch. Four replicated cylinders were prepared with and without the mulch. For convenience in fitting the circular surface of the cylinder, the mulch was mixed and cast directly on the soil surface. A hole with the dimension of the can used to grow the citrus seedling was provided. After planting the tree and inserting tensiometers through this hole, it was later covered with loose pea gravel.

Tensiometer records

Tensiometer records were used to guide irrigation practices. The soil containers were closed at the lower ends, hence the amount of irrigation water required to maintain soil suction within specified bounds gave a reliable measure of the evapotranspiration. Except for transpiration variability of the trees, any difference in irrigation requirements for the mulched and unmulched cylinders was a measure of the difference in evaporation loss at the soil surface. De-ionized water was used for irrigation, hence salinity was not involved in this experiment.

Graph 3 shows tensiometer records for three trees with and without mulch. The records shown are for an average soil depth of 10 cm. Tensiometers installed at deeper depths showed no consistent trends. During the 40-day period shown, six irrigations were required for the unmulched trees, while with the mulch only two irrigations were applied as indicated. Most of the irrigations indicated by the sharp drop in soil suction resulted from an application of 2.5 surface cm of water. Only occasionally, when one tree would be out of phase with others of the same treatment, was the amount of water applied different from 2.5 cm. The minor fluctuations between irrigations resulted from diurnal variations observed by reading tensiometers twice daily at 8:30 in the morning and again at 4:30 in the afternoon. Tree growth measurements based on increasing stem diameters showed no significant difference between the mulched and unmulched trees.

Monetary savings

Based on current water costs, the monetary saving may not often justfy the use of such a mulch. As water becomes more expensive, however, greater emphasis on efficiency is justified. Other factors also favor the use of a mulch. As the example in graph 3 indicates, when extraneous loss of water is reduced, the number of irrigations is reduced and the timing of any one irrigation is less critical. The slopes of the suction curves show that soil water conditions are changing from wet to dry less rapidly. Reducing evaporation losses also tends to minimize soil salinity problems. Soluble salts are left when water is lost by evaporation. Since irrigation water is needed to replace evaporation losses, more salts are added to the soil, particularly when irrigation water is low quality due to high salt content. In theory, having a solid covering over the soil surface should reduce soil compaction and prevent weed growth, although tests to demonstrate these beneficial effects have not been carried out.

Soil temperature

The effect of the porous mulch on soil temperature was observed to be relatively small. Thermograph records at a 10 cm soil depth with and without the mulch showed actual values were never more than 2°C different and most of the time differences were less than 1°C.

While proposed for use in connection with ornamental plantings, this solid mulch might well be used as a research tool for separating the transpiration and evaporation variables on test plots with certain crops and soil conditions.

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